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organic materials and soil productivity in the near east

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS ROME

FOREWORD

This Bulletin contains the papers and proceedings of the FAO/SIDA Workshop on Organic Materials and Soil Productivity in the Near East, which was held with the financial assistance of SIDA, on the premises of the Faculty of Agriculture, Alexandria University, Egypt. In 1974, at the World Food Conference resolutions were passed urging the greater utilization of organic materials to improve the fertility of the soils for maximum crop production. FAO, in cooperation with the Swedish International Development Authority (SIDA), assumed a leading role in promoting the use of organic materials for improving soil productivity. The Expert Consultation on Organic Materials as Fertilizers (Rome, 1974), the Workshop on Organic Recycling in Asia (Bangkok, 1976), the present Workshop on Organic Materials and Soil Productivity (Alexandria, 1978) and others in Latin America and Africa are part of this promotion programme.

In view of the important complementary effect of organic materials to mineral fertilizers and their role in improving the soil's physical properties, the Workshop has dealt with a wide variety of items on techniques and uses of the organic materials and wastes including composting, bio-fertilizers and biogas, the environmental and health aspects, and action guidelines for follow-up activities in the Near East countries.

The proceedings of the Workshop present sound recommendations, the implementation of which would assist in improving the soil productivity, raising crop production levels and producing a better quality of life.

The Arabic summary of the English text and the technical editing of these proceedings were undertaken by Dr. A.S. Abdel-Ghafar, Head of the Soil and Water Department, Faculty of Agriculture, Alexandria University, Egypt.

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I. INTRODUCTION, CONCLUSIONS, AND ACKNOWLEDGEMENTS

1. INTRODUCTION

The use of organic materials for growing crops and improving soil productivity is an agricultural practice that has been followed in the Near East countries for centuries. Until mineral fertilizers were introduced in the mid-nineteenth century, organic materials in the form of compost and animal manures were the only source of plant nutrients added to soils except for certain legumes that supplied nitrogen. The use of organic materials in some Near East countries began to decline about 20 years ago when we entered the era of the "Green Revolution". At that time, the use of mineral fertilizers gained dramatically in popularity, and the use of organic manures was considerably reduced even in countries with long-established and traditional use.

Now, in view of the world energy crisis and the continuing increase in cost of mineral fertilizers, and questions as to their future availability, there is renewed interest in organic recycling to improve soil fertility and productivity.

In 1974, at the World Food Conference in Rome, resolutions were passed urging the greater utilization of organic materials to improve the fertility of soils for maximum crop production. As a result of this Conference, FAO, in cooperation with the Swedish International Development Authority (SIDA), assumed a leading role in promoting the use of organic materials for improving soil productivity, by organizing an Expert Consultation on Organic Materials as Fertilizers in Rome, 1974 and a Workshop on Organic Recycling in Asia, in Bangkok, 1976. Other workshops are planned for Developing Countries in Latin and South America, as well as Africa and Asia. These workshops have fully recognized the urgent need to re-introduce the use of organic recycling to enhance agricultural production and strongly endorse the complimentary use of mineral fertilizers and organic materials for maximum benefit. FAO is intensifying its efforts to assist Member Countries in developing action programmes to increase the fertility and productivity of their soils through a balanced use of organic and mineral fertilizers.

The Workshop was organized by FAO and the Soil and Water Science Department, Faculty of Agriculture, Alexandria University (Egypt) and sponsored by SIDA.

The purpose of this Workshop was to promote and maintain interest in the use of organic materials for improving soil productivity in the Near East Region and to assist Member Countries in developing action programmes to achieve these goals.

At the opening session, addresses were given by the FAO Assistant Director-General and Regional Representative for the Near East, the Dean of the Faculty of Agriculture, the President of Alexandria University, the Governor of Alexandria and the Deputy Minister of Agriculture (Appendix I).

During the working sessions, 31 papers were presented by invited lecturers from Egypt, Hungary, India, Korea, USA, FAO, UNIDO and WHO. In addition, 2 excursions were devoted to observing a land reclamation project and organic recycling operations at Northern Tahrir Province and a biogas unit at Fayoum (Programme: Appendix II).

The Workshop concluded its technical sessions by a presentation of its final report containing conclusions and recommendations.

2. CONCLUSIONS

i. There is no doubt that mineral fertilizers are essential in most cropping systems if maximum yields are to be realized. However, in long term field experiments where only mineral fertilizers have been used, soil structure has deteriorated and crop yields have steadily decreased. The organic matter content of these soils, perhaps the most reliable index of soil fertility and productivity, has also decreased.

ii. The best means of maintaining soil fertility and productivity at a maximum level is through periodic additions of properly processed organic materials in conjunction with mineral fertilizers. These organic materials can contribute substantial amounts of macro-nutrients (NPK) and micro-nutrients (Cu, B, Zn, Mn, Mo) for crop growth, in addition to improving the physical properties of soil, e.g. tilth, soil structure, and water holding capacity.

iii. The recent energy crisis and continuing increase in the price of mineral fertilizers has resulted in a more competitive position for organic manures. There are, however, certain constraints that must be overcome if their full potential is to be realized. For example, some organic wastes such as sewage sludges and night soil could present health hazards when not properly managed.

iv. Among the constraints to full exploitation of organic materials for use in improving soil productivity in the Near East countries are the following:

a. lack of awareness of the kind, amount and availability of organic resources and lack of interest;

b. lack of infrastructure for collection of wastes in rural and urban areas;

c. lack of appropriate technologies in developing countries;

d. lack of concern for possible adverse effects on public health and the environment from the absence of waste management programmes in rural and urban areas;

e. lack of definite policies and programmes on the part of national governments to support the recycling of organic materials for use in agricultural production systems;

f. lack of sufficient funds to carry out remedial measures.

v. Despite their potential economic value, many of these organic resources have remained more or less commercially unexploited.

vi. The collection, processing (e.g. composting), and utilization of organic materials for land application should not be considered as profit-making activities. Their real value, however, should be assessed on the basis of long-term multiple benefits including decreased pollution, improved public health, and better appearance of urban and rural environments.

vii. It is well recognized that biological nitrogen fixation techniques, if properly developed and propagated, can supply a substantial amount of the nitrogen requirement of a crop. However, these techniques have not been fully exploited in developing countries owing to the lack of trained personnel for adaptation and propagation.

3. ACKNOWLEDGEMENTS

The Workshop wishes to acknowledge with grateful appreciation FAO's efforts to organize and service this meeting, and the special contribution from SIDA without whose support this Workshop could not have been held. The Workshop also wishes to express its gratitude to the Egyptian Government, the Ministry of Agriculture, Alexandria University and all other organizations and officials for their cooperation and generous hospitality. Special thanks are due to the Faculty of Agriculture, Alexandria University for the excellent facilities and services provided to ensure the Workshop's success.

II. RECOMMENDATIONS

1. TECHNICAL

1.1 General

i. The Workshop recommended that FAO take whatever steps necessary to convey the proceedings, conclusions and recommendations of this Workshop to all Member Countries of the Near East Region.

ii. It is recommended that the proceedings of this Workshop be translated into Arabic at the earliest convenience, so that Arabic-speaking countries may be fully informed as to its technical content, recommendations, and proposed action programmes.

iii. It is further recommended that a Regional Workshop of this nature be held every two or three years for the purpose of sharing information, reviewing progress and revising recommendations and actions on specific programmes.

1.2 Organic Resources for Recycling to Improve Soil Productivity

The Workshop recommended that assessments of the present and future availability of organic materials for land application be made on a country-to-country basis. Specific information that is needed includes types and quantities of organic materials produced, present level and mode of utilization, constraints in their use for organic recycling (e.g. unsuitable chemical composition and competitive uses), and potential for increased organic recycling.

1.3 Composting of Urban and Rural Wastes

i. Since currently available turn-key technologies may not be best adapted to developing countries, it is recommended that before embarking on a huge capital expenditure for a full-scale plant, pilot scale facilities be established in interested countries for work on process adaptation, ranging from labour intensive methods to mechanical systems, market development, and local fabrication of compost plant machinery. The results of this development work should be used in a national programme for waste management and organic recycling.

ii. It is also recommended that composting authorities be established to ensure that organic wastes are processed according to established methods and standards. This will ensure that the product is environmentally safe, hygienic, and beneficial for land application. Such authorities should include trained compost technologists and public health specialists who would be responsible for monitoring the health of workers involved in collection, transport, composting, distribution, and of the farmers who utilize the compost.

iii. It is further recommended that such established composting authorities should not be organized to operate under a profit motive, but rather oriented towards cost benefit relationships that consider long-term multiple benefits of decreased pollution, improved public health, conservation of resources, and better appearance of urban and rural environments.

1.4 Biogas Technology

The Workshop recommended that biogas technology should be promoted at two levels:

a. village-scale technology to provide a convenient source of energy and to promote rural sanitation, and

b. industrial-scale technology to provide an alternative source of energy and organic fertilizers based on renewable resources.

1.5 Biological Nitrogen Fixation

The Workshop recommended research and application programmes that will lead to achieving the full potential of symbiotic and asymbiotic nitrogen fixation techniques in developing countries of the Near East Region. These programmes should include enhancing biological nitrogen fixation through:

a. introduction of legumes, particularly those having a high nitrogen-fixing efficiency;

b. legume inoculation using highly efficient strains of rhizobia;

c. algalization of rice fields;

d. propagation and adaptation of azolla/blue-green algae systems when and wherever possible; and

e. reduction of genetic and physiological constraints that limit the nitrogen fixing process.

1.6 Organic Materials as Soil Amendments

The Workshop recommended research programmes which would lead to the development of organic soil amendments that are more resistant to microbial decomposition in soils of arid and semi-arid regions. Such studies should be pursued long enough to allow a full and comprehensive economic assessment of the beneficial residual effects of these materials.

1.7 Extension and Training

To ensure that research findings are transferred to and applied at the farmer's level, the Workshop recommended more effective extension and training programmes in the use of organic resources to improve soil productivity. The goals of these programmes should include the following:

a. technology and socio-economic benefits of organic recycling;

b. technology of propagation and adaptation of azolla/blue-green algae as well as other nitrogen-fixing systems;

c. technology of legume nodulation; and

d. transfer and development of biogas technology with emphasis on training of artisans and masons to ensure the successful construction and maintenance of biogas plants.

It was also recommended that this type of training be given to extention service specialists, workers, and the rural population and be included in teaching programmes at the high school and university levels.

2. ACTION PROGRAMMES

2.1 Preparatory Assistance for Assessment of the Availability of Organic Resources

Recognizing that reliable and up-to-date information on the kind, amount, availability, and competitative uses of various organic resources in some countries of the Near East Region may be limited, and since this information is essential to successful organic recycling programmes, the Workshop recommended that the Governments of Member Countries should take immediate steps to acquire this information with the assistance of FAO/UNDP.

Workplan

Through the assistance of a coordinator, who would visit the participating countries in the region, information about the following should be collected:

a. sources of organic materials;

b. kind and extent of organic recycling practices and the degree of success achieved;

c. availability of national personnel in the region to implement activities on recycling of organic wastes;

d. availability of suitable research organizations and infrastructures;

e. required inputs.

It is further recommended that formulation of sound project documents should be submitted to International or Bilateral Agencies for implementation.

Inputs

a. Coordinator (full time - up to one year);

b. Consultants on specific aspects of organic recycling (city waste, sewage, biogas...);

c. Consultants on specific aspects of bio fertilizers;

d. Study tours (to India, China ...).

2.2 Centre for Composting Technology and Utilization of Compost

i. To develop appropriate technologies for production and utilization of compost in developing countries of the Near East Region, the Workshop recommended the establishment of centres for pilot-scale work on process adaptation, ranging from labour intensive methods to mechanical systems, market development, and local fabrication of compost plant machinery. The centre should also be utilized to conduct the following:

   a. short courses on compost technology for policy makers, extension workers, farmers, plant operators, and maintenance personnel;

   b. demonstrations on various aspects of compost utilization on land for best agronomic results including time, method and rate of application, and also best possible combination with mineral fertilizers.

ii. The Workshop recommended that FAO/UNIDO/UNDP/UNEP assistance be provided for the above action programmes, as well as in the planning and execution of new compost plant projects and trouble-shooting and necessary modification of existing compost plants.

2.3 <u>Biogas Technology</u>

The Workshop <u>recommended</u> demonstration projects in rural areas assisted by FAO/UNEP/UNIDO sources for the following purposes:

a. to determine the competitiveness of biogas technology as a source of energy and organic fertilizer, compared with other alternatives;

b. to determine how the biogas plant should be managed as the core of an integrated system with many possible variations in input material and slurry utilization, and how these considerations should be reflected in its design and operation;

c. to arouse public interest and to secure public commitment to proper operation and maintenance of biogas plants;

d. to mobilize financial resources (government loans, subsidies, etc.) for development of infrastructure and for construction of biogas plants;

e. to establish a sound technical advisory service to improve cost, effectiveness, and to promote reliability of plant design through standardization.

<u>Workplan</u>

a. Building up national programmes.

b. Regional advisory programme.

c. Construction of different biogas units for different utilization of the gas produced.

d. Improvement of laboratories.

e. Training, study tours, fellowships. Duration: 3 years.

f. Close cooperation with national institutions and emphasis on TCDC approach.

<u>Inputs</u>

a. Coordinator: (full time, expert in Soil Microbiology with special reference to biogas technology).

b. Consultants for special fields and training.

c. Training course, study tours, fellowships.

d. Complementary laboratory experiments.

e. Construction of biogas units with the suitable machines for different utilization models of the produced gas.

2.4 <u>Biological Nitrogen Fixation</u>

The Workshop <u>recommended</u> research, development, and application programmes, assisted by FAO/UNDP/UNEP sources on the following aspects of symbiotic and asymbiotic nitrogen-fixation techniques.

i. Symbiotic Nitrogen Fixation

a. Strains of rhizobia: distribution of different species of rhizobia in different countries, testing the efficiency of strains in national and regional collections.

b. Inoculants: development of carriers for legume inoculants from locally available materials, e.g. peat, peat moss, bagasse, soil lignite, etc.

c. Inoculant methods: assessment of inoculation methods, e.g. slurry, preinoculation, pelleting, liquid cultures, etc.

d. Response to inoculation: assessment of response to inoculation in terms of nodulation, dry weight, nitrogen content, and crop yield.

e. Efficiency in Nitrogen fixation systems: evaluation of different systems, e.g. sesbania interplanted with rice, or cultivated as windbreaks.

f. Use of non-legume systems: assessment of the potential of these systems to fix nitrogen, e.g. *Casuarina* sp.

g. Azolla: study of the distribution, efficiency, propagation methods, and crop response.

ii. Non-symbiotic Nitrogen Fixation

a. Bacteria: study of the distribution, efficiency and crop response to free-living nitrogen fixing bacteria, e.g. *Azotobacter*, *Beijerinckia*, Spirilla, photosynthetic bacteria, etc.

b. Blue-green algae: study of the distribution, efficiency, method of cultivation, and crop response.

c. Other nitrogen fixing systems: search for other systems, e.g. species of *Spirilla* and *Lemna*.

iii. Technology Transfer

The following measures for technology transfer are recommended:

a. training programmes, seminars, and workshops to be held at the national and regional levels;

b. dissemination of knowledge through assignment of experts from within or outside the Region.

Workplan

a. Building up national programmes.

b. Regional inoculation programme (legume, rice paddy).

c. Supply and selection of strains (rhizobia, azotobacter, spirilla, blue-green algae, azolla).

d. Improvement of laboratories.

e. Training, study tours, fellowships. Duration: 3 years.

f. Close cooperation with national institutions and emphasis on TCDC approach.

Inputs

a. Coordinator: (full time) expert in Nitrogen fixation.

b. Consultants for special fields and training.

c. Contracts.

d. Training courses, study tours, fellowships.

e. Complementary laboratories, equipment.

III. INTRODUCTORY PAPERS

Paper 1

ORGANIC RECYCLING TO IMPROVE SOIL PRODUCTIVITY

by

F.W. Hauck
Chief, Soil Resources, Management and Conservation Service
Land and Water Development Division, FAO, Rome.

1. INTRODUCTION

1.1 Organic Matter and Plant Growth

Organic substances by themselves, are not necessary for plants to grow; nutrients in inorganic forms are sufficient. However, the effect of organic matter on plant growth is not just a matter of nutrient supply. Organic materials influence the physical, chemical and biochemical characteristics of soil, which in turn influence the growth and development of plants.

Normally organic matter improves the physical structure of soils and hence their workability; water-holding capacity is increased and soil aggregation and stability are improved. Chemical effects include increased cation exchange capacity and a decrease in fixation of phosphorus. Soil micro-organisms depend upon a supply of decomposable organic matter for their activity.

Until the introduction of mineral fertilizers in the mid-nineteenth century, organic materials in the forms of compost and farmyard manure were the only recognized source of crop nutrient added to soils with the exception that legumes were used to increase the nitrogen supply.

1.2 Decline in Use of Organic Manures

Organic materials, including green manures, were preferentially used, especially in developing countries, up to the 1960's when, following the lead of more advanced countries, mineral fertilizers gained in popularity. As technical progress was made, mineral fertilizers became more easily available and cheaper. They were relatively easy to transport, handle and use and they produced effective and quicker results. By the time new, high yielding varieties of grain crops had been developed - which need high fertilizer inputs - the era of the "Green Revolution" had been reached and mineral fertilizers had virtually replaced organic manures as a source of crop nutrients. The use of organic manures, which are bulky and difficult to handle, transport and store, fell into disuse even in countries where its application was traditional and long-established.

1.3 Re-introduction of Organic Manures

The mineral fertilizer boom did not endure and, largely due to the world energy crisis and increased oil prices, inorganic fertilizers became less available and considerably more expensive. It became more important for non-renewable resources to be used to the highest degree of efficiency.

As a consequence organic manures are regaining popularity and increased interest is being shown in finding new sources of organic material that can be used to promote plant growth. This change in policy has come at a time when awareness of the increasing pollution of the environment has become an international concern. The fact that recycling organic waste materials for increasing agricultural production also reduces environmental pollution is an added inducement for its increased practice. Using garbage for increased vegetable production instead of accumulating unsightly and insanitary heaps around a city for example, is an attractive alternative.

