Food and Agriculture Organization of the United Nations

Soils, where food begins

Proceedings
of the Global Symposium on soils for nutrition

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Contents

Theme 1

Status and trends of global soil nutrient budget: Where and how are soil nutrients in the world?

A meta-analysis approach to measure the global effect of biofertilizer on soil organic carbon stocks

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Keywords: Soil Organic Carbon, carbon sequestration, biofertilizers, microbial inoculants, soil quality, meta-analysis, sustainable agriculture, plant nutrition

Introduction, scope and main objectives

Methodology

An exhaustive and systematic literature search using the ISI Web of Science and Scopus database was conducted in March 2021. The search string was: (“Soil organic carbon" OR "organic C" OR "carbon sequestration" OR "Soil organic C" OR "SOC" OR "OC”) AND ("biofertili*" OR "bio-fertili*"). This search string yielded 248 papers from the Web of Science and 123 from Scopus. Among the exclusion and inclusion criteria, a total of 51 studies from 15 countries remain for further analysis. For each publication, data from organic carbon in an adequate control and treatment representing 244 unique pairwise comparisons were extracted. The standardized mean difference as a measure of effect size was calculated and a random-effect model without covariables was used to calculate the overall effect. In addition, two additional mixed-effects models including two categorical moderators (biofertilizer type and crop type) were performed.

Results

Overall, biofertilizers had a significant positive effect on SOC stocks. Specifically, soils after biofertilizer application increase their SOC concentration by 0.51 g C/kg soil (95 percent CI: 0.13 to 0.89) on average. Moreover, across all microbial inoculants and crop categories, the increase means was 0.65 g C/kg and 0.44 g C/kg, respectively. The use of cyanobacteria or different combinations of microbial inoculants showed the strongest large increase in SOC. Among the crop types, leguminous crops showed the biggest increase, although there is high interest in biofertilizer applications for cereal crops.

Discussion

Biofertilizer application is a good approach to improve crop production meanwhile increasing the quality of the soil. For this reason, biofertilizers should be part of integrated agricultural practices, defined by greater efficiency in the use of resources and sustainable management of natural processes (FAO and ITPS, 2021.). In addition, biofertilizers are cost-effective, eco-friendly and a good substitute for chemical fertilizers.

Conclusion

This study showed evidence that biofertilization practices can contribute to improve SOC stocks. This practice promotes food security, soil quality and climate action. However, more research is still required to understand what factors could influence their success.

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Abriopack project: preliminary data on the effect of the use of compost added with compostable plastics on crop health and possible interactions with the rhizosphere communities

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Keywords: compost, compostable bioplastics, agroecosystems, 16 rRNA, ITS rRNA, rhizosphere, wheat, circular economy

Introduction, scope and main objectives

Within the field of circular economy and sustainability, the recycling of domestic bio-waste is a very relevant topic today. The use of compost as soil amendment is increasingly encouraged as a way to bring back nutrients and enrich crop systems. The application of compost provides benefits such as improvement of soil structure, increase fertility, and soil organic matter content. However, new materials including compostable plastics are increasingly used today and consequently present in the organic fraction of municipal waste (OFMW), from which the compost could be obtained. Until now, few studies have evaluated the effect of these materials, supposed to be environmentally harmless and completely degradable by soil microflora, on crops and their rhizospheric microbiome. Therefore, to keep using this resource it seems fundamental to test the quality of compost containing compostable bioplastics for ecosystem health (Markus and Ramani, 2021.).According to this, one of the main aims of the study is to evaluate and compare the impact of the use of compost and compost added with compostable bioplastics on crop health and the associated rhizospheric microbiome. The study is part of the ABRIOPACK project financed by Rural Developmental Plan (PSR MARCHE 2014 2020).

Methodology

Different partners are involved in the project, among which the Italian Composting Consortium (CIC), which attended to the production of compost at COSMARI composting plant (Tolentino, Marche). Two types of composts have been used in the experimentation: one obtained from the OFMW alone; and a second one with the addition of 3 percent of compostable bioplastics packaging provided from Novamont S.p.A. Novara, Italy (Alessandroni *et al*., 2022). Field experiments were conducted at Research and Experimentation Centre for Plant Improvement (CERMIS) and the composts have been used to fertilize wheat crops (*Triticum aestivum L*. – SOLEHIO variety). The experimental design included three treatments with 5 replicates each (OFMW compost, OFMW compost added with compostable bioplastics and control). The sampling has been performed in May 2022, in each subplot 10 wheat plants at the flowering stage and the related rhizospheric soil were collected. Physicochemical analyses of the soil ware done before compost distribution and will be repeated after the harvesting to test the level of nutrients as well as the presence of possible pollutants.

Results

At present, the morphological characteristics of the plants (height, ear size, chlorophyll content, wet and dry weight etc.) have been evaluated. Based on the analysed parameters there are no significant differences between the applied treatments. However, significant differences in plants 'height were observed within the subplots of the same treatment (intra-plot), while no differences were found when considering subplots belonging to different treatments (inter-plot).

Discussion

In this regard, the experimental field considered is located on a hillside and present a high level of soil heterogeneity. Thereby, the differences could be related to the distribution of the plots along the field's slope compared to the treatments. However, ear size and chlorophyll content did not show any significant difference when compared both inter and intra-plot.

Conclusion

Next step will be the assessment of the possible impact of the different composts on the wheat rhizosphere communities by 16S and ITS rRNA genes using metabarcoding approaches.

Acknowledgements

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Accessible and informative field tests for soil health: shade trees in coffee systems sustain life above and belowground

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Keywords: soil health, soil testing, biological activity, sustainable soil management, shade-grown coffee, agroforestry, farmer empowerment, Central America

Introduction, scope and main objectives

Soil health, the capacity of soil to support life, is of critical concern in achieving agricultural sustainability and food security in a world where a third of the agricultural land is moderately or highly degraded. The ability to monitor soil health status is critical to its conservation, but this remains a challenge in many global regions where testing services are not available or are prohibitively expensive. This project's objective was to evaluate field-based, low-cost soil health test options vis-à-vis laboratory analysis of soil biological health status through an international cooperation among scientists, agricultural advisors, and producers of shade-grown coffee in Costa Rica. Compared to sun-grown coffee, shaded agroforestry coffee management diversifies agricultural products, multiplies sources of food and income for farmers, and provides habitat for beneficial organisms such as birds.

Methodology

Our field-based soil health tests evaluate soil functions and properties essential for life without relying on expensive equipment: for example, aggregate stability is estimated by a slaking test; resistance to runoff demonstrated by a water infiltration test; and capacity for nutrient cycling by decomposition is evidenced by content of organic matter fragments. Here, we describe our field tests and compare their **Results** with quantitative chemical and biomolecular laboratory analyses for volcanic soils on Costa Rican coffee systems with and without the integration of fruit trees for shade.

Results

We found that laboratory analyses supported the Results of field tests indicating greater soil health and microbial activity in shade- grown coffee systems, with a similar level of difference between the two management practices detected using field- or lab-based methods.

Discussion

These simple field tests have multiple applications, as educational tools for visually demonstrating soil health concepts and as readily accessible evidence of soil health status to empower farmers and agricultural advisors in decision making.

Conclusion

Our project found that both field- and lab-based soil health tests indicate the importance of shade trees in coffee systems for stimulating soil biological activity and protecting soil health. Going forward, we propose that broader development of low-cost soil testing methods is needed to equip agricultural communities around the world to locally assess and implement soil health conservation practices as the foundation for sustainable agricultural production.

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Agroforestry as an effective practice for sustainable soil management in olive orchards in Morocco

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Keywords: soil fertility, soil organic matter, mineral nutrition, olive oil quality, agroforestry, yield, olive orchards, annual crops, Morocco

Introduction, scope and main objectives

Agroforestry is an agroecological practice. It has shown great potential to fill the gaps between providing food security and enhancing soil fertility. It often involves combining one or more woody species with annual crops to obtain a mixed farming system, sustainably managed to produce and protect the environment. Agroforestry intercropping systems present an integral part of traditional Mediterranean agriculture, including olive-based intercropping systems. However, a clear vision of soil fertility and productivity of the olive trees under agroforestry systems is still lacking. Therefore, this work aimed to investigate the effects of intercropping crop type on soil fertility and olive trees' mineral nutrition, productivity, and quality of their products.

Methodology

The experiment was performed under field conditions in the Saiss region of Morocco. It was designed in a randomized complete block with three replications. The factor studied is annual crop type. Five treatments were applied (olive-chickpea intercropping system, olive-faba bean intercropping system, olive-lentil intercropping system, olive-soft wheat intercropping system, and olive trees in a monoculture system). From each treatment, samples were collected at different periods of measurement. These samples were the subject of laboratory analysis to monitor the changes in soil fertility level, olive leaf macronutrient content, olive yield, olive oil content, and quality.

Results

Our Results show that soil organic matter records high values in April and July in intercropping systems compared to olive trees in monoculture. At the end of the experiment, using intercropping systems in the olive orchard significantly improved the soil organic matter content. Olive-chickpea and olive-lentil treatments present respectively 0.9 percent and 0.8 percent compared to 0.5 percent in control plot. In addition, leaf potassium levels were affected by intercropping systems in the olive fruit set stage. However, the intercropping systems did not affect the olive yield and quality. In all the systems studied, the fresh fruit weight is above 2.43 g, and the mesocarp: endocarp fresh weight ratio is on the order of 3, which characterizes the olive fruits destined for olive oil production. Thus, free acidity and Peroxide values were within the range for characterizing oil as Virgin olive oil (IOC, 2019.).

Discussion

This investigation contributes to the ongoing Discussions about the effectiveness of agroforestry systems in soil fertility enhancement correlated to farm production and food security taking environmental problems into account. Consequently, the use of intercropping systems is an ecological way to enhance soil fertility. It can increase soil organic matter and make agricultural practices for annual crops profitable, even for the olive trees. On the other hand, the use of intercropping systems did not affect trees yield and the quality of the olive products when investigating the effect of intercropping crops on the latter.

Conclusion

The findings suggested that using agroforestry intercropping systems can be an effective practice for the sustainable production of olive orchards. It could optimize olive tree productivity, preserve soil fertility, and ensure more returns to farmers.

Acknowledgements

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Assessing phosphorus availability for plants in Malagasy soils

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Keywords: orthophosphate ion, functional and mechanistic method, Freundlich kinetic function

Introduction, scope and main objectives

Ensuring food security relies on ensuring productivity. Knowing process governing availability of elements means having a part of controls of food productivity, especially for phosphorus, which is a limited factor for tropical soil like Malagasy soils.

Methodology

A study was conducted in several type of Malagasy soils to assess availability of phosphorus for plants in a functional and mechanistic method. The functional and mechanistic method is a **Result** of a long-term research on phosphorus in various sites spreading in the world. This method was tested several times in temperate soil. Our study completes its usefulness on tropical soil, tested in several type of soil representing type of soils which do exist in Madagascar. Functional and mechanistic method couples 'sorption-desorption experiments with isotopic dilution kinetics of P-ions in steady-state soil suspensions, conducted in laboratory. After having experimental values of the amount of phosphorus susceptible to be available to plant, this method allows describing dynamic of phosphorus in soil-solution interface by orthophosphate ions concentration in solution (Cp) and time, by using the Freundlich kinetic function. 116 samples of soils type were tested.

Results

Results describe the evolution of orthophosphate ions concentration in solution (Cp) and the amount of orthophosphate ions sorbed (that means fixed) on solid phase. Our Results shows that samples of soil have varied characteristics between them. Some reacts intensively with orthophosphate ions (P-ions), thus for some, transfer of phosphorus in soil-solid interface is gradual. Soils is stated as ‘reacts ’if the known amount of phosphorus introduced in solution disappear after the experiments, only a few amounts remain in solution. That means phosphorus was passes through solution to solid phase. If the transfer is stated ‘gradual’, that means a major quantity of phosphorus introduced remain in solution. This is paired with saturation of solid phase. Handle experimental values of orthophosphate ions diffusible and its values obtained in the Freundlich kinetic function in a regression shows r2 equal to 0.997 with 79 experimental observations.

Discussion

Functional and mechanistic evaluation of dynamic of phosphorus proved its steadfastness, even in tropical soil like Malagasy soils. This method allows to identify both concentration of orthophosphate ions in solution, quantity of P-ions sorbed or desorbed and above all, to quantify the diffusible P-ions at the solid-solution interface as a function of dissolved P-ion concentration and time. The use of the Freundlich kinetic function makes possible knowing the amount of phosphorus available for plants by having concentration of ions in solution and time. From the kinetic equation of Freundlich, parameters (v, w, p) which could characterize the behavior of soils with respect to P-ions are obtained.

Conclusion

We are convinced that knowing phosphorus availability improve success on productivity, that can contribute to reach food security.

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Assessment of the diversity of cultivated microorganisms in samples of soils and plants of the aral sea region in the autumn-winter period

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Keywords: Aral Sea region, microbial communities, halotolerance, *Kraschenínnikovia ewersmanniana*

Introduction, scope and main objectives

The Aral Sea region soils are characterized of high salinity and aridity, leading to the land's degradation (Ramazonov, 2018). To remediation of soil environmentally friendly and safe methods have been proposed using complexes of plants and microorganisms separately or in combination (Bandou, 2006.). The presence of microbes in degraded soils, the tissues of native plants makes it possible to assess the potential and predict the development of saline territories. The scope of work is to assess the microbial communities of nature samples of the Aral Sea region as an indicator of the possibility of land use. The object of the study is 20 samples of soils and halophytic plants from some areas of the Aral Sea region (coast of the sea, the Ustyurt Plateau, the Barsa Kelmes salt marsh). The samples were taken in November-December 2021.

Methodology

The chemical composition of the soil was determined according to the approved State Standards. The isolation of microbes was carried out by standard methods on Czapek-Dox media (for fungi) and NB/NA (for bacteria) supplemented with 0–15 percent NaCl. Microorganisms were identified by studying conidia according to Litvinov's manual (for fungi) and on MALDI-TOF MS (for bacteria).

Results

The chemical analysis of soil samples showed that the water extract of soils has a pH value of 8.23 in the salt marsh area, 9.27 at the Aral Sea coast and the Ustyurt. The salts concentration (in g/l) in the samples from the Aral Sea coast ranged from 4.7 to15; the most saline samples were registered near the Barsa Kelmes salt marsh (11 - 56.6), in the rhizosphere of halophytes a low salt content was observed: 0.2 - 0.8. From the selected samples, 38 fungal and 14 bacterial halotolerant isolates were isolated into a pure culture, including 18 soil fungi and 20 endophytic fungi, 6 soil bacteria and 8 endophytic bacteria. 50 percent of total number of cultures was isolated from the rhizosphere and tissues of the halophyte *Kraschenínnikovia ewersmanniana*, the least - from the coastal soil of the Aral Sea, and from 6 samples of the coastal zone and salt marsh it was not possible to obtain a single culturable form of microorganisms. *Aspergillus, Alternaria, Penicillium* represent the isolated fungal isolates, and 1 isolate was *Mycelia sterilia*. Bacteria are represented by *Bacillus, Staphylococcus, Azoarcus, Ochrobactrum, Pseudomonas, Halomonas, Oceanobacillus, Lactobacillus*, 2 isolates that could not be identified.

Discussion

It was shown that the number of microorganisms and their diversity was small in the autumn-winter period in samples from Aral Sea region. The regularity of the data obtained is confirmed by the literature sources (Begmatov, 2020) and is explained by the uncomfortable life conditions for many microbes specific to fertile soils and glycophyte plants, as well as seasonality. In contrast, the rhizosphere and tissues of *K. ewersmanniana* are inhabited by a relatively large quantitative and qualitative microorganisms. Therefore, this halophyte is a valuable fodder crop, which is also successfully used to reclamation saline desert areas.

Conclusion

As a **Result** of the work, low isolation and diversity of halotolerant fungi and bacteria from soil samples and plants of the Aral Sea region were shown. In the same time the presence of identified groups of microorganisms in the soil under such harsh conditions allows us to hope for the success of remediation projects carried out in the Aral Sea region, which aim to fix shifting sands and create pastures.

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Available phosphorus in soils of conventional and agroecological orchards of Chaco, Argentina

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Keywords: anthrosols, fertilization, family farming

Introduction, scope and main objectives

The World Reference Base, or WRB, is a soil classification system endorsed by the International Union of Soil Science, and has established a reference soil group called Anthrosols, which groups soils with outstanding characteristics resulting from human activities. Soils under orchards are modified by man by permanent removal, addition of manures and/or fertilizers, addition of mulch of different origins, among other practices. The aim of this study was to determine the available phosphorus content in horticultural systems in Chaco province, and to observe if there were significant differences in both treatments.

Methodology

Fourteen orchards were selected, 7 under each type of management, located in urban and periurban soils of the departments of Comandante Fernández, Sargento Cabral and General Güemes, which have a high proportion of family horticultural activity in the Chaco. Agroecological systems (AE) were characterized by applying organic amendments, such as compost and vermicompost, and conventional systems (CO) by using mineral fertilizers, more precisely Triple 15 (NPK) fertilizer. In each orchard we analyzed texture, total organic carbon (TOC), available phosphorus (P), total nitrogen (Nt), and soil pH. Descriptive statistics and non-parametric analysis of variance (Kruskall Wallis) were performed. Associations between soil physical and chemical attributes were analyzed through Pearson correlations.

Results

In every case, the soils evaluated were neutral to slightly basic, the texture was loamy to sandy loam, with average silt+clay values higher than 41 percent. TOC contents corresponded to values considered moderately well supplied to high in organic matter (mean of 1.86 $g.kg^{-1}$ TOC), with no significant differences between treatments, but with a generally higher tendency in the AE orchards. Although the soils of the province of Chaco are very well supplied with phosphorus, in this study values higher than those typical of the area were observed. Soils under conventional management showed higher phosphorus content at both depths, being higher in the upper stratum (maximum value of 250 ppm). At 0.05 m, 106.88 ppm and 164.84 ppm were measured for AE and CO on average, respectively, and at 0.20 m, 95.59 and 157.63 ppm were measured for AE and CO on average, respectively.

Discussion

Anyway, the differences between both types of management do not show significant differences. The points where the highest P values were recorded coincide with the highest Nt and TOC values.

Conclusion

It can be presumed that the extreme values of conventional orchards are attributable to the mineral fertilizers they use year after year. We can highlight the importance of studying the soils known as Anthrosols.

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Bacterial diversity of the rhizosphere of two priority species from Miombo (*Brachystegia boehmii*) and Mopane (*Colophospermum mopane*) woodlands

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Keywords: Miombo, Mopane, fire, 16SrRNA, rhizosphere, plant growth promoting bacteria, Africa

Introduction, scope and main objectives

Miombo and Mopane woodlands are the most predominant type of vegetation in Southern Africa, belonging to one of the five largest wilderness areas of biodiversity, with economic, ecological and ethnobotanical relevance. The woodlands are a repository of biodiversity with a high proportion of native species, mostly legume trees whose dynamics are driven by a combination of human, animal, and climate action. The extent of the contribution of the microbial flora to these dynamics is however unknown. Therefore, in this study, we characterized the diversity of bacterial communities and associated Plant Growth-Promoting functions in the rhizosphere of the dominant tree legumes, *Brachystegia boehmii* (Miombo), and *Colophospermum mopane* (Mopane) in different soil types along a fire gradient.

Methodology

We analyzed the rhizobacterial communities on the samples by targeted 16S rRNA gene (V3–V4 region) sequencing using the Illumina MiSeq. Because the two tree species belong to the *Leguminosae* family, *Vigna unguiculata* was used as a trap to capture nitrogen- fixing bacteria, and culture-dependent methods in selective media were used to isolate plant growth-promoting bacteria (PGPB). PGP traits were analyzed and molecular taxonomy of the purified isolates was performed based on the 16S rRNA gene (1,2).

Results

The study revealed that, despite the fact that both Miombo and Mopane rhizosphere bacteria are quite rich, bacterial communities in the Miombo rhizosphere are more diverse and more abundant, varying according to soil type and fire frequency. Culture-dependent methods allowed the differentiation of bacterial communities between the sampled sites, which were particularly enriched in Proteobacteria, in both rhizospheres, with a wide range of plant-beneficial traits. Using *V. unguiculata* as a trap, a range of symbiotic (rhizobia) and non-symbiotic diazotrophic species were identified in both ecosystems.

Discussion

Bradyrhizobium sp., the most common bacteria that nodulate a variety of crop legumes in Africa, was the most frequent rhizobia in Mopane soils. In Miombo soils, a more diverse and complex pool of rhizobia bacteria was identified, and included *Mesorhizobium sp., Neorhizobium galegae, Rhizobium sp.*, and *Ensifer adhaeren*s. Non-symbiotic diazotrophs included *Azospirillum zeae, Cohnella rhizosphaerae, Pantoea agglomerans* and *Pseudomonas nitroreducens* (Mopane) and *Agrobacterium sp., Cohnella sp., Herbaspirillum huttiense, Pseudomonas sp.* and *Stenotrophomonas sp*. (Miombo). Both ecosystems constitute a source of promising bacteria in terms of beneficial activities for plants, such as mobilization and acquisition of nutrients (nitrogen fixation, phosphorus production), abiotic stress mitigation (bioremediation through siderophores), and hormone modulation (and concomitant biocontrol and phytostimulation).

Conclusion

These groups offer new opportunities that can contribute to ecological, sustainable, and organic agriculture, yield and quality of agricultural campaigns and, consequently, to the bioeconomy and green transition of the seven southern African countries where these eco-regions are dominant. Thus, the rhizosphere of African savannah ecosystems seems to be an untapped source of bacterial species and strains that should be further exploited for bio-based solutions.

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Bacterial metabolites as a component of the biofertilizers dedicated to the improvement of the biological and chemical quality of the soil

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Keywords: biofertilizers, siderophores, agriculture, microbiology

Introduction, scope and main objectives

The demand for innovative biofertilizers is constantly growing in modern agriculture, due to the search for more sustainable ways of growing plants and the rising costs of conventional fertilization techniques. One way to create valuable products is to use the potential of microorganisms to develop more environment-aware fertilizers. Fertilizers based on microbial metabolites could be an efficient plant- growth promoting agent. Excellent examples of such compounds are various microbial chelating agents, e.g. siderophores and organic acids, which play vital role in nutrient acquisition by bacteria. Properties exhibited by those compounds could be also used for enhancing chemical and biological quality of soil. In this study, we present the strategy used to develop innovative liquid bio-fertilizers containing microbial biocomponents.

Methodology

First, screening was carried out to identify bacteria that efficiently produce biochelators, in order to select strain with particularly high application potential. The next step was to optimize the cultivation conditions in order to increase the rate and reduce the costs of biochelators production. Then, the biocomponents were assessed as a soil biological and chemical quality improving agent, thanks to the study of changes in the abundance and activity of soil microorganisms and the bioavailability of nutrients as a result of the application of biofertilizers. Finally, biochelators were validated for plant growth-promoting properties.

Results

Psychrotolerant microorganism form genus Pseudomonas was selected, as an effective siderophore producer. Optimalization of metabolites production was achieved by the appropriate nutrients selection (carbon and nitrogen sources including glycerol, glucose, citric acid), as well as the optimal culture temperature (the use of psychrotolerant microorganisms allowed for cultivation at lower temperatures and lower energy consumption). Application of biofertilizers increased bioavailability of iron and phosphorus in soil by 10- 30 percent. Bacterial count in soil after treatment was significantly elevated. Biochelators influenced significantly germination of beetroot, pea and tobacco seeds. Number of germinated seeds and time of germination improved.

Discussion

Due to creation of complex compounds, chelating agents increase nutrients bioavailability in soil, what allows for wider utilization of soil nutritional potential. Used as mineral fertilizers additive, they enhance supplementation in plants. Containing various easy- accessible carbon sources, metabolites also boost microbial life in soil, including numerous plant-growth promoting bacteria groups, what also indirectly increase bioavailability of nutrients. Another advantage of bacterial metabolites could be cost-efficient production. Thanks to these properties microbial biofertilizers could not only meet current agricultural needs, by providing efficient nutrition. They could also help to build safe agriculture future generations, due to development of sustainable fertilization management and limitation of chemical fertilizers use.

Conclusion

The obtained results allowed for the development of an effective strategy for the production of biocomponents that can be used for the production of innovative bio-fertilizers, fulfilling the potential of bacterial metabolites as an important addition to agriculture.

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Bio-based fertilizers: some case studies

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Keywords: sustainable soil management, bio-residues waste recovery, agro-industrial wastes compost, zootechnical digestates, soil organic carbon, nitrogen management, plant nutrition, circular economy

Introduction, scope and main objectives

Promoting biodegradable waste recycling and recovery techniques is an urgent priority. Optimizing the use of bio-based fertilizer can contribute to the replacement of chemical fertilizers (Chojnacka et al., 2020). Bio-based fertilizers contain mainly nitrogen and phosphorus, which can be recovered to improve soil fertility and crop nutrition (Case and Jensen, 2019.). Furthermore, agronomic systems which adopt fertilization practices with bio-based fertilizers administer organic matter to the soil, increasing soil organic carbon levels, mitigating soil organic carbon loss with positive effects on soil quality (Ayilara et al., 2020). The agricultural use of compost as well as of digestate is rising, allowing the re-use and the transformation of the bio-residues with positive effects on soil fertility and crop productivity.

The study aimed to evaluate the effects of fertilization with zootechnical digestates on *Lolium* spp. (Site A) and the effect of the compost from distillation residues on the productivity and the nutritional characteristics in *Cucurbita pepo* L. (Site B).

Methodology

Site A
Ryegrass was fertilized with three types of zootechnical digestates. During cultivation, six rains were simulated once every 10 days. Plant productivity and nitrogen uptake were determined. At each rain, the concentration of nitrogen in the leached was analysed.

Site B
Zucchini were fertilized with chemical fertilizer, compost or manure. The productivity, the nutrient contents and some quality indexes were determined.

Results

Site A
The crop nitrogen nutrition and nitrogen leaching were influenced by the mineral nitrogen content and C/N ratio in digestates.

Site B
The highest productivity and dry weight were higher in treatment with compost. Few significant differences were determined in nutrient contents of differently fertilized zucchini.

Discussion

Site A

The digested pig slurry as such had similar effects to chemical nitrogen fertilizer. The digested pig slurry-solid fraction had similar effects to a soil improver, supporting sufficient productivity and with limited nitrogen losses in the eluates.

Site B

The use of the distiller's residue compost as fertilizer had a positive effect on the productivity of zucchini crop that reached a higher yield in comparison to the other treatments, due to the greater availability of nutrients for the plant.

Conclusion

The recovery and recycling in agriculture of bio-based fertilizers represents an opportunity to combine sustainable practices and circular economy. It also represents a strategy to create a positive C budget (C input > C output) contributing to soil carbon sequestration.

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Biodegradable plastics: effects on functionality and fertility of two different soils

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Keywords: biodegradable plastics, soil quality, soil respiration, soil microbial activity, soil enzyme activities

Introduction, scope and main objectives

In agriculture, the use of soil biodegradable mulch films could represent an alternative to conventional plastics films to reduce the plastic waste which is more difficult to recycle at the end of the crop cycle. However, biodegradable mulch films incorporation in soil due to its nature is not merely a physical but also a biogeochemical input, and therefore it is expected to influence the soil quality by affecting its functions (Bandopadhyay *et al.*, 2018). Therefore, the eco-compatibility of biodegradable plastics (BDP) needs to be evaluated for their impact on different soil functions. The objective of this study was to understand the effect of increasing amounts of BDP (from 0 to 1 percent) on soil functionality in two soils: a loamy and a sandy soil. Our aim was to determine which amount of BDP and derived carbon (C) affect soil functionality measured by the use of chemical and biochemical parameters (growth and activity of the microbial biomass, nitrogen (N) availability, and soil enzyme activities), which are fundamental in determining soil functionality.

Methodology

A laboratory experiment was conducted over one year on the two soils and the BDP used were commercial biodegradable mulch films made of Mater-Bi (grade EF04P) and certified according to the European standard EN 17033:2018 (specifically designed for biodegradable mulch films). The amount of BDP added in the four treatments was 10 (P10), 100 (P100), 1 000 (P 1 000), and 10 000 (P10 000) mg of BDP per kg of dry soil. The P100 treatment (100 mg/kg soil) corresponds to the mean annual quantity of BDP material incorporated into the soil (EN 1 7033 suggests 0.0063 percent = 63 mg/kg calculated based on mean characteristics of BDP), whereas the P10000 treatment corresponds to a loading rate of 1 percent, the quantity recommended in EN 17033 and used for certification purpose; this quantity corresponds to a high number of mulching treatment in the field. The BDP were added as small fragments (<2 mm) and carefully mixed with the soil. Sampling was carried out at 0, 28, 56, 112, 168, 224, and 350 days of incubation. Soil respiration was simultaneously measured for 35 days with a distinct incubation developed at the same conditions.

Results

The addition of C from BDP influenced the processes linked to the C and N cycles, with positive effects on soil microbial biomass, even if the extent of the processes was significantly influenced by the physicochemical characteristics of the soils considered. Indeed, C and N dynamics and enzyme activities were strongly affected by soil texture, independent of the BDP dose added. The lower doses of BDP (P10, P100, and P 1 000) induced results that were comparable to those of the control, indicating that their addition to the soil did not affect the soil biochemistry. Only the highest dose of BDP (P 10 000) stimulated growth of the microbial biomass, increased C mineralization, and increased immobilization of available N.

Discussion

Indeed, addition of C with the highest BDP dose caused an imbalance in the C/N ratio, thereby increasing the need for microorganisms to immobilize N, the limiting element. This, in turn, stimulated the microbial activity for soil organic matter decomposition and N mining (priming effect) (Chen et al., 2014). On the other hand, the lower doses of BDP added to the soil induced **Results** that are comparable to those of the untreated control, meaning that their addition to the soil did not lead to negative effects on soil biochemistry.

Conclusion

Future studies will need to take into account these results, especially when BDP effect would be tested also on plant growth.

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Bodegradable pva/starch/bentonite polymeric blend to improve fertilizer use efficiency

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Keywords: wheat starch, di-ammonium phosphate, *Aspergillus awamori*, *Trichoderma viride*, wheat, vertisol, inceptisol

Introduction, scope and main objectives

Except in organic agriculture, nitrogen (N) and phosphorus (P) are mainly supplied through fertilizers, which are easily water soluble in nature. Thus, fertilizer is an inevitable part of modern agriculture. These fertilizers often resulted flushed release of plant nutrients, which is responsible for temporary nutrient toxicity. Unused nutrients either become unavailable to plants due to several complex reactions in soil or get lost and contaminate the environment. Indeed, inclusion of controlled/slow release mechanisms in fertilizers could curb the flash nutrient release. This is possible through coating of commercial grade fertilizers and loading of nutrients in polymeric backbones.

Methodology

We emphasized on synthesis, characterization and performance evaluation of PVA/starch/bentonite polymeric blend based controlled release DAP formulation (CRDAPs), monitoring of controlled release mechanism in water and soil medium and compared against uncoated di-ammonium phosphate (DAP), study of N and P recovery efficacy of wheat (*Triticum aestivum L.*) from these CRDAPs treated soils (Inceptisol and Vertisol) with or without *Aspergillus awamori* inoculation. The PVA/starch/bentonite polymeric blends were synthesized by taking different weight-based combinations of PVA, wheat starch and clay fractioned bentonite and synthesized by using graft polymerization. Porosity, water absorption (percent), polymeric density were determined using standard protocols; whereas crystallinity index and polymeric structure were assessed through XRD and TEM. Surface morphology and functional analysis through SEM and FTIR, respectively.

Results

The XRD, FTIR and TEM recognized the compatibility of bentonite with starch/PVA blend; whereas, SEM images revealed several micropores in PVA/starch/bentonite polymeric blends. The X-ray diffraction (XRD) analysis revealed that increasing bentonite content (0-20 wt percent) in PVA/starch/bentonite polymeric blends resulted increased relative crystallinity index (16.8 to 38.6 percent); in contrary, porosity and water absorption decreased. Half-life of PVA/starch/bentonite polymeric blends ranges between 27 and 74 days, but biodegradation accelerates under *Aspergillus awamori* (half-life 20-51 days), and *Trichoderma viride* (half-life 25-71 days) inoculated soil. Overall, greater bentonite content stabilizes the structure of polymeric blends. The DAP was encapsulated at 0, 4 and 8wt percent. Nitrogen and P release data were well fitted to Korsmeyer-Peppas model, the model parameter revealed that N and P release from all CRDAPs were followed non-Fickian diffusion; whereas nutrient release from uncoated DAP was occurred through Quasi-Fickian diffusion.

Discussion

The relative crystallinity index of PVA/starch/bentonite polymeric blends increased with increasing bentonite content. Few published works are also reported that relative crystallinity of starch-based polymers increased with increased content of normal and nano-fractioned bentonite (Lendvai *et al*., 2018; Müller *et al*., 2011.) nano-SiO_2 (Yao *et al*., 2011.). Excess bentonite might have increased the intercalation of starch/PVA polymeric blends with bentonite, thereby condensed the molecular structure (Ye *et al*., 2020). Compared to N, P release decreased more, which may be due to ionic radius of phosphate ions (Tensel *et al*., 2006.; Ge *et al*., 2018).

Conclusion

With the application of CRDAPs N recovery efficiency could be achieved up to 88 percent (44.9 percent for uncoated DAP); whereas, P recovery efficiency could achieved as high as 32.5 percent (15.2 percent for uncoated DAP). Hence this PVA/starch/bentonite polymeric blends could be used for fertilizer modifications for better use efficiency.

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Bioenergy, healthy soil and nutrition: an exploration of the links for win-win opportunities

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Keywords: nutrition security, food security, bioenergy, biochar, digestate, soil quality, phytoremediation, integrated biomass production systems

Introduction, scope and main objectives

Nutrition security has gained attention in global development discourse, and is crucial to achieving the Sustainable Development Goals, particularly SDG2: zero hunger. At least 12 of the 17 goals contain indicators that are highly relevant to nutrition (Scaling up nutrition, n.d.). However, as pressure on global agricultural systems increases due to rapidly growing populations and climate change, nutrition security and the ability to ensure and maintain healthy diets is threatened. Affordable, reliable, sustainable, and modern energy access for all is recognized in Agenda 2030 under SDG7 but also interacts with the achievement of almost all other SDGs. Modern bioenergy, a form of renewable energy produced from organic matter, has the potential to aid in the achievement of the SDGs, particularly for climate targets and nutrition, when managed in an appropriate and sustainable manner. The Global Bioenergy Partnership (GBEP) and FAO has been collaborating to develop and release a Literature Review aimed at collecting and analyzing the available evidence most relevant to the relationship between bioenergy and nutrition. The literature review identifies the various positive interlinkages between bioenergy and nutrition that have been explored in existing research, especially implications on food security and better nutrition, and the impacts on agricultural land and soil quality, which could influence nutrient contents of food.

Methodology

This study was conducted through a review of recent literature on bioenergy and nutrition (from 2006. to 2021.). Articles analyzed for the literature review consisted of peer-reviewed papers, technical papers, and documents prepared by nonprofit organizations and governments. 42 articles were identified through internet searches, specifically Google Scholar, whilst remaining articles were provided by the Partners and Observers of the Global Bioenergy Partnership (GBEP), after a request for specific examples and good practices at national and local level.

Results

The literature review identifies the links between bioenergy and nutrition, and the ways in which bioenergy can be deployed to improve global nutrition. The strongest links between bioenergy and nutrition, as identified in the research, include: improved soil quality through various stages of the bioenergy value chain; enhanced rural livelihoods and income diversification from biomass production for bioenergy; use of modern bioenergy to better cooking practices and reduce indoor air pollution; and use of bioenergy in cold chains.

Discussion

The production and use of bioenergy as part of integrated, sustainable production systems, offers potential to aid in the maintenance and enhancement of nutrition security. Bioenergy production and its byproducts offer the opportunity to facilitate nutrition security by improving soil quality through mechanisms such as phytoremediation, multiple cropping systems, and the use of biochar and digestate as soil amendment. Biomass production for bioenergy additionally presents an opportunity to diversify income, particularly of rural and smallholder farmers, which in turn can have positive impacts on food security.

Conclusion

The findings from the articles reviewed evidence multiple indirect or implied linkages between bioenergy, improved soil quality and nutrition that provide great opportunities for future research and collaborations aimed to address food security and better nutrition.

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Changes in nutrients contents (P, K, Mg) in topsoil over the past 30 years in Mainland France

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Keywords: soil monitoring, fertility, soil test database

Introduction, scope and main objectives

Since the 1970s, amounts of phosphorus and potassium brought to soils through mineral fertilisers have decreased by 70 percent in France (UNIFA, 2018), without organic compensation. This situation has led to a reduction in nutrients balances. Giving the highly changing international context and the increasing tensions on the fertilizer market, knowing the fertility of arable land is crucial to ensure sustainable productivity of soils and food security. The aim of this study was to evaluate using an original source of monitoring data (the French National Soil Test database, BDAT) how this decrease in fertiliser's application reflects in evolution of nutrient contents status of French arable soils over time.

Methodology

The BDAT (https://www.gissol.fr) is a very rich database that gathers physico-chemical soil tests Results performed by commercial laboratories on agricultural topsoil samples since 1990s, at farmers 'request. The spatial and temporal sampling strategy is consequently not controlled. The collected data covers mainland France. The year of sampling is known and the spatial localisation is limited to name of the municipality of the sampled plot. In this work, three periods were compared: 1994-(2002), ((2003))-2011. and 2012- 2019. each with around 1 million soil test results. Soil tests Results were spatially aggregated by administrative entities (small agricultural regions - 713 units in France), and statistical parameters of nutrients contents were computed per time period after a resampling procedure (Monte Carlo approach) aiming at avoiding biases due to the origin of the data. The trends in a selected set of soil fertility parameters were studied: pH, K2O, MgO, P2O5, C and K/CEC. In a second step, agronomic diagnosis of MgO, K2O and P2O5 was performed with the software RegiFert® (Denoroy *et al.*, 2004.). This diagnosis evaluates the necessity of fertilisation to reach the potential yield considering the crop, the soil nutrient status and other soil characteristics. Results are provided according to three classes: low, intermediate and high fertility. Evolution of contents was assessed using the non-parametric Mann–Whitney test, and evolution of diagnosis was assessed using the adequation $\chi2$ test, combined with expert rules on the evolution of the count of results into each fertility class.

Results

Previous studies based on BDAT data have shown an increase in MgO content, a relative stable content in K_2O, and C but a global decrease of P205 between 1990-2004. and 2005-2014, although a risk of crop deficiency seem to concern very limited agricultural areas. Preliminary results of this study with more recent soil tests show the same trend in evolution of soil parameters in French soils for the last period.

Discussion

The results of this study were obtained after aggregating the results of analyses by spatial entity and by time using data not originally collected to monitor soil status at the national scale. The distribution of the samples was not controlled on the national territory. Despite the statistical procedures implemented, it is not possible to exclude possible biases related to the collection method.

Conclusion

The overall decline in nutrients availability in soils encourages vigilance and soil fertility monitoring through regular soil testing. The BDAT proved its usefulness for the long-term monitoring of soil fertility. Despite the fact that soil chemical fertility is apparently well managed in France, its decrease may endanger food security even in developed countries.

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Combined effect of *Trichoderma* x silicon x organic matter on the dry matter production of *Chenopodium quinoa* willd. cultivated in saline soil in the semiarid of Pernambuco

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Keywords: quinoa, salt stress, plant production

Introduction, scope and main objectives

Semiarid regions suffer in relation to several problems, such as soil salinization, what makes plant production difficult, due to the toxic effects caused by the excess of Na^+ and Cl^- salts, which affect the soil structure, causing damage that takes several years to remedy, but these effects are severely felt by plants, such as osmotic stress, preventing the soil water absorption due to the low potential found in the soil solution. The concentration of salts can reach such high values that the plant will eventually lose water to the external environment (Dias and Blanco, 2010). These effects negatively affect plant growth and development (Esteves and Suzuki, 2008; Freire and Rodrigues, 2009.; Dias and Blanco, 2010). Several studies in the literature have developed techniques to remedy these saline soils and instruct the farmer to use these areas in plant production again, as these soils are abandoned. The main alternative is the cultivation of plants adapted to these extreme conditions, to promote a vegetation cover and minimize soil erosion. Halophytes are well know for these purposes as they survive to these conditions. Quinoa (*Chenopodium quinoa Willd*), of the *Amaranthaceae* family, native to the Andean region of Peru, Bolivia, Ecuador and Colombia (Jacobsen, ((2003))), has characteristics such as high resistance to various adverse factors, such as soil salinity, drought, diseases and pests. It tolerates soils with a pH between 4.8 to 9.5, due to mycorrhizal associations, in addition to maximizing the use of scarce nutrients (Tapia, 1979; Mujica, 1994). There are products that applied to the soil can promote an improvement in its physical and chemical attributes, such as organic matter, which can be of vegetable or animal origin and has a low cost, promotes the release of CO2, produces organic acids and stimulates biological oxidation and microbial activity (Gupta, Bhumbia and Abrol, 1984). One of the alternatives to improve plant resistance to stresses arising from soil salinity is the application of the element silicon, which is a micronutrient (Lima Filho, 2009.). There are several studies looking for plant growth promoters to increase production, this due to the search to reduce the use of fertilizers and pesticides (Machado *et al*., 2012). In this context researches show the potential of some strains of the *Trichoderma fungus* for the increase of plant growth. In this context, this study aimed to evaluate the potential of silicon isolated and associated with the fungus *Trichoderma harzianum* and soil organic matter to enhance the dry mass production of quinoa (*Chenopodium quinoa Wild*) cultivated in saline soil.

Methodology

The work was carried out in pots, in the greenhouse of the Irrigated Agriculture Station – UFRPE/UAST, in the municipality of Parnamirim - PE. The experiment carried out used a Flivisol, which was previously collected in the surface layer (0-20 cm), for chemical and physical characterization purposes, as well as a collection of water for the irrigation of the experiment for chemical characterization. After the analysis of soil and water characterization, the treatments were defined: 1- control (without application of inputs); 2- Silicate; 3- Silicate + Trichoderma; 4- Silicate

+ organic matter; 5- Silicate + organic matter + Trichoderma. In setting up the experiment, the entire soil was sieved in a 4 mm mesh, homogenized and placed in polyethylene pots with 15 kg of soil, then submitted to the cultivation of Quinoa (*Chenopodium quinoa Willd*.) using seedlings previously prepared in trays and transplanted 15 days after emergence into pots, irrigated at two levels of irrigation – 30 percent and 80 percent of the soil's field capacity, and 15 days after emergence, the input mixtures were applied. Thus, the experiment consisted of a 2 x 5 factorial arrangement, with two levels of soil moisture and five different mixtures of soil inputs, in four replications, accounting for 40 experimental units. The experimental design adopted was completely randomized. Approximately 62 days after quinoa cultivation, the plants were collected to weigh the fresh and dry mass of the aerial part. The data obtained were subjected to verification of normal distribution and homescedasticity, premises of the analysis of variance. Subsequently, with the data obtained, we performed an analysis of variance (ANOVA) with the means compared by Tukey test at 5 percent probability.

Results

In dry mass production, the treatments Silicate + T at 30 percent CC and Silicate + MO at 80 percent CC achieved the best performance in the roots with respectively 13 g plant-1 and 17 g plant-1. In the stems there were differences between the moisture levels of the CC, and at 80 percent the productivity was better, standing out from the other treatments only Silicate which obtained 23 g plant-1 and Silicate + T with 26 g plant-1. At 30 percent of CC the Silicate + T had a production of 15 g plant-1 and the best performance, however the mixture of Silicate + MO + T had the lowest dry mass production of stems with 11 g plant-1. In leaves, dry mass production at the levels of 30 percent and 80 percent of CC were similar, but with Silicate + T at 30 percent CC being the best, obtaining 21 g plant-1 and only Silicate at 80 percent CC with a production high, 32 g plant-1, clearly superior to the other treatments. For total plant dry mass, the best treatments were Silicate + T at 30 percent CC and Silicate at 80 percent CC . The application of only Silicate promoted the greatest accumulation of total dry mass, a behavior that was observed in the plant parts of stems and leaves, in the roots, being close to the best treatment for mass accumulation.

Discussion

We can associate this performance the presence of Silicon (Si) which reduces plant stress as the lower availability of water that is saline (30 percent CC), to *Trichoderma* (T) which acts to increase the root area and organic matter promoting chemical and physical improvements in the soil combined with greater availability of water when at 80 percent of CC, reducing the effect of salts present in the water. With the application of silicon in the form of potassium silicate, brings numerous benefits, as this element acts as an attenuator of environmental stress in plants, according to a study carried out by Teodoro *et al.* 2015. evaluated the effect of Si foliar application on soybean dry matter accumulation in response to the water deficit suffered by the crop throughout the cycle with the Si source used potassium silicate, at the end of the experiment it was possible to determine that under water deficit conditions, that the foliar application of Si provided normal plant development, with a greater accumulation of stem dry mass. According to Sávio *et al*. 2011., with foliar applications at a dose corresponding to 40 g L-1 of Si in *Braquiaria decumbes cv. Basilisk and Panicum maximum cv. Mombaça,* with the objective of evaluating the agronomic characteristics and leaf contents of the element, concluded that the applications of Si promoted increases in the production of dry matter, thus explaining why the production of dry mass of the leaves obtained similar results even with lower availability of water in the soil and reducing the effect of water salinity.

Conclusion

The treatments of Silicate + Organic Matter and Silicate + Trichoderma were the best, as they promote better growth of quinoa (*Chenopodium quinoa Willd*) and mitigate the effects of irrigation with saline water. Providing greater production of dry biomass of roots, stems and leaves, caused by the application of Silicon, which shows greater efficiency when combined with organic matter and the fungus *Trichoderma harzianum* in relation to its application in isolation.

Acknowledgements

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Contribution to soil fertility management for improved climate resilience in Senegal: case of the avenir project

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Keywords: ISFM, CSA, nutrition, Sedhiou, Tambacounda, Senegal

Introduction, scope and main objectives

In sub-Saharan Africa, most soils have low intrinsic fertility and exported nutrients are not adequately replaced. Agricultural constraints, including salinization and low soil fertility, and water deficit Results low production, food insecurity, and low farm incomes and affects rural agricultural households (FAO, ((2003). In Senegal, it is even more evident that the constraints related to climate change, including rising temperatures, drought, erosion, salinization led to low soil fertility with a low level of production, food insecurity, and low agricultural incomes for agricultural households. The need for appropriate solutions has become more urgent. Improving soil fertility could lead to rural and national economic growth, lead to long-term food security and improve farmers' living standards, while mitigating environmental degradation, one of the main causes of which is climate change. Smallholder farmers as well as the organizations that support them, face the double challenge of increasing food production while adapting to climate change. To overcome these constraints, among the recommended solutions is the Integrated Soil Fertility Management (ISFM). Defined as an approach based on knowledge intensity, rather than input intensity, ISFM uses local, traditional, and scientific knowledge and integrates it into technologies promoting sustainable natural resource management systems (AGRIDAPE, 2008). The benefits of soil fertility management have been known for a long time which include reversing the trend caused by a gradual deterioration of agricultural soils. There is therefore a range of initiatives aimed at improving soil fertility with techniques of fertilization, organic and inorganic amendments, inoculation with microorganisms, improving plant production and good agronomic practices as well as land use systems such as agroforestry. As mentioned before, ISFM is approach and knowledge intensive, rather than a specific practices. Thus, for a wide scale adoption of ISFM, a lot of training and capacity building of the smallholder farmers on a wide range of options is required. It is in this context that the Adaptation and Valorization of Entrepreneurship in Irrigated Agriculture (AVENIR) project intervenes through the Climate-Smart Agriculture (CSA) approach in the regions of Sedhiou and Tambacounda in Senegal, to contribute to the improved socio-economic well-being and the resilience of agricultural households.

Methodology

In its approach, AVENIR aims to directly reach about 10,000 women and young people from agricultural households (70 percent women and 30 percent young people) through several themes, including Integrated Soil Fertility Management (ISFM). The implementation of this will be done at the level of the demonstration sites chosen in the departments of the two pilot regions through training modules aligning theory and practice. Thus, particular emphasis will be placed on learning through practice, in order to enable agricultural households to better understand the issues related to integrated soil fertility management.

Results

In this start-up phase, field survey activities with targets have allowed us to better understand their perceptions of climate change. Thus, targeted agricultural households are aware of climate change and its exposures and the diversity of sustainable soil management practices.

Discussion

In the AVENIR project, ISFM's interventions aimed at increasing agricultural production for healthier diets for food and nutrition security, will be done through agroforestry, organic amendment (manure, compost, mulching etc.) and adapted fertilization (Deep Placement of Urea (PPU) and micro dose). The impact of these different interventions will have a positive effect on the sustainability of production and strengthen the capacity of agricultural households to adapt and be resilient to climate variations.

Conclusion

Overall, the Integrated Soil Fertility Management Interventions in this project will lead to the adoption of an environmentally friendly technical route, contributing to the food security of rural populations by increasing crop yields and production levels.

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Contributions of chiseling and winter cover crops on soil fertility and biomass yield in maize for silage production

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Keywords: no tillage, chisel plowing, soil management, oat, vetch, radish, fallow, Southern Brazil

Introduction, scope and main objectives

The climate and the predominant animal husbandry system in Southern Brazil make maize crops for silage production strategic for food security of dairy herds. Maize silage is important for animal nutrition, milk production and contributes to preserve the income of rural producers in the face of extreme weather events. Despite its importance, most Brazilian research evaluate soil management effects on maize grain yield, leaving gaps in the knowledge about maize for silage production. This study aimed to evaluate the effects of chiseling and winter cover crops on soil chemical attributes related to its fertility in a production system with maize for silage production, as well as aboveground biomass yield of winter cover crops and maize crop.

Methodology

The experiment started in 2018 in Roca Sales Municipality, Rio Grande do Sul State, Brazil. The soil was clay loam texture and was classified as Inceptisols. The experiment design consists of completely randomized blocks in split-plots with three replications. The main plots (12.5 m x 60 m) were related to perform or not chisel plowing after maize harvest and before winter cover crops sowing. The subplots (12.5 m x 5 m) corresponded to different winter cover crops [1- oat (*Avena spp.*), 2- oat+vetch (*Vicia sativa*), 3- radish (*Raphanus sativus*), 4- fallow (spontaneous plants)]. Soil sampling occurred after harvest in the 0-10 and 10-20 cm layers in 2018, 2019., and 2020. Aboveground biomasses yield (dry matter) was evaluated in winter cover crops and in maize crop in the same years. Winter cover crops were desiccated and the maize directly sown above straw. Soil samples were analyzed for pH (in water, 1:1 ratio), cation exchange capacity (CEC) and available phosphorous (P) (Mehlich 1). The results were analyzed according to linear mixed model, considering the soil layers independently ($p<0.05$). Pairwise comparison was performed as a post hoc analysis.

Results

Considering main plots, lower pH and higher CEC were assigned by chisel plowing in both soil layers (0-10 cm: pH: 5,4 and CEC: 30 cmolc dm-3; 10-20 cm: pH: 5,8 and CEC: 28 cmolc dm^{-3}). The soil CEC in 0-10 cm was also significant for subplots of winter cover crops, reaching 31 cmolc dm3 on soil cultivated with oat. The soil P level in 10-20 cm was influenced by both chisel and winter cover crops, with higher levels when chisel plowing occurred (60 mg dm^{-3}) and oats were sown (64 mg dm^{-3}). In the average of years, winter cover crops biomass yield was greater in all sown cover crops (6 t ha^{-1}) in opposite to fallow (3 t ha^{-1}). In each year, radish, oat and oat+vetch alternated among them the highest biomass yield. In contrast, in the average of years, maize biomass yield was greater only in the subplots cultivated with oat+vetch during winter (17 t ha^{-1}) in opposite to fallow system (14 t ha^{-1}). Considering each harvest, maize biomass yield was only responsive to oat+vetch in 2018/2019. Chisel plowing didn’t influence aboveground biomass, neither in winter cover crops nor in maize crop.

Discussion

In general, chisel plowing and winter cover crops contributed to increase soil nutrient availability, although no influence of chiseling was noticed in aboveground biomass. At first sight, chisel plowing may be dispensable to maintenance of maize yield, but in the long run this soil management can contribute to crop resilience as it improves soil fertility conditions.

Conclusion

Long term experiments and other analysis should address this question and investigate how soil physical and biological attributes are affected by chisel plowing and winter cover crops.

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Current state and perspective of effective use of soils of Zaporizhzha region

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Keywords: land resources, agricultural land, humus, soil, peas, crops

Introduction, scope and main objectives

Undoubtedly, land resources are the most important object of the material world, an important national resource, the basis of food security of any country. Therefore, rational and efficient use of land resources should be a priority of Ukraine's state policy, as it means involving in the economic circulation of land and their efficient use for the main purpose, creating the best conditions for agricultural land to have high productivity and the possibility of obtaining per unit area the maximum number of products, compliance with scientifically sound production technologies. Zaporizhzhia region occupies a favorable economic and geographical position. It is located in the south of the Eastern European Plain and borders on Kherson, Dnipro and Donetsk regions. The climate is temperate-continental, characterized by a clearly defined aridity. Zaporizhzhia region is located in the steppe zone with a characteristic flat landscape dominated by chernozem soils (75 percent of the area), 10 percent of the area - saline chestnut and dark chestnut soils (south and southwest). Zaporizhia region is one of the largest producers of agricultural products and food products among the regions of Ukraine. The total area of land use is 99.6 thousand hectares. The main direction of development of the agro-industrial complex is to increase the pace of agricultural production, increase the profitability of enterprises. Agricultural lands in the Zaporozhye region occupy 83 percent, which is 2 242 thousand hectares, the region produces 7 percent of wheat, 8 percent of legumes, 7.6 percent of sunflower, 5.6 percent of barley, 6.9 percent of honey from the total production in Ukraine. Agri-environmental assessment of land is the first stage of a set of works to determine the suitability of agricultural land for growing biologically complete environmentally friendly products and raw materials, which is based on analysis of qualitative assessment of soil fertility, environmental and chemical characteristics and meteorological factors.

Methodology

Agroecological assessment of the conditions for growing crops in the Zaporozhie region was performed by the method of Medvedev V.V. The agro-ecological assessment is based on the principle of ecological correlation of environmental parameters that characterize the needs of agricultural crops for their cultivation.

Results

Arable lands of the northern and central part of Zaporizhia region are mainly represented by common and southern chernozems. To perform agri-environmental assessment, indicators of rationing of parameters of agri-environmental conditions for growing crops on the example of peas were determined. Values of ordinary and southern chernozems on arable land: thickness of humus layer 40-60 cm, particle size distribution 2-4, soil moisture 1.1 -1.4 g/cm^3, content of mobile phosphorus 62-140 mg /kg, content of mobile forms of heavy metals 0.63 mg/kg, air temperature in the formation of generative organs, 16.8 - 18.3 oC, reserves of productive moisture in the soil layer

0-20 cm when the seedlings 30, reserves of productive moisture in the layer 0-100 cm during flowering or the formation of generative organs – 114.

Discussion

Analyzing and comparing the data obtained in our study, we see that the soils of the Zaporozhie region in most parameters are characterized by acceptable conditions, namely agrophysical, physicochemical and meteorological indicators. Intensive use of soils in the Zaporizhia region and reduction in the use of chemical ameliorants, organic and mineral fertilizers, has led to a decrease in the content of humus, mobile forms of potassium and some trace elements.

Conclusion

After conducting research, we see that the soils of the Zaporizhie region are suitable for growing biologically environmentally friendly products and raw materials, which in turn will have a positive impact on public health.

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Dissolved soil organic matter as a fertility indicator in arable soils: how local conditions control its properties and implications for climate change

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Keywords: seasonal soil conditions, soil fertility, dissolved organic carbon (DOC), total dissolved nitrogen, C/N ratio, fluorescence indices, soil nutrient management, arable soils

Introduction, scope and main objectives

Dissolved organic matter (DOM) is a soil quality indicator controlling fertility. It reflects the organic matter stored in the soil and is also a function of the temporal moisture content. In arable land, soil nutrients managements may change DOM concentration and composition. However, environmental conditions such as climate and tillage also affect DOM. The aim of this study is to investigate whether DOM is a robust property of the soil and its fertility or rather a sensitive indicator of the temporary (microbial) conditions. We studied dissolved organic carbon (DOC), total dissolved nitrogen (DN), SUVA254, C/N ratio, fluorescence index (FI), biological index (BIX), and humification index (HIX) in arable soils.

Methodology

The study sites are characterized by a long-term experimental project to study fertilization effects (no fertilizer, NPK+Manure, and NPK treatments; maize and wheat), having Chernozem soil near Martonvásár (47.331196 N, 18.789660 E), Hungary. Soil samples were collected from each treatment and a grassland in different seasons of 2018 and 2019. from the topsoil (5–11 cm). They were air-dried, and sieved to <2mm. Next, 4g of soil was suspended in 40ml distilled water and shaken for 2 hours. Suspensions were centrifuged using 4 800 rpm for 15 min. 0.45 µm glass fiber was applied for filtration. Filtrates were stored at 4 °C. DOC and total DN concentrations were measured using TOC/TN analyzer (Shimadzu TOC-L/TN). Aromaticity was determined using a UV-ViS spectrophotometer (Shimadzu UV2600i). Fluorescence indices were measured using a Shimadzu RF- 6 000 spectrofluorophotometer. Principle component (PC) analysis was used to reduce data variations. Each PC was correlated with environmental conditions (soil water content, air temperature, and rainfall factors).

Results

All soil samples indicated humified DOM with a very limited microbiological contribution, (FI= 1.2-1.5, BIX =~0.5, and HIX= ~0.9). Soil C/N ratio varied seasonally (1-13), indicating microbial activity changes, suggesting the importance of moisture content. The first three principal components explained 78.2 percent of data variations, and PC1 was about the organic C content and DOM complexity explaining 31.5 percent. Component 2 was about N related properties (27.5 percent). The DOM origin was explained in PC3 (19.2 percent).

Discussion

We found that DOM was a sensitive indicator of the temporary conditions and was significantly influenced by the sampling time. Environmental conditions significantly explained DOM variabilities. Although the treatment had a significant effect on soil DOM properties, sampling time as the major controller dominated organic matter compositions. We agreed with previous studies from peaty gley soils (Tipping *et al.*, 1999) to Gelisol in Alaska (O'Donnell *et al.*, 2016) about weather effects on DOM variations. Compared to our arable sites, (Embacher *et al.*, 2007) found seasonality controlled DOM concentration as they studied different soil groups with a spatial variation between sites (>600km).

Conclusion

Our results showed that DOM is also an indicator of recent microbiological activities rather than soil organic matter alone.

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Diverse crop rotations sustain soil management and food security in Kazakhstan

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Keywords: crop rotation, diversification, soil fertility conservation, wheat

Introduction, scope and main objectives

Currently, agriculture faces various challenges. The stable provision of food for humans suffers from negative factors, in particular, under the exponential growth of the world's population (1). Right now, the full provision of food is highly dependent on geopolitics (2). Soil management and conservation of soil fertility take a backseat due to intensive soil cultivation for agricultural production. More countries started to pay attention to safe crop cultivation. We need to consider not how to feed 9 billion people in 2050, but how to do it in a balanced way: supplying food without compromising natural resources? One way is to increase yields through the intensification of cropping systems and the expansion of sowing areas. The selection of a suitable cropping system cannot be determined in a single cycle (sowing-harvesting) for the advancement of crop diversification. Therefore, crop rotation is an important component of an integrated approach to sustainable agriculture coupled with resource conservation (3). Crop rotations and their proper management can provide a multilateral effect (4; 5). It is known that the cultivation of individual crops in a crop rotation can improve the sustainability of the cropping system. Kazakhstan also promotes a policy of diversification of crop production with a tendency towards a balance between the consumer of agricultural products and the conservation of the country's natural resources. Thus, contributing to the sustainable development of agriculture around the world. Diversification of crop production in Kazakhstan is necessary not only to create a biodiversity landscape and obtain various crops but also to grow crops in a changing climate. Under the prevailing circumstances of climate change, not much research has been done on selecting the suitable crop rotations and selection of crops in the arid steppes of Northern Kazakhstan.

Methodology

To do this, we conducted research at the field trial of the laboratory of crop rotations at the A.I. Barayev Research and Production Center of Grain Farming (N 51 38.369', E 071 01.259'). The soil is southern carbonated chernozem. Different crops have been chosen as predecessors of wheat, which is a focal staple crop in Northern Kazakhstan. Four types of crop rotations have been studied including "fallow-wheat-wheat-barley" (control), "oat-wheat-wheat-barley", "lentil-wheat-flax-barley", and "mustard-wheat-pea-wheat". The experiments have been carried out for 3 years (2018–2020).

Results

In all studied crop rotations, we found that oat, mustard, and lentil as wheat predecessors give yields almost identical to the fallow predecessor. It was 21.4 centner/ha after fallow, 20.1 c/ha - after oat, 18.8-18.9 c/ha - after lentil and mustard, respectively. As a result, the oat appeared to be the second-best predecessor. The most productive crop rotation turned out to be "oats-wheat-wheat-barley"- 21.3 centners per 1 ha of arable land. It is 4.5 centners more compared with the control. The productivity of the crop rotation "mustard-wheat-pea-wheat” is slightly less (16.6 c) compared with the control (16.8 c).

Discussion

In Kazakhstan, fallow has historically been used as the best predecessor for wheat. However, recent studies are increasingly promoting avoiding fallow due to climatic conditions in the north of the country.

Conclusion

Thus, cultivating crops in rotations allows producing more biomass and grain, thereby ensuring a stable supply of food and saving soil resources.

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Durum wheat response to no-tillage and nitrogen fertilization in dry areas of Morocco

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Keywords: conventional tillage, durum wheat, nitrogen fertility, no-tillage, soil

Introduction, scope and main objectives

In Morocco, cereal production is still below the expected potential. The adoption of best agricultural practices that reduce vulnerability to climate is a major requirement. Direct seeding is a system that has shown positive effects on the soil by improving cereal production. Indeed, some factors, integrated with no-tillage (NT), can further improve cereal yields, especially, the choice of the adapted variety and the adequate fertilization.

Methodology

The objective of our study is to investigate the effect of no-till and nitrogen fertilization on the yield of 5 durum wheat varieties recently developed in Morocco: 3 new varieties (Luiza, Faraj, and Nachit), and 2 germplasms (M.G and I.C) in a long-term NT trial at the INRA Merchouch experimental station.

Results

The **Results** showed that, under NT, the varieties Nachit, Faraj, and Luiza had respectively 4.5, 4.3, and 3.4 t/ha of grain yield and 9.8, 7.8, and 6.8 t/ha of straw yield.

Discussion

In addition, we observed that this year, Nachit is the most adapted variety under NT with high yield under a low dose of nitrogen (20 units N per hectare).

Conclusion

In general, we observed a significant effect of direct seeding on nitrogen fertilization for the five germplasms.

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Ecosystem engineering by termites (insecta: isoptera): implications for the restoration of degraded agroecosystems in the context of climate change

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Keywords: soil restoration, climate change, traditional soil restoration practices, termites, soil fertility, carbon sequestration

Introduction, scope and main objectives

In Niger, about 26 percent of the country's arable soil is degraded and 16 percent is highly degraded, unsuitable for agriculture. In light of climatic conditions and population growth, agroecosystems restoration is important to sustain food security. Because of its negative effects on the environment, the usage of chemicals and mechanical strategies are unsuitable, traditional soil restoration practices which are not harmful to the environment are promising solutions in this context. The objective of this study is to assess the different traditional soil restoration practices, and to evaluate the role of soil biodiversity based on termites in a promising traditional soil restoration practice in order to restore ecosystem functioning under a changing climate.

Methodology

Initially, this study investigates the use of a suitable practice with which a high crop yield is expected, in a context of climate change. Once the practice was identified, we studied the diversity and ecosystem services of termites in two agroecosystems under farmer practices: a restored (zaï +mulching), compared to unrestored (control) over a 2-year period. Then, a general model of the decomposition process from litter to carbon sequestration and nitrogen was presented to draw many information on the rate of soil carbon and soil nitrogen based on the termites 'communities 'growth.

Results

The **Result** showed that association zaï + mulch could be considered as the best practice that can participate in a successful adaptation to reduce risk from climate change at the same time by reducing the vulnerability of farmers in terms of food security in the Southwest of Niger for now and even for the future. As to termites, 9 species (*Odontotermes sp1, Amitermes evuncifer, Amitermes aff. Guineensis, Microtermes sp, Microcerotermes aff. Parvus, Macrotermes bellicosus, Ondototermes sp2, Trinervitermes geminatus, Ancistrotermes aff. Cavithorax*) have been identified. Their abundance, richness, and diversity were (15 percent to 45 percent) higher in the restored agrosystems than in the degraded ones. Our Results show that actively restored agrosystems have a notable impact on the recovery of termites 'species that provide ecosystem services and need consideration when working towards sustainability.

Conclusion

Our findings provide evidence that activities of termites can promote the significant activity of microbial decomposers and increasing degradation rates of soil organic matter (SOM), positively related to carbon and nutrients release. In addition, based on differences in the rate of decomposition, we assert that litter decomposition is proportional to the growth of the termite population and that this leads to carbon sequestration and higher nitrogen rate.

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Effect of agriculture on soil properties associated with soil health and fertility in the Argentinean Pampas

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Keywords: soil fertility, soil organic matter, soil acidity

Introduction, scope and main objectives

During the last four decades, the Argentinean Pampas Region (APR) (lat: 33o 23'S to 38o 47'S, long: 57o 36'W to 65o 10'W) has been subjected to a land use change process known as "agriculturization", which is the conversion of native grasslands into croplands. This process can result in the depletion of soil organic matter (SOM) and nutrients availability. However, the extent of this degradation process remains unknown (Wyngaard, 2022). The aim of this study was to determine the current levels of SOM, pH, extractable P (Bray-P), and other nutrients (Ca, Mg, K, Zn, Mn, Cu and Fe) in pristine and cultivated soils.

Methodology

A total of 570 sites were sampled. At each site, composite soil samples (0-20 cm depth) were taken from a pristine condition (sampled in 2011.) and a cultivated field (sampled in 2011. and 2018). In these samples, pH (soil:water ratio of 1:2.5), P-Bray I, SOM, basic cations (1N ammonium acetate at pH 7), and micronutrients (extracted with DTPA) were determined.

Results

The SOM reduction between pristine and agricultural soils ranged from 25 percent to 41 percent (5.32 to 3.99 percent and 4.03 to 2.67 percent). The pH of the soils also decreased, as in 2011. 30 percent of the sites showed a pH below 6.26, while this percentage was 44 percent in 2018. From 2011. to 2018 there was a substantial depletion of nutrients which varied depending on the area within the APR: -21 to -38 percent for P-Bray, -19 to -29 percent for Ca, -30 to -40 percent for Mg, -12 to -30 percent for K, -40 to -57 percent for Mn, -29 to -74 percent for Zn. No significant change in exchangeable Fe and Cu was observed between 2011. and 2018, which presented values that are not limiting for agricultural production (Sainz Rozas, 2019.).

Discussion

Since SOM is a commonly used estimator of soil health, the observed SOM depletion indicates that the capacity of the soils to function within the agroecosystems has been compromised by agriculturization. The reduction in soil pH is associated with the observed depletion of basic cations caused by an extractive productive paradigm with limited replenishment of nutrients. The actual concentration of exchangeable basic cations was not currently limiting for agricultural production (from 1 650 to 3 939 mg kg-1 for Ca, 262 to 350 mg kg^{-1} for Mg, and 285 to 682 mg kg^{-1} for K). However, if the current depletion rates are maintained, basic cations would become limiting in 8 to 116 years, depending on the nutrient and the sub-region of the APR. From the evaluated macro- and micro- nutrients, P and Zn are currently at limiting levels in most of the soils, and the surface area with concentration values below the critical thresholds has increased in the last decade. Along this line, the number of sites with concentration values below the critical threshold increased from 43 percent in 2011. to 66 percent in 2018 for P and from 47 percent to 67 percent for Zn.

Conclusion

The intensive agricultural activity in the APR is negatively affecting soil properties associated with its productive potential. Consequently, a change in the productive paradigm and management practices is required to revert this degradation process and decrease the crops yield gap, such as increasing the entry of carbon and N into the soil, liming, and fertilization with low-mobility nutrients.

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Effect of different land-use management on soil organic matter content

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Keywords: organic matter, surface soil, subsoil, land management

Introduction, scope and main objectives

The soil organic matter (SOM) content is the main factor affecting the function and health of soil Ecosystems (Wang *et al*, 2022), and is an important indicator of long-term land management (Demyan *et al*, 2012; Ontl and Schulte, 2012). It is well recognized that soil organic matter increases structure stability, resistance to rainfall impact, rate of infiltration, and faunal activities (Bationo *et al*, 2007). The amount of SOM is controlled by the inputs of organic matter into the soil profile, and losses are predominantly due to microbial decomposition (Hoffland *et al*, 2020). Different land-use managements (e.g., agricultural, forest) influence soil properties and eventually soil quality.

Methodology

In this study, we investigated the impact of different land-use managements (Garden/arable land, Orchard, Forest, meadow/grassland) on SOM content on the surface (0-30 cm) and down to the subsoil (30-60 cm) based on 42 soil samples in southeast Hungary under similar climatic and pedogenic conditions. These soil samples were performed by the Hungarian standard MSZ-08-0210-1977. This Hungarian standard's method for SOM determination is based on the Walkley-Black method.

Results

Based on the Results, forest land use showed the highest percentage of organic matter (OM) content in the surface soil, followed by, grassland, orchard, and garden/arable land respectively. According to multiple ANOVA comparisons, we can see a significant difference between land uses in surface soil, especially between garden/arable land and forest. Also, we found differences between forest-orchard/arable land and between grassland- garden/arable land (P-value < 0.05). However, there is no difference between different land uses in the subsoil of 30-60 cm (P-value > 0.05). Also according to One-way ANOVA analysis, there is a significant difference between SOM in surface soil and subsoil (P-value <0.000). In all land uses, surface soil had higher SOM content compared to the subsoil.

Discussion

In this study, we investigated the impact of different land uses management (Garden/arable land, Orchard, Forest, Meadow/grassland) on SOM content in the surface (0-30 cm) and subsoil (30-60 cm). According to the results OM decreases with depth in all land uses. Among different land uses, natural areas (forest and grassland) showed a higher percentage of SOM compared to two other land uses (orchard and garden/arable land) in surface soil. Also in surface soil, garden/arable land shows significant differences with natural land uses (forest and grassland). It can be the results of tillage operation in the garden/arable land which caused sudden aeration into the soil profile, resulting in increased available oxygen concentration for the microorganisms and leading to a higher rate of organic matter decomposition in the soil. Also, results in the subsoil showed a higher percentage of OM in garden /arable land and orchard than OM in grassland and forest. It can be also due to tillage operation which causes turnover of surface soil to lower depth in this land use. In the final, we found that different land use mostly affects SOM in surface soil.

Conclusion

In this study, we investigated the impact of different land-use managements (Garden/arable land, Orchard, Forest, meadow/grassland) on SOM content on the surface (0-30 cm) and down to the subsoil (30-60 cm) based on 42 soil samples in southeast Hungary under similar climatic and pedogenic conditions. Based on the results, land use of forest showed the highest percentage of organic matter (OM) content in the surface soil, followed by, grassland, orchard, and garden/arable land respectively. According to multiple ANOVA comparisons, we can see a significant difference between land uses in surface soil, especially between garden/arable land and forest. Also, we found differences between forest- orchard/arable land and between grassland- garden/arable land (P-value < 0.05). However, there is no difference between different land uses in the subsoil of 30-60 cm (P-value > 0.05). Totally, OM decreases with depth in all land uses. Among different land uses, natural areas (forest and grassland) showed a higher percentage of SOM compared to two other land uses (orchard and garden/arable land) in surface soil.

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Effect of different organic nutrient solutions on the growth and yield of blackgram

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Keywords: Black gram, foliar application, organic solution, FYM

Introduction, scope and main objectives

Black gram plays a vital role in improving soil health, ensuring environmental security and considered option in organic farming. Although importance of macronutrients in plant metabolism is well known, yet the role played by the different organic nutrient solutions in plants and their important on yield and quality components of pulses is not well understand. Foliar application of different organic nutrient solutions may be the best option to maximise the pulse productivity. However, the different organic nutrient solutions on the growth and yield of black gram has not been attempted so for in the coastal region of Karaikal. Keeping all the above points in view, the present pot culture experiment was formulated with the following objectives: To explore the feasibility of growing black gram under organic condition. To find out the effect of different organic nutrient solution on the growth and yield of black gram. To find out the best organic nutrient management practice for increasing the productivity of black gram.

Methodology

A pot culture experiment was conducted on the effect of different organic nutrient solutions on the growth and yield of black gram at Pandit Jawaharlal Nehru College of Agriculture and Research Institute (PAJANCOA&RI) Karaikal, Union territory of Puducherry during 2017 (Feb -April). The soil character was clay loam in texture. The soil fertility status was low in available nitrogen and medium in phosphorus and potassium. The crop was raised during February 2017 (Feb-March) under irrigated condition. Black gram variety ADT 3 was chosen for the study. The pot culture experiment was laid out in a completely Randomized Design (CRD) with three replications. Different foliar spray treatments were randomized as per statistical procedures. We studied the effect of Amudham solution, Coconut Butter Milk and Fish Extract Solution with FYM and without FYM at different time of spraying on the growth and yield of black gram. The details of the treatments and notations used is given below Control (No FYM+ No RDF+ No Organic Nutrient solution), RDF(25:50:25 NPK Kg/ha), FYM @12.5 t/ha, Amudham solution @ 10 percent on 15th , 30th and 45th DAS, Coconut buttermilk solution @ 5 percent on 15th, 30th and 45th DAS, T5-Fish Extract @ 0.5 percent on 15th ,30th and 45th DAS, T2 +T3 (FYM + Amudham Solution @ 10 percent), T2+T4 (FYM + Coconut Buttermilk Solution @ 5 percent), T2+T5 (FYM + Fish extract @ 0.5 percent). The pot size was 22.5 × 22.5 × 25 cm. The biometric observations recorded were put to statistical scrutiny as per the procedure suggested by Sukhatme and Amble (1985).

Results

In all the three stages significant effect was observed only on plant height of blackgram of 20th DAS. Whereas at 40 DAS and harvest stages, there was no significant difference observed on plant height of blackgram. Among the different treatment imposed. Recording the plant height at 20 DAS, among the different treatment, recommended dose of fertilizer had significantly recorded higher plant height at 20 DAS which was at par with FYM @ 12.5 t ha^{-1} + foliar spraying of coconut buttermilk solution alone at 10 percent on 15th, 30th and 45th DAS was found to be the next best treatment. The least plant height was recorded under control. Foliar spray of coconut buttermilk @ 10 percent in combination with FYM @ 12.5 t ha^{-1} had significantly produced higher number of pods plant-1 which was however at par with foliar spray of coconut buttermilk alone or fish extract alone. They had number of pods plant-1 was recorded under control. Foliar spray of coconut buttermilk @ 10 percent in combination with FYM @ 12.5 t ha^{-1} had significantly produced higher grain yield which was however at par with foliar spray of coconut buttermilk alone or fish extract alone. They had grain yield was recorded under control.