However, in many countries that have recently been increasingly dependent upon mineral fertilizers, the technical knowledge of organic waste utilization has been lost. It is thus necessary to re-introduce the techniques, to improve them and to develop new practices conforming to modern technology.

It must not be assumed that mineral fertilizers are to be superceded; efforts should be directed towards a balanced use of organic combined with mineral fertilizers as giving optimum conditions for sustained soil fertility.

2. TECHNICAL POSSIBILITIES OF USING ORGANIC MATERIALS AS FERTILIZER

2.1 Waste Materials

2.1.1 Animal wastes

Sources of organic, animal waste material for use as fertilizer are farmyard manure, slaughterhouse byproducts, natural deposits of guano, fish meal and human wastes such as night-soil or on the larger scale as city sewage and sludge.

Human and farm animal excreta are rich in many plant nutrient elements which should be recycled in the soil rather than merely disposed of. Tables of analytical data showing the comparative nutrient contents of the materials are available in the literature. As a typical example it can be quoted that cow dung contains from 1-2% N, 1-2% P and 0.8-1.2% K and that 1 ton of fresh dung will yield over 700 kg of manure if digested or about 500 kg if composted. Night-soil averages 3-5% N, 2-4% P and 1-2% K, each individual producing nearly 600 kg per year.

The nutritive value of animal wastes will depend upon the pretreatment given. Farmyard manure can be directly applied to the soil provided that it is immediately ploughed in, but storage in pits in a moist condition and under an earth cover will improve its value as fertilizer.

In some cases animal dung, in particular that of pigs and poultry, is added directly to fish ponds as a fertilizer.

Slaughterhouse waste provides bone meal and sometimes blood meal, which are useful fertilizers on acid-soils, and sometimes such waste is incinerated and the ash used. Human wastes should not be directly applied to soils as this leads to offensive odours, attraction and multiplication of flies, spread of disease and, in any case, is inefficient for fertilization purposes. City sewage is usually digested under controlled conditions yielding sludge which can either be applied directly to soils or composted with more solid materials before use (e.g. night-soil), the material must be composted with vegetable wastes or preferably anaerobically digested when biogas is a valuable extra product to the fertilizer.

Biogas digesters are probably the most efficient and economical means of dealing with animal wastes. Owing to over-exploitation of fossil fuels there is a need for alternatives. Land is being deforested to provide firewood and burning of plant and animal wastes is more the rule than the exception. In

India alone, for example, more than a hundred and fifty million tons of dry cattle dung is burnt as household fuel every year. It has been calculated that if all the cow dung produced in India was digested, it would produce about 17 million cubic feet of gas per year. This gas is efficient and clean; it can be used for cooking, lighting and running engines. Eye disease, which is rampant among women using cow dung as fuel, is eliminated, houses are cleaner and equipment longer lived.

Moreover, apart from the bonus as fuel gas, the ramining effluent forms a manure of far better quality than the original organic wastes. It is richer in humus with a doubled nitrogen percentage, more finely divided and free from harmful bacteria, fly-eggs and so on. Although most investigational work has been done using cow dung, the same conclusions apply when other animal and rural wastes are digested. In large areas of India, notably in India and China, biogas units are widespread and gaining in popularity for the efficient disposal with beneficial products of organic waste materials, especially human and animal excreta.

2.1.2 Vegetable wastes

Most vegetable waste suitable for recycling comes from the agricultural community. Farmyard litter, stubble, stalks, straw, husks and so on, are common, and special agricultural industries provide material such as sawdust, and cotton, fruit, sugarcane, rubber and oil palm trash. All these materials contain valuable nutrient elements which are often lost to agriculture by burning.

In many cases crop residues are returned to the soil by ploughing in directly. Rice straw in Japan for example is produced at the rate of 19 million tons per year and this contains 95 000 tons N, 11 000 tons P and 284 000 tons of K. However, direct incorporation of straw into soils is not always the most efficient way of recycling the elements. A sudden excess of carbon-rich organic matter can lead to nitrogen deficiency in the soil, pests can be simultaneously recycled and, particularly for rice straw, incorporation into flooded soils causes formation of toxic organic acids. In such cases, it has been found preferable to use the straw as a mulch.

All vegetable wastes can be conveniently composted before use or could be added to biogas digestion units. Experimentation with promising results has been made on the use of most industrial vegetable wastes; household vegetable wastes are invariably part of urban waste and not treated separately.

2.1.3 City and industrial wastes

Urban waste is a very heterogeneous substance consisting largely of household garbage and factory wastes; strictly speaking sewage and slaughter house wastes are included in urban waste, but these have been dealt with under animal wastes. The waste can be divided into two broad groups; solid and liquid. In many towns, household and industrial liquid wastes find themselves in an overall sewage system and are eventually separated into effluent and sludge. As a final purification procedure, the effluent can be sprayed on to agricultural land where it provides both water and nutrient elements.

The treatment for solid city wastes is composting if the organic components are to be recycled for agriculture. In industrialized countries many large-scale and often highly sophisticated, composting plants have been constructed. Recently however, the number of such plants has been decreasing and many have simply been abandaned. Although several economic reasons exist for this, the main reason has been lack of demand and even lack of interest, for the produced compost.

Thus most urban waste is being incinerated, used for land-fill purposes or merely dumped. Interest in composting is fortunately now reviving and FAO recently sent a consultant to several member countries to advise the governments on the possibilities for making agricultural use of their garbage.

2.2 Other Materials

2.2.1 Green manures and biological nitrogen fixation

Generally speaking, the emphasis in green manuring is on nitrogen supply although incorporation of green plant material into a soil also provides organic matter *per se* and other plant nutrients.

Thus the best known and more popular green manures are those associated with fixation of atmospheric nitrogen, such as legumes. One method of using legumes is to include them in the rotation purely as a green manure to be ploughed in. This however, is an unpopular method as land is immobilized as it were, for a cropping season with no marketable crop as a result. The method can be successfully followed in some cases; for example, a plant such as Sesbania can be grown around rice fields taking advantage of the rice irrigation water, and being ploughed in after the first rice harvest.

A more common practice is to interplant a green manure crop with the main crop. In this case, the legume must be shade-tolerant; this is successfully done with cereals and especially with plantation crops such as rubber and oil palm. Similarly a suitable legume can be interplanted with pasture grasses.

An alternative, acceptable practice is to use legumes which also yield a food crop, such as soybean or cow pea, before being ploughed in as green manure. In general, research is needed on legume-rhizobium relationships, rhizobium strains suited to specific areas and climates need to be developed, and the whole subject has great potential, particularly in the tropics.

Green manure plants are sometimes grown specifically to be included in composting practices in order to increase the nitrogen content, although in this case the term 'green manure' is perhaps not accurate.

Aquatic weeds have a fertilizer potential in tropical countries and in particular the water hyacinth. This weed is very prolific and a great nuisance in that it clogs up water ways. It also however absorbs considerable amounts of nutrient from water and so forms a particularly rich green manure or even animal feedstuff; for incorporation into soil it is usually composted. Water hyacinth and other aquatic plants are sometimes deliberately grown in sewage-enriched waters; this results in a valuable manure and at the same time purifies the water.

A special aquatic plant is the fern Azolla. This plant is associated with the blue-green algae *Anabaena azolla* which enables it to fix atmospheric nitrogen. This symbiosis can produce about one ton of green manure per hectare per day having 3 kg of fixed nitrogen. If sown on rice fields, it rapidly multiplies and, as in the case of other green manures, provides a cover preventing growth of weeds; normally phosphorus must be provided for its growth but this will be returned to the soil along with the plant. Considerable interest is being shown in the potentialities of Azolla and FAO has already sent a consultant to several Asian countries to foster this interest.

3. FAO ACTIVITIES IN THE FIELD OF ORGANIC RECYCLING

An FAO/SIDA sponsored Expert Consultation on Organic Materials as Fertilizers (Rome, December 1974) and a subsequent workshop on the use of organic materials (Bagkok, December 1976), fully recognized the need to re-introduce organic manures to agriculture. All these meetings recommended complementary use of mineral fertilizers and organic materials. Thus FAO is intensifying its efforts to assist member countries in developing programmes to increase soil fertility through a balanced use of organic and mineral fertilizers.

Already two study tours in China have been made, one in 1977 to study general practices in organic recycling and one early in 1978 to study specifically Azolla propagation and small-scale biogas technology.

Training courses in the agricultural use of Azolla, blue-green algae and biogas have been held in Asia and West Africa and consultant advice has been given on composting of urban wastes. This basic training has, in several instances, been followed up by small-scale projects of a pilot/demonstration nature. One large-scale FAO/UNDP regional project has been formulated for Asia and the Pacific and this is described in the paper of Dr. Hesse, the Regional Coordinator.

Paper 2 THE SIGNIFICANCE OF ORGANIC MATERIALS TO EGYPTIAN AGRICULTURE AND MAINTENANCE OF SOIL PRODUCTIVITY

by

A.S. Abdel-Ghaffar
Soil and Water Science Dept., Faculty of Agriculture
Alexandria University, Alexandria, Egypt

1. INTRODUCTION

Agriculture in Egypt is as old as history. Allison (1973) in his book entitled "Soil Organic Matter and its Role in Crop Production" states "The Egyptians seem to have a well developed agriculture dating back to the first days of recorded hystory". It is a well-known fact that the ancient Greeks recognized the role of soil organic matter in soil fertility and perhaps they learned this fact from ancient Egyptians (Nagar 1975).

The area of Egypt is about 1 million km2 of which only about 5.9 million acres are under cultivation, the remaining land (over 95% of the area) is barren, desert. However, the crop area per year is about 12 million acres due to multiple cropping. The soils of Egypt include the alluvial soils of the Nile Delta and Nile Valley, the sandy soils of the Eastern and Western desert and the calcareous soils of the Mediterranean sea coast. The alluvial soils of Egypt were formed of the suspended matter of the Nile during the annual flood which is the result of the physical and chemical weathering factors on the igneous and metamorphic rocks of the Ethiopian Plateau.

The common features of Egyptian soils are:

a. the alkaline reaction, generally the pH is in the range of 7.2-9.0 and in the majority the pH is 8.0-8.5;

b. the relatively high temperature throughout most of the year. Surface soil temperature shows great variation, reflecting atmospheric temperature and direct exposure to the sun. At the depth of 20 cm, the temperature is between 25°C and 33°C (Abd-El-Malek 1971);

c. low organic matter content, the common range found in cultivated clay soils is between 1.0% and 2.5% while in the calcareous and sandy desert soils it is usually less than 0.5%.

Under arid and semi-arid conditions, the most important two factors limiting soil productivity are water and organic matter. For many centuries, farmers have observed that the capacity of soils to produce crops is more or less directly related to the amounts of added organic matter.

In the old days, Egyptian farmers depended entirely on farmyard manures to supply plant nutrients needed for crop production. These organic manures were the only fertilizers used in Egypt until 1906 when we started to import sodium nitrate fertilizer from Chile.

Recently, much attention has been devoted to the nature, behaviour, and functions of organic matter in Egyptian soils as well as composting of plant residues. Most of these studies are covered by Egyptian colleagues participating in this Workshop.

2. FARMYARD MANURE

Farmyard manure is the greatest organic source of plant nutrients available to developing countries.

The Egyptian farmyard manure is very poor in organic matter and in plant nutrients especially N and P (Abdel-Ghaffar et al 1960a; Risk et al 1968). However its chemical composition varies greatly. On the average, the farmyard manure produced by Egyptian farmers was found to contain about 0.4% total nitrogen, 0.2% P, 0.4% K and 5% organic matter. The low carbon and plant nutrient contents of the Egyptian farmyard manure are attributed to the use of earth as bedding and to the methods followed in its preparation, storage and handling. If straw is used as bedding, the farmyard manure becomes rich in organic matter and plant nutrients as shown in Table 1.

Table 1 AVERAGE CHEMICAL COMPOSITION OF FARMYARD MANURES (Abdel-Ghaffar et al 1960a)

Constituents	Bedding	
	Earth	Rice Straw
Organic C%	2.89	28.23
Total N%	0.48	2.03
P %	0.14	0.66
K %	0.40	1.59
Organic matter %	5.00	48.60
C/N	6.02	13.90

The amounts of farmyard manure available to the Egyptian farmers are not only insufficient but also decreasing with the increasing tendency towards the mechanization of agriculture in the country. An alternative way to meet the growing needs for organic manure is by composting plant and animal residues.

3. COMPOSTING ORGANIC MATERIALS

Riad (1927-1929) developed methods for composting crop residues. He described the methods in detail showing the area needed, the quantity of water required and components of the activator mixture needed for different crop residues. Abdel-Ghaffar et al (1960b) modified this method to reduce the time required for composting crop residues and to ensure a better end product (Table 2).

Table 2 CHEMICAL COMPOSITION OF CROP RESIDUES COMPOSTED FOR 30 DAYS (Abdel-Ghaffar et al 1960b)

Constituent	Corn stalks	Wheat straw	Rice straw
Organic C%	35.9	31.6	29.9
Total N%	1.5	1.6	1.5
P%	0.6	0.3	0.2
K%	2.9	2.3	2.7
Organic matter %	61.9	54.4	51.6
C/N	24.1	26.8	20.6
pH	8.1	6.4	7.8

The utilization of various kinds of organic wastes for production of organic manures has been tried since 1930. Riad (1930-1935) converted street sweepings and household refuse into manure by fermenting these wastes with and without nitrogen fertilizer activator. Chemical analysis of the obtained manure showed that the two methods were alike.

Abou El-Fadl et al (1958) composted cotton bolls infested with pink boll worm (*Pectinophora gossypiella* Saurd) to control the pest and in the meantime have a manure rich in organic matter and nitrogen (0.79% N and 17.45% organic matter). Also, Abou El-Fadl et al (1968) composted water-hyacinth in an attempt to utilize it as organic manure and to present a safe means of eliminating infection of farmers and their animals with water-borne helminths. The manure obtained is much better than farmyard manure (Table 3). Water-hyacinth, in Egypt, occurs both in fresh and brackish water and is considered a serious pest in many canals and drains. However, the authors stated that composting of water-hyacinth should be carried out under careful supervision to ensure the safety of the workers.

Table 3 AVERAGE CHEMICAL COMPOSITION OF WATER-HYACINTH COMPOST AND OTHER ORGANIC MANURES FOR COMPARISON (Abou El-Fadl et al 1968)

Organic manure	N%	P%	K%	organic matter %	C/N
Hyacinth compost	0.58	0.31	1.50	18.1	18
Rice straw compost	1.04	0.26	0.85	30.4	17
Municipal compost	0.74	0.25	0.48	24.3	19
Farmyard manure	0.33	0.21	1.08	8.7	10

4. ORGANIC MATERIALS AS FERTILIZERS

The attempt to investigate the role of organic matter for soil productivity started in 1919 at Bahteem Experimental Station. At that time, the research group of the Ministry of Agriculture started to study the effect of prolonged application of organic and inorganic fertilizers on crop yields.

The results obtained, after 36 years, indicated that the organic matter content of the soil treated with farmyard manure increased by about 0.5% over the control and this was accompanied by increases in yields of cotton, wheat, maize, and clover as shown in Table 4. These results indicate that the farmyard manure was much better than the mineral fertilizers.

Table 4 EFFECT OF PROLONGED USE OF FERTILIZERS (1919-1955) ON 1955 CROP YIELDS AT BAHTEEM EXPERIMENTAL STATION RELATIVE TO THE CONTROL (El-Damaty and El-Baradie 1959)

Fertilizer treatment 1/	Relative yield			
	Cotton	Wheat	Corn	Clover
Control	100	100	100	100
$NaNO_3$	143	147	155	110
$NaNO_3$ + Superphosphate	188	192	229	365
Farmyard manure	191	264	245	437

1/ $NaNO_3$: 100 kg/acre for both cotton and wheat
: 150 kg/acre for maize
Superphosphate: 125 kg/acre for both cotton and wheat
Farmyard manure: 15 tons/acre for cotton, wheat and maize.

Similar results were obtained by many Egyptian workers using different organic materials and different soils (Abd-Elnaim et al 1973, 1975; Hamissa 1967; Makled 1967; Mahmoud et al 1968: Riad and Anwar 1946).

Plant residues may be applied to the soil either directly or after composting. The effects of applying non-composted crop residues to soil were also studied in pot, lysimeter and field experiments by Ishac (1961); Gohar (1963), and Risk et al (1967). Their results indicated that the growing crops did not show symptoms of nitrogen starvation and in most cases gave higher yields than the controls.

Rizk et al (1967) studied the effects of adding non-composted wheat and clover straw on yield of barley grown in clay loam and sandy soils (Table 6). They stated "supplementing soils with non-composted crop residues may be profitable when the application is made 6 weeks before sowing providing that sufficient moisture is always present to permit decomposition of residues. Non-composted crop residues could also be applied to soil just prior to planting but in that case together with nitrogenous activator to prevent competition between plants and micro-organisms for soluble nitrogen".

Table 6

EFFECT OF ADDING NON-COMPOSTED WHEAT AND CLOVER RESIDUES (4 ton/acre) ON BARLEY YIELD RELATIVE TO CONTROL (Rizk et al 1967)

Treatment, straw added	Clay loam soil		Sandy soil	
	Wheat	Clover	Wheat	Clover
Control (no straw)	100	100	100	100
6 weeks before sowing	115	119	175	182
2 weeks before sowing	115	111	168	174
at sowing	81	93	136	137
at sowing + $NaNO_3$	120	119	210	201

Finally, in view of the current world food crisis and the considerable increase in price of mineral fertilizers, the developing countries should use organic materials as fertilizers on a large scale.

Also, the new high yielding varieties of agricultural crops need greater fertilization with inorganic fertilizers. The higher dose of fertilizers not only increases the yield of these crops but also causes a higher activity of micro-organisms in the soil. Many of these organisms need carbon compounds as a source of energy, so the degradation of soil organic matter is accelerated and the soil should be supplemented by organic materials.

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POTENTIAL SOURCES OF ORGANIC MATTER IN EGYPT

by

A. Riad
Ex. Director, Chemical Section
Ministry of Agriculture, Cairo, Egypt.

1. INTRODUCTION

To begin with, I am going to stress two vital points regarding Egypt. Firstly, that irrespective of any advances achieved or long strides taken by us lately in the domain of industry, Egypt will forever remain predominantly an agricultural country. Secondly, a salient fact in our agriculture is that in view of our climate and the characteristics of our soil, the importance of organic matter to us comes directly next to that of water. Also, owing to the disastrous growth of our population and the dire need of creating agricultural soil out of our enormous deserts, the utilization of every accessible gramme of organic matter is to us a sacred task. I have been shouting and imploring by all possible means, for half a century, that our golden motto should be "what comes out of the soil must be returned to the soil" and, therefore, the burning of garbage is a major and punishable agricultural crime.

To compare the values of mineral and organic manuring, suffice to add to the evidence advanced in this Workshop the results of that world famous Broad-balk field experiment at Rothamsted Agricultural Experimental Station where a certain crop has been grown on a certain plot and receiving the same manurial treatment since 1843, the said treatments being farmyard manure (FYM), mineral manure and no manure. The figures show that in the case of barley the loss of total nitrogen from the soil was 40% in the no manure plots; 30% in the mineral manure plots and 3% only in the FYM plots. In the case of wheat the respective figures were 30. 32, and 7%. The loss of organic carbon from the soil was in the case of barley 40, 28 and 0% whereas in the case of wheat it was 17.5, 28, and 0% in the same order.

Now, the language of figures is the most eloquent and convincing language and I am going to resort to that language to make my points clear and to give you a true picture of our present pitiable situation as regards organic sources for our agriculture.

Let us have a look at the bank account of these organic sources, the figures being the last ones I got hold of 5 years ago, but they still give a clear picture. I am going to present my data in the following order:

a. What we need of organic fertilizers calculated as FYM.

b. What we actually have on hand of the said amount: the difference between (a) and (b) will be our yearly deficit.

c. How far we can make up the said deficit from our available but neglected resources.

2. THE REQUIRED AMOUNT OF ORGANIC FERTILIZERS

On the assumption that we have, or are going to have shortly, 8.5 million feddans (3.57 million hectares) under cultivation, one million of which in Upper Egypt does not traditionally receive what we understand by the term organic manuring - I am going to present my figures. The said figures are all calculated on the usual assumption that just under half of the land receives 40 m^3 and the remainder receives only 20 m^3 of FYM per year. Also a cubic meter of our average FYM weighs about 800 kg.

By simple calculation, we find that the 7.5 million feddans (3.15 million hectares) will require 170 million tons of our average FYM.

3. THE ACTUAL AVAILABLE AMOUNTS OF ORGANIC FERTILIZERS

The details of what we actually have on hand of the required amount of organic fertilizers are as follows:

i. From farm animals we produce 100 million tons per year. Subtracting about 15 million tons used as fuel in the villages we will be left in this item with 85 million tons.

ii. From domestic animals like fowls, pigeons, rabbits, ducks and geese etc. we get 80 000 tons.

iii. From human liquid and solid excreta in all forms as sludge, poudrette, etc. we collect 2.4 million tons.

iv. From composted farm and garden refuse, which I named in the twenties artificial FYM, we only produce now a mere 50 000 tons.

v. From converting municipal refuse at that Shubra plant (at Cairo) which, borrowing Somerset Maugham's phrase, is walking hand in hand with death, and from some individual efforts throughout, we get no more than 200 000 tons.

vi. From slaughter house refuse like dried blood, meat meal, powdered horns and hoofs etc., we collect a mere 12 300 tons.

The total of these items is 87 742 300 tons and the present deficit in our bank account is, therefore, more than 82 million tons.

4. THE NEGLECTED RESOURCES

We can make up the deficit from the available but neglected resourced:

i. By correcting our well known vulgar mistakes in preparing, storing and applying FYM, we could raise the organic matter and total nitrogen contents to double what is actually found in our poor manure. If the improvement is realized in even only half the quantity produced of FYM, we would gain an increase in that item equivalent to 42 million tons.

ii. By collecting all the liquid and solid excreta of the population and introducing the rural lavatory, suggested at the 21st Medical Congress of March 1953, which collects and stores excreta for 6 months before use, an extra 13 million tons could easily be added to our credit side.

iii. Even by leaving 80% of the straws, stalks, husks, shives and leaves of our farm and garden crops to complement fodder and to supply fruit wrappings and fuel etc. and by composting the remaining 20% of that source we could increase this item by 10 million tons.

iv. Reckoning 650 g daily of municipal refuse per person in the large cities and 220 g only per day per person for the rest of the population, and on the basis of the latest census figures we can obtain a yearly 9 million tons of garbage, giving about 6 million tons of fertilizer equivalent to 12 million tons of our FYM, thus realizing an increase under that head of 11 800 000 tons.

v. On the basis of the official number of animals killed inside and outside slaughter houses and collecting all the blood (of which 2/3 are officially estimated now as wasted at that antiquated Cairo slaughter house) and if we utilize all the other refuse from that source we could add to the credit side of that item 12 200 tons.

vi. From tanneries we can get fleshings (exported now) equivalent to about 3 000 tons.

From these 6 items we have already got an additional 76 815 200 or roughly 77 million tons of FYM to the credit side of our bank account, through technical improvements and simple sensible management.

vii. From tanneries are left also leather clippings and animal hair containing respectively about 80 and 55% of organic matter and a good percentage of total nitrogen. These materials are very resistant to decomposition under soil conditions but when digested with 5-6% of dilute sulphuric acid or with the ammoniacal liquor from coal gas plants they produce a rich available organic fertilizer.

viii. Another source is sea weeds, inviting attention all along our extensive sea shores. It could be well washed with water and used as bedding for FYM. It contains on the basis of dry matter about 80% of organic matter and 1.5% of total nitrogen.

ix. Fish meal containing not less than 55% of organic matter could easily be obtained from fish cleaning or left over by simple treatment with steam to clear them from fats and gelatin.

x. From vegetable and fruit conservation and processing factories we can get waste matter amounting to hundreds of tons daily which can be added to our compost heaps.

xi. From cane sugar refineries we get sludge and bagasse. From distilleries, rice and starch factories, breweries, cotton seed pressing and flax retting we can get valuable materials which could be utilized collectively or individually.

xii. Mounds and mounds of Koufri deposits all over the country, the maroug deposits in Upper Egypt, bird guanos on the Red Sea Coast, and bat guano in Qena and Asswan Governorates are terribly neglected sources.

xiii. Wood shavings and dust have been composted in Switzerland finishing the decomposition in 5 months by adding 2.5% of cane sugar solution.

xiv. Lignite deposits in unknown quantities are found in the Siane mountains and could be used as a source of organic matter in the soil. Needless to say that if the material is established as a source of organic matter it could only be used locally in Sinae.

xv. Even old car tyres have been subjected by Nikerson and Faber of Rutgers, USA to a host of moulds and fungi which could convert the tyres to organic dust-like material.

And let us hope that from the last 9 sources we can make up the remaining deficit of 5 million tons per year, thus barely saving our skin, only for the present and God help us for the future.

5. BIOGAS

An article was published by me in the early fifties in the Agricultural Magazine issued by the Cooperative Organization for Printing & Publishing about a German process called Bihu gas registered in Germany in 1947 by its inventors. In the process town, animal and agricultural wastes of all kinds are essentially anaerobically fermeted in large towers producing an organic fertilizer, like activated sludge, and a mixture of gases: methane, CO^2, hydrogen, nitrogen, and H_2S, the first forming about 30% of the mixture and the last one forming only traces which could be easily removed. The said mixture of gases was used for lighting, heating and driving engines. The process was successfully tried in several parts of Germany and other countries. In the said article, in my Presidential address to the Egyptian Academy of Scientific Culture and on many other occasions, I begged and prayed our worshipful Ministry of Agriculture to try the process only in one village, the economic minimum for the process being 50 head of cattle, and thus provide manure, energy, cleanliness and a whiff of civilization to an Egyptian village. But the prayers were never heard. I wish to our younger workers on the subject every success and better luck than mine.

Finally, I cannot finish an address like this without referring to the venerable old problem of converting Cairo municipal refuse to organic fertiliser - an infant born in 1929, but one that has never left the nursery yet. But this is a very sad story, and I have not got the heart to end this meeting on a sad note.

Paper 4

THE ROLE AND IMPORTANCE OF ORGANIC MATERIALS AND BIOLOGICAL NITROGEN FIXATION IN THE RATIONAL IMPROVEMENT OF AGRICULTURAL PRODUCTION

by

G.S. Vidyarthy and R.V. Misra
Ministry of Agriculture and Irrigation, New Delhi, India

Summary

Utilization of organic materials as fertilizers would result in increased agricultural production through nutrient contribution and help in solving sanitary, environmental and soil conservation problems. Manifold benefits result from the use of organic materials. Work carried out in India on decomposition of various types of organic materials, effect of application of these materials on plant growth, nutrient uptake, microbiological and chemical properties of soils and crop yields, and the use of bacterial fertilizers, blue-green algae and Azolla are discussed.

Considerable attention is being given in India to the development of programmes like mechanized composting, sewage sludge utilization, biogas popularization, cultivation of legumes, production of urban and rural compost and use of bacterial and biofertilizers.

1. INTRODUCTION

The increasing demand for plant nutrients in agriculture has to be met to maintain an adequate supply of food for the world's growing needs. The world supply capabilities for nitrogen, phosphate, and potash fertilizers are expected to grow to 67.7 million tons N, 39.5 million tons P_2O_5, and 31.2 million tons of K_2O by 1982-83 (Causten, 1978). Inspite of the considerable expansion in the production capacity of fertilizers, it has not been possible to meet the optimum requirement for raising crop production. In most of the developing countries, there is an enormous gap between production and consumption of mineral fertilizers. A rise in the cost of fertilizers, in particular nitrogen, is a stimulant of interest to the use of alternative nutrient resources.

The role of organic materials and biological nitrogen fixation has been known in agricultural production since ancient times. Many of the developing countries, in their enthusiasm to push up mineral fertilizer consumption, paid little attention to the use of organic materials and fixation of nitrogen through biological means. Utilization of organic materials as fertilizer would not only result in increased production through its nutrient contribution potential and balanced nutrient supply, but would also help in solving sanitary, environmental and soil conservation problems. Exploitation of organic material resources would also result in foreign exchange savings for the developing countries. The effect of organic matter on soil productivity may be indirect as well as direct. The direct effects are related to retention and release of plant nutrients (both macro and micro), absorption of organic components of humus, which influence favourably plant metabolism, and release of carbon dioxide following oxidation. The microbial fixation of nitrogen, solubilization of phosphorus, the slowing down of nitrogen release from added fertilizers, improvements in the physical, chemical and biological properties of the soil, and moisture and ion retention capacities are among the several important indirect effects.

In a country like ours, organic matter content of most of the soils is low. Addition of organics will help prevent erosion, retain humidity, adjust pH, improve drainage, prevent crusting and cracking, build up ion exchange capacity and promote normal biological life in the soil. Organic materials, also, increase the efficiency of inorganic fertilizers, particularly in the long run.

In nature, a few micro-organisms are endowed with the capacity to fix atmospheric nitrogen with the help of the enzyme, nitrogenase, and it is possible to make use of these organisms in our agriculture. Biological nitrogen fixation through the use of legumes, green manures, and biofertilizers can to a considerable extent supplement the growing demand of fertilizer nitrogen.

2. USE OF ORGANIC MATERIALS AS FERTILIZER

The role of organic materials in the maintenance of soil organic matter under tropical and subtropical conditions needs no emphasis. Organic materials available as crop residues can be recycled by either composting, mulching, or direct incorporation in the soil. Farmers should be advised by the extension workers to conserve these manurial resources and to use the proper technology for utilization of organic materials. Since the nature of organic matter and the rate of decomposition are variable, the technology for utilization of organic materials will depend on various situations and the farming systems. Some of the work carried out in India is briefly mentioned.

2.1 Rate of Decomposition of Organic Materials and Soil Organic Matter

The rate of decomposition of various organic materials viz. leguminous and cereal straws and farmyard manure (FYM), in different soils, has been studied (All India Co-ordinated Project 1970, 1971, 1972). These studies indicated the differential rate of decomposition under identical conditions. Leguminous plant materials and non-edible oil cakes decomposed faster as compared to the wide C:N ratio of cereal residues and straw. Addition of nitrogen in the form of fertilizers or non-edible cakes to nitrogen poor materials accelerated their decomposition. The rate of decomposition of FYM/Compost is slow and steady. The general sequence is: Cakes $>$ legumes $>$ cereal $>$ + oil cakes $>$ cereal $>$ FYM. These findings can be used to regulate the release of nutrients as needed by the crop.

2.2 Maintenance of Organic Matter in Indian Soils

Through the studies conducted in different soils, it has been established that application of FYM at the rate of 44 tons/ha (0.5% carbon) effectively builds up the organic matter status of different soils (All India Co-ordinated Project 1971). Higher quantities of cereal residues are required for effective build-up of soil organic matter. It has been possible to increase the organic carbon in different soil groups by 10-40% with the application of FYM and crop residues. This information is quite useful in the sense that most of our soils are poor in organic matter and need replenishment.

2.3 Effect on Soil Micro-organisms and Nutrient Availability

Application of organic matter increases the microbial population and the microbial activity in the soil. The response obtained shows variations with the nature and characteristics of the soils and organic materials used. The application of organic matter influences bacteria to a greater extent than fungi and actinomycetes. Azotobacter and anaerobes, growing in a nitrogen free medium, were found to be stimulated by application of straw per hectare (Mukherjee 1975). The addition of FYM and cereal residues resulted in an over-all increase in the nitrogen content, varying from 7 to 74% depending upon the soil type and organic material used. Immobilization of soil nitrogen was observed with the addition of cereal residues in the soil, whereas with FYM treatment no such effect was observed. Phosphorus availability increased with FYM application whereas wheat straw decreased the phosphorus availability in the early period of decomposition, but supplementing with superphosphate at the rate of 60 kg/ha increased the availability of phosphorus. Thus supplementation with the proper amount of nitrogen and phosphorus helps the *in situ* incorporation of wheat straw.

2.4 Organic Mulching and Crop Yields

Field studies have shown that cereal straws when used as mulch, apart from conserving moisture in acidic red loam, sierozem and laterite soils, increased the yield of the wheat crop by 14.3, 24 and 29% respectively over unmulched control. In case of pea, crop mulching has a better effect in acidic red loam, medium black, and laterite soils, and the increase in grainyields was 77.6, 45 and 40% respectively. The beneficial effect of mulching with cereal residues may be attributed to its favourable effect on microbial population and nutrient availability besides conserving soil moisture, control of weeds and maintaining favourable soil temperature.

2.5 Influence of Organic Substances on Crop Yields

The effect of humic substances extracted from farmyard and other sources on the growth of plants and micro-organisms is shown in Table 1. Application of sodium humate prepared from FYM at the rate of 0.03% to soil (W/W) significantly increased the yield of berseem, *dhaincha* and wheat crops. Humus (Humic + fulvic fractions) when applied to sandy loam alluvial soil at the rate of 0.025 and 0.05% (W/W) increased the yield of paddy and gram crops (Mathur and Gaur 1977). Spraying of humates, even in small dosages (10 ppm), 2 or 3 times during the growth of plants, increased the yields of soybean, moong, and tomato crops. Similarly, hydroquinone sprayed at the same rate increased the yield over control but the response was less as compared to humates. The efficiency of *Rhizobium* and *Azotobacter* inoculants increased because of the application of humic materials as shown by the increase in yields of wheat, gram, and dhaincha crops (Table 1). Nodulation was also improved substantially as recorded in the case of gram and dhaincha.

Nodulation of groundnuts was improved by the application of wheat straw both at the 4th and 7th week of growth. The acreage yield of groundnuts was significantly increased by 66.0% and 95.5% because of the application of 2 and 5 tons of wheat straw per hectare, respectively and by only 40% upon the addition of 10 tons straw/ha. The wheat straw was applied one week before sowing the inoculated groundnut seeds.

The application of farmyard manure and wheat straw (0.5%, W/W) to paddy soils increased the soil organic carbon by 72 and 79% over the control, respectively (Mukherjee 1975). Farmyard manure significantly increased the grain yield of paddy by 41% and nitrogen uptake by 10% (Table 2).

In a wheat crop, the effect of inoculation with phosphate solubilizing microorganisms (*Pseudomonas striata* and *Aspergillus awamori*) could be improved by the application of organic matter as shown in Table 3 with maize stubbles. Also superphosphate could be replaced or supplemented with low grade rock phosphate even in alkaline soils in the presence of phosphate solubilizing micro-organisms.

Table 1

INFLUENCE OF HUMIC SUBSTANCES ON YIELD OF CROPS
(Gaur 1978)

Crop	Treatment	Yield increase %
Berseem	Na-humate (0.03%)	47.0
	Rhizobium	23.0
	Rhizobium + Na-humate (0.03%)	52.8
Dhaincha	Na-humate (0.03%)	22.8
	Rhizobium	18.7
	Rhizobium + Na-humate (0.03%)	61.6
Gram	Humus (0.05%)	32.1
	Rhizobium	1.0
	Rhizobium + humus (0.05%)	41.0
Soybean	Hydroquinone (10 ppm) sprayed	8.8
	Humate (10 ppm) sprayed	23.2
Moong	Hydroquinone (10 ppm) sprayed	33.0
	Humate (10 ppm) sprayed	77.0
Tomato	Hydroquinone (10 ppm) sprayed	97.8
	Humate (10 ppm) sprayed	109.0
Wheat	Na-humate (0.03%)	27.7
	Azotobacter	4.6
	Azotobacter + Na-humate (0.03%)	35.4
Paddy	Humus (0.025%)	55.7
	Humus (0.050%)	85.4

Table 2

EFFECT OF ORGANIC MATERIALS ON YIELD AND NITROGEN UPTAKE BY PADDY CROP

		Treatment		
		Control	FYM 0.5%	Wheat straw 0.5%
Yield g/plot	Grain 1/	666.7	941.7	836.7
	Straw 2/	831.7	1 048.3	923.3
Yield increase %	Grain	-	41.2	25.2
	Straw	-	26.0	11.0
Nitrogen in grain %		0.95	1.06	0.98
Nitrogen uptake by grain g/plot		6.3	10.00	8.2

1/ C.D. at 5%: 76.3
2/ C.D. at 5%: 78.4

Table 3

EFFECT OF MAIZE STUBBLE, ROCK PHOSPHATE, AND INOCULATION WITH PHOSPHATE SOLUBILIZING MICRO-ORGANISMS ON YIELD OF WHEAT CROP

Treatment 1/	Grain		Straw	
	Yield 2/ g	Increase %	Yield 3/ kg	Increase %
Control	488.5	-	1.16	-
Maize stubble (C/N:40)	566.1	15.8	1.36	17.3
Rock phosphate	497.0	1.8	1.49	28.4
Rock phos. + M. stubble	629.7	29.0	1.48	27.5
Rock phos. + inoculant	602.1	23.4	1.57	35.3
Rock phos. + M. stubble + inoculant	672.8	37.7	1.71	47.4

1/ Total N in any treatment: 120 kg
2/ C.D. at 5%: 104.7
3/ C.D. at 5%: 0.31

2.6 Effect of Cellulolytic Micro-organisms on Composting of Organic Materials

The effect of microbial inoculants was investigated in composting of paddy straw and karanj leaves (All India Co-ordinated Project 1977). Organic carbon decreased gradually and at the end of 12 weeks the loss in carbon accounted for nearly 50% of the carbon estimated at the 4th week period. On the other hand, total N content increased gradually. The C/N ratio was found to be lower in all the treatments than in the control. Among the cultures, Trichurus spirlis, Aspergillus sp. and Penicillum sp. proved to be the most efficient inoculants. There was about 20% lowering in the C/N ratio over control showing the effect of microbial inoculation in reducing the time of composting.