Discussion

Xu *et al*. 2000 had reported the increased plant height and growth characters of black gram due to application of vermicompost and Panchagavya. The dry matter production of blackgram (g plant-1) at harvest did not vary significantly among the treatment. All most the remained insignificantly and statistically equal among the treatment. The reason for more number of pods plant-1 might be due to the balanced metabolism maintained continuously inside the plant which resulted in increased pods setting and reduced flowers shedding. This was earlier reported by Suresh Kumar *et al*. 2014 have registered the efficiency of Panchagavya foliar spray on the physiological growth and yield of black gram (*Vigna mungo*) cv, ADT-3. They had revealed that foliar application of Panchagavya recorded significant improvement in chlorophyll content, N content of root nodules, plant height, number of branches per plant, leaf area index (LAI) and dry matter production when compared to NPK and control. Similarly, yield attributed such as number of pods per plant, number of seeds per pod, test weight and grain yield were also recorded significantly higher under foliar application of Panchagavya over NPK and control. The reason for the increased number of grain pod-1 might be attributed to the translocation of assimilates to the sink which resulted in improvement in growth and yield parameters thereby result in increased in number of grains pod-1. The same result was reported by Suresh Kumar *et al.* 2014 have registered the efficiency of Panchagavya foliar spray on the physiological growth and yield of black gram (*Vigna mungo*) cv, ADT-3. They had revealed that foliar application of Panchagavya recorded significant improvement in chlorophyll content, N content of root nodules, plant height, number of branches per plant, leaf area index (LAI) and dry matter production when compared to NPK and control. Similarly, yield attributed such as number of pods per plant, number of seeds per pod, test weight and grain yield were also recorded significantly higher under foliar application of Panchagavya over NPK and control. The reason for more grain yield plant-1 might be due to the balanced metabolism maintained continuously inside the plant which resulted in increased pods setting and reduced flowers shedding. This was earlier reported by Nongthombam Rita *et al*. 2014 reported the soil treated with FYM was found to be the best in terms of seed yield and other yield attributed characters.

Conclusion

From the present pot culture experiment, it could be concluded that black gram can be grown organically by following the organic nutrient management practice of either applying Farm Yard Manure @ 12.5 t ha-1 in combination with foliar spraying of coconut butter milk solution @ 5 percent on 15, 30 and 45 DAS or spraying of 5 percent coconut butter milk solution alone or 0.5 percent fish extract alone on 15, 30 and 45 DAS for increased productivity in the coastal region of Karaikal. However, owing to the additional cost involved in the application of Farm Yard Manure @ 12.5 t ha-1, it is suggested that foliar spraying of either 5 percent coconut butter milk solution or 0.5 percent fish extract on 15, 30 and 45 DAS of black gram may be followed as the best organic nutrient management practice for increased productivity of black gram in the coastal region of Karaikal.

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We wish to avail this opportunity and evoke on record the ineffable personal indebtedness, deep sense of gratitude to Dr. S. Mala, Professor (Agronomy), PAJANCOA&RI, Karaikal for her explicit instructions, meticulous guidance, sustained encouragement, expert counselling, constructive criticism, affectionate advice, unaccountable patience and help rendered throughout our study, research work and preparation of this report which enabled us to develop an understanding of the subject.

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Effect of long-term nutrient management practices on soil health and paddy yield of rice-rice-fallow cropping system in tropic humid climate

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Keywords: soil health, nitrogen, phosphorus, potassium, free living nitrogen fixing bacteria, phosphate solubilizing bacteria, enzyme

Introduction, scope and main objectives

Long-term repeated nutrient management practices may have impact on soil properties and thus on soil health and modulate crop production. Contribution of soil biochemical properties such as SOC, nutrient availability, function of soil enzymes and soil microbial population were well documented. On the contrary, effect of this parameters on soil quality of hyperthermic vertic endoaquepts and its alteration due to long term nutrient management practices and impact on paddy yield were not well documented. In addition, due to the long run nutrient management practices the parameters that are sensitive to degrade were also not documented. For future food security, it is urgent to find best nutrient management practices that sustain soil health with higher crop productivity. In the present study, we comprised soil biochemical properties and hypothesized that (i) long-term different nutrient management practices may have impact on soil health related parameters and (ii) by using SQI and AreaSQI technique, it may be able to determine soil quality and the soil parameters that are sensitive to degrade due to different nutrient management practices. Hence objectives of the study were (i) to determine the influence of long-term inorganic and INM practices on soil biochemical properties such as nutrient availability, organic carbon stock, total and beneficial microbial growth, enzyme activities, and (ii) to evaluate the impact of these repeated nutrient management practices on soil quality and rice productivity.

Methodology

The soil is Chhiata clay loam, a member of fine, hyperthermic Vertic Endoaquepts. Initial (i.e. in the year 1985) soil OM was 1.14 percent, total nitrogen (N) was 0.08 percent and soil bulk density was 1.39. The experiment had a completely randomized block design with four replications that had the following treatments as: T1: BCF (balanced chemical fertilizer doses of N, P, K, S and Zn), T2: potassium (K) minus from BCF (-K), T3: phosphorus (P) minus from BCF (-P), T4: N minus from BCF (-N), T5: INM (chemical fertilizer with 3 t ha^{-1} decomposed cowdung, CD-INM), T6: INM (chemical fertilizer with 2 t ha^{-1} decomposed poultry litter, PL-INM), and T7: fertilizer control treatment (no external application of chemical fertilizer or organic amendment). PL and CD were applied since 10 years. BCF doses (kg ha^{-1}) N-P-K-S-Zn was applied @138-10-80-20-5 in dry season, irrigated rice (Boro) and 100-10-80-20-5 in and rainfed rice (T. Aman). The nutrient compositions of PL were: organic C (40 ±2.8 percent), total N (1.25 ±0.4 percent), P (0.7 ±0.03 percent) and K (0.95 ±0.1 percent). Applied CD contained: OC (28 ±3.1 percent), total N (0.98 ± 0.1 percent), P (0.3 ±0.008 percent) and K (0.46 ±0.12 percent). During last tillage operation, except N all of the fertilizers and PL were applied according to the assigned treatment. Urea (N) fertilizer was applied (top dress) in three equal splits at 10-15 days after transplanting, at maximum tillering stage and at 5 to 7 days before panicle initiation. The fertilizer rate was calculated following soil test based nutrient requirement with a yield target of 7.5 t ha^{-1} in Boro and 6.5 t ha^{-1} in T. Aman, respectively. Modern high yielding paddy varieties namely; BRRI dhan29 (dry season) and BRRI dhan49 (wet season) were grown following 20 cm × 20 cm spacing. Standard agronomic practices such as irrigation and weeding were followed for paddy cultivation. At maturity, the crop was harvested manually at 15 cm above ground level. From each plot 5 m2 sample was harvested and it was used for per hectare yield determination. Grain yield was recorded at 14 percent moisture content.

Results

The SOC decreased 8 percent due to 33 years BCF compared to initial soil and increased 18 percent in INM compared to BCF practice during last 10 years. Long term BCF practices did not bring significant changes in soil pH, however 0.09 units increased and 1.45 percent bulk density decreased in PL-INM practice. Urease and phosphatase activities, total bacteria, phosphate solubilizing bacteria, free-living N2 fixing bacteria, water stable aggregates, NH4+-N, available P, exchangeable K were increased in INM practices and between two INM treatments, PL was superior over CD. The highest SQI (0.93) and 10 years 'average paddy yield per season (4.99 t ha^{-1}) was obtained in PL-INM followed by CD-INM (SQI, 0.80 and grain yield 4.12 t ha^{-1}) and the lowest in the N minus from BCF practice (SQI, 0.16 and paddy yield 3.2 t ha^{-1}) and control (SQI, 0.33 and paddy yield 2.9 t ha^{-1}) treatment. SQI due BCF practice was 0.68 and average paddy yield was 4.36 t ha^{-1}. The **Results** of AreaSQI revealed that NH_4-N, available P and enzyme activities are the most sensitive soil parameters that degraded due to different nutrient management practices.

Discussion

Soil quality and sustainability due to the different management practices can be quantified by SQI (Bhardwaj *et al*., 2011.). In the study, we found significant correlation between SQI and paddy yield in different nutrient management practices, which may also prove SQI to be an effective tool for the measurement of soil health and predict yield. Liu *et al*. 2016 reported significant correlation between paddy yield and SQI in the different agricultural management practices. In our study, we determine area of SQI to find the parameters sensitive to degradation (Kuzyakov *et al*., 2020) and we found that PL-INM was the best nutrient management packages for rice cultivation and among the two INM practices, PL-INM exhibited better performance over CD-INM. The composition of PL which was abundant in C and N compared to CD favored N, soil biology and enzyme activities. Liu *et al*. 2017 also found higher SQI value in manure treated plots compared to chemical fertilized treatments. However, omission of P and K nutrient had almost similar area SQI ratios as the soil was inherently not deficient of such nutrients. From the AreaSQI radar plots we found NH_4-N and available P were the most sensitive parameters for all tested treatments to sustain soil health. Besides these two parameters urease, phosphatse, and phytase enzyme were also sensitive to degradation. Without the application of N fertilizer produced the lowest area SQI ratio and was sensitive to degradation in urease, phosphatse, phytase and PSB populations, indicating that N is the most limiting nutrient element in sustaining soil fertility and crop productivity. Nevertheless, since the 1950s, N is considered to be major yield limiting nutrient element (Robertson and Vitousek, 2009.). Moreover, from the PCA analyses we can find that stream of NH_4^+–N is compulsory for sustainable paddy production in this tested soil. However, we found NH_4^+–N, available P and soil enzymes were the most sensitive parameters to degrade due to chemical fertilizer management practices.

Conclusion

The study also proved that imbalance fertilizer application, especially removal of N nutrition, was the most detrimental for paddy soil quality and PL-INM treatment is the best nutrient management practice for maintenance of soil health in the hyperthermic vertic endoaquepts and tropical humid climate.

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Effect of simulated soil salinity conditions and varieties of pigeon pea (Cajanus cajan l.) on growth, yield and yield attributes

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Keywords: pigeon pea, salinity levels, growth and yield attributes

Introduction, scope and main objectives

Salinity is one of the major obstacles for increasing production in coastal areas. Salinity stress delays the onset, reduces the rate and increases the dispersion of germination events, resulting in reduced plant growth and crop yield. Soil salinity adversely affects plant growth and development. An excess of soluble salts in the soil leads to osmotic stress, which results in specific ion toxicity and ionic imbalances and the consequences of these can be plant demise. Increasing crop salt tolerance is a highly attractive approach to overcoming the salinity threat. Therefore, salinity is one of the majorly affecting abiotic factors limiting crop productivity. This is attributed to the fact that Na+ competes with K+ for binding sites essential for cellular function and the latter implication of these two macronutrients in salinity is thought to be the one of the factors responsible for the reduction of the biomass and yield components of plants. High concentration of salt in the root zone (rhizosphere) reduces soil water potential and the availability of water. As a result of this, reduction of the water content leading to dehydration at cellular level and osmotic stress is observed. High levels of salts in the soil can often cause serious limitations to agricultural production and land development. The main factors that contribute to this problem are the arid and semi-arid climates and the salt load in the water used for irrigation. The soil salinity may cause several deleterious effects on growth and development of plants at physiological and biochemical level (Gorham *et al*., 1985; Munns, (2002)). These effects can be due to low osmotic potential of soil solution, specific ion effects, nutritional imbalance or a combined effect of all these factors. In India, pigeon pea crop has four distinct maturity groups viz., early (120-140 days), mid-early (141-160 days), medium duration (161-180 days) and long duration (>180 days). Pigeon pea phenology is strongly affected by temperature (Hodges 1991, Jones *et al*. 1991, Ritchie and NeSmith 1991) and photoperiod (Omanga *et al*. (1996)) emphasized that the effect of temperature on the rates of pigeon pea development can be similar in magnitude to those of photoperiod. The optimum range of temperature for proper growth and development of pigeon pea is 18–38o C, whereas in the controlled environment showed that warm (420C) and cool (200C) temperature delay flower initiation and that the optimal temperature for flowering for early maturing type is close to 240C.

Methodology

A pot experiment was conducted during kharif - 2019.-20 at the Department of Agricultural Chemistry and Soil Science, College of Agriculture, JAU, Junagadh. The experiment soil was silty clayey in texture and alkaline in reaction with pH 8.08, EC 0.30 dS m-1, CaCO3 33.00 percent and CEC 35.20 cmol (p+) kg^{-1}. The soil was low in available nitrogen (180.10 kg ha^{-1}) and medium in phosphorus (48.00 kg ha^{-1}), high in available potassium (407.00 kg ha^{-1}), low in available sulphur (21.38 mg kg^{-1}), medium in available iron (7.64 mg kg^{-1}), high in available zinc (1.17 mg kg^{-1}), medium in available manganese (2.95 mg kg^{-1}) and high in available copper (0.57 mg kg^{-1}). The experiment consists of 20 treatments combinations comprising five levels of salinity and four levels of varieties under the Factorial CRD design. The required quantity of N @ 20 kg ha^{-1} and P_2O_5 @

40 kg ha^{-1} applied to all the pots as basal dose in the form of urea and DAP, respectively. The desired soil salinity was artificially prepared by dissolving pre-determined quantity of salt in a measured quantity of water (i.e. on the basis of saturation percentage of soil). The salts used were viz., $CaCl_2$, $MgSO_4$, $MgCl_2$ and NaCl were used for preparing solution and required quantity of salts. The proportion of cations i.e. Na:Ca:Mg was 5:1:2 and anions as Cl:SO4 was 4:1. The desired quantity of soil was spread on a polythene sheet in this layer and salt solution of different EC values were sprayed and soil were covered with polythene sheet for two days. Ten seeds of pigeon pea were sown in each pot at a depth of 2 to 3 cm on the 12th of July 2019. Only the required quantity of water was applied to avoid leaching during first and second irrigations.

Results

The value of seed yield was significantly affected by salinity levels and found to be reduced with each unit increment in level of salinity. The highest value of seed yield 59.01 g pot-1 was achieved under salt concentration level S1 (Control) and 47.09 g pot-1 in variety V4 (AGT-2). The straw yield (Table 1) of pigeon pea was significantly decreased with increased salt concentration. The highest value of straw yield 151.72 g pot-1 recorded with salinity level S1 (Control) and 144.40 g plant-1 in variety V4 (AGT-2). The highest germination percent, plant height (at 45 DAS, 60 DAS and at harvesting stage), number of branches plant-1 at harvest, pod length, number of pods plant-1, number of seeds pod-1, test weight were found lowest salinity level S1 (Control). The lowest days to 50 percent flowering was attained at salinity level S1 (Control). Different varieties also significantly affected the growth parameters. The highest value of germination percentage, number of branches plant-1 at harvest, pod length, number of seeds pod-1, test weight were attained in variety V4 (AGT-2). While the highest plant height (at 45 DAS, 60 DAS and at harvesting stage), number of pods plant-1 were recorded in variety V3 (BDN-2). The lowest days to 50 percent flowering was obtained in variety V4 (AGT-2). Significantly the highest value of protein content (22.62 percent) observed in S1 (Control), which remain statistically at par with S2 level (40 meq l-1). The highest mean seed yield (44.86 g pot-1) was recorded by variety AGT-2 followed by BDN-2 (41.85 g pot-1) and Vaishali (40.96 g pot-1) shown in Table 4. The pigeon pea variety AGT-2 recorded value of different salt tolerance criteria like higher mean salinity index (71.96 percent), higher mean seed yield (44.86 g pot-1), minimum yield decline (37.97 percent) at 10.0 dS m-1 and for 50 percent yield reduction at EC2.5 (11.72 dS m-1).

Discussion

The accumulation of salts in the root zone reduced absorbtion of water by roots of groundnut which suppress pod yield (Padole *et al*., 1993). The herein reduction in yield due to salinity effect are in harmony with previous investigations (Nayak *et al*., 2001) on Indian mustard. Dry weight of shoot decreased as shoot length declined after salinity levels increased, reported by Kaya and Ipak (2003).

Conclusion

It was concluded that the growth, yield and yield attributes and quality parameters decreased with increasing salinity levels of irrigation water. Pigeon pea variety AGT-2 was found more salt tolerant compared to other varieties. The sequential order of salinity tolerance for pigeon pea varieties was observed AGT-2 > BDN-2 > Vaishali > GJP-1.

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Exploring thermophilic bacteria isolated from anhoni hotsprings of central India for plant growth-promoting potential on pigeon pea (*Cajanus cajan*)

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Keywords: Hot springs, thermophiles, plant growth promotion potential, biofertilizer

Introduction, scope and main objectives

In the present investigation, the main aim is to isolate, identify and characterize the efficient stress tolerant plant growth promoting bacterial isolates or consortium for improving the sustainable crop productivity and soil health.

Methodology

Sixty thermophilic bacterial isolates were isolated from Choti and Badi Anhoni Hot springs of Central India. Bacterial cultures were qualitatively tested for cellulolytic, lignolytic, proteolytic, lipolytic, amylase, phosphatase, siderophore and Indole Acetic Acid (IAA) production potential. Based on screening of isolates, six potential bacterial cultures were selected for plant growth promotion potential with pigeon pea (Cajanus cajan) (variety ICPH-87) as test crop. Pot culture experiment was performed with 8 treatments (T1:BAM3, T2:BAS11, T3:BAS17, T4:CAM1, T5:CAM-29-3, T6:CAS-5, T7:consortia, T8:control) and 3 replications under CRD design.

Results

It was also observed that bacterial culture treatment recorded significant enhancement in the root and shoot growth in comparison with control. Also, the study has demonstrated that the bacterial isolates possessing heat tolerance coupled with PGP properties.

Discussion

Thus, it could serve as efficient biofertilizer candidates for improving plant growth and production of pigeon pea under stress conditions.

Conclusion

It was concluded that the isolate CAM1 showed better crop growth followed by BAS11 and CAS5.

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Interactive effect of tillage and potassium: a stress mitigating strategic approach improving yield, physiology and biochemical activities of lentil in rice-fallows of eastern India

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Keywords: Tillage; Rainfed; Phenol; Soil moisture index; Foliar potassium

Introduction, scope and main objectives

Uncertainty of rainfall intensity and distribution, fast depletion of soil moisture contents affect timely sowing, seed germination and establishment of lentil in rice-fallows. Mid-season and terminal droughts retard growth and development of rainfed lentil by affecting its critical growth stages. The objectives of the study were (1) to estimate the effects of tillage and strategic K applications on the changes of soil moisture storage and risk of moisture stress and (2) to study the physiological- biochemical changes at different growth periods and sustainable grain yield of lentil under moisture stress condition. So, the challenge is to develop a scientific recommendation that would allow comprehensive and sustained lentil production at the face of emerging moisture stress as well as raise the farmers' income in rainfed rice-fallow areas.

Methodology

A two-years field experiment was conducted in split-plot design with tillage (ZT-zero tillage and CT-conventional tillage) in main-plots and strategic K application methods (K0-no potassium, Kb-basal application, Kf-foliar application and K(b+f)-basal-foliar application) in sub-plots using rainfed lentil (var. B-77) as test crop in rice-fallow system. We assessed the yield, physiological and biochemical changes of lentil and soil biological properties under the given treatments.

Results

ZT showed ~15 and 23.5 percent higher yield than CT in 2015 and 2016, respectively. Under both tillage practices, Kf and K(b+f) increased lentil yield along with soil microbial biomass carbon (MBC) and dehydrogenase activity (DHA). Kf under ZT retained highest relative leaf water content (RLWC) and leaf area index (LAI); whereas K(b+f) showed similar results in CT. Irrespective of tillage and growth stages, K(b+f) correspondingly increased the chlorophyll and carbohydrate content by ~24.3 and 41.5 percent. In addition, enhanced concentration of phenol, free amino acids and proline in lentil showed a clear indication of moisture stress in K0 under both the tillage practices over the years.

Discussion

Practicing ZT with standing rice stubbles promotes micro pore formation in soil profile that retard soil moisture depletion (Bandyopadhyay et al., 2016). ZT recorded significantly higher MBC compared to CT might be due to the accumulation of organic carbon from the decomposition of standing rice stubbles that retains moisture and forms favourable condition for microbial proliferation (Franco-Andreu et al., 2017). Umar and Moinuddin (2002) reported that K application retards soil moisture depletion by reducing transpiration; hence, K-fed crops retain higher leaf water content even at moisture stressed condition. In addition, accumulation of free amino acids and proline are marked response of moisture deficiency in soil as well as in plants. Accumulation of proline has been reported by several researchers as one of the clear indicators of moisture stress (Iqbal et al., 2018; Han et al., 2019.). foliar K (Kf) introduced nutrients and provide water to the crops, which promotes rapid translocation within the plants soon after spraying (Amanullah, 2013). Thus, foliar application before two critical stages (pre flowering and pre pod formation) remarkably enhanced yield of lentil.

Conclusion

We can conclude that practicing zero tillage with foliar potassium can be an efficient way to escape soil moisture stress sustaining lentil productivity by regulating the biochemical properties of the plant at initial, subsequently improving crop physiological features under rice-fallow system.

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State of the art on biological nitrogen fixation of leguminous crops in Argentina

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Keywords: legumes, soybean, field pea, vetch, peanut, alfalfa, partial N balance

Introduction, scope and main objectives

The contribution of nitrogen (N) from biological fixation of atmospheric N (BNF, kg N ha^{-1}) in legumes may reduce the environmental footprint of N fertilization and improve the profitability of production systems. On a global scale, BNF represents 16-20 percent of the total N of agricultural land, but the contribution differs in each region depending on the soils and production systems, so local estimations of BNF are important for making global N budgets. In Argentina, soybean occupied more than 16 million ha in the 2020-21 season, representing 94 percent of grain legumes planted at the national level. The other legumes planted for grain production include peanut, chickpea, common bean, field pea, and lentil, which are part of regional economies. Alfalfa is the most spread legume pasture representing 10 percent of the total planted area and vetch as cover crops have increased the planted area in the last years. These crops are planted between 22–39° Lat S and 56–66° Long W, with annual average temperatures of 23–14 °C from north to south, and annual average precipitation of 600–1100 mm from west to east. Soils are mainly Mollisols or Alfisols, with organic matter content between 5.5 and 50 g kg−1 and pH between 5.5 and 7.5 in the upper 20-cm layer. These soil and climatic variations determine diverse seed yield and associated N uptake and, therefore, affect the BNF process differently as compared with other regions in the world. The objective of this work was to summarize the contribution of BNF of the main legumes crops in Argentina.

Methodology

The present study has collected published and unpublished information regarding BNF in soybean, peanut, alfalfa, field pea and vetch under field conditions. In all cases BNF was quantified using the 15N abundance methodology. Also, the effect of legumes in the long term is summarized.

Results

The proportion of N from BNF (Ndfa percent) in soybean averaged 59 percent (interquartile range = 46 - 71 percent). Studies in field pea, peanut, and vetch showed average contributions from BNF of 64, 52, and 61 percent, respectively. In absolute terms, this contribution was a respective 51, 138, and 89 kg N ha-1. In alfalfa, N coming from BNF averaged 53 percent and a cumulative contribution of 872 kg N ha-1. In soybean, in fields with a high frequency of soybean in the sequence, inoculation increased Ndfa percent by 2 percent and BNF by 14 percent. Similar studies in pea and vetch showed increases of ca. 53 and 33 percent in Ndfa percent in response to inoculation, which was reflected in 26 and 63 percent increase in N uptake. Inoculation in field pea and vetch also showed a strong impact when evaluated at the sequence level since the following maize needs no N fertilization (after vetch) or a low N fertilizer rate (after field pea) to achieve the yield goal. In general, when crop sequences include legumes for grain production, the partial N balance (PNB= difference between N from FBN and export with grains) is negative or slightly positive. The inclusion of belowground structures in soybean slightly improves this balance, representing 10 and 5 percent of total biomass and N uptake, respectively. Long-term experiments showed that N balances are positive only when vetch is used as a cover crop, reflected in a rise in indicators related to soil nitrogen fertility.

Conclusion

Future studies in the region should complete vacancy information on other legumes like chickpea, common bean, and other pastures like lotus, melilotus, or clover. In soybean, a better understanding of the N demand and the BNF process in high-yielding crops deserves more research. Finally, the impact of BNF in the long-term management practices should be evaluated deeply.

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Phosphorus and sulphur role in potato (*Solanum tuberosum*) nutrition on brown hill soil of Shimla, India

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Keywords: Phosphorus, Sulphur, interaction, potato

Introduction, scope and main objectives

Phosphorus is a component of the complex nucleic acid structure of plants, which regulates protein synthesis. Phosphorus is, therefore, important in cell division and development of new tissue. Phosphorus is also associated with complex energy transformations in the plant. Adding phosphorus to soil low in available phosphorus promotes root growth and winter hardiness, and often hastens maturity. Similarly, sulphur (S) is an essential element in forming proteins, enzymes, vitamins, and chlorophyll in plants. Sulphur is also important in photosynthesis and contributes to crop winter hardiness. An adequate supply of sulphur is very important for crops with high nitrogen requirement which without sulphur cannot optimize their utilization of nitrogen. Taking into consideration in the relevance of two nutrients, a field study was conducted at Shimla during 2019. to evaluate the effect of P and S on tuber yield, quality and nutrient uptake by potato (Solanum tuberosum L) as well as to work out relationship between P: S, ratio in leaves and yield parameters under rainfed conditions of Shimla hills, India.

Methodology

Treatments- T1- Control T2-P0 + S20Kg/h T3- P0+ S40Kg/h T4- P50 percent+S20Kg/h T5- P50 percent+S40Kg/h T6-P100 percent+ S20Kg/h T7-P100 percent+S40Kg/h Design –RBD Treatment- 7 Replication-3 Total Plot-21 Plot Area-3*2.5m2

Results

The optimum P dose varied from 100-50 kg/ha with potato tuber yield response ranging from 5 to 3 tonnes/ha, whereas optimum sulphur dose varied from 21 to 30 kg S/ha with yield response of 4 to 7 tonnes/ha. Interaction between P and S was found to be significant in terms of potato tuber yield.

Discussion

It has been reported that optimum phosphorus and sulfur application has significantly increased the yield of the crop similar to the result of Tekalign et al., 2001. Phosphorus and Sulphur fertilizers application have shown good yield responses, indicating low sulfur and phosphorus status of the soils

Conclusion

Several factors limiting crop yields have been reported by many workers and the current investigation showed that the effect of both phosphorous and sulfur rates was found highly significant in all growth parameters studied.

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Sustainable soil management for food security and better nutrition; digital mapping and values of heavy metal quality reference in soils of the North and Northwest Fluminense, rj.

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Keywords: Natural heavy metal contents. Soil pollution. Digital soil mapping

Introduction, scope and main objectives

The demand for information about heavy metal contamination in agroecosystems has increased in the last decades, due to the massive use of agrochemicals and animal production waste. These factors have caused the accumulation and transfer of toxic metals to food, offering risks to human health. The North and Northwest regions of the State of Rio de Janeiro have heterogeneous physiographic characteristics, requiring information to support soil management and conservation. Thus, in search of the reference values of heavy metals, associated with the mechanisms and spatial distribution of chemical and physical attributes in soils of heterogeneous environments. The present research aimed to establish reference values for soil quality for the heavy metals: As; Pb; Cd; Ni; Cu; Co; Ba; Cr; Zn; Mn, and Al, and spatialize the contents of these metals, in the North and Northwest Fluminense regions.

Methodology

For the methodological procedures in chapter I, the digital soil mapping technique was used, with the aid of the RStudio (3.6.1), SAGA-GIS (2.1.2) and Quantum GIS (v. 3.4) softwares. For morphometric terrain variables, the Hydrologically Consistent Digital Elevation Model (MDE-HC) and Landsat8 sensor data were used, totaling 23 predictive environmental covariates with 90 m spatial resolution. For the sampling procedure, the Latin Conditional Hypercube Method (cLHS) was used, collecting samples in areas with low or no anthropic activity. Data from the superficial layer (0-20 cm) were used, in 95 sampling points. For the prediction of chemical and physical attributes the Random Forest (RF) model was adopted, implemented via RStudio.

Results

The Results obtained from cross-validation of the models showed a variation in the R^2 determination coefficients for heavy metals and soil texture ranging from 0.21 - 0.39. The models showed performance classified from weak to moderate was found for: Ba (0.24); Ni (0.34); Co (0.39); Mn (0.31); Cu (0.26); Al (0.28), Zn (0.25) and As (0.24). As for the granulometric fractions, clay (0.30), sand (0.31) and silt (0.28), present dissimilar variability patterns and similar use of predictor covariates.

Discussion

The root mean square error (RMSE) was found to range from 2.76- 1 402.95 (mg kg^{-1}), also with significant variation in the data set. The Results obtained, from the VarImport ranking, showed that the predictor covariates of land attributes obtained higher potential in relation to the indexes coming from Landsat-8 images. As for the spatial variability, promising Results were verified from the RF model.

Conclusion

Thus, the spatial distribution of heavy metals from the Northwest region towards the North showed a tendency of the phenomenon as a function of the soil-landscape model, with a gradual increase of the contents in the North region, which are areas of pleasantness, especially in valley bottoms. It was found that, besides the natural geological sources, the anthropic factor has a small magnitude of contribution in the concentrations, which can be associated with the presence of various classes of land use and coverage in the regions.

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Soil organic carbon stock under land management practices in the landscapes of Ethiopian Highlands

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Keywords: A.decurrens, Climate, Carbon, Guder, Land management, Spatial, Stock

Introduction, scope and main objectives

The decline and spatial variability of soil organic carbon have become a known challenge in the highlands of Ethiopia. Soil organic carbon management has a substantial influence on soil-based ecosystem services and combating climate change. This study was conducted to estimate and map soil organic carbon stock (SOCS) as a result of land management practices across landscapes in the Guder watershed.

Methodology

A total of 90 soil samples were collected and analysed for selected soil properties. Analysis of ANOVA was carried out to see variation among studied factors.

Results

The Result revealed that the higher SOCS was found in the A. decurrens tree farmland (174.3 Mg ha^{-1} ± 16.4) next to natural forest land (229 Mg ha-1 ±27.1) at 0-30 cm soil depth. In contrast, the lowest (33.5 Mg ha^{-1} ± 4.2) SOCS was observed in the subsurface layers of cropland. Thus, A. decurrens tree farmland had contributed about 33 percent higher SOCS than cropland. The predicted map showed that SOCS ranged from 25 to 438 Mg C ha^{-1} in the upper 50 cm soil depth in the Guder watershed.

Discussion

A. decurrens tree farmland had contributed about 33 percent higher SOCS than cropland. This implies that planting trees on degraded agricultural land restored 24.5 Mg C ha^{-1} into soils or fixed 90 Mg ha^{-1} CO_2e from the atmosphere. Among the semivariogram of the models, the exponential model was best fitted with a nugget/sill value of between 0.25 and 0.75.

Conclusion

Overall, the soil organic carbon stock is increased when cropland is converted into A.decurrens tree farmland then which can boost agricultural productivity by improving soil fertility. Therefore, integration of tree planting on degraded agricultural farmlands is needed to restore SOCS. Sustainable land and soil management are recommended to sequester and stock carbon in a similar degraded hotspot area.

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Impact of mulching on soil health and productivity of peach (*Prunus persica* l. batsch)

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Keywords: Productivity; mulch; peach; microbial activity

Introduction, scope and main objectives

Crop yield has been boosted by farming strategies that involved use of mulch (Qin *et al.* 2022). The response of peach under different mulches on soil hydrothermal regimes, weed infestation and microbial properties of soil along with change in weather-associated variables from bud development to fruit maturity is documented in study.

Methodology

A field experiment was conducted with use of seven treatments with four replications under Randomized Block Design (RBD): T1 (UM) – Unmulched control, T2 (GM) – Grass mulch (10 t ha-1), T3 (PM)- Pine needle mulch (10 t ha-1), T4 (BP)- Black plastic mulch (100 µ), T5 (TP)- Transparent mulch (100 µ), T6 (MM)- Nylon mulch mat (90 GSM), T7 (RP)- Recommended practice

Results

The impact of all treatment levels indicated that highest amount of moisture (19.85 and 20 percent) and fruit productivity (22.7 t ha^{-1}) was under black polythene mulch and application of irrigation water in treatment RP enhanced fruit diameter and fruit weight that significantly increased fruit yield and fruit productivity (22.5 t ha^{-1}). Black mulch and mulch mat treatments also reported 100 per cent weed control efficiency at pit hardening and fruit maturity stage. The maximum frequency, density, relative frequency and relative density were of Anagalis arvensis, whereas abundance and relative abundance was highest of Biden pilosa. The impact of grass and pine mulch is also of interest in this study as it moderated soil hydrothermal regimes and significantly enhanced total viable count, microbial activity and microbial biomass carbon that was higher at surface (0-15 cm) over sub surface (15-30 cm). It was also observed that soil moisture and temperature exhibited negative correlation. Air temperature and soil temperature showed positive linear trend.

Discussion

In the study black polythene mulch was effective in conserving moisture at upper and lower depths. This was because black colour has zero albedo and proximity of the surface soil to sunlight might have enhanced the absorption of UV-rays that increased evaporation but presence of a layer of mulch might have prevented evaporation but increased condensation inside the mulch. Mean values of minimum (at 0730 hrs) and maximum (at 1430 hrs) soil temperatures at 7.5 and 15 cm depths indicates organics mulches created their own specific effect on soil temperature regimes. The organic mulches raised minimum temperature and lowered maximum temperatures because between the layer of mulch and soil surface there is air trapped inside that has lower heat capacity which act as an insulator (Mulumba and Lal 2008; Thakur *et al.* 2021.). Black plastic mulch showed the best control of weeds, followed by mulch mat because significant higher soil temperature reduced the weed population due to light interception of black mulch outgoing radiation and smothering effect of mulch mat when compared to other mulches. Also, organic mulches like GM and PM, provides favorable conditions by moderating soil temperature, increasing availability of moisture and aeration and adding organic carbon which eventually helps in microbial growth and proliferation that might have enhanced activity of microorganisms (Das and Dutta 2018)

Conclusion

It can be concluded that both black mulch and mulch mat were superior in moderation of soil hydrothermal regimes by providing favourable conditions for plant growth and development. While in situ moisture conservation and weed suppression followed by organic mulches viz. locally available GM and PM that enhanced microbial growth. So, mulching will aid farmers to capitalize productivity and profitability of crop.

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Soil fertility status and oil palm productivity in coastal plains of southwest Cameroon

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Keywords: Oil palm, coastal plain soils, soil fertility status, yield variation, site-specific management, oil palm intensification

Introduction, scope and main objectives

The African oil palm (Elaeis guineensis Jacq.) is the most productive oil crop in terms of oil yield per hectare and resource use efficiency. In the best-managed plantations, the average yield of palm oil is about 4.2 t ha^{-1} yr^{-1}, and can exceed 6.0 t ha^{-1} yr^{-1} (Fairhurst and Mutert, 1999). Over the past decades, Cameroon has recorded low and variable oil palm yields and this situation has rendered her a major importer of crude palm oil with importation increasing from 16 000 to 95 000 tonnes between 2016 and 2017. With a potential to produce about 25 t ha^{-1} of fresh fruit bunch (FFB) (Feintrenie, 2012), actual yields range from 0.29 – 21.2 t FFB ha^{-1}. Based on the aforementioned problem, a study was conducted in the Coastal plains of Southwest Cameroon with the objective to assess the soil fertility status under oil palm plantations and to establish appropriate management practices that will contribute to oil palm intensification and sustainable production.

Methodology

The study was carried out in the coastal lowlands of southwest Cameroon, which is a representative of the oil palm belt of Cameroon. The area has the equatorial climate, precisely the Cameroon type which is quite hot and humid. Both primary and secondary related data on soil, climate and oil palm yield were collected and used, alongside adapted field, laboratory and statistical analysis methods in order to achieve the objectives.

Results

Soil data from forty-two sites indicated that > 80 percent of soil properties were highly variable (CV > 35 percent). Principal components analysis (PCA) yielded four components with surface (0-30 cm) and five components with subsurface (30-60 cm) soils, accounting for 81.1 percent and 83.6 percent of the variation, respectively. Land suitability evaluation indicated that current climate is not a limiting factor for oil palm growth. With respect to soil physical characteristics, soil texture (clayey) and poor drainage are the major constraints to oil palm productivity. Soil fertility appears to be the major constraint for optimal oil palm production. Specifically, cation exchange capacity, base saturation, organic carbon and soil pH pose slight to moderate limitations, while K mole fraction is the most serious constraint, and is the most limiting factor in all the sites. Based on the suitability evaluation, about 70 percent of the soils are potentially marginally suitable (S3), 23 percent are moderately suitable (S2) and 7 percent are not suitable (N).

Discussion

Based on the principal components derived, the main soil properties necessitating management vis-à-vis oil palm growth and productivity are base status (exchangeable K and Mg, CEC and base saturation), soil pH, soil organic matter and available P content. The high variability of soil properties observed informs on the necessity for site-specific soil fertility management. Based on the critical soil fertility levels for oil palm growth, recommended management practices to sustain productivity include adequate use of chemical fertilizers (N, P, K, Mg), the use of legume cover crops for improving on N status and addition of soil organic matter through proper residue management.

Conclusion

Although oil palm yields in coastal plains of southwest Cameroon are very low, there is a potential to increase and sustain yields if adequate management practices are adopted, especially with respect to K fertilization and soil water management in flooded areas. Further studies on soil potassium fractions (forms) and dynamics in oil palm agro ecosystems shall be carried out to better understand its effect on oil palm productivity.

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Multiscale evaluation of nitrogen use efficiency (*NUE*) in common bean (*Phaseoulus vulgaris*) under different inoculation strategies in Cuba.

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Keywords: Nitrogen Use Efficiency, common bean, N biological fixation, co-inoculation, fertigation, small-producers

Introduction, scope and main objectives

Cuban agriculture sows around 550 000 hectares of tubers, vegetables, grain, and fruits each year; but due to economic difficulties, the country protected less than 25 percent of the total planting areas with imported chemical fertilizers until 2020. After the COVID-19 pandemic, the worsening of the economic crisis, coupled with the increase in prices of fertilizers of mineral origin has caused agricultural production to be carried out at the expense of the use of soil nutrient reserves, a phenomenon that causes the gradual loss of their fertility and a decrease in agricultural yields. In addition, the fertilization rates considered did not allow for a positive nitrogen balance after the harvests. Among the solutions proposed to mitigate these problems, the use of inoculation with microorganisms with PGPR activity, and genotypes with "improved N use efficiency" are pointed out. The use of these technologies makes it possible to: i) reduce the requirements of chemical fertilizers and greenhouse gas emissions; ii) increase carbon sequestration associated with increases in the levels of N_2 fixed in the air; iii) reduce environmental pollution, loss of organic matter and soil fertility and iv) increase efficiency in water use and protection of crops against stress (Galal, 2012; People and Fillery, 2012; Vadez et al., 2012). For these reasons, the evaluation of the Nitrogen Use Efficiency (NUE) in common bean issue to different agricultural management and at different scales constitutes a priority for the country, to continue improving the N utilization coefficients, and to continue protecting the soil fertility and the environment. The aims of this work is to evaluate the NUE associated with the introduction of two inoculation strategies: fertigation with a central pivot irrigation machine and Rhizobium-mycorrhizal co-inoculation, in two production systems of contrasting scales: one state-owned company (13.42 ha) and a small private producer (1 ha).

Methodology

For the physical-chemical characterization of the soils, the following techniques were used: pH (potenciometric method, relation 1:5), percentMOS (Walkley – Black method), available phosphorus (Bray – Kurtz I method), N total (Kjeldahl method). In the large-scale production system (13.4 ha), an experimental design of divided plots (3.5 ha each plot) was used, in order to allow mechanized work, which included the incorporation of harvest residues. Two treatments were used: 1) Rhizobium, strain 6BIII, inoculated by seed pelletization and fertigation + 30 kgN/ha (foliar) and 2) 75 KgN/ha as urea (foliar). In the case of the farms of small producers, an experimental design of randomized blocks was used. In the agronomic trial, three treatments were used: 1) *Rhizobium*, 6BIII strain, 2) *Rhizobium*, 6BIII strain + Mycorrhizal fungi and 3) Nitrogen as urea (80 kgN/ha). The bean variety BAT 304 was used. The plants were sampling at R6, R8 and R9 stages. Shoot, root and nodule were separated oven dried at 65°C for 72 h, and dry weights were determined. N content was determined according to the Kjeldahl method. NUE was calculated by the following equations: EUN1 (partial productivity factor) = (grain yield)/ (amount of fertilizer N applied) and EUN2 (plant use efficiency) = grain Yield/N accumulated or incorporated from the fertilizer.

Results

In the large-scale production system (13.4 ha), the introduction of inoculation using fertigation using a central pivot irrigation machine, combined with seed pelletization, allowed to achieve a high nodulation (120 nodules per plant), which was significantly different from that obtained in the treatment without inoculation (73 nodules per plant) and increased agricultural yield, with a fertilization scheme where the application of urea was reduced by 75 percent, with the consequent savings in bean production costs. All this allowed to obtain 2.5 times more grain for each kg of fertilized nitrogen, that is, a greater NUE through inoculation. In the case of the farms of small producers the results showed that: 1) the production of biomass and foliar N and the number of pods were higher in the treatments inoculated with Rhizobium and Mycorrhizae than the treatments with application of a dose of 80 kg N per hectare, 2) the nodulation was affected by nitrogen fertilization and 3) despite the fact that the number of pods was higher in the inoculated treatments, the plots fertilized with mineral N had an average of 48 percent more grain yield than the inoculated variants. In relation to the efficiency of nitrogen use, it was found that this was higher in treatments 1 (inoculation with Rhizobium) and 2 (co-inoculation Rhizobium and mycorrhizae) in all cases, but a significant difference was found between the farms, the which was due to the agronomic management and the experience of the producer.

Discussion

The Results show that, regardless of the scale of agronomic management of common bean crop and the various strategies used to adapt the technology to the resources available to the producer, the use of microbial inoculants constitutes an important source of savings in mineral fertilizers, as a consequence of the increase in the efficiency of nitrogen use. This Result is particularly important because the introduction of inoculation with *Rhizobium* and mycorrhizae in the cultivation of common beans in the country has been moderately accepted by small producers; but its use is still incipient in larger-scale companies. This phenomenon responds to the decrease in net agricultural yield observed after the introduction of the technology; regardless of the increase in the efficiency of nitrogen use and the reduction of production costs. All this brought as a result, that after the effects of the COVID -19 pandemic already exposed, the state companies reduced the areas planted with beans, as they did not have imported nitrogen fertilizers, with the consequent effects on the availability of this food for the population, which constitutes the main source of vegetable protein in Cuba In this sense, the present work manages to demonstrate that it is possible to achieve sustainable yields with the application of inoculation with *Rhizobium* and mycorrhizae in combination with minimum doses of mineral fertilization, adapting the inoculation technology to the mechanization schemes available in both large and small-scale production systems.

Conclusion

Inoculation with beneficial microorganisms and low doses of nitrogen fertilization allow sustainable yields (around 1.5 t/ha) to be achieved in common bean cultivation, regardless of the agricultural scale in which said production is managed. It is possible to adapt this inoculation technology to the diversity of conditions and resources existing in the different production systems. The Results achieved depended on the available resources and the experience of the producers. In all cases, higher nitrogen use efficiency was observed, regardless of the various variants of inoculation technology used. The Results allow us to recommend the massive introduction of this technology, as an alternative for sustainable nutrition.

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Supplementary fertilization with magnesium increases both yield and nutritional quality of potato tubers in tropical soils

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Keywords: Solanum tuberosum L, NPK formulation, plant nutrition, tuber production, magnesium, fertilizer, liming

Introduction, scope and main objectives

Potatoes (*Solanum tuberosum* L.) are the basis of human diet of many populations. It is considered the third-most important food crop, with estimates pointing to more than one billion daily consumers worldwide (EMBRAPA, 2015). In 2020, 3.7 million tons of potato tubers were harvested in 121 785 hectares of farmland in Brazil, with an average yield of 31 t ha-1 (IBGE, 2020). At least 12 percent of potato production is believed to be used to prepare pre-fried potato products (ABBA, 2008). From all factors contributing to increased yield and nutritional quality of potato tubers, an adequate nutrient supply, including a magnesium supply, stands out. Magnesium plays an important role in several metabolic processes as well as biochemical reactions such as ATP formation within chloroplasts, carbon dioxide fixation, protein synthesis, chlorophyll formation, partitioning and use of photoassimilates, reactive oxygen species generation, and photooxidation in leaf tissues. Around 35 percent of the Mg found in plants is located on chloroplasts and around 6 to 25 percent of total Mg is linked to chlorophyll molecules (Marschner, 2012). Due to its importance on several metabolic processes, studies have shown positive effects of Mg on plant growth and yield, amid accumulation, and nitrite and nitrate content reduction on tubers (Barroso, 2013; El-Hadidi et al., 2017; Wszelaczyńska et al., 2020a). Nowadays, close attention has been given to not only yield but also nutritional quality of food products. About 500 mg of Mg is ingested for each kilogram of potato consumed depending on aspects such as production sites, cultivation practices, and Mg doses applied (Navarre et al., 2019.). Studies suggest that adults should consume from 310 to 420 mg of Mg on a daily basis (Navarre et al., 2019.). Insufficient Mg consumption has been linked to high risks of inflammatory and cardiovascular illnesses. However, estimates point out that more than 70 percent of the Brazilian people have Mg-deficient diets (Araujo et al., 2013). Liming is considered to be the simplest and cheapest way to apply Mg to the soil. However, the use of liming materials with low Mg content, the recommendation of lime requirement based on increasing the soil base saturation up to 60 percent, and the great demand for Mg by plants in order to achieve high yields have led to positive responses to additional fertilization with Mg in potato plants as shown by studies of Lopes (2014 and 2018) and Wszelaczyńska *et al.* (2020b). Magnesium applications seem to be needed for achieving high yields of potato tubers, specially in tropicals soils. Despite unusual, adding Mg to the NPK formulation appears as a viable alternative to nutrient supplementation. However, to the best of our knowledge, there are no studies regarding the addition of Mg as well as its adequate proportions to the NPK formulation in potato cultivations available today. The objective of this study was to evaluate the effect of increasing doses of Mg added to the NPK formulation, with or without liming, on yield and nutritional quality of potato in tropicals soils.

Methodology

A field trial was carried out in the in Viçosa – MG, Brazil,located at 20°45' S and 42°51' W, at 693 m of altitude. According to Köppen's classification (1048), regional climate is of type Cwa. Soil samples were collected from the top layer (0-20 cm), air dried, and sieved to < 2 mm prior to chemical characterization. For planting, the soil was first furrowed, followed by lime and fertilizer applications. Lime was applied in the soil surface of those plots assigned to receive the liming treatment, which consisted of half of the whole experimental field. Dolomitic lime with a relative neutralizing value (RNV) of 76 percent and CaO and MgO content of 30 and 10 percent, respectively, was applied in the dose of 2.8 t ha-1. Soon after superficial application, lime was manually incorporated into the 0-20 cm soil layer using a hoe. The lime dosage applied was based on increasing the soil base saturation up to 60 percent as recommended by (Lorenzi et al.,1997). The 5-30-10 NPK + Mg formulations used in this experiment were prepared by mixing monoammonium phosphate (MAP), single superphosphate (SSP), potassium chlorate (KCl) and magnesium oxide (MgO). Magnesium concentration within the NPK formulation varied from 0 to 6 percent (w w-1) (D1= 0 percent Mg; D2= 1 percent Mg; D3= 2 percent Mg; D4= 3 percent Mg e D5 = 6 percent Mg). The experiment consisted of a 5 x 2 factorial scheme, with five Mg doses (0, 1, 2, 4, and 6 percent of Mg) added to the NPK formulation 5-30-10, under liming and no-liming conditions. Plots were arranged according to a completely randomized block design with four replications. Each plot was 1.8 x 3.2 m (length x width) large and consisted of 4 rows with six plants on each row. In-row and between-row spacing was 0.30 x 0.80 m, respectively. Pre-planting fertilization was performed by applying 2,000 kg ha-1 of the NPK formulation 5-30-10 (160 g m^{-1} within the row). Mg quantities added to the soil by both liming and the fertilization using the NPK formulation on each treatment. Four days after plant emergence (DAPE), we applied micronutrients to the soil surface according to recommendations of (Fontes, 2005) for the potato crop: 10 kg ha^{-1} of bórax (11 percent B); 15 kg ha^{-1} of zinc sulfate (22 percent Zn); 10 kg ha^{-1} of penta-hydrated copper sulfate (25 percent Cu) and 0.5 kg ha^{-1} of sodium molybdate (39 percent Mo). Seed tubers of the cultivar Asterix we used. Plant emergence date was that on which 90 percent of the plants showed at least one potato stem above the soil surface. Water was provided to plants on a weekly basis, through conventional aspersion, following the procedures adopted by (Nunes, 2004.), keeping soil water content close to field capacity. Cultivation practices were based on recommendations of (Fontes, 2005). Pest and disease control were performed using commercial chemical products registered for the potato crop.

Results

At both 25 and 65 DAPE evaluation periods, a linear increase in Mg content on leaves as Mg doses added to the NPK formulation increased was observed. Such increase in Mg content was found on both liming and no-liming conditions. However, Mg content on leaves was always higher on those treatments at which dolomitic lime was applied. At 25 DAPE and under liming conditions, leaf Mg content varied from 2.66 to 320 g kg-1 in the treatments with 0 and 6 percent Mg added to the NPK formulation, respectively. Without liming, Mg content on leaves varied from 1.95 and 3.03 g kg-1, in the treatments with 0 and 6 percent Mg added to the NPK formulation, respectively. It means that, under liming conditions, leaf Mg content was 20.3 percent higher on the treatment with 6 percent Mg added to the NPK formulation in comparison to the control. Under no-liming conditions, leaf Mg content was 55.4 percent higher on the treatment with 6 percent Mg added to the NPK formulation in comparison to the control. Such Results reinforce the importance of Mg supplementation in potato cultivations, especially when liming is neglected. At 65 DAPE and under liming, leaf Mg content varied from 4.53 to 5.31 kg^{-1}, in the treatments with 0 and 6 percent Mg added to the NPK formulation, respectively. Without liming, leaf Mg content varied from 2.61

to 4.05g kg^{-1}, in the treatments with 0 and 6 percent Mg added to the NPK formulation, respectively. It represents an increase of 18 and 55 percent on leaf Mg content with and without liming, respectively. Highest tuber yield was verified when combining liming and the addition of 3.30 percent Mg to the NPK formulation. In such combination, leaf Mg content at 25 and 65 DAPE was 2.96 and 4.96 g kg-1, respectively.   The addition of Mg to the NPK formulation promoted a linear increase in Mg content of potato tubers. Such increment was observed on both liming and non-liming conditions, but it was more prominent on those treatments with liming. Under liming conditions, Mg content on tubers varied from 0.95 to 1.11 g kg^{-1}, in the treatments with 0 and 6 percent Mg added to the NPK formulation, respectively. Under no-liming conditions, Mg content in tubers varied from 0.84 to 0.95 g kg^{-1}, in the treatments with 0 and 6 percent Mg added to the NPK formulation, respectively.

Discussion

According to Lorenzi et al., (1997), 3 to 5 g kg^{-1} is the ideal interval of Mg content on potato leaves. Therefore, on both liming and no-liming conditions, Mg's supplementary addition to the NPK formulation was essential to raise Mg content on leaves to the ideal interval, with a more prominent effect observed for the no-liming condition. Lopes 2018 found out that at 21 DAPE, leaf Mg content on top fourth leaves associated with highest tuber yields was 5.70 g kg^{-1}. (A. M. Fernandes et al., 2011.) observed leaf Mg content values ranging from 3.50 to 4.60 g kg-1 at 30 DAPE depending on the potato variety We also observed that at 65 DAPE, leaf Mg contents were higher than those found at 25 DAPE, on both liming and no-liming conditions. In other words, the older the plant, the higher the Mg content on leaves. Also, the apparent higher Mg concentration at 65 DAPE can be associated with intense absorption of Mg due to tuber formation. Indeed, (A. M. Fernandes et al., 2011) observed that the demand for macronutrients in potato cultivars is greater during the beginning of tuber filling (42 to 70 DAPE).

Conclusion

Therefor, the highest tuber yield was observed when liming and 3 percent Mg to the NPK formulation were used. Besides the liming, complementary fertilization with Mg can be necessary to increase yield and nutritional quality of potato in tropicals soils, reinforcing the importance of Mg supplementation in potato cultivation, especially when liming is neglected.

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Modelling phosphorus soil dynamics and p budgets in European agricultural soils

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Keywords: P model; P budget; P input; P export; agricultural soil; fertilization

Introduction, scope and main objectives

Phosphorus (P) is an essential element for all life on earth. Fertilization of P is subject to non-renewable geological P deposits or the use of organic sources such as animal waste or compost. The use of geological P deposits and the subsequent emission of the element to freshwaters and finally into oceans are considered to be beyond the safe operating space for sustainable human development. The importance of P for all life, its unsustainable use and its subsequent possible future limitations create urgency in finding ways to use P in a more sustainable way. The European Green Deal includes policy initiatives that tackle these environmental issues. But a method that is able to assess this political goal in a spatial manner is still missing. The objective of this work is to understand the current state of P in European soils and to assess such policy goals affecting the P cycle.

Methodology

We use a spatially explicit crop and ecosystem model together with an erosion model and national statistics to map P stocks and fluxes to assess the current state in Europe and scenarios where policy initiatives are implemented. For this we use state of the art input data and models.

Results

The results are maps of the P budget and P stocks in Europe of the current state and when possible policy initiatives are instated. Thus they point out possible effects of the policy initiatives.

Discussion

This model will help connect soil science, ecological systems design and land management policy.

Conclusion

The results can be applied to assist in developing management strategies to supply adequate amounts of P for crop production while limiting the harmful effects of excessive P to help protect the environment.

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Soil fertility and suitability evaluation for barley cultivation using gis (geographic information system) in an arid region in Syria

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Keywords: soil fertility index (SFI), land suitability, GIS (Geographic Information System)

Introduction, scope and main objectives

Soil fertility evaluation is critical to agriculture, and it is an appropriate factor for selecting suitable land for agricultural production at the lowest economic and environmental costs. for the purpose of achieve more sustainable agricultural systems.with growing food demand, soil fertility evaluations will become even more important for the agricultural regions in the coming years. This study was conducted to evaluate soil fertility and land suitability for barley cultivation, and to prepare the fertility and suitability mapping during 2022 using GIS (Geographic Information System), in a chosen area in Al Hasaka Governorate (Wadi Khribet Al Maliha) with 35°47'00" to 36°1'00" north latitude and 40°19'00" to 40°39'00" east longitude.

Methodology

The district covers an area of 41,895 hectares and often consists of uncultivated lands. It follows The Agricultural Land Evaluation System for arid and semi-arid. A geo-pedological soil survey was done, and 10 soil profiles representing the physiographic units in the study area were classified, and Soil samples were collected and analyzed for the different soil fertility indicators. slope, soil texture, soil depth, organic matter content, calcium carbonate content ($CaCO_3$), available P, gypsum content ($CaSO_4.2H_2O$), capacity (CEC), pH, and electrical conductivity (EC). to compute soil fertility index (SFI). The parametric method (Square-Root) was used, Lands were evaluated by intersecting barley crop requirements with land and climate characteristics by using Geographic information system.

Results

Results of Soil Fertility Index showed that 52.09 percent, 27.31 percent, 20.6 percent of the area were high, moderate and low fertility, respectively. The Results of the soil suitability classification for barley cultivation indicate that, the most units fall under the moderately suitable class (S2) which represents 45.90 percent of the total area and the highly suitable class (S1) covers 17.00 percent. of the whole area while marginally class (S3) covers about 37.10 percent of the whole study area

Discussion

According to the parametric method (Square-Root) used in the study, the majority of the study area was classified as moderately suitable (S2) for barely cultivation. The Results showed that the main limiting factor were depth. The other limiting factors were texture, pH, and available phosphor. After removing the limiting factors, it becomes high suitable (S1) in the future.

Conclusion

Soil fertility can be evaluated to help identify regions that have problems or needed, soil fertility and land suitability maps for growing barley, generated using GIS, can improve planning alternatives with a purposeful strategy to obtain optimal management, and utilization of available land resources for sustainable barley crop production.

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Efficiency of biological preparations based on nitrogen-fixing and phosphate-solubilizing bacteria for optimizing the plant nutrition

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Keywords: Biological preparations, number of microorganisms, soil enzymatic activity

Introduction, scope and main objectives

Ensuring optimal mineral nutrition of agricultural plants depends on the degree of availability of nutrients for plants. Improving the nutrition of plants only by applying of mineral fertilizers leads to undesirable environmental consequences. Soil microorganisms in the root zone are trophic mediators between the soil and the plant. Micro-organisms convert compounds inaccessible to plants into mobile forms. One of the methods for optimizing plant nutrition is pre-sowing inoculation of seeds with microbial preparations based on nitrogen-fixing and phosphate-solubilizing bacteria (Volkogon et al., 2006.) . The purpose of research was to identify the efficacy using microbial preparations Microhumin at growing spring barley and Polymyxobacterine at growing sunflower, maize, buckwheat.

Methodology

In the field experiment we identified the efficacy of Microhumin based on nitrogen-fixing bacteria Azospirillum brasilense at growing spring barley on typical chernozem in traditional farming system. The scheme was as follows: control without fertilizers; mineral fertilizers backgrounds: N30; N60; P30; P60; N30P30K30; N60P60 K60. And the same with the use of Microhumin. Efficacy of Polymyxobacterine based on the phosphate-solubilizing bacteria *Paenibacillus polymyxa* at growing sunflower, maize and buckwheat was studied in the small-plot field experiment and at sunflower cultivation in the stationary field experiment on podzolized chernozem in organic farming system. In the soil samples taken from plant root zone we identified a number of microorganisms of main ecotrophic groups by Petri dishes method and soil enzymatic activity by colorimetric method.

Results

The use of Microhumine increased depending on the fertilizers' doses the number of microorganisms in the plants' root zone an average by 1.3 – 2.9 times, invertase activity by 13 – 42 percent, dehydrogenase by 15 – 59 percent, polyphenol oxidase by 25 – 84 percent. The maximum values of soil biological indicators noted with the simultaneous use of Microhumin and dose fertilizers N60P60K60, but at conditions of drought the best result was obtained with lower doses N30P30K30. Yield increases were respectively by 66 and 54 percent. Application of Polymyxobacterine increased the number of microflora by 10 – 55 percent, soil enzymatic activity increased also. Sunflower yields increased by 1.7 times, buckwheat by 1.5, maize by 1.2. Use of preparation improved the quality of maize grain. In the stationary field experiment the number of rhizosphere microflora enhanced by 21 percent, the enzyme activity by 10 – 20 percent, the sunflower yield by 29 percent.

Discussion

The Results of the study showed the feasibility of using Microhumin with moderate doses of mineral fertilizers. This helps to optimize plant nutrition, increase yields and minimizes the use of mineral fertilizers, as well as prevents soil and environmental pollution. Synthetic mineral fertilizers and chemical plant protection products cannot be used in organic farming. The use of Polymyxobacterine in an organic farming positively effects yields and solves the problem of fertilizing and protecting plants from pathogens.

Conclusion

A positive effect of Microhumin and Polymyxobacterine on the soil biological indicators in the plants root zone and crops was revealed. The maximum effect on the yield was noted with the combined use of Microhumin and moderate doses of mineral fertilizers. Use Polymyxobacterine in sunflower growing under conditions of organic farming increase harvest by 29 percent. The ecological effect is to keep the environment clean and prevent soil pollution.

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Enhancing seed and mace yield in nutmeg (*Myristica fragrans*) through scientific nutrient management

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Keywords: nutmeg,Seed yield,Nutrients

Introduction, scope and main objectives

Nutmeg which is an important tree spice with two distinct spices, nutmeg and mace belongs to the family Myristicaceae. Nutmeg is the seed kernel inside the fruit and mace is the covering (aril) on the kernel. Both mace and nutmeg are used as condiment and medicine. In India, nutmeg is grown in some parts of Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra, North East India and Andaman,J. In Kerala nutmeg is mainly cultivated as a homestead crop in coconut and arecanut gardens. World average production of nutmeg is estimated between 10 000 and 12 000 tonnes per year, with annual world demand estimated at 9 000 tonnes. India produces about 11 424 tonnes of spice in an area of 15 131 ha. Under Indian conditions the production potential is very low i.e., 800 kg nutmeg and 125 kg mace/ha and the present production is not sufficient. The major nutrient disorder observed in nutmeg farmers field in Kerala is immature fruit splitting and fruit drop which reduce the yield and quality of seed and mace in nutmeg. Most of the nutmeg farmers are applying nutrients through organic manures alone which often aggravate the nutrient imbalances in soil and crop. Nutrients are important crucial elements, which are required for the plant for its growth and development. All major and micronutrients are required in correct quantity and right proportion for the translocation of photosynthates and for enhanced economic yield. The optimum dose of fertilizer application not only increases the yield, but also improves the quality. Therefore, proper management of nutrients is essential to realize maximum potential yield of the crop and to get higher economic benefit. One of the important yield and quality limiting factor in most of the nutmeg growing soils are the unscientific nutrient management practices. In addition to yield depression most of the fields are susceptible to diseases due to poor crop health. Usually farmers dump huge quantity of fertilizers in the soil irrespective of the source of nutrients Resulting in nutrient imbalances in the soil and environmental pollution. Many organic farmers apply only FYM, poultry manure and bone meal, unknowingly giving priority to phosphorus rather than potassium. Nutmeg requires more of potassium compared to other nutrients. Application of major nutrients in proper ratio and optimum quantity can help growers to get the maximum benefit out of these inputs. To obtain high yield of nutmeg, timely application of all the required nutrients is a pre-requisite. In these circumstances, the present investigation was taken up as an On Farm Trail, to find out the role of scientific nutrient management based on soil tests for enhancing seed and mace yield in nutmeg.

Methodology

The experiment was carried out in farmer's field in Vaikom block of Kottayam district in Kerala, India. The soil of the experimental site was very acidic with high organic carbon, high phosphorus, low potassium content and was deficient in micronutrient boron. Soil was clay loam with pH of 4.2, EC of 0.004 dS/m. Organic carbon was 1.8 percent with high phosphorus (38.5 kg ha^{-1}) and low potassium (72 kg ha^{-1}). The calcium, magnesium and sulphur contents were respectively 195 ppm, 58 ppm and 7ppm. The micronutrients Iron (Fe), Manganese (Mn), Zinc (Zn), Boron (B) and Copper (Cu) respectively were 125 ppm, 38 ppm, 6 ppm, 0.2 ppm and 1 ppm respectively. The different treatments tried included Absolute control (T1), Farmers practice(T2), treatment with application of major nutrients as per package of practices of Kerala Agricultural University (T3), application of major and micronutrient on soil test basis (T4). It was replicated five times. The NPK recommendation for Nutmeg plants of greater than 15 years of age is 500:250:1 000g per year along with 50 kg of FYM per plant as per POP of KAU. All the crop management practices were done as per POP of KAU. In treatments T3 and T4, Borax was also applied @ the rate 50 g per plant. Observations on mace and seed yield was taken for the study.

Results

The Results of the experiment showed that the yield of the fruits increased in treatment where both major and micronutrients applied on soil test basis. Maximum seed and mace yield of 8.73 kg/tree and 1.936 kg/tree respectively were observed in treatment T4. In farmers practice the seed yield was 6.09 kg/tree while in T3, 8.73 kg/tree . Similarly yield of the mace the most important economic part of nutmeg fruit was significantly increased in T3 and T4 compared to farmers practice

Discussion

In treatment T3 and T4 application of boron as borax and potassium as muriate of potash reduced immature fruit splitting and fruit fall .There was an increase in the no. of mature fruits. Seed and mace yield was increased by the application of deficient nutrients. Farmers practice of dumping of nitrogenous and phosphatic fertilizers irrespective of soil nutrient status caused nutrient imbalance with fruit drop affecting mace and seed weight. Fruit splitting and fruit drop in the immature stage was significantly decreased with the application of essential major and micronutrients especially potassium and boron which were low in these soils. Philip, J (1986) observed the significant influence of potassium, calcium, boron in flowering in nutmeg Maximum yield of seed and mace was observed in T4 compared to all other treatments. Available phosphorus in the soil was high while potassium was low as per initial soil test value. In nutmeg, among the major nutrients phosphorus is the nutrient which is needed in less quantity and potassium requirement is four times that of phosphorus. Hence in T4 with the addition of more quantity of potassium fertilizer and less quantity of phosphorus fertilizer on soil test basis compared to general recommendation of nutmeg helped in maintaining the nutrient balance and enhancing yield compared to T3.

Conclusion

Application of major and micronutrients on soil test basis in a balanced proportion as per package of practices of Kerala Agricultural University reduced immature fruit splitting and fruit fall, increase seed and mace yield of nutmeg.

Acknowledgements

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Initial changes in microbial biomass, functional diversity and soil organic matter mineralisation after showing maize in an old meadow field

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Keywords: fodder maize, meadow, alternative cropping practices, soil functionality, soil use change

Introduction, scope and main objectives

In the new European agricultural policies there is an evident concern for the soil, highlighting the need to protect biodiversity, care for soil resources and implement a circular economy. Galicia is located in the Atlantic area of Spain under a temperate-humid climate. One of the traditional crops is maize, which is currently grown intensively and almost exclusively for fodder, following two types of rotations: fallow-maize or prairie-maize. The new European policies encourage agricultural practices that reduce the use of inorganic fertilizers, avoid the loss or promote the recovery of organic matter, reduce/avoid erosion and foster biodiversity of cropland soils. To this end, a project investigating several agricultural alternative practices has been recently initiated. As a first step the present study investigates the impact that the transformation of a natural meadow into a maize crop has on the soil functionality.

Methodology

The study area was a more than 50 years old meadow which was partly transformed for the production of rainfed forage maize. In both meadow and maize cropland areas, three plots were established and soil samples (composed of several subsamples) were collected at 0-10 and 10-20 cm depth at the end of May (2 weeks after maize sowing) of the first year of transformation. The soil analysis carried out included the main physico-chemical properties, microbial biomass C, soil basal respiration and functional diversity of the bacterial community. Microbial biomass C was determined by the fumigation-extraction method (Vance et al., 1987), soil basal respiration was determined measuring the CO_2 emitted by soil samples incubated under optimal temperature and moisture conditions (Guitián and Carballas, 1976) and microbial community-level physiological profiles (CLPPs) were analysed using Biolog EcoPlates™. The chemical and physical properties of the soils were analysed following the methods described by Guitián and Carballas (1976).

Results

The land-use change induced a slight reduction of both total N and organic C contents, more pronounced in the 10-20 cm than in the 0-10 soil layer, and had a significant impact on most of the analysed parameters related with soil functionality. In contrast to organic matter content, both microbial biomass and basal soil respiration increased in maize soil compared to the original meadow, especially in the 10-20 layer. Regarding microbial community-level physiological profiles, most of the modifications were observed in the 10-20 cm. In this layer the cultivation induced increases in the degradation of some carbohydrates (β-methyl-D-glucoside, i-erythritol, D-cellobiose, α-D-lactose), D-galacturonic acid and L-arginine. The degradation of L-serine tended to be higher in the 0-10 cm layer of the maize field than in the meadow, while the opposite was observed for malic acid in both layers.

Discussion

The modifications in the parameters investigated are related to the tillage carried out and to the decomposition of the remains of the vegetation buried as part of the management. Both the breaking up of aggregates and the burial of the remains of the meadow grasses, as well as the fertilisation applied for the planting of the maize field, favours microbial activity and the growth of soil micro-organisms

Conclusion

The conversion of meadow into a maize field induces a strong decrease of the soil organic matter content and early modifications in diverse parameters related to soil functionality, Further analysis in successive cropping seasons are necessary to adequately evaluate the transformations of soil properties caused by the land use change

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Spatial analysis of the soil nutrient availability in agricultural lands of Morocco: trends and challenges

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Keywords: spatial variability soil fertility trends Morocco organic matter

Introduction, scope and main objectives

In Morocco, agriculture is a strategic sector for the national economy (around 20 percent of GDP) and most crops cultivated in the country are highly nutrient demanding. Moroccan soils are generally basic with high amount of calcareous which impacting the availability of the soil nutrients. Demand for fertilizer use has increased because the national agricultural sector expansion during the last decade. To improve productivity without environmental impact, there is the need for the utilization of climate smart techniques to optimize fertilizer application. This includes the digital soil fertility mapping in different scales. This paper is based on the Result of a four-year national soil fertility project, realized during 2014 to 2018 by National Agricultural Institute of Morocco (INRA-M) and its partners.

Methodology

This paper is based on the Result of a four-year national soil fertility project, realized during 2014 to 2018 by National Agricultural Institute of Morocco (INRA-M) and its partners. The purpose was to map soil fertility in national and regional scales for more than 7 M ha. A soil data set in national scale (1:500 000) and in the regional scale (1:50 000) was constructed from the soil archives of INRA Soils and from a recent soil fertility study analyzing more than 30 000 soil samples from 33 areas in Morocco.

Results

The spatial analysis of soil fertility properties was doing using GIS tools and the trends of the main soil fertility parameters (Organic Matter (OM), pH, Phosphorous (P_2O_5) and Potassium (K_2O)) were realized. The results showed that more than half of the samples has less than 2 percent of OM and low level of K_2O and P_2O_5.

Discussion

This **Result** showed that the actual trend of soil nutrient is not sustainable and there is a need to rethinking the actual cropping system based on monocropping system and to propose agro-ecological fertility approaches such as conservation agriculture and nutrient sensitive farming.

Conclusion

This study showed that there is a need to rebuild the soil organic carbon pool by using sustainable soil management and the collected soil data could help to propose the appropriate fertilizer formulas to meet with the potential crop yield.

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Novel spent coffee ground-based biofertilizer: effects on crops and bacterial rhizospheric microbiome

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Keywords: biofertilizer; metabarcoding; soil health; plant health; coffee; rhizospheric microbiome; circular economy; food waste

Introduction, scope and main objectives

Coffee is one of the most consumed beverages in the world. Nearly 6 million tons of spent coffee grounds (SCG), obtained as a byproduct of the coffee production/brewing activities, are produced every year. The management of this huge amount of waste is an economic and ecological problem. On the other hand, SCG is rich in nutrients (C, N, P), making it a potentially good ingredient for the development of novel coffee-based biofertilizers. The need for reuse of waste materials as biofertilizers has increased in the last few years, especially in the historical/political moment we are living in. Indeed, European Union nearly totally relies for the import of raw materials (such as phosphate rock, one of the main ingredients of fertilizers) on politically instable Middle East and Eastern Europe countries. Thus, the use of nutrients-rich SCG as biofertilizer could, at least partially, replace the expensive and often polluted by heavy metals raw materials imported from those countries. Previous researches have highlighted contrasting effects of SCG when used as soil amendment. On one side, SCG inhibits plants growth, mainly due to the presence of phytotoxic compounds and a high C/N ratio; on the other side, plants treated with SCG show a higher nutritional value with an increased content in antioxidants and mineral elements (http://doi.org/10.1080/03650340.2017.1387651). The aims of this research were: a) to develop a new SCG-based biofertilizer (BF) able preserve the positive effects of the SCG alone while mitigating the negative ones; b) to test its effects on salad crops (Lactuca sativa) and on their associated rhizospheric bacterial communities by mean of 16S rRNA gene metabarcoding analysis.

Methodology

To assess the effects of the new formulation, a randomized block design experiment in a growth chamber was performed. Both SCG and BF were tested at 3 different concentrations (2.5, 10 and 20 percent of the pot volume) with negative controls, each with 5 replicates, for 90 days.

Results

With respect to the raw SCG, the newly developed BF showed a higher presence of antioxidants and lower C/N ratio. Soil treated with BF at 20 percent showed an increase in nutrients content, cation exchange capacity and electrical conductivity compared to SCG-treated and control samples. In comparison with samples treated with SCG, the use of BF, especially at the highest concentration, triggered changes in soil bacterial communities with an increase of plant growth-promoting rhizobacteria (e.g., *Azospirillium* and *Arachidicoccus*) and taxa involved in the metabolisms of caffeic acid and nitrogen. Regarding plant functional traits, both treatments (BF, SCG) increased the crops total leaves area by more than double of the control samples, but plants treated with SCG alone showed signs of stress (i.e., yellow, smaller, and flatter leaves).

Discussion

In general, the novel BF Resulted able to reduce the negative effects of SCG, increasing soil nutrients content, modulating the rhizospheric bacterial community and, therefore, promoting a healthier growth of crops.

Conclusion

This study demonstrated the high agronomic (and ecologic) potential of the novel formulation, in line with the new European strategies for sustainable development and growth

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Evaluation of polyhalite fertilizer for soybean balanced nutrition using a novel root phenotyping system

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Keywords: Polyhalite, fertilizer, plant nutrition, prolonged nutrient availability, carbon footprint, organic fertilizer

Introduction, scope and main objectives

Polyhalite is a unique, multi-nutrient fertilizer containing sulfur, potassium, calcium, and magnesium in available forms for plant uptake. Polyhalite is mined in its natural state from 1 200 m below the North Sea in the UK. It can be used as straight fertilizer, blends, or raw material for compound fertilizers. Since Polyhalite is actually applied in its original natural state, its manufacturing process has a low carbon footprint and low environmental impact and it is also certified for use in organic agriculture. Polyhalite contains: 48 percent SO_3 as sulphate, 14 percent K_2O, 6 percent MgO and 17 percent CaO. Since the fertilizer is a natural crystal, it provides a prolonged release of nutrients. This feature decreases the leaching risk of sulphate and increases the nutrient use efficiency. It was found that it has residual effect on the subsequently grown crop. Another advantage of Polyhalite is the simultaneous release of the four major nutrients through the mineral dissolution in the soil solution. The purpose of this experiment is to test the efficiency of Polyhalite as a source of sulfur, potassium, calcium, and magnesium for soybean plants.

Methodology

The experiments were carried out under net-house conditions in Givat Brenner, Israel, in pots. The first set contained different levels of Polyhalite and equivalent soluble salts. The second set contained soil with Polyhalite residual and residual equivalent taken from a previous experiment which was conducted on chickpeas and tomatoes. Advanced methods of root phenotyping, measurements of the shoot and root traits development were conducted to quantify and compare the treatments' effect.