In addition, prepared composts were enriched with rock phosphate, Azotobacter, and phosphate solubilizing micro-organisms.

3. BIOLOGICAL NITROGEN FIXATION IN AGRICULTURAL PRODUCTION

Nitrogen being one of the most important limiting factors in increasing crop production, it is necessary to examine critically the economics of different sources of nitrogen supply for crop production, keeping in view the cost factor and the lasting benefits. Bacteria, symbiotic and non-symbiotic, fix atmospheric nitrogen which becomes readily available for plant growth. The symbiotic relationship of Rhizobium with various species of legumes and the ways and means of exploiting this relationship for better fixation of atmospheric nitrogen is an important line of work. Recent studies take into account strain variations among the rhizobia, genetic variations in the receptivity of the symbiont by the host plant and the various factors which influence to symbiotic relationship and nitrogen fixation process.

3.1 Symbiotic Bacteria and Nitrogen Fixation

Application of efficient rhizobium inoculants not only establishes legumes by symbiotically fixed nitrogen, but also leaves residual nitrogen in the soil. Under good management, rhizobial inoculation can save up to 80% of the crop nitrogen requirements, provided the introduced efficient strains dominate the rhizosphere and profusely nodulate the roots. Effect of seed inoculant with rhizobial cultures on the yield of various crops as obtained under the field conditions is summarized in Table 4 (Subba Rao 1978).

Table 4 FIELD RESPONSE TO RHIZOBIAL PRODUCTION (Subba Rao 1978)

Name of crop	Place	Yield response, % increased over control
Urad	Kanpur	14.5
	Ranswara (Raj)	69.2
Gram	Delhi	28.0
	Palwal (Haryana)	50.0
	Bangalkot	60.0
Moong	Jadhpur	14.2
	Amravati	17.0
	Aithpally (A.P.)	100.0
Arhar	Murtizapur (M.P.)	50.0
Soybean (different strains)	Kanpur	15 to 36
	Pantnagar	14 to 23
	Jabalpur	73 to 88
	Kalyani	10 to 34
	Junagadh	172 to 255
	Ludhiana	33 to 36

In Icar's All India Pulse Improvement Project the efficiency of various strains of Rhizobium for different crops is regularly tested. Some of the significant findings under the project are listed below (Subba Rao 1976):

a. Rhizobium inoculation increased yields of certain leguminous crops in certain soils up to a maximum of 71% over corresponding non-inoculated controls. These included important crops such as gram (Cicer arietinum), arhar (Cajanus cajan), and after pelleting inoculated seeds with wood charcoal or lime, lentil (Lens culinaris) and soybean (Glycine max.);

b. phosphatic fertilizer application increased the yields of legume crops;

c. application of inorganic nitrogenous fertilizers to soil in the absence of Rhizobium inoculation was detrimental and in many instances reduced yields were obtained.

Some of the recent results from Rhizobium inoculation trails with arhar (Cajanus cajan), Bengal gram (Cicer arietinum) and lentil (Lens culinaris) show that the percent increase in crop yield due to Rhizobium inoculation varies from 19.47 to 32.20 over uninoculated controls (Table 5). Furthermore, the yield increases by

Rhizobium inoculation were equivalent to those obtained by the application of 40 kg N/ha. The nitrogen fixing capacity of some legumes is indicated in Table 6 (Subba Rao 1972).

The nitrogen fixing capacity of the legumes, based on *Rhizobium*-host symbiosis, should be one of the important strategies for fixing atmospheric nitrogen. Use of legumes in the crop rotations needs to be increased and use of legumes as cover crops should be popularized.

Table 5 EFFECT OF SEED INOCULATED WITH RHIZOBIAL CULTURE ON THE YIELD OF VARIOUS PULSE CROPS IN TARAI SOIL (pH 7.3)

Treatment	Arhar		Bengal gram		Lentil	
	Yield (q/ha)	Increase %	Yield (q/ha)	Increase %	Yield (q/ha)	Increase %
Uninoculated (control)	11.3		10.5		8.7	
Inoculated with IABI culture	13.5	19.47	12.7	20.94	11.5	32.20
40 kg N/ha	13.2	16.82	11.8	12.38	12.1	39.10

Table 6 ESTIMATED AMOUNT OF NITROGEN FIXED BY SOME LEGUMES (Subba Rao 1972)

Legume	Nitrogen fixed (kg/ha)	Legume	Nitrogen fixed (kg/ha)
Alsike clover	130	Beans	45
Bur clover	120	Cowpea	62-128
Crimson clover	103	Kudzu	99
Ladino clover	224	Lentils	144
Red clover	82-145	Laspedza	95
Sour clover	120	Peas	62-115
Sweet clover	130	Groundnuts	46
Alfalfa	125-327	Soybean	57
Blue lupine	208	Velvet bean	73
White clover	132	Vetch	87-154

3.2 Free-living Bacteria and Nitrogen Fixation

Free-living nitrogen fixing bacteria include aerobic, microaerophyllic, and anaerobic genera. The relative abundance and distribution of these organisms depend largely on several soil factors such as pH, moisture and C/N ratio. Recent studies bring out the importance of bacterial nitrogen fixation in the plant rhizosphere. The mutual relationship between certain cereal plants and bacteria such as Azotobacter, Pseudomonas, and Spirillum that exist on the rhizoplane or underneath the epidermal layers of plant roots results in fixation of atmospheric nitrogen to benefit the plants. Quantities up to about 79 kg N/ha in a cropped rice field are reported to be fixed through the biological process stimulated by the root surface micro-organisms.

In India, further studies are being made on the use of Azotobacter chroococcum as inoculant for the cereals. The advantages of this inoculant is that it is non symbiotic and non-specific. However, it suffers from some limitations such as its capacity to function only in the rhizosphere, dependence on the soil organic matter content for multiplication, slow multiplication under Indian conditions, and its primary role as a growth producer rather than as the nitrogen fixer (Subba Rao 1976). Inspite of these limitations, its role in developing countries like India is important considering the fact that even 10-15% general increases in yield for the meagre cost of inoculant may be worthwhile under certain situations. At the Tamil Nadu Agricultural University, Coimbatore, inoculation with Azotobacter has been shown to save 25% of inorganic nitrogen applied to the rice crop (Oblisami 1978).

Tropical temperatures (28°-32°) were found conducive to maximum performance by Azospirillum (formerly Spirillum). Trials conducted have shown that inoculation significantly improved the yields of grasses, rice, barley and wheat. The results point out that Azospirillum has great promise in the tropics as a supplement to the application of inorganic N fertilizer (Table 7).

Table 7 EFFECT OF Azospirillum brasiliensis INOCULATION AT VARYING LEVELS OF INORGANIC NITROGEN FERTILIZATION ON WHEAT YIELD (Field trials, 1977-1978)

Urea fertilization kg N/ha	Wheat yield, q/ha				
	Inoculation	Niphad, sonalike	Delhi Hd 2122	Shillong, HP 1287	Hissar, HO 2009
0	-	7.57	27.63	13.79	37.78
	+	9.22*	29.21*	14.59	38.96
30	-	-	-	16.58	-
	+	-	-	20.20*	-
40	-	-	39.19	-	45.39
	+	-	41.90	-	45.76
60	-	-	-	17.53	49.38
	+	-	-	19.00	57.53
120	-	-	-	-	49.47
	+	-	-	-	62.68*
C.D. at 5%					

* Significant over corresponding control.

3.3 Blue-green Algae as Biofertilizer

Nitrogen fixing algae are another effective means of adding organic nitrogen to the soil. Species of *Anabaena*, *Nostoc*, *Aulosira*, *Calothrix*, *Tolypothrix*, *Cylindrosperma*, *Plectenoma* etc. are free-living blue-green algae known to fix atmospheric nitrogen. Also Azolla-Anabaena symbionts fix large quantities of nitrogen. Under rice field conditions, blue-green algae occupy a prominent place as agents of biological nitrogen fixation. Using tracer techniques, it has been found that nitrogen fixation by blue-green algae in rice fields is in the order of 40 to 80 kg N/ha. No depression of nitrogen fixing activity occurs in the presence of ammonium below 40 ppm or in the presence of various pesticides used for rice. Besides nitrogen, the algae also synthetize growth promoting substances like auxim and amino-acids which help the growth of the rice plants. The work conducted at Indian Agricultural Research Institute shows that:

a. in areas where commercial nitrogen fertilizers are not used for various reasons, application of algae can give the farmers the same benefit as applying 20 to 30% nitrogen;

b. where commercial nitrogen fertilizers are used, the dose can be reduced by 30% by supplementing it with algae, thus resulting in a saving of commercial fertilizers;

c. even at high levels of nitrogen fertilizers, the yield per unit input can be increased through algal inoculation (Table 8).

Table 8 EFFECT OF ALGAL INOCULATION ON THE GRAIN YIELD OF PADDY (IR8), AVERAGE OF SIX REPLICATIONS

Treatment	Grain yield kg/ha	Increase %
PK (Control)	2 762.0	-
PK + Algae	3 372.3	22.07
PKN	3 567.3	29.14
PKN + Algae	4 007.4	45.07

C.D. at 5%: 0.612

3.4 Use of Azolla as Biofertilizer

Use of Azolla fern for biological nitrogen fixation is an attractive proposition. Its use in rice fields has widely spread in Vietnam, China, Thailand and Indonesia and is being investigated in various parts of the world including India.

This fern is commonly found floating on water in shallow ditches and channels containing idle water mostly during the winter and early summer in India, when it forms a thick mat appearing mostly reddish in colour along with other aquatic plants like Lemna and Spiredela. The symbiont (algae) is present during all stages of leaf development and there is no need for external algal inoculation, as in the case of legumes. Azolla decomposes very rapidly and 80% of the ammonia is released in 3-4 weeks after incorporation in soil in flooded conditions.

Essential requirements for the multiplication of Azolla are the application of phosphate and standing water. If enough water is available in the field before planting, the fern is grown in the field and used as green manure. In this case, fresh Azolla is sprayed on the surface of the water (6–10 cm) at the rate of 500–1000 kg/ha along with 4–8 kg P_2O_5/ha and after 10–20 days it is incorporated in the soil; then rice seedlings are planted. If Azolla cannot be grown before planting, due to scarcity of water, fresh Azolla is added with superphosphate after the establishment of the rice seedlings. In this case, the fern (after 20–40 days) is incorporated in the soil after draining the field. Mixing the pesticide Furadan with the inoculum is recommended in areas where Azolla pests occur frequently. Field experiments conducted during the last 3 years revealed that the use of Azolla increased growth, tillers, nitrogen content, and grain and yield of rice significantly (Table 9).

Table 9 EFFECT OF AZOLLA INCORPORATION BEFORE PLANTING ON THE YIELD OF HIGH YIELDING VARIETIES OF PADDY

Season	Variety	Grain yield kg/ha		Yield increases %
		Control	Fresh Azolla 10 tons/ha	
Autumn 1976	IR 8	4 237	4 708	11
	Vani	3 340	4 188	25
	Supriya	3 445	4 416	28
Spring 1976	CR 1005	4 875	5 316	9
	IR 8	3 844	5 313	38
	Van	2 615	4 032	54
Autumn 1977	Jaya	2 969	3 773	27
	CR 1005	5 286	5 753	8
	CR 188-10	4 590	5 084	11
	CR 191-5	3 926	4 736	21
	SG 61-8	2 484	2 846	15
Spring 1977	Supriya	3 489	5 125	47
	Kalinga-2	1 722	2 423	41
	IR 8	4 722	5 918	25

4. PROGRAMME FOR UTILIZATION OF ORGANIC MATERIALS AND BIOLOGICAL NITROGEN FIXATION IN INDIA

Programmes for the utilization of organic materials have received constant attention by the Government in India. To ensure the development of an integrated nutrient supply system through utilization of organic materials in combination with organic fertilizers, an ambitious programme designed to yield quick and definite results was launched (Vidyarthy and Misra 1976).

4.1 Mechanical Composting

The traditional methods of composting as adopted hitherto are not proving suitable for the bigger cities. In the present context, the mechanization of composting which has several advantages, such as sanitation control, recovery of discarded materials and production of good quality organic fertilizers, is considered to be better suited to the Indian cities, where the city refuse is rich in organic materials.

As a result of several steps taken, the level of urban compost production per annum has been raised from 4.5 million tons in 1973-74 to 5.8 million tons in 1977-1978. Similarly, the level of rural compost production has been raised from 150 million tons in 1973-74 to 200 million tons in 1977-78.

4.2 Sewage/Sludge Utilization

The discharge of sewage/sludge in a river or stream results in water pollution and at the same time deprives agricultual land of two scarce materials, namely water and plant nutrients. Potential availability of sewage in the country is estimated to be of the order of 800 million gallons per day. A programme for tapping 250 million gallons per day of sewage/sludge for irrigation was taken up in the Central Sector.

4.3 Biogas Development Programme

It is commonly recognized that the predominant use of non-commercial fuel, namely cattle dung and fire-wood, in rural India entails high social cost to the nation. In the wake of the continuing energy crisis, the use of biogas plants has been advocated as an ideal way to ease the situation. To provide impetus to the programme, financial assistance in the form of grants and loans are provided to the individualssetting up such plants. The scope of the programme has been further widened by setting up of community biogas plants and biogas plants based on night soil. The capital investment in 100 ft^3 plants can be recovered in a period of 4 to 6 years. The pay back period becomes smaller for larger gas plants.

However, some of the major problems militating against the widespread adoption of biogas plants are listed as: high installation cost, fall in gas supply during winter, heavy corrosion of gas holders, necessity to own or have large number of cattle; lack of suitable extension, maintenance, servicing facilities, cluster distribution of rural houses; leading to the problems of slurry disposal, social prejudice against acceptance of night-soil in biogas plants; and lack of alternative sources of fuel for villagers who do not own any cattle.

Co-ordinated efforts in the field of research and development are under way to find solutions to these problems.

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Paper 5

PROBLEMS RELATED TO THE USE OF ORGANIC MATERIALS AS FERTILIZERS IN THE RURAL ENVIRONMENT AND REMEDIAL MEASURES

by

Joan S. Davis
Federal Institute for Water Resources and Water Pollution Control
Dubendorf, Switzerland

1. INTRODUCTION

The role of organic fertilizers in the improvement of agricultural productivity has remained far below its potential. This is due less to the problems involved in using organic fertilizers, than to the criteria used to judge their beneficial effects. For the most part, the evaluation of organic fertilizers in their contribution to raising yields has been separated from their contribution to the goal of feeding more people better. That these two goals do not completely overlap is constantly seen through the problems of distribution of goods and insufficient purchasing power of the individual. If pertinent criteria, among them the goal of nourishing more people, were used to judge measures to be implemented, the benefits of organic fertilizers would be more positively evaluated. In addition, some of the perceived problems would become insignificant, some could even be rebooked as benefits.

Since increasing yields as an isolated criterion does not necessarily mean feeding people better, we must look at what interferes with this main goal, and how we can better achieve it. With this aim, the following paper looks first at our current standards, which are often a hindrance to real aid, then describes new criteria for judging the benefits and problems associated with various measures for agriculture and applies these criteria to the evaluation of organic fertilizers.

That monocultures, techno-farming, etc. exist, is obvious. That the changes mentioned here cannot take place immediately, is also obvious. The emphasis is thus placed more on the direction that changes in agriculture should be taking and less on specific data and statistical evaluation, whose interpretation is not necessarily only objective. The current direction, as all too well known, is marked by increasing pollution, lowering of the earth's carrying capacity, increasing unemployment, decreasing resources, increasing dependency on external sources of food, energy, etc. Therefore, instead of asking "how much further can we go on this path before we reach the limit", we should be asking "are we still going in the direction we want to?". It appears that all too long we have been looking for exact answers to the wrong questions. In trying to help with the orientation, the following paper attempts to start asking the right questions. In order to reduce the risk of making the same mistakes as before, we need to examine critically the criteria upon which the answers are based.

2. WHY LOOK FOR NEW CRITERIA?

2.1 Because now a restricted economic consideration lays the basis for most decisions, thus neglecting many aspects in agriculture which cannot be directly analysed for an economic interpretation and decision

If a price could more easily be placed on the costs involved or benefits accruing, such positive measures as organic fertilizers would long have been more heartily recommended. In the use of organics the costs are mainly the time and inventiveness of the farmer, and among the benefits are unmarketed foodstuffs (which may be consumed by the family, thus improving their health and work capacity) and a contribution to the soil health (thus supporting future production). Neither of these would be immediately reflected in an economic analysis, but both are extremely important in indicating the direction the development is taking, and the economic viability of the families involved. The decisions of the farmers are thus economically significant and affect the resource utilization, but our standard criteria do not give us enough information about true costs and benefits to guide decisions for better utilization of available resources.