Results

The experiments results showed that the Polyhalite is as efficient as the commercial soluble fertilizer that was applied in these experiments The Polyhalite enhanced the vegetative growth of the soybean plants. The measurements indicate that the Polyhalite contributes more to the development of leaves vegetative growth than the equivalent fertilizer. Regarding the residual effects, the Polyhalite showed better residual effect than the equivalent

Discussion

Generally, the advantage of the Polyhalite over the equivalent fertilizer appeared in shoot parameters rather in root parameters. This phenomenon is due to the higher influence of the Polyhalite nutrients on the shoot development than the root development. The root phenotyping technique was successful in detection of mineral deficiency, as was observable in the fine root diameter frequency. The fine root diameter frequency is an indication of the change of the root system architecture morphology in response to mineral deficiency.

Conclusion

The Polyhalite fertilizer is a source of sulfur, potassium, calcium, and magnesium (S, K, Ca, and Mg) nutrients. The efficiency of the Polyhalite does not fall beyond the efficiency of equivalent fertilizers. The Polyhalite has a higher residual effect compared to the equivalent soluble fertilizer. The residual Polyhalite has similar effect on the plant growth and development as Polyhalite applied in a standard way. The prolonged pattern of its nutrients release matches the nutrient needs of crops and minimizes the risk of leaching, reducing the unused sulfur that can be washed away by rainfall or irrigation through the soil and into waterways. The added benefit of low carbon footprint makes Polyhalite a fertilizer of choice for those farmers carrying out carbon counting on their enterprise and wanting to lower their carbon footprint.

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Rhizosphere microbiome community diversity of *Coffea arabica* implanted in the Gorongosa National Park (Mozambique) across different agroforestry systems

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Keywords: Agroforestry system, Gorongosa Park, Coffea arabica, Rhizosphere Microbiome.

Introduction, scope and main objectives

The Gorongosa National Park (GNP) in Mozambique is perhaps Africa's greatest wildlife restoration story. To create employment for smallholder farmers while promoting rainforest reforestation, *Coffea arabica* has been planted in the GNP through sustainable farming practices using different agroforestry systems. However, the linkage between soil microbial diversity and the productivity of the *C. arabica* is currently unclear.

Methodology

This study, based on high-throughput sequencing, explores the diversity, structure, and composition of C. Arabica rhizosphere communities (Bacteria, Fungi, and Archaea) grown in the GNP at different elevations (600m, 800m, and 900m) and under different levels of canopy shading (no shadow, 50 percent and 100 percent of shadow from native trees).

Results

Alpha-diversity (Observed operational taxonomic units and Shannon index) was significantly different, particularly in the case of fungi which showed the lowest diversity in the rhizosphere of C. arabica plants grown at 600m without shade. Evaluation of the microbiome composition revealed the presence of abundant phyla as Proteobacteria and Verrucomicrobia for Bacteria, Ascomycota, and Mucoromycota for Fungi, while Archaea was dominated by Thaumarchaeota. The most abundant genera were *Chthoniobacter* for Bacteria, *Nitrososphaera* for Archaea, and *Linnemannia* for Fungi.

Discussion

These groups exhibit a wide range of beneficial plant characteristics, including protection, nutrition, direct growth stimulation, and disease protection, and some are potential decomposers and recyclers of organic matter, which might influence the productivity of *C. arabica*.

Conclusion

This study demonstrates that coffee cultivation at high altitudes and levels of dense shade (100 percent) positively influences the biomass and activity of microorganisms in the soil relative to low altitudes and no shade.

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Enhanced yield and quality in chilli with calcium, magnesium and boron nutrition

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Keywords: Chilli, gypsum, magnesium sulphate, borax, lime, dolomite, yield, quality

Introduction, scope and main objectives

Chilli (*Capsicum annuum* L.) is a highly valuable crop and cultivated all over the world. It is known as universal spice of India and is well known for its pungent flavor. In Kerala, chilli is one of the important crop in majority of homesteads. Nutrient deficiency was severe in Kerala soil due to high rainfall and soil acidity. About 60 percent of Kerala soils were deficient in Ca and 75 percent soils were deficient in Mg. Boron deficiency accounts around 40 percent in soil (Rajasekharan et al., 2014). Chilli being an important vegetable crop which is cultivated throughout Kerala, present study is carried out with an objective to manage the deficiency of calcium, magnesium and boron in chilli to enhance its yield and quality. The field experiment was conducted at Instructional farm, Nileswar, College of Agriculture Padannakkad, Kerala, India during a period from December 2020 to May 2021.

Methodology

Experimental layout was carried out in randomized block design with ten treatments and three replications and experiment was done using chilli variety KAU Anugraha. Treatments consisted of application of gypsum, $MgSO_4$ and borax along with KAU POP recommendation as both combined and individual forms. Treatment combinations were T1(KAU POP + lime (based on soil test)), T2 (T1 + 125 kg gypsum per hectare), T3 (T1 + 80 kg magnesium sulphate per hectare), T4 (T1 + 125 kg gypsum per hectare + 80 kg magnesium sulphate per hectare), T5 (T1 + foliar application of borax (0.2 percent)), T6 (T2 + foliar application of borax (0.2 percent)), T7 (T3 + foliar application of borax (0.2 percent)), T8 (T4 + foliar application of borax (0.2 percent)), T9 (KAU POP + dolomite (based on soil test)) and T10 (T9 + foliar application of borax (0.2 percent)). Lime and dolomite was applied @ 350 kg/ ha and fertilizer NPK was given @ 75:40:25 kg/ha as urea, rajphos and muriate of potash. Gypsum and MgSO4 were applied through soil as single dose and borax was given as foliar at four times.

Results

An initial soil analysis was carried out and the soil of the experimental site was sandy loam having pH 5.08 and electrical conductivity 0.14 dS m^{-1}. Available nitrogen content was low, available phosphorus was high and available potassium was medium in range. All the secondary nutrients were deficient and micronutrient were sufficient except boron. The results of the experiment showed that yield and quality of chilli was significantly improved with various treatments. Maximum fruit weight (7.43g) and total fruit yield (4 456.79 kg/ha) was recorded with combined application of gypsum, $MgSO_4$ and borax along with KAU POP recommendation and lime (T8). Fruit quality parameters such as capsaicin, oleoresin and ascorbic acid content showed significant response to various treatments. Highest capsaicin (0.352 percent), oleoresin (11.00 percent) and ascorbic acid content (96.83 mg/ 100 g) were also recorded with combined application of gypsum,

$MgSO_4$ and borax (T8). Maximum shelf life (13.67 days) was Resulted in the treatment with combined application these nutrients (T8) and it was on par with all the treatments with foliar application of borax (T5, T6,T7 and T10).

Discussion

Combined application of Ca, Mg and B significantly increased total fruit yield and fruit weight. Higher yield might be due to the effect of these nutrients on physiological function, growth parameters and nutrient uptake. Magnesium is a constituent of chlorophyll and increased Mg content in plants contributing to increased photosynthesis and involved in carbohydrate partitioning which may also lead to higher yield. Boron had a role in flowering, fruit setting and pollen tube growth. It also contributes to increased yield. Ca, S and K had close relation to oleoresin content in chilli (Bidari, 2000). This might be leads to increased oleoresin content T8. The treatments showed significant difference in the capsaicin content of fruit. N had a positive effect on capsaicin content. Calcium enhances the N uptake by plants and this might be contributed to increased capsaicin content in treatments. Calcium and boron played a vital role in increasing the ascorbic acid content in fruit. High Ca content was observed in fruits of Ca treated plot. When fruit Ca level increases it will reduce respiration. As the respiration decreases it may increase the ascorbic acid content. This might be the reason for increased ascorbic acid content calcium and boron treated plots.
Shelf life of chilli was significantly influenced by various treatments. In the present study maximum shelf life was recorded in T8 which was on par with T10, T6, T5 and T7 .Calcium application increases Ca content in tissue thus it reducing the deterioration of fruits. Boron enhances cell wall integrity along with promoting the calcium metabolism. Calcium - boron interaction stabilizes Ca complexes in middle lamella which makes cells compact and increase the shelf life by reducing weight loss and maintaining its firmness (Islam et al., 2016).

Conclusion

The Results obtained from the experiment revealed the significant influence of soil amendments over KAU POP recommendation and it can be concluded that combined application of gypsum, magnesium sulphate and borax along with KAU POP recommendation was effective for increasing fruit yield and quality in chilli.

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Phoretic mites as microclimate originators in special ephemeral soil habitats and as presumed co-creators of nutrient-rich soil areas using examples of Histiostomatidae (Acariformes, Astigmata)

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Keywords: soil fertility, Mesofauna, Acari, Histiostomatidae, life-strategies, micro-climate, biodiversity

Introduction, scope and main objectives

A healthy soil microclimate supports a high soil quality and fertility. Besides other factors the interaction of different organisms contributes to the provision of such a suitable microclimate. My acarological long time studies on mites of the Histiostomatidae (Astigmata) being phoretically bound to arthropods contribute to a better understanding of relevant and complex close associations of different organisms (phoretic host, phoretic mites, hyperphoretic fungi). The species diversity and the life strategies of such mites, which are carried for dispersal by mostly fast or even airborne arthropods (phoresy), is still comparatively sparsely investigated.

Methodology

Light-microscopy, SEM and video analyses contributed to my Results.

Results

In order to finish their life cycles, phoretic mites need either the brood chambers of the transporting hosts (mostly insects) or decomposing organic tissue, where the transporter rests in order to feed or to reproduce. Mites contribute there remarkably to the microclimate based on their introduced fungi and also on their complex glandular secretions, which serve to an interspecific communication and regulate the growth of fungi. This microclimate provides suitable living conditions for the various organisms that live there and supports an efficient decomposition of organic matter. Healthy and nutrient-rich soils can be the result. I herewith introduce information about the current state of knowledge and my recent findings about biodiversity, phoretic interactions with hyperphoretic fungi, new aspects about the specialized feeding mechanism of the mites and possible applied consequences for soil improvement.

Discussion

According to my morphological, ecological and behavioral studies and the corresponding work of other mite specialists on Histiostomatidae, the following partly still speculative thesis can be justified: The mite dispersal stage (deutonymph) attaches itself to larger arthropods and carries fungal spores on its body, which germinate where the deutonymph leaves its carrier and serve as food for the mite. The adult mites and free nymphal stages produce fungicides in glandular organs that prevent unwanted fungal growth and keep the food fungus in a reduced growth habit, so that fungal components can be easier ingested using the remarkably modified mouthparts, which form a complex filter organ.

Conclusion

Due to the good breedability in a short development time, mites of the Histiostomatidae are well suited as study objects for understanding complex micro-ecological relationships in soils and their importance for soil quality.

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Modelling and mapping of fertilizer recommendations for major crops in West Africa; a proof of concept

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Keywords: soil fertility, nutrient gap, fertilizer recommendations, site-specific, upscaling, soil map, QUEFTS, Africa

Introduction, scope and main objectives

Site-specific fertilizer recommendations for major food crops in West Africa have been updated and mapped by ISRIC – World Soil Information in collaboration with the International Fertilizer Development Center (IFDC) and experts from the NARs of Benin, Burkina Faso and Ghana. The project served as a proof of concept and was carried out within the context of the UNITED STATES OF AMERICA ID - West Africa Fertilizer Program which was implemented over five years in collaboration with the Economic Community of West African States (ECOWAS).

Methodology

A tiered approach was developed which makes use of the Africa SoilGrids (soil property maps at 250m resolution) including maps of macro, meso and micro nutrients produced using soil analytical data selected and standardized from near 70,000 sample locations. In the first tier, QUEFTS was parameterized with georeferenced fertilizer trial data compiled from a number of countries and used, together with available maps of attainable yield of millet, sorghum, maize, rice and cassava, to calculate and map soil nutrient supply, crop nutrient demand and the unfertilized and fertilized crop nutrient uptake and yield together with the corresponding efficiencies. Herein, crop nutrient demand at target yield was downsized using a map of the soil's root zone plant-available water holding capacity and compared with soil nutrient supply to map nutrient deficiencies and the corresponding NPK fertilizer recommendations. These maps were added to regional covariates in the second tier to model and map the fertilizer recommendations, as reported from the fertilizer trial data, using machine learning. Resulting recommendations were spatially aggregated by agroecological zones and the variance within each zone was expressed by a probability distribution.

Results

First tier maps of fertilizer recommendations proved poorly related with the recommendations reported from the fertilizer trials. This proved largely due to the heterogeneity in the ways that the reported recommendations had been derived to start with. Modelled yield responses seemed also poorly related with observations, not in the least due to the highly heterogeneous nature of the trials (different years, managements, etc.), but very reasonably when only considering trials for which nutrient uptake, serving model parameterization, had been reported. The second tier Resulted in reasonable to good validation statistics but also in an important loss of site specificity. Therefore we maintained the first tier recommendations. The variance in these recommendations, aggregated or not, proved more determined by crop nutrient demand than soil nutrient supply reflecting the variance in attainable yield.

Discussion

The heterogeneous nature of the available trial data and the ways that the reported recommendations were derived hindered an adequate validation, and evaluation, of the first and second tier Results. It also justified to consider the first tier Results consistent and appropriate for scaling purposes. The variance in fertilizer recommendations proved most determined by that in attainable yield which though is not a factor modelled with QUEFTS. This provides room for improvement of the overall approach.

Conclusion

The proof of concept provides an operational framework for progressive and collaborative updating and upscaling of site-specific fertilizer recommendations across the region, adding value to additional and adequate soil-crop-response data, using techniques based on both agronomic and artificial intelligence.

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Towards a global nutrient budget data platform

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Keywords: nutrient budgets, nutrient use efficiency, data, open access, public-private partnership

Introduction, scope and main objectives

Accurate estimates of nutrient inputs and outputs on agricultural land at national and sub-national scale are critical for (i) quantifying nutrient balances and nutrient use efficiency, (ii) assessing the impact of nutrient use on food production, biodiversity, global climate, water and air quality and other environmental functions, (iii) developing realistic nutrient and emissions targets and roadmaps, and monitoring progress towards them, and (iv) forecasting future fertilizer demand. Such data are of particular importance for national action plans on SDG Target 2.4 (sustainable food production systems, including in the context of climate change). Various national and sub-national scale databases on nutrient inputs and outputs have been created by organizations and researchers worldwide. They have resulted in coarse and widely ranging estimates because of large uncertainties due to data scarcity and differences in data sources and estimation methods used. The accuracy of many data layers remains poor in many countries. Persisting data gaps are difficult to fill with the current methods and the resources available. An improved dataset will Result in stronger messages to a wide range of stakeholders, including policy makers.

Methodology

We first review the current status of data on nutrient inputs and outputs on agricultural land in the world and we discuss major trends as well as knowledge gaps. We then present a vision and strategy for a coalition to create and manage a joint nutrient budget data platform that brings together data and expertise available in public and private sectors. We discuss the general framework and principles to follow, including distributed co-creation, collective ownership, openness and innovation in creating novel data sourcing pipelines and analytical tools.

Results

The joint platform, a test version of which is being built for dissemination in FAOSTAT and IFASTAT, will lead to more timely and better aligned reference data, reduced uncertainty, and increased granularity in terms of sub-national and crop-specific data. Novel data collection methods focus on acquiring better agronomic information at a suitable aggregation level, including data on fertilizer use by crops, manure use, crop residue management, crop biological fixation, etc. The basic data collection will be complemented with existing and emerging datasets from top-down measurements such as remote sensing.

Discussion

see above

Conclusion

Filling critical data gaps through a collaborative effort will greatly enhance use of global nutrient data for specific policy and investment purposes. It will enable countries to better monitor and report on nutrient use, nutrient use efficiency, risks, and emissions from agriculture.

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Prospects of sustainable food security in tribal areas with improvement in soil health by adopting practices of summer green gram cultivation

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Keywords: Green Gram, Summer, Tribal, VAAGDHARA, Soil-Health, Rajasthan, Leguminous, Livelihood

Introduction, scope and main objectives

Soil is the one of the most important natural resources available on earth, which is directly or indirectly required by any living thing. Consistent degradation of soil health due to various reasons like unethical use of chemical fertilizers, removal of topsoil due to erosion in hilly areas, water-logging is having a devastating impact on productivity and eventually impacting food security across the globe. The global trends show that 20 percent of cropland, 16 percent of forest land, 19 percent of grassland, and 27 percent of rangeland are in persistent decline in productivity due to soil degradation (UNCCD, 2017). The structure of cultivated soils has a very important bearing on drainage, ease of tillage, root penetration and resistance to erosion and ultimately their general productivity. In the tribal areas of Southern Rajasthan in India, the quality and texture of soils having undulated topography is deteriorating day by day. Further, the soil of small and marginal farmers is also degrading due to adopting inappropriate, soil exhaustive crop rotation methods (cereals after cereals) like maize-wheat, rice-wheat, whereas agricultural science indicates that inclusion of one leguminous crop in a crop rotation is an effective tool for improving soil health. Leguminous crops have the capacity to restore fertility of soil. These crops can bind the free atmospheric nitrogen by means of nitrogen fixing bacteria; enrich the soil with organic matter; enrich the soil aeration through their well-developed root system; improve the physical properties of soil through its sufficient surface foliage; help in dissolving nutrients and thus has great significance in crop rotation.

Methodology

The properties of the soils in these areas can be improved by cultivation of summer green gram. VAAGDHARA in an initiative during 2016-17 for improving livelihood, nutrition security and improvement of soil health; sensitized and motivated 1000 farmers for summer green gram cultivation in 2-gram panchayat of Banswara district of Rajasthan. Farmers were initially supported with certified seeds and other inputs.

Results

The land which usually remained fallow during summer season, these 1000 small and marginal farmers were able to cultivate 1 to 1.5 quintal of green gram per acre and each family could earn Rupees 7 000 to 8 000, which also improved their livelihood. Cultivation of green gram also provided fodder for animals during the summer days. More importantly, an improvement was observed in the germination, growth and yield of the next sown kharif crop of maize and paddy, indicating improvement in soil health.

Discussion

The Agricultural Experts And Department Officials Acknowledged The Role Of Rhizobium And Its Nitrogen Fixation Tendency, Which Improved The Fertility Of Soil By Fixing Nitrogen And Was Helpful In The Cultivation Of Maize And Paddy And Revitalized Kharif Cultivation. This Initiative Provided A Multi-Dimensional Result To The Farmers And Played An Important Role In Strengthening The Family Farming System And Sustainability.

Conclusion

Considering the positive Results of this initiative, regular cultivation of green gram in summer season is being done in Banswara in an organised way. The sowing area has now increased up to 3000 hectare which was nominal earlier. Thus, cultivation of green gram in summer season helps to sustain food security, supplementing nutritional requirements of the family and also improve livelihood and more importantly soil health.

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More than an organic fertilizer: mealworm frass as a substitute to conventional fertilizer to ensure a sustainable future

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Unilasalle

Keywords: Insect frass - Organic fertilizer - Soil life

Introduction, scope and main objectives

Climate change and the recent increase of conventional fertilizers prices force us to identify more sustainable fertilizer sources. With the fast growth of the insect production sector, frass (insect excreta) have the capacity to reduce our reliance on conventional fertilizers and improve our sustainability.

Methodology

Frass: Frass from mealworm (*Tenebrio molitor* L.) was provided in the form of powder by Ÿnsect (ŸnFrass, Paris, France), an industrial company farming this insect at the large-scale. The mealworms were fed exclusively on local agricultural raw materials (wheat bran) authorized by French and European regulations for farm animal feeds. The frass was hygienized (70 °C, 60 minutes) and used without any chemical input, making it a fertilizer compatible with organic farming and not subject to any specific restrictions. Incubation experiment - N mineralization: The kinetics of frass mineralization were followed during laboratory incubations of control and frass treatments, based on the French normalization [1]. An amount equivalent to 25 g of dry soil mixture was incubated in 1.2 L hermetic jars kept in a dark room at 28 °C. The experiment was conducted in four replicates and lasted 91 days. The water content of the mixtures was adjusted at field capacity with demineralized water and controlled during the incubation period. Mineral N (N-NH_4^+ and N-NO_3^-) was extracted by shaking the mixtures for 1 h with 100 mL 1 mol L^{-1} KCl after 0, 7, 14, 28, 56 and 91 days of incubation [2]. The mineral N in the extracts was analysed by colorimetry on a continuous flow analyser (Skalar, The Netherlands). The release of mineral N from frass was calculated by subtracting the mineral N measured in the control treatment from the mineral N in the frass treatment. SEM-EDS characterization of frass: The inner morphology of frass was investigated on polished section of frass particles impregnated with epoxy using a scanning electron microscope (SEM; Hitachi S3400N). The SEM was equipped with an energy-dispersive X-ray spectrometer (EDS; Thermo Ultradry) for element detection and element mapping was carried out on frass particles mounted on double-sided adhesive carbon tape. Voltage was set at 20 kV and counting time was 200 seconds. Soil analyses: Water-soluble phosphorus concentration in soil (soil:water 1:60; w-v) was determined as described by Sissingh [3]. The available K and P concentrations were determined using the ammonium acetate-EDTA soil test [4]. Soil pH was measured in H_2O (soil:water 1:5; w-v). Community-level physiological profiles (CLPPs) based on the ability of microorganisms to oxidise various substrates were assessed using BIOLOG EcoPlates (BIOLOG Co., Hayward, USA). Each 96-well plate consisted of three replicates, each one comprising 31 sole C sources and a water blank. Five grams of soil collected at the end of the pot experiment, were shaken with 45 ml of sterile 0.85 percent NaCl for 30 min at 200 rpm and then diluted to 1:1 000. Each plate well was inoculated with 150 µL of the dilution and the plates were incu bated at 25 °C. Color development for each well was obtained in terms of optical density (OD) at 590 nm using an automated plate reader. Pot experiment - Earthworms/Frass effects: Briefly, plastic plant pots were filled with 3 500 g of either soil or a mixture of soil and frass at a rate of 10 Mg dry matter ha^{-1} (hereafter called "Frass" treatment), or untreated soil (hereafter called "Control"). Three earthworms (*Lumbricus terrestris* L.) were added in half of the pots (hereafter called "Frass + earthworms" or "Control + Earthworms" treatments) representing biomass of 12.05 +/- 0.24 g and 12.25 +/- 0.17 g in Frass + Earthworms and Control + Earthworms treatments respectively, according to the recommendations by Vos *et al.* [5]. Each of the four treatments was replicated four times. References: 1. AFNOR. FD-U-44-163 Soil Improvers and Growing Media - Characterization of Organic atter by Potential Mineralization of Carbon and Nitrogen. (AFNOR, 2016). 2. Doublet, J., Francou, C., Poitrenaud, M. & Houot, S. Influence of bulking agents on organic matter evolution during sewage sludge composting; consequences on compost organic matter stability and N availability. Bioresour. Technol. 102, 1298–1307 2011.. 3. Sissingh, H. A. Analytical technique of the Pw method, used for the assessment of the phosphate status of arable soils in the Netherlands. Plant Soil 34, 483–486 (1971). 4. Houben, D., Meunier, C. & Pereira, B. & Sonnet, P. Predicting the degree of phosphorus saturation using the ammonium acetate–EDTA soil test. Soil Use Manag. 27, 283–293 2011.. 5. Vos, H.M.J.; Ros, M.B.H.; Koopmans, G.F.; van Groenigen, J.W. Do earthworms affect phosphorus availability to grass? A pot experiment. Soil Biol. Biochem. 2014, 79, 34–42.

Results

Results & Discussion: Its well-balanced nutrient composition (NPK ratio 4-3-2) and its quick mineralization (37 percent of total N mineralized after 17 days) makes mealworm frass suitable to be applied on any kind of crop and can be as effective as a conventional fertilizer [6,7]. Analysis of the mealworm frass surface also revealed an even distribution of P, K and Ca within the organic matter [6] which imply an homogeneous soil nutrient distribution after mealworm frass application. These findings suggest a very good mealworm frass potential to be used as substitute to conventional fertilizers. Unlike conventional fertilizers, mealworm frass high organic matter content (around 80 percent) and composition have the ability to increase soil microbial activity and maintain soil functional diversity [7]. Studies also revealed a synergetic effect between mealworm frass and earthworms [8] which improves plants capacity to uptake mealworm frass nutrients when earthworms are present. Moreover, after mealworm frass application, water soluble P is five times lower compared to conventional fertilizers which prevent P loss and sorption improving the P use efficiency [6]. Thus, mealworm frass seems to be a good asset to maintain or even increase soil quality and micro/macro organisms biodiversity. As an organic fertilizer, mealworm frass soil application can also increase soil organic carbon storage between 3.1 and 27 tC/ha/yr [9]. Life cycle assessment revealed that the use of mealworm frass as a substitute to conventional fertilizer can significantly reduce crop production environmental footprint [10]. Given its capacity to capture carbon into the soil and to reduce agriculture environmental footprint, mealworm frass is promising fertilizer.

Discussion

see the above Results & Discussion part.

Conclusion

More than an organic fertilizer, mealworm frass have a great potential to stimulate soil life, reduce the use of conventional fertilizer and improve environmental footprint. Considering the fast growth of the insect industry, frass will become a commonly used organic fertilizer which has a great potential to ensure a more sustainable agriculture.

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can characterize the soil, crop and environment rapidly and cost-effectively and with greater precision scale. Such information is being used to develop ICT based tools for precision nutrient management as well as in-season adaptive management at an affordable scale. Future gains in productivity and input-use efficiency will require technologies that can manages soil, water, and crop and are more knowledge-intensive and tailored to the specific characteristics of individual farms and fields. Precision nutrient management approach manages the soil variation, nutrient status and crop responses.

Discussion

The concept for optimizing the supply and demand of nutrients according to their variation in time and space. However, for scaling such approach ICT tool can be tailored to specific local conditions for precisely providing field specific nutrient recommendations to the farmers as web- and mobile phone based application/software. Current efforts towards this include, Soil Health Card Portal developed by Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Govt. of India for registration of soil samples, recording test Results of soil samples and generation of Soil Health Card (SHC) along with Fertilizer Recommendations through STCR prescription equations which is a single, generic, uniform, web based software accessed at the URL www.soilhealth.dac.gov.in. Nutrient Expert® is another effective tool that is based on the plant-based approach of SSNM. An example of region specific Decision Support System for Integrated Fertiliser Recommendation (DSSIFER) which was developed by STCR centre at TNAU, Coimbatore was found useful for about 1645 situations and for 190 agricultural and horticultural crops for prescribing fertilisation schedule.

Conclusion

However, there is no denying fact that as on today we are mainly dealing with soil chemical fertility evaluation through soil testing which is only the tip of the iceberg. Constraint analysis with respect to biological and physical properties has seldom been touched upon. These two factors account for about one-third of unaccounted variations in soil health assessment. We need to include some easily measureable biological parameter like dehydrogenase and physical parameter like penetration resistance. The twin aspect of devising strategies for leveraging resources to tackle the challenge of low carbon transformation and strategies to enhance soil health and carbon sequestration will help in combating climate change without compromising agri-economic development. Moreover, the region-specific amalgamated technological prescriptions refined with targeted policy analysis are required for effective implementation and obtaining positive outcomes within a finite time horizon. This will provide a strong foundation for pragmatic policy formulation on natural resource conservation and combating climate change. Halting and reversing land degradation as well as sequestering soil organic carbon is a high priority for transitioning to achieve a land-degradation neutral world in the context of sustainable development. It was observed that adoption of ICT, incorporating externalities for making economic decisions, accounting for capital invested in the face of climate change, strengthening local and community governance structures, and development of voluntary guidelines on sustainable land management in sync with local law are essential elements for development of sound soil policy.

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Long-term irrigation with alkali and partially neutralized water changes soil nutrient availability, carbon fractions and microbial activities in sandy loam soils

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Keywords: Alkali water, carbon fractions, microbial activities, phosphorous availability, potash availability

Introduction, scope and main objectives

To improve the food, nutrition and livelihood security of humankind, a conspicuous increase in groundwater exploitation for irrigation has been noticed throughout the world. However, in several arid and semi-arid regions, even the poor quality groundwater [alkali water containing high residual sodium carbonate (RSC)] is used for irrigation (Minhas et al., 2019). Therefore, the effects of long-term irrigation with alkali and partially neutralized water were quantified on sandy loam soils.

Methodology

The study was conducted in concrete lysimeters of 2m x 2m x 2m with drainage outlets at the bottom. The adopted cropping systems [rice-wheat (2004.-2012), sorghum-wheat (2012-2015), sorghum-mustard-sunflower (2015-2018) and rice–wheat (2018-2019.)] were irrigated with five types of irrigation water i.e. good quality water, synthetic alkali water (SAW) having the RSC ~5 me/L (SAW1), SAW of RSC ~10 me/L (SAW2), SAW2 neutralized up to RSC ~5 me/L with gypsum (SAW2+GYP) and SAW2 neutralized up to RSC ~5 me/L with sulphuric acid (SAW2+SA). In October 2019 (after 16 years of the study), two soil samples were drawn out from 0-15 cm soil depth (after harvesting of rice) and mixed to make a composite sample. One part of the sample was air-dried, ground to pass through a 2-mm sieve and stored in plastic bags for analysis of soil reaction (soil pH), electrical conductivity (EC), soil organic carbon (SOC) and its fractions, available nitrogen (N), available phosphorous (P) and available potassium (K). Whereas the remaining fresh samples were passed through a 2-mm sieve and stored in the refrigerator at 4 °C for analysis of various soil microbiological parameters viz., bacterial population (BP), fungal population (FP), soil microbial biomass carbon (SMBC), alkaline phosphatase activity (ALKPA) and dehydrogenase activity (DHA).

Results

Long-term use of high RSC water for irrigation significantly declined microbial activities (BP, FP, SMBC, ALKPA and DHA) and increased pH and EC of the soil. Total inorganic carbon increased but SOC and its active pool decreased significantly. The availability of P and K increased significantly in soil, while N availability remained unaffected under various treatments.

Discussion

A significant depletion observed in SOC and its active pool under alkali water irrigation could be a consequence of lower organic matter inputs from plants as crop growth is drastically reduced under sodicity stress (Basak et al., 2021.). Moreover, soil microbial activities drastically affected under the different quality of alkali water irrigation might be due to change in the root rhizospheric microbiomes structure under abiotic stress (Fonseca et al., 2020) along with depletion in SOC content. An increase in P and K availability in the soil might be due to lesser uptake by reduced crop growth, with the increase in alkalinity of irrigation water.

Conclusion

The addition of gypsum and sulphuric acid, for partial neutralization of RSC in irrigation water, proved equally useful for recovering the soil quality parameters. But, partial neutralization was not satisfactory to maintain the long-term soil quality and crop productivity. Our findings propose substantial revision in the rate and method of application of the amendments as well as phosphorous and potassium fertilization on sandy loam soils where alkali water is the only source of irrigation.

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Use of citrus pruning waste and plant covers as a source of organic matter in soils

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Keywords: citrus, pant covers, pruning waste, valorizations, soil quality

Introduction, scope and main objectives

The study seeks to make use of citrus pruning waste in agricultural soil in order to generate value for the farmer and society. Turning a waste into an asset. Indirectly, it aims to value and promote plant covers as a sustainable practice.

Methodology

The studies have been carried out on orange and mandarin trees in the Ribera area (Valencia, Spain) with calcareous Fluvisol-type soils. 6 different treatments have been tested combining two types of residues (pruning + grass and pruning + grass + legume) and three application points (on the street, on the ridge on the irrigation line and on the ridge under the irrigation line) applied for 32 weeks. The samples were taken at four times throughout the project and have included both soil and leaf samples, following what had been programmed in the project, analyzing the main parameters of interest. In addition, additionally part of the soil samples were subjected to analysis to determine the microbial biodiversity of both bacteria and fungi.

Results

The application of pruning wastes induces greater humidity in the soil and an increase in organic C and biological activity in the soil, along with an enhancement of the presence of microorganisms linked to biorefertilization by nitrogen, phosphorus and potassium. An important increase in the contents of organic matter, C and N was observed in the first days after the application, which decreased after 32 weeks. On the other hand, while in the control areas the sequestration of C was negative, in the areas with cover and fertigation it was positive. The contribution of P+G+L residues contributed more to this process in the fertigation zone than in the vegetal cover zone.

Discussion

The Results show that the application of pruning wastes does not negatively affect the nutritional status of the soil-plant system or the production of the fields. On the contrary, it generates a whole series of environmental benefits. Also, a greater biodiversity, increasing the microorganisms of relevance for the mobilization of nutrients. Finally the evolution of the organic content indicates that there was an important degree of mineralization.

Conclusion

As Conclusion, these Results illustrate that these practices can be a sustainable approach for the sequestration of C and could contribute to the mitigation of atmospheric CO_2 in this type of agrosystems. Likewise, this management of residues represents an innovation to be implemented in good agricultural practices within the cultivation of citrus fruits in the Valencian regions of l'Horta and La Ribera.

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Microbial source shapes the community of endophytic bacteria in rice roots

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Keywords: Bacteria, Colonization, Endophyte, Hydroponic experiment, Microbial sources, Sequencing, Soil

Introduction, scope and main objectives

Plants-microbe interaction is a complex process, wherein an assembly of plant-associated microbes known as 'endophytes' are recruited via their root system. Specifically, endophytes are an endosymbiotic group of microorganisms that can colonize the internal tissues of plants and provide several benefits. Endophytic colonization begins with the adherence of soil bacteria to the plant root surface. To achieve this, soil bacteria may utilize mechanisms such as motility (stimulated by root exudates), exopolysaccharide synthesis compounds, and biofilm formation to facilitate root colonization. Elucidating the factors affecting endophytic colonization like soil pH, organic matter content, and soil type has become a hot topic. However, little is known about the microbial source effect as an individual factor on the endophytic bacterial community of rice plants (*Oryza sativa* L.), which serves as the purpose of this study.

Methodology

This study was performed using the microbial communities of 5 different soil types collected from different geographical locations in Japan. In this study, hydroponic systems were inoculated with five different soils, which provided the microbial sources for the rice plants were prepared. Rice seedlings grown under sterile conditions were transplanted into the systems after 21 days and kept in the growth chamber. After 3 and 6 weeks, the rice roots were collected, and the endophytic bacterial communities were determined by Illumina MiSeq-based 16S rRNA gene amplicon sequencing.

Results

Our results show that the dominant bacterial phyla of the microbial sources were Firmicutes, Chloroflexi, Proteobacteria, and Acidobacteria. Two-way ANOVA results showed that the endophytic bacterial diversity and richness significantly differed with respect to the microbial sources. PCoA plots showed distinctive microbial clusters indicating that microbial sources influenced the assemblage of bacterial endophyte communities. Similarly, PERMANOVA results proved that the microbial source was a determinant factor of bacterial endophyte communities in rice roots ($p < 0.001$). Venn diagram analysis showed an assemblage of shared endophytic bacterial taxa dominated by Proteobacteria, and different endophytic groups observed for each microbial source treatment.

Discussion

The microbial sources used in this study exhibited differential bacterial community diversities and compositions, which were reflected in the overall endophytic bacterial communities for the rice plants of each treatment. Although rice plants can recruit a distinct community of endophytic bacteria that may be beneficial for their growth and development, this study showed that rice plants inoculated with different microbial sources assembled distinct endophytic bacterial communities that included plant growth promoters like *Azospirillum*, *Bradyrhizobium*, *Burkholderia*, and *Herbaspirillum*.

Conclusion

The rice plants exposed to each microbial source exhibited distinct endophytic bacterial communities. Therefore, the Result here sufficiently confirms the hypothesis that the microbial source is important in the endophytic bacterial colonization of rice plants, thereby providing valuable information for the manipulation of the microbiome of rice for sustainable plant growth promotion purposes.

Acknowledgements

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Innovating organic fenugreek (*trigonella foenum-graecum*) cultivation using a unique locally produced liquid biofertilizer

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Keywords: Vegetables, fenugreek, growth-stimulation, greenhouse, biofertilizers, sandy soil

Introduction, scope and main objectives

Soils play a critical foundational role in agriculture production. Yet, the soils of Kuwait are sandy and infertile. Kuwait is hyper-arid and water-scarce country. Open field agriculture is focused on forage production and vegetables (conventional & organic) are grown in greenhouses. In organic farming (OF) organic fertilizers add organic matter, nutrients, heavy metals and salts. The use of liquid BFs in OF is limited due to high cost and unavailability. Bio-fertilizers (BF) contain living cells of efficient strains of microorganisms (bacteria, fungi, actinomycetes etc), that help crop plants' uptake of nutrients through their interactions in the root zone. The objectives of this paper are; i) to develop an LBF locally and; ii) to innovate organic fenugreek cultivation in the greenhouse (GH).

Methodology

A pilot-scale LBF (10 L batch) was prepared aerobically using compost to extract nutrients, acids and grow the microbial population in water by using molasses/oat meal as an energy source for the growth of microbes and fungi, and Kelp (containing cytokinins and Auxins growth stimulant) over an optimized brewing time of 16 hours. To test the efficacy of LBF a pot (surface area 227 cm^2) experiment was conducted to grow fenugreek in the GH (29 Sept - 15 Nov 2021.). The lower 1/2 of six pots was filled with 2.5 kg native sandy soil/pot, the upper half was filled with the mixture of 1.5 kg soil and 68 grams compost/pot (@ 3kg/m^2 a standard farmer practice. No chemical fertilizer was used. Twenty-five seeds were placed in each pot at 0.5 cm depth. Three pots were irrigated with freshwater (T1-control) and 3 pots were irrigated with 1:9 (LBF:water) (T2) based on ETo measured in the greenhouse. All seeds germinated within 2 days.

Results

At the start of LBF production, the initial electrical conductivity (EC) of the freshwater was 200 µS/cm, which increased to 1321 µS/cm after 30 minutes, 2930 after 4 hrs, and to a maximum of 3580 µS/cm after 16 hrs. The pH of the fresh water (8.14) was decreased (3.56) after 16 hrs. The fresh biomass per pot (average of 3 pots) was 16.3 g (T1) and 26.1 g (T2), a significant increase of 59.3 percent with LBF. The average fresh weight of roots/pot was 5.37 g and 10.93 g for T1 and T2 respectively (100 percent increase). Similarly, an average 29 percent increase/plant length was recorded in T2 (26.9 cm) over T1 (20.9 cm). The root/shoot was increased significantly in T2 over T1.

Discussion

The increase in EC is due to the release of electrolytes, nutrients, and organic acids. The pH is decreased due to the release of humic, fulvic acids, microbial growth, and the production of carbonic acid due to CO_2 released. The positive effects of LBF has been found in the form of increased above and belowground biomass and plant length. This is due to the presence of organic acids, growth stimulants, nutrients, and lower pH of LBF relative to freshwater. The lower pH can increase the release of fixed soil nutrients (P, Fe, Cu, Mn, Zn) in soil. The enhanced mineralization of compost in the pots due to LBF may be another factor. All these factors have contributed to intensifying FN-greens production.

Conclusion

A significant increase in fresh biomass, root growth, and plant length with LBF has shown great promise to further this preliminary research on other strategic vegetable crops grown in Kuwait. The production of LBF can be upscaled for use in open-field and greenhouse vegetable production. However, it is recommended to investigate LBF further on other organically grown vegetables before upscaling in open field and greenhouse conditions.

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Major integrated nutrient management strategies for rice-wheat cropping, and their impact on nutrient cycling, use efficiency and climate resilience of the system

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Keywords: Nitrogen and carbon cycling, integrated nutrient management, mineralization, carbon sequestration, climate resilience, soil quality

Introduction, scope and main objectives

Rice-wheat is the most prevalent cropping system in the South Asian region, the breadbasket of India. Being very energy-intensive, the rice-wheat cropping systems have low build-up (and faster depletion) of soil organic carbon (C), low nutrient use efficiency, and other adverse environmental impacts. Management practices have key control over agro-ecosystem carbon and nutrient cycling, influencing the long term the crop productivity, nutrient use efficiency, soil health, and climate resilience. Integration of organics in nutrient management provides multi-pronged benefits like C build-up in the soil as well as enrichment with slow yet consistently released nutrients during a cropping cycle. Major integrated nutrient management systems for rice-wheat cropping include growing legumes during the lean period and recycling their biomass, recycling main crop biomass, and use of composts.

Methodology

We used long term rice-wheat cropping experiments (2005-2016) on a sandy loam soil at ICAR-CSSRI, Karnal, to study five integrated nutrient management systems, including five with reduced inorganic fertilizer doses in combination with organic sources [LE- legume (Vigna radiata), GM-green manure (*Sesbania aculeata*), FYM- farmyard manure, WS- wheat straw, RS-Rice straw], compared to 'full recommended doses of inorganic fertilizer' (F) treatment and 'no fertilizer at all' (O) treatments. The studies were done on nitrogen mineralization (daily rates), nitrogen use efficiency, micronutrient availability, and soil organic C sequestration and fractionation (very labile, labile, less labile, and non-labile). Management indices indicative of C sequestration were calculated to interpret management effects. Calculations were done for estimating plant C assimilation each year, ex-situ contributions of C, and soil organic C fractions. C input to soil was estimated annually by measuring the entire C added to the soil. The climate resilience of the system was also tested under different management.

Results

Our studies reveal that the integration of organics in the nutrient management schemes enhance nutrient availability, Use efficiency, soil health, and climate resilience. The INM strategies resulted in improved NUE compared to 100 percent chemical fertilizers (F). The INM had significantly higher net N mineralization and improved enzymatic and microbial activity aligning with the NUE trends. The soil organic carbon (C) significantly increased in INM, and a significant effect of the labile C fraction was evident on the NUE of the wheat crop. With an increased C return to the soil, the most significant contributions went to very labile carbon (C) fractions. Soil C stock showed a decreasing trend with an increase in depth, and it was maximum in the case of green manuring (1724 g m^2) as the annual plant assimilated C, and C return to the soil was also maximum in the case of GM (21 and 7 t ha^{-1}, respectively).

Discussion

The reductions in redox potential (Eh) and pH during rice season improved NUE under integrated management. Highly reduced conditions favored N mineralization and plant availability in form of NH_4^+-N Resulting in enhanced uptake efficiency in case of rice. The integrated management systems also provided better climate resilience and mitigation of greenhouse gas emissions. Legume-based management showed no responses to increased soil C inputs in different years, perhaps indicating nutrient richness shadowing the beneficial effects of soil C (beyond a certain level). Integrated management of nutrients provided significant soil fertility benefits via favorable effects on nitrogen mineralization and use efficiency, micronutrient uptake by plants, and increased crop productivity.

Conclusion

The study indicated that INM strategies can immensely benefit the rice-wheat system via improvement in soil biological health along with electrochemical changes for flooded rice, and labile-C-assisted improvement in soil conditions for wheat. Almost 50 percent cut down in inorganic fertilizer use could be afforded with the use of green manuring, integration of a legume crop in the main cropping system and soil incorporation of its residues, retention and soil incorporation of cereal crop residues, and use of manures.

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Native arbuscular mycorrhizal fungi of salt affected soils: an alternative for enhancing P-nutrition and salt stress tolerance in crops

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Keywords: Salt-affected soils, arbuscular mycorrhizal fungi, native mycorrhiza, saline soils, sodic soils

Introduction, scope and main objectives

Salt-affected soils (SAS) are the degraded soils having high osmotic and matric stress for crop plants due to excessive soluble salts and exchangeable sodium. According to FAO, about 20 percent of global croplands are converting to less productive or wastelands due to land degradation associated with salinization. Abuscular mycorrhizal symbiosis is one of the important components of soil-plant natural ecosystems as it improves water and nutrient acquisition and also enhances plant strategies to cope with abiotic and biotic stresses. Native arbuscular mycorrhizal fungi (AMF) have an advantage of performing better in terms of providing beneficial affects to plants than the newly introduced mycorrhiza due to their adaptation in a native environment. The present study was started with the hypothesis that under stressed conditions the symbiotic relationship between adapted native AMF and sorghum crop will Result in increased productivity and stress tolerance. Hence, the objectives of our study were to (i) characterize the native mycorrhizal spores, (ii) evaluate their efficacy in sorghum under saline and sodic soils, and (iii) characterize the AMF-crop interactions in different soil types.

Methodology

This present study was carried out to characterize, isolate and identify the native arbuscular mycorrhizal fungi from SAS (saline and sodic soils). The efficacy of most abundant AMF was evaluated in sorghum under three soil types (normal, saline and sodic soils).

Results

The Results demonstrated the abundance of native AMF which depends upon the level of stress in SAS. The AMF spore density was significantly affected soil pH and nutrient availability and soil salinity. However, AMF abundance varied with cropping systems. The rice-wheat cropping system in sodic soils harbored highest AMF spore density which were trapped in maize roots and further isolated. The sequences of the amplified fungal ribosomal DNA of the 18S region of the isolated AMF were identified as Funneliformis mosseae and Funneliformis geosporum. The efficacy of native AMF was evaluated in sorghum in normal soil, sodic and saline soils. AMF inoculated plants demonstrated improved plant height, fresh and dry biomass and were greater in normal soil followed by sodic and saline soils. Sodic soil showed highest increase in root to shoot ratio compared to saline soils. The P content, P uptake, and K^+/Na^+ were better in AMF inoculated plants. AMF demonstrated highest increase in Olsen's-P in inoculated normal then sodic and saline soils. Glomalin content, dehydrogenase and alkaline phosphatases enzymes were also high in AMF inoculated soils.

Discussion

Variation in AMF abundance is associated with the varied capabilities of crops in forming a mutualistic association with native AMF. Greater root to shoot ratios was mainly because of partitioning more photosynthates to roots under salt stress and AM hyphae also increases absorptive surface area. The increased Olsen's P because of AMF inoculation increases solubilization of phosphorus through secretion of organic acids.

Conclusion

Application of native AMF was found very effective in improving growth, yield, and P nutrition of sorghum under salt-affected soils. The AMF relationship was effective in both saline and sodic soils. Therefore, the application of native AMF, under salt stresses conditions can be a convenient strategy for rehabilitation and management of salt-affected soils. Such practices also present an economically and ecologically secured alternative for enhancing salt tolerance in important cropping systems.

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Traditional coffee system that improves production and soil fertility

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Keywords: Soil quality index, seed quality index, nutrients quality index, agroecological crop systems.

Introduction, scope and main objectives

Healthy and fertile soils are necessarily required to achieve food security, especially in crucial times of pandemic and global change scenarios. Recently, worldwide coffee producers have selected cropping systems that increase yield without considering soil fertility, greenhouse effect gas emissions, or sustainability. In contrast, alternative and traditional systems used by small growers, such as shade-grown coffee, may have several advantages for soil conservation, productivity, and carbon sequestration. This research analyzes the association of coffee-mango or coffee-banana trees as a traditional cropping method that may positively influence soil fertility-plant nutrition-crop productivity. The objective was: To analyze three coffee production systems regarding physical, chemical, and biological aspects related to soil fertility to obtain quality indexes for soil, foliar nutrients, and seeds. Based on scientific data, we may recommend a sustainable production system while protecting the soil.

Methodology

The study was performed in a field located at the Tinaja, Emiliano Zapata municipality at Veracruz, México. Three coffee crop systems were characterized by analyzing physical, chemical, and biological soil properties. Two traditional systems were shade-grown coffee-associated systems; one with mango (*Mangifera indica*) and another with banana (*Musa paradisiaca*, var. Cavendish). The third system is an open-sun coffee. Fifteen composed samples per hectare for each system were analyzed. pH, total N, available P, available Cu, Mn, Zn, Fe, Ca, Mg, and organic matter, electrical conductivity (EC), soil moisture (field capacity and permanent wilting point; PWP), –C and N-microbial biomass, agro-industrial yield, parchment to gold coffee yield (GCY), and finally quality indexes for soil, leaf nutrients, and seeds were analyzed. Statistical analyses such as ANOVA, Tukey test, PCA, and conglomerates were performed.

Results

Highly statistical differences ($p \leq 0.001$) among coffee systems were observed for the soil parameters (pH, K, Ca, Mg, N, P, Fe, Cu, OM, moisture) and significant ($p \leq 0.05$) for C:N, EC, and PWP. Nutrimental foliar concentration was highly significant among systems for K, Ca, N, Fe, and Mn. Similarly, the Cu and Mg concentrations in seed were highly significant ($p \leq 0.001$), and significant for Ca, N, and Fe grain concentration ($p \leq 0.01$) and for yield GCY, P, Mn, and Zn grain concentrations ($p \leq 0.05$). There were also differences in C and N-microbial biomass ($p \leq 0.001$). Finally, the indexes of soil, foliar nutrients, and seed showed that the coffee–mango association is a more sustainable system than coffee-banana or open-sun coffee systems.

Discussion

In general, coffee associated with mango showed the higher soil, foliar, and seed quality indexes; however, only the foliar quality index was optimum. Soil and seed quality indexes were moderate. Probably due to OM and COS in the shade systems were low. Therefore, major additions of soil OM should be improved with organic fertilization, but less chemical fertilization is recommendable. Although the soil quality index was moderate, coffee associated with mango had the highest coffee grain yield. This yield was 60 percent higher than the national coffee seed yield compared to coffee-banana (33 percent) and open-sun coffee (20 percent). Similar trends were observed for agro-industrial and GCY yields. More advantages taking into account mango and banana production in coffee systems will be discussed.

Conclusion

These Results help smallholders to make wise decisions for soil and nutrient management and promote a cost-effective and environmentally friendly coffee production system. This kind of associated system involves several advantages: Soil conservation practices with organic matter from mango and banana, low input into the soil-plant cycling, the rescue of good traditional management at risk of disappearing, and the application of possible innovative approaches. The associated management may promote sustainable coffee, mango, banana productivity, and efficient soil ecosystem services. These systems should be upscaled to promote sustainable soil fertility based on organic fertilization sources and reduce their environmental impact.

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Soil fertility improvement under conservation agriculture: effect of fertilization on soil physicochemical properties and wheat yield under both conventional and no-till systems

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Keywords: Soil fertility, Conservation agriculture, No-tillage, Crop yield, Vertisol, Soil quality

Introduction, scope and main objectives

The soil resources of the agricultural areas of Morocco are undergoing degradation of different degrees and forms, such as erosion, compaction, salinization and decrease in organic matter content. Limiting these risks is the most important challenge of sustainable development. The benefits of conservation agriculture (CA) over conventional tillage (CT) could remedy the degradation of natural resources, in particular soil. The adaptation and transfer of direct seeding (NT) with residue mulch opens new perspectives for reconciling increased production, which guarantees food security, and environmental protection.

Methodology

The objectives of this study are (1) to report the differences in soil chemical (nitrogen, phosphorus, potassium, and pH) and physical (structural stability, bulk density, moisture, and soil organic matter content) properties which Resulted from the conversion from CT to NT in contrasting cropping systems in two types of soils (Vertisol and Isohumic), representative of the agricultural zone in northwest Morocco and (2) to draw Conclusions and recommendations on the state of fertility and the management of fertilizers.The first long-term experiment (13 years) was set up at the Marchouch (I) experimental station of INRA, located 68 km south-east of Rabat While the second short term experiment (7 years) was carried out with a farmer in the Ain Sbit (II) site. In both sites, the rotation practiced is legume / cereal.

Results

Results indicate a significant improvement (p-value <0.05) in soil stability structure under NT (with mean weighted diameter, MWD = 1.32 and 1.13 at sites I and II) compared to CT (0.72 and 0.60 mm) for the three treatments (Rapid moistening, slow moistening, and mechanical disintegration by agitation). In contrast, we recorded a significant difference in soil organic carbon content with higher levels over the five soil depths in NT compared to CT. The analysis of the humidity Results shows significant differences between the two systems. Regarding nutrients, direct seeding showed a significant effect on available phosphorus (p value = 0.0027) and total nitrogen (p value = 0); on the other hand, it did not show a significant effect on exchangeable potassium and pH. Despite the delay in rainfall recorded during the 2017/2018 campaign, the yields of soft wheat in direct sowing (48.8 Q/ha) were significantly higher than those recorded in conventional sowing (41.6 Q/ha), particularly in terms of grain yield. As a Result, conservation agriculture is an option that even seems to be favored for increasing yields, sustaining agricultural production, and continuously improving soil quality.

Discussion

After 13 years of experimentation in Merchouch and 7 years in Ain Sbit, NT and vegetation cover have modified several soil properties. Improved structural stability, water retention, carbon sequestration, nitrogen conservation, increased P levels, lower pH, SOM accumulation and gradual yield increase are the main changes associated with the shift from conventional to NT system. This shows that no-till has helped build a good soil structure over time, which is highly desirable for improving agricultural productivity and conserving natural resources, especially water.

Conclusion

As a Result, conservation agriculture is an option that even seems to be favored for increasing yields, sustaining agricultural production, and continuously improving soil quality.

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Native AMF communities in hop cultivation with bokashi type fertilization in Brazil

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Keywords: Humulus lupulus; Glomeromycota; bokashi; Species Survey; family farming; sustainable agriculture

Introduction, scope and main objectives

Brazil is beginning to cultivate hops (*Humulus lupulus* L.) with the adaptation of varieties to the climate and has obtained excellent organoleptic Results in the product (Durello, Silva, and Bogusz, 2019). The crop is being encouraged to small producers and family farming due to the high income in small areas, encouraging the emergence of small breweries (Soares and Firmo, 2018). Large breweries also see the culture as an opportunity to promote the social development of the surrounding communities of small farmers. Thus, the crop is being studied to receive agroecological treatments that can guarantee the farmers' health and produce in a sustainable way. As hops have mycorrhizal dependence reported in the literature (Davis, Young and Rose, 1984), studies on the effect of fertilization on AMF communities in this crop become important. This work aims to evaluate how different levels of bokashi fertilizer affect native AMF communities occurring in the hop crop.

Methodology

Rhizospheric soil samples of hops of the Cascade variety were collected in an experiment implemented in October 2021., in the georeference -22.183417° -42.844111°, that evaluates fertilization with 0, 1, 2, 4, 8 and 16 Mg/ha of bokashi type fertilizer in the establishment of this irrigated crop in Teresópolis, RJ, Brazil, in a randomized block design with 4 repetitions. The samples were collected during the period of maximum rainfall and heat (summer) by three transects at a depth of 0-10 cm in the plot (one per useful plant) making a composite sample for each plot, totaling 24 composite samples. In the Mycorrhizae Laboratory of Embrapa Agrobiology, the AMF spores were extracted from 50 cm³ of soil of each sample by wet sieving with the sieves of 0.42 and 0.053 mm. The spores were mounted on slides for microscopy and identified taxonomically by their morphology.

Results

A total of 16 species of AMFs were found in hop rhizosphere: *Acaulospora denticulata, Acaulospora foveata, Acaulospora laevis, Acaulospora scrobiculata, Ambispora leptoticha, Gigaspora sp. Glomus clavisporum, Glomus glomerulatum, Glomus macrocarpum, Glomus multicaule, Glomus* sp, *Glomus sp.2 Glomus* sp.3 *Racocetra fulgida, Rhizoglomus microaggregatum*, and *Sclerocystis sinuosa.* The first year of application of fertilizer treatments did not significantly affect the number of spores and the number of species among treatments, although the number of species (diversity) tended to be lower in the absence of fertilizer. *Glomus glomerulatum, Glomus multicaule,* and *Sclerocystis sinuosa* did not occur in the treatment without fertilizer application. Acaulospora species tended to decrease in the percentage of occurrence with increasing doses of fertilizer.

Discussion

The number of samplings and the effect of the Bokashi fertilizer on the community of AMF is still incipient. Trap cultures of the samples already collected are being conducted to extend the survey of the species of AMF present and the field sampling will be repeated during the cooler and drier period of the year (winter).

Conclusion

The data currently collected indicate that the application of bokashi type fertilizer in the formation of the hop crop is not significantly influencing the community of AMF in its rhizosphere.

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Improve soil fertility through circular use of agricultural plant waste: new mulching techniques

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Keywords: natural horticulture, mulching, circular economy, soil fertility, compost, Bois Raméal Fragmenté

Introduction, scope and main objectives

This project intends to pursue the improvement of the functionality and fertility of the soil in natural horticulture through the greater diffusion of rational soil cover techniques, such as mulching of vegetable origin with compost. (Fini et al., 2016) The research investigates some innovative techniques of small pioneer farms used to maintain soil fertility without the addition of synthetic substances nor even manure but using vegetables waste. 4 aspects are considered: • Optimize new mulching techniques and propose mature or semi-mature compost and the BRF (Bois Raméal Fragmenté) as soil cover. (Boselli et al., 2020) • Create a network to connect innovative agricultural companies and disseminate information about the correct application of mulch of vegetable origins. • Spread the application of these techniques to other more conventional companies. • Create an interactive app to provide advice on the production and use of compost and to collect data to build an detailed database on the various needs in different areas of Italy and in the perspective of the European Union indications.

Methodology

In Italy, an Operational Group was set up, made up of a set of agricultural production companies (coordinated by: il Bosco delle Galline Volanti di Viviana Germano), a public research organization, Council for Agricultural Research and Economics (CREA), represented by two structures (AA - and IT), agricultural associations, producers of the "zero km" agro-food chain, companies for the production of BFR and compost which operate in the maintenance of public green areas, local authorities, animation groups of the territory, local schools.

Results

The expected Results are: the adoption of rational vegetable mulching techniques which the consequent improvement of soil functional qualities; increasing of plant, animal and microbial diversity of horticultural systems. Also, the increase in the quantity and quality of naturally managed vegetables productions and the spread of integrated land cover techniques (Beni et al., 2018).

Discussion

The advantages due to the cooperation between the subjects participating in the project can be: At the company level: census of natural production companies, aggregation (promotion of a regional or national association), grand exchanges of information within research bodies on products and processes. The development of production protocols, the use of a consultancy service interactive online. For the research organization: the establishment of direct relationships with the agricultural part, collaboration with the consulting service for the growth of the sector, an increase in design and analytical potential induced by the integration of production / research / consultation For the community: the guarantee of quality and healthiness conditions of products, the integration of production with collateral social activities, the increase in environmental protection. As well as the protection of the territory, reduction of energy inputs, and activation of a "virtuous" cycle of waste.

Conclusion

The focus of this project will increase the level of innovation of mulching techniques by creating a positive economic impact, linked to their use and the creation of a supply chain between all the "actors" involved. This is particularly interesting also in small rural realities, not only in Italy but in the world. The ultimate goal is to increase productivity, food safety and environmental sustainability. Also gives the possibility to improve in terms of territorial circular economy and waste disposal.

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Effects of different organic mulching on soil moisture retention and crop productivity increase of maize farming system under degraded soils of northern Tanzania

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Keywords: TARI - Tanzania Agriculture Research Institute ANOVA- Analysis of Variance RCBD -Randomized Completely Block Design

Introduction, scope and main objectives

Organic mulches play important roles in conserving soil moisture, soil erosion mitigation, improving soil conditions, suppressing weed growth, providing organic matter and plant nutrients in the soil (Bilalis et al., 2002; Jodaugienė et al., 2006). An on-station experiment was conducted to assess the effect of different organic mulching materials on Maize (*Zea Mays* L). Specific objective of the trial was to assess the effects different organic mulching on maize growth parameters, weed abundance, maize yields (biomass, cob weight and grain yields) and soil moisture retention at 0-20cm depth and 20-50cm depth. Growth parameter (plant height), weed abundance, maize yield components (biomass, cob weight and grain yields) and finally, soil moisture retention at 0-20cm and 20-50cm depths were collected at the experimental trial.   The objective of the study was to investigate whether the use of different mulching materials from off-site material as surface mulch enhances maize (*Zea Mays* L.) yields, weed suppression and moisture retention.

Methodology

A field experiment was set at TARI Research farm in Arusha-Tanzania using a RCBD design replicated three times during 2021./2022 cropping season (April-September, 2021). Growth parameter (plant height), weed abundance, maize yield components (biomass, cob weight and grain yields) and finally, soil moisture retention at 0-20cm and 20-50cm depths were collected at the experimental trial. A composite coffee Vermicompost sample (Monduli Coffee Estate, Arusha, Tanzania), the samples were air-dried and analyzed at TARI TanSIS Soil Lab using Spectroscopy method (NIR reflectance) for pH in water, Organic carbon (OC), Total N, Available P, Exchangeable base cations (Ca^{2+}, Mg^{2+}, K^+, Na^+), Particle size analysis (PSA)- Only soil sample. Plot size of 2.5x2m was used with a spacing of 0.5m between plots. Maize (SITUKA M1 variety) was used as a test crop and was planted at a spacing of 75cmx50cm. A planting fertilizer (NAFAKA) of 20kg/ha was applied in all plots at the same rate (except the control). Six (6) treatments were randomly assigned in the plots (broadcasted within the plots).The rate of mulches used was 6 kg per plot which is equivalent to 10 ton/ha (Ramakrishna et al., 2006.; Aminu-Taiwo et al., 2014). Data on soil moisture (0-20cm, 20-50cm depth), maize stover weight, cob weight, number of weeds per plot, grain yield per plot and 100 seed weight were collected and subjected to One-Way ANOVA using GenStat Software. Significant means were separated using Turkey Test at 5 percent level of significance.

Results

Generally, all mulching material showed significant soil moisture conservation than no mulch plot throughout growing stage of maize crop. In week 2 (14 days after planting), organic mulching had highly significant difference ($p < 0.001$) on soil moisture content in all soil depths. In the upper soil depth (0–20cm) among the mulching treatments Banana Leaves(BL) had statistically similar soil moisture Result so do Grass (GR) and Rice Husks (RH) mulches. The highest soil moisture (16.18 percent) was conserved under sawdust mulch while the lowest soil moisture content (8.49 percent) was conserved under the control. In the lower soil depth (20-50cm) the highest soil moisture (21.30 percent) was conserved in rice husks (RH) mulching material while the lowest soil moisture content (11.98 percent) was conserved under the control. The conserved moisture due to mulch treatments had a positive role in maize seedling as compared to no mulch plots which had shown symptoms of water stress such as wilting and leaf rolling.

Discussion

Results of this study indicated significant ($p<0.01$) influence of organic mulching on plant height throughout different consecutively as compared to other mulches and the control. Mulching in this study showed significant ($p<0.01$) influence in suppressing weed emergence. Lowest number of weeds was scored 2 under the sawdust mulch at harvest while 6.3 for control at harvest. The results further indicated that organic mulches positively influenced higher biomass, fresh cob weight and maize grain yield. Results indicate that higher biomass (10.93 t ha^{-1}) and grain yields (0.9280 t ha^{-1}) were recorded under Sawdust mulch followed by Thithonia leaves while the lowest values of the aforementioned parameters were obtained under the control (No mulch) plant growth stages. Sawdust and banana leaves mulch resulted into maximum plant height of 167.2cm and 165.9cm

Conclusion

Therefore, the findings of our investigation indicated that organic mulching had an influence on soil moisture retention at different growth stages and yield of maize as the yield increased with mulch compared to the control (No mulch) hence the more moisture content retention on the soil the more microbes survive in the soil and the higher yield produced by the crop.

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Improving the soil fertility and crop productivity of intensive rice-wheat systems by crop residue recycling via integrating in nutrient management

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Keywords: Rice-wheat system, integrated nutrient management, nitrogen use efficiency, crop residue, legume, green manure, Mineralization

Introduction, scope and main objectives

Rice-wheat cropping system is the most extensively followed crop rotation in the Indo-Gangetic plain. It is a highly intensive cropping system with expensive energy inputs on tillage, irrigation water, and fertilization. The farmers of the region have problems managing the crop residues, especially those of rice crop, and therefore burning of crop stubble is one of the major environmental issues. The residues of both crops are rich in nutrients (~ 0.5-1.5 percent N). If recycled the residue can become a useful biofertilzer/soil conditioner. There can be various means of using these residues for soil fertility enhancement. Some of the means include, in situ residue retention and incorporation into soil after crop harvest, transforming the residues into compost via suitable composting method and applying to soils, and integrating these crop residue-based options with other options like green manuring.

Methodology

An integrated nutrient management (INM) experiment was initiated in 2014-2015 at Central Soil Salinity Research Institute (CSSRI), Karnal, used to assess the suitability of eight INM-modules viz; RS-F100= in situ 1/3rd rice stubble retention and incorporation + 100 percent recommended fertilizers, RS-F150= in situ 1/3rd rice stubble retention and incorporation + 150 percent recommended fertilizers, WS-F100= in situ 1/3rd wheat stubble retention and incorporation + 100 percent recommended fertilizers, WS-F150= in situ 1/3rd wheat stubble retention and incorporation + 150 percent recommended fertilizers, PSC-F50=Paddy straw compost @ 5 t ha-1 + only 50 percent of recommended fertilizers, PSC-FYM-F50= Paddy straw compost @ 5 t ha-1 + Farm-yard manure @ 5 t ha-1 + only 50 percent of recommended fertilizers, GM-FYM-F50= Green manuring with *Sesbania aculeata* + Farm-yard manure @ 5 t ha-1 + only 50 percent of recommended fertilizers,   GM-PSC-F50= Green manuring with *Sesbania aculeata* + paddy straw compost @ 5 t ha-1 + only 50 percent of recommended fertilizers, compared to F = 100 percent recommended fertilizer, and O= absolute control.

Results

The Result of the experiment showed that both, grain yields and nitrogen use efficiency (NUE) increased significantly under GM-PSC-F50 (green manuring with application of paddy straw compost and only 50 percent fertilizers), GM-FYM-F50 (green manuring with application of FYM and only 50 percent fertilizers). These INM practices can afford cutting down of chemical fertilizer to 50 percent. In cereal residues (RS, WS) based INM, wheat stubble retention showed promising impacts on soil fertility and yield over the years while rice stubble retention could not match upto

100 percent fertilizer (F) without addition of 50 percent fertilizer as in RS- F150. Similar trends were also noted for N mineralization.

Discussion

Wheat straw in-situ retention showed increasing trends in yields overs the years indicating it be promising INM-modules with long term impacts. The most important change that explained the trends in rice season include changes in redox potential and pH during rice reason, while the changes in soil organic carbon played significant role during wheat season.

Conclusion

Overall, the study revealed that the green manuring with Sesbania aculeata + Paddy straw compost @ 5 t ha-1 + only 50 percent of recommended fertilizers (GM-PSC-F50), 1/3rd wheat stubble retention and incorporation + 100 percent recommended fertilizers (WS-F100), and 1/3rd rice stubble retention and incorporation + 150 percent recommended fertilizers (RS-F150) are the promising INM technology modules for adoption by farmers.

Acknowledgements

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Soil salinity management in coastal smallholder vegetable production in Mozambique – the role of synthetic and organic fertilizers and manures

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Keywords: integrated nutrient management, local knowledge, nutrient use efficiency, soil organic matter, saline agriculture, soil health, soil salinity

Introduction, scope and main objectives

Salinization of agricultural soil resources is an ever-increasing problem for global sustainable food production. Often, it results from interplay of climate change impacts and human agronomic mismanagement. The concept of Saline Agriculture (SA) provides a versatile toolbox of agricultural practices which have the potential to sustain agricultural production under saline conditions. A well-tuned application of synthetic and/or organic fertilizers and manures plays a central role in SA. It allows for a mitigation of the following detrimental phenomena typical for salt-effected soils: (a) nutrient imbalances (b) compromised soil structure, and (c) reduced soil life. At the same time, agricultural practitioners need to consider the potential risks of increasing soil salinity through the use of inadequate fertilizers or manures. SA practices in general, and soil fertility management approaches in particular, are not universally applicable. They need to be tested locally and adapted to the particularities of production systems. Especially smallholder vegetable production systems in (sub-) tropical environments are still rather poorly understood in this regard.

Methodology

Addressing this knowledge gap, an ongoing project initiative is implementing a participatory pilot of SA practices in Maputo's peri-urban coastal vegetable production zones, in southern Mozambique. Multi-year field trials for the evaluation of different soil fertility management approaches under saline conditions are under implementation. The trial plots are established in farmers' fields. They rely on strong farmer participation in terms of decision making on treatment selection, trial plot management and overall research design. The trials are based on a randomized complete block design (RCBD) with factorial arrangements. Collard greens (*Brassica oleracea*) and lettuce (*Lactuca sativa*) have been selected as research crops, representative for the production system. The experimental cycles are aligned with the local vegetable cropping season, the fresh and dry season between May and October. In a first trial phase 2021., three factors were evaluated: (1) chicken manure, (2) mineral fertilizer (NPK compound 12:24:12), (3) a combination of factors 1 and 2, and (4) local practice based on top dressing with urea (46 percent N). The trial plots were implemented in 3 sites with different salinity level assessed as EC1:2.5 (0.5 and 0.7 in two sandy loam soils; and 1.2 in a sand clay loam soil). Several soil, water and crop parameters were monitored during crop growth on a weekly basis, along with yield parameters at harvest (EC1:2.5, EC of irrigation water, pH, soil water content, plant height, plant diameter, number of leaves).

Results

Preliminary results indicate the importance of organic manure application, especially in lettuce production, as an effective approach for soil salinity management in smallholder wetland vegetable production. Both chicken manure and mineral fertilizer application, as well as the interaction of both, showed advantage over the traditional practice of simple urea top dressing.

Discussion

Further detailed assessment is necessary to separate the effects on salinity and nutrient dynamics in the studied sites for a complete understanding.

Conclusion

Following the same experimental setup, the project currently investigates the viability of further innovative organic manure strategies for the local production system (e.g. biochar, biofertilizer, compost).

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Hidden nutrient leaks in agricultural soils

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Keywords: nutrient balances livestock feed agricultural estimates Argentina storage losses

Introduction, scope and main objectives

More accurate nutrient balances are a key tool for keeping soils healthy and land use sustainable. In Argentina, simplified macro-balances underestimates nutrients´ extraction through grazing, biomass harvesting, residues, and losses during grains´ storage and transport. The study proposes an extended nutrient balance equation, and estimates the proportion of N, P, K and S extracted from soils in these unaccounted factors for 12 grain crops in the period 2009-2019.

Methodology

A database was built including the Ministry of Agriculture, Livestock and Fisheries´ information on areas planted, harvested, and their production and yields. Volumes of stubble and forages produced, and losses in grain storage and transport were estimated for each of the value chains, based on local bibliographic References. From the conventional nutrient balance equation (Roy et al., 2003), this study further developed the "Nutrients extracted by crops and residues in the Δt interval" factor as follows: 1) Nutrients extracted by the main harvested product 2) Nutrients extracted by the harvested by-product or secondary product 3) Nutrients extracted by harvest secondary residues 4) Nutrients extracted in the biomass of primary residues 5) Nutrients extracted in secondary storage losses and 6) Nutrients extracted in secondary transport losses of the main product

Results

Grain production figures showed to be good indicators of extracted nutrients in oilseeds but not in cereals, mainly due to an increased proportion destined for cattle in feed-lots.

Discussion

Compared with previous studies, estimated extraction rates are at least 46 percent higher for N; 25 percent for P and 176 percent for K for the five main crops. The amounts of potentially recyclable nutrients contained in secondary storage losses and residues represent 8 percent of the total N and 43 percent of the total K_2O applied per year for all crops in Argentina.

Conclusion

Unlike more developed countries where the great concern is nutrient excess, there is enough evidence that the deficit of nutrients is a central sustainability problem for Argentinian agriculture. The problem of nutrient extraction is deepening because -among other factors- the technological changes during the last decade made the yields of a set of 12 crops (malt barley, peanuts, sunflower, soybeans, pasta wheat, corn, oats, feed barley, sorghum, rye, rice and bread wheat) gone from 3 044 kg ha^{-1} to 3 817 kg ha^{-1} (+ 25 percent).   To properly address this problem, it is necessary to adapt nutrient balance´s methodological approach avoiding the simplification of understanding the soil as a “black box” from which grains simply come out and fertilizers enter in. This study shows how in cereals this way of looking is insufficient to explain the balances, although in the case of oilseeds it could be relatively indicative of the nutritional status of the soils. In corn, sorghum, rye, oats and feed barley crops, the volume of green biomass (stems, leaves) extracted from the field are better indicators of the total nutrient output.

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Soybean nutrition using *Trichoderma* spp. and organic acids in the seeding furrow

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Keywords: *Glycine max*, inoculation, humic acid, fulvic acid

Introduction, scope and main objectives

The large consumption of fertilizers associated with exhaustible reserves has increased the search for alternatives in the supply of nutrients to plants. The use of growth-promoting microorganisms and/or capable of providing nutrients to plants can be an alternative with lower cost and environmental impact, reducing dependence on inputs and increasing their efficiency. The objective of this work was to evaluate the effects of different commercial products based on Trichoderma spp. applied in the sowing furrow, associated or not to organic acids, in the nutrition of the soybean crop in no-tillage system

Methodology

The experiment was carried out in the field, at the University of Caxias do Sul, Campus Vacaria in the 2019/20 and 2020/21 harvests. The experiment was carried out in a 4x2 factorial scheme, with a control and four commercial products containing Trichoderma spp. and with and without application of organic acids. Arranged in completely randomized blocks, allocated in split plots, with six replications. The composition of the commercial products were: commercial product 1 *Trichoderma harzinum*, commercial product 2 by *Trichoderma harzianum*, *Trichoderma asperellum* and *Trichoderma koningiopsis* and commercial product 3 by *Trichoderma harzianum*. The organic acid used has the following composition: K_2O 4.00 percent, TOC 6.00 percent, humic acid 16.00 percent, fulvic acid 2.50 percent and seaweed extract 10.00 percent. The treatments were applied via the sowing furrow of the soybean crop, at the dose recommended by the manufacturers, diluted in a solution volume of 90L.ha^{-1}. Fertilization was carried out with 340 kgha^{-1} of triple superphosphate at sowing and 200 kg.ha^{-1} of potassium chloride as a cover on the soil surface in all treatments. During the two years of the experiment, the macro and micronutrient content in the leaves during the full flowering period were evaluated. The 3rd mature leaves of the upper third of the main stem were collected from 30 plants per plot (CQFS, 2016) and analyzed according to the Methodology and Malavolta et al., (1997).

Results

The Results of foliar analyzes did not show a significant effect in applications with *Trichoderma* spp. for both macro and micronutrients in the first year evaluated. However, in the second year of evaluation, there was an increase in boron absorption with the use of the commercial product, a mixture of three species of *Trichoderma*. The use of organic acids did not affect the nutrition of the soybean crop and did not interfere in the action of the different products based on Trichodermas tested.

Discussion

The greater absorption of boron in the treatment with commercial product 2 may be due to the greater availability of the nutrient by *Trichoderma* spp. and/or greater efficiency in its absorption, considering that boron was the only nutrient below what was considered adequate for the crop.

Conclusion

Therefore, the application of *Trichoderma* spp. in the sowing furrow is a promising technique for soybean nutrition in a no-tillage system.

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Omission plot technique for assessing the nutrient contribution towards productivity of rice-maize cropping system in calcareous soils in eastern India

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Keywords: Omission plot technique, Calcareous soil, Rice, Maize, Return on Investment

Introduction, scope and main objectives

Crop plants are the major source of dietary nutrition. Nutrient uptake by plants is crucial for plant fitness, and global food and nutritional security. However, the complex nature of plant-nutrient dynamics under variable soil composition is poorly understood. Thus, the aim of the present study was to evaluate the indigenous nutrient supplying capacity of calcareous soil using a nutrient omission plot technique under rice-maize cropping system.

Methodology

The trials were conducted in calcareous soils (at 22 locations) with treatments included ample application of Nitrogen (N), Phosphorus (P), Potassium (K), Sulphur (S) and Zinc (Zn); unfertilized check and omissions of N, P, K, S, and Zn in rice and maize for six cropping seasons.

Results

Omission of the nutrients reduced the rice equivalent yield (REY) over ample fertilization, and in general, N (52.5 percent) was most limiting nutrient followed by P (19.8 percent), K (16.2 percent), S (11.4 percent) and Zn (10.9 percent). Ample fertilization based on target yield in hybrid rice and maize crops produced additional 32 and 40 percent grain yield, respectively than the inbred crop. The return on investment (ROI) for N, P, K, S and Zn (i.e. US$ per US$ invested on fertilizer nutrient) for hybrid rice varied from 7.3 to 25.5, 2.1 to 12.3, 1.0 to 10.0, 0.9 to 8.9 and 0.1 to 0.7 with an average ROI of 15.2, 5.5, 4.3, 3.9 and 0.3, respectively. While, in hybrid maize the ROI for N, P, K, S and Zn varied from 14.2 to 35.6, 1.4 to 11.4, 0.5 to 7.4, 2.6 to 13.9 and 0.04 to 1.1 with an average of 26.3, 5.2, 3.6, 7.9 and 0.6, respectively. The contribution of available nutrients towards uptake by hybrid crops (N 25.4, P 53.5, K 70.6, S 24.3 and Zn 26.9 percent) was more than the inbred crops (N 18.0, P 37.6, K 55.5, S 18.9 and Zn 20.8 percent).

Discussion

The decrease in the yield was more pronounced in second and third year than the first year that might be due to regular omission of the nutrient from fertilizer schedule (Salam et al., 2014; Singh et al., 2021.). The yield potential and harvest index of hybrid crops was more than the inbred crops that might be due to more accumulation of nutrients in its biomass than the inbred crops (Virmani and Kumar, 2004.). The more contribution of nutrients to hybrid crops than inbred crops might be due to better root growth, leaf area and translocation of nutrients in hybrid crops. The fertility was found to decline more in respective nutrient omitted plots and unfertilized plots, while a build up was observed in balanced fertilized plot.

Conclusion

The study on nutrient omission helps the farmers about the diagnosis of nutrient deficiency symptoms and to apply the required nutrients especially secondary and micro-nutrients as these are required by the crops in lesser quantity. Thus, cultivation of hybrid crops with balanced fertilization may help in enhancing the productivity and fulfill the food demand of the increasing population and also helps in sustaining the soil fertility. However, extensive research is needed at different land situations to determine and optimize the nutrient demands by the hybrid crops for attaining sustainable yield and soil fertility.

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Understanding the adoption of zero budget natural farming in andhra pradesh, India

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Keywords: participatory photography, zero budget natural farming, regenerative agriculture, ZBNF, India

Introduction, scope and main objectives

Zero Budget Natural Farming (ZBNF) in Andhra Pradesh emphasises home-made, locally sourced, agrochemical-free inputs and regenerative techniques as a means to achieve socio-ecological resilience for smallholder farmers. Public messaging about ZBNF describes transformations in the soil through enhanced microbial activity and nutrient availability, and across society, as lower input costs and higher yields are able to protect farmers against debt, food insecurity, and change. This study explored the accuracy and efficacy of ZBNF public messaging through an interdisciplinary soil and social science investigation, which sought to understand motivations behind the adoption of an agricultural practice projected to reach over six million farmers in Andhra Pradesh by 2024.

Methodology

Working in the same communities across three agroecological zones, spanning over 800km, we established 44 controlled field experiments comparing ZBNF, conventional and organic treatments, alongside participatory photography investigations led by farmers.

Results

Field experiments revealed that the performance of ZBNF agriculture, when compared to conventional or organic farming yields and soil nutrients, is largely congruent with the public messaging. The participatory photography–focusing on farmer perceptions of ZBNF innovations–demonstrated that farmer-defined reasons behind adoption defy a simple cost-benefit analysis and point toward a combination of subjective gains not limited only to yield and income but inclusive of memory, legacy, independence, and a rejection of industrialized agriculture.

Discussion

Together, the parallel soil and social science approaches reveal the effect of ZBNF on the soil, as well as the perceptions of those transformations among the community members themselves, including the way those transformations became embedded in the overarching narratives farmers used to define their lives.

Conclusion

These Results will contribute towards an evidence base to understand the strengths and weaknesses of the ZBNF approach, to what extent that success has come from context-specific conditions, and whether there are principles that could be useful in other geographic and cultural areas.

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The European space agency world soils monitoring system

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Keywords: soil organic carbon, soil spectral libraries, remote sensing

Introduction, scope and main objectives

Soil is a key biotic element to the environment while soil organic carbon (SOC) is the main component of soil organic matter (SOM). SOC contributes to nutrient retention and turnover, soil structure, moisture retention and availability, degradation of pollutants, and carbon sequestration. SOC is an indicator of soil health and essential for food production, mitigation and adaptation to climate change, and the achievement of the Sustainable Development Goals (SDG). Recent developments in satellite and airborne sensors have sparked the interest in Earth observation for monitoring soil properties. The spectral and spatial resolution of sensors is gradually increasing together with the capacity for data analysis. Therefore, a range of present and future options exists for the workflow towards an Earth observation soil monitoring system. The availability and data quality of recent satellite missions like Copernicus Sentinels, have dramatically changed the paradigm, making remote sensing of top soils feasible in a coherent manner from regional to global scales. The ambition of the WORLDSOILS Monitoring System (WOSOMS) is to achieve a system with the following characteristics:

- Modular implementation, allowing future additional soil indices into the system.
- A double spatial resolution grid of 100m x 100m for continental monitoring and a 50m x 50m for regional covering.
- Appropriate confidence metrics provision.
- Use of large time series of a minimum of 3 years.
- Validation over three regions.

Methodology

WORLDSOILS feasibility studies have focused on intermediate soil organic carbon indexes (bare and vegetated soils, forest and grassland) from a satellite reflectance composite, built from a three to five year-series of satellite observations. Intermediate SOC indexes are selected to cope with land cover diversity and aligned with bare soils and permanently vegetated areas. The project has systematically assessed the impact on prediction performance of various options at each step of the workflow towards a global EO Soil monitoring system. The options considered consist of current benchmark technology, options available in the near future and realistic scenarios taking into account corrections for potential disturbing factors. The first step taken towards the development of the WOSOMS has been the compilation of a set of user requirements considering: i) the outcomes of the feasibility and impact assessment studies, ii) existing scientific literature, iii) applicable EO data policies and iv) user needs gathered from potential end-users. The Resulting consolidated requirements, agreed with the stakeholders, will be used to design and implement this monitoring system on a suitable cloud environment, presumably one of the Data and Information Access Services (DIAS).

Results

The system will operate during one year over three pilot regions in Greece, the Czech Republic and Wallonia, designed in coordination with National Reference Centres of Soil, representing different bioclimatic regions across Europe with a range of vegetation types, land use and soil types. The case studies will be based on data acquired during the operations phase in addition to data from the previous two years (three-year time series). The project will culminate with a final symposium to present and discuss the Results of the validation, and will present the starting point for the future evolution and enhancement of the system.

Discussion

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Acknowledgements

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Factors in the formation of paddy soil bacterial communities

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Keywords: bacterial community soil type active aluminum humic acid

Introduction, scope and main objectives

Soil bacteria are one of the components that play an extremely important role, contributing to the decomposition of organic matter, the supply of nutrients for crop growth, the transformation and cycling of nitrogen, nutrient storage as microbial biomass, and the formation of the soil aggregates. In paddy soils, anaerobic bacterial community structure is formed after flooding, and then stabilized. This process is influenced by differences in soil physicochemical properties such as total carbon content and soil pH, as well as agricultural management that alters these factors. Similarly, several other factors affecting bacterial community formation in paddy fields have been reported separately. The main objective of this study is to determined which of thems is the most critical one.

Methodology

First, amplicon sequencing analysis of soil DNA for bacterial 16Sr RNA genes was performed on 57 paddy fields in various regions of Japan. The soil type of each paddy field was andosol, gley soil, gray upland soil, or gray lowland soil, and was managed by either organic, conventional, and natural farming methods. Then, to clarify the relationship between bacterial community composition and soil type, bacterial communities were extracted from andosol, gray upland soil, and gley soil, and were inoculated into a different-type sterile soil. The bacterial community compositions established after incubation under flooded conditions were then analyzed by amplicon sequencing analysis for 16S rRNA genes. Finally, the effects of adding active aluminum (alophene, aluminum hydroxide gel) and humic acid (from andosol, commercial product) on soil microbial community compositions were evaluated in a model experiment using gray upland soil and gley soil.

Results

The first experiment showed that differences in soil type had a greater impact on the bacterial community compositions more than for fertilizer management did. The Ssecond experiment suggests that the bacterial community composition established after the incubation was influenced more by the soil type of the culturing soil than by the source of inoculum. In particular, a distinctly different bacterial community was formed when cultured on andosol compared to the other two. The third experiment indicates that none of the additions of active aluminum or humic acid to soil had a significant impact on the bacterial community composition.

Discussion

Fertilizer management is unlikely to be a significant factors in determining bacterial community compositions. The present experiments indicates that some factors specific to eachof soil type , but not the amount of active aluminum or humic acid, may affect the bacterial community.

Conclusion

Further investigation of the effects of other soil physicochemical properties is needed to clarify the mechanism of bacterial community formation under flooded conditions.

Acknowledgements

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Phosphorus stocks in eu agricultural soils: inputs, outputs and fluxes

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Keywords: phosphorus budget; fertilizers; manure; plant uptake; erosion losses; Farm to Fork; food security

Introduction, scope and main objectives

Phosphorus (P) is an important nutrient for all plant growth and it has become a critical and often imbalanced element in modern agriculture. A proper crop fertilization is crucial for production, farmer profits but also for ensuring sustainable agriculture. The European Commission has published the Farm to Fork (F2F) Strategy in May 2020, in which the reduction of the use of fertilizers by at least 20 percent is among one of the main objectives. Therefore, it is important to look for the optimal use of P in order to reduce its pollution effects but also ensure future agricultural production and food security. It is essential to estimate the P budget with the best available data at the highest possible spatial resolution.

Methodology

The European Soil Observatory (EUSO) modelled both the available Phosphorus (P-Olsen) and the total Phosphorus stocks at European scale using the Land Use/Cover Area frame Survey (LUCAS) topsoil data that include measured values for almost 22,000 samples. In addition, we modelled the P inputs by inorganic fertilizers, manure, atmospheric deposition and chemical weathering. Those estimations were based on regional scale statistical data such as fertilization inputs, livestock density, crop productivity rates, and crop systems. Regarding the P outputs, we focus on estimating the P removal from soils by crop harvest and removal of crop residues. Specifically, we attempt to estimate the P removal by taking into account the production area and productivity rates of 37 crops for 220 regions in the European Union (EU) and the UK. To estimate the P removal by crops, we include the P concentrations in plant tissues (percent), the crop humidity rates, the crop residues production, and the removal rates of the crop residues. Using a sediment distribution model, we also quantified the P fluxes to river basins and sea outlets.

Results

For European Union (EU) and UK, the sum of P inputs is about 2.8 Mt with an uncertainty of ±13 percent at 90 percent confidence level. Those estimations were based on regional scale statistical data such as fertilization inputs, livestock density, crop productivity rates, and crop systems. For European Union (EU) and UK, the sum of P inputs is about 2.8 Mt with an uncertainty of ±13 percent at 90 percent confidence level. The inorganic fertilizers and manure have the largest contribution to those inputs. The P outputs came mainly from the exportation by the harvest of crop products and residues (97.5 percent) and, secondly, by erosion. The total P removal is about 2.65 Mt (±9 percent uncertainty) with crop harvesting having the larger contribution.

Discussion

We also compiled the P budget at the regional level, which is surplus of circa 0.8 kg ha^{-1} yr^{-1} for the 180 000 000 ha of agricultural soils in EU and UK. By providing this picture, we aim to improve the current P balances in the EU and explore the feasibility of the Farm to Fork objectives. The Results of this European study can contribute towards better understanding the global P balance and improve current methodologies in place. The improved Empirical Model Phosphorus Balance (EMPBa) which was applied for the EU allows the estimation of P budget both at regional and national scale.

Conclusion

Mean P removal by crop harvesting is 14 kg ha^{-1} yr^{-1}, with cereals and vegetables having higher rates, while fruits having much lower ones. In most of the North-western European regions, the rates of P removal are higher than 20 kg ha^{-1} yr^{-1}, while are lower than 10 kg ha^{-1} in Mediterranean regions and South-East EU countries. The P outputs with plant residues and erosion fluxes contribute to about 1.2 kg ha^{-1} yr^{-1}. The mean P input in EU and UK is about 16 kg P ha^{-1} yr^{-1} with fertlizers and manure having the largest proportion of this. In regions with high density of livestock, the manure inputs are much higher than inorganic fertilizers. The P annual budget at regional scale showed ample possibility to improve P management by both reducing inputs in regions with high surplus (and P soil available) and rebalancing fertilization in those at risk of soil fertility depletion.

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The effect of different doses of organic and mineral fertilizers on the availability of trace elements in soils through the transformation of their organic matter

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Keywords: Fertilizers, transformation of soil organic matter, fulvic acids, humic acids, micronutrients mobility

Introduction, scope and main objectives

The effect of different doses of organic and mineral fertilizers on the availability of trace elements in soils through the transformation of their organic matter

Methodology

The research was based on data of long-term field experiments in different soil/climatic zones of Ukraine to determine the impact of application of different doses of mineral fertilizers and manure on the transformation of soil organic matter (SOM), and as a consequence, changes in the availability of micronutrients (Zn, Fe, Mn), which we noted in our previous publications (Fateev, 2015).

Results

It was found that increased doses of mineral fertilizers often led to a decrease in the content of fulvic acids. For example, the use of increased doses of mineral fertilizers (N120P100K140) for sugar beets on chernozem podzolic of Verkhnyatskaya Research Field reduced the content of fulvic acids carbon (Cfa) from 0.37 to 0.30 percent. The high input of manure on the background of mineral fertilizers led to some increase in the content of humic acids carbon (Cha) - up to 0.51 percent, but the Cfa content continued to decrease - up to 0.25 percent. Similar Results were obtained for Uladovo-Lyulinetska and Ivankivska Research Fields. Increase in saturation per hectare of crop rotation area of the latter to N32P50K42 even against the background of 7.5 t/ha of manure led to a decrease in Cfa content in typical heavy loam chernozem from 0.38 to 0.31 and increased humatization of SOM – Cha/Cfa ratio reached 3.07. Probably, not the last role in SOM' transformation is played by the saturation crop rotations with beet, which contributes to increased mineralization of fulvate substances are most susceptible to microbiological destruction. The moderate input of mineral fertilizers in the vast majority of cases led to an increase in the content of fulvic acids in soils. For example, the use of N60P60K40 on typical heavy loamy chernozem of the Myronivka Institute of Wheat, increased the Cfa content from 0.36 to 0.42 percent. The application of 30 t/ha of manure increased the Cha content to 0.72 percent, and the fulvate content remained unchanged.   Similar data were obtained on the Vinnytsia Research Field, where the use of mineral and organic fertilizers provided an increase in Cfa at the level of 0.02 - 0.04 percent. An exception is the Results of the Bast Crops Research Station, where long-term use of N60P45K45 fertilizers Resulted in a significant reduction in Cfa from 0.39 percent in the control version to 0.32 percent. However, the combined use of such a dose with 20 t / ha of manure provided an increase in Cfa content to 0.42 percent.

Discussion

Data's analysis of long-term stationary experiments shows that mobile forms of Mn in soil were characterized by a decrease in accordance with the increase in both humic and fulvic acids in soils due to the concentration of this micronutrient mainly in mineral soil components. Some different data were obtained for Fe – it was found a statistically confirmed decrease in the content of mobile forms of this micronutrient with an increase in the content of humic acids in comparison with control variants (ΔCha). For example, an increase in the Cha content of chernozem typical of the Verkhnyanskaya Research Field by 0.04 percent led to a decrease in the Fe content from 3.32 to 0.83 mg / kg of soil (1N ammonia-acetate buffer pH 4.8). For mobile forms of Zn, an increase was found together with an increase in the share of Cfa in the soil organic matter, which is associated with a significant concentration of zinc in fulvic acids.

Conclusion

Thus, the transformation of SOM should be taken into account both from the standpoint of determining the impact of mineral and organic fertilizers on the Environment and in the context of soil nutrients management as well.

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Selection of PGPR bacteria to improve and increase bean productivity

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Keywords: food safety, growth promotion, bean, rhizosphere, PGPR traits

Introduction, scope and main objectives

Confronted to an increase in the world's population, the planet is in front of a problem of food security and agriculture will have no choice but to increase production to keep pace and therefore increase the use of chemical fertilizers which present negative effects on both the environment and human health. Among the available solutions, the use of rhizobacteria to promote plant growth. They also have an important role in maintaining the soil balance. Among these bacteria there are those that have shown their ability to promote plant growth: Plant Growth Promoting Rhizobacteria (PGPR). Scientists identified some PGPR characters involved in promoting plant growth, while all these characters are not able to study. The aim of this study was to evaluate PGP activities of bacterial isolates, isolated from bean rhizosphere.

Methodology

In our work, we characterized 110 isolated strains. These bacteria were isolated from 5 varieties of faba bean rhizosphere grown in the region of Constantine Algeria. After bacterial isolation and purification from root and soil samples, isolates were screened in vitro for plant growth promoting traits Phenotypic and biochemical characterization showed that most isolates are cream-colored, slightly elevated, flat and opaque, gram-like, catalase+ and oxidase-Bacilli.

Results

The Results obtained have oriented towards different taxonomic groups (*Rhizobium, Pseudomonas, Bacillus* etc.). Evaluation of the PGPR potential of bacteria (phytostimulation, biofertilisation and biocontrol), has shown that 100 percent of bacteria are able to produce auxin with the highest concentration (177.77µg/ml) for isolate 6, that more than 50 percent of isolates are able to produce nitrogen, ammonia and mineralize phytate.

Discussion

The potential plant growth promotion mechanisms of the strains were evaluated in vitro based on the growth on nitrogen-free medium, phosphorus subilization on agar plates, and phytohormone (IAA) production. Bacterial IAA production has an effect on hormonal balance in the plants and thus influences its growth (Govindasamy et al., 2009). Among the plant hormones, auxin production is the most common, additionally the production of auxin instead of phosphorus is primarily responsible for the stimulation of the root development (Kloepper et al., 2004.; Walia et al., 2014).

Conclusion

This study shows that most of the bacterial strains which were isolated from faba bean had PGP activities and these PGPR traits have a direct effect on the growth of plants of five varieties of bean and can be used to select the most effective bacteria for inoculation testing as eco- friendly fertilizers.

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Utilizing basalt quarry wastes in improving soil fertility and the growth of rubber

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Keywords: Silicate, Acidity, Nutrients, Cation Exchange Capacity, pH, Amendment, Amelioration, plant

Introduction, scope and main objectives

Most of the soils in the upland regions of Southeast Asia are highly weathered. The low fertility soils require proper agro-management practices to sustain crop production. After a few cycles of crop cultivation, soils in plantations under mono-cropping system often Results in increased acidity that lower their fertility (Shamshuddin and Noordin, 2011). Agro-geology or the use of rocks for crop production is an interdisciplinary approach that aims to study geological processes and natural rock and mineral materials that contribute to the maintenance of agro-ecosystems (van Straaten, 2006). In Malaysia, basalt is sometimes used for road construction. During the process of preparing the materials for road construction, basalt dust of size < 5 mm is produced. The quarry wastes can be applied on land for crop production. On disintegrating and dissolution, pH will be increased, alleviating soil acidity. Besides, Ca, Mg, K, P and S released by the basalt can be taken up by crops to sustain their growth and/or production. This study was carried out to explore the potential of ground basalt as a soil ameliorant and to determine the effects of its application on the growth of rubber seedlings in a glasshouse.

Methodology

The soil used in the experiment was Lanas Series, yellow and red variants (fine, clayey, kaolinitic, isohyperthermic, Typic Kandiudult). Both of the soils were treated with different rates of basalt dust (< 0.01 mm size): 0, 5, 10, 20 and 30 tonnes/ha. The experimental design was Randomized Complete Block Design (RCBD), with three replications. Rubber seedlings of RRIM 3001 clone at the age of 3 months were planted in pots. The growth parameters such as girth and height were measured every three months for 12 months. Destructive sampling of rubber seedlings was done after 6 and 12 months to determine the biomass production and soil chemical properties. Analysis of Variance on data obtained was performed using Statistical Analysis System. Least Significant Different (LSD) at 0.05 significance level was employed for mean comparisons only if F values were found to be significant.

Results

The Result of the study on Lanas Series (yellow and red variant) showed that basalt applied at 30 t/ha had the highest soil pH among the treatments for both soil types after 6 months (4.75 and 4.76, resp.) and 12 months (4.87 and 5.04, resp.). Soil pH and the CEC increased steadily and significantly with increasing rate of basalt applied over time. In response to pH increase, exchangeable aluminium decreased significantly with the increasing of rate basalt application. It seemed that basalt application gave a positive impact the growth of rubber seedlings in terms of their girth.

Discussion

The Results of the study showed that the dissolution of basalt (especially olivine present in basalt) released Ca, Mg, K, P and S into the soils, which could be taken up by the rubber seedlings required for their growth. The hydrolysis of SiO44- released by basalt produced OH- that increased soil pH. Increase in soil pH to the level above 5 Resulted in precipitation of the toxic Al3+ present in the soil solution. This would enhance the growth of rubber seedlings. On the other hand, the dissolved silicates formed non-toxic complexes with Al3+, which were precipitated in the rhizosphere (Elisa et al., 2016). The presence of extra Ca in the soil may, to a certain extent, reduce Al3+ toxicity that affected rubber growth. Soil pH increase due to basalt application Resulted in higher CEC (Anda et al., 2015), which in turn reduced the loss of cations into the groundwater via leaching under tropical environment. As such, ground basalt can be used as a substitute for lime in alleviating soil acidity or as a source of Ca and Mg. The study found that ground basalt application enhanced rubber growth in terms of its height and girth.

Conclusion

Application of basalt dust improved soil fertility that eventually enhanced the growth of young rubber planted in a glasshouse. The effects of basalt dust application were evident after three months of application and it continued to enhance over time. Hence, basalt can be used as an excellent soil ameliorant or an alternative supplier of Ca and/or Mg.

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Four directions for enhancing plant nutrition management system under arid growing season

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Keywords: integrated plant nutrition system, dry growing season, crop yield, stress-protective preparations, depth localization of mineral fertilizers, optimal ratio of nutrient, high soil phosphorus levels

Introduction, scope and main objectives

The strategy of integrated plant nutrition system (IPNS) is being actively developed and promoted by FAO. IPNS is based on maintaining or enhancing soil productivity through a balanced use of mineral fertilizers combined with organic sources of plant nutrients (Roy et al., 2006.). In our opinion, one of the important practices of this strategy should be the adaptive management of fertilizer application according to the nutritional status of plants during the growing season, soil agrochemical characteristics and hydrothermal regime. Developing appropriate directions of IPNS based on integration these clauses would help in better exploiting the soil's potential by correcting nutrient imbalances in crops without compromising soil health. The aim of this study was: to investigate the efficiency of using four directions of plant nutrition management system to crops yield and plant production indicators under condition of dry growing season on chernozem soil; to develop the elements of the strategy for an integrated plant nutrition management system based on the Results of the research.

Methodology

Field experiments were conducted in different options at the long-term research field experiment (started in 1969) on a chernozem typical soil of the State Enterprise "Experimental Farm "Grakivske" (Ukraine). Soil and plant samples analyses included macro- and mezoelements content, soil moisture, chlorophyll and water fractions content in leaf tissue. Stress drought was typical for each of the growing season. April-May and July-August was very dry - the amount of precipitation was 1.7-2.7 times lower than the average annual data, and the air temperature, on the contrary, was 1.4-2.0 higher.

Results

The following directions were studied to enhance the plant nutrition management system under arid conditions of the growing season: formation of high soil phosphorus levels (research results determined the high importance of residual phosphates accumulated in the soil for increase efficiency of plant using both moisture and nitrogen); combined application of mineral fertilizers and stress-protective preparations (the optimal doses and terms of applying fertilizers and stress protectors (synthesized by us) for cereal crops were determined); regulation of the depth of fertilizers placement (research in this direction proves the expediency of deeper band fertilization, no less 20 cm, under conditions of unstable moisture); proportion optimization of macro- and mezoelements for nutrition plants in soil and fertilizers (studies proved the importance of maintaining the optimal ratio for NPK and S, which was determined for chernozem soil and fertilizer mixtures).

Discussion

The obtained Results confirm that each of the studied directions of IPNS contributed to a significant improvement in the water regime of plants (increased the content of bound water by 10-60 percent), the content of chlorophyll in plants (by 10-40 percent), and the nutritional regime (accumulation of nutrients in plants was higher by 10-17 percent) for obtaining maximum crop yields (increased the yield of grain crops was by 30-50 percent). Since studies on each of the elements were carried out under arid growing conditions, it can be argued that all it contribute to improve drought tolerance of crops, as well as efficient use of nutrients and soil moisture, environmental safety by reducing inefficient losses of fertilizer components.

Conclusion

Each of the four studied elements can be used in farming both separately and integrated into a single plant nutrition management strategy.

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Micro sol - a ready to use liquid micronutrient formulation for banana (*Musa* sp)

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Keywords: Micronutrient banana yield quality sandy soil

Introduction, scope and main objectives

Micronutrients are essential for plant growth and required in small quantities. Deficiency of minor nutrients Results in disrupted plant functioning leading to decreased yield and poor quality of produce. Banana (*Musa* sp) is a tropical fruit grown throughout the state of Kerala, India. The productivity of the crop is low due to the intense leaching environment and prevalence of acidity and presence of low activity clays in the soils of Kerala state. This has resulted in widespread deficiency of boron, particularly in sandy tracts where zinc, zinc, copper, manganese and iron are also limiting crop growth. Foliar nutrition of multi-micronutrients serves as a better method of enhanced plant growth and quality of produce. In this context, an attempt was made to develop a liquid multi-micronutrient formulation containing zinc, boron, iron, manganese, copper and molybdenum and standardized for banana cultivated in sandy soils.

Methodology

A liquid multi-micronutrient formulation containing sulfate salts of zinc, boron, iron, manganese, copper and molybdenum.was developed and standardized for banana cultivated in sandy soils. The composition of the formulation was fixed after trial and error method. The formulation was applied as foliar nutrition at second month after planting, at second and fourth month after planting , at second, fourth and sixth month after planting of banana.

Results

A liquid multi-micronutrient formulation containing sulfate salts of zinc, boron, iron, manganese, copper and molybdenum.was developed and standardized for banana cultivated in sandy soils. The formulation contains 2.1 percent Zn, 1 percent Cu, 0.4 percent Fe, 0.35 percent B, 0.03 percent Mn and Mo and organic chelates. The concentration was standardized at 3 percent. Foliar nutrition with 3 percent formulation at second, fourth and sixth month after planting produced 12.19kg average bunch weight, 54 average number of fingers per bunch, 270g average weight of fingers, The fruit quality parameters such as average total sugars recorded 19.7 percent, average reducing sugars 14 percent and 4 days average shelf life of fruits. Trials conducted on farms and farmers field growing banana showed that there was an increase in 126 percent yield, newly emerging banana leaves were devoid of any symptoms and plants were found healthy.

Discussion

Foliar nutrition with 3 percent formulation containing zinc, boron, copper, iron, manganese, molybdenum at second, fourth and sixth month after planting produced high yield and yield parameters of banana such as high bunch weight, number of fingers per bunch average weight of fingers, The fruit quality parameters such as total sugars, reducing sugars and shelf life. The application of micronutrients as foliar spray would increase the content in leaves and becomes easily available for metabollic activities. Soil application through poor fertile soils, mainly sandy soils would Result in imbalanced nutrition leading to nutrient deficiency in banana (Abdel-Kader et al., 1992). Trials conducted on farms and farmers field growing banana showed that there was an increase in yield, newly emerging banana leaves were devoid of any symptoms and plants were found healthy.

Conclusion

Application of Micro sol at 3 percent at second, fourth and sixth month after planting for banana grown in sandy soil.

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Synergistic interaction of thermochemical organic fertiliser and *Piriformospora indica* in growth promotion parameters of tomato

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Keywords: Thermochemical organic fertiliser, Piriformospora indica, Mass multiplication, Root biomass, Growth attributes

Introduction, scope and main objectives

Indian demographic graph is spiralling up day by day. Food security and healthy nutrition of citizens can be achieved only through enhancement of quality food production. While on the one hand we concentrate on quantum jumps in production, there occurs a piling up of agricultural bio waste on the other side. An effective and efficient management strategy of wastes is the need of the hour. There are different alternative technological options for solid waste management like mulching, fodder, fuel, composting etc. In the analysis of solid wastes of several Indian cities, it is revealed that 60-80 percent consists of degradable organic material. Although this organic material cannot be alternatively used as fuel due its high moisture and low calorific value, the plant nutrient content makes it compatible for recycling as manure for improving crop production. Kerala Agricultural University has developed a patented technique that uses thermochemical degradation to convert garbage into organic fertiliser quickly (Sudarmaidevi et al., 2017). This transformation of solid waste into a highly adoptable organic fertilizer brings not only an effective waste management practice but it also provides a potent source of nutrients and soil organic carbon. Such organic fertilizer obtained through thermochemical processing is known as Thermochemical Organic Fertilizer (TOF). Research on TOF indicates its suitability for application in vegetables (open field as well as container cultivation). Wide species of microbes can easily proliferate in organic manures. Beneficial microorganisms are being studied in sustainable agricultural and horticultural ecosystems in order to improve crop yield, nutrient assimilation, and plant tolerance to diverse (a) biotic stress conditions (Oelmuller et al., 2009.; Varma et al., 2012). Piriformospora indica is an endophytic beneficial root fungus that colonises the roots of a variety of plant species, establishing a symbiotic connection and promoting overall plant growth. P. indica is known to mobilize micronutrients from soil and makes them available to plants through its colonisation (Achatz et al., 2010). Nutrient potential of TOF and the colonization potential of P. indica as separate entities is well known. Main objective of my research is to explore the possibility of TOF for the mass multiplication of P. indica and to evaluate its potential for the release, acquisition, translocation and utilization processes in conjunction with the microbiological aspects involving P. indica in tomato.

Methodology

A tomato nursery was raised with six different treatments in protrays. Protrays were filled as follows T1: Soil alone T2: Soil+ coirpith T3: Soil+ TOF T4: Soil+ coirpith+P.indica T5: Soil+TOF+ P.indica T6: Soil+coirpith+TOF+P.indica Different growth attributes like days for germination, plant height, leaf number, shoot fresh weight,shoot dry weight,root fresh weight and root dry weight were evaluated among these six treatments. The means were compared using the

Completely Randomised Diference (LSD) at a 5 percent level of significance using Duncan's Multiple Range Test (DMRT).

Results

The treatment 5 (T5) soil + TOF + P. indica found best in all growth parameters of tomato. The treatments (T5) were on par with the treatment soil + coirpith + TOF+ P. indica (T6)in case of root fresh weight and root dry weight. Greator proliferation of P.indica found in TOF medium than in coirpith medium

Discussion

Beneficial fungal root endophyte named *Piriformospora indica* (syn. *Serendipita indica*) which colonizes both monocots and dicots. *P. indica* - root colonization leads to a better plant performance in all respect, including enhanced root proliferation and production which further leads to better nutrient-acquisition and subsequently to improved crop growth and productivity. The *P.indica* can be grown in variety of synthetic and complex media. But these readymade media consists of about 20-25 expensive chemicals. To minimize the cost for *P.indica* production and to enhance its nutrient potential the cost effective TOF is used as a medium for the mass multiplication of *P.indica.*

Conclusion

Application of TOF inoculated with *P.indica* stimulates the growth factors of tomato which enables tomato crop for easier and faster nutrient uptake. Potential of thermochemical organic fertilizer (TOF) produced from the degradable solid waste through as a prospective substrate for the colonization of root endophytic fungi *Piriformospora indica* is made clear. Synergistic effect on root phenology and phenomic characters owing to the mutualism of the inoculated organic substrate is well understood. This study can further be extended to know the efficacy in acquisition, adsorption and plant uptake of soil nutrients N and P Resultant to the enhanced solubilisation, mobilization and transport efficiencies

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Minimum soil disturbance and increased crop residue retention improve N, P, K, and s budgets in rice-based cropping systems

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Keywords: Conservation Agriculture, Leaching, Nutrient balance, Nutrient uptake, Strip planting

Introduction, scope and main objectives

An investigation was undertaken to synthesize a number of nutrient budget studies to determine the likely impacts of Conservation Agriculture (CA) on recommended N, P, K and S rates for a range of rice-based cropping patterns in Bangladesh

Methodology

We have examined the effects of two crop establishment methods - conventional planting (CP) and strip planting (SP), two crop residue levels –15 percent residue by height (low residue, LR) and 40 percent residue (high residue, HR) and three rates of nutrient supply – 50 percent or 75 percent (low dose, LD), 100 percent (recommended dose, RD) and 125 or 150 percent (high dose, HD). Field experiments with T. aman rice (3rd crop) based diverse 3-cropping systems were conducted in four locations of the country with varied soil and climatic conditions. The major nutrient inputs were fertilizer and residue retention and the major nutrient outputs were crop uptake (seed, grain or tuber and the rest biomass). The other measured inputs for P, K, and S were irrigation water and rain water and measured output was leaching loss. In addition, for calculation of N inputs the biological nitrogen fixation (BNF) and that of N outputs the gaseous loss of N (volatilization and dentrification) and leaching were also considered. An addition of 20 kg N ha^{-1} for BNF contribution ((Roger and Ladha, 1992) and a 60 percent N loss through leaching, denitrification and volatilization) (Saleque et al., 2004) for each rice crop was assumed for N budget calculation.

Results

The N balance was found negative showing a range of -91 to -120 kg ha^{-1} yr^{-1}; SP and HR gave relatively lower negative N balance. The P balance was positive except where P was added at 50 percent recommended rate which showed a negative P balance (-3.64 to -14.0 kg ha^{-1} yr^{-1}). The contribution of irrigation water and rain water to P supply was minimum (0.75-2.2 and 2.7 - 3.2 kg ha^{-1} yr^{-1}); leaching loss of P was also only 0.50-0.73 kg ha^{-1} yr^{-1}. The K balance was negative with a range of −64.6 to –80. kg ha^{-1} yr^{-1} for crop establishment methods, -59.3 to -85.6 kg ha^{-1} yr^{-1} for residue levels and -33.4 to -109.2 kg ha^{-1} yr^{-1} for K doses. Irrigation water contributed 8.2-12.6 kg K and rain water 10.6- 10.9 kg ha^{-1} yr^{-1}; the leaching loss of K was 28.0–33.7 kg ha^{-1} yr^{-1}. The values of K balance are less negative for high dose of K application and for increased level of residue retention. The K uptake by rice varied a little between seasons (Aus and Aman rice), between sites and between years. The K balance is negative so the difference between SP and CT or HR and LR in K forms in the long term is partly due to depletion of soil K. The S balance across the factors was positive giving a range of 0.71-8.17 kg ha^{-1} yr^{-1}. Irrigation and rains together contributed 24 percent of total S input and the S leaching accounted for 28 percent of S output. Strip planting, increased residue retention and high dose of nutrient addition had significant positive effect on nutrient budget.

Discussion

There were apparent negative budgets for N and K, and positive balances for P and S in soils across the factors (planting method, crop residue retention and N treatments). Adoption of strip tillage practice accompanied with increased residue retention might increase nutrient use efficiency of crops, decrease nutrient depletion and sustain soil nutrient levels in rice based cropping systems.

Conclusion

Long-term monitoring of nutrient uptake and balance is required to understand nutrient use efficiency and to arrest nutrient depletion in soil. Fertilizer recommendation should consider how to minimize negative balance of nutrients for sustenance of soil fertility with profitable crop productivity.

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Khethi Sudhaar (improving soil health) & NBF (nutritionally balanced farming) practices in India

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Keywords: Soil Health, Nutritionally Balanced Farming, NBF, Khethi Sudhar, Farmer education, Global Soil Doctor Program, IIBA India, Dr. M.S.R Raju

Introduction, scope and main objectives

In India indiscriminate application of NPK fertilizers impacted physical, chemical, and biological factors imbalanced nutrients impacted the soil health conditions. Reasons are many to name a few like Lack of awareness, educations, standard tools, and infrastructure for nutritionally balanced farming practices. Scope: Khethi Sudhar & NBF Programme innovates new age farming Skills which promotes Affordable and Safe agricultural practices to improve the soil health and balance the nutrition thereby enhance the opportunity towards ease of doing profitable agricultural practices. This programme creates awareness through education, follows UN FAO's best practices to diagnose the health of soil and plants. We provide technical training through Soil Doctor Program and commercial support through digital platforms.   Main Objectives: Under this programme Indian Farmers leverage organic resources effectively and chemical resources efficiently to provide stable and high returns. We educate farmers through Khethi Sudhar Programme is blend of traditional Vedic science principles and new age technologies to improve the soil health which includes required Organic Carbon, Oxygen, pH levels, EC, CEC and other secondary/ micro-nutrients.

Methodology

NBF Program educate, diagnose, and treat the plants by managing 16 holistic health constituents in the right proposition which promotes crop growth and treats insects, fungal, bacterial, and viral deceases. Khethi Sudhar& NBF pilot Program designed Kits on farmer & channel education, diagnosis with the support of UN FAO's Soil Doctor Programme. Further technical advise is available through qualified professionals. Demographic & Crop specific products are recommended considering unique PLL (Plant LifeLine) approach.   Our research brings profitable farming practices which include minimize excess fertilizers, neutralize the soil health damage, and maximize the yield (By quality and quantity) through Khethi Sudhar. NBF Practices.

Results

Human health is directly connected with plant nutrients, NBF Programme impact human health by bringing best agricultural practices where proportionately 16 nutrients are balanced which impacts qualitative and nutritious food to Indian people.   NBF practices innovates a product called PHYTOKIT which is technically feasible due to its crop centric balanced nutritional approach and financially affordable for the farmers due its proportionate nutrients.

Discussion

Next steps towards sustaining Khethi Sudhar & NBF programme will be continuous improvement of microbial ecosystem. Introducing suitable cultures which is important for soil mineralization and atmospheric nitrogen fixation which is our top priority.

Conclusion

Ultimately Khethi Sudhar & NBF programme lead the farmers, channels towards better soil and plant health. We understand plants are so vulnerable and our guidance help farmers and plants alive through balanced nutritional practices

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Nutrient management and crop establishment methods in paddy to improve productivity and income from salt-affected coastal soils: from a fallow land to a bountiful harvest

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Keywords: coastal soil salinity; paddy; plant growth promoting rhizobacteria; site-specific nutrient management; soils for nutrition

Introduction, scope and main objectives

Soil salinity due to the saline water ingression and intrusion poses a severe constraint to crop production in the coastal region of India leading to fallowing and abandonment of agriculture by the farmers. A two-year study was carried out on a 10-year fallow land with an aim to develop a strategy of nutrient management and crop establishment methods for the the salt-tolerant rice varieties to improve the yield and income from these marginally productive soils.

Methodology

The experiment was laid out in the split-split-plot design. The nutrient management strategy was assigned as the main plot (Soil test based fertilizer recommendations, modfied blanket recommendations, recommended dose of fertilizers, control), crop establishment method (broadcasting and transplanting) as the sub-plot and variety (Goa Dhan 1, Goa Dhan 2 and Goa Dhan 3) as the sub-sub-plot.

Results

The effect of nutrient management strategy, crop establishment methods and variety were significant on the grain yield, straw yield, net income and benefit to cost ratio. A nutrient management strategy of soil test-based fertilizer recommendation or modified blanket recommendation (120-30-00 kg $N:P_2O_5:K_2O$ ha^{-1}) recorded a significantly higher grain yield, straw yield, net income and benefit to cost ratio compared to the control (without nutrient management) and farmers' fertilizer practice. The lowest values were observed in the control. Significantly higher grain (2.92 t ha^{-1}), straw yield (4.62 t ha^{-1}), net income (Rs. 35276/ha) and benefit to cost ratio (2.09) was achieved with the transplanting 35-days old Goa Bio-1, a talc-based bioformulation of Bacillus methyllotrophicus STC-4, nursery treated seedling than the broadcasting (2.41 t/ha, 3.08 t/ha, Rs. 28313/ha and 1.92). The variety, Goa Dhan 3, outperformed Goa Dhan 1 and Goa Dhan 2 with the highest grain yield (3.61 t/ha), net income (Rs. 49334/ha) and benefit to cost ratio (2.50). Though the grain yield of Goa Dhan 1 and Goa Dhan 2 was at par, the performance with respect to the net income and benefit to cost ratio of the order was observed as Goa Dhan 3 > Goa Dhan 2 > Goa Dhan 1.

Discussion

Thus, a package of the practice of transplanting of 35-days old Goa Bio 1 nursery treated seedlings of an improved salt-tolerant rice variety with improved nutrient management is the potential to increase the paddy productivity and income under salt-affected coastal soils. A systematic transfer of technology through a consecutive two-year demonstration on a 29 ha land with 35 farmers revealed a 38 percent increase in the net annual income over the farmers' practice. The package identified in the study has the potential to generate an additional net income of about Rs. 22 crores by covering 18 000 hectares of salt-affected coastal soils in the state of Goa alone (Mahajan and Ramesh, 2022).

Conclusion

Feeding the fallow land with appropriate nutrient management coupled with suitable crop establishment methods yielded a bountiful harvest of paddy and improved the income of the farmers providing scope for improved livelihood security.

Acknowledgements

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The potential of cereal- legume intercropping in lowering the carbon footprints of agriculture

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Keywords: soil respiration, carbon mineralization rate, cereal- legume intercropping, carbon footprints

Introduction, scope and main objectives

Cereal legume intercropping increases aboveground and root biomass per unit land enhancing C in the soil over time due to greater litter input into the soil. Soil carbon sequestration is the positive difference between C inputs to the soil and the emission of C to the atmosphere in the form of CO_2 (or methane) from the decomposition of accumulated organic matter by heterotrophic soil organisms. There are two ways to enhance C sequestration: by increasing the rate of input to soils of crop-derived residues and/or by reducing the rates of turnover of organic C stocks, that are already stored in the soil. The latter can be measured by the rate of carbon mineralisation and the respiration rate of micro-organisms in the soil. Soil respiration (SR) was defined as the exchange process of carbon dioxide (CO_2) between the soil and the atmosphere and it is a traditional used parameter for quantifying microbial activity in soil. It was hypothesized that long term cereal- legume intercrops of barley (*Hordeum hexastichon* L) with field bean (*Vicia faba* minor Beck) could affect the microbial soil activity and the C-mineralization potential (Cmin)– turnover of organic C stocks – of soil and the effect could be intensified by the presence of nitrogen and phosphorous.

Methodology

At the "Rottaia" experimental field in Pisa, Italy, during the 2018/19 and 2019-20 seasons, 2nd and 3rd cropping years respectively, changes in soil respiration rate and cumulated C were measured at the end of cropping cycle after harvest in plots cropped by: 1- intercropping of barley with field bean (1:1 IC), 2- sole cropping of barley (C50), and 3- sole cropping of field bean (Fb100) at two nitrogen and phosphorous supply: 0 and NP. The 1:1 IC was arranged by alternating one row of C with one row of Fb. Both IC and sole crops (SC) were sown at 100 seeds m-2. Sole crops were rotated and IC, conversely, were sown, on a bare soil. The IC sown on new bare soil was named as New (New 1:1 IC), while the IC cultivated after themselves as Old (Old 1:1 IC): two and three years old.

The method used to determine soil respiration was the same for the two sets of soil samples collected in 2019 and 2020 (Isermeyer, 1952). The principle of this method is estimating the CO_2 evolved during the incubation of soil in a closed system (500 ml glass jars). The CO_2 is trapped in a NaOH solution, which is then titrated with HCl. The air-dried soil samples were rehydrated and kept at 60 percent of water holding capacity by supplying deionized water every detection time and incubated at 25 ºC in order to create the optimum environmental conditions for biological activity. All data were subjected to ANOVA separately in the two cropping years, to test differences in soil respiration and C mineralization, in response to the treatments crop systems: New 1:1 IC, Old 1:1 IC, C50 and Fb100; NP levels (0 and NP); time of incubations (20 days), and their interactions (SAS, version JMP 2014). Cumulated Cmin was tested in response to the treatments crop system, NP level, and their interactions. All the data were subjected to tests for normality and homoscedasticity before ANOVA analyses. Differences between the means of each variable were determined by post hoc Tukey's HSD test at the 0.05 probability level.

Results

In this research, the supply of NP levels did not affect soil respiration and C mineralization in any of the crop systems for all crop cycles. The soil samples of the cropping systems differed significantly in SR and Cmin, but only at the first 48 hs of incubation.
The SR of C50 was the highest and was 21.5 percent higher than Fb100. The SR of New 1:1 IC was by 20.2 percent higher than that of Old 1:1 IC. The same ranking, C50 > New 1:1 IC ≥ Fb100 ≥ Old 1:1 IC was observed for the Cmin.
SR declined sharply after 48 hs of incubation and remained nearly constant, from day 5 to day 20. This indicates the rapid depletion of immediately available C and highlight that conditions of basal respiration were attained from five days of incubation on. The amount of Cmin increased progressively with incubation time in all cropping systems. The slope of Cmin was 18.2 percent higher in the C50 soil than the Fb100, New 1:1 IC and Old 1:1 IC.

The amount of Cmin of C50 over the entire period of incubation was 18.4 percent higher than Fb100, and 12.6 and 24.7 percent higher than New 1:1 IC and Old 1:1 IC, respectively. This may be due to IC decreases the soil C/N ratio compared to SC, regardless of their composition and the presence of legumes that increase the atmospheric N.

Discussion

The absence of response to N in our study could be explained by the fact that soil samples were collected after harvest, when the soil respiration decreases (Fu, Cheng and Susfalk, 2002). At this time, moreover, it is to presume that the N distributed pre-seeding and at pseudo-stem-elongation has been taken up by crops and thus is no more available to microbial populations, while the decomposition of residues has not yet started. However, the combination of cereals + legumes and the incorporation of atmospheric N by the latter could influence Cmin suppression.

The lower soil respiration and Cmin registered in the intercrops demonstrated the ability of them to reduce the emission of C to the atmosphere in the form of CO_2 (Chai et al., 2014) and reduce carbon footprint (Chapagain and Riseman, 2014; Gan et al., 2011). In the soils collected after harvest in the second crop cycle, the equations clearly show that the IC soils contain a smaller fraction of easily mineralizable C compared to the SC soils.

Decomposition of soil organic matter, which is one of the principal drivers of releasing CO_2 from the soil, increases when C/N ratio decreases (Booth, Stark and Rastetter, 2005) and soil temperature and water content increase (Rey et al., 2002). Since grass residues have a high C/N ratio, it was expected that field bean soil would register a higher CO_2 release than the cereal soil. In our research, indeed, the C release was higher in the cereal soil in 2019 and did not differ significantly between crops in 2020, though values were slightly higher in Fb100.

Conclusion

This preliminary results highlight that intercrops may have the capacity of reduce CO_2 emissions of soil and, and potencially enhance C sequestration. This aspect is worth further investigation to elucidate the potential of intercropping in lowering the carbon footprints of agriculture. However, soil carbon sequestration is highly dynamic and strongly influenced by environmental, soil type and crop management factors, so trying to avoid or reduce CO_2 emissions with different agroecological practices (such as intercropping, cover crops, reduced or no-tillage) could be much more effective in limiting global warming than relocating atmospheric CO_2 into the soil.

Clearly, when dealing with such an all-encompassing issue as the path to climate change mitigation, hundreds of agroecological practices must be combined together in a holistic approach, as the mere consideration of one of them, such as reducing CO_2 emissions, is only a small contribution, a small grain of sand in a desert.

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New protocol for phosphorus estimation in organically managed acidic soils, Meghalaya, India

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Keywords: Phosphorus, pools, extractants, acidic soil, organic farming system, soil testing protocol

Introduction, scope and main objectives

Organic farming systems possess somewhat different nature of nutrient pools as compared to the conventional farming systems. Besides the solution phosphorus (P) pool, the organic as well as insoluble inorganic P pools are quite significant as far as the phosphorus nutrition of the plants is concerned. The dynamic fraction of P, which is considered in conventional soil testing, cannot explain the correct status of phosphorus in soils under organic production systems as the conventional soil testing protocols do not take into account the potentially available P pools. Proper interpretation of these pools is very important to suggest a balanced manuring plan for a sustainable and successful organic production system. Hence, a different extractant which can extract such potentially available P pools in an acidic soil under organic production system is highly required. The extraction, mineralization and solubilization of the potentially available P pool by various organic acids produced by the beneficial soil microorganisms can serve this purpose. Therefore, the present investigation was carried out to identify the best suitable P extractant(s) to extract such potentially available P pools.

Methodology

Under this investigation, 40 random soil samples from two soil orders (Alfisols and Inceptisols) were collected from each of the five selected sites viz. two conventional farms: CPGS-AS farm, Umiam; a farm of Palwi village, and three organic farms: ICAR organic farm, Umiam; a farm of Krydem village, and a virgin forest farm of CPGS-AS, Krydemkulai. The soils were acidic with low available P content. Further, five organic acid extractants viz., 2 percent citric acid extractant; double lactate extractant (0.02 M Ca-lactate + 0.05 M lactic acid at pH 4.1); 2, keto-glutaric acid extractant (0.05 M 2 keto-glutaric acid + 0.02 M HCl at pH 4.0); acetic acid extractant (0.54 N acetic acid + 0.7 N sodium acetate at pH 4.8) and lactic acid extractant (0.02 M Ca-lactate + 0.02 M HCl at pH 3.7) were employed to obtain different sizes of potentially available P pools which were compared with the conventional Bray 1 extractant (check). Multiple linear regression models were obtained for each of the extractants taking total P as the dependent variable, organic carbon and the extractants as independent variables.

Results

The amount of P_2O_5 solubilized by five different organic acid extractants showed 2, keto-glutaric acid as the highest contributing P pool in acidic soils under organic production system. The outcome revealed that this pool demonstrated a gradual increase in the sizes of soluble P_2O_5 from 60.413 kg/ha to 63.344 kg/ha up to 68.120 kg/ha in the organically managed soils of the ICAR farm, Umiam, Krydem village, Bhoirymbong block and the farm of CPGS-AS, Krydemkulai, respectively. Significantly lower values of 29.631 kg/ha and 25.257 kg/ha were recorded in the conventional soils in the farm of CPGS-AS, Umiam and the farm of Palwi village of Bhoirymbong block, respectively. The data obtained were subjected to multiple linear regression analysis considering all the possible combinations of extractants with total P as dependent variable revealed that both citric acid extractant and double lactate extractant were able to strongly define the variation of total P content in organic soils with the highest R2 value of 0.93 i.e., 93 percent of the variability in total P could be explained by running this model. This is followed by the combination of citric acid and acetic acid extractants as well as the citric acid and lactic acid extractants which were statistically at par with R2 values of 0.81 for both the models. The combinations of citric acid and 2, keto-glutaric acid extractants, acetic acid and lactic acid extractants, acetic acid and double lactate extractants, acetic acid and 2, keto-glutaric acid extractants, lactic acid and double lactate extractants, lactic acid and 2, keto-glutaric acid extractants and double lactate and 2, keto-glutaric acid extractants Resulted in the R2 values of 0.78, 0.59, 0.64, 0.69, 0.69, 0.60 and 0.63, respectively. The detailed relationships of the variation of total P with the independent variables as described by the ten equations. Hence, the citric acid and double lactate extractants could be claimed as suitable extractants to explore the potentially available phosphorus in acidic soils under organic production system.

Discussion

The amount of P_2O_5 solubilized by five organic acid extractants was found to be in the order in organically managed soils: 2, ketoglutaric acid soluble P_2O_5 > double lactate soluble P_2O_5 > citric acid soluble P_2O_5 > lactic acid soluble P_2O_5 > acetic acid soluble P_2O_5 (kg/ha). The reason behind the large size of 2, keto-glutaric acid extractant soluble P_2O_5 might be because 2, keto-glutaric acid has a keto functional group along with two carboxyl group in its structure which Resulted in its tremendous chelating property. The findings of Dey et al., 2019. supports the findings of present investigation with respect to 2, keto-glutaric acid extracted P_2O_5. Whereas, the overall contribution of acetic acid extractant soluble P_2O_5 towards P nutrition was relatively smaller as compared to the contributable sizes solubilized by the other extractants. This might be because acetic acid is a monobasic acid with one carboxyl functional group which triggered lesser extent of chelation of the predominant iron and aluminium ions. Similar Results were obtained by Korndorfer et al., (1995) while using water, Mehlich 1, and 0.5 M acetic acid as P extractants. The good size elaborated by citric acid extractant might be because citric acid extractant has a superior chemical property as it is an alpha-hydroxy derivative of tribasic acid with three carboxyl and one hydroxyl functional groups. The higher contribution of lactic acid extractant pool in organic soils towards P nutrition as compared to the acetic acid extractant might be because lactic acid extractant, being an alpha-hydroxy derivative of monobasic acid, has a carboxyl and a hydroxyl functional group which facilitated greater chelation property than that of the acetic acid extractant and the Results of extraction by lactic acid extractant yielded more than 130 percent of soluble P_2O_5 as extracted by acetic acid extractant. Further, the higher sizes of double lactate soluble P pool evident in organic soils compared to the conventional soils might be because the lactic acid and its calcium salt result in a highly buffered extractant which could work maximally thereby facilitating maximum chelation.

Conclusion

Result revealed that in comparison to the conventional Bray 1 extractant, 2 percent citric acid and double lactate extractants, among 6 different tested extractants were found to strongly define the variation of total P in organic soils. Hence, 2 percent citric acid and double lactate extractants may be proclaimed as the promising extractants which can best estimate the potentially available phosphorus pools in organic farms of Meghalaya and the soil must be tested with these extractants to march towards a successful organic cultivation.

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Effects of poultry droppings and NPK on the growth and yield of carrot- *Daucus carota* L.

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Keywords: Poultry droppings, NPK, growth, yield, Carrot

Introduction, scope and main objectives

Carrot (*Daucus carota* L.) is an important vegetable which is ranked third among the succulent vegetables in world production (Yamaguchi, 1983). The edible roots are nutritious and contain water, protein, ash, vitamins and mineral (Norman, 1992). Carotene which is extracted from the roots is used in colouring margarine and for improving the colour of egg yolk when added to layer feed. The leaves and mature roots are used in the preparation of animal feed (Kahangi, 2004). Carrot which belongs to the family Apiaceae is a biennial and is usually cultivated as an annual crop in the tropics (De Lannoy, 2001). The crop is tolerant to soil pH of 5.5 to 6.5 and it requires a deep and well-drained loamy soil with high amount of organic matter (Yayock et al., 1988).

Carrot production can be a beneficial enterprise for small-scale farmers because it is a short duration crop and higher yields can be obtained per unit area (Ahmad et al., 2005). However, Sarkindiya and Yakubu (2006) reported low average yields in Nigeria. In most developing countries, carrot yield per unit area remains below the world average (FAO 1999). One reason for low yield is low soil fertility and low technological know-how in production methods. In order to obtain high and sustainable carrot yields, good soil fertility and constant growth are required to facilitate production and translocation of carbohydrates from leaves to roots. The key limiting factors in crop growth, development, and yield are nitrogen, phosphorous, potassium, and water. In most cases, carrot growers use chemical fertilizers as the major supply of nutrients to attain higher growth and yield (Hochmuth et al., 1999; Amjad et al., 2005). Continuous application of synthetic fertilizer may lead to soil acidity, human health problems, and soil degradation because they release nutrients at a faster rate. Increasing costs of synthetic fertilizers have made them generally unaffordable to most small-scale farmers.

Fordham and Biggs (1985) recommended the application of 70-120 kg/ha N, 30- 35 kg/ha P and 0-55 kg/ha K for high yield of carrots. Application of 300 - 450 kg/ha NPK (15:15:15) before planting has been recommended for improved growth and yield of the crop (Norman, 1992). Kahangi (2004) has recommended the application of 10-20 t/ha poultry manure for improved growth and yield of carrot in the tropics. However, there is not much work on this study in Nigeria. The present research was therefore, undertaken to determine the effects of inorganic fertilizers and organic poultry droppings on the growth and yield of carrot.

Methodology

The experiment was carried out at the Faculty of Agriculture demonstration farm, University of Port Harcourt. Soil samples of the experimental plot were collected and analyzed. The seeds were sourced from Songhai farm Sapele Delta State. The carrot seed is a Thema variety and the fertilizers (NPK 15:15:15 and poultry droppings) used were provided by the Faculty of Agriculture demonstration farm, University of Port Harcourt.

The experiment was laid out in a completely randomized design of four treatments with three replications. The four treatments used in this experiment are as listed below: Treatment 1: poultry droppings (organic fertilizers), Treatment 2: NPK 15:15:15 (inorganic fertilizers), Treatment 3: combined effect of organic and inorganic fertilizers (poultry droppings and NPK), Treatment 4: no fertilizer (control). Carrot seed were soaked in water for 24hrs and wrapped with a cloth for 5 hrs (Shahid et al., 2011). Beds were made and seed were sown at a spacing of 25cm x 25cm at a depth of 1.5cm. 35days after sowing, the treatments were applied; poultry dropping, NPK and combined effect of poultry droppings and NPK were applied on the plot using mechanical ring method. Two thinning operations were done at 25 and 35 days after sowing of seed to maintain the spacing. The experimental plot was kept free from infestation by weed. Intercultural and irrigation operations were carried out when required. The carrots were harvested 90 days after sowing. The crop was disease free and no fungicide were used. The following parameters were analyzed: number of leaves, plant height, diameter of root, length of root, fresh weight of roots, dry weight of roots, fresh weight of leaves, dry weight of leaves, gross yield, and marketable yield. The leaves of the plant of the various treatments were counted visually. The number obtained was then recorded appropriately against each sample. The plant height was measured with a metre tape in centimetres from the soil surface to the plant apex. The diameter of the root was measured at the thickest portion of the root at harvest. This was done using slide clippers. Marketable yield of the root was computed from conversion of the total marketable roots per plant and was recorded in hectares. Data collected for each parameter were subjected to analysis of variance (ANOVA) using Microsoft Excel 2010 version. Means were compared using the least significant Difference (LSD) (Steel and Torrie,1960).

Results

The experiment was conducted to study the effects of poultry droppings and NPK 15:15:15 on the growth and yield of carrot. The results of the effects of Poultry dropping and NPK 15:15:15 on the number of leaves. From the result, after application of treatments, there was significant P=0.05 difference in number of leaves. At week 12, the highest number of leaves was recorded in the combination of NPK 15:15:15 and Poultry droppings (11.97), followed by NPK 15:15:15(11.63) and poultry dropping (11.27). The Plant height varied significantly P=0.05 with the application of the poultry droppings, NPK 15:15:15 and their combination (poultry droppings and NPK15:15:15). At 12 weeks the highest plant height (61.67cm) was found with NPK15:15:15 and poultry droppings treatment, followed by poultry dropping (59.50 cm), NPK 15:15:15 (56. 33cm) and the shortest height were found in control (53.33cm). The maximum leaf weight per plant was recorded in the combination of poultry droppings and NPK15:15:15 (138.44g) followed by NPK15:15:15 (107.15g) and poultry droppings (92.43g) and the control were recorded to have the minimum weight (84.91g). The fresh weight of root per plant was significantly P=0.05 different with respect to the treatments. The highest fresh weight of root per plant was found in the combination of poultry droppings and NPK15:15:15 (64.55g) followed by NPK15:15:15 (53.54g) and poultry droppings (46.04g) while the lowest weight (38.09g) was found with control. The maximum dry weight of leaves was found in control (17.94 percent) followed by poultry droppings (16.94 percent) and NPK15:15:15 (16.29 percent) while the combination of NPK 15:15:15 and poultry droppings (15.15 percent) was the minimum dry weight.

The maximum dry weight was found in the combination of poultry droppings and NPK15:15:15 (16.65 percent), followed by NPK15:15:15 (14.98 percent) and poultry droppings (13.86 percent) while the control (11.71 percent) had the minimum percentage of dry weight. The cracked root production was significantly P=0.05 influenced by the application poultry droppings and the NPK15:15:15. The maximum number of cracked roots (0.08) was obtained from the treatments of poultry droppings followed by NPK15:15:15 (0.07) and the combination of NPK151515 and poultry droppings (0.04) while the control had the lowest (0.03) number of cracked roots.The branched root production was significantly P=0.05 influenced by the application of poultry droppings and the NPK15:15:15. The maximum number of cracked roots (0.12) was obtained from the control followed by treatments of poultry droppings (0.07) and NPK15:15:15 the combination of NPK151515 and poultry droppings (0.04) while the combination of NPK151515 and poultry droppings had the lowest (0.03) number of branched roots.

Discussion

The results from the experiment showed that the parameters studied varied significantly at $P<0.05$ by the application of poultry droppings and NPK15:15:15. The cumulative increase in root length, root diameter and individual root weight resulted in the maximum gross yield of roots per hectare.

The application of the combination of poultry droppings and NPK15:15:15 attained the highest values except for dry weight of leaves and branched root. The control gave the lowest values in all parameters studied except for branched roots and dry weight of leaves.

The effect of increased number of leaves was as a result of the quick release of nutrients from the combination of NPK15:15:15 and poultry droppings that enhanced the soil conditions, which might have increased the number of leaves. Generally, the control showed lowest number of leaves.

The combination of poultry droppings and NPK15:15:15 were found to have the maximum weight, this is due to the adequate supply of nutrient leading to higher vegetative growth of the plant.

The fresh weight of root per plant was significantly P=0.05 different with respect to the treatments. This may be due to the fact that the combination of the fertilizers supports the soil physical condition for better development. The result on the fresh weight of root is in agreement with Mehedi et al, (2012). They reported that the maximum fresh weight of root was achieved in combination of the organic and inorganic fertilizer used. The provision and supply of adequate nutrient for better growth by the combination of the poultry droppings and NPK15:15:15 enhanced the production of maximum amount of dry weight of the root.

Conclusion

Organic manures helps to improve the soil fertility and productivity, inorganic fertilizers also supply adequate nutrients in known proportion but on the other hand creates problem to the environment when use indiscriminately. From the results of the present study, it can be concluded that the combination of poultry dropping and NPK15:15:15 is suggested for maximum carrot production.

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Role of integrated nutrient management for improving crop yield and enhancing soil fertility under smallholder farmers in degraded soils of Tanzania

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Keywords: Food security, Nutrition, Soil fertility, Integrated Nutrient Management, degraded soils, bio-fertilizers

Introduction, scope and main objectives

Low soil fertility, high nutrient mining and inadequate replenishment of nutrients are among the main factors limiting sustainable agricultural production in most soils of Tanzania (Adu-Gyamfi et al., 2007, Kiriba et al., 2019). Soil fertility management technologies considered to address low soil fertility for sustainable agricultural production and productivity in Tanzania include use of mineral fertilizers alone and or integrated use of inorganic fertilizers and organic soil amendments (e.g. animal manures) or bio-fertilizers (Kwesiga and Coe, 1994). Use of bio-fertilizers such as Azospirillum spp and Bacillus spp, either alone or in combination with inorganic fertilizers have been shown to increase yields in maize, sorghum, and wheat (Ahmed, 2010).

Methodology

A field study was set at SUA farm to evaluate the effects of graded doses of NPK fertilizer, with and without inoculation of phosphorus solubilizing bacteria (P-solubilizers) on improving yields of SITUKA maize variety and soil fertility. The experiment arranged in a randomized complete block design (RCBD) with three replications. Six treatments, namely: i. control (without fertilizers), ii. Inoculation of P-solubilizers alone at manufacturer's recommended rate, iii. Inoculation of P-solubilizers alone at double rate, iv. Inoculation of P-solubilizers + 10 kg P ha^{-1} fertilizer, v.10 kg P ha^{-1} fertilizer and vi. 20 kg P ha^{-1} fertilizer were used.

Results

The study findings revealed that, application of P-solubilizers treatments, either alone or in combination with P-fertilizer (10 kg P ha^{-1}), showed significant ($P \leq 0.05$) differences amongst themselves and with the control, with P-solubilizers (5ml/0.5 kg maize seed) Resulting in significantly ($P \leq 0.05$) higher grain yields. Similarly, at harvest, the concentrations of P, N and Zn in soil showed significant ($P \leq 0.05$) differences across some treatments.

Discussion

Results of increase in maize grain yields are agreement with the findings recorded by Rokhzadi et al., 2008 and Bano and Afzal, 2008, who indicated significant increase in grain yield of chickpea, soybean and wheat, respectively, following inoculation with P-solubilizers. Similar trends have been recorded by Patil et al., 2012 and Mousavi et al., 2011., also working on maize with P-solubilizers and P fertilizer. The increase in grain yields with the application of P2O5 + P-solubilizer might be attributed to the fact that P-solubilizers increased the amount of available P in soil. Similarly, at harvest, the concentrations of P, N and Zn in soil showed significant ($P \leq 0.05$) differences across some treatments. The current study findings showed insignificant increase of available P in soil at harvest due to P-solubilizers (Bio-soil crop booster) inoculation as opposed by

Qureshi et al., 2012, and Dorahy et al., 2008., who observed significant ($P \leq 0.05$) increase of the available P in soil at different growth stages of cotton when phosphate solubilizer microorganisms were used.

Conclusion

Our study found positive Results when P-solubilizers were applied alone or in combination with P-fertilizer increased the concentrations of P, N and Zn in soil at harvest and the final maize grain yields. It is therefore, recommended that Tanzania fertilizer regulatory authority should require manufactures to improve the quality standards of bio-fertilizers before the commercial products are accepted in the country and they should further be tested in other P-deficient soils.

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Soil nutrient management for healthy dry edible beans

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Keywords: Dry Bean, Fertilizer N, Digestible protein, Bioavailable protein, Function protein

Introduction, scope and main objectives

Dry edible beans (*Phaseolus vulgaris*) are an excellent source of dietary proteins. Nebraska farmers plant dry beans on 50 000 to 80 000 hectares annually, with the production being concentrated in western Nebraska. As the demand for plant-based protein continues to grow, it brings with it a large market for bean proteins that can be optimized with nitrogen (N) management. In addition, plant-based protein is more climate-friendly than meat protein. The objective of the study is to evaluate the effects of different fertilizer N treatments on bean yield and protein.

Methodology

The 2-year (2021.-2022) field trial is in progress in Scottsbluff, Nebraska. The experiment design is a randomized complete block split-plot design with four replications. The main plot factor is N application timing (all around emergence, half at emergence, and a half at flowering) and the sub-plot factor is N rates (0, 33, 66, 100, 133 percent recommended N rate based on yield goal and spring soil test). Trials are planted following standard production practices (planting time, seed rate, row length, etc). Bio-accessible and bio-available proteins from harvested bean samples are identified using in-vitro gastrointestinal digestion. The content of amino acids and peptides are measured in the digested bean samples to determine the bioaccessibility of bean-derived proteins and peptides. After that, the gastrointestinal epithelial cells are used to determine the bioavailability of the bean-derived amino acids and peptides.

Results

Data from the first year showed the positive bean yield response to applied N rates. Increasing rates of N also increased total and soluble N in bean samples. Bioavailability test is yet to be conducted.

Discussion

Dry beans are one of the most important legume crops, a major source of protein in some countries, and N is the most yield-limiting nutrient for these beans. Therefore, increasing the bean yield through proper soil management techniques has become an essential component of dry bean production. Using adequate soil management techniques with N fertilizer, such as application rate and timing, may reduce the cost of bean production and improve bean yield at the same time The use of N management to enhance the bean quality by increasing total digestible, bioavailable, and functional proteins will add more economic and health value to the beans.

Conclusion

The first-year data demonstrated that we could optimize fertilizer N management to achieve healthy bean production. The second year of the study will begin this year. We anticipate determining the best management practice for high-quality bean production.

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Nebraska Dry Bean Commission US Department of Agriculture

Geochemical analysis of rock waste of a mining exploitation as potential remineralizer of soil fertility

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Keywords: Agrominerals, stonemeal, basalts

Introduction, scope and main objectives

According to Theodoro (2000), fertilizing the land with the same land can represent a viable and easy implementation option for small and medium agricultural producers who, in addition to productivity, seek to preserve their land as a resource for permanent use. The technique known as rochagem, stonemeal, rocks of crops consist of the addition of rock powder as a way of increasing soil fertility conditions, considering rocks as natural sources of a series of macronutrients and micronutrients essential for plant nutrition. The use of rock dust as a fertilizer can help reduce costs in agricultural production and contribute to the management of waste from mining activities, giving added value to a waste product without value. In this sense, the value of the geological sciences and their important role and becoming a constructive tool for agricultural development are pondered, especially through the exploration and development of fertilizer raw materials used directly or in modified forms to produce a of our most basic needs, the food. In the countries where this stonemeal or rochagem technique is developed, sterile material is mainly used as raw material, that is, that which has no economic value from the mining activity. Except for the use of the best-known agrominerals such as gypsum, calcium carbonate and phosphates used as fertilizers and conditioners in traditional agriculture, this technique of exploiting mining residues as a source of agrominerals has been little studied so far in Uruguay. In this paper, preliminary studies on the potential use of basalt rock powder residue from agate and amethyst mining in Uruguay as a source of agrominerals are presented.

Methodology

1.Location and geology of the study area The study area is located in the open-pit quarry linked to the exploitation of agates and amethysts by the company Urumining S.A., in the Los Catalanes Gemological District, Artigas, Uruguay (30º 47' 39.79" S and 56º 17' 22.50" W). From a geological point of view, the lithology is defined by a succession of basaltic spills, among which sheets and barjanes (half-moon dune) of aeolian sands, currently silicified, were deposited, corresponding to the Los Catalanes Formation of the Arapey Group. The Lower Cretaceous basaltic block constitutes the most important stratigraphic unit with an outcropping area of 41 000 km^2 and up to 900 m thick. The most characteristic rocks are massive, fine-grained, dark-colored basalts. The geochemical data for this unit establish that there are two types of basalt, with low content of Ti and P that are in the South of the basaltic province of the Paraná Basin and basalts with high Ti and P that appear in the North zone of these, that lean on those of the South. It is also mentioned that in some cases there is crustal contamination, but most of the magmas were derived from the lithospheric mantle enriched in trace elements. 2.Sampling For this work, three dump areas were surveyed with a total of 10 samples: Dump 1 (E1): It is located in the surroundings of the quarry where the piles of oldest material, characterized by being heterogeneous in size. Its composition varies with fractured and entire geodes loose and levels of weathered vacuolar basalt with gray to reddish-brown colorations that flake easily. In some sectors it presents a cover of vegetation. Dump 2 (E2): Material composed mainly of vacuolar basalt levels, with reddish-brown colorations of less degree of alteration than the material sampled in the E1 piles, but also easily shelled. Fragments of geodes ranging from 20 cm to mm are observed. Dump 3 (E3): Two sectors called E3a and E3b were sampled. The E3a samples represent the piles of material recently removed from the mineralized basalt level. They are fragments of metric sizes, gray to brown in color and have mineralized vacuoles. The E3b samples are of the same level, but more altered where reddish-brown colorations predominate. In each of the dumps, the homogeneity of the material was observed, and it was complemented with a random subsurface sampling (depth 10cm) of an approximate total weight of 5 Kg. 3.Sample treatment The samples were ground and sieved in the geology laboratories of the University Development Center for Geology and Mineral Resources of CURE at the headquarters in Treinta y Tres, Uruguay. For a coarse grinding was used a jaw mill and for a fine grinding was used the Retsch RS 200 mill. A Retsch AS 200 sieve shaker was used for sieving, keeping the samples with a particle size <125 microns. The geochemical analysis was performed at the Activation Laboratories Ltd., ACTLABS (Ancaster, Canada). The analytical techniques used were X-Ray Fluorescence to determine the percentage by weight of the oxides present; and Inductively Coupled Plasma Source Emission Spectrometry (ICP – OES), to determine the chemical composition of elements in ppm.

Results

The samples analyzed from each dump showed the following Results: Dump 1 (E1): The XRF analyzes correspond to four samples (n=4), SiO2 is determined as the main component with an average of 50.02 percent; followed by Fe2O3 with an average of 14.12 percent. In lesser proportion, it was determined other oxides: CaO with values around 4.98. percent, MgO with 2.2 percent, Na2O with a mean of 2.27 percent, TiO2 around 1.44 percent, K2O with 2.25 percent and finally P2O5 with a mean of 0.24 percent. The ICP Results show potentially toxic elements such as As and Cd with values less than 3 ppm and for Pb with mean of 15 ppm. The high content of Mn, Ba, Sr, V, Zn and Zr are stands out. Dump 2 (E2): The XRF analyzes for this dump correspond to data obtained for a sample which presents SiO2 as the main oxide with 46.89 percent, followed by Al2O3 with 17.77 percent and Fe2O3 with 14.77 percent. To a lesser extent, MgO is present with 2.23 percent, CaO with 1.81 percent, TiO2 with 1.62 percent and K2O with 1.51 percent. The ICP Results show As and Cd with values less than 3 ppm and Pb less than 7 ppm. The content in Mn, Ba, Sr, Zr, Zn and Cu are stands out. Dump 3 (E3a and E3b): For the material E3a, the XRF Results show a high content of SiO2 oxides with an average of 47.74 percent, followed by Al2O3 oxide with 13.85 percent and Fe2O3 oxide with values around 13.72 percent. It is followed in a smaller proportion by CaO with values around 5.29 percent, MgO with an average of 3.24 percent, Na2O 1.98 percent, TiO2 with an average of 2.05 percent, K20 with values around 1.01 percent and MnO with values less than 1 percent. Of the potentially toxic elements, in a sample the values are 6 ppm were obtained for As and Cd while for rest samples the values were less than 3; as for Pb the values are around 14 ppm. High values of Mn, Ba, V, Zr, Zn, Cu and to a lesser extent of Li and Ni are stand out. In the material corresponding to E3b, the XRF data show high values of SiO2 with an average of 49.41 percent, followed by Fe2O3 with values around 14.41 percent, Al2O3 with an average of 13.11 percent, in a lower proportion CaO with 4.90 percent, MgO around 2.81 percent, Na2O with an average of 1.99 percent, Ti2O with 1.96 percent and to a lesser extent K2O with 1.59 percent. Of the potentially toxic elements As and Cd with values less than 3 ppm and Pb around 14ppm. There is also a high concentration in Mn, Ba, V, Zr, Zn, Cu, Li and N. From the geochemical data it can be inferred that the materials correspond to the basaltic flow associated with magmas with tholeiitic affinity, characterized by low Ti (TiO2 less than 2 percent) and variable composition between 51 percent-58 percent SiO2.