2.2 Because progress is now measured by the wrong type of efficiency

Much of that which is currently considered progress is based on an increase in "efficiency". This efficiency is considered in a limited and isolated way. Generally it means the amount of human labour involved in producing a unit of goods, whereas only the direct human labour is considered. If a more realistic and less isolated evaluation is made, by examining the relationship between material resources used as inputs and the value (also on a resource basis) of the products coming out, one sees that real efficiency has actually decreased. We continue to use more and more resources - and less human labour - for our production system ... paradoxically in the face of decreasing resources and increasing labour potential.

2.3 Because of the need for more food and more jobs

One of the most negative aspects of the above mentioned trend with respect to less developed countries, which need both food and jobs, is that the "efficiency" provided by modern agriculture means less people directly involved in the production (although more jobs may be created in other countries where the fertilizers, biocides, and machines are produced), accompanied by a resulting decrease of purchasing power of the individual, and thus of the food effectively available. In addition, the trend toward larger farms, with fewer people has not necessarily meant an increase in the yield/area which is a critical point. For example:

- the value of output per acre in India is more than one-third higher on the smaller farms than on the larger farms (Owens and Shaw 1972);
- in Thailand plots of two to four acres produce almost 60% more rice per acre than farms of 140 acres and more (World Bank 1975);
- in Taiwan net income per acre of farms with less than one and a quarter acres is nearly twice that of farms over five acres (Owens and Shaw 1972);
- for several countries in South America, the situation is shown in Table 1.

Table 1 RATIO OF HECTARE YIELDS OF SMALL FARMS TO LARGE FARMS IN SOUTH AMERICA (Holenstein and Power 1976)

Country	Yield/hectare (small farms) / Yield/hectare (large farms)	Yield/worker (small farms) / Yield/worker (large farms)
Argentina	8.2	0.21
Brazil	8.8	0.14
Chile	8.2	0.23
Columbia	14.3	0.10
Guatemala	3.9	0.14

2.4 Because of the need for a more stable production, and thus for more resistant crops

It must be recognized that the lower the standard of living and the more unpredictable the natural environment, the more decisions will be governed by the need to a oid risks (Duncan 1975). Thus, low cost reduction of risk to meet subsistence requirements sets free capacity for increased production. However, conditions are becoming more difficult for this. For example, the trend toward a more narrow genetic base means that a single blight affecting a particular strain could ruin an extremely high percentage of the crop in an entire area at once. Unlimited biocide use is not the answer. For varied reasons, such as costs, side effects, toxicity, etc., a lower biocide use belongs to the boundary condition for future development. Thus the need to increase inherent resistance arises. Plant resistance is known to be a function of soil health, but in view of the ready access to biocides, attention is no longer paid to the adaptive and corrective capacities of the natural bacterial reactions of soil, which strongly influence soil health. The bacteriological composition is to a large extent a function of the chemical composition of the soil. The same is true for the type of weeds present, whose valuable capacity to favourably affect an unharmonic chemical composition in soil has essentially been ignored in modern agriculture.

In both cases, there is an attempt on the part of nature to create a favourable balance by influencing the availability of components, either by binding those in excess, or making more available those which are less sufficient. For this reason, organic fertilizers, by affecting the bacterial composition, can strongly influence the productivity of the soil even by low nutrient concentrations. The absolute amount is not the only criterion for productivity. For this reason, strictly chemical analysis does not give full information about the soil health or insufficiences, since the regulating capacity of natural organisms is not taken into consideration.

The attempt to compensate chemically for an apparent insufficiency may only make another component rate-limiting, thus coercing a change in bacterial type distribution, which means at least a temporary loss of stability. If an addition is made in soluble form, the loss in stability can be much longer. This occurs partially because the concentration of the components is subjected to stronger fluctuations, thus preventing a stable, adapted bacteriological composition being reached. This affects significantly the health and resistance of the plants. The use of herbicides to eliminate weeds can also unfavourably affect the regulating capacity, as well as the use of other biocides which are shown to reduce the capacity of nitrogen fixation (Chandra 1966).

Essential to meeting the increasing demands placed upon agriculture is a more consistant production, which implies good plant health. This requires more attention to soil health based on natural capabilities. Available knowledge on this subject has been poorly utilized, partially due to the attempt to rationalize the information transfer in agriculture by preparing guide rules which are generally applicable. This has meant however, a distinct loss in the specific and critical information for the local situation, and prevents the proposals from having a greater effect.

In addition, the emphasis of current implementation in agriculture is more toward an increase in yield (i.e. production) rather than toward the capacity of the soil to maintain production (i.e. the aspect of productivity). This often means short term profits paid for by a decrease in long term productivity - an unacceptable situation. By not contributing (via humus care, plant combinations or sequences, etc.) to the intrinsic capacity of soil to create and maintain an effective nutrient and trace element balance in order to support productivity, we are forced to increase the external inputs such as fertilizers, biocides, irrigation, etc. for this purpose. This development can generally be shown as in Fig. 1. It indicates that initially, external inputs raised the yields considerably. Then comes a phase where more energy only manages to maintain the same level of yields. This is the state of many agricultural areas today. In some areas however, there has been a change for the worse. Yield is beginning to decrease in spite of further increasing energy inputs and investment. This has come about for various factors, many arising from a decrease in soil health.

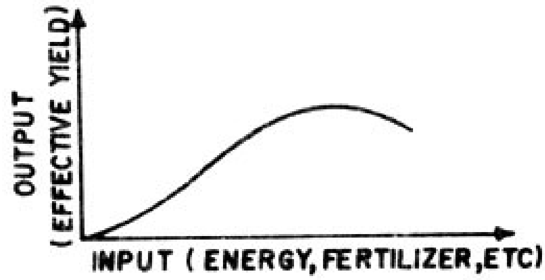

Fig. 1 Effect of increasing inputs (fertilizers, etc. on output)

This curve can be considered characteristic of many aspects in agriculture. A similar example is the effect upon protein quality as a function of increasing nitrogen (Fig. 2).

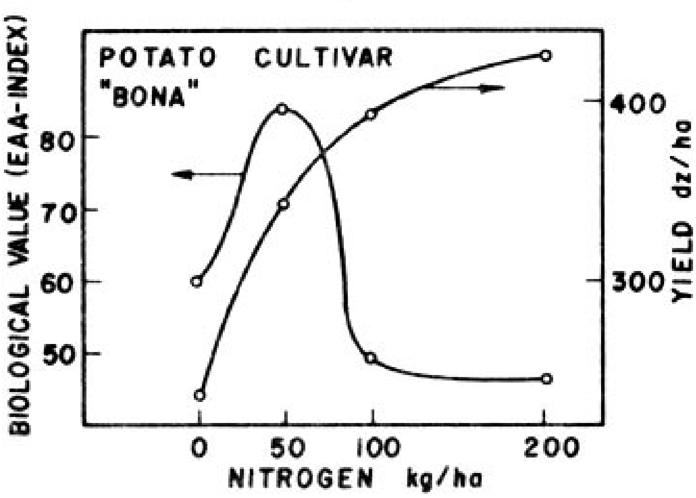

Fig. 2 Effect of increasing nitrogen fertilizer on the biological value (EAA-Index).

2.5 Because we cannot continue at the same rate of energy and resource consumption

The general trend in agriculture shows a continuous increase in the amount of non-renewable energy and other resources in food production. The change in agriculture from being a net energy producer (ca. 1 calorie input yielded ca. 50 calories of food) to a net energy consumer (ca. 2-5 calories required for 1 calorie output) has forced it faster along the path of resource depletion than is necessary. Industrial countries are gradually coming to the conclusion that they themselves cannot continue this kind of agriculture. One now begins to calculate the trade-off of land for chemicals (an increase of ca. 12% land could allow a decrease of ca. 50% insecticides (Chapman 1973)). In some cases, the trend will not be too easily reversible. The land remaining is not of the same good quality. The land used has been depreciated by humus destruction, erosion, imbalances in nutrients, toxic accumulation, etc.

2.6 Because people need to be fed better

The standard for crop improvement has all too often been only the weight of yield and not quality of yield. The increased yields have often been paid for by a lower protein content, meaning a decrease in nutritive components. Thus weight is not an acceptable single criterion. The inverse relationship between weight and protein is shown in Fig. 3 (Decau 1975). This plots the experimental information for wheat. This has had marked effects in the practical situation.

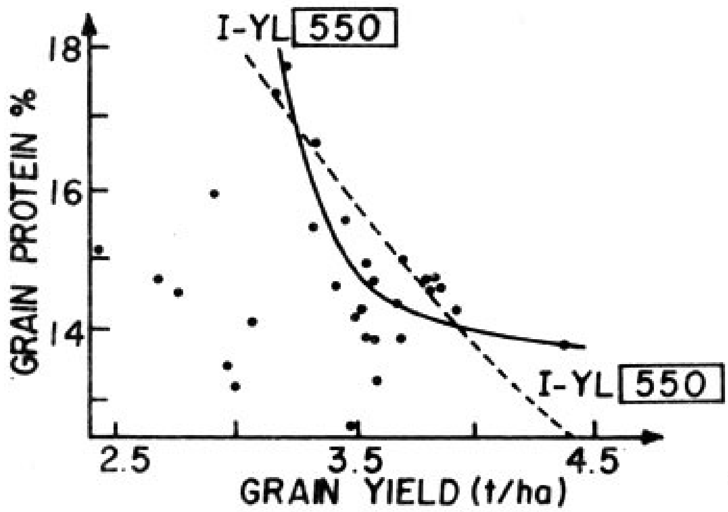

Fig. 3 Grain protein content and grain yield of 28 winter wheat cultivars. I-Y.L. (550): 550 kg/ha protein isoyield line

For example, low-yield Indian corn (maize) has shown a protein content of ca. 12-15%. Seeds selected for yield resulted in considerably lower protein. Between 1911 and 1956, the crude protein content of selected hybrid samples in the USA fell from 10.3% to 5.15% (Perelman 1972). For the States, this has meant such a decrease in the quality of animal feed, that it is now supplemented by fish protein from South America, affecting very unfavourably the food situation there.

The need to increase both yields and protein content is obvious. However, selective breading can cause a disproportionate increase in energy and nitrogen requirements as compared to base strains. As shown in Table 2 a 1% increase in protein content demands a 6-12% increase in nitrogen requirement. Perhaps the old cereal strains, containing twice the protein (up to ca. 32%) as newer strains should be re-evaluated. These may be particularly valuable for areas not having much water, since only little is required.

Table 2 STANDARD CHEMICAL COMPOSITIONS AND NITROGEN REQUIREMENTS (MILLIGRAMS OF N PER GRAMME OF PHOTOSYNTHATE) FOR CEREAL GRAINS (Bhatia and Rabson 1976)

Crop	Assumed standard composition (% dry matter)				Nitrogen requirement (mg/g)		Increase in nitrogen requirement (%)
	Protein	Carbo-hydrate	Lipid	Ash	With standard protein	With 1% increase in protein	
Wheat	14	82	2	2	16.0	17.0	6
Rice							
NO_3 as N source	8	88	2	2	9.7	10.8	11
NH_4 as N source	-	-	-	-	10.4	11.7	12
Maize	10	84	5	1	11.3	12.3	9
Barley	9	80	1	4	11.5	12.3	10
Sorghum	12	82	4	2	13.6	14.6	7
Oats	13	77	5	5	14.8	15.8	7
Rye	14	82	2	2	16.0	17.0	6

2.7 Because attempting to import a solution makes for larger problems elsewhere

The trend has been to look for possible solutions from other countries, with the creation of additional problems and additional dependencies. This holds true for developed and less developed countries. For example, the amount of fish protein imported by the USA from South America to compensate for lower grain quality would be sufficient to eliminate half of the protein deficiency there (Commoner 1968). Thus North America's imports of fish protein creates problems for South America, costing more than the profit from the sale of protein. The case is similar for other less developed countries, where the external sale of cash crops often does less to help solve the nutritional and financial problems than if the available local agricultural resources had been wisely used for the production of locally consumed food. The attempt to reach a global solution in this way is in all probability unrealistic. If we are at some time to reach a global solution to such critical problems as hunger, it will more likely come as the sum of the small, local solutions based on local needs and resources, which gradually take on global significance.

3. LOOKING FOR MORE VALID CRITERIA

Assuming that our primary goal is feeding people and not "only" increasing the quantitative yield, we have seen that existing criteria are inefficient. New criteria should at least consider the following questions, in addition to the question of increasing the yield.

a. Do more people participate in the production (and therefore either directly obtain food, or indirectly by earning money to pay for it)?

b. Does the measure contribute to the maintenance of the soil, and therefore to the ability to continue production?

c. Does the measure contribute to the stability of the agricultural system and therefore to the reliability of the crop production (less affected by blights, pests drought, etc.)?

d. Does the measure improve the quality of the crop (and not only quantity)?

e. Does the measure decrease the requirement for external (in particular non-renewable) energy in the form of fertilizer, biocides, irrigation, etc.?

f. Does the measure help solve some other problem which would otherwise need to be solved in a more costly or environmentally destructive way? For example:

- reducing the need for imports (and therefore reducing need for economic crops);
- providing cash crops for those imports needed (mixed cultures, etc.);
- using organic wastes (and thus decreasing requirement for fertilizer and waste problems).

g. Does the measure use local resources to help solve local problems?

4. PROBLEMS INVOLVED WITH USING ORGANIC WASTES AS FERTILIZERS AND THEIR EVALUATION ACCORDING TO CRITERIA DEFINED ABOVE

4.1 Amount of Organic Fertilizers

Concern about the quantitative sufficiency of organic fertilizers has lead to work on increasing the amount available, via technical methods (composting, further waste treatment, etc.). However, even with minimum technical assistance, most estimates of available organic material are favourable, being in the range of several times the amount of fertilizer now used in developing countries. In addition, the amount of nitrogen which can be fixed by tropical legumes ranges up to ca. 600 kg/ha/yr (Ayanaba and Okigbo 1975), the utilization of which should be the main goal in organic fertilizers. If indeed there is a problem, it will be more in making the materials available when and where they are needed. Increasing the available amount is only one approach to deal with the quantitative sufficiency. Another approach is to consider what can be done directly in the fields in order to reduce the need (but still maintain yields) of external organic material. This latter approach has the advantage that additional energy and infrastructure for treatment, storage, transport etc. can be reduced. The energy required is mainly human labour, which is of course the main resource available.

4.1.1 Reducing demand for external organic material

i. Consideration of soil health

As mentioned in section 2.4, the ready availability of chemical additives has distracted attention from measures supporting the soil's capacity to remain productive, and looked rather at chemical compensation for the failing productivity. This is again a case of substituting energy for the specific information of the local situation. The direct utilization of information about plant and weed combination, or humus care, reverses this trend, while increasing ecological stability and thus plant resistance. That better consideration of local conditions alone could substantially raise the yields, without any increase in inputs other than labour and better use of existing information, is no longer the view only of ecologists, but is accepted more and more by the economic advisors as well. For example, the latest report of the World Bank (1978) strongly emphasizes these considerations, pointing out that simple measures, adapted to the local conditions can, for example in India, increase yields 10-30% on rainfed land and 25-50% on irrigated land.

ii. Increase of on-field organic sources (intercropping, weed utilization)

The tendency toward increased use of machinery and decreased human labour has been the major factor for intercropping not assuming the role it can and should. For the same reasons, the traditional role of weeds (as ground coverage and organic source) has been neglected. Both aid in maintaining the humus layer, which is critical for soil health, and productivity are prerequisites for good production. In addition to these most important advantages, it is obvious that material which can directly be produced "on field" possesses further advantages by not requiring transport, storage, additional purchasing power or infrastructure. It should be noted that in certain areas intercropping is again becoming used, but the use of effective weed growth as a contribution to soil health and organic source has been lagging behind. Future development could profit from the better combination of nitrogen fixation along with these aspects. Further, the crop combination for intercropping must be guided by the soil composition, respective requirements of the plants and, equally important, the interrelationships of the various beneficial and harmful insects associated with each crop and weed growth. By clever combination of crops, use of the non-edible portion and weed growth as mulch, the requirement for external organic material and pest-control measures can be reduced markedly.

4.1.2 Evaluation (of sufficiency problem) according to adapted criteria

Meeting the organic fertilizer requirement by a reduction of external organic needs meets all the criteria used here. Especially it accomplishes the following goals:

a. substantially increases (by intercropping) the per area output;

b. favourably affects the productivity of the field and therefore stability of production;

c. increases the requirement for human labour, and

d. decreases external energies by using local resources.

4.2 Competition of Economic Crops with Green Manure

To a large extent economic crops are needed for the importation of agricultural aids, such as mineral fertilizers and oil pesticides. The purchase of these is however based on an increasingly unfavourable "terms of trade" situation. Prices for the aids are rising faster than the prices of the products produced to pay for them. Therefore, even for the same amounts of imports, an increasing amount of goods must be exchanged - a lost race from the start. For this reason alone, it becomes desirable to solve the problem locally where at all possible.

4.2.1 Decreasing the competition

The first goal is thus to decrease the need for imports. This is one of the main roles of organic fertilizers. The second goal is to allow the integration of economic crops (for those imports nonetheless needed), and therefore avoid the "either or" situation of cash-crops or green manure. In a well functioning system, all three goals of agriculture can be met at once: food, economic crops and maintenance of soil productivity. Soil conditions and customs determine how these can best be met.

How such a multipurpose goal can be elegantly fulfilled is shown by examples of groups and cultures long restricted to small areas of land, thus learning to produce and maintain within the boundary conditions as set by manure (which are of course the ones we all have to meet, only up to now, we have always sound some way to import materials in shortage from another area, and thus temporarily avoid a clash with the local limitations). Wise use of temporary weed covering can add to the overall productivity of such a system. The effective yield of such a mixed system can be several times that of a field where only one crop is grown at a time. The technological requirements are minimal. Knowledge of compatible and complementary crops and weeds for the local conditions on the other hand is critical.

4.2.2 Evaluation (of competition problem)

Considering that a major coercion for growing economic crop stems from the need to purchase agricultural aids, there are two ways to approach the problem:

a. increase production in order to meet payments although, as mentioned, due to the "terms of trade", this is increasingly difficult; or

b. decrease the needs for economic crops, mainly by the increased use of organic fertilizers and mixed farming. This latter approach meets all the main criteria used here. Of particular importance, it reduces the dependency on foreign markets and increases the reliability of the local crops by increasing soil health and ecological stability.

4.3 Organic Material in Competition with Traditional Fuels

The characteristics of the organic material used for heat determine partially the ease of transition to other fuels. For example, the burning of animal dung remains a main source of heat in many areas. Foods and cooking methods based on the slow, mild heat have evolved accordingly during the centuries. Even social functions are involved; for example, the food can be allowed to cook while work is carried out in the field. A change to a higher temperature (i.e. faster cooking fuel, such as methane) necessitates changes in social habits and in the types of foods, both of which are major events. However, without such adaptations, substitution may lead to a decrease in nutrient utilization due to the new cooking methods. These may not provide the same degree of digestibility or, just the opposite, may cause too much destruction of critical substances.

In such changes, consideration of the finely woven web of interrelationships among nature, agriculture, nutrition, and social customs is necessary. An unwise change in any one of these could lead to unintended damage in others, creating more difficult problems than one initially had.

4.3.1 Substitution of organic materials by other fuels

As discussed in another paper, the use of biogas plants provides multiple benefits. In addition to providing heat, an excellent manure is produced. Further, the necessary infrastructure for collection and storage of organic materials is created. The cultured growth of algae or water hyacinths, perhaps in connection with water treatment, can provide additional organic material for the biogas production, or can be used separately as a source of organic material for composting or direct mulching.

Depending on the purpose to be met, solar energy can be substituted domestically for other fuels. It is to be noted however, that the emphasis, at least initially, should be upon "passive" solar energy, which requires a minimum of technology. Passive solar energy could make a major contribution where low grade heat is required, by simple, appropriate construction for capturing and storing heat. In any case it can help decrease the demand for higher value energy, which should be used only where high temperatures are really required. Solar cookers have often been mentioned, but their real contribution is difficult to estimate, since they require a change in cooking habits and therefore can be adopted only gradually.

Fast growing trees have again been gaining attention as an energy source. These, too, can provide multiple benefits - being used as wind breaks, shade for other cultures, access to deeper levels of moisture and nutrients (thus enlarging the depth over which nutrients are recycled) and in general stabilizing the agricultural system. In the selection of trees suitable to the area and this purpose, the possibility of combining with the capacity for symbiotic nitrogen fixation, known for many trees, should not be overlooked.

4.3.2 Evaluation

Changes in the use of organic materials for fuels should be governed by two additional criteria beside those already mentioned:

a. where only low grade heat (as for warmth) is required, this should be met by low grade energy (in particular passive solar energy), in order to reduce the need for high grade (i.e. capable of high temperatures) energy;

b. since burning represents a loss of organic material, energy sources should be used which make multiple use of the material. Examples are biogas units and trees (especially fast growing), integrated into the agricultural system where possible.

In all cases, the suggestions made here allow for local solutions with low level technology, thus increasing independency and decreasing the need for economic crops.

4.4 Inefficient Composting

Compost can contribute in a major way to the diversity of the organics and organisms of soil, critical to humus formation and to soil and plant health. For several reasons the contribution of composting has remained far below its capacity. That it requires additional labour is often mentioned as one point, but more important has been the lack of attention paid to the characteristics of the particular location and material to be composted, as well as to the time required for a good compost. One has become all too used to fast effects and fast reactions by technological aids, but here we are dealing with a biological system whose benefits accrue slowly. The biological information needed for such a biological system, cannot be blindly transferred like technical information, from one area to another. The attempt to do so has led to inefficient composting, which has not aided the implementation or reputation of this highly valuable aid to soil care.

4.4.1 What can/should be composted in rural areas?

The largest amount of organic material comes from crop wastes and is not usually available for composting because it finds direct use in mulching. There are of course exceptions, for example, cotton plants are often burned to prevent proliferation of plant diseases. In such a case, composting could preserve the organic components while also destroying contaminating organisms. Organic wastes from the village may be used to a large extent as fodder and thus lead to animal wastes. Where possible, these can be used together with human wastes for biogas production. The collection in tanks or pits to prevent loss of organic materials should be emphasized. In connection with animal wastes, used for biogas or composted, the suggestion of a preliminary step involving the production of additional organic material (to then be used for biogas or compost) via water-hyacinths or algae production has often been made. In cases where waste water is to be used for irrigation, a partial treatment of the water could be obtained via such fast growing plants. Waste water is often used for irrigation without treatment, which practice is not without dangers of spreading communicable diseases. A study in Israel for the summer months showed that the incidence of Shigellosis, Salmonellosis, infectious hepatitis and typhoid fever was between 2 and 4 times as high in waste water irrigated areas as compared to areas where treated water was used (Katzenelson et al 1976). Thus, pretreatment via algae or water-hyacinth growth, followed by plant use for composting (or biogas), could provide several benefits at once.

4.4.2 Evaluation

The difficulties associated with composting are mainly due to incorrect usage. Properly used, it provides one of the most valuable additions to the organic and organism content of soil. By thus increasing the health of the soil it contributes increasingly also to higher yields. Its effect may initially be less dramatic, since an effective humus layer requires years to build. It is thus in strong contrast to the effect of mineral additions, which may show a stronger immediate effect, but are however not known for maintaining a basis for long-lasting productivity.

Its requirement of additional human labour has perhaps been a factor in its less than full use, but where available labour counts as a main resource, this should not be an accepted hindrance. The need for construction and technology is minimum. The quantitative contribution under rural conditions may not be large, since a large part of the available organics may be used as fodder, but it is nonetheless to be supported for its qualitatively valuable contribution.

4.5 Storage

4.5.1 Low volume - minimum problems

In rural areas, in contrast to urban, a large part of the treatment of organic material whether for composting or gas production can take place decentralized. The amounts thus being treated do not need to constitute a major problem for either transportation or storage. Beyond the requirement for pits for adequate storage of animal wastes, little is needed. For composting itself a static rather than dynamic treatment is preferred, thus requiring no mechanization. The transport and application of compost can also be accomplished with a minimum of mechanization.

4.5.2 Evaluation

On the scale to be expected under rural conditions, storage and transport of substances for composting, as well as of the compost itself, present a minimum of demands on technical or mechanical infrastructure. The major additional input is the human labour required for the application, particularly in view of the emphasis to be placed on intercropping.

4.6 Health Hazards and Environmental Pollution

4.6.1 Inappropriate and incomplete treatment as cause

With respect to composting, the preparation of a ripe compost is essential for hygienic considerations. As is well known, pathogenic spores are destroyed by correct composting due to the slow rise in temperature, which induces germination, through which they lose their thermostability and are destroyed by the further rise in temperature. An attempt to speed up the process by too rapid temperature rise, leads to inferior products. Being a biological system, a change in rate is accompanied also by a change in the types of reactions, not all of which aid in compost ripening.

Environmentally polluting substances found in urban wastes such as heavy metals, chemical toxins, etc. are not generally found in material used for rural composting and thus do not generally constitute a problem.

4.6.2 Evaluation

Under proper conditions, an appropriate use of organic material for fertilizing can decrease the environmental load by:

a. decreasing pathogenic organisms through composting;

b. improving humus and therefore soil retention capacity, with a resultant decrease in run-off of nutrients;

c. replacing or reducing mineral fertilizer, leading to lower costs and energy use.

Since its application decreases demand on fossil energy (but increases human labour) it further decreases the dependency on external resources.

5. CONCLUSION

Until recently, an evaluation of measures to be taken for agricultural improvement has been based on criteria incompatible with long-term productivity and survival. Isolated increases of yield have been separated from the goal of feeding more people. For example, the criterion of efficiency leads to a higher yield per person involved in the production, but simultaneously excludes many from the production, and thus of income and the chance to buy food. For this and similar reasons, the use of organic materials in agriculture must be re-evaluated according to criteria concerning the whole system or society involved, and not only according to isolated factors. Thus, if we look at the social benefits in addition to the increased yields, resulting from direct participation of people, we see that the use of organic fertilizers must be much more positively evaluated. Further, many associated problems, once they are brought into relation to the overall benefits, must be considered negligible. Some "problems" can be moved from the debit to the credit side - particularly the requirement of human labour.

We have gone through a stage of development where we have been able to substitute energy, or the products of energy for insufficient (or un-used) knowledge about soil and productivity. We have been able to increase outputs by adding "more" of various components, instead of supporting the soil's own capacity to be productive. For our future development we should attempt to reverse this substitution trend, and start to utilize our knowledge, rather than the dwindling resources, to increase yield. As a result, Figure 1 could be altered to take the path shown in Fig. 4. It should be noted that the new curve rises above its original course, indicating a higher level of productivity and production with less energy or resources in general.

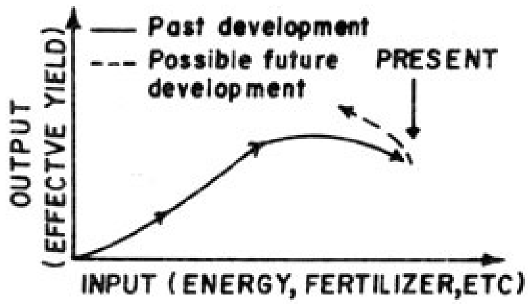

Fig. 4 Possible effect of substituting information for energy and other material resources

This is considered quite possible, because we have gained additional knowledge in the years that have passed since our energy consumption was at a lower level. We can now take advantage of this knowledge. That this is indeed the case is examplified by the wise use of organic fertilizers and (labour) intensive farming - yielding significantly higher yields at significantly lower energy inputs.

One constantly reads of "discoveries" which emphasize this trend in the scientific approach as well. For example, ancient wild wheat and barley strains, believed to be extinct, but now found as weeds in Israel, have twice as much protein (15-32%) as newer strains and, in addition, are adapted to difficult local conditions (Miron 1978). Knowledge of such extremely well developed systems should be integrated in the attempt to develop an agriculture benefitting mankind, while preserving nature and her resources - and only such can be of any real benefit in the long run. We know that the problems of feeding growing populations are increasing. Thus we can no longer afford an agriculture which all too often attempts to solve the problems of today, at the cost of being able to maintain productivity for the future. The wise use of organic materials allows solutions for both today and tomorrow.

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Paper 6

IMPROVING SOIL WITH ORGANIC WASTES: MUNICIPAL SLUDGE COMPOSTS

by

J.F. Parr, G.B. Willson, and D. Colacicco
US Department of Agriculture, Beltsville, Maryland, USA

Summary

Recent legislation in the USA has imposed restrictions on the disposal of sewage sludge by incineration, freshwater dilution, landfill, and ocean dumping. Consequently, many municipalities are considering land application methods for disposal of their sludges. There are, however, certain problems associated with land application of sludges that can largely be overcome by composting. The US Department of Agriculture at Beltsville has developed an Aerated Pile Method for composting either undigested or digested sewage sludges. The method transforms sludge into usable compost in about 7 weeks, during which time the sludge is stabilized, odours are abated, and pathogens are destroyed. The finished compost is an environmentally-safe, humus-like material, that is free of malodours, and can be beneficially used as a fertilizer and soil conditioner. Unlike sludges, it can be conveniently stored, easily handled and uniformly spread on land with conventional equipment.

1. INTRODUCTION

Legislative actions in the United States over the last decade have imposed restrictions on the disposal of municipal (sewage sludge and garbage) and industrial wastes by incineration, fresh water dilution, ocean dumping and landfilling. These actions include the Air Quality Act of 1967; the Federal Water Pollution Control Act of 1972 as amended; the Marine Protection, Research, and Sanctuaries Act of 1972 as amended; and the Resource Conservation and Recovery Act of 1976. According to the US Environmental Protection Agency, ocean dumping of sewage will supposedly cease by 1981. Meanwhile, the costs of present methods of sludge disposal, including trenching, landfilling, and incineration are increasing rapidly and will have a significant impact on future sludge disposal options (Colacicco et al 1977; Colacicco and Christiansen 1977; Colacicco 1977).

Sewage sludge is the residual material which remains after waste water treatment. Unfortunately, the more extensive the treatment, the greater the amount of sludge produced. For example, secondary treatment such as trickling filter or waste activation yields more than twice as much sludge as primary treatment. Tertiary or advanced waste water treatment (AWT) methods will generate up to three times as much sludge from the waste stream as secondary treatment methods. Thus, the annual US sludge production is expected to increase from the present rate of about 5 million dry tons to more than 10 million tons by 1985.

According to Farrell (1974), some 20% of municipal waste water sludges in the US are now spread on land, while 40% goes to landfill, 15% is disposed of by ocean dumping, and 25% is incinerated. Landspreading of sludge should increase markedly during the next decade as more and more municipalities are now considering land application methods for the disposal and/or utilization of their sewage sludges.

2. SEWAGE SLUDGE: A POTENTIALLY VALUABLE RESOURCE

Sewage sludge is a potentially valuable resource. It consists of 40 to 60% organic matter and contains both macronutrients (e.g. nitrogen, phosphorus, and calcium) and micronutrients (e.g. zinc, copper, and manganese) that are essential for plant growth. Epstein (1975) and Epstein et al (1976b) demonstrated that both sludge and sludge compost were beneficial as organic amendments for improving the physical properties of marginal soils. The application rate on agricultural land will be limited by the entent of contamination from heavy metals, toxic organic chemicals, and pathogens (Epstein and Parr 1977). Sommers (1977) and Chaney et al (1977) reported that the chemical composition of municipal sewage sludges can vary tremendously, depending on the method of waste water treatment and the type and amount of industrial effluents that are discharged into the sanitary sewers.

3. PROBLEMS WITH LAND APPLICATION OF SEWAGE SLUDGES

Sewage sludges can be applied to land as liquids (2 to 10% solids), as partially dewatered materials (18 to 25% solids), or as heat-dried and air-dried products (>90% solids). However, a number of problems can arise when these materials are applied to land.

i. Odours can be a major problem. Avoidance of odours necessitates immediate incorporation of sludge into the soil. Sites for landspreading of sludge must be selected with respect to population density, air movement, and the prevailing wind direction.

ii. The potential impact on human health is a matter of concern. Sewage sludges contain human pathogens some of which may survive for months or even years (Burge et al 1977; Burge and Marsh 1978).

Heath risks are considerably greater with raw or undigested sludges (i.e. unstabilized sludges) compared to digested sludges (i.e. stabilized sludges).

iii. Specialized and expensive equipment is often required to haul, inject, spread and/or incorporate sludges on land. Partially dewatered sludges are difficult to spread at uniform application rates.

iv. Lack of public acceptance can be a problem (Epstein and Parr 1977). Residents along hauling routes as well as those living close to the application site often object to sludge disposal/utilization on land.

v. Improper site management can cause environmental problems such as transport of sludge in runoff water, nitrate pollution of groundwater or surface waters, and release of malodours.

vi. Sludge application may have to be curtailed in certain regions during the winter months. Some states prohibit the application of sludge on frozen or snow-covered ground, which necessitates costly storage facilities. Sludge storage can lead to anaerobic decomposition and the production of malodours.

vii. The high cost of land for sludge disposal projects near some urban areas may eventually prohibit, or greatly limit, future operations (Sobers 1978).

viii. Excessive amounts of heavy metals and industrial organic chemicals in sludges applied to land are of concern because of possible phytotoxic effects, because some metals and chemicals may be absorbed by crops and endanger human health by entering the food chain, and because long-term use of contaminated sludges may permanently impair the use and productivity of soil for crop production (Chaney and Giordano 1977; Chaney and Hornick 1977; Parr et al 1977; Chaney et al 1977).

4. RELATIVE EFFECTS OF DIFFERENT TREATMENT PROCESSES ON PATHOGEN DESTRUCTION AND SLUDGE STABILIZATION

In view of these problems, and especially those of public concern about odours and pathogens, along with a growing consensus that good quality sludges should be recycled beneficially on land, there is increasing interest in the US in composting as a means of stabilizing sludge for land application. Most of the problems associated with land application of sewage sludges can be alleviated by composting.

Table 1 RELATIVE EFFECTS OF VARIOUS TREATMENT PROCESSES ON DESTRUCTION OF PATHOGENS AND STABILIZATION OF SEWAGE SLUDGES (adapted from Farrell and Stern 1975)

Processes	Pathogen	Putrefaction	Odour
Anaerobic digestion	fair	low	good
Aerobic digestion	fair	low	good
Chlorination, heavy	good	medium	good
Lime treatment	good	medium	good
Pasteurization (70°C)	excellent	high	poor
Ionizing radiation	excellent	high	fair
Heat treatment (195°C)	excellent	high	poor
Composting (60°C)	good	low	good
Long-term lagooning of digested sludge	good	-	-

Farrell and Stern (1975) summarized the relative effects of different treatment processes on pathogen destruction and stabilization of sewage sludges (Table 1). Pathogens can be completely eliminated by pasteurization, ionizing radiation, or heat treatment; however, the sludges remain unstabilized and when reinoculated and/or applied to land will undergo putrefaction with the production of malodours. Both anaerobic and aerobic digestion can effectively stabilize sludge, but destruction of pathogens is incomplete. Lime treatment and chlorination of sludge provide good pathogen control, but stabilization is incomplete. Composting is the only process that ensures acceptable pathogen destruction and effective stabilization.

5. THE COMPOSTING PROCESS: PRINCIPLES AND PRACTICES

Golueke (1972) defines composting as "the biological decomposition of the organic constituents of wastes under controlled conditions". According to Golueke, the term "decomposition" is preferable to "stabilization" because the process is rarely allowed to proceed to the point at which the waste is completely stabilized. Complete stabilization implies that the residual organic fraction, after composting, would decompose at only a negligible rate, even if conditions were favourable for microbiological activity. Another key word in this definition is "controlled", since it is the application of control that differentiates composting from the natural putrefaction or fermentation (or other decomposition processes) of organic wastes in soil, open dumps, and sanitary land fills.