Discussion

The Arapey Group basalts analyzed for this study show favorable Results to be considered as a source of macro and micronutrients for the soil, mainly: Ca, Mg, Si, Fe, Na, Mn, K, P, Cu, Mo and Zn. Due to its chemical composition and abundance, basalt is one of the most used rocks in the rochagem or stonemeal technique. Assay of the application of basalt powder in sandy soils confirmed an increase in pH and K, Ca, Mg and P values after the first year compared to those plots in which it was not used(Fyfe, Leonardos, & Theodoro, 2006.). One of the critical points in the use of rock powder is its low solubilization, which is why it is considered a slow-release fertilizer. Although, this same low solubility of the material can be considered as an advantage since it could reduce the losses due to leaching and fixation. The fact that it is absorbed slowly and for a longer period, facilitates the recompositing of fertility conditions and improves the balance of ions in the soil. The amount of material used depends on the type of soil, the scale, the type of crop and the granulometric size of the particles. The use of rock powder in different granulometry is recommended to favor the conditions for the reaction in the short, medium, and long term. This point is because the increase in the contact surface facilitates the action of weathering processes and increases the solubility of the material. Some authors maintain that the availability of nutrients in rock dust can be improved with a combined application with organic materials, such as manure(Arcobeli & Simão, 2012). Likewise, there is a natural contribution to the dissolution of minerals that is given by the organic acids generated in the biological processes of the soil (exudates from the roots, decomposition of organic matter, presence of mycorrhizae). This activity allows to increase the rate of dissolution of minerals and, therefore, the supply of nutrients for plants. It is important to highlight that in a mining operation it is common to produce a greater amount of rock waste than material with economic interest, which becomes a problem due to their final disposal and environmental management. The material of economic interest is found in the mineralized levels where the geodes (agates and amethysts) are found; the rest is waste whose final disposal is carried out in the surroundings of the mine. The use of mining waste as agrominerals is considered an alternative for better disposal and use of rocky waste generated by the mine. The potential use of this technique in soils associated with tropical climates and in practices linked to agroecology has been widely demonstrated. Also, experiences are being carried out in soils of temperate climates and their application in the recovery of degraded areas.

Conclusion

The preliminary geochemical data of the basalts of the Los Catalanes Formation of the Arapey Group associated with the piles of sterile waste from the agates and amethysts exploitation, present encouraging data on their possible use as a source of agrominerals. However, more geochemical studies are needed in addition to agronomic tests and evaluation of its economic feasibility to confirm the viability of developing this technology (stonemeal). By way of Conclusion, we can affirm that the double function of agrominerals as conditioner and fertilizer, providing macro and micronutrients, present them as an interesting alternative to the use of conventional fertilizers. In addition, the possibility of combined use with organic amendments of residues from other agricultural activities is added, as well as providing possible solutions to the environmental management of mining activity. In this sense, the concept of circular economy would be applied very well to the proposal to produce agrominerals from the discarded material from the extraction of agates and amethyst in Uruguay, which comply with international trade standards.

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Improving crop resilience through plant microbiome

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Keywords: crop protection, endophytes, microbiome, biocontrol

Introduction, scope and main objectives

The increasing interest in bacteria living inside plant tissues is linked to the urgent need to find sustainable solutions for global crop production. Such bacteria, named endophytes, promote plant growth, act as biocontrol agents and can be beneficial to their host by producing a range of natural products, so providing a sustainable alternative to agrochemicals. Here, we focus on the chemical dialogue between the plant and its microbial partners, in order to unwire the dynamics underlying plant protection mechanisms against the fungal plant pathogen Rhizoctonia solani.

Methodology

We used a collection of endophytic strains and compared their antagonistic activity against R. solani. We cultured them in pure bacterial culture or in co-culture with Arabidopsis seedlings, and performed competition bioassays against the fungal pathogen. Furthermore, analysis of the metabolites produced by plants and endophytic bacteria was performed to get more insight on the communication between the two organisms.

Results

Surprisingly, R. solani inhibition was largely increased in bacteria-plant co-cultures, pointing out the eliciting role of the plant. This Result was confirmed in vivo, Resulting in the protection of Arabidopsis seedlings against the fungus in soil. Metabolomic analysis revealed the presence of at least two molecules with strong antifungal properties, both produced by bacteria and regulated by plant signals. By exploring the metabolome of the host-plants, we observed the production of phytoalexins, plant antimicrobial response to (a)biotic stresses.

Discussion

We show that the plant can "cry for help' and stimulate the production of protective compounds by its microbial partners. We observed the production of two strong antifungal compounds and, to the best of our knowledge, this is the first study reporting these disease suppressive compounds to be elicited by plant cues. Furthermore, we show that endophytic bacteria can protect their host-plant at least in two ways: by releasing bioactive compounds, directly inhibiting the pathogens, and by inducing a physiological state of enhanced defensive capacity.

Conclusion

More studies like this are needed to fully understand and exploit the potential of endophytes in protecting our crops and making them more resilient. This knowledge will contribute to the usage of plant microbiomes and the development of tools for sustainable soil management, providing a valid alternative to the use of chemicals in the control of plant pathogens.

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Phosphorus biogeochemistry regulated by carbonates in soil

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Keywords: Carbonate; Phosphate; Soil; Microorganisms; Sorption

Introduction, scope and main objectives

Phosphorus (P) is an essential nutrient for all living things. Phosphates are the dominant P source in terrestrial ecosystem and govern the P availability in soil. The common deficiency of available P in carbonate-rich soils suggests the tight correlation of P and C biogeochemistry. The purpose of this review is to summarize the influence of carbonates to P biogeochemistry in soil. The role of soil microorganisms is also considered in this article.

Methodology

The influences of C on P cycles were reviewed in this study, via both abiotic and biotic pathways.

Results

The abiotic processes at geochemical scale include element release, transport, sorption, desorption, weathering, precipitation, etc. The sorption of P on carbonate and the buffering ability of carbonates were particularly addressed. Biotic factors are ascribed to various microorganisms in soil.

Discussion

As the most active P pool in soil, microorganisms prefer to consume abundant P, and then accumulate it in their biomass. Carbonates, however, can not directly utilized by microorganisms, but can be converted to organic C through general C circulation. Meanwhile, extracellular precipitation of Ca-P phases significantly regulates transportation of P in or out the cells. Moreover, they boost and complexify both carbonates and P turn over in soil via bioweathering and biomineralization, i.e., the intense interactions between biosphere and lithosphere.

Conclusion

Based on this review, we proposed that carbonates may negatively affect P supply to soil system. Comprehensive review on carbonates' regulation on P biogeochemistry would serves as a prerequisite to predict long-term P cycling instructs sustainable agriculture.

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The potential of silicon, *Trichoderma*, and organic matter to promote the growth of forage sorghum under saline stress

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Keywords: Salinity; Semiarid; Sorghum bicolor L.

Introduction, scope and main objectives

The element silicon is widely reported in the literature as an attenuator to saline stress, arousing interest in vegetable production (Cantuário et al., 2014). Silicon improves plant resistance to abiotic stresses, such as soil salinity, acting mainly in photosynthetic regulation, activation of antioxidant enzymes, forming a silica barrier in the roots to reduce the passage of salts to the shoot and increase production osmoregulatory (Coskun et al., 2016). In addition, when combined with other mitigators, the mitigation capacity of silicon can be improved.

Organic matter of animal origin promotes improvements in the soil and enables more favorable cultivation conditions in the face of the salinization process or the use of saline areas. In addition, it has a low acquisition cost or is readily available in most rural properties. According to Freire and Freire (2007), organic conditioners (cattle manure) contribute to the reduction of the percentage of exchangeable sodium (ESP) in the soil, possibly due to the release of CO_2 and organic acids during the decomposition of organic matter, in addition, to act as a source of calcium and magnesium, which can replace sodium in the exchange complex.

Trichoderma harzianum is a fungus that has a symbiotic relationship with plant roots and releases various compounds that improve plant resistance to abiotic stresses, especially salinity (Afzal et al., 2006). In addition to improving root growth, antioxidant enzyme activity, osmoregulatory production, and photosynthetic rate, which are mechanisms that control the level of salinity tolerance (Zhang et al., 2019).

The works reported in the literature have studied the isolated effects of these saline stress mitigators, and efforts need to be made to test the effectiveness of their interaction. With this, the objective was to investigate the ability of Trichoderma harzianum and organic matter to maximize the action of silicon as attenuating salinity and promoting plant growth in sorghum.

Methodology

The study was carried out in the field, at the Parnamirim Irrigated Agriculture Station – EAIP, of the Federal Rural University of Pernambuco, Parnamirim, Pernambuco, Brazil (8º 5' 19" S; 39º 34' 40" W, altitude 390 m). The climate of the region is characterized as semiarid type BSwh', according to the characterization of Köppen. The experiment was installed in a Fluvisol, classified as saline according to Richards (1954).

The experiment was arranged in a randomized block design, with five treatments and four replications. The treatments consisted of testing the effectiveness of the attenuating *Trichoderma harzianum* (T) and organic matter (OM) to improve the performance of silicon (SI) in mitigating salinity in sorghum (Sorghum bicolor [L.] Moench), cv. Sudan. Thus, the treatments were: control (sorghum without attenuating); sorghum + SI; sorghum + SI + OM; sorghum + SI + T; and sorghum + SI + T + OM. The spacing adopted was 0.50 m between rows and 20 plants per linear meter. The dimensions of the experiment were 20.0 x 16.5 m for the total area, 4 x 4 m for the plots, and 2 x 2 m for the useful plots.

The study was conducted between June and September 2021, totaling 90 days. During this period, there was no rainfall. The experiment was irrigated using a drip irrigation system, with emitters spaced at 40 cm and an application interval of 48 hours. Irrigation was performed based on the total replacement of crop evapotranspiration (ETc) (Allen et al., 1998). The water for irrigation came from an artesian well. The water was classified as C4S1, with a very high risk of promoting soil salinization and a low risk of sodification, according to Richards (1954).

T. harzianum was applied via soil, applying 39.06 mL of solution per linear meter, following the planting line. The solution concentration was 250 mL 20 L^{-1}, as recommended by the manufacturer.

Potassium silicate, the source of silicon used in this work, was applied twice via soil and two foliar applications. 39.06 mL m^{-1} linear was applied under both conditions.

The organic matter, composed of goat manure, was applied at the time of sowing in the proportion of 50 t ha^{-1}.

At the end of the cycle, biometry was performed to determine the height, stem diameter, and the number of tillers of the plants. Data were subjected to analysis of variance and the Scott-Knott test at the level of 5 percent probability, using the statistical program Rstudio (R Core Team, 2019).

Results

Both T. harzianum and organic matter in association with silicon, and the interaction between the three, promoted a significant increase in plant growth compared to the control. Isolated silicon did not promote a significant difference for this same variable. Silicon increased plant height by 14.78 percent, and when associated with OM, *T. harzianum*, or a mixture of both, this increase was 30.62 percent. Due to the high saline concentration present in the soil, silicon alone could not alleviate the damage caused by salts to plants.

Discussion

The ability of *T. harzianum* to mitigate salinity damage to plant growth is known. Furthermore, it increases root growth to promote a more significant absorption of water and nutrients (RAWAT et al., 2011). *T. harzianum* in wheat cultivation improved germination and plant growth due to metabolic changes (Rawat et al., 2011.). In addition, *T. harzianum* produces phytohormones, such as cytokinins and gibberellins, which induce plant growth, even under stressful conditions (Benìtez et al., 2004.). Other studies show that the effectiveness of *T. harzianum* is improved when it is combined with organic compounds (Kong et al., 2021.); however, in the present study, there was no significant difference between the treatments SI + T, SI + OM, and SI + T + OM. OM favors soil water retention, improves soil structure, allows salts to be leached, reduces the osmotic potential of the soil solution, and releases Ca2+, which can replace Na+ in the exchange complex (Yousaf et al., 2021.). Due to this, several works in the bibliography report the effectiveness of OM in reducing salts' damage in plants. The results obtained in the present study coincide with those verified by Sousa *et al.* 2018 and Lacerda *et al.* 2017. Sorghum plant growth was associated with improved soil chemistry and increased fertility. There was no significant difference in stem diameter. The highest values were found for the control and the SI + T treatment. For the control, the highest values may be associated with a higher concentration of carbohydrates in the stems of the plants, and this characteristic induces the plants to increase the degree of tillering (Magalhaes; Duraes; Rodrigues, 2003. In the same sense, *T. harzianum* induces plants to concentrate more carbohydrates in the stems and, consequently, increase the number of tillers (Musa; Bahrun; Kardina, 2021.).

Conclusion

The Results proved that the combination of silicon with *Trichoderma harzianum* or organic matter is more effective in alleviating the harmful impacts of salts on the growth of sorghum plants.

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The effect of fallow technology on soil fertility of kastanozem of cropland in Mongolia

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Keywords: organic matter, soil biology activity

Introduction, scope and main objectives

Our study covers all soil cultivation technology methods, rotations and crops used in our country and is implemented in a total area of 8 hectares close to the production technology. According to the Results of the study of soil organic residues, the reduction of organic residues was high in 2001-2004, but in 2014-2016, the decrease in organic residues was reduced, and there is a possibility of accumulation in the chisel plough fallow. The total number of soil microorganisms on ploughed fallow increased by 283.8 million cubic meters compared to virgin land and decreased to 126.75 million cubic meters by chemical fallow. The sharp increase in the total number of microorganisms in ploughing and cultivating the soil creates the main conditions for the intensification of microbiological processes that are the basis of biological processes in the soil.

Methodology

The field experiment was conducted at the Nart Center of the Mongolian University of life science in Bornuur soum, Tuv aimag from (200) to 2016. The estimated size of one floor of the experimental area is 16.8x50 m2 (840 m^2). Soil organic residue - Incineration method, percent: Organic residue in the soil is determined by calculating the amount of ash or mineral residue to be burned at 500 ˚C. The intensity of soil fibre decomposition - Saturkan mesh method, percent: The intensity of the soil fibre decomposition process was calculated by subtracting high-fibre materials such as cotton, linen, straw, and photographic film from the soil for a certain period of time. Soil respiration rate - Karpachev's method, kg/ha: determined by soil respiration or CO_2 emitted from the soil by absorption and titration of NaOH, a suitable absorbent. General analysis method for determining the total number of soil microorganisms, thousand units: The total number was calculated by diluting the coke and injecting it into Peter's cup.

Results

Our study covers all soil cultivation technology methods, rotations and crops used in our country and is implemented in a total area of 8 hectares close to the production technology. According to the Results of the study of soil organic residues, the reduction of organic residues was high in 2001-2004, but in 2014-2016, the decrease in organic residues was reduced, and there is a possibility of accumulation in the chisel plough fallow. According to the Results of the study, the intensity of soil fibre decomposition was high in 2001-2004. in the area of ploughed fallow, chisel plough fallow and chemical and chisel plough fallow. Still, the variability in the chemical fallow variant was negligible during the study period. In the 2001-2004. survey, soil respiration was most intense in the ploughed fallow, reaching 1.15 percent in September, an increase of 1.0 percent compared to May. Soil respiration intensity increased by 0.8 percent in September or 0.43 percent from May at the maximum chemical fallow. According to the Results of the 2014-2016 survey, carbon emissions have decreased, but the Results of previous years' surveys are consistent. The total number of soil microorganisms on ploughed fallow increased by 283.8 million cubic meters compared to virgin land and decreased to 126.75 million cubic meters by chemical fallow. The sharp increase in the total number of microorganisms in ploughing and cultivating the soil creates the main conditions for the intensification of microbiological processes that are the basis of biological processes in the soil

Discussion

According to our research, the biological process is intensive, the physical characteristics are stable, and the chemical parameters are better in the alternative wheat, which shows that mulching cultivation is necessary for our country.

Conclusion

• The total number of microorganisms in the soil has increased dramatically (137.9 million units), which is the main condition for intensifying microbiological processes that are the basis of biological processes in the soil. • Increasing the number of groups that play a key role in the decomposition of organic matter in ploughing and cultivating the soil intensifies the mineralisation process of organic matter, which has a negative effect on increasing the loss of soil organic matter (-1.92 - (- 55.2) percent). • Therefore, developing advanced crop management technologies based on knowledge of soil biological processes and implementing them in an environmentally friendly and cost-effective way is the solution to today's agriculture problems.

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Increasing cassava yield and quality on acid tropical soils

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Keywords: cassava yield, postharvest quality, acid soils, nitrogen rate, liming

Introduction, scope and main objectives

Cassava (*Manihot esculenta* Cranz) is the third largest carbohydrate source in the Caribbean (IAEA 2018) after maize and rice. It provides the versatility of either serving as the last resort food crop for limited-resources farmers or as a crop, which provides opportune prospects along the value chain (Stone, 2002). According to IAEA 2018, cassava is drought and flood tolerant enabling it as a superb crop for combating the constraints of climate change, food security and sustainability. It can be used as a source of starch and sugar for industrial uses. Cassava is viewed as a priority crop regionally for food security, rural agro-industry advancement, and opportunities for income generation and employment (IAEA, 2018). Cassava is a promising crop that can be grown on acid and infertile soils due to its tolerance to soil acidity (Howeler, Oates and Allem, 2001). The crop uses available water and soil nutrients effectively and has strong drought and pests and disease resistance. These attributes make cassava a suitable starch for import substitution and food security. The resilient nature of the crop has also played a key role in its mismanagement, Resulting in below average yields (Howeler et al., 2001). The regional cassava industry combats numerous agronomic factors contributing to low yields including acid soils (Kiiya et al., 2006.) and inappropriate soil fertility management and crop nutrition (Berga, Siriri and Ebanyat, 2001). The Resultant yield gap compromises farmers' livelihoods and industry development. Bian (2004) stated that approximately 30 to 70 percent of the world's arable soil is acidic and located in the tropics. Soil acidity has adverse effects on plants and soil biodiversity (Bolan and Hedley, 2003). Moreover, nutrient availability declines under pH values <5.5. Macronutrients such as N, P, K, Ca and Mg (Riley and Barber 1971; Barber 1995; Sumner, Fey and Noble, 1991) and micronutrients (Stone, 2006; Hinsinger and Gilkes 2010; Voss 1998) become unavailable, which combined with nutrient toxicities and deficiencies lead to poor soil fertility and reduced yields (Han et al., 2019.). Therefore, a yield deficit exists between actual and potential productivity. According to This is further compounded as cassava is not fertilized adequately when cultivated. There has been mismanagement of soil fertility leading to low availability of soil nutrients, (Bationo and Waswa, 2011.), mono-cropping (Sebuwufu, 2013) and careless applications of agricultural fertility inputs to these soils (Roberts and Georges, 2013). Improved soil fertility management presents a suitable and economic option for sustainable intensification of cassava production. The study sought to (1) determine the interactive effects of N application rate and liming on soil fertility, yield and post-harvest quality of cassava. An optimal N application rate for cassava grown on tropical acid soils, was also investigated.

Methodology

A demonstration field at the Central Experimental Station, Centeno 10° 35' N, 61° 19' W in county Caroni, Trinidad and Tobago was selected for the study. The land was left to fallow for two years prior to which it was cropped to cultivate herbs and spices. At Centeno, the soil type is classified as

Piarco Fine Sand (Typic Kanhaplaquult). A split plot design was used with liming treatments applied to the main plots and N treatments applied to the subplots. All treatment combinations were replicated three times. The cassava variety used was M Mex. Main plot treatments consisted of a control (no lime) and lime application based on a lime requirement test. Thirty subplots (36 m^2) were established, 15 each, randomly assigned to main plots. The plot size was 1110 m2 x 20 m2. The subplots contained six single rows of cassava (inter and intra spacing at 1 m2) with five plants each, for a total of 30 plants per plot. Lime (80 percent Effective Neutralizing Value (ENV)) was applied at (200) kg ha^{-1} to the limed main plot. Urea equivalent to 0, 50, 100, 200 and 400 kg N ha^{-1} was applied together with muriate of potash (MOP) equivalent of 200 kg K2O ha-1 in two split applications, one month after planting (MAP) and again at three MAP. Triple super phosphate (TSP) equivalent of 80 kg P2O5 ha^{-1} was applied as a basal application pre-plant to all experimental units. Soils were sampled after the tubers were harvested using a composite sample for each plot. Samples were prepared and tested for essential nutrients in addition to pH and EC. Tuber yield was measured from 6 plants within the micro plot (6 m_2) for each treatment at 9 months after planting. The occurrence of vascular streaking (PPD) in cassava tubers was evaluated for ten days (0, 4, 7, 10) by using the Philippine Root Crop Research and Training Centre's (PRCRTC) scoring method based on the discoloration changes during PPD (Uritani et al., 1983). Data were analysed statistically by GLM ANOVA, examining main and interaction effects, using Minitab 19.1.1.0 Statistical Software (Minitab Inc. PA, USA). Tukey's honestly significance difference (HSD) test was used to discriminate the means for significant treatment effects. Fitted line regression was used to analyse the relationship and dependence of yield, crop nutrient concentration, soil nutrient concentration and PPD rate on N rate.

Results

Soil Fertility and Nutrient Concentration Soil pH Content Relative to the non-limed control, soil pH was significantly ($p<0.05$) higher for limed treatments in both trials. For limed treatments, soil pH was significantly ($p<0.05$) higher than in the 1st trial. Soil Macronutrient Concentration Table 1 shows that soil K, Ca and Mg concentration were influenced by the interaction of lime and N rate. An initial increase in N rate from the control increased and decreased soil K concentration for limed and non-limed soils, respectively. K concentration was significantly greater at 100 and 400 kg N ha^{-1} for limed soils relative to the no-N control. In non-limed soils, increasing N rate Resulted in fluctuating K concentration with the greatest N rate Resulting in the smallest K concentration relative to the lime no-N control. In non-limed soils, a non-significant increase in soil Ca concentration was observed at 50 and 400 kg ha^{-1}, whilst in limed soils, a non-significant decrease was observed at 50 and 400 kg ha^{-1} relative to the no-N control. Irrespective of lime treatment, increasing N rate increased soil Mg concentration. However, the increase was only significant between the control and the 400 kg N ha^{-1} application rate with the lime application. In non-limed soils, a slight increase of Mg concentration was observed until 100 kg N ha^{-1}; however, a decline in soil Mg concentration occurred at N rates of 200 and 400 kg ha^{-1}. All the non-limed treatments showed significantly ($p<0.05$) lower soil Mg concentrations relative to the three highest N rate treatments also subjected to lime. Soil NH_4^+ concentration was significantly influenced by trial year. In the year 1, NH_4^+ concentration (0.75 mg kg^{-1}) was significantly greater than year 2 (0.13 mg kg^{-1}) ($P < 0.05$). Micronutrient Concentration Soil Mn and Fe concentration were significantly greater for the limed soils in the year 2. The difference was non-significant for the non-limed soils. As for Fe and Mn, Zn concentration, there was no response to liming in year 1. However, more Zn was detected in soil in year 2 than year 1 with a greater increase with the no lime treatment than with the lime treatment. Soil Fe concentration was significantly influenced by trial and N rate. Within the trial years, there was no difference in soil Fe concentration in response to N rate. Between years, a significant difference was observed at 400 kg N ha^{-1} in soil Fe concentration. Although most treatments were non-significantly different, greater soil Fe concentrations were observed at 200 and 400 kg N ha^{-1} in the 2nd year. Yield was significantly influenced by a significant interaction between trial year and lime. Cassava yield in limed soils was almost twice (21 427kg ha^{-1}) the yield of the non-limed control (12 667 kg ha^{-1}) in 1st year, whilst in the 2nd year, the yield margin increased further to almost three times greater than with limed treated soil (21 840 kg ha^{-1}), compared to the non-limed control soils (6 560 kg ha^{-1}). Crop yields increased significantly with the addition of N to a maximum at 100 kg N ha-1. Doubling the rate to 200 kg N ha^{-1} Resulted in a significant ($p<0.05$) reduction in yield. Crop yield increased slightly at 400 kg N ha^{-1} relative to 200 kg N ha-1 but remained lower than the maximum at 100 kg N ha-1 (Table 6). Post-Harvest Quality Figure 7 shows the occurrence of PPD in cassava tubers influenced by trial year and N rate. For both years, increasing N rate decreased the occurrence of PPD, with the reduction being significantly at 200 kg N ha-1, relative to the control in the first trial. However, at 400 kg N ha-1, PPD occurrences increased and were similar to the no-N control, significantly higher than at 200 kg N ha^{-1}. However, at rates of 100 kg N ha^{-1}, the occurrence of PPD were non-significant when compared to 200 kg N ha^{-1}. This highlights that a reduction in the occurrence of PPD is achievable at an application rate of 100 kg N ha^{-1}. The addition of lime and nitrogen reduced the occurrence of PPD in cassava tubers. For limed treatments, the occurrence of vascular streaking reduced considerably with increasing N rate up to 200 kg ha^{-1}. In non-limed soils, increasing N rate showed fluctuating effects on PPD, with non-significant differences among treatments. The lowest occurrence of PPD was observed in tubers at 200 kg N ha^{-1} with the lime application, which was significantly lower than the limed control and all non-limed treatments. The occurrence of PPD in cassava tubers was lower at all N rates for limed treatments. This effect was significant for all N rates except the no-N control. The largest difference occurred at 100 kg ha-1, between the limed and non-limed treatment. Regression analysis revealed that N rate significantly accounted for 3 percent of variation (R2 adj.) in the occurrence of PPD in cassava tubers.

Discussion

Soil pH Choudhry 1984 and Mutonyi 2014 observed similar consistencies in their research. Subsequently, Dos Anjos et al., (2011). stated when lime is applied, soil pH increases. The higher pH for the 2nd year implied that neutralization of soil acidity took longer than expected likely associated with the cultivation of the first crop and application of N fertilisers. The higher soil pH during the 2nd trial supports the positive effect of lime on Ultisols. This serves as a guide for convincing farmers to invest in these practices as it provides benefits beyond the initial year of application. Soil Macronutrients Application of limestone and 100 kg N ha^{-1} presented the highest soil K, Ca and Mg concentration among all treatments and for both trials. Djabou *et al.* 2018 stated the lime application enhanced Ca and Mg concentrations in soil, which supports this research. Additionally, Von Uexkull (1986) stated that adequate lime application improves the retention of potassium. In this experiment, higher K concentration was observed in soil with lime application and N fertilizer. As stated previously, cassava requires large amounts of K for tuber development. Although cassava utilised a great quantity of K, soil K levels were still in the sufficiency ranges (Howeler,1996) with concentrations higher than the crop's requirements. This is likely associated with the split application of K, as tissue testing four MAP showed K concentration in the deficient range. This would have been addressed with the 2nd split application soon after tissue sampling leading to adequate K concentrations for growth, development, and bulking. Soil Micronutrients Soil micronutrient concentration was not very responsive to the interactive effect of N rate and lime.

Lime treatments showed higher concentrations of available Fe and Mn in the 2nd trial. In contrast, soil pH was significantly and negatively correlated with soil Mn (r= -0.319) and Fe (r = -0.378). Higher concentrations of Fe and Mn in the 2nd trial may be associated with continued reactivity and neutralization of residual acidity through replacement of Fe and Mn by Ca (Rengel (200)), which was not directly linked to higher pH, which may explain the negative correlation. According to Rengel 2000, Mn and Fe becomes more available at <5.5. Under experimental conditions, Mn concentrations were within sufficient ranges implying greater availability to the plant for photosynthesis and chlorophyll formation. Furthermore, the increased levels of Fe, enhanced uptake associated with increased growth as minute amounts of accumulated Fe was translocated from older to budding leaves (Zhang, Romheld and Marschner, 1996; Burton, Halow and Theil, 1998; Irmak, Surucu and Aydin, 2008). Soil Zn levels in limed soils were lower for both trials. Soil Zn was negatively correlated (r = -0.785) with pH. Vondrackova et al., 2013 stated that reduced availability of Zn in soil might be because of liming as available plant Zn fractions become unavailable Resulting in effective immobilisation (Behera et al., 2016). Yield Higher yields were obtained with limed soils for trial year one (21 427 kg ha^{-1}) and two (21 840 kg ha^{-1}), respectively and the magnitude of the difference in yield between limed and non-limed was greater in year 2 than in year 1. The Results suggest that cassava is very responsive to lime application as significant yield differences were observed compared to non-limed treatments for both trials (6 560 kg ha^{-1} and 12 667 kg ha^{-1} respectively). It is important to note that national average yields were doubled and almost tripled with the combined use of lime and nitrogen. Non-limed soils produced 59 and 30 percent, respectively of their limed counterparts. While cassava is particularly tolerant to very acid Ultisols and shows more resistance to high levels of Al (Howeler, 2011), liming reduces Al toxicity (Fageria and Moreira, 2011.) and facilitates improved plant growth and partitioning of assimilates. It was discussed previously that liming did not significantly influence crop macronutrient concentration other than N, which alludes to the key role of lime in cassava yield, but more so that the effect may be associated mechanistically with a reduction in Al toxicity; though this was not measured in this study. Nitrogen is potentially the greatest yield promoter and its ability to increase cassava yields (21 733 kg ha^{-1}) by 100 percent as compared to 10 733 kg ha-1 for the no-N control, has been demonstrated in this study at 100 kg N ha^{-1}. Similar Results were obtained in Carimagua, Colombia, where the highest yields were obtained from the application of 100 kg N ha^{-1} in cassava (Howeler, 2011). A decline in yield was observed in rates >200 kg N ha^{-1}. Kaweewong et al., (2013) observed a reduction in cassava yield with rates >312 kg ha^{-1} N. They further noted that excess application of N might favour plant growth and reduce tuberization. Application of limestone and 200 kg N ha-1 presented the best shelf life among all treatments for both trials. Research done by Djabou et al., (2018) opined that lime (Ca) deferred the occurrence of PPD up to 10 days in “SC5”, a PPD-susceptible cassava genotype. Aghofack-Nguemezi and Tatchago (2010) observed an extension of the storage life of red-ripe tomatoes (*Solanum lycopersicum* L.) and a prolongation in the ripening of mature green tomatoes ameliorated with limestone. The authors reported that Ca defer maturation and deterioration by maintaining cell wall integrity (AghofackNguemezi and Tatchago, 2010). Though tissue Ca concentration was not significantly influenced by lime, tuber Ca concentration may have increased, (Ozgen and Palta, 2004), as there was greater soil Ca and Mg concentrations under liming. Palta (2010) posited that the influence of lime has a significant effect on the mineral concentration of the harvested cassava tuber.

Conclusion

This study confirmed the benefit of limestone combined with N fertilizer on improved soil fertility, yield and post-harvest quality of cassava tubers. Temporal responses to the influence of the of lime and N rate were observed. Repeated trials showed that 100 kg N ha^{-1} in combination with lime application presented the best treatment for maximum benefit. The optimum N rate derived from the quadratic regression equations was 100 kg ha^{-1}, which was validated by the ANOVA test Results and post-hoc tests. Under this nitrogen application rate, the cassava could obtain a balance between yield and quality. The response to the combination of lime and 100 kg N ha^{-1} produced the highest yields, lower PPD rates and improved soil fertility. These recommendations should complement the existing cultivation practices for improved cassava productivity.

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Inorganic fertilizer use in rice fields and its association with yield gap in different growing environments in sub-saharan Africa

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Keywords: Agro-ecological zone, nutrient use efficiency, Oryza sativa, partial factor productivity, yield gap

Introduction, scope and main objectives

Inorganic fertilizer use on arable land is low in sub-Saharan Africa (SSA). Increasing its use is essential for improving productivity. However, a comprehensive synthesis of current fertilizer use and the related yield in different rice-growing environments at the continental scale is lacking. The objectives of this study were to quantify spatial variation in fertilizer use and assess its relationship with yield and yield gap (i.e., the difference between the potential yield in irrigated lowland or water-limited yield in rainfed systems and the actual yield obtained by farmers) across rice-growing environments and agro-ecological zones (AEZs) in SSA (Dossou-Yovo et al., 2020).

Methodology

We reviewed and compiled data from farm surveys or farmers' field trials in which fertilizer management practices were conducted according to farmers' practices. The dataset included 228 data points from studies conducted between 1995 and 2020 in three different rice-growing environments [irrigated lowland, (IL), rainfed lowland (RL), and upland (RU] across 24 SSA countries, and covering five AEZs.

Results

There was a large variation (CV ranging between 110 and 140 percent) in N, P, and K fertilizer application rates with an average of 54, 10, and 9 kg /ha, respectively. N and P fertilizer application rates were higher in IL (93 kg N/ha and 17 kg P/ha) and arid zone (139 kg N/ha and 18 kg P/ha) than in RL (38 kg N/ha and 6 kg P/ha), RU (23 kg N/ha and 4 kg P/ha) and humid zone (32 kg N/ha and 6 kg P/ha), respectively. Similarly, rice yield was high in IL (4.6 Mg/ha) and arid zone (5.3 Mg/ha) and low in RL (2.5 Mg/ha) and RU (1.7 Mg/ha) and humid zone (2.5 Mg/ha). Higher N and P fertilizer application rates were associated with higher yield and lower yield gap in IL, whereas K application rate was not correlated with them. There was no clear relationship between N, P, and K fertilizer application rates and yield as well as yield gap in RU. About 40 percent of data points had high partial productivity factors (PFP) (i.e., the ratio of the grain yield to the applied rate of nutrients) of N, P, and K compared to the optimum level, implying insufficient supply from inorganic fertilizer and a high risk of soil nutrient mining. Moreover, rainfed systems tended to have lower PFPN than IL, and a higher P application rate could improve PFPN.

Discussion

Overall, we show that there is a large room for increasing rice yield and narrowing the yield gap in SSA, especially in rainfed systems. Therefore, improving fertilizer use efficiency while reducing other limiting factors is needed especially in those growing environments (Tanaka et al., 2017).

Conclusion

Improving access to financial services and input supply and dissemination of tailor-made crop, soil, and nutrient management practices could be essential for improving fertilizer use and narrowing the yield gap in SSA.

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Rice - pasture rotation as sustainable cropping management in Entre Rios, Argentina.

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Keywords: rice-pasture rotation, soil carbon fractions, soil nitrogen fractions, biological nitrogen fixation, Lotus spp

Introduction, scope and main objectives

Continuous rice (*Oryza sativa*) cropping system (RR) is widely used in many Asian countries. However, many authors reported that the RR productivity is still low. This phenomenon is attributed to the continuous flooding period affecting soil environments with the subsequent deterioration of soil quality due to the imbalanced fertilization and limited organic carbon recycling. Continuous rice cropping system (RR) is widely used despite it can be improved by other strategies that enhance rice yield and the sustainability of soil quality. Thus, the rice-pasture rotation system (RP) has raised as an alternative to increase rice yield diversifying the agroecosystem by the use of implanted pastures. Therefore, a RR and a RP agroecosystem, where the pasture is composed by the legume Lotus corniculatus, among others species, were studied.

Methodology

This study was developed to characterize the soil quality in the agroecosystems with RR and RP strategies by determination of multiple soil quality indexes (SQI) in order to analyze differences in soil quality between management strategies and the relationship between SQI from soil N and C parameters. The second aim was to generate relevant information that supports the idea that the Biological Nitrogen Fixation (BNF) associated with the legume from the pasture stage of the RP soil could be linked to the soil N content and at the same time with soil C variables. Soil N and C parameters were analyzed by a mass spectrophotometer according to the Dumas combustion method. For the quantification of the amount of N derived from the atmosphere, the 15 N stable isotopic abundance technique was used to determine the δ 15 N.

Results

The Results indicated better soil quality indicators in RP compared with RR according to soil N and C determinations and indicated a close relationship between them. In line with this, the most relevant Result was that total N explained 90 percent of the carbon pool index variability and this relationship was a reflection of the strong correlation found between the N-NH4 + fraction and the percentage of particulate organic carbon. In parallel, a biological N Fixation (BNF) study carried out in RP indicated that almost 80 percent of the N content in L. corniculatus plants was explained by the BNF.

Discussion

For decades, several authors agreed that intensive tillage in agricultural systems induce a decrease in soil organic C caused by degradation of soil structure and increased decomposition of soil organic matter. This agreed with our Results from a previous study that included the study of the

RR and RP agroecosystems (Maguire et al., 2020). Our new report indicated particularly higher organic matter levels in the RP agroecosystem in comparison with the RP and that this could be related with the differences found in rice yields between them.

Conclusion

The Results of this work led us to think that the increase in soil C in RP could have been a consequence of the increase in soil N content derived this mainly from BNF associated to the legumes in the pasture stage.   In turn, the implementation of a rice-pasture rotation could be a useful strategy to increase not only the soil C content, but also to improve its structure increasing at the same time the sustainability of soil quality.

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Evaluating the effects of jeevamrutha application on soil parameters- a field study

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Keywords: Jeevamrutha, soil organic carbon, microbial load, water holding capacity

Introduction, scope and main objectives

Jeevamrutha is a microbial biodynamic formulation used for decades by farmers in India. Previous studies have claimed its potential to rejuvenate soil and improve soil health. Considering this background, in this study, a field experiment was conducted for four years to evaluate the ability of JA to improve the beneficial characteristics of soil.

Methodology

The experimental plot was situated at Mahatma Gandhi Gramodaya Parisar, Indian Institute of Technology of Delhi, India (28º32'31.7"N 77º11'22.7"E). Topsoil (6 inches) was collected at regular intervals of three months for 4 years (2017, 2018, 2019., 2020). The soil samples from treated and control plot were analyzed for parameters such as pH, water holding capacity (WHC), soil organic carbon (SOC), cultivable microbial load (bacteria and fungi) and FDA hydrolysis activity throughout the experimental period. The field was prepared as 1 m^3 box lined with polythene cover and allowed to stabilize for 3 months before starting the experiments. JA application was done every 15 days once (20 L/plot), and vermicompost was applied every 6 months once (30 Kg/plot). Further, in the trial plots three different treatments were given, namely only chemical fertilizers (T1), only FYM/VC (T2), and JA+FYM/VC (T3).

Results

Towards the end of the experiment period, decrease in soil pH was seen, ranging between 7.3 to 6.9 in which T3 recorded the least pH. Further, increase in SOC content was apparent in 2019., highest SOC of 1.37 percent was recorded by T3 followed by T2 (1.19 percent) and T1 (0.876 percent). An increase in other parameters such as WHC, microbial abundance, and microbial activity was seen towards the end of the experimental period. The increase was evident in case of T3 compared to T2 and T1.

Discussion

Earlier studies have associated SOC of soil with other soil parameters such as WHC, soil porosity, microbial activity, etc. A positive correlation between microbial load and SOC was observed in our study. The increase in microbial load seen in T2 and T3 indicates improvement in soil health. Further, the significant increase in microbial activity in T3 can be mainly due to the difference in microbial community composition between T2 and T3.

Conclusion

This study evidenced that long term JA application in combination with organic amendments can enhance soil health, fertility, microbial load, and diversity. Hence, integration of JA in organic farming seems promising.

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Fertility and quality of soil as affected by external additives: effect of integrated biochar and polymer application

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Keywords: soil fertility, biochar, crop productivity, soil quality, amendments, sustainable management

Introduction, scope and main objectives

Application of biochar along with traditional mineral fertilizers, and combined with other soil amendments could be an effective approaches for improvement of soil fertility and health and crop production, and soil and water conservation. However, inconsistent results regarding soil fertility and biochar types, crop growth and development, and soil chemical and physical properties were reported (Saffari et al., 2020; Singh et al., 2022). The objective of the study was to examine the effect of corn biochar as the external nutrients and anionic polyacrylamide (PAM) as a soil stabilizer on wheat yield and fertility or quality of a clay loam Alfisol under rainfed field condition.

Methodology

Experiments were conducted in November–July period during two years, in the temperate region of Turkey. Effect of three treatments with three replication were tested in the field plots (2 x 8 m): control (no treatment), biochar (2 t/ha), and biochar (2 t/ha) + PAM (20 kg/ha). All plots received same agronomic and soil management practices (e.g. cultivation, reduced mineral fertilizer N-60 kg/ha, P-20 kg/ha) along with treatments before wheat seed sowing (200 kg/ha) in rows. Crop growth were regularly monitored and yields were measured. Topsoil soil fertility and quality parameters (0-20 cm) were determined at the beginning and end of vegetation. Runoff and erosion samples were collected and soil and nutrient loss were calculated.

Results

Compared with the control, biochar and biochar + PAM treatments (i) noticeable grown (7 to 12 percent) soil pH, total nitrogen, exchangeable Ca, and cation exchange capacity, (ii) significantly improved soil organic carbon (SOC, 28 percent and 36 percent), available phosphorous (P, 22 and 41 percent), wheat yield (21 and 34 percent), and (iii) significantly increased soil macroporosity, soil water content (12 and 19 percent) and infiltration (15 and 42 percent), and decreased soil loss (28 and 42 percent) and associated nutrient loss (N, 18 and 34 percent, P, 21 and 48 percent). Applying biochar in combination with PAM on acidic soils had an interaction effect, leading to the improved soil fertility and quality and crop yield by the following order: Control < Biochar < Biochar +PAM.

Discussion

The affirmative effect of the treatments were related to the improved (i) soil pH, soil nutrients content (N, P, SOC), and water content as a consequence of biochar adding as an external stable nutrient sources, and (ii) soil structure and water retention capacity and thus decreased soil erosion and nutrient loss by the PAM application, as a faster soil stabilizer. Combined effect of the both amendments increased soil water and nutrient use efficiency and subsequently crop development and yield (Saffari et al., 2020; Mamedov et al., 2021; Singh et al., 2022).

Conclusion

The effect of biochar application on crop productivity was associated with to both chemical and physical properties of soils. As a feasible soil fertility management, Biochar + PAM influence on soil quality and fertility and crop yield was much more effective than biochar alone treatments, and could be used as an integrated application in the context of sustainable management and climate change mitigation opportunities.

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Nitrogen diagnosis in maize-forage grasses intercropping receiving nitrogen as side-dressing for production sustentabilty

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Keywords: Congo grass, diagnostic leaves, intercropping system, no-tillage, degrated pasture, sustainable agriculture, sustainable livestock

Introduction, scope and main objectives

The maize-forage grasses intercropping has been used in Brazil for the recovery of degraded soil and has been identified as part of the new brazilian agricultural revolution. This practice when used in autum-winter season possibilty soil coverage and animal feed in the dry season. Forage grasses and maize needs nitrogen adequate supply for ensure adequate production, but in this system only maize is fertilized. Thus the purpose of this study was to evaluate nitrogen in the diagnostic leaves of the maize and forage grasses intercropped receiving nitrogen rates as side-dressing in the dry season for sustentability of this system.

Methodology

A field experiment was carried out in Southeastern Brazil (latitude 22°42′S, longitude 47°18′W and altitude 570 m). According to the classification of Köppen the local climate is Aw type rainy tropical forest with rains in the summer and drought in the winter. During the experimental period, the soybean-grass intercropping in the summer and maize-grass intercropping receiving nitrogen rates in the autumn was cultivated from September 2019 to September 2021. Here we showed the Results of the 2021 autum crop. The experimental design was randomized blocks with four replications in a split-plot scheme. The main plots were: maize in monoculture system; maize intercropped with Congo grass (*Urochloa ruziziensis* cv. Comum); and maize intercropped with Aruana Guinea grass (*Megathyrsus maximus* cv. Aruana). The subplots were four nitrogen rates: 0, 50, 100 and 150 kg ha^{-1}. There was evaluated nitrogen in the leaves diagnostics of the maize and grass at the maize flowering.

Results

Nitrogen concentration in the diagnostic leaves of the maize and in the diagnostic leaves of the grasses showed significance for the interaction between maize-Congo grass intercropping and nitrogen rates applied as side-dressing. Nitrogen rate of 10.36 kg ha^{-1} showed the lowest concentration of nitrogen in the diagnostic leaves of the maize intercropped with Congo grass (15.49 g kg^{-1}). The increase in the nitrogen rates applied as side-dressing promoted linear increase in the nitrogen concentration in the leaves diagnostic of the Congro grass intercropped with maize.

Discussion

Nitrogen concentrations in diagnostic leaves of maize intercropped with Congo grass are below the level considered adequate (27.5 to 32.5 g kg^{-1}), even at rates higher than the one responsible for the lowest concentration. The linear increase in nitrogen concentration in diagnostic leaves of Congo grass with increasing nitrogen rates demonstrated that Congo grass when cultivated with maize can induce nitrogen deficiency in the cropping system. The variation in nitrogen concentration in the diagnostic leaves of maize and Congo grass demonstrated that when these plants are intercropped in the autum both have high nitrogen requirements.

Conclusion

We concluded the nitrogen concentration variation in the diagnostic leaves of the Congo grass and maize showed that when these plants are intercropped they have high demand by nitrogen supply for production sustentabilty.

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Profitability of pure vs. integrated application of organic and inorganic n-fertilizers under rice-wheat system

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Keywords: rice; wheat; nitrogen; crop residues; animal manure; poultry manure; urea; inorganic N; organic N; profitability; net returns

Introduction, scope and main objectives

Among the cereal crops, rice (*Oryza sativa* L.) is the 2nd major crop after wheat, and it provides 50-60 percent of the calo-ries to 2.7 billion peoples globally. The rice-wheat cropping system (RWS) has been practiced for more than 1 000-years in Asia have adversely affected the soil fertility and productivity because both rice and wheat (cereal crops) are exhaustive in nature. The RWS is the major system in southern and eastern Asia. It is essential to investi-gate the impact of integrated use of organic plus inorganic N-fertilizers for the long-term sustainability of RWS. As nitrogen (N) is the most important essential nutrient for plant and microbial growth, therefore, best N-fertilizers management practices are important under RWS. For example, the use of organic N-fertilizers which act as source for micro and macronutrients improve soil fertility, crop productivity and its quality. The uses of organic fertilizers sources (OS) are essential for field crops production because it provides essential plant nutrients which can balance the sink source relationship. The trend in use of OS in agriculture soil has been an increasing interest due to im-provement in crop yield, and recycling of plants nutrients. The retention of OS in the form of crop residues (CR) or animal manures (AM) incorporation in soil is essential for enhancing soil chemical, physical and biological proper-ties (soil health). Incorporation of OS enhances N immobilization and increase the ration of carbon relative to N in cropping systems. To make cereal based cropping system more profitable, the use of OS is more essential without degrading the natural resources and environment. Therefore, integrated nitrogen management i.e. combined use organic-N (form AM or CR) plus inorganic-N (from synthetic fertilizers, e.g., urea) is a best approach for sustaina-ble and profitable crop production under rice-wheat cropping system (RWS).

Methodology

Field experiment was conducted to integrative the effect of organic N-fertilizers sources (animal manures and plant residues) and inorganic N-fertilizer (urea) on profitability [Net returns (NR) of hybrid rice (Pukhraj) and their car-ryover effects on the NR and VCR of succeeding wheat (Siren-2010) under rice-wheat cropping system (RWS). Six different sources of organic N-fertilizers sources (OS) used were three animal manures viz. poultry manure (PM), sheep manure (SM) and cattle manure (CM), and three crop residues viz. onion residues (OR), berseem residues (BR) and wheat residues (WS). The C: N ratio of urea was the lowest (0.4:1) and that of SW was the highest (125:1) as compared with CM (19:1), PM (15:1), SM (16:1), OL (15:1), and BR (20:1). The experiments were carried out on progressive farmer's field at Batkhela, Malakand Division (Khyber Pakhtunkhwa, Pakistan) during 2011-12 (Y1) and 2012-13 (Y2). Batkhela is located at 34°37' N and 71°58'17" E. The soil of the experimental field was clay loam, slightly alkaline (pH = 7.3), non-saline (ECe = 1.02 dS/m), moderately calcareous in nature ($CaCO_3$ = 7.18 percent), low in soil fertility (containing less organic matter (0.71 percent), total N (0.51 percent), extractable P (5.24 mg/kg) and Zn (0.93 mg/kg).

All organic N-fertilizers sources were applied 30 days prior to rice transplanting, while N from inorganic N-fertilizer source (urea) was applied half at transplanting and half at 30 days after transplanting. Phosphorus and potassium ware applied each at the rate of 60 kg ha^{-1} homogeneously to whole experiment from TSP and SOP, re-spectively at the time of transplanting. Wheat crop (cv. Siren-2010) was sown on November after the rice was har-vested in October in both years. Simple RCB design having four replications (26 treatments in each replication) was used. Net area of 12 m2 plot-1 with distance of 20 cm plant to plant, separated by 30 cm band to prevent the water and nutrient flow among treatments, and each plot was irrigated separately from water channel. After rice maturity, 2 m^2 of rice within each treatment was harvested, the harvested material was dried and weighed to calculate biological yield (kg ha^{-1}). These materials were then threshed, and rice grains were separated and weighed to calculate grain yield (kg ha^{-1}). Straw yield (SY) was calculated using the formula: Straw yield (kg ha^{-1}) = Biological yield (kg ha^{-1}) – Grain yield (kg ha^{-1}).

Economic Analysis

The net returns (NR) (the value of the increased yield produced as a result of N-fertilizers applied minus the cost of nitro-gen-fertilizer) was determined. The costs or prices (PKR) of different nitrogen sources applied at the rate of 30 kg N ha^{-1} (25 percentN), 60 kg N ha^{-1} (50 percentN), 90 kg N ha^{-1} (75 percentN) and 120 kg N ha^{-1} (100 percent) of the total required N (120 kg N ha^{-1} was applied from the combination of different sources).

Statistical Analysis

Data on yield and yield components of both rice and wheat crops in this study were subjected to analysis of variance (ANOVA) according to the methods described for randomized complete block design combined over the years, and means between treatments were compared using LSD (least significant difference) test ($p \leq 0.05$).

Results

Net returns:

The net returns (NR) (the value of the increased yield produced as a result of N-fertilizers applied minus the cost of nitrogen-fertilizer) and the value cost ratio (VCR) is the ratio between the value of the additional crop yield with N-fertilizers applied divided by the cost of N-fertilizer) were determined according to the procedures of Amanullah, *et al.* [11, 13]. The total cost for the required 120 kg N ha-1 was less while using onion residues (4 000 PKR), followed by urea (10 440 PKR) and poultry manure (12 414 PKR), while the cost was very high in case of wheat residues (120 000 PKR) because of less N percentage (0.4 percent) and high amount (30 t ha^{-1}) required.

Comparison of pure organic N-fertilizers sources:

Among the pure (sole application) six organic sources used in the experiment, the highest net returns (NR) for the current rice crop was obtained with application of PM (336 244 PKR), followed by SM (258 519 PKR), and the lowest NR was obtained for WR (42 668 PKR). Similarly, the highest NR for the subsequent wheat crop (was obtained with application of PM (74 704 PKR), followed by SM (63 849 PKR), and the lowest NR was obtained for WR (37 182 PKR). Likewise, the highest NR for the whole rice-wheat cropping was obtained with application of PM (410 948 PKR), followed by SM (322 368 PKR), and the lowest NR was obtained for WR (79 849 PKR). Among the crop residues, application of OR resulted in the higher NR of 222 824 PKR for the current rice crop, and 279 975 PKR for the whole R-W-S. In case of subsequent wheat crop (SWC), the highest NR of 60 831 PKR was obtained with the application of BR.

Comparison of inorganic (urea) and organic N-fertilizers sources ratios (U: OS):

Among the three different ratios of U: OS (on percent N basis, e.g., 75U:25OS, 50U:50OS and 25U:75OS)], the ratio of 50U:50OS had produced the highest NR for the CRC (412 206 PKR) and RWS (462 193 PKR). In case of SWC, the 25U:75OS ranked first with NR of 53 532 PKR, followed by 50U:50OS (49 987 PKR), and 75U:25OS with 42 292 PKR ranked in the bottom.

Comparison of integrated (mixtures) use of inorganic (urea) plus organic N-fertilizers sources (U + OS):

In the six mixed combinations of inorganic + organic N-fertilizers (mixtures), integration of urea (U) + PM resulted in the highest NR (480 503 PKR), followed by U + SM (442 151 PKR), and the lowest NR (264 428 PKR) was obtained with the integration of U + WR for the CRC. Likewise, for the whole RWS, U + PM also resulted in the highest NR (560 047 PKR), followed by U + SM (487 356 PKR), and the lowest NR (297 715 PKR) was obtained when U + WR were used in RWS. In case of SWC, the combined use of U + PM ranked first with NR of 59 544 PKR, followed by U + OR (51 611 PKR), and U + WR with 33 287 PKR ranked in the bottom.

Planned means comparisons of inorganic and organic N-fertilizers sources:

The planned mean comparison for CRC, SWC and RWS revealed that the N-fertilized (treated) plots tremendusly produced highe NR than the N-fertilizer control plots. Sole inorganic N-fertilizer (urea) application had higher NR than U + OS and pure OS under CRC and WCS. In case of SWC, sole inorganic N-fertilizer (urea) application had lower NR than U + OS and pure organic N-sources. Sole OS applications had lower NR than combined use of U + OS under CRC and WCS. In case of SWC, sole OS had higher NR than U + OS. Animal manure (AM) was found better in terms of higher NR under CRC (406 527 PKR), SWC (53 619 PKR) and RWS (460 146 PKR) than the crops residues (275 067, 48 623, and 323 690 PKR.

Discussion

The net returns (NR) was highest with application poultry manure (PM) than other sources. The increase in NR in this study was attributed to the increase in yield and yield components, total above ground biomass (BY) and soil N. The drastic decline in NR with application of WR (wheat residues) was attributed the wider C: N ratio (125:1) of wheat residues. Organic materials with a high C/N ratio are likely to compete with crops for N, which can lead to N deficiency in extreme cases. Moreover, the OS with higher C/N ratio having less decomposition and less nutrients (especially N) availability which reduce plant growth, GY and NR. The residual effect of the WS also had negative impact on the YC and GY of the SWC also resulted in the less profitability under SWC in the RWS in this study. Our study confirmed that combined application (integrated use) of organic and inorganic N-fertilizers in different ratio (75:25, 50:50, 25:75) was most profitable than sole use of OS. The difference in nutrients absorption from different sources combination greatly improved growth, biomass and yield potential. Nitrogen applied at the ratio of 75 percent from urea (U) and 25 percent from OS (75U: 25OS) had higher NR in Y1, while in Y2, N applied as 50 percent (50U: 50OS) had positive relationship with both GY and BY, and therefore increased NR.

We assumed from these results that with the passage of time (long term basis) the ratio having higher organic N-fertilizers (25U: 75OS) could increase crop productivity and profitability under RWS. From this experiment we also find an interesting result that pure OS re-sulted in higher income from different ratios under SWC. The residual effect of the higher amount of organic N had significantly increased YC and GY under SWC and therefore NR was increased. Our results confirmed that NR in-creased with the mixture of urea with poultry manure (U + PM) and reduced drastically with urea plus wheat resi-dues (U + WR). The improvement in NR in this study with integrated use of U + PM was attributed to the lower C/N ratio of 12:1 of PM < SM (15:1) < BR (14:1) < OR (17:1) < CM (18:1) < WR (125:1). In Y1, sole urea application was better than mixture (U + OS), while in the Y2, the mixture (U + OS) performed better than sole urea in terms of NR. On the other hand, sole OS in both years had less NR than mixtures (U + OS). Mineral fertilization generally gave the highest plant growth and nutrient uptake in one-season of cultivation compared to OS. In Y1, sole urea applica-tion produced higher GY and therefore had higher NR than mixture (U + OS). In the Y2, due to the better decompo-sition of OS along with urea (U + OS) produced higher GY over sole urea that resulted in higher NR. The maximum NR in our experiment with combined application of U + OS was due to the luxuriant growth of rice plants and higher yield components and GY. The high nutrients availability from U + OS in the Y2, helped the plants to en-hanced crop growth rate, leaf area and leaf area index that resulted in higher photo-assimilates and more biomass accumulation and so NR was increased. Application of combined organic and inorganic N-fertilizer increased number of panicles per square meter, panicle length, panicle weight, number of filled grains/panicle, 1000-grains weight and grain yield, and therefore resulted in higher income.

Among the pure (sole application) OS, the highest VCR under CRC and RWS was obtained with application of OR, followed by PM, and the lowest VCR was obtained with the application WR. On the other hand, the highest VCR under SWC was obtained with application of PM, followed by SM, and the lowest VCR was obtained with the ap-plication WR. Under RWS, the performance of all organic N-fertilizers sources in terms of VCR increased signifi-cantly in the Y2 than Y1, and AM performed better than CR (PM > SM > CM > OR > BR > WR). The increase in VCR with application of AM especially PM was accredited to its low C/N ratio (12:1). The higher C/N ratios OS (e.g., WR) incorporation in soils caused N deficiency that had negative influence on the crop growth and yield that resulted in reduced VCR. The increase in VCR with both PM and OR was attributed to their low costs. On the other hand, the lowest VCR in case of WR was due to its higher costs. Based on two years data, the VCR under CRC and WRS in-creased when inorganic N (urea) was increased over OS-N and vice versa (75:25 > 50:50 > 25:75). In contrast, under SWC the highest VCR was obtained when OS-N was more than inorganic N (25:75 > 50:50 > 75:25). A greater amount of N from urea (75 percent U: 25 percent OS) may have less C/N and more available N, which resulted in higher VCR under CRC and WRS. On the other hand, the more N availability under SWC from OS had positive impact on wheat yield and so the VCR was increased. Integration of U + OR or U + PM increased VCR, while integration of U + WR decreased VCR under CRC and RWS. It was confirmed from this study that combined application of urea and OS protect the plant from nutrient deficiency in the whole growth period. Application of OS increased yield through improvement in soil water holding capacity, physical and chemical condition, reduction of volatilization of N fertilizers to NH3 gas, and greater availability of plant nutrients for longer time improved growth, yield and VCR.

Conclusion

Profitability (net returns-NR) increased tremendously in N-treated plots (rest) over N-control plots under CRC, SWC and RWS. Among the organic sources, application of poultry manure because of its less C/N ratio (12:1) and lower cost was considered the most beneficial in terms of higher NR. Wheat residue, on the other hand, because of its higher C/N ratio (125:1) and higher cost had the most negative impact on NR. Among the crop residues, berseem and onion residues increased profitability over wheat residues. It was also concluded that integrated use of nitrogen in the form of 50 percent N each from poultry manure and urea (50 percent U: 50 percent PM) improved soil fertility, crop productiv-ity and profitability under rice-wheat system.

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Potential alteration of soil extracellular enzyme activity and earthworm ingestion under different toxicity of microplastics and heavy metal mixture in soils

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Keywords: microplastics, heavy metals, co-exposure, earthworm, microplastic ingestion, extracellular enzyme and microbial activities

Introduction, scope and main objectives

As microplastics (MiPs) have become ubiquitous in both aquatic and terrestrial environment, a growing attention has recently been paid to these new anthropogenic stressors. However, little is known about the negative effects of co-contamination by MiPs and heavy metal mixture on terrestrial environment and biota. This study was to assess the adverse effects of co-exposure to MiPs and heavy metal mixture (Cu2+, Cr6+ and Zn2+) on survival and ingestion MiPs of earthworm *Eisenia fetida* and on soil quality collected from two locations in the Dong Cao catchment through the alternation of extracellular enzyme activity and microbial activity.

Methodology

The experimental soil was collected from W1 and W4 of Dong Cao catchment premises at a depth of 0–20 cm. The two different concentrations of heavy metal mixture solution (Cu2+, Zn2+, and Cr6+) for the study were 1X (environmental concentration) and 2X (double of environmental concentration) for each studied station, W1 and W4. Each pot soil tested was added 1.0 gram of polypropylene microplastic beads (concentration of 1 percent dried w/w). The number of particles of MiPs was estimated about 5.9 x104 particles g^{-1} (dry weight). The toxicity of soil miroplastic effect on heavy metal were caried out using assays as below: - The metals (Zn2+, Cu2+, and Cr6+) content in each sample was measured by ICP-MS methods - We measured the potential activity of three hydrolytic soil extracellular enzymes: β-glucosidase, N-acetylglucosaminidase and phosphatase as those enzymes can be tied to carbon, nitrogen and phosphorus cycling. - Microbial activity was determined using fluorescein diacetate (FDA) - Detarmine the ingestion rate and microplastic ingestion of earthworm

Results

The Results indicated that mortality rate was the highest at co-exposure of polypropylene (PP) MiPs and heavy metal mixtures. Although ingestion rate of earthworm had no significant differences between exposure conditions and control, MiPs ingestion rate of earthworm significantly decreased when exposed to metals-associated heavy metal mixture at high concentrations (2X) in soils of both locations. Metals-asociated PP MiPs stimulated the activities of β-glucosidase, β-N-acetyl glucosaminidase and phosphatase enzymes in soils. Principle component analysis showed that those enzymes were positively correlated with the concentrations of Cu2+ and Cr6+, but negatively correlated with microbial activity. Zn2+ did not show any correlation with the alteration of the soils excellular enzyme activity or microbial activity.

Discussion

All exposure conditions in our study were added PP MiPs with the concentration of 1 percent and mortality of earthworms was observed 100 percent at 2X environmental concentration of heavy metal mixture after exposure for 14 days. This finding can Result from the exposure to the combined toxicity of PP microplastic and heavy metal mixture, leading to the damage of the self-defense system of earthworm.   This study also indicates the increase activities of extracellular enzyme under the co-exposure context of metals-associated PP MiPs due to probably Cu2+, Zn2+ and Cr6+ existing in soils in insoluble forms or in complex organic-bound fraction; and therefore they did not show the inhibition of extracellular enzyme activities in soils. Further studies are also needed to understand the deeper mechanisms involved in responses of soil extracellular enzyme activities, which deserves special attention especially under some elevated contamination scenarios of several heavy metals combinated with microplastics such as PP.

Conclusion

This study demonstrated that the co-exposure of MiPs and heavy metal mixture (Cu2+, Zn2+ and Cr6+) increased the mortality of E. fetida. 100 percent of mortality was observed at exposure condition which was presented by PP MiPs and 2X concentration of heavy metal mixture. The Results demonstrated that the ingestion MiPs of earthworm had a positive correlation with the concentrations of PP MiPs in earthworm or in its cast. We also found that the presence of PP MiPs can favour biologically inactive forms of metals in soils, and that PP MiPs stimulated the extracellular enzymes activity in soil. These findings provide a further understanding of the adverse effects of the combination pollution of MiPs and heavy metal on soil fauna.

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Exploring thermophilic bacteria isolated from anhoni hotsprings of central India for plant growth-promoting potential on pigeon pea (*Cajanus cajan*)

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Keywords: Hot springs, thermophiles, plant growth promotion potential, biofertilizer

Introduction, scope and main objectives

In the present investigation, the main aim is to isolate, identify and characterize the efficient stress tolerant plant growth promoting bacterial isolates or consortium for improving the sustainable crop productivity and soil health.

Methodology

Sixty thermophilic bacterial isolates were isolated from Choti and Badi Anhoni Hot springs of Central India. Bacterial cultures were qualitatively tested for cellulolytic, lignolytic, proteolytic, lipolytic, amylase, phosphatase, siderophore and Indole Acetic Acid (IAA) production potential. Based on screening of isolates, six potential bacterial cultures were selected for plant growth promotion potential with pigeon pea (*Cajanus cajan*) (variety ICPH-87) as test crop. Pot culture experiment was performed with 8 treatments (T1:BAM3, T2:BAS11, T3:BAS17, T4:CAM1, T5:CAM-29-3, T6:CAS-5, T7:consortia, T8:control) and 3 replications under CRD design.

Results

It was also observed that bacterial culture treatment recorded significant enhancement in the root and shoot growth in comparison with control. Also, the study has demonstrated that the bacterial isolates possessing heat tolerance coupled with PGP properties.

Discussion

Thus, it could serve as efficient biofertilizer candidates for improving plant growth and production of pigeon pea under stress conditions.

Conclusion

It was concluded that the isolate CAM1 showed better crop growth followed by BAS11 and CAS5.

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Global soil nutrient and nutrient budget maps

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Keywords: digital soil mapping, soil fertility, pedometrics, nutrient balance, nitrogen, phosphorous, potassium, country-driven approach

Introduction, scope and main objectives

The global food supply chain is facing a number of challenges, including the impacts of climate change and the COVID-19 pandemic, as well as armed conflicts that have led to increased fertiliser prices. In order to address these issues, sustainable management of soil nutrients is essential. To this end, the Global Soil Partnership (GSP) of the UN-FAO has launched a global initiative called the Global Soil Nutrient and Nutrient Budget Map (GSNmap) initiative, which aims to map soil nutrient status and budget at a national level. The International Network of Soil Information Institutions (INSII) will be responsible for implementing this initiative, which will take place in two phases.

Methodology and results

The first phase will focus on generating baseline maps of various soil characteristics, including macro and micronutrients, organic carbon, cation exchange capacity, texture, pH, and apparent density. The second phase will involve the development of Nitrogen, Phosphorus, and Potassium budget maps. The GSNmap initiative will be carried out in a country-driven manner, with participating countries using a conventional digital soil mapping approach. The traditional method will involve the use of quantile regression forest modelling and repeated 10-fold cross-validation to assess uncertainty.

The expected results of the GSNmap initiative are the generation of several raster layers at a resolution of 250 m, covering the soil depth of 0-30 cm. These products include maps of total and available Nitrogen, Phosphorus, and Potassium, as well as cation exchange capacity, soil pH, texture, clay content, silt content, sand content, soil organic carbon, and bulk density. The acceptable age of the samples used to create these maps ranges from 2017 to 2022 for Nitrogen, Phosphorus, and Potassium, between 2000 and 2022 for soil organic carbon, and from 1980 to the present for the rest of the soil properties. These data products will be submitted as GeoTiff raster files and will be compiled to develop the global layer map.

Conclusion

Overall, the GSNmap project represents a crucial effort to better understand and manage soil nutrients on a global scale, with the ultimate goal of improving food security and sustainability in the face of ongoing challenges.

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Assessing nutrient management strategies in Mediterranean cropping systems under current and climate change scenarios

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Keywords: Agri-environmental impacts, climate change, EPIC model, GHG emissions, long-term sustainability, nitrogen fertilization, soil organic carbon, Water-Food-Energy Nexus

Introduction, scope and main objectives

Mediterranean basin is a recognized hotspot for climate change, that is expected to severely affect agricultural sector and food security. Important impacts caused by intensive agricultural farming systems are related to the reduction of soil fertility mainly due to several factors: loss soil organic matter (SOM), nitrogen (N), and agrobiodiversity, increase of soil erosion, water pollution, and greenhouse gas (GHG) emissions. The study aimed at promoting sustainable N fertilization strategies in a typical Mediterranean cropping system using a "Water Energy Food nexus" (WEF) analysis and a modelling approach. The WEF analysis was used to evaluate the interactions between natural environment and human activities, while EPIC model was used to predict the long-term performance (30-yrs) of fertilization strategies under current climate (baseline; BL) and near-future climate change (CC) scenarios on crop yields, soil organic carbon (SOC) stock change, NO_3^- leaching, and N_2O emissions.

Methodology

The study was carried out in a 20-ha private farm in central Italy, conventionally cultivated with a durum wheat - processing tomato rotation. A conservative strategy (CONS) - including compost, poultry manure, and introduction of fava bean as cover crop - was compared to the synthetic N fertilization (SYN) strategy (mineral N fertilizer, used as control). Primary and secondary data were collected at farm level and used both for WEF and modelling approaches. For the WEF analysis, specific agro-environmental, and economic indicators were selected. For the EPIC model, site-specific physico-chemical soil parameters, long-term daily weather data, and field operations were used for calibration and validation. Further details are reported in Vanino et al., (2018), Fabiani et al., (2020), and Di Bene et al., (2022).

Results

The WEF analysis showed an increase in environmental sustainability, by highlighting a significant reduction of energy use (both direct and indirect) in SYN compared to the CONS fertilization strategy. Considering the modelling approach, the predicted near-future climate scenarios compared to current climate showed that tomato yield under CONS increased by 9 percent, while in SYN it remained stable. Conversely, wheat yield both in CONS and SYN increased, but the average yield of CONS in the near-future climate was much lower than SYN (34 percent reduction). NO_3^- leaching followed the same trend of yield and decreased in the near-future climate in CONS. N_2O

emissions under CC were negligible or slight positive. Regarding SOC, the effect of CONS was always positive.

Discussion

The WEF findings showed difference between the marketable yields obtained with CONS and SYN strategies. For environmental sustainability, WEF results highlighted the high value of renewable energies compared to non-renewable ones. The findings from the 30-year CC simulations compared to BL indicated that future crop yield variations are influenced by changes in both temperature and precipitation patterns. The results indicate that the CONS fertilization strategies are influenced by environmental or productive aspects.

Conclusion

The WEF approach can increase the farms ´competitiveness by switching to a more environmentally friendly production process able to increase the efficiency of agricultural measures. The overall evaluation of the N fertilization strategy proposed as alternative, considering profitability and environmental factors, suggests that it is a good performance and a good option for farmers and for environmental purposes.

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Results from two national field experiment networks with maize and wheat: effects of enhanced efficiency nitrogen fertilizers on crop yields, greenhouse gas emissions, and soil organic carbon sequestration

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Keywords: Nitrogen use efficiency, urea, urease inhibitor, coated urea, N_2O emissions, soil organic carbon, Argentina.

Introduction, scope and main objectives

Nitrogen fertilizer losses decrease nitrogen use efficiency (NUE) and increase nitrous oxide (N_2O) emissions (IPCC 2019). The use of controlled release N fertilizers (CRNF), such as urease enzyme inhibitors (UI) and polymer coated urea (ULC), minimize N losses and increase the NUE. Little is known about the impact of CRNF sources on maize and wheat yields, on the C balance of fertilized soils, and on the overall net GHG emissions. In this work we analysed a database from a long-term fertilization network established on private farms covering about 35 Mha, (in charge of a private company). Our objectives were to answer the following questions: a) what is the impact of different CRNF on crop yields and NUE in maize and wheat?; b) What is the CRNFs impacts on GHG emissions per unit of N applied and per unit of produced grain? and c) What is the potential for offsetting emissions from agricultural soils with the different CRNFs?

Methodology

One hundred eighteen field experiments in 62 sites located in subtropical to temperate environments cultivated with maize (2005/06 - 2019/20), and 66 sites located in temperate and humid and semiarid environments cultivated with wheat (2005/06 to 2016/17) were analysed , to compare crop yields, greenhouse (GHG) emissions and SOC sequestration under conventional (urea 46 percent N) and CRNF (urease inhibitor [UI-eNeTotalR]; and controlled release urea polymer coated -ULC) N sources. GHG emissions (crop residues, SOC mineralization, N fertilizers, fuel combustion) were calculated using the IPCC Guidelines (IPCC, 2019). SOC sequestration was estimated with two carbon models: a) the AMG model (Clivot et al., 2019, and b) the Roth C model (Coleman et al., 1997). The results of the study were analysed by regression analysis and ANOVA using mixed linear models.

Results

Mean yields of unfertilized crops were 8 918 kg ha^{-1} in maize and 3 381 kg ha^{-1} in wheat, whereas in fertilized plots ranged 10 476 - 10 952 kg ha^{-1} in maize, and 3 930 - 4 391 kg ha^{-1} in wheat. Compared to conventional fertilizers, CRNF increased yields up to a 9.8 percent in maize and 4.5 percent in wheat. In both crops, 61 percent of GHG emissions (N_2O) were caused by N fertilizers, with an only minor contribution of fossil fuels by agricultural operations. SOC sequestration contributed to mitigate emissions from fertilisers in both crops: average CO_2 removals of -470 kg

CO_2-eq/ha and - 790 kg CO_2-eq/ha were estimated in fertilized treatments in wheat and maize trials, respectively. Compared with traditional fertilizers, EEF significantly ($P<0.05$) reduced net GHG emissions per area unit up to a 35 percent in wheat, and up to a 41 percent in maize. The intensity of GHG emissions was also e significantly ($P<0.05$) lower with ULC than with urea and UI in maize (0.12 vs 0.05 kg CO_2e kg grain-1) and in wheat (0.26 vs 0.15 kg CO_2e kg grain^{-1}), and were minimized when crop yields were higher than 7 800 kg ha^{-1} in maize and 4 200 kg ha^{-1} in wheat.

Discussion

As expected, N fertilizers significantly increased maize and wheat yields. Between the CRNF sources analysed, the ULC had better performance than urea, since it not only had lower direct and indirect N_2O emissions, as well as UI (IPCC, 2019), but also had significantly higher crop yields than the other sources. This determined a lower intensity of GHG emissions with ULC. This better yield performance should be attributed to lower N losses and higher NUE. Because of the higher crop yields, and increased C residue inputs to soils, SOC models showed that soils were mostly a carbon sink in maize (93 percent of experiments), and in wheat (76 percent of experiments).

Conclusion

GHG emissions were decreased by about 15 percent by CRNF. ULC showed the lower GHG intensity (CO_2e per kg grain) across most experiments in maize and wheat.

N fertilizers were highly effective to offset GHG emission in maize (93 percent cases) and to a lesser extent in wheat (76 percent cases).

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Symbiotic properties of soybean rhizobia isolated from soils of the Nigerian Sudan savanna

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Keywords: rhizobia, symbiosis, soybean, variety, nitrogen, inoculation, effectiveness, nodulation

Introduction, scope and main objectives

Soybean is one of the most important legume crops that form symbiosis with native rhizobia (Zhang et al., 2011). The distribution, abundance and nitrogen-fixing efficiency of soybean rhizobia are strongly related to genotypes or cultivars of soybeans (Saeki et al., 2008). Many soils contain native rhizobia while at other times, desired rhizobia strains can be indirectly introduced as inoculants to the soil or plants to add nitrogen from the atmosphere to the soil in order to improve soil fertility. Response to such inoculations are often times challenged by host-strain limitations. Hence the need to screen native rhizobia on the basis of effective symbiosis for use in inoculation program . The objectives are to: 1. assess growth and nodulation characteristics of specific soybean varieties 2. quantify the amount of nitrogen fixed through their symbiotic effectiveness (percent)

Methodology

The rhizobia isolates used for the study were obtained from Amawa and Karaye soils while the study was conducted in Minna, Nigeria.