During composting, complex organic molecules are decomposed into simpler compounds through the growth and activity of bacteria, actinomycetes, and fungi. While these organisms utilize a portion of the carbon and nitrogen fraction in the composting biomass for synthesis of cellular materials, they also convert chemical energy into heat through respiration. As the temperature continues to increase, a point is reached where specific types of micro-organisms called thermophiles dominate the process. These organisms have a temperature optimum over the range of 40 to 75°C. The intensity and duration of this internal heat causes the rapid and complete destruction of pathogenic micro-organisms, thereby ensuring a safe and useful product. Moreover, as a result of this thermophilic activity, malodorous organic compounds are rapidly decomposed which enhances the acceptability of the final product.

Composting is an ancient practice used by farmers to convert organic wastes into soil amendments that supply available nutrients to crops and replenish depleted soil organic matter. The practice remained more of an art than a science until about 40 years ago when Sir Albert Howard, a British agronomist in India, developed the Indore Process for composting. This method, named after the State in India where Howard conceived it, was a significant advance in the "Science of Composting". The method utilizes a 5-6 ft layered pile of various organic wastes such as leaves, nightsoil, animal manure, sewage sludge, straw, and garbage. The pile is turned after 2, 4, and 8 weeks, and composting is complete in about 3 to 4 months. The method is essentially a combination of aerobic and anaerobic composting. Howard's work demonstrated that composting can be a beneficial alternative to the disposal of refuse and sewage sludges by incineration and landfilling. Excellent books on the fundamentals of composting municipal wastes include Golueke (1972), Gotaas (1956), and Satriana (1974).

6. COMPOSTING SEWAGE SLUDGES FOR UTILIZATION AS A FERTILIZER AND SOIL CONDITIONER

In 1973, the Biological Waste Management and Soil Nitrogen Laboratory at USDA's Beltsville Agricultural Research Center developed a windrow method for composting digested sludge containing 20 to 25% solids (Willson and Walker 1973; Epstein and Willson 1974). The method consists of mixing sludge with a bulking material, such as woodchips, and then forming the mixture into windrows that are mechanically turned to maintain aerobic composting conditions. While the windrow method proved to be quite suitable for composting digested sludge, it was not acceptable for composting undigested (raw) sludge because of the greater level of malodours associated with those sludges. Moreover, undigested sludges generally contain a higher level of pathogens and there was concern that some of these organisms might survive in the outer layers of the windrow where lower temperatures might occur.

6.1 The Beltsville Aerated Pile Method

This laboratory has now developed a process for composting undigested or raw sewage sludges (Epstein and Willson 1975; Epstein et al 1976a; Parr et al 1978; Willson et al 1977-1978). The method is widely referred to as the Beltsville Aerated Pile Method, whereby undigested sludge (approximately 22% solids) is mixed with woodchips as a bulking material and composted in a stationary aerated pile for 3 weeks. Sludge at this high moisture content will not compost aerobically without alteration because sufficient air cannot penetrate the biomass, either naturally or through forced aeration. Therefore, it is necessary to mix the sludge with a bulking material to provide the necessary structure and porosity to accommodate forced aeration, and to lower the moisture content of the biomass, thereby ensuring a rapid aerobic/thermophilic composting process. Other bulking materials that could be utilised include leaves, refuse, paper, groundnut hulls, straw, corn cobs, cotton gin trash and sugarcane bagasse.

A three-dimensional schematic diagram of the aerated pile method is shown in Fig. 1. This method differs from the windrow method in that the composting biomass is contained in a stationary pile and remains undisturbed for 21 days. A 12-inch layer of woodchips or unscreened compost comprises the base of the compost pile, which also contains a loop of 4-inch perforated plastic pipe. One volume of sludge is mixed with two volumes of woodchips (about 1:1 on a weight basis), which produces the necessary absorbency to lower the moisture content from 78% (sludge: 22% solids) to about 60% (sludge and chips: 40% solids). The pile is constructed on the base and the loop of perforated pipe is connected to a 1/3-hp blower controlled by a timer. Aerobic composting conditions are maintained by drawing air through the pile at a predetermined rate. The effluent air stream is conducted into a small pile of screened, cured compost, where odorous gases are effectively absorbed. After construction, the pile is covered with a 12-18 inch layer of screened compost for insulation and odour control. The blower is then turned on and the composting period begins.

High temperatures generated through the activity of thermophilic micro-organisms are essential in the aerobic composting process for effective destruction of pathogenic organisms and undesirable weed seeds. Temperatures above 55°C (131°F) will effectively destroy most pathogens. During the first 3 to 5 days, temperatures in the pile increase rapidly into the thermophilic range reaching as high as 80°C (197°F). Temperatures start to decrease after about 3 weeks, indicating that the more decomposable organic constituents have been utilized by the microflora and that the sludge has been stabilized. If the piles are constructed properly, neither excessive rainfall nor low ambient temperatures have any adverse effect on temperatures within the pile or the composting process. Failure of temperatures to increase rapidly during the initial stages of sludge composting by this method could be due to improperly constructed piles, excess moisture in the sludge or bulking material, and excessive aeration (Epstein and Willson 1975; Epstein <u>et al</u> 1976a). Uniform thickness of the blanket material covering the pile is important to prevent the occurrence of zones having suboptimal temperatures.

The aerated pile method is a major advance in sewage sludge composting because a very expensive step in waste water treatment (i.e. anaerobic digestion) can be bypassed. Further advantages of this method over the windrow method include: (a) greater reduction of pathogenic organisms, (b) greater flexibility in scale of operation, (c) lower capital costs, and (d) greater flexibility in labour vs. capital intensiveness. It should be pointed out, however, that either raw or digested sludges can be composted by this method.

6.2 The Aerated Extended Pile

The USDA composting facility at Beltsville processes approximately 60 tons of wet (22% solids) raw sludge each day. The resulting piles are 7 to 8 ft high, 65 ft long (this dimension could be increased or decreased accordingly), and about 15 ft wide. An added dimension of the aerated pile is the aerated extended pile illustrated in Fig. 2, in which each day's sludge increment is mixed with woodchips and the resulting pile is constructed by utilizing the shoulder (65 ft side) of the previous day's pile, and so on, forming a continuous or extended pile. The concept offers certain advantages for larger municipalities since the required operating area is considerably smaller than with individual piles. Moreover, the amount of blanket material needed for insultation and odour control is decreased by 65%, as is the woodchip requirement for the pile base. Research at Beltsville has shown that approximately 1 acre is needed for every 3 tons of sludge (dry weight basis) composted. This includes the entire operating area, space for runoff collection and storage, curing, materials storage, and administrative and maintenance buildings.

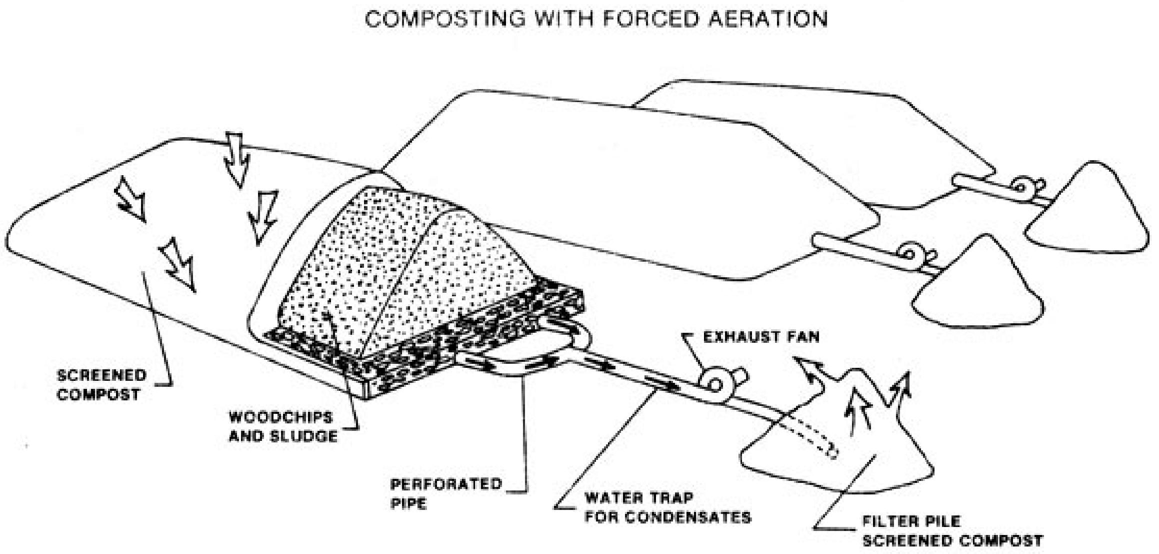

Fig. 1 Three-dimensional schematic diagram of the Beltsville Aerated Pile Method for composting sewage sludges

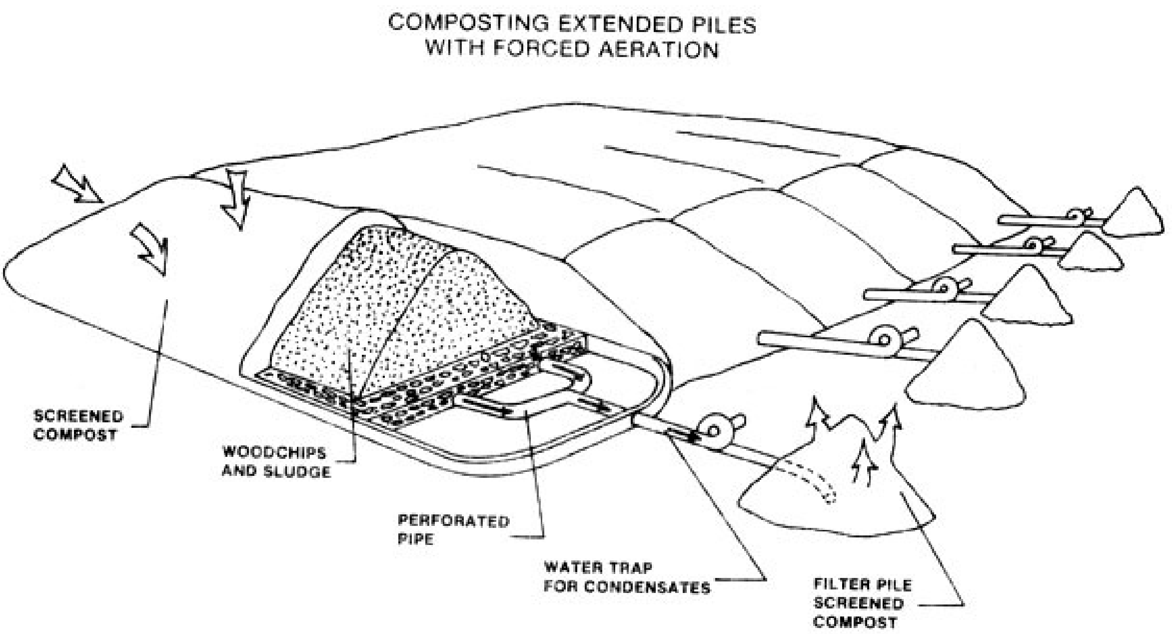

Fig. 2 Three-dimensional schematic diagram of the Beltsville Aerated Extended Pile Method for composting sewage sludges

6.3 Unit Operations and Available Options

A flow diagram showing the various unit operations for composting sewage sludge by the Beltsville Aerated Pile Method is shown in Fig. 3. There are two options which provide considerable flexibility for the process. If weather and climatic conditions are favourable, and if labour and equipment are available, option A is usually followed, whereby windrow drying and screening are performed prior to a 30-day curing period. The compost and woodchip mixture is usually dried to about 40 to 45% moisture to ensure clean separation of compost from chips during screening. The recovered woodchips are recycled with new batches of sludge.

During periods of inclement weather or if labour and equipment are not available, option B can be followed, whereby the composted biomass is taken directly from the aerated pile and placed in a curing pile for 30 days before drying and screening. Curing is actually an extension of the composting process and is associated with elevated temperatures, though somewhat lower than the mean temperatures attained during the initial composting period. The reheating provides a backup to the very effective pathogen destruction of composting. Where compost is used for land reclamation and erosion control, users often prefer the unscreened compost containing woodchips.

6.4 Chemical Composition of Sludge Composts

Composition of raw and digested sludges from the Washington, D.C., Blue Plains Waste Water Treatment Plant, and their respective composts processed at the USDA Composting Facility at Beltsville, Maryland, is shown in Table 2. The low heavy metal content of these sludges makes them quite acceptable for composting and utilization

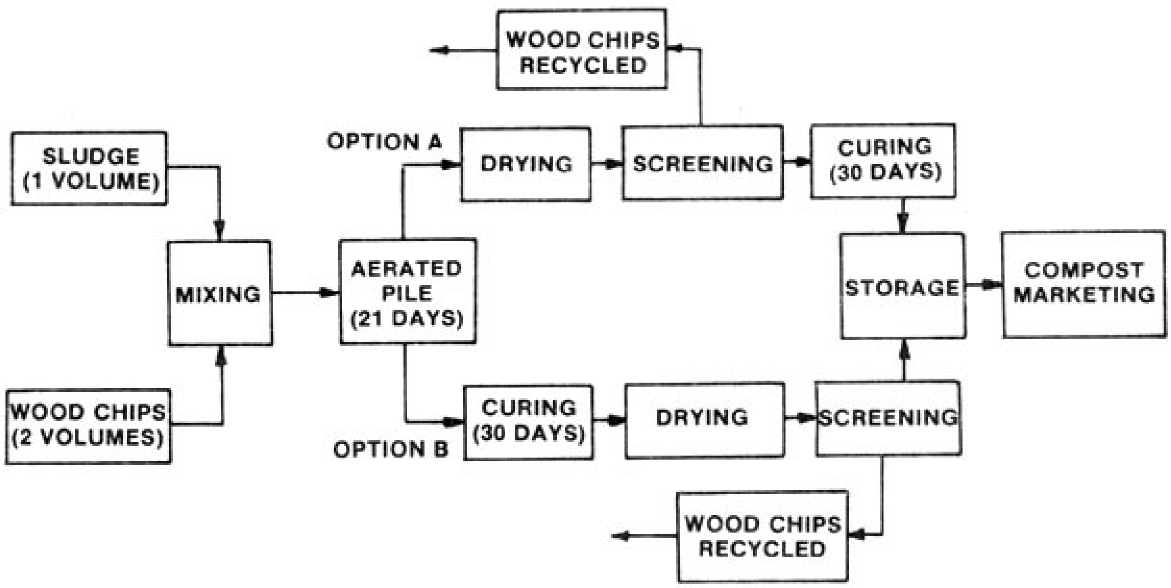

Fig. 3 Flow diagram of the Beltsville Aerated Pile Method and related process technology for composting sewage sludge.

Table 2 COMPOSITION OF RAW AND DIGESTED SLUDGES FROM THE WASHINGTON, D.C., BLUE PLAINS WASTE WATER TREATMENT PLANT AND THEIR RESPECTIVE COMPOSTS PROCESSED AT THE USDA COMPOSTING FACILITY, BELTSVILLE, MD

Component	Raw sludge	Raw sludge compost	Digested sludge	Digested sludge
pH	9.5	6.8	6.5	6.8
Water, %	78.0	35.0	76.0	35.0
Organic carbon, %	31.0	23.0	24.0	13.0
Total N, %	3.8	1.6	2.3	0.9
NH_4^+-N, ppm	1 540.0	235.0	1 210.0	190.0
P, %	1.5	1.0	2.2	1.0
K, %	0.2	0.2	0.2	0.1
Ca, %	1.4	1.4	2.0	2.0
Zn, ppm	980.0	770.0	1 760.0	1 000.0
Cu, ppm	420.0	300.0	725.0	250.0
Cd, ppm	10.0	8.0	19.0	9.0
Ni, ppm	85.0	55.0	-	-
Pb, ppm	425.0	290.0	575.0	320.0
PCBs 1/	0.24	0.17	0.24	0.25
BHC 2/	1.22	0.10	0.13	0.05
DDE 3/, ppm	0.01	0.01	-	0.008
DDE, ppm	0.06	0.02	-	0.06

1/ Polychlorinated byphenyls such as Arochlor 1254.

2/ The gamma isomer of benzene hexachloride is also called lindane.

3/ DDE results from the dehydrochlorination of DDT.

on agricultural land. Digested sludges are typically higher in heavy metals than the raw or undigested sludges from which they are derived, because metals are concentrated during anaerobic digestion. The sludge composts have a lower heavy metal content than their parent sludges because of a dilution effect from the woodchips. The level of chlorinated hydrocarbon pesticides in most US domestic sludges is now quite low since these chemicals are no longer used. The presence of industrial chemicals such as polychlorinated biphenyls (PCB's) in sludges being returned to land is of concern because of possible adverse effects on the food chain.

The macronutrient content of sewage sludges and their composts is rather low. For example, the N-P-K analysis of the raw sludge compost shown in Table 2 is 1.6 - 1.0 - 0.2. Thus, if compost alone were used to provide the levels of nutrients necessary to sustain optimum crop yields rather large amounts would have to be applied. The best practice would be to apply the compost in combination with inorganic fertilizers, thereby enhancing its value as a slow release N fertilizer and as a soil conditioner. Another option would be that a "spiking" or amending compost with inorganic sources of N, P and K to increase its fertilizer value. Sludges are typically low in potassium since this element is water soluble and remains in the liquid phase.

6.5 A Manual for Composting Sewage Sludge by the Aerated Pile Method

The staff of the Biological Waste Management and Soil Nitrogen Laboratory in co-operation with the US Environmental Protection Agency has prepared a manual for composting sewage sludge by the Aerated Pile Method that will soon be published as a joint USDA/EPA document (Willson et al 1978). The manual contains specific details on such topics as the economics and benefits of composting, factors affecting the composting process, site selection and design criteria, bulding materials, mixing operations, pile construction, aeration parameters, odour filter piles, curing and storage, human health, and aspects of utilization and marketing.

7. ECONOMIC FEASIBILITY OF COMPOSTING

To evaluate the economic desirability of composting for a municipality, one must first evaluate the costs of converting raw sludge into compost and the benefits that the compost will furnish to the community. Benefits will partially offset costs and the net cost of composting may then be compared with the cost of other forms of sludge management.

The cost of composting will very among projects. Much of the variation will result from differences in physical inputs in response to (1) the amount of sludge composted, (2) the topography of the composting site, (3) state and local restrictions, (4) local institutional constraints, and (5) the availability of existing public works equipment for the composting. The unit prices of the physical inputs will also differ among localities, adding another cost variable. More complete details on the costs of sewage sludge composting can be found in the report by Colacicco et al (1977).