Clean seeds were planted at the rate of 4 seeds per poly pot containing sterilized sand watered with 100ml of Calcium solution (Sandsman, 1970). At one week after planting, seedlings were thinned to two prior to application of 3 varietal treatment (TSB4810, TGx1998-2E, TGx1904-2E) and 9 Nitogen source treatments (rhizobia inoculant USDA110, and rhizobia isolates Am2, Am5, Am2-4, Am6-1, Kr3-4, Kr5-2 at 5ml per plant), urea at 100 kg N ha-1 and Control at 0 kg N ha-1). All treatments were replicated 3 times and arranged in Completely Randomized Design (CRD). Watering with nutrient solution at a day interval continued till harvest at 5 weeks after planting. All data were subjected to ANOVA

Results

Association of the varieties with inoculant USDA110 produced the highest nodule numbers and also produced the lowest shoot biomass for TGx1998-2E.

TSB-4810 and Tgx 1998-2E association with isolate kr3-4 produced their heaviest shoots of 0.81 and 0.87g respectively and their highest percent symbiotic effectiveness of 96.6 percent and 64.3 percent respectively while Tgx 19o4-6f association with isolate Am6-1produced its heaviest shoots of 1.01 g and the highest percentSE of 101 percent .

Discussion

Inoculant USDA110 with the highest nodule number produced the lowest shoot biomass on TGx1998-2E suggesting that there was a negative effect on vegetative growth when plants formed too many nodules as the nodules served as nutrient sinks. The best soybean-rhizobium symbiosis that will eliminate the use of inorganic fertilizer completely will arise from the association of TGx1904-6F with Am6-1(Saeki et al., 2008). However, since soybean ideally needs an external supply of inorganic N within 20 – 30 Kg N, association that permits symbiotic effectiveness within the range of 70 to 80 percent should be encouraged (Adjei et al., 2002).

Conclusion

In summary, any association resulting from shoot biomass accumulation that is not significantly higher than the shoot biomass of the control should be considered ineffective even if their percent SE is presumably high and should be discouraged. In view of that, all the rhizobia associations with TSB4810 and TGx1998-2E should be discouraged while all TGx1904-6F associations with rhizobia except Kr5-2 should be encouraged and selected for further evaluation on the field.

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Theme 2
Sustainable soil management for food security and better nutrition: The nutrients we need are in soils!

Biofortification of rice with iron and zinc using indigenous micronutrient mobilizing beneficial rhizobacteria

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Keywords: soil, micronutrient deficiency, hidden hunger, rice, biofortification, PGPR

Introduction, scope and main objectives

Soil phyto-available micro and macro nutrients adversely impact crop nutrient productivity as well as soil nutritional quality and human health. Indiscriminate inorganic fertilizer and pesticide use has led to deterioration of soil physio-chemical properties, nutrient leaching, water pollution, soil acidification or alkalization, floral and faunal diversity loss, increased pest and disease attack, thus impacting ecosystem services. Micronutrient-deficient soils are widespread worldwide as million hectares of land are deficient in one or more micronutrients. In India soil micronutrient deficiency such as sulfur (S), zinc (Zn), boron (B), iron (Fe), copper (Cu), and manganese (Mn), has remarkably increased in recent years. The major reasons attributed to this problem is due to application of high levels of NPK fertilizers with lower micronutrients ratio, use of fertilizer responsive high-yielding varieties, increased cropping intensity, and less or no use of organic manures. Majority of these micronutrients are essential for plant growth and development; non-availability at recommended levels critically impacts grain nutrient productivity. The available Zn is less in sandy, alkaline and calcareous soils with high content of calcium carbonate. The poor availability of zinc is caused by water logging due to a relatively high pH, elevated concentrations of ferrous, bicarbonate, and phosphate ions, as zinc is present in an insoluble form of sulphide (ZnS). Iron deficiency is most common in calcareous and other alkaline soils with a pH >7.5. Due to the conversion of ferrous form of iron (Fe2+) into less available ferric form (Fe3+) under drought or moisture stress conditions, the concentrations of available Fe is reduced, and is also often linked to high concentrations of P, NO3-N, and organic matter conc. A lack of phyto-available micronutrients Zn and Fe in the soil not only impacts crop micronutrient productivity but also human health. Thus, consumption of plant-based diets has led to high prevalence of micronutrient deficiencies in human populations due to low bioavailability of micronutrients. Micronutrient deficiency referred to as “hidden hunger”, has clinical presentations like stunted growth, fatigue, weakness, shortage of breath and dizziness, etc. impacting more than two billion people worldwide. This also has led to significant economic loss to the tune of 2.4 percent of India’s gross domestic product (GDP). Hidden hunger is reported to affect one third of the global population, predominantly in developing countries that depend on cereal based diets such as rice. The micronutrients are essential for multiple functions of the plants; but due to the various complex chemical reactions taking place within the soil, the availability is ultimately controlled by the interaction between the soil solution, root exudates, soil organic matter exchange, and also the complex insoluble micronutrients. However, micronutrient deficiencies in the context of soil–crop relations are increasingly gaining importance. Rice (*Oryza sativa* L.) cultivated over 100 and odd countries is a primary staple food that feeds over 50 percent of the world's population, and provides 21 percent of the energy and 15 percent of the protein needs of the human, but lacks essential micronutrients. In cereals, the micronutrients content can be enhanced through biofortification either by plant breeding methods or by using micronutrient mobilizing PGPRs that play a vital role in soil processes and enhances micronutrient availability by various mechanisms. Hence, the present study focuses on biofortification of the rice by i) Isolation and identification of indigenous Fe and Zn mobilizing PGPR from rice rhizospheres ii) Determining the Fe and Zn mobilization efficiency of these isolates under in vitro and in vivo conditions and iii) Estimating the increase in Fe and Zn content in rice grains treated with these potential isolates

Methodology

Rhizosphere soil samples were collected from rice fields of 12 different varieties viz., ADT37, ADT45, ADT43, ASD16, IR50, IR37, CO51, Vellai kar, Andhraponni, IR32, Vellai Ponni and Sona Masuri of Villupuram, Cuddalore and Dharmapuri districts of Tamil Nadu, India. The soil physicochemical properties of the rhizosphere samples were analysed including the micronutrient content. The Zn and Fe mobilising bacteria were isolated from these samples using different media. The positive isolates were identified based on 16S rRNA sequence analysis, Zn and Fe mobilising potential was quantified through AAS (Atomic spectroscopy). The selected isolates were tested for their compatibility, micronutrient mobilising efficiency and enhancing the grain Zn and Fe **content in rice was determined by pot assay under greenhouse condition.**

Results

The soil available Zn ranged between 0.44 to 7.17 ppm and Fe, 30 to 135 ppm. About 41 Fe and Zn mobilizing bacterial isolates were isolated. The highest Zn solubilisation of 1259 ppm was observed in ZnO by isolate MSSRFCCAD1; 614 ppm in Zn3(PO4)2 by isolate MSSRFCCIR28, 854 ppm in ZnSo4 by isolate MSSRFCCAP3 and 474 ppm in ZnCO3 by isolate MSSRFCCAD7, compared to control with 151 ppm in Zn3(PO4)2, 179 ppm in ZnCO3, 39 ppm in ZnO and 291 ppm in ZnSO4 respectively. Among the 21 potential Fe solubilisation isolates maximum solubilization was observed with *B. velezensis* MSSRFCCAD7 (0.1 ppm) and minimum in *S. marcescens* MSSRFCCAP1 (0.61 ppm) compared to control (0.89 ppm). Among the 41 total isolates, 21 isolates exhibited PGPR traits such as solubilization of Zn, P, K, Fe and IAA production. Based on 16S rDNA sequence analysis the isolates MSSRFCCAD7, MSSRFCCAD5 were identified as *Bacillus velezensis* and *Bacillus s*afensis respectively; MSSRFCCAD1, MSSRFCCIR26, MSSRFCCVK1, MSSRFCCIR8, MSSRFCCAD17 and MSSRFCCAP28 as *Pseudomonas aeruginosa*; MSSRFCCIR13, MSSRFCCAP1, MSSRFCCAD2 and MSSRFCCCO5 as Serratia marcescens; MSSRFCCAS11 as *Serratia nematodiphilia* MSSRFCCCO1; MSSRFCCWP6 and MSSRFCCIR27 as *Enterobacter cloacae, Enterobacter huaxiensis* and *Enterobacter mori* respectively; MSSRFCCIR21 and MSSRFCCAP3 as *Acinetobacter junii*; MSSRFCCIR28 and MSSRFCCIR27 as *Stenotrophomonas maltophilia*; MSSRFCCAP6 and MSSRFCCIR1 as *Staphylococcus* sp. and *Tsukamurella inchonensis* respectively. A consortium of 2 isolates MSSRFCCAD5 and MSSRFCCAD7 from native rice rhizosphere and two non-native isolates MSSRFD41 from finger millet and MSSRFCCN83 from groundnut rhizosphere were found to be compatible. Zn and Fe biofortification using either single isolate or consortia in 10 treatments in ADT37 rice variety revealed a relative increase in shoot and root length in all the treatments T1 to T9 compared to control -T10. Among the treatments consortia application (T7) showed maximum plant biomass of 0.97 g, (0.1-0.6 g in all others treatments), shoot length of 70.7 cm and significantly higher 100 seed weight and increase in Zn and Fe content in rice grain. Among the single isolate treatments, *Bacillus safensis* MSSRFCCAD5 (T1) showed comparably better performance.

Discussion

In the present study the use of PGPR were evaluated as individual as well as consortia for biofortification of micronutrient Fe and Zn in rice grains. Indiscriminate use of chemical fertilizers has driven to macro and micro nutrients deficiency in soil. It is a known fact that there is an intricate networking between soil, plants, and microbiomes of soil and plants that is responsible for crop productivity and soil fertility, hence including microbes as one of the components to address soil nutrient deficiencies needs to be explored in-depth. The application of consortium of micronutrient mobilising bacterial isolates exhibited ability to mobilize Fe and Zn as determined by qualitative and quantitative analysis and showed promising nutrient yield enhancement. Thus microbe mediated biofortification can be achieved through the synthesis of siderophores, organic acids and exopolysaccharides by the PGPR strains which enhances the uptake of micronutrient by plants and accumulation in grains. Microbe mediated biofortification can have a strong impact on minimizing mineral fertilizer use for achieving enhanced crop nutrient yield, soil fertility and sustainable agriculture. The inoculants application either as individual, or as consortia form, showed their potential for improving Zn and Fe contents in rice grains.

Conclusion

The present study confirmed microbe mediated biofortification can be adopted as one of the approaches for micronutrients fortification in shoot and grains of rice. Application of bio-inoculants, encompassing either individual or consortia led to an enhancement in the plant growth parameters, besides enriching rice grains ’nutritional status. A consortium of *Bacillus velezensis* MSSRFCCAD5, *Bacillus safensis* MSSRFCCAD7, Pseudomonas sp. MSSRFD41 from finger millet and MSSRFCCN83 from groundnut rhizosphere enhanced the micronutrient Fe and Zn in rice grains. These approaches can be a suitable option for the biofortification of Fe and Zn in rice grains, a staple food grain to address the malnutrition deficiency of majority of the population globally. But, monitoring over time is essential to understand the rate of micronutrient depletion of soils. Research on the availability of micronutrients in inundated paddy soil is essential.

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Biofortification of romaine lettuce (*Lactuca sativa* l.) on soils treated with zeolite chabazite and magnesium sulphate for better nutrition and sustainability

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Keywords: biofortification, functional foods, sustainable management, chabazite, soil fertility, human nutrition, human health

Introduction, scope and main objectives

Lettuce (*Lactuca sativa L.*) constitutes a very numerous varietal group. It is an important food source, one of the most popular vegetables in the world, and has low-calorie content, around 15 kcal/100g. It contains important nutrients such as Ca, P, K, Mg, Mn and Fe, essential in the diet and has many properties for health (digestive, circulatory, etc.). Italy is a large producer, consumer and exporter of lettuce, (Aromolo *et al.* 2019.). Mg is one of the most important trace elements for the human body, present in greater concentration in bone and muscle tissue. It is essential because it allows energy to be produced from food and is an integral part of numerous processes, including the transmission of nerve signals, the control of heartbeat and blood pressure and protein synthesis. Mg reduces the sense of fatigue, ensures the correct functioning of the skeletal system, improves psychic balance. Its daily requirement is around 350 mg in adults. Specific dietary supplements rich in Mg are currently widely used, (Pinotti *et al.* 2021.).
In this work, a study case is presented, referred to the biofortifying of romaine lettuce in magnesium using an amendment with chabazite zeolite combined with magnesium sulphate. The work aims to obtain a functional food, easy to grow, with a low caloric value and with a better value nutritional as it is richer in Mg. In this way, sustainable management of soil fertility for crops and human nutrition is promoted.

Methodology

The pot trial was conducted in a greenhouse at the CREA-IT experimental Centre (Monterotondo - RM), near Rome (42° 05' 50" N, 12° 38' 03" E), using a calcaric cambisols soil (pH 7.9) and lasted about six weeks. The vegetable is Roman lettuce (*Lactuca sativa,* var. longipholia Janchen). The zeolite used is a chabazite from Sorano, Piandirena (GR), Italy, (42° 41 '25" N, 11° 44 '33" E), milled and sieved at Ø 0.6 - 2 mm. Magnesian fertilizer is a salt of K and Mg. To investigate the main effects and interactions of the studied factors (Zeolite and Mg fertilizer), a full factorial experiment was adopted using a two-factors design combining 3 Zeolite levels (0, 2, 4 kg m-2) and 3 Mg fertilizer levels (0, 30, 60 g m-2). The 9 factorial combinations (treatments) were replicate in 4 randomized blocks (n. 36 pots in total). Before transplanting the lettuce, all treatments were distributed in the pots and carefully mixed to the 0 - 15 cm layer of soil.

The following were assessed on lettuce: biometric parameters (fresh weight, height of the plant, number of leaves, LAI, root system), chlorophyll, N, nutrients, including Mg.

Results

The Results showed significant differences in the parameters considered between the theses.

Discussion

Based on the results of our study, the importance of using chabazite as an amendment of natural origin is confirmed. Zeolites possess peculiar properties: they increase water retention of the soil, concentration of nutritional elements in the area adjacent to the root systems, exchange capacity and aeration of the soil. Their use, therefore, has positive ecological and economic effects, (Ramesh and Reddy, 2011).

Conclusion

Globally, there are phenomena of nutritional deficiencies in humans and animals which can be filled with functional foods. The study will provide agri-food indications to stakeholders on how soil fertility supports better production, better nutrition, a better environment for a better life.

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Biofortified maize in Zimbabwe: nutritional quality depending on field position and crop management

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Keywords: hidden hunger, vitamin A deficiency, agronomic biofortification

Introduction, scope and main objectives

Genetic and agronomic biofortification of maize offers an intermediate intervention to reduce nutrient deficiencies in target beneficiaries, especially women and young children. Provitamin A (PVA) maize with an increased concentration of α-carotene, β- carotene and β-cryptoxanthin has been developed and released in southern Africa since 2012. But research gaps remain in how the nutritional quality of PVA maize is affected by the farming environment and agronomic management. In Zimbabwe, farmers have several fields on which they grow maize. Homefields are those fields close to the homestead where manure, organic amendments, ash, mineral fertiliser and labour are preferentially invested. Fields further away from the homestead are referred to as outfields, often receiving less or no inputs. Over time the concentration of nutrient resources in homefields and nutrient depletion in outfields can **Result** in a gradient of soil fertility with distance from the homestead.

Methodology

To investigate the effect of field position on nutritional quality of maize, we conducted a study in the Murehwa district of Zimbabwe to quantify the PVA concentration across a soil fertility gradient. Control and PVA maize varieties were planted in home and outfields of 60 farms. Fertilizer inputs were identical for all fields and corresponding to the average level used by the households in this area. Soil chemical properties and grain micronutrient content were quantified at harvest. A food monitoring survey, conducted in the same district in parallel to the field experiments, confirmed the prevalence of vitamin A deficiency in our target population, regardless of farm typology and in both, the main and offseason.

Results

There was a trend for less favourable conditions of soil fertility indicators between the homefield and outfield, but only few of these differences were significant. In average, homefields had a less acidic soil pH and more plant available P (Olsen P), Ca and Zn (Mehlich 3), but there was no difference in e.g. soil organic carbon. However, even these small differences cause significantly lower grain yields on outfields (2.72 t ha^{-1}) versus homefields (3.37 t ha^{-1}) across all hybrids tested. And PVA hybrids yielded in average lower (2.86 t ha^{-1}) than the commercial control hybrid (3.35 t ha^{-1}) and a quality protein hybrid tested (3.06 t ha^{-1}). The PVA content in our on-farm trials was slightly lower than that under optimal management conditions on research stations, but this difference was substantially greater on outfields which had the lowest yield and PVA content. The PVA hybrids ZS244 A and ZS500 proved to be popular with farmers and rated highly in terms of taste, nutrition and early maturing characteristics while the QPM variety Mama scored poorly with respect to yield and vulnerability to pests and diseases.

Conclusion

We concluded that PVA maize can contribute to a better nutrition of smallholder farmers, even when grown under farmers management. However, PVA maize on homefields is more likely to reach the PVA concentrations necessary for the projected nutritional intakes. And women, who generally are the custodians for food security at the household level, farm outfields more often than male plot managers. In addition, there were significant gender differences in agronomic management practices at both the plot manager and household head level. In contrast to previous studies in Zimbabwe, higher fertilizer use was found to be predictive of female managed plots but they had less access to manure.

Acknowledgements

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Can cobalt-ferrite nanoparticles be an alternative fertilizer for the agronomic iron fortification of wheat?

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Keywords: nutritional security, biofortification, micronutrient deficiency, precision nutrition

Introduction, scope and main objectives

Producing food with better nutritional quality is a growing demand, and due to the COVID-19 pandemic and global change, it augmented. Data show that between 2019. and 2020, the world's undernourished population increased from 8.4 percent to 10 percent, while iron deficiency (a form of hidden hunger) is the cause of 12.5 percent of anemia cases worldwide. The principal causes of iron deficiency are the intake of foods low in iron and restricted iron absorption from diets rich in phytates. Under this frame, developing iron biofortified staple crops is a feasible approach to combat micronutrient malnutrition without changing the entrenched consumption patterns of the population. Agronomic biofortification is an economical and short-term solution. It represents an advantage over breeding programs. Therefore, using nanomaterials in agriculture may improve the efficacy of agricultural inputs while reducing environmental pollution and saving labor costs. Therefore, this research aimed to explore the use of citrate-coated cobalt ferrite ($CoFe2O_4$) nanoparticles (NPs) as an iron source for the fortification of wheat.

Methodology

We conducted a pot experiment in an open greenhouse from April to September 2021. A clay, moderate alkaline soil was used. The Fe bioavailable concentration in soil was 3.23 ± 0.31 mg kg^{-1}. Three wheat lines were tested. Two lines differ in their efficiency on grain Zn- store (efficient and inefficient), and one is inefficient on P-absorption. The NPs were supplied by foliar (330 mg Fe L^{-1}) or soil addition (46 or 68 mg Fe kg^{-1}). Foliar fertilization was done four times at 5.5, 5.9, 6.0, and 7.3 on Zadoks ’scale. While the soil fertilization was performed before wheat seed sowing. A treatment with Fe-EDTA salt, a conventional iron fertilizer, was also tested to compare the NPs effect. Moreover, a control treatment without any fertilization was included.

Results

Soil fertilization with NPs improved the wheat grain yield and iron-grain concentration compared to the foliar addition of NPs and Fe- EDTA. Soil NPs treatment at 68 mg Fe kg^{-1} increased the iron concentration in grains by 96 percent and 72 percent more than the control and soil Fe-EDTA treatment, respectively. Furthermore, in the soil NPs treatment (68 mg Fe kg^{-1}), the phytic acid concentration in grains and the phytic acid:iron ratio decreased by 5.7 percent and 62 percent, respectively. Additionally, plants fertilized with NPs (68 mg Fe kg^{-1}) had 1.37 (Zn-store inefficient line) and 0.26 (P-uptake inefficient line) folds higher iron-grain concentration than the target biofortification concentration (60 g kg^{-1}).

Discussion

Our research shows that using this iron-nanofertilizer may be a promising approach and an effective tool for wheat biofortification. These NPs had advantages over a conventional fertilizer, such as improving crop yield and nutritional quality. Therefore, NPs may improve the sustainability of current agricultural practices due to their use in low amounts and efficient effects.

Conclusion

Citrate-coated cobalt ferrite NPs may be an alternative fertilizer for iron biofortification; however, further research should ensure they are safe for users, the environment, and food consumers.

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Effect of zinc and iron biofortification on profitability and productivity of chickpea (*Cicer arietinum* l.) varieties

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Keywords: biofortification, profitability, iron, productivity, zinc

Introduction, scope and main objectives

Zinc involved in the root nodulation of plant and enables to the pulse crops to fix inert nitrogen in the root nodule. It is also participating in the signal transduction during stress condition in the plant system. conducted trial at IARI, New Delhi and found that chickpea productivity was declined due to deficiency of micronutrient particularly by zinc. Iron (Fe) plays an important role in chlorophyll synthesis and act as structural component of hemes, hematin and leghaemoglobin involved in the nitrogen fixation in pulses catalysed by an enzyme called ‘nitrogenase ’. Moreover, iron is the most essential micronutrient for plant growth especially for chickpea grown on saline and alkaline soils.

Methodology

A field experiment was comprised with two varieties namely GNG-1581 and RSG-974 in main-plots and seven fortification treatments included various doses and modes of application of zinc (Zn) and iron (Fe) were assigned to sub-plots. In this way, the experiment had fourteen treatment combinations and replicated three times in Factorial Randomized Block Design (FRBD) that makes forty two plots in total. The treatments were allocated randomly to different plots by using the random number table (Fisher and Yates, 1963).

Results

Chickpea variety RSG-974 have higher number of pod/plant (41.55) and 100 seed weight (14.45g) however, number of seeds/ pod (1.99) was higher with variety GNG-1581 which resulted higher seed yield (1 539 kg/ha.) stover yield (2 863 kg/ha.) and biological yield (4 402 kg/ha.) in variety GNG-1581 as compared to variety RSG-974. Similarly, monetary advantages in terms of gross return (89 330/ha), net return (62 905/ha) and B: C ratio (3.38) were higher with GNG-1581. Among different biofortification treatments, number of pods/plant (45.16), number of seed/pod (2.18) and 100-seed weight (15.98 g), seed yield (1 827 kg/ha), stover yield (3 449 kg/ha), biological yield (4 876 kg/ha) and harvest index (37.47 percent) were maximum under application of ZnSO4 @ 25 kg/ha (SA) + 0.5 percent FeSO4 (FA) over rest of the treatments. Similarly, gross returns (104 327 and 94 122/ha), net returns (77 648 and 67 491/ha) and B: C ratio (3.91 and 3.53) were also higher under the application of ZnSO4 @ 25 kg/ha (SA) + 0.5 percent FeSO4 (FA) followed by ZnSO4 @ 25 kg/ha (SA) + 0.5 percent ZnSO4 (FA).

Discussion

Agronomic biofortification of zinc and iron produce marked variations on cost of cultivation, gross return, net return and B:C ration in the year of study. It was noticed that application of ZnSO4 @ 25 kg/ha (SA) + 0.5 percent FeSO4 (FA) in chickpea fetched higher monetary advantages with respect to gross return (1 04 327/ha), net return (77 648/ha) and B: C ratio (3.91) during economic analysis.

Profitability of any treatments is directly correlated with the yield obtained and expenditures incurred on cost of crop production during the investigation. The trends revealed that application of $ZnSO_4$ @ 25 kg/ha (SA) + 0.5 percent $FeSO_4$ (FA), which not only recorded slightly lower cost, but also produced significant quantity of grain and stover as compared to that noticed under various treatments fertilized with zinc and iron.

Conclusion

Economic feasibility with respect to gross return (89 330/ha), net return (62 905/ha) that correspondingly improved B: C ratio (3.38) were fetched by the growing of chickpea varieties GNG-1581 as compared to variety RSG-974, which recorded satisfactory amount of gross return (76 968/ha), net return (50 544/ha) and B: C ratio (2.91) during investigation.

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Evidence of micronutrient fertilizer effect on agronomic fortified tef under different landscape positions in Amhara region

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Keywords: biofortification, contrasts, Ethiopia, landscape position, Selenium, Zinc

Introduction, scope and main objectives

Agronomic fortification using mineral and organic nutrient resources to improve micronutrient concentration in staple crops is a potential strategy to promote production and access of micronutrient-dense foods at farm-level. Most on-farm experiments with iodine (I), iron (Fe) selenium (Se) and zinc (Zn) fertilizers were conducted under uniform field landscape positions. Here, we test effects of Zn and Se containing fertilizer on grain Zn concentration of tef (Eragrostis tef Zucc.) grown under different field landscape positions and with different micronutrient fertilizer application methods; in Western Amhara region of Ethiopia.

Methodology

Field experiments with tef were established under three landscape positions (hill-, mid-, and foot-slope) at two sites over two cropping seasons (2018, 2019). Treatments were:

1 Standard recommendation + Urea (Control)
2 Standard recommendation + Urea + Basal Zn (25 kg ZnSO4.7H2O ha^{-1})
3 Standard recommendation + Urea + Basal Zn + Foliar Zn (12.5 kg ZnSO4.7H2O ha^{-1}) + Foliar Se (20 g sodium selenate ha^{-1})
4 Standard recommendation + Urea + Basal Zn + Side dressing Zn
5 Standard recommendation

At each field, one replicate per treatment was established Resulting in 300 sites. Grain samples were analysed for multi-elements using the microwave digestion method. The effect of the 5 treatments, with 4 degrees of freedom were partitioned into four orthogonal contrasts (C) using R:

C1: No Zn input vs Zn applied
C2: Soil vs Soil + Foliar application
C3: Basal vs Basal + Side dressed
C4: Control vs 1⁄3 Standard recommendation

Results

Zinc fertilization and method of application had significant effects on grain Zn concentration. Zinc application significantly increased grain Zn concentration (C1; P<0.001) compared to treatments without Zn. The application of basal and foliar Zn fertilizer significantly increased tef grain Zn concentration compared with treatments receiving basal Zn fertilizer alone (C2; $P<0.001$). Similar effects were observed when basal Zn + side dressing was applied (C3; $P<0.05$). When no Zn fertilizer was applied, there was a larger Zn concentration in tef grain at 1⁄3 standard fertilizer application rate compared to the standard recommended rate (C4; $P<0.01$). No evidence of significant landscape effect ($P>0.05$) or interaction thereof, with treatment on grain Zn concentration was reported.

Discussion

To our knowledge, our findings are the first to test effects of agronomic biofortification on tef and explicitly show effects of Zn and N fertilizer and Zn application method on grain Zn concentration of tef grown under different field landscape positions. The application of basal and foliar Zn fertilizer yielded the highest tef grain Zn concentration of up to 34 mg kg^{-1}. Lower N rate Resulted in higher grain Zn concentration compared with standard recommended rate. While Ethiopia is characterized by fields on variable topographic positions, our initial findings from Western Amhara indicate that Zn and N fertilizer application, and not landscape position, are important in improving grain Zn concentration of tef grown with different Zn fertilizer application methods.

Conclusion

Targeting of micronutrient fertilizer application in ongoing agronomic biofortification interventions is unlikely to be influenced by field landscape position but more so by micronutrient and N fertilizer application, and method of micronutrient fertilizer application.

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Foliar zinc fertilisation in soybean

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Keywords: *Glycine max*, micronutrients, mineral nutrition, plant analysis, threshold

Introduction, scope and main objectives

Zinc deficiency in humans Results from the low soil Zn availability and the consequent Zn deficit in staple food crops (Cakmak *et al*., 2017). It is estimated that about one-third of cultivated soils globally contain low amounts of available Zn (Alloway, 2008). Zinc deficiencies have become widespread in soils from the Argentine Pampas Region (RPA) (Sainz Rozas *et al*., 2019.). In this region, soybean (*Glycine max L.*) is the main crop, occupying more than half of the total cropped area. However, limited information is available regarding the effectiveness of foliar Zn fertilization for improving soybean Zn grain concentration. The aim of this study was to assess the response of soybean grain yield and Zn grain concentration (ZnCg) to foliar Zn application and evaluate the use of ZnCg as a Zn complementary diagnostic tool in soybean.

Methodology

Ten soybean field experiments were carried out in 2017 and 2018 on Haplustol soils from Córdoba province (Argentina), using a randomized complete block design with four replications. The DTPA extractable Zn (Zn-DTPA) ranged from 0.29 to 2.91 mg kg^{-1}. Two treatments were evaluated: control (without Zn) and foliar Zn fertilization at vegetative growth stage 8 (V8) (700 g ha^{-1}). Soil samples (0-20 cm) were collected at planting and edaphic proprieties were determined. At physiologic maturity, grains were harvested and the ZnCg was determined by atomic absorption spectrophotometry after nitroperchloric digestion. The critical threshold (CT) was determined by the arcsine-logarithm method.

Results

Zinc foliar fertilization at stage V8 increased yield in 50 percent of sites. The average yield response was 0,51 Mg ha-1 in responsive sites. The grain Zn content ranged from 19.8 to 43.5 mg Zn kg^{-1} (average: 33.54 mg kg^{-1}). A significant site*fertilization interaction on ZnCg was observed. However, the effect of Zn fertilization on ZnCg was inconsistent. Zinc foliar application increased in ZnCg only in two sites. The CT for ZnCg was 36,1 mg kg^{-1} (ranging from 32.3 to 40.4 mg kg^{-1}), and 70 percent of the sites were below that threshold.

Discussion

Our results indicate that the used Zn rates would be insufficient to significantly increase ZnCg. Since Zn fertilization increased grain production at all sites, there might have been a Zn dilution on grains resulting from the low translocation of Zn from vegetative to reproductive organs.

Conclusion

Plant analysis was an adequate diagnostic method that provided information on the Zn status and can be used to complement soil tests. Zinc grain content analysis was useful for diagnosing Zn deficiency and allowed the generation of critic threshold for diagnosis in soybean.

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Influence of mobile iron forms on the fertility of meadow alluvial soil

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Keywords: mobile form of iron, field pea, meadow alluvial soil

Introduction, scope and main objectives

Soil is the main source trace elements for plants. Quantity trace elements in soils determined them content in original maternal breed. Also amount trace elements determined influence soil-forming process on their further redistribution. Absorption trace elements soils depends on particle size distribution, reaction soil solution, redox capacity soil, content humus and carbonates, capacity absorption and water regime conditions. Trace elements play important role in biochemical processes how plants and soil but heavy metals in excess MPC levels are applied harm (Chukov, 2002). The provision of plants and saturation of forage grasses of trace elements depends not only on the content in the soil, but also on the presence and interaction with other biogenic elements in the soil environment. Iron is typomorphic element of hydromorphic and semihydromorphic soil floodplains, which renders conspicuous influence on behavior and conditions trace element food meadow legume herbs. The purpose of the study is to establish the nature of the impact on growth and development legumes plants mobile forms of iron in the alluvial meadow soil of floodplains.

Methodology

TThe arable layer meadow alluvial light loamy soil of floodplains of Merla river of Krasnokutsky district Kharkov areas is explored. Options soil: pHaq. – 7.4; content movable form elements nutrition: N-NH4+ – 12.3 mg/kg, N-NO3- – traces, P2O5 – 21.3 mg/kg, K2O – 110.9 mg/kg; content humus - 6.0 percent, average content physical clay (particles less than 0.01 mm) – 28.74 percent. Test plant – pea field variety "Flora". Ferrous sulfate was applied at a dose of 200 mg/kg of soil. Content trace elements was determined by the atomic absorption method on a Saturn-4 spectrophotometer. Experiment scheme: control without fertilizers, N60P60K60, N60P60K60+Fe.

Results

Content gland is 32.4 mg/kg in the control variant in the meadow alluvial soil. Content trace element several decreased when making N60P60K60, and when making additional doses iron content – increased in the soil to a level of 43.3 mg/kg. Increased amount iron in biological mass plants peas – 1 247 mg/kg dry masses formed due to soil application – sulfate iron. Decrease quantity iron in plant weight in comparison with the control without fertilizers was recorded when N60P60K60 was applied to the soil. Also, when entering gland arises phenomenon twisting leaves, and the height plants at 2.8 cm was less than in control. In addition, the mass plants decreased compared to control option for 9 percent in green mass and 28 percent – in dry mass. Increase biological masses plants in general occurs when making N60P60K60.

Discussion

Knowledge of the patterns of influence of nutrients in the general regime of mineral nutrition of plants in specific conditions makes it possible to assess the characteristics of edatope. Lack of knowledge on the impact of compounds of available forms of iron, especially on soils that are subject to periodic waterlogging and accumulation of available compounds of iron do not allow effective use of soil potential and micronutrient fertilizers.

Conclusion

It was found that excessive content mobile iron in the meadow alluvial soil floodplains leads to inhibition of growth and development peas and the growth of its quantity in the biological mass.

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Linking adsorption-desorption characteristics with grain Zn concentrations and uptake by teff, wheat and maize in different landscape positions in Ethiopia

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Keywords: soil Zn, grain Zn, cereals, Zn application, East Africa

Introduction, scope and main objectives

The retention and release potential of Zn in soils affects its availability and subsequent uptake by crops and is associated with soil parameters that differ between landscape positions. This study aimed at understanding soil factors influencing Zn uptake and grain Zn concentrations of crops grown in a landscape position.

Methodology

Zinc potentially available for crop uptake was estimated from previously published adsorption-desorption data. Data on grain Zn concentrations and uptake by crops was used from on-farm experiments on teff, wheat, and maize in the West Amhara region, Ethiopia. Three landscape positions, five farms as replicates in each landscape position, were involved in this study. Zinc fertilizer applied at planting (basal), basal plus side-dressing, and a control with no Zn fertilizer applied treatments were considered. The on-farm experimental design was Randomized Complete Block Design (RCBD) with farmers as replicates in each landscape position.

Results

Soils with higher soil pH, Soil Organic Carbon (SOC), and clay content (typical of footslope landscape position) tended to adsorb more Zn applied as fertilizer and resulted in lower Zn uptake and grain Zn concentrations than soils from lower soil pH, SOC, and clay contents (typical of upslope landscape position).

Discussion

NETSOIL Zn computed based on the amount of applied fertilizer along with soil pH and SOC through estimating the amount of adsorbed and desorbed Zn explains the variations in the actual grain Zn concentration in the crop. Together, these three factors explained 37–49 percent of the observed variation in grain Zn concentration.

Conclusion

In landscape positions where Zn adsorption is low, agronomic biofortification with Zn uptake is likely to be more effective. Wheat and teff seem to be more efficient than maize in accumulating Zn from the soil in the grain. Knowledge of soil properties and crop characteristics can help to determine where agronomic biofortification can be effective and when foliar applications are the better approach.

Acknowledgements

In landscape positions where Zn adsorption is low, agronomic biofortification with Zn uptake is likely to be more effective. Wheat and teff seem to be more efficient than maize in accumulating Zn from the soil in the grain. Knowledge of soil properties and crop characteristics can help to determine where agronomic biofortification can be effective and when foliar applications are the better approach.

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Manganese management in different soils in relation to its availability to manganese efficient and inefficient wheat genotypes

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Keywords: Manganese availability in soils, Manganese managements, wheat genotypes

Introduction, scope and main objectives

Manganese (Mn) deficiency limits wheat productivity on sandy loam, calcareous and alkaline soils cropped with rice. Cultivation of Mn tolerant wheat genotype in deficient soil and sustainable Mn fertilizer management strategy reduces the risk of yield loss and produces a higher return to the farmer and maintains the soil Mn pools. The study aims to optimise the Mn fertilizer dose and methods in different Mn containing soils regarding its availability to manganese efficient and inefficient wheat genotype.

Methodology

Two season greenhouse pot experiment was carried out using Mn efficient (HD-2967) and inefficient (HW-4065A) wheat genotypes, selected from the screening experiment, in three types of Inceptisols having low (2.87 mg kg^{-1}), medium (4.36 mg kg^{-1}) and high (8.86 mg kg^{-1} Mn) DTPA-Mn content with 6 different Mn management treatments (control, soil application with MnSO4.H2O @ 20 mg Mn kg^{-1} soil, foliar application with 0.5 percent MnSO4.H2O, foliar application with 1 percent MnSO4.H2O without lime and with 0.1 percent Ca(OH)2 lime and Mn mobilizing microorganism - *Piriformospora indica*) to test the response of Mn efficient and inefficient genotype under different soils and Mn management options.

Results

The Results indicated that grain yield and Mn content increased significantly by 32 percent with 1 percent foliar application without lime than soil application in Mn deficient condition over both genotypes. In Mn deficient soil, Mn efficiency index of grain yield and dry matter translocation efficiency increased by 13 percent and 16 percent due to introduce of Mn efficient genotype, respectively. There was a significant effect of application of Mn mobilizing microorganism than control but not up to the mark of Mn application in soil and foliar spray. Mn efficient genotype was superior to the inefficient on the basis of greenness index (14.4 percent), mean grain yield (34.7 percent), mean Mn content (57.3 percent), and Mn uptake (58 percent) in grain after two seasons. The per cent decrease in water-soluble, exchangeable and organic bound Mn was positively correlated with Mn content in wheat grain.

Discussion

Mn efficient wheat genotype produced more grain yield and retained high Mn content in low Mn containing soil compared to inefficient genotype due to its ability to use limited Mn available from soil (Jiang, 2006.), appropriate partitioning of nutrients and photosynthates between vegetative and reproductive parts (Jhanji et al., 2013). Foliar application of Mn was more effective than soil application to control Mn deficiency due to the fact that low and medium Mn containing soils had high pH values, 8.4 and 8.3, respectively. The reduction of total Mn content in surface soil appears to be due to organic matter decomposition by microbial process, weathering of minerals, phytocycling and leaching to the subsoil by irrigation or rainfall in sandy loam soil especially under submerged conditions (Sharma *et al*., 2011.).

Conclusion

This study clearly showed that wheat grain and biomass yield and its Mn level could be maintained in Mn deficient soil by the selection of suitable Mn management practices and Mn efficient genotype. The lead observed in this investigation requires further systematic testing under field conditions.

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Micronutrient constraints in sodic soils of Israna, Haryana, India

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Keywords: deficiency, micronutrient availability, sodic soil, soil attributes, toxicity

Introduction, scope and main objectives

Sodic soils covering more than 581 Mha globally, are considered to be one of the most challenging land degradation processes that affect the world's food and feed demand adversely. The forecasted climate variability induced stresses such as erratic rainfall, increasing temperature and freshwater scarcity will further increase their global extent and socioecological importance in the future. Such soils are generally associated with high pH and excess levels of sodium ions, low organic matter and presence of high calcium carbonate content. Consequently, nutritional disorders varying from deficiency to toxicity of micronutrients in sodic soils are one of the most important limiting factors to crop yield and productivity. Exploring the distribution of available micronutrients and influencing soil attributes can provide the basis for effective management of such soils. Thus, the present study was conducted to determine the availability of boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn) in sodic and non-sodic soils of Israna, Panipat.

Methodology

Available content of Cu, Fe, Mn and Zn was extracted using diethylenetriamine pentaacetic acid (DTPA) whereas Mo and B were extracted by ammonium acetate and hot-water soluble (hws) method respectively. Random composite surface sampling was performed and influence of some relevant soil attributes viz. pH, electrical conductivity (EC), exchangeable sodium percentage (ESP), calcium carbonate (CaCO3) and different size fractions (sand, silt and clay) on plant-available micronutrients was also investigated.

Results

The mean available concentration of micronutrients followed the order: B > Mn > Fe > Mo > Zn > Cu for sodic soils and Mn > Fe > Cu > Zn > B > Mo in farmland soils. In sodic soils, the available content varied from 3.47-17.89 for B, 0.4-0.91 for Cu, 1.78-4.88 for Fe, 1.67-7.0 for Mn, 0.72-2.99 for Mo and 0.46-1.4 mg/Kg for Zn whereas in farmland soils, B ranged from 0.3-0.59, Cu from 2.05-2.84, Fe from 10.81-11.85, Mn from 12.6-16.26, Mo from 0.24-0.61 and Zn from 1.76-2.38 mg/Kg**.** Results revealed that available concentration of Cu, Fe, Mn and Zn in sodic soils was significantly low than non-sodic farmland soils whilst Mo and B were found to be in toxic range in sodic soils.

Discussion

Based on the linear coefficients of correlation, pH, EC, ESP and calcite exhibited strong influence on availability of micronutrients. DTPA- extractable cations increased with decreasing pH but increased with increasing EC in sodic soils. In contrast, available B increased with increase in pH and CaCO3 content but decreased with decreasing EC. On the other hand, non-sodic soils demonstrated some remarkable association with soil attributes. Available Cu, Fe, Mn and Zn increased with increase in pH, EC and sand content but decreased with decrease in size fraction while hws-B and available Mo displayed reverse trend with these attributes.

Conclusion

The Results of this study suggested that micronutrient constraints of Fe, Zn, Mn, Cu, Mo and B were common in sodic soils, thereby making it imperative to monitor status and factors controlling their availability at regular intervals for judicious management of these nutrients in such soils.

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Micronutrient deficiency assessment in rural Zimbabwe: translating geonutrition (zimgrta) study

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Keywords: agro-ecological regions, blood and urine sampling, crop sampling, forage sampling, geospatial mapping, selenium, smallholder rural households, soil sampling, zinc

Introduction, scope and main objectives

Global micronutrient deficiency affects over 2 billion people. In Zimbabwe, micronutrient deficiency affects >40 percent of the population, especially women and children under five years of age. Studies have shown that it is possible to increase micronutrient density of staple crops (wheat, maize and cowpea) through organic matter management. Farmer preferential allocation of organic nutrient resources have been reported to influence zinc (Zn) and iron (Fe) supply in smallholder farming systems in Zimbabwe. The GeoNutrition project, in Malawi and Ethiopia, considers the effects of environmental conditions on micronutrient concentrations in staple foods at different spatial scales, and showed that these concentrations show spatial variation which can be attributed to soil and environmental factors. Here, we translate work from Malawi and Ethiopia to Zimbabwe through:

1. Co-designing a pilot national survey to assess baseline micronutrient deficiencies.

2. Sampling and analysis of soil, crops, and forage using the Natural Region (NR) stratification design and on-farm questionnaires.

Methodology

Blood and urine samples were collected from 900 women of reproductive age and children under 5 years of age respectively, in three Districts in rural Zimbabwe according to a cluster sample design. Samples of grain and forage, with corresponding soil samples, were collected in these same districts, and an additional three, giving a total of six Districts spanning five agro-ecological regions. Sampling was done between April 2021 and January 2022. Within-District sampling was done using a spatially balanced sampling design with spatial spread, implemented on the R platform. Questionnaires were administered to record past and current agronomic information from the sampling field sites and household demographic information. Grain, soil and forage samples will be analysed for multiple elements including Zn and selenium (Se) using standard methods.

Results

Preliminary anthropometric findings show that stunting was observed in >25 percent of children under five years of age and severe stunting in 6 percent of the children. About 835 soil and grain samples were collected. Most grain samples were maize with some sorghum, finger millet and pearl millet. About 147 forage and corresponding soil samples were collected mostly from communal grazing lands (78 percent) with fewer samples collected from fallowed fields (20 percent) and other grazing areas.

Discussion

The high stunting prevalence observed from the preliminary results, strengthens the drive to utilise appropriate sampling design in mapping of micronutrient deficiency at household level and in agricultural fields. Furthermore, the broader evidence from this work will inform agriculture and nutrition policies to implement sustainable interventions to better manage soil, crop and human micronutrient deficiency in Zimbabwe.

Conclusion

Targeting of micronutrient fertilizer application in ongoing agronomic biofortification interventions is unlikely to be influenced by field landscape position but more so by micronutrient and N fertilizer application, and method of micronutrient fertilizer application.

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Novel fertilizer strategy to biofortify zinc concentration in wheat grains

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Keywords: grain zinc, wheat, biofortification, foliar application, zinc fertilizer

Introduction, scope and main objectives

Wheat provides a fifth of humanity's food. Zinc deficiency in soils does not only reduce crop productivity, but it also leads to low-Zn food causing human malnutrition. The problem is global; however, it is more acute in India as billions of people suffer from Zn malnutrition. Today, increasing grain Zn concentration, especially in staple cereals, represents an important humanitarian challenge because dietary Zn deficiency, caused by low-Zn staple foods, is a growing concern in the developing world (Bouis and Saltzman 2017, Cakmak and Kutman, 2018, Rashid *et al.*, 2019.). A robust and scientifically based zinc fertilizer strategy is required for improving the delivery of this essential micronutrient. There is an urgent need to address a major crop productivity and human nutrition issue with specific objective as: To biofortify wheat grains with zinc through Zn fertilization.

Methodology

Field experiments on wheat were conducted over two cropping seasons at a total of 25 field sites. All field experiments were laid out in randomized complete-block design with three replications. The multi-locational 25 field experiments were conducted across Uttar Pradesh, Haryana, Punjab, and Himachal Pradesh states of northern India using wheat as test crop to study the effects of both soil (50 kg/ha $ZnSO4.7H2O$) and foliar applications of Zn (0.5 percent) on the grain Zn concentration. Effectiveness of wheat (*Triticum aestivum L.*) crop to be biofortified through foliar applications of $ZnSO4.$ $7H2O$ at boot and milk stages and basal Zn application at the time of sowing was investigated under field conditions. The concentration of Zn in harvested whole grains was determined by AAS.

Results

Grain yield of wheat varied across years and among the selected field locations. The results showed that grain zinc concentration increased from 0.1 percent to 6.3 percent during first year and 3.2 percent to 10.3 percent during second year by soil Zn application as compared to control. However, increase in grain Zn concentration by foliar Zn application was higher over control which ranged from 47.6 percent to 93.7 percent during first year and 32.4 percent to 98.8 percent during second year.

Discussion

Foliar spray of Zn produced the highest agronomic efficiency, Zn use efficiency apparent recovery of Zn and utilization efficiency as compared to soil Zn application. It was found that foliar application of Zn is an important agronomic practice for the farmers to enrich wheat grains with zinc. Increasing grain Zn concentration by soil as well as foliar applications of zinc fertilizer also provides additional positive impacts in terms of yields and economic benefits.

Conclusion

The present field study clearly showed that wheat grain can be very easily bio-fortified by nearly two-fold by foliar application of Zn fertilizers. A novel and low cost fastest approach of agronomic biofortification of wheat grain with Zn was validated. This agricultural intervention strengthens the links between agricultural research and nutrition.

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Nutritional evaluation of coffee soils in the North Sierra of Puebla, Mexico

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Keywords: coffee systems, nutritional status, soils

Introduction, scope and main objectives

Soils are indispensable in the dynamics of ecosystems and are the ones that sustain food production, their degradation reaches alarming dimensions, increasing in mountainous regions, since limiting natural factors are combined with inadequate agricultural management, presenting nutritional deficiencies in coffee systems. In this context are located the coffee soils of the state of Puebla, Mexico, which occupies the 4th place nationally in coffee production. The objective of this project is to carry out the nutritional status of coffee systems in three areas of the state of Puebla.

Methodology

Soil analyses were carried out according to NOM-021-SEMARNAT-(200), nutritional recommendations were made for the crop to improve the application of agricultural inputs, to favor the increase of yields and avoid ecosystem deterioration. Selecting 3 municipalities in the northern sierra, 7 in the northeastern sierra and 3 in the sierra negra. 30 soil samples (0-30 cm) were collected: pH, CE, Texture, MOS, N, Ca, Mg, K, Na, B, P and CIC and microbiological analysis: bacteria, actinomycetes and fungi, Healthy leaves were collected from the cultures and B, Ca, Cu, Fe, K, Mg, Mn, Na, P and N were determined. The micronutrients evaluated were Cu, Zn, Fe and Mn; in soil by extraction with DTPA by EAA (Varian-AAB55). Soil analyses were carried out according to NOM-021-SEMARNAT-(200), nutritional recommendations were made for the crop to improve the application of agricultural inputs, to favor the increase of yields and avoid ecosystem deterioration. Selecting 3 municipalities in the northern sierra, 7 in the northeastern sierra and 3 in the sierra negra. 30 soil samples (0-30 cm) were collected: pH, CE, Texture, MOS, N, Ca, Mg, K, Na, B, P and CIC and microbiological analysis: bacteria, actinomycetes and fungi, Healthy leaves were collected from the cultures and B, Ca, Cu, Fe, K, Mg, Mn, Na, P and N were determined. The micronutrients evaluated were Cu, Zn, Fe and Mn; in soil by extraction with DTPA by EAA (Varian-AAB55).

Results

The **Results** obtained can be summarized in: The average pH values, presents strongly acidic values, (4.5) so it is necessary to carry out the liming of the soils. The concentrations of K, Ca, Mg do not present a good balance which Results in a limiting factor for the development and growth of the crop. The contents of MOS, for coffee cultivation are recommended in concentrations of 7 to 10 percent, so the soils analyzed are below these requirements. The CIC shows low values in the soils, which hinders the availability of nutrients to the crop. The micronutrients that present a constant deficit in the soils analyzed are: Cu and Zn. The foliar analysis shows correspondence with the state of fertility of the soils. El N presented nutritional deficit in 34.4 percent of the samples analyzed. P and K concentrations do not have low concentrations. Boron has a deficit in 17 percent of the samples.

Discussion

The order of micronutrient deficiencies in the analyzed leaves is: Zn>Mn>Fe>Cu. The CFUs of bacteria are within the ranges of healthy soils, however, the strongly acidic pH of some soils limits metabolic activity, 1 sample registers low values. Actinomycete CFUs are within the ranges for healthy soils, which is satisfactory given that they are responsible for the humification of organic matter. Fungal CFUs are within normal ranges for healthy soils.

Conclusion

Fertility as an emergent property of the physical, chemical and biological properties analyzed, present a category of low to medium. The study requires collecting complete data on agronomic soil management, such as planting density, type of shade, fertilization history, and relief, among others. The pH values, a fundamental aspect for the crop, for the most part, have very strongly acidic values (NOM-021-RECNAT-(200)) so it is necessary to carry out the liming of the soils. The concentrations of major cations (K, Ca, Mg) do not present a well-balanced balance so that the relationship between them does not become a limiting factor for the development and growth of the crop. The organic matter contents are below the recommended values for coffee soils (7 percent-10 percent), so it is important to add organic matter, to improve physical and chemical conditions of the soils and increase the contribution of nutrients. Cation Exchange Capacity (CIC), shows low values in the soils, which hinders the availability of nutrients to the crop, the addition of MO would help increase the CIC. The micronutrients that present a deficit in the soils were Cu and Zn. The foliar analysis shows correspondence with the state of fertility of the soils and improve in the sampling, which must be adjusted to the conditions of the different areas. And to establish the critical ranges according to the particular area, each variety, etc. The N presented a deficit in 34.4 of the samples analyzed. P and K have adequate values. Boron has a deficit in 17 percent of the samples. The order of micronutrient deficiencies was: Zn>Mn>Fe>Cu.

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On multinutrient deficiencies in rainfed agroecosystems – a case study from India

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Keywords: soil nutrients, rainfed agriculture, grid sampling, multinutrient deficiency

Introduction, scope and main objectives

Countries 'food grain demand can be achieved either by bringing additional lands under cultivation or by intensifying cultivation with better management practices. Nonetheless, both necessitate continuous soil fertility monitoring to avoid nutrient deficiency, which is one of the key restrictions to crop yield and is a critical tool for farmers and policymakers in soil nutrient management (Lalitha *et al.*, 2021.). Soil fertility in rainfed areas of arid and semiarid regions has been further complicated by widespread nutrient deficiency despite climate change (Shukla *et al.*, 2019.). The integrated watershed management program called SUJALA by the watershed development department, Karnataka, facilitated the diagnosis of soil fertility status with the objective to assess and identify the nutrient deficiency in rainfed areas of Karnataka.

Methodology

A total of 34 011 geo-referenced composite samples were collected from the plough layer (0–15 cm) at 325 X 325 m grid intervals to analyze the nutrient status of soils. Soil organic carbon, available phosphorus, available potassium, sulphur, boron, and micronutrients were measured following standard procedures (Jackson, 1979).

Results

The soil organic carbon content ranged from 0.03 to 4.3 percent with a mean value of 0.69±0.36 (mean±SD). The soil available P ranged from 1.25 to 483 kg ha-1 with a mean value of 16.3±22.6. The soil potassium values ranged from 44 to 5 986 kg ha-1 with a mean value of 273±215. The soil available sulphur values ranged from 0.06 to 1 692 mg kg-1 with a mean value of 17.4±52.9. The soil available boron values ranged from 0.01 to 8.2 mg kg-1 with a mean value of 0.52±0.36. Extractable Fe ranged from 0.04 to 198.4 mg kg-1 with a mean value of 8.1±9.0. Likewise, the extractable zinc varied from 0.01 to 46.5 mg kg-1 with a mean value of 0.6±1.4 mg kg-1. Among the micronutrients, copper and manganese were sufficient in more than 90 percent of the samples analyzed.

Discussion

Overall, the widespread deficiency was observed for soil available Zn (80 percent), P (60 percent), B (60 percent), and S (50 percent), and to some extent for Fe (40 percent). Soil available phosphorus, sulphur, boron, iron, and zinc deficiency is foreseeable in places where crop uptake and other losses are not met by inputs because of the meager quantity of fertilizer application and minimum care taken for secondary and micronutrients and soil constraint management such as pH and EC. The principal component analysis revealed that organic carbon has a strong influence on the availability of Cu and Mn, whereas available P, K, Fe, and Zn were strongly influenced by soil pH. Soil EC has a significant effect on the availability of sulphur and boron.

Conclusion

Widespread multi-nutrient deficiencies across the agro-climatic zones of Karnataka feature that rainfed soils are not only thirsty but famished too. Soil fertility management is apparent in rainfed regions to improve and sustain crop production against widespread multi- nutrient deficiency across the agro-climatic zones of Karnataka. Thus, the application of secondary and micronutrients along with a recommended dose of major nutrients based on crop requirement and soil nutrient availability is desired for sustained rainfed crop production to increase nutrient use efficiency and factor productivity.

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Si bioavailability and fate of the applied phytogenic silica in a soil plant system in acidic, neutral and alkaline soils

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Keywords: silicon, PhSi, rice, uptake, plant available Si

Introduction, scope and main objectives

As typical silicon (Si) accumulator plant, rice removes approximately 250-500 kg Si ha^{-1} yr^{-1}. (Majumdar and Prakash, 2020). Utilizing the rice crop residues as a source of Si to reduce the Si depletion in the field is the need of the day. Information about the importance of phytogenic Si (PhSi) and influence of agricultural management practices on Si cycling in paddy soil is lacking in the Indian perspective. Accordingly, a pot experiment was conducted at net house in the department of soil science and Agricultural Chemistry, University of Agricultural Sciences, Bangalore on comparative study of different sources of PhSi to study the dissolution of PhSi and Si budgeting in soils of contrasting pH.

Methodology

The pot experiment was laid out in the factorial completely randomized design with the treatments viz., factor T:source of phytogenic Si (4) T1:control without plant (Ck – RP), T2:control with plant (Ck + RP), T3:Rice straw @ 20 t ha^{-1}, T4:rice straw biochar @ 20 t ha^{-1}, T5:rice husk @ 20 t ha^{-1} and T6:rice husk biochar @ 20 t ha^{-1} and factor S: types of soil (3) S1:acidic, S2:neutral and S3:alkaline. The tested plant was rice. Soil solution sampler (rhizon) was placed horizontally at 10 cm depth of the pots. Soil solution samples were collected at 0, 7, 15, 30, 45, 60, 90, and 120 days after transplanting (DAT) and analysed for dissolved silica (DSi) content by adopting standard procedures. The dry weight of straw, grain and root and Si uptake were determined for each pot. Soil Si pools viz., calcium chloride extractable Si (CCSi), acetic acid extractable Si (AASi) and phytogenic Si (PhSi) were extracted using standard protocols.

Results

Among the soils the DSi (mg L^{-1}) content in soil solution ranged from 0.63-12.67 mg L^{-1}, 3.74-31.49 mg L^{-1} and 8.24- 48.25 mg L^{-1} in acidic, neutral and alkaline soils, respectively. The higher Si uptake was recorded in the order neutral (1032 -2076 mg pot-1) > acidic (609 -1614 mg pot-1) > alkaline (324-716 mg pot-1). Whereas, Si pools in post-harvest soil were recorded higher in the alkaline soil followed by neutral soils and acidic soils recorded the lowest. Among the treatments, a large variation in the Si uptake was noticed with the application of different sources of Si and recorded higher in treatment receiving rice husk biochar and was recorded lowest in the T2:Ck + RP. Si pools in post-harvest soils were recorded higher in alkaline soils which were two times higher than the acidic soils. Delta (Δ) Si content is calculated by differences in post-harvest and initial content of soil Si pools such as CCSi, AASi and PhSi to determine the Si budget. Among the treatments it was recorded lower in T2: Ck + RP. Among all three soils, the extent of soil Si stock (Δ±CCSi, Δ±AASi and Δ±PhSi) was recorded lower in the acid soil compared to neutral and alkaline.

Discussion

Increased Si uptake of rice plants in the treatments receiving different PhSi sources over control clearly shows that the Si released during the decomposition of these materials are plant available. In the alkaline and neutral soils, the dissolution of native soil PhSi could have contributed more to the DSi. Whereas the advanced weathering stage of the acidic soil contributes to low soil Si content. Thus, recycling crop residue directly or through biochar could be a potential source of Si fertilizers.

Conclusion

In conclusion, the phytolith rich Si materials enhance the plant available Si pools soil-plant systems by increasing Si bioavailability, which may further depend on soil types.

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Soil factors influence the geospatial variation in zinc nutritional quality of maize in Malawi

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Keywords: geospatial variation, hidden hunger, maize grain Zn concentration, soil properties, zinc deficiency

Introduction, scope and main objectives

Deficiencies of micronutrients, including zinc (Zn), remain a major global health challenge. Approximately 1 billion people worldwide are at risk of Zn deficiency due to inadequate dietary intakes, with greatest prevalence in sub-Saharan Africa and South East Asia. In Malawi, where dietary diversity and consumption of animal-source foods are low, Zn deficiency is widespread with an estimated prevalence of 62 percent. Maize, the staple crop of Malawi, provides on average more than half of dietary Zn intakes, with an even greater proportion among poorer households. Thus, variation in Zn concentration of maize grain may lead to nutritionally-important variations in dietary Zn intakes. The present study was conducted to identify potential soil properties which might explain longer-range spatial variation in maize grain Zn concentration.

Methodology

In the GeoNutrition project, a national survey was conducted with cereal grain and soil samples taken at 1600 sites across agricultural land areas of Malawi. Labile and non-labile soil Zn forms were determined using isotopic dilution methods, alongside conventional agronomic soil analyses. Soil properties as potential predictors of the concentration of Zn in maize grain were tested using a priori expert rankings and False Discovery Rate (FDR) controls within the Linear Mixed Model **(LMM) framework.**

Results

Median maize grain Zn concentration was 21.5 mg kg^{-1}, with the range of 10.0 – 48.1 mg kg^{-1}. Long-range geospatial variation in maize grain Zn concentrations was observed at distances of up to 100 km. Three soil properties were found to influence the geospatial variation of maize grain Zn concentration: soil pH(water), isotopically exchangeable Zn (ZnE), and diethylenetriaminepentaacetic acid (DTPA) extractable Zn (ZnDTPA).

Discussion

The predictive value of soil factors for maize grain Zn concentration was significant. There was a positive relationship between soil pH and maize grain Zn concentration. The isotopically exchangeable Zn fraction had significant predictive power for maize grain Zn concentration, as did DTPA-extractable Zn.

Conclusion

The findings of the study provide a basis for implementation of appropriate interventions to improve Zn nutritional quality of staple crops through agronomic means, including the application of Zn-enriched fertilizers, a process called agronomic biofortification or agro- fortification.

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Soil-based biofortification to alleviate selenium deficiency - an isotopic study to investigate sulphur and selenium competition for ryegrass uptake

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Keywords: SDGs, selenium, sulphur, biofortification, hidden hunger, micronutrient deficiency, isotope, polyhalite

Introduction, scope and main objectives

Selenium (Se) deficiency is a world-wide challenge distributed globally affecting one billion people. The condition jeopardizes the health of livestock and humans, leading to food insecurity and malnutrition and impedes efforts to achieve UN SDGs. Soil- and fertilizer- based strategies to improve micronutrient status in our cropping systems have been demonstrated as effective approaches. For example, food and forage crops treated with Se incorporated into major compound fertilizer products show improved Se concentrations in edible parts of plants, thus enhancing the availability of dietary Se for animals and humans. Sulphur (S) is a key plant nutrient, vital for crop growth. In recent decades, reductions of S atmospheric depositions, greater use of fertilizers with low S contents and limited return of manure S to land have increased the need for additional S inputs directly to arable land for crop production. However, evidence from both hydroponic and field trials shows antagonistic effects affect S and Se bioavailability to plants. Sulphur fertilizer application can impede Se uptake by plants because the groups of genes which encode sulphate transporters also govern Se transport and the mechanisms enabling incorporation Se into organic compounds are also involved in S incorporation due to chemical similarity between sulphate and selenate. In the current study, we investigated soil-based Se biofortification of grass under variable S fertilizer regimes using application rates typically employed in agronomy, in which the different order of magnitudes between applied Se and S usually shows over a thousand folds.

Methodology

Spikes of two enriched stable Se isotopes, Se-74 and Se-77, added as selenate or selenite were applied at 20 g/ha in solutions, both separately and mixed, to investigate the fates of applied Se in a grass pot trial and distinguish them from indigenous soil Se. In addition, the Se was applied by ‘fertigation ’(FG) or ‘liquid placement ’(LP) to the soil surface. Several S fertilizers, Polysulphate®, $MgSO_4$, PotashpluS37 and Patentakali® at 60 kg/ha S were used synchronously with the applied Se to provide variable S release rates to the grass yield and levels of Se uptake suppression in sequential harvests (4 cuts) during the growing season.

Results

i) Applied S increased grass yield during 4 cuts, but differences in the S release rate did not affect the yield. Selenate bioavailability (1.47-3.29 percent total offtake from the applied selenate) was greater than that of selenite (0.122-0.159 percent total offtake from the applied selenite).

ii) The Se-74 concentration in grass was up to 64.5 µg/kg in comparison with 1.70 µg/kg for Se-77. Bioavailability of selenate decreased exponentially across the growing season due to the fixation into organic (humus-bound) forms in the soil whilst selenite availability was more consistent but at a much lower level of uptake.

iii) The application of slow-release S (e.g. Polysulphate) enhanced Se uptake by approximately 19.2-27.5 percent in the first grass harvest but surprisingly showed no difference in S nutrition compared with other S fertiliser forms throughout the 4 sequential harvests.

Discussion

The data reveal a plant physiological influence in which S and Se compete for (grass) root transporters. An effect of soil chemical and biological processes in which Se adsorption and assimilation into organic forms is inhibited by the presence of sulphate.

Conclusion

The application of slow-release S fertilisers with selenate can ideally satisfy the sulphur requirement of grass but also promote selenate uptake through reduced physiological competition immediately after Se application and possibly by increasing phytoavailable selenate later in the post-fertilised period. A contrasting outcome in the two following sequential harvests suggests the need to consider some more involved soil-plant factors arising from the Se:S application ratio used (1:3000).

Acknowledgements

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Sustainable soil management and biodiversity friendly practices in protected areas: the Sentina natural regional reserve case study

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Keywords: QBS-ar, QBS-ab, agroecosystem, sustainable management, soil mesofauna, protected area, soil health, soil biodiversity

Introduction, scope and main objectives

Soil has been defined as a vital living system and the organisms inhabiting it are considered as a potential and still unknown nature- based solution able to deliver and maintain fundamental soil-based ecosystem services for plant, animal, and human health. In this regard, soil mesofauna is involved in organic matter decomposition and translocation, nutrient cycling, microflora activity regulation, and soil structure formation. The application of the Soil Biological Quality index based on arthropods (QBS-ar) is a way to assess soil health condition and sustainability of agricultural practices through the analyses of the structure of soil microarthropods communities, which are highly sensitive to soil disturbances (Parisi *et al*., 2005.). Furthermore, practices such as tillage and overfertilization, typically applied in intensive agriculture, give rise to different soil threats such as loss of biodiversity, nutrient imbalance, and soil compaction. While the adoption of sustainable management practices proved to preserve soil-related ecosystem services, and consequently the processes which contribute preserve soil fertility. In fact, achieving sustainable soil management is crucial within the context of the European Green Deal (Montanarella and Panagos, 2021.). The objective of the present study is to assess the health of the agricultural soils located within the Sentina Natural Reserve, central Italy. In this regard, two farms (referred as FE and RL) involved in pasta and flour production and applying conventional management systems with different degree of intensity were selected. FE applies deep tillage, monoculture, and pesticide applications, while RL applies minimum tillage, crop rotation with legumes, false sowing and, set- aside with radish. The final aim is to compare the two farms 'systems and to suggest a sustainable management model for the preservation of soil health that could be adopted by smallholders, even in protected areas in which the natural fertility of soil could be enhanced.

Methodology

In each site, soil samples for physicochemical analysis and QBS-ar were collected in summer and autumn 2021. In addition to the classical "qualitative" (i.e., no abundance-based) approach of QBS-ar, the novel approach QBS-ab (Mantoni et al., 2021.) that includes in the calculation of the index also the microarthropods 'abundance was determined.

Results

Results show that both farms, even if in conventional management, present an excellent biological quality of the soil with values comparable to those of natural environments. Comparison between the two farms in the summer season show that RL, with respect to FE, had a higher density of microarthropods (6099 vs 1521 ind/m^2), averaged values of QBS-ar (151.5 vs 123.3) and QBS-ab

(242.8 vs 187.3). All the above-mentioned parameters show significant differences between the two farms, even when considering fields with the same texture (sandy loam) (Tukey, p-value < 0.05).

Discussion

This study shows the potential of protected areas for the production of food. Further, it suggests sustainable agricultural practices to be applied to preserve biological soil fertility.

Conclusion

The adoption of biodiversity friendly practices reaches out to the needs of the consumer who is interested in finding a food that is not only safe, healthy, and nutritious but also produced in a sustainable way. There is a new awareness on food which gave birth to the willingness to pay for the preservation of biodiversity.

Acknowledgements

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Sustainable soil management for nutrition-sensitive agriculture in Bangladesh

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Keywords: Bangladesh, micronutrient, zinc, boron, ssm, malnutrition,

Introduction, scope and main objectives

Micronutrient deficiency is considered as one of the emerging challenges to food and nutrition security in Bangladesh. There is a growing realization of food-based approach for addressing this issue. Soil health is directly related to human health. Current estimate suggested that almost half of the world population suffers from mineral deficiencies, primarily of iron and zinc. Rice feeds almost 50-58 percent of the world's population and considered as a global grain but it is deficient in micronutrient (Bouis and Welch, 2010). Therefore, even a small increase in the nutritive value of rice can be highly significant for human nutrition (Zhang *et al*., 2012). Sustainable agricultural production, maintain its production quality and protecting the deterioration of soil health are the major challenges in the changing global climate. Bangladesh agriculture has been passing through a transition from subsistence farming to commercial agriculture. Crop production and cropping intensity increased several times during the last three decades. A long-term study finding of Soil Resource Development Institute (SRDI) showed that low to very low soil Zn status in soils were increased 28.71 percent to 78.84 percent in arable land since 2010-2020 in Bangladesh and in case of boron (B) it was increased 25.99 percent to 30.78 percent in arable land area in the same period (Hasan *et al*., 2020). It indicates that there prevails a deficiency of micronutrient like Zn and B and the deficiency is increased with the advance of time. So, sustainable soil management is urgent required for safe and quality food production. Considering the above perspective, a yearlong cropping pattern-based field study was conducted to identify best practices for Sustainable Soil Management (SSM) to address micronutrient deficiency issues taking following objectives:

i. To quantify the micronutrient contents in major cereals, vegetables and pulse crops by SSM practices;
ii. To assess baseline and post farming nutrient status of the soil, harvestable and edible parts of different crops and
iii. To identify the best management practices and their effects to increase nutrient status of soil and yield.

Methodology

To identify the best management practices of SSM and their effects to increase nutrient status of soil and yield, multilocation field study was conducted at three sites namely Chandina, Chuadanga and Baliadangi where T. *Aman* (Binadhan-20) was the first crop. Cauliflower, Maize and Potato respectively were cultivated in same plot as the second crops and the third crop was Mungbean in all three study sites. The field study was laid out in randomized complete block design (RCBD) comprise of six fertilizer management treatments and replicated five times. The treatments were T_1= Farmer's practice (Dose was decided as per the opinion of the farmers during baseline survey); T_2 = Recommended Fertilizer Dose of NPKS (RFD) with Zn as basal; T_3= RFD with Zn as foliar spray; T_4= RFD with Zn & B as foliar spray; T_5= 50 percent RFD + 50 percent Organic manure-Cowdung; T_6 = 50 percent RFD + 50 percent Organic manure- Cowdung + Zn & B as foliar spray. The individual plot size was 20 m^2 (5m× 4m). Pre-Cropping composite soil sample were collected from each field to know the initial soil nutrient status as well as fertilizer recommendation. Yield and other crop data for different crops were collected following standard procedures. Statistical analyses were done following CropStat software, and the mean separations done using LSD at 5 percent level of significance.

Results

Yield

The fertilizer management affect was found significant on yield at different study sites. The recommended fertilizer dose (NPKS) as basal application along with zinc and boron as foliar application (T_4) showed higher yield as compared to that of NPKS & Zn as basal (T_2) in all sites. The trend was almost similar for all the studied crops.

Soil Organic Matter

Organic matter status of Bangladesh soil is gradually in decreasing trend and hence soil health also deteriorated which can be ameliorated by adding organic manure to the soil. Reducing 50 percent chemical fertilizer and adding 50 percent organic manure (T_5) increased the organic matter content of soil compared to RFD. The increment was maximum after cover crop (mungbean) cultivation.

Zinc Content of Edible Parts

Basal application of zinc is recommended in Bangladesh by 'Fertilizer Recommendation Guide 'that can increased the zinc content of soil compared to that of foliar application but foliar application of zinc increased the zinc content of grain/edible parts. Hence for improvement of human nutrition (SDG 3) it is suggested to apply zinc as foliar spray during anthesis period of crops. Time series analysis indicates that micronutrient concentration in a given genotype remains more or less constant when cultivated under similar environmental conditions (Magatani *et al.,* 2020).

Protein Content of Edible Parts

In Bangladesh, farmers are not generally followed the balanced fertilization that reduced the protein content of edible parts that can be increased by application of zinc and boron as foliar spray (T_4) along with the recommended doses of NPKS. The increment was found as 8.93, 22.75, 3.24, 13.74 and 3.16 percent for rice, maize, cauliflower, potato and mungbean, respectively.

Discussion

The data reveal a plant physiological influence in which S and Se compete for (grass) root transporters. An effect of soil chemical and biological processes in which Se adsorption and assimilation into organic forms is inhibited by the presence of sulphate.

Conclusion

The use of chemical fertilizer is remarkably increased in Bangladesh due to the higher demand of food and as a Result the fertility status of the land decreased including soil organic matter, macro and micronutrients. Though the balanced use of fertilizer is recommended by Fertilizer Recommendation Guide of Bangladesh, it was not practiced in farmer's field. Our aim of this project is to develop awareness to the farmers about soil health and micronutrient that ultimately affect human health. Baseline survey, field demonstration, use of zinc rich fortified variety, addition of organic matter, inclusion of a cover crop in the cropping pattern, foliar application of micronutrient, field day, awareness development training were few attempts to fulfill the target. Long term study throughout the country is necessary to implement a technology in the policy level. Our cropping pattern based one year study resulted the benefits of foliar application of zinc and boron along with NPKS to increase yield, improve soil health and increase micronutrient status of edible parts of studied crops. Fertilizer management significantly affected soil organic matter and micronutrient content. Therefore, in every crop in the pattern it is necessary to apply organic manure to maintain the soil fertility and crop productivity.

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The issue of soil pollution solved using organic farming #03 - tried out research on soils for nutrition

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Keywords: soil pollution solving, organic farming, nutritious food, legumes planting for soil nutrition, soil fertilizer fixation process, macronutrients, secondary nutrients, organic matter for soil nutrition

Introduction, scope and main objectives

According to the research, The Issue of Soil Pollution Solved Using Organic Farming No.01 and No.02-Tried- out research of Soil Biodiversity, has archived practiced to support SDG2 – Zero hunger provide a more nutritious agri-food system for enhancing human health and wellbeing while protecting the environment. For this research #03, we focused on a better soil nutrition, which can be transformed to a better agri- food's nutrient. By this method, we used the legumes which can freeze nitrogen gases in the air to the form of which the roots of plants are absorbed into the soil, or nitrogen fertilizer fixation process into the soil. After harvest, it's ploughed and buried them for 15-30 days decompose to create the macronutrients and secondary nutrients and organic matter to the soil and delivered as organic fertilizers to the main crops as rice.

Methodology

The research of fresh fertilizer from the plowing and buried the leguminous, to create more nutrient to the yield of rice via the soil. We used 6 types of nutrients that rice needed with different qualities on 134 plot sites of rice planting field in Chiang Mai Province, Thailand. We cultivated leguminous: Peanut, Soy bean and green bean as the treatment of the experimental research operation in form of the crop rotation plants after harvest the rice and a[er leguminous harvest, they were plowed and buried to be the fresh fertilizer to improve soil.

Results

The macronutrients (nitrogen, phosphorus and potassium) and the secondary nutrients (calcium, magnesium, sulfur, etc.) and the physical soil tests were carried out before and a[er the planting of legumes and plowed. The sample by randomize selected to plant peanut, Soybean and green bean. After the planting of legumes and plowed. the results of the one-way ANOVA were performed to compare the nutrient defined level in soil of three different conducted studying.

Discussion

The Result of soil by pre-test, and post-test in categories of nutrient as nitrogen, phosphorus, potassium, calcium, magnesium, sulfur and the soil physical. We found that the nutrient of soil is increasing in every test and the soil qualification had improved in every test. We found the sufficient moisture and the organic matter in the soil which improved the soil structure and increased the soil nutrient that can be transformed to the rice in finally.

Conclusion

Pathawit Chongsermsirisakul and Siripen Iamurai 2020, The issue of soil pollution solved using organic farming #2:... www.fao.org › 3 › cb4302en

2. Pathawit Chongsermsirisakul 2020, Panyapiwat Institute of Management, assets.fsnforum.fao.org › public › PROCEEDINGS_EN_near-realPROCEEDINGS - assets.fsnforum.fao.org secondary nutrients and improved the physical soil to suitable advantage for the nutrient to the rice in next planting as fresh plant fertilizers interspersed with the main crops such as rice, which are sustainable soil management for food security and better nutrition.

Acknowledgements

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Where do we need to apply Zn fertilizers in Sub-Saharan Africa?

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Keywords: zinc, maize, yield response, agronomic biofortification, soil tests

Introduction, scope and main objectives

Zinc (Zn) deficiency among humans is widespread, especially in sub-Saharan Africa (SSA) where crops are often grown in soils with low Zn levels. In addition, micronutrients such as Zn are suspected to limit crop growth in this region, thereby hampering maize yields. However, it remains unclear at which locations Zn fertilization may be a feasible strategy to address both Zn deficiencies in maize and humans.

Methodology

Field trials were executed at various farms in Kenya (n=5), Zambia (n=4) and Zimbabwe (n=10), to test whether soil properties can be used to predict where Zn availability is limiting maize yields (quantity) and grain Zn concentrations (quality), and whether the application of Zn fertilizers increases yield quantity and/or quality. The experimental set-up consisted of a randomized block design in which maize was fertilized with macro-, secondary and micronutrients that either included or excluded Zn. Soil properties were measured, including Zn concentrations in DTPA, 0.43 M HNO3, 0.01 M CaCl2 and Mehlich-3 soil extractions. Grain and stover biomass were measured after harvest, and nutrient tissue concentrations were measured in both grain and stover. Linear mixed effects models were used to test treatment effects, as well as soil-plant relations.

Results

In terms of yield quantity, we found that Zn fertilization led only to a positive yield response for the minority of sites and that soil properties or various soil Zn measurements could not explain this response. In terms of yield quality, we found that a particular set of soil Zn measurements could explain 35 percent of the variation in Zn uptake, but that grain Zn concentrations were less explained by soil Zn levels. Next, we found an increase in Zn uptake and grain Zn concentrations upon Zn fertilization for most of the sites, and the magnitude of this response increased with decreasing soil organic carbon content and pH.

Discussion

The lack of yield responses to Zn fertilisation was not expected, given that the majority of these locations had soil Zn levels below the critical values reported in literature. Similar as to soil Zn levels, tissue concentrations measured in this study were found to be a poor indicator of a positive yield response to Zn fertilisation. The plots with yields below ~ 6 Mg/ha, had the highest probability for a positive yield response to Zn fertilisation, which is similar as found in previous studies that reported the effect of micronutrient fertilization on maize yields. The Results from our study have shown that soil tests that measure the Zn quantity rather than the intensity, and more specifically the HNO3 extraction, performs best in quantifying the soil available Zn for the plots without Zn fertilization, based on the significant relation with Zn uptake. Due to the relatively low pH and low SOC content of the soils in this study, the adsorption affinity for Zn in the solid phase is relatively low as illustrated by the fact that a large proportion of the Zn measured in the HNO3 is also extracted by the CaCl2 solution. We hypothesize that the relatively low adsorption affinity for Zn in the soils in this study explains why soil tests that measure Zn quantity relate better with Zn uptake. Based on our findings in this study, we question the general feasibility of using soil properties as proxy for grain Zn concentrations and the associated likelihood of human Zn deficiencies, since soil properties only explained 20 percent of the variation in grain Zn concentrations. Our Results have demonstrated that the application of 5 kg/ha Zn fertiliser can lead to an average increase of 20 percent in grain Zn concentrations. The effectiveness was found to be increased with decreasing adsorption affinity for Zn in the soil solid phase.

Conclusion

Zinc fertilisation did not lead to higher yields in our study, despite low soil and plant Zn concentrations. It requires further research to find out why an increase in Zn uptake does not generally lead to higher yields, even when Zn is strongly diluted in the maize crop. Additionally, we suggest to avoid using the average yield response to evaluate the necessity of micronutrient fertilization for crop production in sub-Saharan Africa, given the large variation in responses found in this study and in previous work. The application of Zn fertilisers can be a feasible strategy to combat human Zn deficiencies since we found that Zn fertilisation improved Zn uptake and grain Zn concentrations. However, grain Zn concentrations were still below target values, and other strategies may be more effective. Soil tests could reasonably predict Zn uptake. Grain Zn concentrations were found to be less related to soil properties than aboveground Zn uptake, and an effect of variety and/or agroecological zone was found to contribute to the variation in grain Zn levels. These results show that the identification of areas in which crop and human Zn deficiencies may be problematic, based on soil properties, remains challenging.

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Selenium biofortification of staple maize: a way to combat hidden hunger in Malawi

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Keywords: Maize, Malawi, conservation agriculture, selenium biofortification, micronutrient deficiency.

Introduction, scope and main objectives

In Malawi dietary intake of selenium (Se) is < 7.5 µg day^{-1} for 90 percent of the population, against a recommended dietary Se intake of 55 µg day-1. Intake is linked to soil characteristics and geographical location. Maize grown on calcareous Vertisols, representing 6 percent of the cultivated area, has a comparatively high Se concentration which can provide a dietary intake >55 mg Se day^{-1}. However, the majority of soils in Malawi are acidic and produce a typical maize grain Se concentration of <5 µg kg^{-1}. Dietary intake of Se can be increased through agronomic biofortification of staple cereal crops by application of Se-containing fertilizers. Hence the initiation of Se biofortification studies of maize crops grown in contrasting soil types and under conservation agriculture (CA) cropping systems. The objectives of these studies were:

1. To determine the potential for biofortifying maize (*Zea mays* L.) in Malawi through application of sodium selenate (Na_2SeO_4(aq));

2. To assess the dynamics of Se bioavailability to maize and a range of legumes (cowpeas, groundnuts, pigeon peas and velvet beans) under CA management, as well as quantifying the residual Se effects in the year following biofortification.

Methodology

Experiment 1

Fields experiments were conducted under rain-fed cropping systems in 2008/09 and 2009/10 at Bvumbwe, Chitala, Chitedze, Makoka, Mbawa and Ngabu. Sodium selenate (Na_2SeO_4aq) was applied at early stem extension (~knee high) at eight treatment levels (0, 5, 10, 15, 25, 50, 75 and 100 g Se ha^{-1}) in the first season.

Experiment 2

A biofortification study was conducted on an Alfisol within a long-term CA field trial at Chitedze Research Station in Malawi. Isotopically labelled selenate (>99 percent enriched 77SeVI) was applied to each plot, in solution, at a rate of 20 g ha^{-1} at maize flowering (75 days after planting), in February 2017. Samples of grain and stover from maize and legumes, and topsoil, were collected at harvest in May 2017 and May 2018. Plant and soil samples were analyzed by ICP-MS for selenium isotopes (77Se and 78Se).

Results

Experiment 1

The increase in grain Se concentration was approximately linear for all Se forms and application rates (R2 > 0.90 for 27 of the 30 experimental units). On average, whole-grain Se increased by 20, 21 and 15 ug Se kg−1 for each gram of Se applied as $Na_2 SeO_4$(aq), NPK + Se and CAN + Se, respectively.

Experiment 2

The concentration of 77Se in the grain of maize and single-cropped legumes exceeded 200 µg kg^{-1} in all the treatments. This would contribute approximately 56 – 64 µg day-1 to the Malawi diet, as refined maize flour. Residual 77Se in the soil (35 percent of the applied) measured at harvest in 2017 was still present at harvest in the residual year (2018) but was completely unavailable to any of the crops.

Discussion

A single application of Se to crops grown either under CA or conventional cropping systems, at the grain filling stage, provides a viable approach to Se biofortification. Application of 20 g ha^{-1} Se produced sufficient grain Se enrichment in maize and legumes to provide the recommended dietary Se requirement. The additional organic inputs to the soil through CA cropping systems has no apparent influence on the rapid fixation of applied Se. The results confirm the potential of fertilizer to increase Se in staple grain as has been demonstrated in previous studies.

Conclusion

Agronomic biofortification with Se in Malawi is feasible in theory through the existing national Farm Input Subsidy Programme (FISP) if deemed to be economically and politically acceptable.

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Theme 3

Impacts of soil nutrient management on the environment and climate change:

Why misuse and overuse of nutrients pollute and worsen climate change?

Aerial deposition of polyethylene microplastics affects tomato (*Solanum lycopersicum l.*) rhizosphere ecology

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Keywords: microplastics, soil, bacterial and fungal diversity, metabolome, crop plant

Introduction, scope and main objectives

Due to the fast population growth, the use of fertilizer has intensified. New technologies have been introduced to mitigate the possible side effects of the intensive use of fertilizer on the environment, such as coating microplastics (e.g., polyethylene and polypropylene), which ensures a slow release of nutrients is more persistent and durable. Furthermore, microplastics are added intentionally to fertilizers as additives (e.g., anti-caking and coloring agents). In addition, organic fertilizers (composts, digestates, and percolate- leachates from digestion used as liquid fertilizer) are highly loaded with microplastic fragments, even though processing plants typically try to sieve plastics out. In all, liquid and granule fertilizers are a potential source of microplastic pollution in agriculture. These microplastics directly enter the soil and interact directly with crops and organisms. Here, we investigated the impact of microplastic aerial depositions on the growth, root metabolome, and bacterial and fungal communities associated with the rhizosphere of tomato (*Solanum lycopersicum L.*).

Methodology

Tomato plants were treated with three concentrations (10, 100, and 1000 mg L-1) of a solution composed of polyethylene microspheres (PE-MS) and distilled water. Control plants were supplemented only with distilled water. The leaves were sprayed with the solutions after 15 and 21 days of growth. After 31 days of growth, shoots, roots, and rhizosphere soils were collected. The plant material was used to measure shoot biomass, shoot water content, and root metabolomic profiling through high-resolution gas- chromatography/mass spectrometry. Rhizosphere microbial diversity was investigated via DNA metabarcoding of the bacterial 16S rRNA gene and fungal ITS2 region.

Results

Tomato shoots did not show differences in dry and fresh weight, but a significant reduction in water content was observed at 100 and 1 000 mg L^{-1}. PE-MS aerial depositions increased the roots relative abundance of amino acids and carbohydrates and their conjugates. PE-MS significantly decreased the relative content of a pyrimidine derivative (5,6-Dihydrouracil), organic acids (lactic acid and tartaric acid), and fatty acids (palmitic acid and stearic acid). Further, the microbial analysis revealed that PE-MS affected bacterial but not fungal beta-diversity.

Discussion

Our Results showed that exposure of tomato leaves to PE-MS did not affect plant growth. Oppositely, PE-MS significantly altered the root metabolome and the bacterial diversity in the rhizosphere. Several studies have shown that plants can absorb up to sub- micrometer micro-plastics (Li *et al*., 2020). In the agroecosystem, nutrients and contaminants interact with each other, with plants, and with the rhizosphere microorganisms. These interactions modulate the growth and enzymatic activities and are critical for many molecular and cellular functions (Fu *et al*., 2022). These lead to a modulation of the rhizosphere community, altering the microbial taxonomic composition and functionality (Huang *et al*., 2019).

Conclusion

Bacterial communities were more sensitive to the treatments than fungi. Further investigations are needed to fully understand the effect of the indirect addition of microplastic in agriculture and the mechanisms underlying microplastics-microorganisms-plant interactions, especially in the long term.

Acknowledgements

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Agroecological assessment of radiocesium contamination of seeds and sunflowers on irrigated lands of the Zaporozhye region

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Keywords: soils, irrigation water, radiocaesium contamination, model, sunflower harvest

Introduction, scope and main objectives

Among the many problems that have arisen in connection with the Chernobyl accident, one of the most acute and large-scale is the possibility of agricultural activities in lands contaminated with radionuclides. The consequences of the incident at the Zaporizhzhya NPP can now cause six times more damage. Therefore, the organization of constant monitoring of soil and vegetation pollution is especially important to obtain edible crop products. The purpose of the presented research is to assess the contamination of soils, irrigation water, seeds and sunflower oil grown on farmland in the Zaporozhye region.

Methodology

The initial information was the results of agrochemical and agroecological survey of soil conditions in Ukraine. The research was carried out using a dynamic mathematical model of radionuclide activity formation in the system "water - soil - plant - product", ECOSIS - 87.

Results

Numerical calculations of the accumulation of radiocaesium activity in 1986 and 2021. in the total biomass and in seed biomass due to the transition of radiocaesium from soil and irrigation water are assigned to the work. Numerical calculations of radiocaesium contamination of sunflower products as a result of a possible accident at the Zaporizhzhya NPP have been performed. The activity of radiocaesium accumulation during seed processing into sunflower oil was studied. The most rational scheme of use of potash fertilizers in a complex with liming for decrease in activity of radiocesium in a sunflower crop is established.

Discussion

According to the State Hygienic Standards, the specific activity of radiocaesium in 1986 and 2021. in seeds and sunflower oil was an order of magnitude lower than the TDR, which allowed the use of these products in food without restrictions.

Conclusion

Due to a possible accident at the Zaporizhzhya NPP, agricultural lands in the Zaporizhia region, Vasylivka, Mykhailivka, Kamyanka- Dniprovska will become unsuitable for growing food and fodder crops, as soil contamination density is expected to exceed 40 Ki / km^2, and in Mariupol and will be the implementation of a full set of protective measures to reduce the activity of radiocaesium in sunflower products to a temporarily acceptable level.

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Assessment of heavy metal contamination in soils from selected agricultural areas in tropical southwest India

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Keywords: soil, agriculture, heavy metals, pollution indices, ecological risk assessment

Introduction, scope and main objectives

High incidence of crop pests has always been a matter of concern in developing countries leading to intensive usage of agrochemicals for crop protection and improved yield. Although the chemicals are quite effective against pests, their influence on soil is a matter of serious concern. The study investigates the levels of heavy metals in agricultural soils from Udupi region which has a strong traditional agricultural background.

Methodology

Twenty soil samples that were collected during the pre-monsoon season were analyzed for Cr, Cu, Ni, Pb, and Zn. The soil samples were ground, sieved through a 2 mm mesh, and digested (0.1 g soil sample) in Teflon beakers using 5 ml HNO3, 3 ml HCl, and 2 ml HF on a hot plate at 120-150°C for 40 mins. The mixture was filtered, diluted to 50 ml, and analyzed for heavy metal content using ICP-OES. Triplicate measurements were carried out to maintain accuracy and precision within the Results. The heavy metal content was evaluated using various indices like geoaccumulation index (Igeo), contamination factor (CF), pollution load index (PLI), and potential ecological risk index (PERI) (Adimalla, 2020; Al-Taani *et al.*, 2021; Rahmanian and Safari, 2022).

Results

The results revealed that the levels of heavy metals varied in the ranges 22.85-190.18, 11.80-68.12, 9.56-57.80, 26.20-75.47, 35.35- 130.65 mg/kg for Cr, Cu, Ni, Pb, and Zn, respectively. The highest concentration was that of Cr with an average value of 190.18 mg/kg. The concentration of the heavy metals in the decreasing order is Cr > Zn > Pb > Cu > Ni. Based on CF, the heavy metals can be ranked in the order Pb > Cr > Ni > Zn > Cu. The PERI values in the soil samples ranged from 19.05 to 203.54. These values are indicative of a low to moderate potential ecological risk.

Discussion

Variations in bulk metal content in the soil samples were attributed to natural and anthropogenic sources, including agrochemicals. Based on the geo-accumulation index (Igeo), the soil samples appeared to be uncontaminated to moderately contaminated with Cr, Cu, Pb, Zn and contaminated with Ni. The average pollution load index (PLI) revealed unpolluted to polluted soil samples in the study area. The ecological risk assessment (PERI) indicated that all heavy metals posed a low risk, except for Pb which exhibited a moderate ecological risk.

Conclusion

The study provides an insight into the status of the heavy metal content in the agricultural soils of the region. The study found that traditional farming practices and low consumption of synthetic fertilizers have aided in the preservation of soil health despite the long- term agricultural practices undertaken in the region. These findings could aid in the development of practical economic methods for sustainable management of heavy metals in soil to protect environmental and human health.

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Available Cd mitigation through elevation of soil base saturation using lime and gypsum

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Keywords: soil pH, pollution, remediation, heavy metals

Introduction, scope and main objectives

The presence heavy metals (HM´s) in soil has a direct relationship to their presence in food, raising the awareness to several governments and institutions globally. Due to HM´s capacity to be easily absorbed by plants and translocated into the tissues. Soil pollution is related to human activities as mining, industry, and agriculture. Highly contaminated soils are not likely usable for agricultural activities. In this context the objectives of this research was to evaluate the mitigation of Cd by using $CaCO_3$ and $CaSO_4$, which are products that growers can obtain easily in the local market and elevating the soil base saturation, which promotes a better soil nutrition state.

Methodology

It was studied a Lixisol collected from 3°53'54"S 38°26'34" W, Ceará, Brazil with sandy-loam texture, pH=5.22, organic matter = 4.5 g/kg, Ca and Mg ≤1.5 cmolc/kg and low metal concentrations (except Fe). Soil base saturation (V percent) of 62.29 percent and cation exchange capacity (CEC) of 2.48 cmolc/kg. A completely randomized design (CRD) was established with a unique dose of Cd (30 mg/kg) via solution from $CdCl_2.H_2O$ in bags containing 1 kg of soil previously air-dried and sieved (2 mm) sealed until analysis 30 days later. Three levels of soil base saturation (control, 80 percent and 100 percent), 4 conditioners being them lime 100 percent (L), 2 limestone/gypsum mixtures (75 + 25 percent and 50 + 50 percent respectively) and gypsum 100 percent (G) in a 3X4 factorial arrangement with 3 replications, totaling 36 experimental units. Samples were analyzed according to EMBRAPA 2009 2017.

Results

Means showed that when base saturation increased to 100 percent available Cd decreased significantly from the content extracted when there was no conditioners applied and no change in the natural V percent of the soil (62.29 percent). Available Cd was lower with treatments using L and its availability increased as $CaCO_3$ proportions decreased. G was only able to reduce the available Cd when applied in higher doses and raising base saturation to 100 percent. Reducing it to 15.93 mg Cd/kg with $CaCO_3$, and 16.13 mg/kg when used in 75+25 percent proportion. Treatments with $CaCO_3$ predominance obtained higher pH levels (6.64) and 6.46 when applied in 75+25 percent proportion of L and G with an increase in V percent to 100.

Discussion

Similar results were observed by He et al., (2019) evaluating different organic and inorganic soil conditioners found that a gradual increase in the Ca^{2+} content with a similar incubation time caused decrease of almost 15 percent of available Cd. In the present study, this difference was observed when Ca was supplied in the form of $CaCO_3$. It can be explained by the high affinity of $CaCO_3$ for Cd. (Li et al., 2012). It was possible to observe changes in soil pH using $CaCO_3$, unlike gypsum that can neutralize the toxicity of various elements. SO_4 effect can be significant in subsurface layers due to the formation of ionic pairs that are easily lost in the profile (Pauletti et al., 2014). Similar effects were observed by Castro and Crusciol (2013) demonstrating this increase in soil pH in the superficial layer (0-5 cm) when lime was applied to the soil surface and had less effect in the subsurface soil layers.

Conclusion

1. Lime mitigates available Cd in greater proportions than gypsum because of its effects on soil pH and elevations in soil base saturation.
2. Gypsum has less influence on soil pH and affects Cd availability related to H^+ and Al^{3+} substitution by Ca^{2+}.

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Bovine manure mineralization and organic matter quality on ultra high density grazing (puad) in the Colombian tropic

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Keywords: mineralization, organic carbon, manure, mineralizing organisms

Introduction, scope and main objectives

Area for meat and milk production cattle has increased in Colombia, generating changes in agricultural uses for livestock. The high volumes of manure produced are potential sources of water pollution, oil, greenhouse gas emissions and compaction. Alternatives such as transformation and decomposition controlled of manure by adding microorganisms can help. Compare decomposition rate of manure below vacuum by adding a commercial mix of mineralizing microorganisms to organic matter and the contribution of soil organic carbon (SOC).

Methodology

Manure was take from PUAD system at Hacienda La Cascada (Vereda Carrizales, Norcasia-Caldas, Colombia) under tropical conditions; 18 wooden frames dimensions 0,50*0,50*0.06m located on 3 different parcels; 12-kg of fresh manure were deposited per frame. Commercial organism mix (5 percent v/v) was activated for 48 hours and 9 cells were inoculated. The samples were collected every fifteen days by 6 months. Moisture, SOC, pH in the waste and soil, the distribution of SOC in fine and coarse fraction and the proportion of mineralization of the waste material are determined.

Results

From fresh manure, 2.2-3.0 kg was dry matter; The mineralization rate indicates that in 30 days 65.1 percent of the manure was transformed into the inoculated and 70.3 percent into the inoculated; the final level of mineralization indicated 97.74 percent in manure in the inoculated and 98.15 percent in the inoculated, without significant differences. Correlation between mineralization of manure and acidification of the mixture was evidenced, varying in 150 days from pH 7.48 to 5.69 for inoculated manure and 5.96 for inoculated manure. At 30 days the SOC content in the manure went from 23.45 percent to 17.68 percent in the inoculated and 12.65 percent in the inoculated, in 150 days the SOC values were 7.48 percent in the inoculated and 7.48 percent in the inoculate. Inoculation accelerates the initial mineralization processes, but there are no differences in the final content of the transformed SOC. This research was financing with resources from the Academic Vice-rector of Caldas University.

Discussion

Manure high volumes produced are potential source of contamination in water, soil, greenhouse gas emissions and compaction. Alternatives such as transformation and controlled decomposition of manure by adding microorganisms can help. The decomposition rate of cattle manure was compared by adding a commercial mixture of mineralizing microorganisms of organic matter and contribution of Organic Carbon (OC) to the soil. Manure was collected from the PUAD system at Hacienda la Cascada (Vereda Carrizales, Norcasia-Caldas, Colombia) under tropical conditions; 18

wooden frames of 0,50*0,50*0,06 m located in 3 different lots; 12-kg of fresh manure were deposited by wooden. The mixture of commercial organisms (5 percent v/v) was activated by 48 hours and 9 wooden were inoculated. Samples were collected fortnightly for 6 months. Moisture, OC, manure and soil pH, OC distribution in fine and coarse fraction and the mineralization rate of the manure were determined.

Conclusion

Although the inoculation with microorganisms accelerates the initial mineralization processes, no significant differences or changes were found in the final content of the transformed CO.
This could indicate that the initial rates of manure mineralization are due to the initial action of organisms that take their energy by breaking down the rapidly degrading materials in the manure, although if there are significant changes in the degree of acidity of the materials through of time, which can generate changes in the behavior of some soil properties

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Characteristics of the soil conditions of the southern part of the Odessa region

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Keywords: soils, humus content, heavy metals, radionuclides, agricultural products

Introduction, scope and main objectives

An important component of the agroecological state of the land is the soil cover, the indicators of which are both natural and anthropogenic in nature. In modern conditions with a high level of man-made load, the relevance of research in this direction is obvious.
The purpose of the presented studies is to assess the agroecological state of soils in the southern part of the Odessa region by the following indicators: the content of humus in the soil, the pH reaction of the soil solution, the content of heavy metals (Pb, Cd, Mn, Zn, Cu, Co, Hg) and radionuclides (90Sr and 137Cs).

Methodology

The initial information was the result of the agrochemical survey of the study area, which were presented in the Internet resource. The study was carried out using an integrated geographical approach to the analysis and evaluation of the conditions for the formation of the agroecological state of land, the method of classification of land for each of the indicators of the soil cover and their complex and the cartographic method for assessing their spatial distribution using GIS technologies.

Results

The assessment of the agroecological state of soils is carried out according to the developed classification of soil quality, according to which the criterion for the allocation of classes is the ratio of humus content and pH-reaction relative to the optimal value, and the content of heavy metals and radionuclides is in relation to the value of the MPC. The 1st class includes soils, the content of heavy metals and radionuclides in which does not exceed 20 percent of the MPC, to the 2 class - 20-70 percent, to the 3 class - 70-99 percent and to the 4th class - the size of the MPC and above. In the future, the territory was typed according to each of the indicators of their complex and their mapping was carried out. Land differentiation is carried out on the basis of large-scale mapping of the complex indicator of agroecological state. 3 agroecological districts have been allocated: 1 – the ecological status score is < 3.0, 2 – 3.0 – 3.5, 3 – >3.5.

Discussion

It is established that 90 percent of the territory of Kiliya belongs to the 1st district with the best and good agroecological conditions. about 50 percent of Izmail and Tatarbunar and 10 percent of Belgorod-Dniester districts. districts, 40 percent of Tarutino and 90 percent of Belgorod-Dniester districts and the territory of Ovidiopol district. Half of The Reni, Bolgrad, Artsyz, Saratsky and 60 percent of Tarutino districts are characterized by unsatisfactory agroecological conditions and are included in the 3.

Conclusion

The obtained results of soil quality in the content of heavy metals and radionuclides in the southern part of the Odessa region allow us to draw conclusions about possible contamination of agricultural products. Throughout the study area, there is no radionuclide 90Sr in the harvest of all grain, technical, vegetable and fruit crops and grapes, but there is no risk of contamination of products with radionuclide 137Cs in the Kiliya and Reni districts and heavy metals, especially Mn everywhere Cu, Co, with the exception of Kiliya, Ovidiopolky, Reni, Saratsky and Tarutino districts.

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Composting of municipal solid waste a remedy for water pollution and soil fertility decline in Uganda

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Keywords: mineralization, organic carbon, manure, mineralizing organisms

Introduction, scope and main objectives

Soil, water and environmental resources are strategic natural resources crucial for sustenance of life, agricultural production and industrialization. The increasing pressures on water and environment resources coupled with challenges of climate variability and climate change compromise the natural resource base and absorptive capacity of ecosystems. Consequently these affect the quality of life, natural economies and sustainable progress. One of the factors tainting water quality in Africa is pollution by municipal solid waste. Cities around the world currently generate about 1.3 billion tonnes of waste annually and this value is expected to increase to 2.2 billion tonnes by 2025 with its associated increase in the waste management cost being most severe in low income countries (Hoornweg and Bhada –Tata, 2012). Other negative impacts of solid waste which include high emissions of methane which is a Greenhouse gas may come in as well. This impact is exacerbated by the fact that over 75 percent of the waste generated globally is landfilled. Yet the leachate generated from landfills is also a contaminant to surface and ground water bodies. It is vivid that the organization and planning of public waste collection and disposal services are still rudimentary in most Sub- Saharan African countries (SSA) Uganda inclusive which has Resulted into limited amounts of municipal solid wastes being recovered and recycled. For this reason, the municipal solid waste most of which is putrescible has remained a nuisance rather than a resource for most SSA countries. In Africa and Uganda in particular, composting plants under the Clean Development Mechanism (CDM) have been set up in most municipalities in a bid to reduce emissions and water pollution. However, the question that remains in many researchers 'minds is, "can compost produced from composting of municipal solid wastes be trusted for use as a soil amendment material without impacting soils and water negatively?" Therefore, a study was conducted to assess the quality of compost produced at Mbarara Municipal Compost Plant (MMCP). The objective of this research was to assess the quality of compost produced at MMCP in reference to the international standards for high quality compost. The study followed a whole composting process of MMCP which has been producing compost in western Uganda for the past nine years. The impact of age on compost quality in terms of nutrient content at different stages of composting was tested. Most compost parameters tested such as C: N ratio (18:1-23:1), pH (9.8), percentOC (15.54±3.47) percent and percentN (0.79±0.04) percent were found within acceptable limits set by international standards of high quality compost as of July 2017. percent P (0.46±0.01) percent and percent K (2.14±0.08) percent of compost were within critical levels for agronomic soil conditioning. However, the texture (sandy loam) of compost was found to be different from the expected. This therefore calls for investigation about the possible sources of the high sand content in the compost and at what stage it gets there. , established at the plant.

Methodology

Mbarara municipal compost plant was used as the study area. It is located in Kenkombe village, Kakoba division in south- western Uganda. Its exact location is Longitude 300371 East and Latitude 00361 South. The study was arranged in a randomised complete block design (RCBD) with time (age) of the compost substrate being the blocking factor. Compost substrates/ materials of the same time of decomposition are in specific windrows right from the fresh sorted two weeks old materials being in block 1, then the four weeks materials in windrow 1 which is block 2, followed by six weeks materials in windrow 2 being block 3, then 8 weeks materials as lock 3 and block 4, 10 weeks materials in windrow 4 and block5, 12 weeks materials in windrow 5 and block 6, 14 weeks materials as windrow 6 and block 7 and finally, 16 weeks materials which is sieved as block 8. A windrow was the sampling unit and four sub samples were collected from selected points at different depths, well mixed in a basin to form a composite sample. Four composite samples were collected from each block. For leachate, randomised complete design was used in which leachate samples were scooped out of the leachate collection tank from different locations. The samples were transported to the Soil and nutrient laboratory at School of Agricultural Sciences, Makerere University where pretreatment and latter laboratory analyses of different parameters such as pH, texture, electrical conductivity, organic carbon, water soluble carbon, nutrients total nitrogen, total phosphorus, total potassium and calcium were determined using procedures by Okalebo *et al.,* 2002. The data obtained was entered into Microsoft Excel and cleaned. Then the data was exported into GenStat statistical software eleventh edition where data transformation to meet ANOVA requirements was done. ANOVA was then run at alpha value 5 percent. Means were then separated using Dancan's Least significant difference (LSD) at 5 percent probability level.

Results

Most compost parameters tested such as C: N ratio (18:1-23:1), pH (9.8), percentOC (15.54±3.47) percent and percentN (0.79±0.04) percent were found within acceptable limits set by international standards of high quality compost as of July 2017. percent P (0.46±0.01) percent and percent K (2.14±0.08) percent of compost were within critical levels for agronomic soil conditioning. However, the texture (sandy loam) of compost was found to be different from the expected. This therefore calls for investigation about the possible sources of the high sand content in the compost and at what stage it gets there.

Discussion

Generally time had an impact on compost quality and reduced the turnover since the compost quantity in relation to the quantity of municipal solid waste delivered at the compost plant reduced. This means that composting not only helps to clean the environment but also provides a soil amendment (compost) which will in turn lead to soil vitalization.

Conclusion

Generally, compost produced at MMCP can be used as a soil vitalizer and the same composting technology would be a great deal if adapted in all municipalities of Uganda to utilize an often neglected resource “municipal solid waste” into a useful resource to vitalize the depleted soils. However, to further improve quality of compost and its sustainable production, a well-equipped laboratory to test compost quality and ensure quality assurance for compost produced at the plant for different markets should be established at the plant.

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Dynamics of soil nitrates in a plot under onion cultivation in the Saiss Basin

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Keywords: nitrogen fertilization, onion, soil nitrate dynamic, Saiss basin, Morocco

Introduction, scope and main objectives

Morocco has always made the development of the agricultural sector a priority and a strategic choice. This sector, which is one of the main levers of economic development, is faced with the challenge of the intensive use of nitrogen fertilizers which threaten the agricultural soil quality. This study is part of the research related to this issue which holds an important place in the research field in Morocco. It aims to establish the spatio-temporal variation of soil nitrate concentration in an onion plot.

Methodology

A nitrogen fertilization trial was carried out in the “Douyet” experimental station of the Regional Center of Agronomic Research of Meknes. The experimental design adopted is Complete Random Blocks. Six nitrogen treatments (0, 90, 135, 180, 225 and 270 KgN/ha) were tested in the onion plot. Soil samples were taken at five depths (0-20 cm, 20-40 cm, 40-60 cm, 60-80 cm and 80-100 cm) for their nitrate content.

Results

The monitoring shows a richness in nitric elements, besides the highest levels are recorded in the 0-20 and 80-100 cm layers and can reach 84 mg kg^{-1}. For the rest of the profile, it appears that the amount of nitrogen applied does not reflect the concentrations obtained in the soil. The difference in soil NO3- concentrations is clearly noted between the 0, 90 and 135 kgN/ha rates and the 180, 225 and 270 kgN/ha rates.

Discussion

The direct impact of nitrogen application is more felt after the herbaceous growth stage, and it seems to have more of a marked impact at shallow depths (0-20cm), this root zone could lose NO3- at the time of bulbing when the crop rapidly absorbs nitrogen. The results show that for each of the rates, the soil measured concentrations decrease gradually with time. The assimilation of nitrogen by the plant during its development cycle may explain this result.

Conclusion

Increasing the rate of application favors an increasing storage of NO3- in the soil profile and an increase in bulb yield. A significant difference in soil nitrate levels over time was observed. However, no significant difference was observed between the concentrations measured at different depths for the different N application rates.

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Effect of a biological system on the management of soils contaminated with extra heavy crude oil

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Keywords: vetiver, mycorrhizae, hydrocarbons, soils, oil, bioremediation, phytoremediation, pollution

Introduction, scope and main objectives

In Venezuela, oil activity can cause different problems during the processing, transport and storage of hydrocarbons, considerably altering ecosystems, causing a negative effect on the soil, water, air, flora, fauna, and the microorganisms that inhabit these ecosystems, in addition an indirect harm to human beings. The presence of crude oil in the soil directly affects the efficient development of crops, which is a major problem, since this type of contaminant causes a deterioration in the quality of the soil, altering its chemical composition, especially the carbon-nitrogen ratio, vital for the growth of beneficial microorganisms, as well as the structure and composition of organic matter, pH, conductivity, the distribution of microbial populations, among others. Therefore, the recovery of degraded soils is considered a necessity, in order to mitigate their desertification. Currently, there is an increase in the development of strategies to reduce the effects generated by contamination with crude oil; one of them is bioremediation, which is based on the use of microorganisms, bacteria, fungi and by-products for soil recovery. The use of arbuscular mycorrhizae (AMF) and plants has shown excellent results in reducing the concentration of oil in the soil, since this symbiosis generates a synergistic effect favoring the degradation of toxic compounds. Therefore, the objective of this work was to evaluate a symbiont system for the management of a soil contaminated with extra-heavy crude oil.

Methodology

The experimental design consisted of the evaluation of two soils from the eastern savannah (S1 and S2) impacted with extra-heavy crude oil. The concentration of total hydrocarbons in the soil was determined by the Soxhlet extraction method using chloroform as extractant solvent. The soil was treated by a system composed of *Chrysopogon zizanioides* L Nash (vetiver) inoculated with commercial arbuscular mycorrhizae in triplicate for each concentration of the contaminant and the controls. The trial lasted 90 days. The agronomic indicators evaluated were root length and biomass production.

Results

The results obtained show different TPH values, with S1 having a TPH of 3 percent and S2 a TPH value of 6 percent. On the other hand, no significant differences were observed between the treatments. However, the results suggest that Vetiver grass with AMF, tolerates different doses of hydrocarbon, being S1 the one that reached the best height (17.03) and S2 (13.19). Regarding biomass, no statistically significant differences were observed in the treatments.

Discussion

The biological system was able to incorporate soluble soil nutrients, which favored the growth of aerial biomass, no foliar lesions were observed in S1, unlike S2, which presented violet spots, in addition to necrotic areas in the leaf lamina, which indicates that there could be toxic effects derived from crude oil.

Conclusion

The biological system used showed a positive effect on the management of soils contaminated with extra-heavy crude, which suggests that it can be used in the recovery of impacted soils.

Acknowledgements

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Effects of biodegradable and un-biodegradable plastic mulches on soil abiotic characteristics and microbial populations involved in N cycle

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Keywords: soil DNA, microbial populations, agricultural mulching, Mater-Bì, polyethylene

Introduction, scope and main objectives

Plastics are among the main global environmental pollutants that have been extensively detected in both aquatic and terrestrial ecosystems. Agricultural practices, such as plastic mulching, sewage and sludge applications, wastewater irrigation and atmospheric transport are the major sources of plastic pollution in soils. As agroecosystems provide food, fragment of plastics in soils could cause unknown effects on farm ecosystems and food security. In addition, the microplastic presence in soil can cause alteration on soil properties, nutrient contents and in turns on soil organism biodiversity and functionality. Nitrogen is a limiting factor for agricultural soils and it is essential for plants and soil microorganisms. Microbial populations involved in N cycle can be altered by stress conditions such as plastic contamination, with important consequences on N cycle. Therefore, the research aimed to evaluate the abundances of different microbial populations involved in N cycle in soils exposed to biodegradable (Mater-Bì: M) and un-biodegradable plastic mulches (Polyethylene: PE). The data were compared to that in uncovered soils (Control: C).

Methodology

The experiment was performed in outdoor mesocosm trial (4 pots C, 5 pots M and 5 pots PE). Surface soils (0-10cm) were collected, at each pot, at the mesocosm setting-up (T0) and after six months (T2). The soils were analyzed for the main abiotic proprieties (pH, water content, concentrations of organic C, total C, total N, NH4+, NO2-, NO3-) and for the abundances of total DNA (DNA yield), eubacterial DNA (16S rDNA), and N2-fixer, ammonia oxidizer, archea ammonia oxidizer and denitrifier DNA that were quantified by qPCR.

Results

The **Results** showed that the exposition of plastic and bioplastic mulches cause an increase the water content and a decrease of NO3- and NH4+ contents. The exposition to PE caused a decrease in soil pH and an increase in total and organic carbon concentrations. By contrast, the DNA yield and eubacterial DNA did not statistically vary among treatments. Soil archea ammonia oxidizer decreased significantly under M treatment compared to PE and C treatments. A temporal evaluation highlighted that all microbial populations involved in N cycle decreased, with the exception of total microbial biomass and ammonia oxidizers that showed a static trend over time.

Discussion

The Results agreed with other researchers that found a decrease of soil bacteria richness and diversity in soil contaminated by plastic mulches. In fact, the relative abundance of bacterial community would be affected by the soil conditions that vary under covered soils. Besides, the presence of mulches on soil could also alter the soil and in turns influence the bacterial populations.

Conclusion

Finally, the exposition to PE and M negatively impact on soil microbial populations involved in N cycle.

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Evaluation of the phytotoxic effect, through tests with *Lactuca sativa*, of soils contaminated with extra heavy crude treated with a biological coupling

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Keywords: toxicity, bioremediation, petroleum, soil, *Lactuca sativa*, contamination, rhizoremediation, phytoremediation

Introduction, scope and main objectives

Petroleum and its derivatives are the main source of energy for industry and daily life, as well as being the raw material in numerous processes in the chemical industry. This dependence on fossil fuels has Resulted in serious environmental problems, including soil contamination. Venezuela is the country with the largest oil reserves (OPEC, 2021.), which makes it highly vulnerable to environmental degradation due to the activities of the oil industry; therefore, the aim of this work is to evaluate the phytotoxic effect, through tests with *Lactuca sativa*, of soils contaminated with extra-heavy crude biotreated with a biological coupling.

Methodology

Samples of soils impacted with extra-heavy crude oil from the Orinoco Oil Belt, Venezuela, were used. The soil nomenclature is as follows: Soil 1 (TPH3), Soil 2 (TPH6) and Soil 3 (TPH13). The bioremediation treatment of these was carried out in triplicate in microcosms of 250 gr for each concentration of TPH, using a biological coupling with a grass (*Chrysophogon zizanioides*) and the mycorrhizal fungus *Rhizophagos manihotis*. The phytotoxicity test was carried out using *Lactuca sativa* seeds at the initial time and final time of the bioremediation test (Pernía *et al*., 2018; Aguirre *et al.*, 2022).

Results

The percentage of seed germination was affected by the contaminant in the three impacted soils, decreasing between 80 and 100 percent before the soils were biotreated. After treatment, it reached values close to those of clean soil. The growth of the structures of the *L. sativa* seedlings was also affected by the contaminant. In soils 1 and 2 there was a significant difference in the lengths of radicles and hypocotyls before and after treatment; in soil 3, the difference was observed only in the radicles. The IIF at the initial time indicated that the soils had extreme toxicity (with values between 89 and 100). After 90 days of treatment, the samples decreased their toxicity to the low toxicity condition, with values between 10.2 and 25.3.

Discussion

The negative effect of the presence of extra-heavy crude oil on seed germination and on the growth of *L. sativa* structures was evidenced, even inhibiting the germination process. The results obtained do not show a direct relationship with the concentration of TPH and its effect on germination, since the toxicity of a hydrocarbon also depends on the complex and variable interaction between the characteristics of the crude and the soil. After the bioremediation treatment, the germination percentage was similar to that of a clean soil. The soils went from an extreme toxicity condition to a low toxicity condition after treatment. The results infer that increasing the time in the Methodology used could lead to better results in terms of toxicity.

Conclusion

The biological coupling used showed tolerance to extra-heavy crude oil concentrations in terms of TPH and was an appropriate technology for reducing the toxicity of impacted soils.

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Fertimanure: upcycling animal manure into improved fertilising products

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Keywords: nutrient recovery, bio-based fertilisers, agronomic quality, manure management, pig slurry

Introduction, scope and main objectives

Annually, total farm livestock population in Europe excrete around 1 400 Mt of manure, and more than 90 percent of this manure is returned to agricultural fields increasing soil contamination and greenhouse gas emissions. The main objective of FERTIMANURE project is to develop, integrate, test and validate innovative Nutrient Management Strategies to obtain reliable and safe fertilisers ("bio-based fertilisers", BBF) from manure that can compete in the EU fertilizers market. Therefore, FERTIMANURE is focused on "How to improve the agronomic use of recycled nutrients from livestock manure" to reconnect nutrient flows between plant and livestock production. To this end, the technological approach will be covered by the implementation of 5 innovative and integrated nutrient recovery on-farm experimental pilots in Spain, France, Germany, Belgium and The Netherlands.

Methodology

The Spanish pilot integrates two different treatment trains either to treat solid or liquid streams obtained from raw pig slurry. To produce different BBFs, the pilot plant is divided in 5 connected treatment stages: i) solid/liquid separation unit to obtain liquid and solid streams to be valorised; ii) biodrying system coupled with a biomass boiler to valorise the solid fraction either as dry organic amendment rich in macronutrients or phosphoric acid from ashes; iii) membranes system to treat the liquid fraction to produce ammonium sulphate and other by-products (permeate and concentrate streams); iv) freeze concentration to treat the concentrated stream generated in the membranes system and produce a liquid concentrate rich in NPK, organic matter and reclaimed water; and v) the permeate stream from the membranes feed a microalgae reactor coupled with enzymatic hydrolysis reactor to produce biostimulants rich in free amino acids.

Results

To validate the ability of the BBFs produced to substitute mineral fertilisers, the agronomical and environmental performance of these products will be assessed during at least 2 years. Specifically, N, P and C release dynamics will be assessed with the BBFs and compared with mineral fertilizers in soil incubation assays under controlled conditions, whereas pot-tests will be performed in mesocosms to study the BBF effects on phosphorus bioavailability and crop grown. Crop yield of FERTIMANURE products, as value tailor-made fertilisers (TMF) to cover specific needs of crop-soil pairs, will be also compared with conventional fertilization in field trials.

Discussion

Combination of fully controlled lab trials and the observations of nutrients in the soil and crop in the field will provide a full range of data that allows full comprehension and comparison of novel fertilising products against mineral fertilisers.

Conclusion

FERTIMANURE seeks to provide an innovative circular economy model to favour rural development in agricultural sector by creating real synergies and links within farmers and other industrial activities.

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References

We have not used References for the preparation of this abstract.

Greenhouse gas emissions and dynamics of soil nutrients in coffee crops

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Keywords: carbon dioxide, leaf litter, fermentation horizon, nutrients; nitrous oxide

Introduction, scope and main objectives

World coffee production generates annual revenue approx. 200 billion dollars. However, soil degradation, the inappropriate use of agricultural inputs and global climate change (CCG) place this crop in a scenario of vulnerability, but also of greenhouse gas (GHG) emissions. Proper management of these crops can be part of the solution to these challenges, but a better understanding of GHG emissions, loss of fertility and soil degradation that threaten the productivity of coffee plantations is necessary. Given this scenario, a diagnosis was made of the nutritional status of agroforestry systems (shade and sun) and this condition was related to carbon dioxide (CO2) and nitrous oxide (N2O) emissions from the soil.

Methodology

Three production systems for coffee (*Coffea arabica*) with plantain (*Musa paradisiac*a), coffee with mango (*Mangifera indica*), and coffee in full sun were selected in the State of Veracruz, Mexico. In an experimental area of three hectares, three plots of approximately one hectare each were selected, representative of the three coffee production systems of interest. The land corresponding to each system was divided into quadrants of 100 m^2 and these were randomized to establish the sampling points. Soil samples, fermentation horizon, litter and GHG emissions (CO_2 and N_2O) were taken at the same sampling point in each quadrant. Leaf sampling was done according to the technique described by Snoeck and Lambot (2004). The litter and fermentation horizon samples were collected in a 900 cm^2 sampling area. Soil samples were collected with a 2.5 cm diameter auger at a depth of 15 cm. In total, 18 litter samples, 18 fermentation horizon samples and 18 soil samples (simple samples) were taken in the experimental area. The CO_2 and N_2O emissions were measured in situ, using the permanent static closed chamber technique (Mogge *et al.*, 1999). The basis of this technique is based on collecting gas samples from inside the chambers four times at 10 min intervals. Gas samples were read on a Greenhouse Gas Analyzer Shimatzu model GC2014 gas chromatograph. The concentration of micronutrients (Fe, Cu, Zn and Mn) and macronutrients (Ca, Mg, K and Na) was determined by atomic absorption spectrometry in the foliar samples (from the coffee plants of the three production systems) and from I usually. The concentration of total C and N was determined by the dry combustion method (Thermo Scientific Flash (200) automated analyzer) in the foliar samples, leaf litter, fermentation horizon and soil. In the soil samples, pH in water (1:2), soil organic matter concentration was measured using the Walkley-Black method (Nelson & Sommers, (1996)), extractable phosphorus using the Bray and Kurtz II method, and the concentration of nitrates (NO3-) and ammonium (NH4+) by steam distillation (Bremner, 1965). The C:N ratio was calculated with the total carbon and nitrogen concentration data of the soil.

Results

The Results showed that the foliar concentration of C, nitrogen N, zinc and the C:N ratio was different in the production systems. The coffee-plantain system is the one that stored the highest concentration of nitrogen in the litter. The coffee-banana and coffee-mango systems are the ones that stored the highest concentration of carbon and nitrogen in the fermentation horizon. The coffee-banana and coffee-mango systems had higher availability of nutrients in the soil. The soil of the coffee-mango system stored a higher concentration of C and soil organic matter (SOM). Soil CO_2 emission was higher in the coffee-mango system.

Discussion

The shaded systems stored a higher concentration of C and N in the fermentation horizon and a higher availability of nutrients in the soil was also observed, compared to the coffee-full sun system. This is probably related to the quantity and quality of the organic residues that the study systems contributed to the soils. While the low concentration of C and N in the fermentation horizon and of nutrients in the soil of the coffee-full sun system was associated with its high C:N ratio of the leaf residue and litter. The C:N ratio in organic residues deposited naturally or applied to soils becomes relevant due to the effect they have on the availability of C and nutrients in soils. In the soils studied, the highest concentration of SOM was observed in the coffee-mango system. The difference between the study systems would be explained by the greater amount of litter residues provided by the coffee-mango system. Plant residues are the main source of SOM input, when it is mineralized, C and nutrients such as N are released. In the coffee-mango system, the concentration of C and N was higher in the fermentation horizon than in the coffee-full system sun. The concentration of C and N in the soil was twice higher in the coffee-mango system than in the coffee-full sun system. This C was stored in the MOS of the coffee-mango system. Factors such as soil temperature and moisture also influence the decomposition of SOM. In our study, the percentage of soil moisture was higher in the soil of the coffee-mango system than in the coffee-plantain and coffee-full sun systems. In the coffee-plantain system, environmental conditions such as low soil moisture percentage and low soil C inputs were factors that could limit SOM mineralization in this system. In the coffee-full sun system, high temperature, low soil moisture content, low C concentration in the fermentation horizon and soil probably limited the SOM mineralization process. Consistent with the MOS values, the CO_2 emission from the soil of the coffee-mango system doubled that of the coffee-full sun system. CO_2 is produced by the respiration of plant roots and microorganisms that occurs during the decomposition of litter and SOM. The greater release of CO_2 in the coffee-mango system could be due to a greater respiration of the roots of the plants and microorganisms in this system. In the study systems, no differences were observed in N_2O emissions from the studied soils. This probably occurred because, despite the fact that the fertilization doses are high, the environmental conditions (high moisture content and availability of NO3- in the soil) are not favorable for the denitrification process to occur in the systems studied. Denitrification is the main source of N_2O under conditions of high water content and application of nitrogenous fertilizers.

Conclusion

The shade tree species in the coffee production system influences the dynamics and availability of nutrients, as well as the concentration of C and SOM. The coffee-mango system has favorable characteristics in its physicochemical fertility that would probably make it more resilient to the effects of GCC, in addition to having the potential to mitigate atmospheric CO_2. The information generated from this study is relevant from the point of view of monitoring and generating a baseline of CO_2 and N_2O emissions in the soils of coffee production agroforestry systems of this study site. This research shows that shade trees in coffee production systems are key in the formation and emissions of CO_2 and N_2O, which should be considered for future studies.

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Identification of wheat root traits that improve soil structure and optimize nitrogen cycling: the wish-roots project

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Keywords: rhizosphere, soil microbiome, nitrogen, wheat, root architecture, crop system, nitrification

Introduction, scope and main objectives

Soils provide about 99 percent of the food and water consumed by humanity. To meet the sustainable development goals (SDGs) targeting 'food security '(SDG 1 and 2) and 'sustainable production' (SDG 12) it is necessary to maintain healthy soils in crop systems and to restore degraded agricultural land. Wheat is the most widely grown crop in agricultural system and is the staple crop for 35 percent of the world population, providing 20 percent of daily protein and food calories. The WISH-ROOTS project recently funded through the EJP Soil program, builds upon root traits identified in wheat that impact key markers of soil health such as the capacity to control the cycling of essential nutrients, and to improve soil structure, water retention capacity and biodiversity. The project has brought together experts in soil science, plant genetics and soil microbial ecology and seeks to introduce these beneficial root traits in wheat crop systems.
Application of nitrogen (N) fertilisers to agricultural soils supports half of the world's food production. However, approximately 50 percent of this N worldwide is transformed by soil microbes (through nitrification/denitrification) and lost to the environment by leaching/gaseous emissions. Biological nitrification inhibitors (BNIs) exuded from the roots of certain varieties of plants can reduce loss of N-fertilizer (Coskun *et al.*, 2017).

Methodology

A recombinant inbreed population was obtained by crossing an elite bread wheat variety and a historic landrace with contrasting capacity to control nitrification rates in soil. The parentals and the resulting 88 recombinant inbred lines were grown in one square meter plots in an agricultural field in Norwich (UK). The field trial was randomised and run in triplicate. Composite rhizosphere soil samples were collected from each plot after harvest. Soil DNA extraction and amplification of the 16S rRNA hypervariable V4 region was performed using BiomeMakers®custom primers (Patent WO2017096385). Reads per sample were generated using 2 × 301bp paired-end sequencing with an Illumina MiSeq platform. Taxonomic assignment was performed against SILVA database release 138 and functions assigned using PiCRUSt2. Quantitative trait locus (QTL) analysis was performed to link variations in the nitrogen cycle related genes in the rhizosphere soil with regions of the wheat genome.

Results

We have identified genomic regions in the wheat genome significantly linked to the abundance of specific nitrifying communities (*Nitrospiraceae*, *Nitrosomonadaceae* and *Nitrosococcaceae*) and associated ecological functions assigned with PICRUSt2: aerobic ammonia oxidation and nitrification.

Discussion

The identification of potential target genes in the wheat genome which may influence soil microbial communities can be used to develop breeding targets for wheat breeders to incorporate BNI activity into modern bread wheat varieties. This strategy can provide advantageous bread wheat varieties for farmers that support a more sustainable use of land improving soil microbial biodiversity and N cycling while ensuring wheat production for food security.

Conclusion

Microbiome diversity in rhizosphere soil and associated functionality can be used for QTL mapping of agronomic traits such as control of soil nitrification. Introducing this agronomic trait into modern cultivars could improve the efficiency of use of N-fertilizer by crops while reducing N loses to the environment.

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Reference

Coskun, *et al.* 2017 "Nitrogen transformations in modern agriculture and the role of biological nitrification inhibition." *Nature Plants* 3.6: 1-10.

Increasing the efficiency of Ukrainian agriculture in arid conditions

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Keywords: crop, fertilizers, irrigation, soil fertility

Introduction, scope and main objectives

Climate change is causing increased aridity and unpredictable harvests. At the same time, there are significant reserves for increasing soil productivity and efficient use of moisture (Adaptation, 2018). One of the most important measures to increase productivity and efficient use of soil moisture reserves is the introduction of a scientifically based system of fertilizing crops in crop rotations (Crop, 2016). The objectives of the work are to evaluate the possible ways increasing the efficiency of Ukrainian agriculture in arid conditions.

Methodology

We employed an experimental expert assessment approach. We reviewed extensive material on Crop Fertilization Systems in Ukraine. Field investigations in the Forest-Steppe and Steppe zones of Ukraine have been undertaken.

Results

The fertilizers efficiency is dependent on the weather conditions of the year. The increase in yield from fertilizers in arid conditions is reduced by 25-30 percent compared with years with favorable moisture. Water consumption per unit dry matter of corn is reduced by 20-25 percent on a typical chernozem with a high phosphorus content compared to soil with a low phosphorus supply. Fertilizers use reduces this difference, but does not eliminate it. The coefficient of water consumption for wheat, which was grown without fertilizers, was 526 m3/t of grain, with the introduction of PK fertilizers - 496, NK fertilizers - 446, and complete mineral fertilizer (NPK) - 336 m3/t of grain. The combined application of organic and mineral fertilizers in crop rotation reduces the moisture consumption for crop formation by 20- 30 percent, and in the driest years - even up to 35-40 percent. Fertilizer application in irrigation is the most effective and provides 2-4 times increase in yield (Balyuk *et al*., 2009.).

Discussion

An unequal reaction to weather conditions of different types of fertilizers has been established. In dry years, the positive effect of phosphate fertilizers is most often noted. The water consumption during the application of NPK decreased by 36.1 percent compared to the unfertilized control. The greatest impact on the stabilization of crop yield growth is observed in variants with the application of mineral and organic fertilizers. The decrease in yield growth under unfavorable water regime conditions is only 1-7 percent compared with favorable conditions for moisture supply. The high needs of agricultural crops in the nutrients content in irrigated soil are due to the large removal of elements by the larger harvest.
Fertilization system on irrigated lands should be based on taking into account a number of factors:

- assessment of the current ecological and agro-reclamation state (complex of hydrogeological, engineering-geological, soil- reclamation, agronomic and environmental-toxicological indicators)

- nutrient content in the soil (and the ratio with their optimal content), - nutrient removal by the planned harvest

- optimization of times and methods of fertilization

- preventing the possibility of nitrate migration into groundwater

- the possibility of combining irrigation with the application of mineral fertilizers, herbicides, ameliorants and microelements

Conclusion

Scientifically substantiated use of organic and mineral fertilizers, irrigation increase soil fertility and significantly reduce the dependence of agricultural crops on adverse weather conditions.

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Kuyka: an urban vermiculture experience from Cuenca, Ecuador

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Keywords: vermiculture, worm, urban, biomass, reduction, soil , pre-composting, humus

Introduction, scope and main objectives

The Kuyka project (a Quichua word, whose meaning is earthworm) is located in the third most important city in Ecuador, Cuenca. According to data provided by the Composting Plant of the Cuenca Municipal Cleansing Company, 55 percentto 60 percent of household waste is organic. Approximately 520 tons per day of waste, of those 65 percent tons is organic production and only 30 tons are processed for organic fertilizer processing. The objective of this project is to enable Cuencan families to process their organic waste directly at home, producing quality humus and generating biomass in each of their homes. Actually approximately 40 families have the vermicomposter system.

Methodology

The methodology consisted of the following steps:

1) Design and construction of a functional urban vermicomposter that allows citizens (regardless of whether or not they had knowledge of how to compost their waste), to obtain quality humus through the work of the Californian red worm.

2) Search for quality wood that, through proper treatment, can at least resist for a period of 4 years as a niche and breeding ground for the California red worm.

3) Construction of an urban vermicomposter, with a composting capacity of 50 pounds of organic matter, consisting of two wooden boxes for composting, as well as a stainless steel tray for collecting liquid humus. The system is fully portable and convenient to use in small or large urban spaces.

4) Installation of composting systems, in the houses of different clients located throughout the city, technical follow-up, and advice until the first humus harvest.

5) Positioning of the Kuyka Project in networks and advertising,

Results

In the city of Cuenca, approximately 40 families to date compost their organic waste at home with the Kuyka system, they have been provided with all the necessary technical advice and follow-up so that they can carry out the transformation of their waste, in the same way. This way they are provided with the necessary worm, obtaining excellent harvests and Results. The interesting thing about the project is that during the pandemic, food insecurity caused many people to seek to generate their own land to plant, and with the Kuyka system at the urban level it was possible to achieve it.

Discussion

In the city of Cuenca, with more than 500 000 thousand inhabitants, the sanitary landfill has a useful life until 2030. By getting citizens to compost their organic waste at home, we are prolonging the life of the sanitary landfill, generating quality biomass in each one of the homes. In the same way, the Kuyka experience is a way to connect with learning about the wonderful organism that is the Californian red worm, and its incredible benefits for the soil.

Conclusion

Each person is able to compost their waste at home, through small urban vermicomposter systems, with the correct advice and monitoring.

Linking straw use, carbon balance, greenhouse gas emissions, and crop growth for a sustainable sugarcane production

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Keywords: adaptation, bioenergy, C sequestration; mitigation, N immobilization;, nitrous oxide

Introduction, scope and main objectives

Sugarcane is one of the world's largest biomass-producing crops and its production is expected to rise as global demand for bioenergy increases1. After harvest, a huge amount of straw can be used for energy purposes, which could threaten soil conservation. This study aimed to determine a suitable removal rate of sugarcane straw based on its impact on greenhouse gas (GHG) emissions, soil carbon (C) balance, and crop growth.

Methodology

A field experiment with a horizon of three years was arranged in a completely randomized block design with three replicates in October 2021. in the department of Ledesma, Jujuy, Argentina. Treatments applied were: 100, 65, 30, and 0 percent of straw removal. We report the effects of these treatments on GHG emissions for the period of 135 days from straw removal. Gas samplings were performed 1, 7, and 24 days after harvest (October 5th, 2021.), 3, 4, 7, and 10 days after N fertilization (November 1st, 2021.), and monthly thereafter, by using the static chamber method.

Results

Straw removal treatments had no significant effect ($p > 0.05$) on the adjusted mean values of CO_2 and N_2O emission fluxes. The differential response of cumulative CO2 and N2O emissions through time by treatments was not significant ($p > 0.05$) in this period and environment. This response, however, showed a consistent trend for cumulative N2O: 32.7 ±19.1; 21.3 ±11.8; 12.7 ±5.6; and 10.4 ±5.1 mg N_2O-N m^{-2} for 100, 30, 0, and 65 percent straw removal, respectively. Unexpectedly, the treatment with 65 percent of straw removal showed the lowest cumulative N_2O emissions.

Discussion

We hypothesize that N_2O emissions reflect the availability of inorganic soil N as a result of the balance between soil and/or fertilizer N immobilization and soil and/or straw N mineralization. At 100 percent of removal, there was almost no N immobilization, leading to high N availability and the highest N_2O emissions. At 30 percent of removal, cumulative straw N mineralization counterbalanced fertilizer N immobilization, Resulting in considerable N available and cumulative N_2O emissions. At 0 percent of removal, cumulative straw N mineralization could not offset fertilizer N immobilization, Resulting in low N availability and N_2O emissions. Finally, at 65 percent of removal, cumulative N mineralization (limited by a low straw amount) was also overcome by N immobilization, leading to low N availability and similar N_2O emissions than 0 percent of removal.

Conclusion

At 100 percent of removal, straw exploitation was penalized by the highest cumulative N_2O emissions and lack of C input to the soil (which is unsustainable). In contrast, 0 percent of removal allowed C to enter the soil and reduced cumulative N_2O emissions, but this practice did not allow its exploitation. The range of 30 to 65 percent of removal seems to be the desirable sustainable straw use. In fact, when N_2O emissions were relativized to C inputs, these treatments showed mean and similar ratios among them, whereas 100 percent and 0 percent of removal showed the lowest and highest ratios. Thus, depending on soil C stock, these two management strategies could be used to exploit straw while decreasing the environmental impact. Measurements and analyses need to be continued to determine the impact of straw removal rates on the rate of change of soil carbon, crop yield, and annual cumulative CO_2 and N_2O emissions.

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Micronutrient management adaptations to climate change: extrapolations from findings on copper and zinc chemistry in semi-arid to arid climate of The United States

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Keywords: fixation kinetics, extrapolation, nutrient interactions, biotechnology, climate-smart, soil, power function

Introduction, scope and main objectives

Micronutrients are integral in maximizing crop potential. However, the chemistry of micronutrients could vary depending on climatic and soil characteristics, most of which vary temporally and spatially. Climate change which introduces variability in weather pattern has also compounded nutrient management problems. This work drew inferences from two published studies (Udeigwe *et al*, 2016; Udeigwe *et al.*, 2017) on the chemistry (fixation kinetics and interactions) of copper and zinc micronutrients in a semi-arid climate of the US. The study area is significant because of the site soil characteristics (aridic and/or thermic; alkaline with pH range of 7.52 – 8.39), and climate (semi-arid to arid; mean annual precipitation of 470 mm; mean annual temperature of ~16°C). Given the aforementioned, the objective of this work was to extrapolate the findings from the referenced studies to the management of these micronutrients in times of climate change.

Methodology

The Methodology (including site and soil description, soil characterization, treatments, and statistical analyses) are all detailed in the referenced studies (see Udeigwe *et al.*, 2016; Udeigwe *et al.*, 2017 and for brevity will not be repeated.

Results

About 80 percent of applied Cu was fixed within 14 d of application, this compared to Zn was 57 percent. Short term (14 d) Cu fixation was controlled by organic matter (OM) and pH, while long term (90 d) fixation was controlled by pH and a combination of pH and calcium carbonate ($CaCO3$). Zinc fixation within the experimental period of 90 d showed a weak positive trend with pH and total P. Fixation of both Cu and Zn over the entire experimental period (90 d) was better described by the power function model. The reaction rate constants obtained from this study could be used to approximate how much of added Zn material could be available at a specific time in these semi-arid soils.

Discussion

Extrapolating the findings of these studies and other observations to micronutrient management in time of climate change, the following climate-smart recommendations were arrived at:

(1) timing is critical as a majority of the applied micronutrients was fixed within the first 14 days,
(2) chelated compounds of these micronutrients should be constantly used as a complementary study showed lower reaction/fixation rate constants for chelated compounds,

(3) given the established interactions with soil constituents e.g., $CaCO_3$ (for Cu), OM (for Cu), and P (for Zn), foliar application should be preferred,

(4) organic residue incorporation is encouraged, given the demonstrated significant impact of this on the soil properties relevant to soil recovery, productivity, and sustainability, and

(5) incorporation of biotechnology products to maximize natural soil and plant potentials, particularly in these days of global fertilizer shortage. is more paramount than ever.

Conclusion

Timing, chelating, foliar application, organic residue, and biostimulants are paramount to our sustainable management of micronutrients.

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Mixed application of compost and inorganic fertilizers increases maize (*Zea mays* l.) yields, grain minerals, and nutrient use efficiency and mitigates greenhouse gas emissions in southwestern Ethiopia

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Keywords: compost, crop yield, grain minerals, greenhouse gas

Introduction, scope and main objectives

To feed the world's growing population, sustainable crop intensification is required without affecting the soil production capacity for the next generation. Appropriate soil nutrient management can be a strategy to balance crop production and environmental pollution. The mixed application of organic and inorganic fertilizers has been proposed as a tool for sustainable yield intensification, increasing grain minerals and nutrient use efficiency (NUE), and reducing greenhouse gas (GHG) emissions. However, the suitable combination of organic and inorganic fertilizer has not been well documented under the maize cropping system in smallholder farming conditions. The current study aimed to analyze and identify the appropriate combinations of organic and inorganic fertilizers which increase maize yield, grain minerals, NUE and mitigate GHG.

Methodology

To achieve the aimed objectives both field and laboratory incubation experiments were conducted with seven different ratios of compost and inorganic fertilizers consisting of nitrogen, phosphorus, and sulphur on maize (*Zea mays L.* Bako-hybrid) and four replications in Jimma Ethiopia and the University of Rostock, respectively.

Results

The results showed that maize yield, grain minerals, and NUE were increasing about 12 to 18 percent, 6 to 123 percent, and 4.8 to 27.4 percent, respectively, when combining organic and inorganic fertilizers compared to inorganic application alone. The combinations are also suitable to reduce the emission of N_2O by about 22 to 80 percent in comparison to the inorganic fertilizer, especially in wet soil, while CO_2 and CH_4 emissions were less affected.

Discussion

The significant influence of combined application on maize yield, grain minerals, NUE, and GHG is due to its impact on soil physicochemical and biological properties.

Conclusion

The application of inorganic fertilizer (30 to 60 kg N ha^{-1}) and compost (2.8 to 4.9 t ha^{-1}) would be a promising option for the most vulnerable people, such as smallholders, to increase maize grain, grain minerals and NUE without increasing GHG emission.

Acknowledgements

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Nitrogen release mechanisms of lignite-based nitrogen fertiliser in calcareous soils

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Keywords: Lignite, slow-release fertilizers, N losses, N release, alkaline calcareous soils

Introduction, scope and main objectives

Slow-release fertilizers (SRFs) are considered one of the most efficient strategies to extend the nitrogen (N) supply in the soil and can effectively mitigate N losses. But, finding a suitable, affordable, and climate-smart, N-carrier is the real challenge for researchers to formulate an SRF that can be adopted on large scale. Lignite is an abundant and efficient adsorbent and has ameliorating effects as a soil amendment. Lignite as an N carrier needs investigation, and this study was planned with the objective to develop a novel lignite- based slow-release N fertilizer (L-SRF) and its evaluation and effectiveness to prolong the N availability in calcareous soils and control the N losses.

Methodology

The lignite was ground in a mechanical grinder and passed through a 0.50 mm sieve. The collected lignite meal was soaked in 1 M HCl and shaken for 24 h. The contents were, then, filtered through 0.45-micron filter membrane following the several washings with distilled water till the stabilized pH, to remove the indigenous minerals and toxic substances. The deashed lignite was dried in oven at 70℃. A concentration of urea solution @ lignite: urea (1:1) was prepared and deashed lignite was soaked in it for 8 h. Then, a solution containing mixture of polyvinyl alcohol and starch (50:50) was mixed in the ingredients @ 10 percent on w/w basis. This mixture was dried in oven at 70℃ to remove the extra moisture. The partially dried mixture was passed through an extruder which yielded cylindrical strands. These strands were chopped into 2-4 mm sized pellets upon drying which were finally regarded as multifaceted lignite-based nitrogen fertilizer. Treatments such as conventional urea, commercial coated urea and lignite-based N fertilizer were applied to two different calcareous soils viz. coarse and fine textures soils. The experiment was conducted in a CRD arrangement with three replications. In brief, screw lid plastic jars were filled with one kg of soil and mixed with the required quantities of fertilizer treatments, equivalent to 200 kg ha^{-1}.

Results

The extensive surface area, porosity, and diversity of organic functional groups are the main mechanisms to complex the N for extended-release and minimized losses. The XRD of raw lignite, modified lignite, and L-SRF confirmed the emergence of new peaks recognized as urea. The FTIR patterns also displayed the new functional groups identified as hydroxyl, carbonyl, and amide which showed the adsorption of urea. The urea loading SEM images were seen as pore-filling and surface precipitation. The results of the study revealed that L-SRF extended the N release up to 70 days in different soils. It has decreased the NH_3-volatilization up to 44.55 percent, NO_3-leaching up to 57.01 percent, and N_2O-emission up to 52.18 percent. The lignite-based slow-release N fertilizer can offer many supplementary benefits to improve soil health and quality.

Discussion

The application of lignite-based nitrogen fertilizers as opposed to conventional urea significantly reduced NH_3-volatilization in alkaline calcareous soils, according to the findings in this study. This could be due to the complexation of N onto surface of carbon-based adsorbents, which causes delayed hydrolysis of N from lignite-based designer fertilizers. The impact of lignite-based amendments on NO_3 leaching is influenced by a variety of physical, chemical, and biological processes. The potential of lignite to retain NO_3 and NH_4 or the suppression of nitrification by clay particles has been considered as a factor in soil NO_3 leaching.

Conclusion

Lignite-designer fertilizer was more effective in controlling N losses in fine and coarse texture soils than conventional urea fertilizer. The reduced N losses imparted by these new fertilizer formulations could be a viable option to replace the conventional urea and high- cost commercially available slow-release fertilizers. The lignite-based designer fertilizers could bridge the gap left by the lack of defined slow-release fertilizers for alkaline calcareous soils. Field-level validation experiments, on the other hand, could provide a more accurate assessment of the efficacy of these lignite-based nitrogen designer fertilizers in increasing crop yield and nutrient use efficiency.

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Phosphorus fractionation in soil and sediments along a continuum from agricultural fields to lake sediments

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Keywords: phosphorus, sediment, lake, agricultural field, streams

Introduction, scope and main objectives

Export of P from agricultural land and other land use is an important factor contributing to the enrichment of streams with P and eutrophication of water bodies. The current study was carried out in the lake Chilika, the largest brackish water lake in Asia and has been designated as a Ramsar site by the Ramsar Convention of Wetlands in 1981. We investigated the changes in P fractions as they eroded from the agricultural field to Lake through streams.

Methodology

P fractionation was carried out using wet sediment by the method of Van Eck (1982) as modified by Moore and Reddy (1994). Different extractants such as 1 M KCl, 0.1 M NaOH, and 0.5 M HCl are used to extract Loosely bound P, Aluminum, and iron-bound P (Al & Fe- P) and calcium-bound P (Ca-P) respectively. Residual and total P was determined following the digestion mixture (nitric acid + perchloric acid + Hydrofluoric acid).

Results

The mean TP in the field soil, stream sediment, and lake sediment was 395.12, 457.27, and 519.60 mg P kg^{-1}. Residual P was the dominant P fraction contributing 56, 64, and 63 percent of the total P in the agriculture field, stream sediment, and lake sediment. Al and Fe-P and Residual-P were dominant in the field soil contributing 88 percent of the TP. Whereas in the lake sediment Ca-P and Res-P were dominant contributing 80 percent of the TP. The mean value of Al and Fe-P in the agricultural field, stream sediment, and lake sediment were 109.32, 128.52, and 37.29 mg P kg^{-1}.

Discussion

As the soil is transported from field soil to lake, total P concentration increases. The lake receives its major portion of riverine inflow from the north and northwest part by the rivers Daya, Bhargavi, and Luna carrying anthropogenic inputs which might be the reason behind the highest total P observed in the lake. Freshwater inflow from the riverine contributes to the external loading while the sediment contributes to the internal loading of lake water P through the release of P from different P fractions into bioavailable P. Especially, shallow water lake is most vulnerable to internal P loading owing to their frequent mixing of the overlaying water with bottom and sediment which release P and triggers primary production. Significant changes in P fractions occur during the transport and deposition of soil from agricultural fields to the lake. Ni *et al.*, 2020 reported that agricultural activities increase the proportion of organic P dramatically. This suggests that the dominance of organic P in our lake could be attributed to intense agricultural activities in the catchment area.

Conclusion

Overall, there is increase in P content from agricultural field to lake sediment. Both the external and internal nutrient loading are threat to the ecosystem of the lake. Therefore, Identification of different mechanism within different P fractions helps to formulates management policies to protect its biodiversity and the source of P in the lagoon ecosystem.

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Potential of lignocellulolytic microbial consortia in achieving in-situ crop residue decomposition to abate residue burning

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Keywords: crop residue burning, nutrient loss, in-situ decomposition, lignocellulytic microbes, microbial consortia, rice, wheat, sugarcane

Introduction, scope and main objectives

Open field burning of crop residue has been reported as an important contributor to severe air pollution and greenhouse gas emission. Indo-Gangetic Plains of India contribute to highest crop residue burning as this region is the main contributor to India's total cereal production, accounting for 23 percent and 40 percent of India's total rice and wheat area, respectively. Similarly, sugarcane-based system of Maharashtra, contributing the second largest area (1 M ha) and production of sugarcane (84.70 Mt) in India, also represents the hot spot of sugarcane trash burning. To find out an ecologically viable alternative to burning, the current study was executed to explore the prospective of lignocellulolytic microbes to accelerate the in situ decomposition of crop residues and its effect on soil health and crop productivity.

Methodology

A farmers 'participatory field experiment was established at Geong and Bhaupur villages of Kaithal district in Haryana, India. Similarly, the experimental sites in Maharashtra are located in Pune region covering Satara, Pune, Sangli and Kolhapur districts. Through this study we attempted to simulate the farmers 'practices and compared three treatments such as crop residue removal (CRR), crop residue burning (CRB) and in situ decomposition of crop residues (IND; this treatment involves application of microbial consortia along with urea, jaggery and curd) in the farmers 'field. The plot size for CRR, CRB and IND was 200 m2. After 30 days of in situ decomposition of rice/wheat residues, samples were collected to test the cellulose and lignin content of the un-decomposed residue left in the field, to check the status of decomposition. Similar, treatment imposition was followed in the case of sugarcane-based system, and in situ decomposition of sugarcane trash was achieved within 45 days of application.

Results

To assess the extent of decomposition of crop residue in field under IND treatment, cellulose and lignin content of the crop residues at the initial stage and after decomposition was analyzed. Lignocellulolytic microbial consortia showed a promising effect by significantly reducing lignin and cellulose content of the incorporated crop residues, where the ratio of lignin to cellulose increased ($p<0.05$) from 0.23 to 0.25, 0.21 to 0.23 and 0.24 to 0.27, respectively, for rice, wheat residues and sugarcane trash respectively.The in situ decomposition of rice and wheat residue was achieved after 30 days of incorporation, whereas in the case of sugarcane trash, it was achieved in 45 days. Field trials of in situ decomposition of crop residue have shown relatively better crop yield as compared to crop residue burning and removal. Basal soil respiration, metabolic quotient (qCO_2) and sodium adsorption ratio (SAR) had been found to be the sensitive indicators for the experimental sites of Haryana whereas β-Glucosidase activity, WSC, BSR and pH were the sensitive indicators causing most discrimination among CRR, CRB and IND in the experimental sites of Maharashtra. The environmental impact assessment of residue burning indicated a substantial loss of nutrients (28–31, 23–25 and 51–77 kg ha^{-1} of N+P2O5+K2O for rice, wheat and sugarcane residue) as well as the emission of pollutants to the atmosphere.

Discussion

The macromolecular complex components of crop residues such as cellulose, hemicelluloses and lignin degrade very slowly, thus requiring extensive microbial enzyme system for their faster decomposition. In this regard, the external application of lignocellulolytic microbes to enhance the in situ decomposition rate of crop residues appears promising. The present study also affirms the rapid decaying capability of consortia of thermophilic and mesophilic microbes, which were found to be promising in our previous study (Sahu *et al*., 2019.; Sahu *et al.*, 2020) for rapid ex situ residue decomposition or composting, to enhance the rate of in situ decomposition of crop residue. Crop residue burning is also reported to increase outflow of CH_4, CO, NH_3, OC, CO_2, NOx and PM2.5. However, this emission of toxic pollutants can be prevented if we opt for a more sustainable management practice like in situ residue decomposition by employing lignocellulolytic microbes. Moreover, the substantial amount of nutrients that are also being lost due to residue burning could be returned to the soil which could replenish the soil nutrient reserve and reduce fertilizer requirement for the next crop. Furthermore, in situ residue decomposition can also enrich soil organic carbon (SOC) that often decreases due to intensive cropping system and in turn improvessoil health (Lehtinen *et al.*, 2014; Singh and Sidhu 2014). Another important concern of yield reduction of the succeeding crop due to in situ crop residue decomposition has been addressed as no yield loss as compared to farmers practice has been noticed (Singh and Sidhu 2014).

Conclusion

In situ decomposition of crop residue by efficient lignocellulolytic microbial consortia has been found to be a viable and eco-friendly alternative to the crop residue burning. Although it was a short-term study, it holds the potential to abate residue buming by the rapid decomposition of crop residue in the field. Besides, the technique did not have any adverse effect on crop yield and soil health. However, more field trials are needed to validate and establish the positive potential of in situ decomposition of crop residue to make it a successful solution against the nuisance of crop residue burning.

Acknowledgements

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Spatial Differentiation Of Soil Micronutrients In Eroded And Pb-Contaminated Agricultural Landscapes In The Donetsk Region: Availability And Potential Toxicity

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Keywords: soil micronutrients, soil erosion, heavy metal contamination, micronutrient composition of grain, cereal yield

Introduction, scope and main objectives

Ukraine exports about 10 percent of all wheat and about 16 percent of all corn in the world. Overall more than 400 mln people globally depend from grain supplies from Ukraine only (KSE, 2022). The Donetsk agricultural landscapes are characterized by a combination of complex relief, high plowing and heavy metal contamination relative to the background (influence of industrial enterprises, highways, intensive agricultural production, periodic fighting as a Result of the Russian regular troops invasion to the Donetsk region in 2014). The most common soils in the region are the calcic chernozem and its eroded varieties. The objectives of the work to determine the spatial differentiation of micronutrient and heavy metals in soils and cereal plants in eroded and Pb-contaminated agricultural landscapes in Donetsk region of Ukraine for to develop methods to optimization micronutrient composition of cereal grain.

Methodology

Field and vegetation experiments were carried in the lands of State Enterprise "DG "Donetske" NSC ISSAR in Pokrovsky and Bakhmut districts of Donetsk region in 2016-2021. The crops were fertilized with 250 kg/ha of NH4NO3 and 150 kg/ha UAN. Systematic expeditionary studies were conducted in agricultural lands near the Kostiantynivka, Avdiivka, Toretsk, Bakhmut and Yasynuvata in 2011-2021. Analytical studies included determination of the NO3-N, P2O5, organic carbon, calcium carbonate, moisture content, structural-aggregate composition is the soil samples by standard methods. Available Cu, Zn, Mg, Fe, Co, Cr, Ni, Pb and Cd were determined in the soil samples (with AAB at pH 4.8) and plants (with mineralization) by an atomic absorption spectrophotometer.

Results

According to expeditionary research, approximately 55 percent of the soils are Pb-contaminated (from Low to Increased levels). This increases the frequency Fe deficiency by 38-39 percent and Co excess by 45 percent in plant (if the soils with organic matter content <3 percent) and the frequency of Zn deficiency by 54 percent and Cd excess by 15 percent in plants (if the soils with an organic matter content >3 percent). The Results of field experiments show that moderately Pb-contaminated eroded soils (slope from 3° to 5°) contain 0.5-1.5 percent less of organic matter, 28 percent less of N-NO3, 55 percent less of P2O5, 2-3 times less structural aggregates with a size of 0.5-0.25 mm and <0.25 mm and 17 percent more of CaCO3 (which are distributed in the lower horizons of soil profile) than soils of the transaccumulative areas. Eroded soils also have a higher content of available Fe and

Cu and a lower Co-content. Yield of crop grain on eroded soils was also by 50-80 kg/ha less than on soils of accumulative relief. We recorded Fe-deficiency and Co-excess in wheat plants from transeluvial areas and Zn, Cu-deficiency with high Cd-content in plants from transaccumulation zones. Excessive Pb-intake into cereals is observed only on contaminated Pb soils with high content of organic matter (> 4 mg / kg of soil) and N-NO3 (> 60 mg / kg of soil) and low content of carbonates.

Discussion

The Calcium carbonate in soils inhibits the translocation of Fe and Pb to plants. The high soil Pb-content can further block the entry of Fe into plants. This enhances the uptake of Co (competitor) by plants. The good supply of macronutrients increases the plants needs for micronutrients Zn and Cu, and causes Cd translocation into plants.

Conclusion

The micronutrient composition of grain and cereal yield in Pb-contaminated agricultural landscapes with complex relief can be optimized through precision farming and differentiated use of ameliorants and microfertilizers.

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Status of soil pollution with heavy metals and fluorine derived from the application of high doses of phosphate fertilizers

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Keywords: pollution coefficient, total pollution index, physical and chemical properties of soil, agrochemical properties of soil, soil buffering capacity

Introduction, scope and main objectives

The systematic and irrational use of fertilizers at high rates can lead to serious disturbances in the biogeochemical cycle of nutrients in the soil (Lin Jia et al., 2010). The threat of such violations is possible in areas of intensive agricultural production, as well as in case of non-observance of crop rotations, in case of improper use of fertilizers. The main aim of our research was to determine the impact of the 25 years aftereffect of high doses of phosphorus fertilizers application in the reserve on the state of chernozem pollution with heavy metals and fluorine.

Methodology

Field experiments were conducted at the long-term research field experiment (started in 1969) on a chernozem soil of the State Enterprise "Experimental Farm "Grakivske" (Ukraine). Soil samples were taken at the end of the sixth rotation on options where during this period the total amount of applied phosphorus was 1800 kg ha^{-1}; 3 370 and 4 660 kg ha^{-1}. Mobile forms of Cd, Cu, Ni, Pb, Co, Mn, Fe, Ni, Zn (extracted with an ammonium acetate buffer solution with pH 4.8) were determined by atomic absorption spectrometry, fluorine in water extract.

Results

The research Results show that no excess of the maximum permissible concentrations (MAC) in the selected soil samples was observed for any of the heavy metals. At the same time, there was an excess of background values by 1.1–2.3 times for almost all elements. Also, high values of the soil pollution coefficient for individual elements were noted: Cd, Cu, Ni, Pb, they ranged from 575 percent to 174 percent in the plow layer and from 460-104 percent in the sub plow layer. For Co and Mn, this indicator was at a safe level - 116-108 percent (in the plow layer) and 99-92 percent (in the sub plow layer). The total pollution index (Zc) of the complex of heavy metals, which was determined in the soil, was also calculated, it was within the category of low pollution level (Z=4-8). The research results showed that the chernozem of the experimental field has a low natural content of water-soluble fluorine (0.1 mg kg^{-1}), and the application of high doses of phosphate fertilizers leads to an increase in its content by 5–9 times. But at the same time, no excess of the MPC for this element (10.0 mg kg^{-1}) was observed in any of the options. It should be noted that the accumulation of fluorine mainly occurs in the plow layer of the soil, and already at a depth of 20–40 cm its content significantly decreased by 2.5 times. This was due to the presence of calcium carbonates in these horizons, which strongly bind fluorides with the formation of sparingly soluble CaF2.

Discussion

A slight increase of the concentrations of mobile forms of heavy metals over the background values in the options with the application of high doses of phosphorus fertilizers was primarily due to a change in soil pHKCl from 5.2 (in control option) to 4.8 (fertilized option) with prolonged use of physiologically acidic fertilizers. After all, the effect of fertilizers on the content of heavy metals in the soil is not limited to their replenishment with the application. Long-term use of agrochemical agents leads to noticeable changes in the physicochemical and biological properties of the soil. This affects the state and mobility of heavy metals in the soil, which was reflected in our experiment.

Conclusion

The obtained data indicate only certain regularities in the increase in the content of mobile forms of fluorine and heavy metals in the chernozem under the influence of the aftereffect of high doses of phosphate fertilizers, mainly due to the high buffering capacity of this type of soil.

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Study of municipal solid waste as a resource of organic fertilizers

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Keywords: municipal solid waste, compost, soil fertility

Introduction, scope and main objectives

At present, much attention is paid to sorting and recycling of waste in Uzbekistan. Based on the creation of devices for sorting waste, the production of new products by recycling the separated waste of each type is one of the most preferred methods of waste disposal. One of the ways to process MSW is the composting of its organic components, which is needed by the irrigated soils of Uzbekistan.As a result, the amount of waste, which contains a large amount of useful organic and chemical substances, is growing. When substances are returned to the biological cycle, the recycling and efficient use of organic waste is of paramount importance. Processing of organic waste, especially solid waste, has become one of the most urgent problems.

Methodology

The morphology and chemical composition of the municipal solid waste were studied on the basis of generally accepted methods. Changes in waste disposal during (200)-2020 were analyzed on the generaly accepted scientific methods.

Results

In the production of compost from organic and food waste, it is important to separate them into types. Such a processing method prevents environmental pollution with waste, increases soil fertility and improves the ecological and socio-economic environment. Waste sources in the city cover all aspects of life, mainly 68 percent from residential areas, 16 percent from trade, 14 percent from government agencies and 2 percent from industry. Comparing the obtained long-term data, it was found that the amount and composition of solid waste in Samarkand is changing dramatically.

Discussion

The largest amount of municipal solid waste in the city is food waste. Its volume increased from (2002) to 2020. The increase in food waste is mainly due to the growth of the population and its income. The low growth in 2010-2020 may be due to the COVID-19 pandemic last year. The amount of organic waste at the Samarkand city landfill in 2020 amounted to 70.7 percent. Processing of organic waste increases the base of secondary raw materials, reduces their negative impact on nature and environmental pollution, and the biological cycle of substances improves. The amount of plastic and polyethylene waste has also increased over the analyzed years. Initially, this increase was about 1 percent every 4 years ((2002)-2004.) and almost 1 percent in the next 10 years (2010-2020). The main reason for this is that plastic is heavily recycled and the use of plastic and polyethylene containers is low due to the pandemic period. Other wastes and wastes with a diameter of less than 15 mm account for about 16-18 percent in recent years.

Conclusion

Thus, about 70 percent of Samarkand's MSW components are organic. This allows them to be used in the production of organic compost fertilizers. High-quality organic compost fertilizers made from organic waste, increase the supply of organic fertilizers and increase the fertility of soils.

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The effectiveness of neem materials and biochar as nitrification inhibitors in reducing nitrate leaching in a compost-amended ferric luvisol

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Keywords: Leaching, Nitrification, Azadirachtin, Inhibition, Biochar, Neem, Nitrate, Amendment

Introduction, scope and main objectives

Nitrates produced after mineralization from compost may be prone to leaching, especially in tropical sandy soils, because of the increased rate of nitrification and the porous nature of such soils. This may result in low nitrogen (N) use efficiency and adverse environmental effects. Inorganic nitrification inhibitors are costly and mostly unavailable in Ghana. Research on simple but effective local materials for use as nitrification inhibitors is therefore a priority. Two such materials are neem materials and biochar. Neem materials can suppress nitrifying bacteria due to its antimicrobial properties. Biochar can hold ammonium ($NH4+$) in the soil, making it temporarily unavailable to nitrifying bacteria. This study seeks to determine the efficacy of neem materials and biochar as nitrification inhibitors and their influence on nitrate ($NO3-$) leaching. To achieve this goal, three objectives were set:

Objectives

1. The objective of the study is to determine the potential rate of nitrification and/or N mineralization of a Ferric Luvisol amended with compost, cow dung manure in one set-up, and neem leaves, seeds or bark in another set-up.

2. To identify the biochar type among three (Saw dust, Rice husk and groundnut husk) that has the high $NH4+$ sorption and desorption capacity.

3. To determine the nitrification inhibition and the amount of $NO3-$ leached in a compost-amended Ferric Luvisol treated with neem seeds, bark and saw dust biochar.

Methodology

Objective one

A pot incubation was conducted for 60 days to estimate nitrification rate and/or mineralized N with manure, compost and $NH4Cl$ as the N sources (150 kg N /ha) in one set and neem seeds, bark or leaves (1.25 µg azadirachtin/g) in another set, using $NO3-$ concentrations.

Objective two

Ammonium sorption and desorption capacities of sawdust, rice husk and groundnut husk biochar were determined.

Objective three

Pot incubation with compost as N source but treated with milled neem seeds or bark (1.25 µg azadirachtin/g) or saw dust biochar (20 ton/ha) was conducted for 60 days where; nitrification inhibitions using NO3- concentrations were determined. Leaching experiment in columns with similar treatments and maize sown was then conducted to quantify NO3- in leachates.

Results

Objective one

The highest rate of potential nitrification was recorded in the NH4Cl amended soil (10.4 µg/g/day). The manure and compost amended soils had insignificantly ($p > 0.05$) different rates of 4.4 and 4.6 µg/g/day respectively, representing about half the rate in the standard (NH4Cl). In the other set-up, there was a significantly ($p < 0.05$) higher NO3- concentration in the soil amended with neem leaves (57.8 µg/g) at the end of the incubation period as compared to those amended with seeds (25.6 µg/g), bark (16.7 µg/g) and the control (4.1 µg/g).

Objective two

Results showed that NH4+ sorption maximum for groundnut husk biochar (212.77 mg/kg) was slightly higher than that of rice husk biochar (208.33mg/kg). The saw dust biochar (SDB) had no sorption maximum for NH4+, as it continues to sorb in layers (multi-molecular layers), giving it the highest sorption capacity. Quantifying the amount of NH4+ sorbed at 40 mg/L NH4+ revealed, an amount of 312.6 mg NH4+/kg, 185.2 mg NH4+/kg and 179.2 mg NH4+/kg held by SDB, GHB and RHB respectively. The SDB had the highest percentage desorbability of 35.3 percent making it the best in terms of the ability to release sorbed NH4+ for crop uptake.

Objective three

SDB resulted in 40 percent nitrification inhibition (lasted the entire incubation period). Neem seeds with azadirachtin concentration of 3.92 mg/g resulted in similar nitrification inhibition but lasted for forty days. Inhibition caused by both materials resulted in about 60 percent reduction in NO3- leached relative to the control.

Discussion

Objective one

The similar physio-chemical properties of the manure and compost explains why there was no significant difference between the two. Nitrification rates of the compost and manure amended soils being half as fast as that of the inorganic may be considered to be significantly rapid enough for considerable leaching because, the latter has readily available N. Similarly, high rate of mineralization was observed by He et al., (2000) who recommended that application rates of composts should be adjusted for high N release to minimize the risk of nitrate leaching into groundwater. The high mineralized N from the neem leaves-amended soil was attributed to its high N content as well as its low C/N ratio, lignin and phenol contents. Its low azadirachtin content may have also played a role in this observation.

Objective two

Sorption of NH4+ to SDB better fitted to Freundlich isotherm model than the Langmuir model and that explains why it had no sorption maxima. Difference in equilibrium pH may have attributed to the difference in amount of NH4+ sorbed, with SDB’s near neutral equilibrium pH creating the most conducive situation for the most NH4+ sorption. The numerous pores of the SDB (woody feedstock) relative to its agricultural counterparts may have also contributed to it sorbing the most. The highest desorbability recorded in the SDB could be attributed to its least binding energy as calculated from the isotherms.

Objective three

The short-lived inhibition of the neem seeds may be attributed to the decomposition of azadirachtin with time. Sundaram et al. (1997) found the half-life of azadirachtin in soil to be 25.8 days. The presence of oil in the seeds may have also played a role in its inhibitory effect. The inert nature of biochar, making it to resist decomposition with time might account for its longer-lived inhibition. The significantly lower amounts of N leached in the amended soils may be attributed to the inhibitory effect of the materials applied as observed in the inhibition study. The higher inhibitory effect caused by neem seeds and SDB explains the least amount of nitrate leached from those soils and subsequently resulting in better agronomic indices examined.

Conclusions

The results suggested a relatively high potential nitrification rate in the manure and compost amended soils and hence, the need to consider possible ways of controlling NO3- leaching.

Saw dust biochar was the best among the three biochar types to be used for the purpose of NH4+ sorption and desorption with agricultural significance.

Neem seeds (498 kg/ha) are very effective as nitrification inhibitor in the soil within forty (40) days after application and may be recommended for use when it involves short duration crops like some cereals, vegetables and legumes. However, for a longer period of nitrification inhibition in the soil, saw dust biochar (20 ton/ha) is better and may therefore be applicable when it involves long duration crops like the tree crops.

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The influence of climate change on the functioning of soil microbiocenosis

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Keywords: Climate, soil, ecosystems, hydrothermal regime, model conditions

Introduction, scope and main objectives

In the aspect of global environmental problems, climate change and its impact on the functioning of the soil microbiocenoses problems has considerable researchers' attention. Given the high sensitivity of microorganisms to various environmental and anthropogenic factors and uncertainty about the impact of hydrothermal conditions on the taxonomic and functional structure of soil microbial groups, in global climate change, it is important to determine changes in the structure of the microbial complex with changes in hydrothermal regime.

Methodology

The number of major ecological-trophic groups of microorganisms is determined by the methods of sowing of consecutive dilutions of soil suspension on standard nutrient media generally accepted in soil microbiology. During the experiment, microbiological and biochemical parameters in the soil are defined.

Results

On the example of chernozem soil of the natural ecosystem as a reference system, in the simulated conditions, the influence of hydrothermal factors on microbial productivity and accumulation of microbial biomass due to climate change in global warming will be determined. . In the course of our research, it was shown that the increase in temperature has a greater negative impact on microbial productivity in the agroecosystem, and the presence of moisture has a positive effect on the development of microorganisms. Studies of biochemical properties are often offered because they act as indicators of soil disturbance and provide information about changes occurring in the soil. There is growing evidence that microbial activity has a direct impact on the stability and fertility of ecosystems, microbiological parameters are sensitive indicators of both ecosystem responses to stress, such as drought, and their recovery. The obtained experimental data contribute to the assessment of hydrothermal factors on the soil microbiocenosis and show that the dynamic changes in the content of microbial biomass in the soil are associated primarily with changes in such environmental factors (Nannipieri, 2012).

Discussion

Our research has shown that the rate of CO_2 production is more dependent on temperature than humidity. The results of the model experiment showed that the temperature range 5-25°C had different effects on the ecological-physiological diversity of microorganisms. The best conditions for the development of soil microorganisms were formed at the temperature of 15°C, the least favorable – at 5°C and 25°C. In our studies, the enzymatic activity was significantly positively correlated with the number of *Azotobacter* and micromycetes, for which the best conditions for proliferation were in soils at 15°C (Bradford, 2013). Determining the influence of such a factor as the level of soil moisture on microbial and biochemical activity in the soil showed that the optimal moisture content in the soil is about 20 percent (Chen, 2007).

Conclusion

It was found, that increasing the temperature has a greater negative impact on microbial productivity in the soil, and the presence of moisture has a positive effect on the development of microorganisms. Due to the correlation-regression analysis of the studies, a reliable relationship was established between the content of microbial biomass and hydrothermal conditions.

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Suitability of plant growth-promoting bacteria to decrease nitrous oxide emissions: a case study in sugarcane

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Keywords: biofertilizers; climate change; mitigation; nitrogen use efficiency

Introduction, scope and main objectives

Sugarcane requires a high amount of synthetic nitrogen (N), generating concern because it is partially lost to the environment as nitrous oxide (N_2O), a powerful greenhouse gas. It could be mitigated by enhancing the nitrogen use efficiency (NUE) [1] by using plant growth-promoting bacteria (PGPB) [2, 3]. Bacteria could increase sugarcane biomass per unit of available N, allowing a replacement or reduction of synthetic N. This study aims to determine the effect of PGPB on the growth, yield, and N_2O emissions compared to traditional N-fertilization in sugarcane.

Methodology

A greenhouse experiment was performed in a soil with a microbial activity 18 to 36 percent lower than the soil outside the greenhouse (FDA method). Treatments were: Gluconacetobacter diazotroficus strain PAL5 (PAL5); Pseudomonas fluorescens and Azospirillum brasilense strain AZ39 (P+AZ39), each one (PAL5 and P+AZ39) with (+T) and without trace elements; urea (U1); urea with urease inhibitor (U2), both (U1 and U2) incorporated with a dose of 110 kg N ha^{-1}; and a reference treatment without any application (control). Inoculation was performed at planting by immersion of one-bud stalks in inoculant with a concentration of 108 CFU ml^{-1} (each bacteria) for 10 minutes. A re-inoculation was applied at the N-fertilization moment (59 days after planting; dap) by located irrigation. The effects of these treatments on the initial growth and N_2O emissions were assessed. Gas samplings were performed 1 day before and 3, 6, 10, and 28 days after N fertilization by using the static chamber method.

Results

In general, inoculation with PGPB increased plant population (p= 0.004) and sprouting rate (p= 0.009) with an interactive effect of trace elements. All treatments with PGPB had a higher mean population of plants than the control 55 dap. At this moment, the percentage of sprouting was as follows: PAL5+T (66.7 percent) > P+AZ39 (66.3 percent) > P+AZ39+T (58.2 percent) > PAL5 (55.2 percent) > Control (47.4 percent, average of all treatments without PGPB as fertilization was performed later at tillering). This Resulted in coverage percentages (p= 0.007) of 49.1, 42.3, 40.8, 38.9, and 33.4 percent for P+AZ39, PAL5+T, P+AZ39+T, PAL5, and control, respectively. Overall, N_2O emissions were low and steady; they picked up 10 days after N fertilization for U1 and U2 treatments. The mean of N_2O emissions (adjusting a mixed model) for 87 dap were 30.4 ± 3.9, 13.5 ± 9.8, and ≤ 4.5 μg N_2O-N m_{-2} h_{-1} for U2, U1, and the average of the rest of the treatments, respectively.

Discussion

Although the roles of PAL5 [4,5] and P+AZ39 [6,7] on N and phosphorus nutrition and plant growth are well recognized, this work is one of the few that studied its effect on N_2O emissions [8]. However, additional treatments to explore the interaction between reduced rates of synthetic N fertilizer and PGPB will be required [8].

Conclusion

Our Results suggest that the enhanced initial growth promoted by PGPB without external N could mitigate N_2O emissions while maintaining crop yields. Measurements and analyses need to be continued to determine the impact of PGPB on yield components and cumulative N_2O emissions.

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Analysis of the source of wheat lead pollution and study on soil solidification and remediation technology

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Keywords: Wheat tissue; lead; Isotope; Atmospheric

Introduction, scope and main objectives

Wheat is the world's third-largest food crop after rice and corn. It is the main dietary component of our residents and is also considered to be one of the main sources of human lead (Pb) intake. Atmospheric dust and soil are the main sources of Pb in wheat grains. In thispaper, the “fingerprint characteristics” of Pb stable isotopes are used to systematically analyze the source of Pb in wheat tissues and grains, and the functionalized magnetic nanomaterial SiO2@Fe3O4@C-COOH is developed. The Pb contaminated farmland soil is repaired by applying solidification with conventional soil Pb passivation agent.

Methodology

Pb-contaminated soil was collected from farmlands (Latitude 35° 08′ 00″ N and Longitude 112° 34′ 30″ E) near a Pb smelter in Ji Yuan City, Henan Province, China. The study area belongs to a temperate monsoon climate. Four distinct seasons, rain and heat in the same period, dry and cold in the same season. Suitable temperature conditions, sufficient light, and abundant rainfall in the crop growing season constitute good agrometeorological conditions. But Pb smelter is an important source of heavy metals in the regional environment, Atmospheric particulate matter is an important carrier of heavy metals (Ma et al., 2021). Atmospheric deposition is the main way of material exchange between soil and atmosphere. Deposition eventually returns to the surface through atmospheric dry and wet deposition and accumulates in soil in different forms. Approximately 100 kg of topsoil (0-25 cm) was taken back to the laboratory where it was dried naturally, ground, screened, and bagged.

Results

The average content of Pb in soil was 5.78 ± 0.09 $mg \cdot kg^{-1}$, and the average content of Pb in dust was 76.22 ±0.14 $mg \cdot kg^{-1}$, which was lower than the secondary agricultural standard (80 $mg \cdot kg^{-1}$, pH > 7.5) of soil environmental quality standard (GB15618-1995). The soil Pb isotope ratio 208Pb/206Pb was 2.0848 ±0.0012 206Pb/207Pb and 1.1865 ±0.0017, while the atmospheric dust Pb isotope ratio 208Pb/206Pb was 2.1060 ±0.0017 206Pb/207Pb and 1.1651 ±0.0028. There were significant difference between the soil and dust. The contribution rates of atmospheric deposition to Pb in roots, stems, leaves, bran and grains of Triticale were 71.03 percent, 84.04 percent, 92.79 percent, 79.68 percent and 79.89 percent respectively, while that from soil were 28.97 percent, 15.96 percent, 7.21 percent, 20.32 percent and 20.11 percent respectively. The contribution rate of atmospheric deposition to Pb in roots, stems, leaves, bran and grains of *Triticale* were 50.40 percent, 42.01 percent, 59.04 percent, 53.13 percent and 54.68 percent respectively, while the proportion of Pb from soil were 49.60 percent, 57.99 percent, 40.96 percent, 46.87 percent and 45.32 percent respectively.(2) In order to find out whether the source of wheat lead pollution in the high pollution area is consistent with that in the low pollution area, a comparative experiment was carried out between the experimental farmland around a lead-zinc smelter in Jiyuan and the farmland in the northwest suburb of Zhengzhou. It was found that the soil and dust fall in Jiyuan were 355.32 ± 14.78 and 5477.90 ± 187.85 mg·kg-1, respectively. It was significantly higher than the soil environmental quality standard, and the air and soil were polluted by Pb. The contributions rate of Pb from atmospheric dust were 14.24 percent, 66.13 percent, 84.02 percent, 77.18 percent in roots, stems, leaves and grains of wheat, and 85.76 percent, 33.87 percent, 15.98 percent, 22.82 percent in soil. In the northwest suburb of Zhengzhou, the Pb content of soil, dust and wheat roots, stems, leaves and grains were 6.10 ± 0.75, 78.50 ± 4.35, 2.47 ± 0.23, 1.03 ± 0.07, 2.11 ± 0.13 and 0.08 ± 0.01mg · kg-1, respectively. The Pb contribution rate of wheat roots, stems, leaves and grains was 49.26 percent, 73.11 percent, 93.02 percent, 83.05 percent, and the soil contribution rate was 50.74 percent, 26.89 percent, 6.98 percent, 16.95 percent, respectively. The Pb contribution rate of soil to wheat plants in Northwest suburb of Zhengzhou is lower than that in Jiyuan. Atmospheric dust is the main source of Pb in grains, leaves and stems of wheat above ground in Zhengzhou and Jiyuan, while most of Pb in wheat roots comes from soil.(3) By analyzing the two ways of Pb pollution of wheat, it is found that soil is the final destination of atmospheric dust. Therefore, it is necessary to study the remediation of heavy metals in soil. The removal efficiency of SiO2@Fe3O4@C-COOH is greatly affected by particle size, and the best particle size is 40-80 mesh. The saturated adsorption capacity of the material was 169.36 mg · g-1, and the adsorption equilibrium was established immediately after 10 days. The best moisture content was 50 percent, and the adsorption speed was faster. Among them, the removal efficiency of Pb by SiO2@Fe3O4@C-COOH reached 86.65 percent.(4) The effect of various stabilizers on the stabilization of heavy metals is the most significant in SiO2@Fe3O4@C-COOH, and calcium superphosphate is equal to calcium oxide, but weaker than organic matter. Under the combined application of 1 percent SiO2@Fe3O4@C-COOH, 0.5 percent superphosphate, 2 percent calcium oxide and 60 g·kg-1 organic matter, the morphological distribution of heavy metal lead in soil was 4.29 ±0.025 percent in weak acid state, 24.04 ±2.83 percent in reducible state, 31.61 percent ±2.47 in oxidizable state and 40.06 ±2.92 percent in residue. The general trend of Pb content in different parts of corn and wheat was root ＞ leaf ＞ stem. The lead content of wheat tissue root, stem and leaf decreased by 64.17 ±1.19, 14.28 ±0.32, 12.43 ±0.13 mg·kg-1, respectively. The lead content of maize tissue root, stem and leaf decreased by 61.21 ±0.79, 6.12 ±0.04, 3.76 ±0.16 mg·kg-1, respectively. The combined use of stabilizers can not only give full play to the characteristics of different mechanisms, but also solve the defect of unstable effect of a large amount of single stabilizer, and reduce the environmental risk to a certain extent. It also provides soil for heavy metal pollution in the process of field cultivation.

Discussion

When 0.5 percent of CSP was added, the total amounts of weakly acidic and reducible Pb decreased significantly and continued to decrease with increasing CSP dosages. Additionally, CSP promoted the transformation of weakly acidic Pb to residual Pb. Upon application to the soil, the strongly acidic solution caused a series of effects that ultimately reduced the soil pH, change the precipitation and dissolution reaction conditions, and caused water-soluble phosphorus to be rapidly fixed or absorbed. OM dosages of 20, 30, 40, 50, 60, and 70 g·kg^{-1} resulted in Pb immobilization rates of 24.02 ± 1.33 percent, 27.51 ± 0.55 percent, 27.61 ± 0.80 percent, 28.70 ± 0.34 percent, 30.86 ± 0.35 percent, and 30.67 ± 0.15 percent, respectively. With an OM content of 60 g·kg−1, the soil Pb consolidation rate reached stepwise equilibrium. The addition of OM mainly promoted the transformation of weakly acidic and reducible Pb to residual and oxidizable Pb .In summary, the optimal dosages of SiO2@Fe3O4@C-COOH, CaO, CSP, and OM were 1 percent, 2 percent, 0.5 percent, and 60 g·kg−1, respectively. At these dosages, the Pb immobilization efficiencies were 47.35 ± 0.23 percent, 16.90 ± 0.50 percent, 15.12 ± 0.31 percent, and 30.86 ± 0.35 percent, respectively. The superior immobilization performance of SiO2@Fe3O4@C-COOH was due to the presence of functional groups, such as −COOH, on the surface of the agent. As the SiO2@Fe3O4@C-COOH dosage increased, the number of active sites and the amount of adsorbed

Pb also increased. This resulted in complexation and chelation reactions with Pb ions, thereby reducing the content of weakly acidic Pb and increasing the content of residual Pb.

Conclusion

The results showed that the Pb contribution rate of the exposed area was higher than that of the non-exposed area in the whole dynamic growth period, and the Pb contents of the tissues in the different growth period showed the trend of root > leaf > stem > bran > grain The Pb contents of root, stem and leaf in booting stage were higher than that in turning green stage, jointing stage, filling stage and mature stage.

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Theme 4
Governance of soil fertility and soil nutrients: Why should soil properties be in our policies and laws?

Effect of government of Ghana fertilizer subsidy policy on major cereals yield

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Keywords: cereals yield, fertilizer subsidy, Ghana government, soil organic carbon, sustainability, site specific fertilizer recommendation

Introduction, scope and main objectives

Cereals such as maize, rice, millet and sorghum form the major staple foods in Ghana. However, the yield of cereals is very low compared to potential yields Resulting in higher yield gap. In an attempt to bridge the yield gap, Ghanaian government introduced a fertilizer subsidy policy in 2008. The policy efforts are geared towards reducing the cost of fertilizer to farmers in order to increase the purchasing ability of farmers as well as fertilizer use in cereal production. It is anticipated that the policy will significantly improve cereal yield, close yield gaps, increase farmers profit and improve the livelihoods of the poor resource farmers. However, adoption of the fertilizer subsidy did not improve farmers profit and livelihoods. This triggered the need to carefully evaluate the impacts of fertilizer policy on the cereal productivity in Ghana. Specifically, the study assesses the effects of Ghanaian government fertilizer subsidy on main cereal yield and yield gaps. To this end, we hypothesized that Ghanaian government fertilizer subsidy increased cereal yields and closed yield gaps.

Methodology

Annual cereal production (yield and area cultivated) and annual fertilizer subsidy data 2009-2018 were sourced from Ghana Ministry of food and Agriculture (MOFA) and used to assess cereal productivity since the inception of the fertilizer subsidy policy. Average yield per hectare of maize, rice, sorghum and millet were calculated and compared with their potential yields. Percent yield gaps of the respective cereals were then computed see if the fertilizer policy has closed the yield gaps. Correlation analysis was used to establish relationship between fertilizer subsidy and the various cereal yields to help identify whether or not fertilizer subsidy has influenced cereal yields.

Results

The average yields of maize, rice, sorghum and millet for 2009-2018 period have been 1.89, 2.70, 1.12 and 1.23 MT/HA, respectively as against their respective potential yields of 5.5, 6.0, 2.0 and 2.0 MT/HA. Percentage yield gap of maize, rice, sorghum and millet were found to be 65, 55, 49 and 44 percent respectively. Correlation analysis on fertilizer subsidy policy and the yield for the cereals produced R2 of 0.59, 0.53, 0.30 and 0.20 for maize, sorghum, rice and millet, accordingly. Percentage yield growth rate in 2007- 2009/2010-2012 for maize, sorghum, rice and millet was 8.42, 3.2, 17.62 and 1.72 percent compared to 4.9, 1.86, 6.23, and 2.52 percent in 2013-2015/2016-2018, respectively. The difference in the two period percentage yield growth rates was found to be -3.52, -1.34, -11.39 and 0.74 for maize, sorghum, rice and millet, accordingly.

Discussion

The high yield gap observed for the cereals indicates there is much more to be done for yield improvements. The modest to low R2 observed in the correlation analysis depicts that the fertilizer subsidy policy had modest to low relation with the various cereal yields, indicating that the policy did not translate into high cereal yields. The negative percentage cereal yield growth rate recorded between the two periods, signals decline in yield growth rate. The high yield gap, poor relation between fertilizer subsidy and cereal yields as well as declining yield growth rate could be due to the fact that Ghanaian soils are over exploited and highly degraded/depleted soils, rendering them non-responsive to fertilizer inputs on crop yields due to soil low organic C content. Low soil organic C, results in poor soil structure, low CEC and above all poor soil health such that the soil cannot support sustainable and profitable crop production systems. The high yield gap despite government's fertilizer subsidy policy can be explained by the fact that the fertilizers used in Ghana are general or blanket recommendations which do not meet site and crop specific nutrient requirements and growing conditions. Thus, soils in Ghana differ between and within the various agro-ecological zones and needs site and crop specific nutrient management or fertilizer recommendations that can translate to yields to close the high yield gaps.

Conclusion

Ghanaian Government fertilizer subsidy policy did not help close yield gaps of major cereals as there is still a higher yield gap in cereal production in Ghana. Thus, the fertilizer subsidy has not improved cereal production. We recommended that the government should not only focus on chemical fertilizer subsidy but should also put in more efforts to curtail constant burning of crop residue and/or competitive use of these residues for domestic use. Also, the government should consider to include nutrient rich bio-based or organic fertilizers in its fertilizer subsidy policy to help build soil C in Ghanaian arable soils for cropping sustainability and profitability. Finally, government of Ghana should sponsor Soil Scientist to develop site and crop specific fertilizer recommendations so that fertilizer subsidy adoption can translate into closing high yield gaps in Ghana.

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Governance of nutrient management in Bulgaria to reduce the risk of soil and water pollution

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Keywords: soil nutrients, soil monitoring, soil acidification

Introduction, scope and main objectives

Agriculture is defined as one of the most significant sources of anthropogenic pressure on soil and water. This is the reason for a number of negative effects and deterioration of the components of the environment, such as loss of biodiversity, soil acidification, erosion, salinization, pollution of surface and ground waters, eutrophication, gas emissions, etc. Due to the listed environmental risks, there is a need to develop strategies, new standards for management, and adoption of normative documents to regulate the protection of agro-ecosystems from pollution. One of the first EU acts of legislation aimed at controlling pollution and improving the quality of agricultural water was the nitrates Directive (91/676 / EEC), officially implemented in Bulgarian by (200). Consequently, the protection of water from nitrate pollution from agricultural lands in the Bulgarian government introduced a number of laws, regulations, and programs that regulate the use of organic and mineral fertilizers and require compliance with certain rules for manure storage, nutrient management, etc. The main purpose is at maximum inclusion of main nutrients (especially nitrates and phosphates) in the biological cycle of substances in order to protect soil and water from pollution and acidification.

Methodology

Soil monitoring points used to identify nitrate vulnerable zones are regulated by an order of the Minister of Environment and Water. Vulnerable areas in Bulgaria cover about 36 percent of the entire territory of the country and 68 percent of its arable agricultural land. The total number of sample points in the state is situated in the four river basin regions, as control and operational monitoring of surface and groundwater is performed. The programs are implemented for a period of four years, except in cases where the content of nitrates in groundwater is less than 25 mg/l. In that case, the monitoring is eight years. Areas vulnerable to nitrate pollution can be identified as the basis for multi-annual observations that are appropriate in areas where surface and ground waters are polluted (above 50 mg/l) or they are at risk of nitrate pollution from agricultural sources. The vulnerability of territories to eutrophication is also determined. Each year, 25 percent of the points are sampled each year. In 2019., 690 soil samples were taken from 115 points. The assessment of soil reserves is made on a five-point scale according to the content of organic C, total N, and P (ExEA, 2019).

Results

The most vulnerable zones to nitrate pollution are groundwater in areas where there is a combination of sandy or loamy soil texture, leaching water regime, high water table, and intensive agriculture, which is associated with intensive irrigation and use of organic and mineral fertilizers. The tendency to improve the quality of physicochemical indicators of surface waters in the short and long term is preserved; and, in general, there has been a gradual improvement in groundwater quality for most indicators. The main prerequisites for the loading of water with macronutrients are a consequence of the incorrect application of practices in agriculture and animal husbandry, including one-sided unbalanced nitrogen fertilization, underestimation of its stock in the soil and its content in manure used, non-compliance with the content of digestible forms of phosphorus and potassium, overestimation of expected yields, etc. Soil fertility in agricultural lands of Bulgaria contains an average of about 17.32 g/kg organic carbon, 1.6 g/kg total nitrogen, and 0.86 g/kg total phosphorous in the soil surface (0-20 cm) horizon (ExEA, 2019).

Discussion

Fertilizer prices had raised significantly by 2021 as a Result of high natural gas prices following the COVID-19 crisis, as well as in 2022 when the Russian-Ukrainian war began. As a result of that, many Bulgarian farmers decided to reduce their fertilizers by 30 percent. Contemporary soil acidification of arable lands in Bulgaria is because of fertilization with ammonium sulfate, ammonium chloride, and ammonium nitrate. It could be also from industrial processes emissions and natural biochemical cycles. The assessment is made on the basis of the measured acidity of the soils and the calculated base saturation in monitoring points. To limit the development of the acidification process in arable soils, it is necessary to apply appropriate fertilization models. Along with the acidification process, the mobility and availability of a number of soil elements changes, this has a direct and indirect impact on the soil-plant-human system. Soil acidification is spread over the area of 2 million hectares, of which: 0.5 million ha with pH from 4.1 to 5.0 and 1.5 million ha with pH from 5.1 to 6.0. Other 4.3 million ha are potentially vulnerable to acidification. (Teoharov *et al*., 2019). Most vulnerable soil types to acidifications in Bulgaria are Planosols, Luvisos, Cambisols, Umbrisols, Phaeozems, Luvic Chernozems and Fluvisols. Usually, Calcic Chernozems, Veritsols, and Rednzinas are resistant to acidification, because of their high carbonate content and good buffer capacity.

Conclusion

Solving the problem of protecting the quality of soil and water is relevant not only for economic reasons but also because of its great social significance. Applying balanced fertilization, irrigation control, the knowledge of specific climatic conditions, soil type, and agricultural practices are ways to realize the productivity of crops and maximize the potential of soil resources. The objectives for maintaining the natural balance of the agro-ecosystem and its components include determining the sustainable use of nitrogen, phosphorus, and potassium fertilizers on agricultural lands.

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Governance of soil fertility for adaptation to climate change in Ukraine

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Keywords: soil strategy, the national concept of soil use and protection under climate change

Introduction, scope and main objectives

The current Ukraine's agricultural policy does not have a generalizing legislative act that would establish objectives and a basic conceptual framework of national-level policy of renewal and preservation of soil fertility and adoption of climate-smart agriculture practices. To fulfill international obligations under the Paris Agreement, as well as to reduce the vulnerability of the agricultural sector to climate change, the Ukrainian government has developed a draft of Strategy for Prevention and Adaptation to Climate Change in Agriculture until 2030. However it has not been enacted yet.

Methodology

Current national-level policies, strategies and aspects of soil fertility maintenance in Ukraine were analyzed.

Results

The Environmental Security and Climate Adaptation Strategy of Ukraine until 2030 among the main tasks highlights the establishment of action plan for adaptation to climate change in agriculture and soil management, ensuring the support of organic farming and reduced tillage practices for preserving and increasing soil organic matter.

The State Strategy for Regional Development for 2021-2027 also declares the provision of land protection to achieve a neutral level of degradation. With the reference to Ukraine's land degradation neutrality target it is planned to increase the content of soil organic carbon (humus) in agricultural land by not less than 0.1 percent by 2030.

The Concept and the National Action Plan to Combat Land Degradation and Desertification declares conducting continuous soil surveys of the lands of Ukraine, which is still has not been started, and application of soil conservation practices to protect soils and prevent their degradation, however there is no state support for farmers in Ukraine to apply soil conservation practices.

Measures to adapt soil management to climate change are provided by the Concept of the National Target Program of Soil Use and Protection, 2022. The first stage of the Concept's objectives (until 2028) provides the improvement of legislative, scientific, informational, organizational and technical support for the rational use of land resources and their protection at the national level and the establishment of a legal and regulatory framework.
Agreement on the financing of the event "EU Support for the Development of Agriculture and Small Farms in Ukraine" (ENI/2020/042- 345), signed in 2020, aimed at the development of policies and programs of state support of small and medium-sized farms, and the implementation of reforms for sustainable soil management.

Discussion

The planned Results of the implementation of national policy until 2030 in Ukraine are: a decrease land use for agricultural purposes (by 5 percent) and areas of arable land (by 10 percent); increase productivity of agricultural lands (by 40-50 percent) through the rational use of organic, organo-mineral and mineral fertilizers and chemical soil improvers on acidic and saline soils; higher share of the area of agricultural lands under extensive use (hayfields, pastures), higher content of organic carbon (humus) in the soils, expansion of area of reclaimed lands and land under conservation measures.

Conclusion

Ukraine's existing legal framework for adaption the agricultural production and soil managment to climate change needs to be improved. In addition, European integration processes require further harmonization of Ukrainian legislation to EU legislation. The current state and trends of soil degradation postulate the development of a program to stimulate the soil conservation and climate-smart farming in Ukraine. The adoption of the Law on Soil Conservation and Protection and the establishment of the State Service for Land Monitoring and Soil Fertility Protection are urgent issues, especially in conditions of intensified soil degradation under military action by Russia in Ukraine.

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Manure management and soil biodiversity: towards more sustainable food systems in the EU

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Keywords: soil biodiversity, manure management, nutrient losses, soil pollution, ecosystem functions, soil organisms, environmental policy, common agricultural policy

Introduction, scope and main objectives

In the European Union (EU-27) and UK, animal farming generated annually more than 1.4 billion tonnes of manure during the period 2016–2019. Of this, more than 90 percent is directly re-applied to soils as organic fertiliser. Manure promotes plant growth, provides nutritious food to soil organisms, adds genetic and functional diversity to soils and improves the chemical and physical soil properties. However, it can also cause pollution by introducing toxic elements (i.e., heavy metals, antibiotics, pathogens) and contribute to nutrient losses. Soil organisms play an essential role in manure transformation into the soil and the degradation of any potential toxic constitutes; however, manure management practices often neglect soil biodiversity. In this review, we explored the impact of manure from farmed animals on soil biodiversity by considering factors that determine the effects of manure and vice versa. By evaluating manure's potential to enhance soil biodiversity, but also its environmental risks, we assessed current and future EU policy and legislations with the ultimate aim of providing recommendations that can enable a more sustainable management of farm manures.

Methodology

This review explored the relationship between manure and soil biodiversity by considering 407 published papers and relevant legislative provisions. In addition, we evaluated whether benefits and risks on soil biodiversity are considered in manure management. Thereafter, we analysed the current legislation in the European Union relevant to manure, an important driver for its treatment, application and storage.

Results

This review found that coupling manure management with soil biodiversity can mitigate present and future environmental risks. Our analyses showed that manure quality is more important to soil biodiversity than manure quantity and therefore, agricultural practices that protect and promote soil biodiversity with the application of appropriate, high-quality manure or biostimulant preparations based on manure, could accelerate the move towards more sustainable food production systems enhancing agricultural productivity, reducing farmers' costs and enabling positive environmental effects.

Discussion

Rising prices for mineral fertilisers due to scarcity and geopolitical dependencies emphasise the need to boost the usage of organic fertilisers. However, to prevent environmental risks, manure quality in the EU requires greater attention, calling for more targeted policies. Our proposed approach could be applied by European Union Member States to include soil protection measures in national legislation, and at the EU level, can enable the implementation of strategic goals.

Conclusion

Soil biodiversity needs to be appropriately factored in when assessing manure amendments to provide better guidelines on the use of manure and to reduce costs and environmental risks. However, radical changes in current philosophies and practices are needed so that soil biodiversity can be enhanced by manure management.

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Peculiarities of cation exchange capacity of agricultural soils of Kakheti region, Georgia

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Keywords: soil fertility, soil organic matter, cation exchange capacity, based saturation, soil texture

Introduction, scope and main objectives

The aim of our work was to determine the peculiarities of cation exchange capacity (CEC) and base saturation (BS), as one of the important characteristics, in soils used under different climate and land use conditions in Kakheti region (Georgia) and correlation of exchangeable Ca and Mg concentrations with organic matter (OM) and texture, and their distribution through soil depth, as well as evaluation of soils according to the exchangeable cations (Ca/Mg) ratio, as it is very important for proper nutrient management

Methodology

Soils of different farms of relatively humid (Kvareli) and arid (Sighnaghi, Dedoplistskaro, Sagarejo, Akhmeta, Telavi) municipalities of the Kakheti region were selected as study areas. In total 16 sites were assessed and 32 composite soil samples were taken at depths of 0-30 and 30-60 cm. The laboratory studies were carried out on the following properties: particle size distribution by sedimentation using pipette method; soil pH in aqueous solution using 1:2.5 ratio by potentiometric method; OM by dry combustion method; Exchangeable Ca and Mg content by atomic absorption spectrometric method followed extraction with barium chloride solution.

Results

Under a moderately humid subtropical climate of the Kakheti region, the sum of exchangeable Ca and Mg at the depth of 0-30 cm of the study soils is 14.35-51.45 cmol (+) kg-1, while OM varies in the range of 1.69-6.86 percent. In deeper soil layer (30-60 cm), there is a tendency to decrease the exchangeable cations considerably - 14.75-14.79 cmol (+) kg-1. Soils with weakly alkaline and alkaline pH have relatively higher levels of exchangeable Ca and Mg cations than neutral and weakly acid soils, indicating a relatively strong degree of their leaching. In humid conditions, the amount of exchangeable calcium in soils is high (10-20 cmol (+) kg-1) and very high (> 20 cmol (+) kg-1), while the amount of magnesium fells in low (0.3-0.1 cmol (+) kg-1), medium (1.0- 3.0 cmol (+) kg-1) and high (3-8 cmol (+) kg-1) category. In the arid climate of the Kakheti region, at a depth of 0-30 cm the exchangeable Ca is very high (24.44-63.61 cmol (+) kg-1), which also shows an increased amount of OM, the concentration of exchangeable Mg is mostly average and high; At a depth of 30-60 cm in the soil, concentration of exchangeable cations is reduced in most cases. In heavy-textured soils where the finest fraction (<0.001 mm) exceeds 40 percent, exchangeable Ca + Mg> 50 cmol (+) kg-1 in soil. The percentage of exchangeable calcium is quite high compared to that of magnesium; Magnesium deficiency (Ca/Mg> 10), low exchange rate magnesium (Ca/Mg - 6-10) and optimum exchange cation content (Ca/Mg - 4-6) are rarely observed for almost all sites. Measures to adapt soil management to climate change are provided by the Concept of the National Target Program of Soil Use and Protection, 2022. The first stage of the Concept's objectives (until 2028) provides the improvement of legislative, scientific, informational, organizational and

technical support for the rational use of land resources and their protection at the national level and the establishment of a legal and regulatory framework.
Agreement on the financing of the event "EU Support for the Development of Agriculture and Small Farms in Ukraine" (ENI/2020/042- 345), signed in 2020, aimed at the development of policies and programs of state support of small and medium-sized farms, and the implementation of reforms for sustainable soil management.

Discussion

The Results showed that despite climate and crop types differences OM concentration is mostly reduced in the layers with lower CEC. In heavy-textured soils under different soil management practices showed an increase in OM content indicating a direct close correlation between them.

Conclusion

The variability of exchangeable cations is associated with changes in OM and clay content.

- The percentage of calcium in the exchangeable cations is high and greatly exceeds the magnesium content;

- Soils with relatively low pH and more leaching conditions, exchangeable calcium is decreased;

- The almost equal content of both individual exchange cations in the surface and depth layers is likely to be related to the deep plough;

- Based on the exchange ratio of calcium and magnesium, most of the study soils suffer from magnesium deficiency.

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Soil governance and integrated plant nutrient management for agricultural production and sustainable ecosystem in district Chakwal, Pakistan

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Keywords: soil, agriculture, advisory, analysis, characterization, recommendations, integrated, ecosystem

Introduction, scope and main objectives

Agriculture is the primary sector to provide food, fiber, and fuel, and other important commodities for sustaining life on Earth. At current time, the growing human population requires a large amount of agricultural production to fulfill the need. Therefore, agricultural approaches have changed rapidly, which introduced various modern practices and technologies that affect the environment in many ways. The excessive use of chemical fertilizers and pesticides deteriorates soil quality and contaminates the air, water, and soil (Saha and Bauddh, 2020). Therefore a study was conducted at soil and water testing laboratory Chakwal to collect and analyze the soil samples from farmer fields with the objective of better soil governance and sustainable agricultural production by adopting integrated plant nutrient management for a safe ecosystem.

Methodology

The total of 1 689 number of rhizospheric soil samples from farmer's field of different villages of district Chakwal (Pakistan) were collected / received from July 2020 to June 2021. These samples were air dried at room temperature about 25 ±5°C. After drying samples were grinded, passed through 2mm sieve and stored in jars for further analysis. The samples were analyzed by using standard procedures for soil characterization and distribution including soil EC, pH, organic matter, available phosphorus, extractable potassium and texture by using standard test methods (Khalid et al., 2012).

Results

The soil analysis revealed that 99.35 percent soils were normal/ non saline and 0.65 percent soils were saline in nature. The pH of 2.07 percent soils was recorded less than 7.5. Whereas, in 97.28 percent soils pH was in the range of 7.5 to 8.5 and 0.65 percent soils had pH more than 8.5. The organic matter was poor in 67.26 percent, satisfactory in 25.75 percent and adequate in 6.99 percent of soils. The available phosphorus was deficient / poor in 68.09 percent, satisfactory / medium in 28.42 percent and adequate in 3.49 percent of soils. The extractable potassium was deficient in 43.69

percent, satisfactory in 43.64 percent of soils and adequate in 12.67 percent of soils. The soil texture analysis revealed that 49.08 percent soils were sandy loam (light), 49.62 percent were loam (medium) and 1.30 percent soils were clay loam (heavy) in texture.

Discussion

The Results showed that despite the use of chemical fertilizers the health of soil is deteriorating and excessive use of chemical fertilizers is also damaging the ecosystem badly. Therefore, there is a need of time to govern the soil quality precisely at farm level for better sustainable management.

Conclusion

Based upon the soil analysis Results the recommendations were given to the concerned farmers for adoption of integrated plant nutrient management like application of biofertilizer, application of nutrient inhibitors for slow release of targeted nutrients especially nitrogen, biochar, vermicompost (Blouin et.al., 2019), crop rotation, addition of organic manures, minimum tillage, legumes-cereal cropping system etc., for enhanced agricultural production and sustainable ecosystem.

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Sustainable soil management for food security and better nutrition

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Keywords: Sub-Saharan Africa, soil health, sustainability, food security, ecosystem, biodiversity, smallholder farmers.

Introduction, scope and main objectives

Agro-ecosystems are confronted with the sustainable management of soils to ensure food security. Apart from crop production, soils are responsible for other ecosystem services, such as purification of water and as a habitat for important fauna and flora. From the destruction of the ozone layer to global warming and climate change, the destruction of forest ecosystems and pollution of aquifers, the events occurring in the soil have far reaching consequences for our ecosystem (Kookana et al., 2010). The soil's quality and resilience and its management in a sustainable way will ensure food security for a burgeoning population. Currently, anthropogenic activities such as road construction, mining, waste disposal, environmental pollution, disposal of chemical effluents into adjacent soils and the indiscriminate use of agrochemicals and other hazardous chemicals threaten to destroy soils and render them unable to perform their core function-which is food production to ensure food security (Yang et al., 2005). These problems emerge from the abandonment of sustainable soil management and ecosystem principles. As a result, the soil is taking longer to regenerate and soil salinity is on the increase. A holistic approach to soil management, where science partners with policy, indigenous knowledge and sustainable cultural practices to enable the soil to satisfy current and future nutritional needs of humanity is needed. These approaches must be underlined by ecosystem principles and the underpinning knowledge that the soil is a living and dynamic system whose status is critical to the survival of our species. Producing food in a sustainable way means that soils are managed in such a way that farming systems are resilient to shocks and cropping systems are designed in such a way that organic matter which is a valuable resource is added to the soil, technologies are employed to avoid soil erosion, fertilizers are applied with precision in combination with appropriate technology (FAOSTAT, 2017). Sustainability also means deliberate actions are taken to promote soil health. It also means the development of appropriate indicators to monitor soil quality. It will also mean training all the stakeholders whose activities relate to the soil to enhance their skill in sustainable soil management. Efforts made to enhance sustainable soil management in sub-Saharan Africa from 2015-2022 will focus on the following objectives:

Identify the main problems confronting the sustainable management of soils in the sub-region

Identify policies and interventions implemented to restore or remediate degraded lands

Efforts made to sustainably manage salt-affected soils in the sub-region and

Technological interventions being implemented to improve soil health and improve food security.

Methodology

The review employed the Participant-Intervention-Comparator-Outcome (PICO) model in searching for information on the topic of interest. The search was narrowed down to the following areas.(1) causes of soil degradation in SSA and efforts to improve upon soil fertility in SSA (2) sustainable soil management in the context of SSA and (3) links between soil fertility and malnutrition and health in SSA. In the search of literature Boolean logic was employed thus connectors such as

“AND”, “OR” and “NOT” were used in various combinations to expand or narrow down the search results and findings where necessary. Furthermore specific symbols such as ‘*’ and ‘$’ were used to truncate the search and find related items. Articles which were not relevant to the study or fell outside the years 2015-2020 were ignored. After the search was completed the Preferred Reporting Items of Systematic Reviews and Meta-Analysis (PRISMA) model was used to form a process diagram or PRISMA chart. The abstract of all the articles for the review were read before accepting it in the meta-analysis. The validity of the information in the articles were then determined by studying the theories and hypotheses of the research. Finally a Cochran’s Q test was conducted to test the heterogeneity of the information from the various articles. Databases used in the Meta analysis were “Google”, “FAOstat.com”, “research gate” and “Google scholar” in addition to conference papers on soil fertility decline. In total 535 documents were perused while 100 articles were rejected for not having the required information while 55 were excluded from the analysis for other reasons such as duplication and ethical grounds.

Results

Results indicated that soil degradation is on the rise in SSA and is being driven by extensification and intensification to meet the dietary needs of a burgeoning population. It is estimated that 40 percent of land in SSA has poor drainage, 24 percent is having Al-toxicity and a combined 30 percent have salinity, steep slopes, and low nutrient reserves, presence of allophane, high P retention, shrink-swell properties and high leaching potential. An indication that at least 70 percent of the soils of SSA are degraded (Khaliq and Abbasi, 2015). Between 2015 and 2020 malnutrition has been on the rise in SSA from an initial 5 percent of the general population in 2015 to almost double the figure in 2020. While protein deficiency has been on the decline from the 80’s due to governmental interventions, recent data indicates that it is on the rise. This has been driven by rising soil infertility as most of the protein in the diets of people in the region is supplied by crops which are cultivated on soils low in N and P. Studies have also indicated that soils in areas low in Ca, Zn Cu and Mn in addition to low SOM have high child mortality, high malaria incidence and stunting and high levels of child wasting. This links bad soil management directly to the health and well-being of the population. Governments seeing this trend have initiated irrigation schemes, fertilizer and seed subsidies and research and other policy programs to either reclaim or manage soils sustainably and improve nutrition and food security. A few countries such as Kenya in the sub-region are reaping the benefits of such interventions as indicated by positive nutrient balances on farmers’ fields and reductions in malnutrition and maternal and child mortality. Sustainable soil management strategies in the sub-region are mostly implemented by governments at the state and provincial levels and include promotion of residue retention and the addition of animal manures to improve SOM status of soils and soil physico-chemical properties and the implementation of organic farming albeit on a small scale. Certain countries such as Kenya have introduced Tithonia and N-fixing legumes into their farming systems in addition to agro-forestry systems as part of a broader SSM strategy. Key among all these strategies has been the prevention of soil erosion and the mechanization. Main challenge to the maintenance of these policies has been funding and commitment and infrastructure.

Discussion

The review has highlighted the importance of soil status in the fight against malnutrition on the sub-continent. The high percentages recorded for the extent of soil degradation indicates that the drivers of soil degradation are complex than initially thought and will take concerted effort to solve. Because most economies in the sub-region rely on agriculture which is dependent more on the soil than any other natural resource, soil degradation should be treated as national security problem. The costs resulting from unsustainable soil management on the continent is in the billions. An ELD report suggests that starting from 2016 if inaction against soil degradation continues, SSA could well lose close 4.75 billion tonnes of NPK/year worth 72.40 billion dollars which will lead to more malnutrition and conflict (Manzoor, 2020). Agriculture has been identified as one of the main causes of soil degradation and as such sustainable soil management is the solution to food security. Finally the little successes made from governmental interventions and other such policies indicate that the technology to manage soils sustainably is available if the willingness to access it is there. When this is done it will lead to improvements in livelihoods.

Conclusion

The study highlighted the importance of sustainably managing soils to improve nutrition in the population of SSA. The main findings however indicate that the soils of the sub-continent are not being sustainably managed and will require a concerted effort from farmers, researchers and policy makers to manage soils sustainably. Key to SSM will be the maintenance of soil organic matter, introduction of legumes and other N-fixing species to soils and the careful management of fertilizers.

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Sustainable soil management technologies upscale through research-extension-farmers-input linkage system; implications for effective policy implementation in Nigeria

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Keywords: Sustainable Soil Management, appropriateness, REFILS, Policy

Introduction, scope and main objectives

The Sustainable Development Goals have identified the need to restore degraded soils and improve soil health to be able to support food production and also store and supply more clean water, maintain biodiversity and achieve resilience in a changing climate (FAO, 2017). This goal therefore calls for the implementation of Sustainable Soil Management (SSM). The study identified the specific Sustainable Soil Management (SSM) technologies generated, disseminated and adopted among the actors through Research- Extension-Farmer-Input Linkage System (REFILS) activities; determined the level of actors 'involvement in linkage activities for the upscale of SSM technologies and also assessed the perceived appropriateness of SSM technologies transferred among the farmers in Oyo State, Nigeria.

Methodology

TA Multi-stage sampling technique was used to select thirty researchers across the four research institutes, 44 extension agents across the four Agricultural Development Programme (ADP) zones, 336 farmers across the four ADP zones and 33 input dealers from the registered members in the state. A total of 443 respondents were sampled for the study. Questionnaire and structured interview Schedule were used to elicit. Data collected were analysed using frequency, percentage, mean and standard deviation. Linear regression analysis was employed to draw inferences for the study.

Results

24 SSM technologies were identified to have been generated, disseminated and adopted by the SSM actors. These were categorized into Soil Erosion Control, Soil Nutrient Management, Minimum Soil Disturbance, Water Management Techniques, Vegetation Management and Agroforestry System. The extension agents and researchers had high level of involvement in linkage activities for SSM upscale of 88.6 percent and 62.2 percent, respectively while 61.9 percent of the farmers and Input dealers 63.6 percent recorded a low level of involvement in the linkage activities. Perceived appropriateness of SSM technologies among the farmers showed that 9, 10, 12 and 14 SSM practices, respectively were beneficial to farmers on ease of application, ecological, economic and socio-cultural bases. Results of the linear regression revealed that farmers 'perception ($b=0.06$) significantly influenced their level of involvement in linkage activities for SSM upscale at $p \leq 0.01$.

Discussion

The findings of this study have revealed that the Extension Agents were more involved in linkage activities for SSM upscale than other actors while the farmers had the least level of involvement in linkage activities.

Conclusion

It is concluded that for the upscale of SSM technologies in the area, Extension Agents are more involved in linkage activities than other actors. Farmers in the study area perceived the appropriateness of SSM technologies based on their ease of application, ecological benefits, economic benefits and socio-cultural acceptability. Implementers of SSM policies and the extension agents involved in SSM technology dissemination should leverage on this by creating more awareness of those technologies that are favorably perceived to be appropriate so as to influence the farmers ‘eagerness to participate in linkage activities that will promote the use or application of these technologies among them.

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How to improve the uptake of sustainable nutrient management practices in Catalonia?

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Keywords: Fertilisation Management, agro-environmental scheme, contracts, payments, profits, N content

Introduction, scope and main objectives

The European agricultural land areas provide important and valuable goods in the form of food, fibre and biomass for the world. They are also crucial for the provision of a number of environmental and climate goods and services. EU member states have implemented agri-environmental schemes, investment grants for environmental technologies, and private actors have established environmental certification and labelling schemes targeting these services. However, many initiatives are arguably not cost-effective in boosting environmental and climate service provision, may be skewed in terms of distributional impacts, increase risks to farmers, or involve excessive transaction costs. EFFECT will develop and pilot a theoretically well founded and empirically well-adapted package of new contractual frameworks. This will enable farmers to reconcile agricultural production with enhanced delivery of environmental and climate public goods and services to the benefit of society at large. EFFECT pursues this through a transdisciplinary effort involving a review of past successes and failures; and development and test of new forms of contracts. We combine agricultural and environmental science knowledge with theoretical and empirical insights from law, political science and economics. We further combine efforts from researchers and multiple practice partners and stakeholders to ensure that lessons learned from previous initiatives and our testing of emerging contract frameworks are validated on the ground. Our ambition, which is based in the solid experience in the consortium, is to facilitate that our co-developed agri-environmental contract arrangements are being put to actual use towards the end of the project. Furthermore, to ensure durable impact of the project, EFFECT initiates a cross European innovation process, supports capacity building among decision making bodies and develops a policy evaluation framework. Nine innovation cases conducted in different economic, social and legal contexts are used to empirically test the effectiveness of the new contractual frameworks. They are co-designed and developed with local stakeholders, in order to reconcile farmers' activities with the achievement of public benefits for the entire society.

Methodology

Case study Spain: Contracts to improve uptake of nutrient management technologies in Catalonia. Catalonia is one of the EU regions with a highest livestock unit in Europe. Moreover, within Catalonia 1/ 3 of N from manure is generated in only 3 out of 41 counties. This land is privately owned by farmers. The fact that 2/3 of the territory is forests (which is land where you cannot apply manure) makes critical the good use and management of fertilizers. This trend is not changing. The environmental challenge* here is how to reduce the N content in groundwater. New agricultural measures to protect ground water sources have not been adopted by farmers despite attempts to design programmes targeting their uptake. The Sustainable Fertilisation Management agro-environmental scheme aimed to encourage farmers to analyse their soil composition and to plan fertilization management accordingly. Each farmer individually could apply to this scheme that was part of the EU's CAP (pillar 2). No direct reference is done to the ecosystem service at stake, in this case: water and soil quality (Reduce their nitrate content). The Department of Agriculture, Livestock and Fisheries (now: Department Climate Action, Food and Rural Agenda, DACC) establishes the contracts with farmers as a part of a global agreement (DUN) regulated under the Rural Development Program (RDP) 2014-20, funded under the European Agricultural Fund for Rural Development (EAFRD) of the European Commission. In particular, this contract compensates the costs of analytical measurements and procedures to optimize fertilizer application. There are no intermediaries, however in many cases technicians working in cooperatives or consultancies deal with the administrative work associated to contracts under the global agreement (DUN) are subcontracted to. These contracts are associated with the following length and terms:

- Maintain the crop area for at least 5 years (which is the length of the contract)
- Interpretation of Results and follow recommendations of technicians
- Fertilize according to the Results obtained
- Exploitation booklet with phosphorus and potassium fertilization recommendations
- Participate in training sessions

In EFFECT, even more particular in this case study, the object of study is the "Sustainable Fertilisation Management agro-environmental scheme 2014-20" which was part of the measures taken under EU Rural Development Program PAC (Pillar2). This scheme won't be renewed in the next EU Rural Development Program PAC due to its low uptake. In our study we assessed the reasons for the low participation rate and will provide recommendations for designing a new type of contract (y. 1-2). Based on these, we establish a pilot project testing a new form of contract arrangement (y. 3-4). DACC is the practice partner in EFFECT for this case. A farmer survey was conducted targeted towards farmers during the second half of 2020 (n = 52). Only 30 percent of these 52 respondents are (or had previously been) enrolled in AES. Also, eight expert interviews were targeted towards policy advisors and other stakeholders who had the experience of AES and rural development processes. These two approaches help us to better understand, the role of farmers influencing EAS in the context of the future Common Agrarian Policy, and in particular the rural development process.

Results

From our study of factors influencing uptake, we observed that for increasing the effectiveness of economic incentives, we might work as well on other two treatments:

1. Education, leading to change in values especially for future farmers

2. Knowledge transfer, leading to change in communication and how farmers are mobilized. In order to achieve our ultimate goal "reduce soil and water pollution in farming systems" and according to the step mentioned below, we organize a workshop to discuss what were the main needs that is linked to change in three particular treatments:

•WORKING GROUP 1 on Subsidies (Type of measures and their design features)

•WORKING GROUP 2 on Environmental education

•WORKING GROUP 3 on Technical knowledge transfer and farmer mobilization.

Discussion

The summary of the Discussion about different design features that might contain a new agro-scheme are as follows:

1 Not focussing just in one practice but a few. All the practices should have a positive effect on the soil and water quality. Maybe even can be asked a combination of one practice associated with farming, and another in relation with fertilization management. These bundles will come with the conditionality of soil analysis and advise upon Results.

2 The importance to keep the scheme as flexible as possible: annual with flexibility on the practices (and probably lands)

3 Focusing on input payment (as is difficult to measure the impact on soil/water on the short term) but with bonuses rewarding efficiency (some practices are more efficient that others) and continuity (what matters in terms of water is the years that a good practice has been sustained). Monitoring input based will ease the costs and feasibility.

4 The scope still is individual, but a bonus can be considered for collective action (land gathering)

5 To include these types of agro-schemes in the current system (DUN) to reduce bureaucracy

6 The need of communication and technical support along with the technical requirements

7 As conditionality add educational training

8 The summary of the Discussion about how to use environmental education as a measure to change values fold as follows:

1. The focus should be in agricultural schools and the target population young or future farmers as well as young farmers that are in a subsidy program to support them as new incomers to the agrarian activity (ajuts per a joves agricultors)

2. The need to improve trainers' training in legislation and current subsidies schemes. Schools are aware of what they are publishing in the administration. However, sometimes the administration is requested to update on the above-mentioned topics. It will improve the efficiency to cluster and unify agrarian schools for this communication/capacity building efforts.

3. New farmer low environmental awareness derived from what they have experienced at home, inertia of the father / grandfather: "crops must be fertilized as much as possible"

4. Experimental pilots to show how farmers apply much more fertilizer than the crop needs. They need to understand good fertilization practices not only from theory but practices

5. This strategy to change behaviors/values is long term since students trust more familiar traditions that knowledge or the administration (which is perceived negatively).

6. To promote Network of groups of entrepreneurs that focus more on agricultural practices than in applying fertilizers

7. To work on the environmental cost of producing and applying (residue waste) these products (beyond the economic savings) to enhance the sense of community and the feeling of contribution to society.

8. To promote/copy/communicate good practices (good seeds) to reduce the perception of subsidies as a cost/Threat. The summary of the Discussion about different possibilities to enhance Technical knowledge transfer and farmer mobilization Resulted as follows:

Currently there are many tools/channels to promote this knowledge transfer and farmer mobilization:

1.Particular the transfer days at county-ca / PATT-Ruralcat level; agricultural training courses, etc). The problem is that normally the audience is always the same. How to reach beyond the usual subjects is a challenge.

2.Technical days and demonstration projects where the benefits of soil analysis (of aid) beyond fertilization are visible, punctual is not interesting, but consecutive yes.

3.Basin projects with good reception linked to each crop / area.

•The communication structures to outreach farmers are also stablished:

4.Cooperatives, Agricultural Offices, Unions, Associations of Vegetal Defense (ADV).

5.These organizations process farm subsidies, and therefore they need to be involved. Even they might be rewarded in case they manage to group individual farmers/farms – note that one limiting factor was that smaller farms do not apply for this type of subsidies). The need to be more than just managers, but also supportive on the farmers' behavioral transition.

6.ADV technicians who accompany farmers have been successful. However, their knowledge usually is focused on pests, some work on fertilizers as well but they are few. New capabilities* will be needed but they could be a good channel for knowledge transfer. For instance, their work is already close to fertilization adjustment and advise on measurements. New subsidies could include a share for new services provided by ADV

7.There are authorized advisers for fertilization (existing list).

8.Fertilizer companies (mineral) have direct tb communication with farmers> but they have their own interests.What messages should be communicated? Along with the technical requirements and commitments associated to different agri-environmental schemes, communication should also contain other important messages as such:

9.Fertilization optimization increases economic efficiency (reduce input costs for save harvesting). It's about savings.

10.Beyond economic efficiency, not enough attention has been done in communicating that fertilization optimization reduces costs and the collective gain of a healthy environment (e.g. what's the cost of recover one well? Who bears the costs of pollution?)

Conclusion

Based on this analysis, we have started building a theory of change to investigate potential solutions to complex socio-environmental problems, such as how to reduce soil and water pollution in farming systems. We focused on treatments that address changes in attitudes, awareness, and changes in habits since new agrarian or fertilization management techniques are not accepted by farmers. Also, two more workshops will be conducted till the end of the project to address the need to investigate deeper on potential solution in how to reduce soil and water pollution in farming systems

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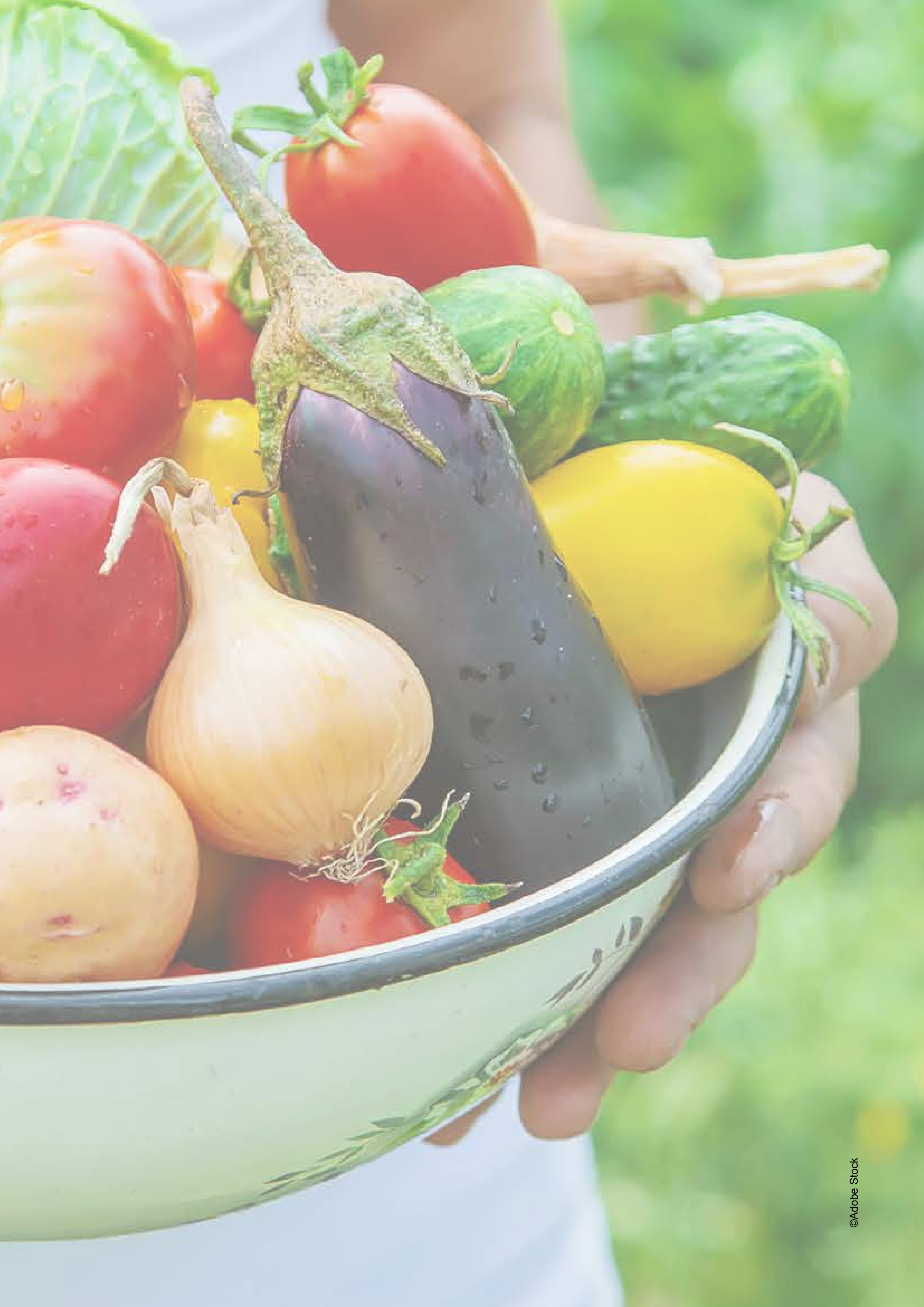

The Global Soil Partnership (GSP) is a globally recognized mechanism established in 2012. Our mission is to position soils in the Global Agenda through collective action. Our key objectives are to promote Sustainable Soil Management (SSM) and improve soil governance to guarantee healthy and productive soils, and support the provision of essential ecosystem services towards food security and improved nutrition, climate change adaptation and mitigation, and sustainable development.

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