Table 3 compares costs of various sludge disposal methods. The wet sludge actually composted contained 23% solids. The dry ton figures presented may be converted to approximate wet tons by dividing by 4.

The fertilizer value of sewage sludge compost must be considered in determining the economic feasibility of this alternative. A market study is necessary to determine the net benefits to a community from the distribution of the sludge compost. Most refuse composting operations that started in the 1950's and 60's have now closed because of the lack of a developed market for compost in their area, poor product quality, and because the investors expected to show an immediate profit from the production and distribution of the compost (Satriana 1974). Composting will benefit the sewage authority economically if the net cost of production and distribution is less than that of any other environmentally acceptable disposal system. A well-planned and managed marketing programme is essential to derive a profit over distribution costs. If the sludge compost is used for its fertilizer value alone, there could be a net cost of distribution, depending on the hauling distance.

Table 3

APPROXIMATE COMPARATIVE COSTS FOR VARIOUS SLUDGE DISPOSAL PROCESSES - 1976

Process		Range of costs in $ per dry ton
Digested sludge by:		
	Ocean outfall	10 to 35
	Liquid landspreading	20 to 54
Digested and dewatered sludges by:		
	Ocean barging	31 to 44
	Landfilling	23 to 53
	Landspreading	26 to 96
Dewatered sludges:		
	Trenching 1/	116 to 134
	Incineration 2/	57 to 93
	Heat drying 2/	62 to 115
	Composting 2/	35 to 50

1/ Costs exclude transportation of sludge to disposal site.
2/ Costs include cost of removal of residues and benefits from resource recovery.

Compost may be used in place of peat moss or topsoil for certain horticultural applications. During preparation for the 1976 US Bicentennial, the National Park Service used Beltsville sludge compost to construct Constitution Gardens in the Mall area of Washington, D.C. The Park Service saved over $200 000 by making and artificial topsoil with the compost instead of buying topsoil, which was then selling for about $5 per cubic yard, not including hauling. Compost contains small amounts of nutrients, so the Beltsville compost has a value of about $4 per cubic yard in terms of 1977 fertilizer prices in Maryland for nitrogen and phosphorus. The yield of compost is about 5 cubic yard per ton of dry sludge solids, so the net profit or loss on distribution per yard must be multiplied by 5 to obtain the effect per ton of sludge solids.

Composting may be a cost-effective alternative for some municipal sludge management problems. The net cost of composting will vary among municipalities because the production costs and the utilization benefits will also vary. Therefore, a feasibility study of sludge composting must include not only a cost analysis of the process but also a comprehensive analysis of the potential market for the product.

8. ADVANTAGES OF COMPOSTING SEWAGE SLUDGES FOR LAND APPLICATION

In summary, there are a number of advantages of composting sewage sludge for land application:

a. Stabilization of raw sludge by composting eliminates the need for costly anaerobic digestion, or other means of stabilization.

b. Microbial decomposition of the volatile organic fraction during composting eliminate malodours and produces a stable, humus-like, organic material.

c. Heat produced during composting effectively destroys human pathogens.

d. Compost can be conveniently stored, and easily and uniformly spread on land without expensive equipment.

e. Compost is a valuable product that can be applied to land as a source of nutrients for plants, and as an organic amendment to improve the physical properties of soil.

9. UTILIZATION OF SEWAGE SLUDGE COMPOST AS A FERTILIZER AND SOIL CONDITIONER

It is unlikely that sewage sludge compost will be used to supply the total nutrient requirements of agricultural crops because of the large amounts that would have to be applied. The greatest potential value of these materials will be realized when they are used as organic amendments to improve soil physical conditions. At these rates they will also provide a significant amount of nutrients for crops and the fertilizer requirement can be decreased accordingly.

Since most of the nitrogen in sewage sludge compost is in the organic form it must be mineralized to inorganic ammonium or nitrate before it is available for crops. Research at Beltsville indicates that from 10 to 20% of the organic N will become available during the first cropping period following application. Thus the sludge compost functions as a slow release N fertilizer.

The application of sludge compost alone, at fertilizer rates (i.e., the N or P requirements of the crop), to marginal soils can produce significantly higher yields than when commercial fertilizers are applied alone at the same level of N (L.J. Sikora and E. Epstein, Unpublished data). This result is thought to be due to an improvement in soil physical properties by the compost. It is well known that maximum crop response to inorganic fertilizers is dependent upon favourable soil physical conditions. The addition of sludge composts to soil are known to improve their soil physical properties as evidenced by (a) increased water content, (b) increased water retention, (c) enhanced aggregation, (d) increased soil aeration, (e) greater permeability, (f) increased water infiltration, and (g) decreased surface crusting. Addition of sludge compost to sandy soils increases their ability to retain water and renders them less droughty. In heavy textured clay soils, the added organic matter will increase permeability to water and air, and increase water infiltration into the profile, thereby minimizing surface runoff. In turn, these soils will have a greater water storage capacity to be utilized for plant growth. Addition of sludge compost to clay soils has also been shown to reduce compaction (i.e., lower the bulk density) and increase the rooting depth (Epstein 1975; Epstein et al 1976b).

The finished compost can be used as both a fertilizer and a soil conditioner. Large quantities of the sludge compost produced at Beltsville have been used successfully as a topsoil substitute by a number of public agencies, including the National Capitol Park Service and the Maryland State Park Service, for land reclamation and development projects. Research in progress at Beltsville indicates that sewage sludge compost can be utilized to great advantage in the commercial production and establishment of turf-grasses, and by commercial nurseries in the production of trees and ornamental plants (Gouin and Walker 1977).

Plants and turfgrasses produced with sludge compost were of better quality, had developed more extensive root systems, were transplanted with lower mortality, and were marketable earlier than those grown only with inorganic fertilizer. It is likely that large amounts of sludge compost will eventually be used on golf courses, cemeteries, and for landscaping the grounds of public buildings.

In addition to these uses, sludge compost has a major potential for use in the revegetation and reclamation of lands disturbed by surface mining, by removal of top-soil, and by excavation of gravel deposits. Stripmined lands in the eastern US are among the most hostile of all environments for the establishment and growth of plants because of (a) extremely low pH, often below 3.0, (b) extreme droughtiness from lack of organic matter, (c) very high surface temperatures, (d) lack of nutrients, and (e) very poor physical conditions. Research by USDA has shown that through the proper use of dolomitic limestone, rock phosphate and sewage sludge compost it is possible to grow a wide variety of both agricultural and horticultural crops, as well as many forages (Armiger *et al* 1976; Bennett *et al* 1976; Griebel *et al* 1977). With proper management, such disturbed lands can be reclaimed in a surprisingly short period of time and restored to a high level of production.

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Paper 7

EFFECT OF CERTAIN CHEMICAL AND PHYSICAL FACTORS ON THE COMPOSTING PROCESS AND PRODUCT QUALITY

by

J.F. Parr, G.B. Willson, R.L. Chaney, L.J. Sikora,
and C.F. Tester
US Department of Agriculture, Beltsville, Maryland, USA

Summary

The US Department of Agriculture at Beltsville, Maryland in co-operation with the Maryland Environmental Service, has developed an Aerated Pile Method for composting either undigested or digested sewage sludges that transforms sludge into usable compost in about 7 weeks.

There are certain fundamental parameters, including temperature, moisture, aeration or oxygen supply, carbon to nitrogen ratio, pH, and particle size of organic wastes, that are essential to the composting process, and which must be at optimum levels if aerobic/thermophilic composting is to proceed rapidly and effectively.

Certain chemical properties of sludges and bulking materials can also affect the composting process as well as product quality. These include excess soluble salts, toxic organic chemical such as PCB's, heavy metals, lime, and ferric chloride. There are also some physical properties of sludges and bulking materials, such as fluidity and compactness, that must be considered if the composting process is to achieve a high degree of reliability. After composting, product quality can be improved by selective screening, leaching, nutrient enrichment, granulating, and pelleting.

To ensure that proper conditions of moisture, temperature, and aeration are achieved during composting, and that a safe and acceptable high quality product is marketed, a comprehensive monitoring programme is absolutely essential.

1. INTRODUCTION

Golueke (1972) defines composting as "the biological decomposition of the organic constituents of wastes under controlled conditions". He prefers the word "decomposition" rather than "stabilization" because the process is rarely allowed to proceed to a point where the waste is completely stabilized. Another key word in this definition is "controlled", since it is the application of control that differentiates composting from natural putrefaction or fermentation, or other decomposition processes. In their review of composting, Gray et al (1971a and 1971b) defined this process as "the decomposition of heterogeneous organic matter by a mixed microbial population in a moist, warm, aerobic environment". Finstein and Morris (1975) defined composting as "the microbial degradation of organic material that involves aerobic respiration, passes through a thermophilic stage, and yields a stabilized end product", i.e. compost.

A more complete definition of the composting process as applied to sewage sludge, and particularly as practised at Beltsville, seems appropriate. The following definition combines a number of others and is offered here for the reader's convenience and comprehension: Composting is the aerobic, thermophilic decomposition of organic wastes by mixed populations of indigenous micro-organisms under controlled conditions which yields a partially stabilized residual organic material that decomposes slowly when conditions again become favourable for microbiological activity.

The US Department of Agriculture at Beltsville, Maryland, in co-operation with the Maryland Environmental Service, has developed an Aerated Pile Method for composting either undigested or digested sewage sludges. The method transforms sludge into usable compost in about 7 weeks, during which time the sludge is stabilized, odours are abated, and human pathogenic organisms are destroyed (Willson et al 1978a). The principal objective in composting sewage sludges is to produce an environmentally-safe, humus-like material that is free of malodours and pathogens, and that can be used beneficially on land as a fertilizer and soil conditioner.

This paper considers certain chemical and physical characteristics of sewage sludges and bulking materials that can affect the composting process as well as compost quality.

2. BIOCHEMICAL ASPECTS OF COMPOSTING

Composting is a microbiological process that depends on the growth and activities of a mixed population of bacteria and fungi contained in the organic materials to be composted. When temperature, moisture and oxygen levels are favourable, the micro-organisms will grow and aerobic decomposition proceeds. The microbes utilize the organic materials for available carbon, nitrogen and other nutrients. As the activity continues, the temperature begins to increase from the heat generated through microbial oxidations and their respiratory functions. If the composting biomass is insulated and assumes a geometrical form, such as a pile or windrow, heat is retained for an extended period. Eventually, however, as the available carbon and other nutrients are depleted, microbial activity subsides, decomposition slows, and cooling occurs.

Poincelot (1975 and 1977) suggested six fundamental parameters which are essential to the composting process and which must be at optimum levels if aerobic/thermophilic composting is to proceed rapidly, effectively, and efficiently. These are briefly summarized as follows:

i. Temperature

A typical time/temperature relationship for composting raw sewage sludge by the aerated pile method is shown in Fig. 1 (Curve 1). As microbial activity increases, temperatures increase rapidly (i.e. within several days) from the mesophilic into the thermophilic stage (Curve 1) which begins at about 40°C (104°F). At this point, the mesophilic micro-organisms are inhibited by temperature while the thermophiles become very active. Decomposition of the organic materials is most rapid in the thermophilic stage. Optimal temperatures for sewage sludge composting have been found to range from 60°C to 70°C. Pathogen destruction has been shown to occur rapidly in the thermophilic stage according to specific time/temperature functions (Burge et al 1978). More specific details on the temperature dynamics of composting by the aerated pile method are presented elsewhere (Willson et al 1978b).

ii. Moisture

The optimal moisture content of the biomass for rapid aerobic/thermophilic composting is from 50 to 60% (w/w). If the moisture content is below 40%, decomposition will be aerobic but slow. If the moisture content is above 60%, there may be insufficient air space to sustain aerobic decomposition, and anaerobic conditions may result.

iii. Aeration or oxygen supply

A continuous supply of oxygen (O_2) must be available to ensure aerobic/thermophilic composting. It should also be recognised that the rate of consumption

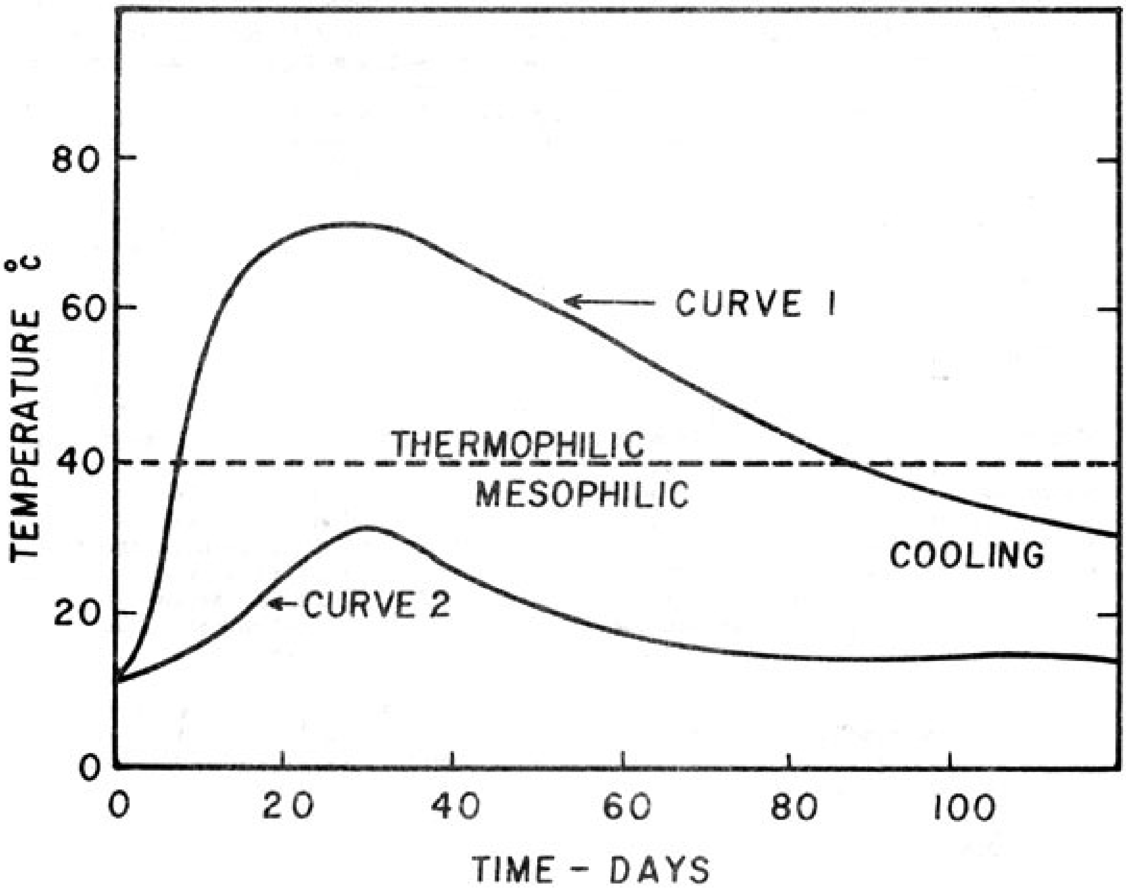

Fig. 1 A typical time/temperature relationships for composting sewage sludge by the Aerated Pile Method. Curve 1 depicts a situation where conditions of moisture, temperature, and aeration are at optimum levels for rapid transition from the mesophilic into the thermophilic stage. Curve 2 represents a condition where certain parameters are deficient or outside their optimum range, resulting in adverse effects on the growth and activity of the indigenous micro-organisms

of O_2 by micro-organisms depends on a whole host of other factors including pile or windrow temperatures, type of material being composted, particle size, and degree of mechanical agitation. The aeration requirement for composting sewage sludge may range from 5 to 10 ft^3 of air per pound of volatile solids per day.

iv. Carbon: nitrogen ratio

Probably the most important aspect of composting is the carbon (C) and nitrogen (N) content of the biomass (e.g. sludge plus bulking material) to be composted, usually expressed as the C:N ratio. Since the micro-organisms involved require C for growth and energy, and N for protein synthesis, the rate of decomposition is affected accordingly. Rapid and efficient composting is achieved with C:N ratios of between 25 and 35. Lower ratios can result in the loss of N as ammonia, while higher ratios can lead to longer composting periods.

v. pH changes

The optimum pH for rapid aerobic/thermophilic composting is somewhere between 6 and 7.5. However, research at Beltsville has shown that there is a wide latitude over which sewage sludges can be composted with little apparent effect on the rate of decomposition (Parr et al 1977; Willson et al 1976).

vi. Particle size reduction (i.e. grinding or shredding)

In some cases, grinding or shredding of the starting materials can accelerate the rate of decomposition during composting by increasing (a) the surface area for microbial attack, and (b) the extent of contact between the sludge and the bulking material. Excessive grinding could also lead to compaction and poor aeration.

Thus, if any of these fundamental parameters are deficient, or outside their optimum range, the growth and activity of the indigenous micro-organisms may be adversely affected, and the rapid, aerobic/thermophilic composting depicted by curve 1 (Fig. 1) may not be achieved. If deficiencies are extensive, the resulting time/temperature relationship during composting may not be unlike that of curve 2.

3. PROPERTIES OF SLUDGES AND BULKING MATERIALS THAT MAY AFFECT THE COMPOSTING PROCESS AND PRODUCT QUALITY

Sludges will vary greatly in their chemical and physical characteristics depending on the method of waste water treatment used, and the kind and amount of industrial wastes discharged into the sanitary sewers. Thus "compostability" of a particular sludge will depend on its chemical composition and how it was treated. In addition to pH, and the C:N ratio, there are other chemical properties of both sludges and bulking materials that may affect the composting process and product quality. These include soluble salts, toxic organic chemicals such as pesticides, polychlorinated biphenyls (PCB's) and wood preservatives, sludge conditioning agents (lime, alum, and ferric chloride), and heavy metals.

i. Soluble salts

Sewage sludges contain varying amounts of soluble salts depending on their source and the type of waste water treatment employed. Where alum, lime and ferric chloride ($FeCl_3$) are used as flocculating and conditioning agents during sludge treatment, potential problems can arise since the soluble salt content increases accordingly, and some plant species are highly sensitive to soluble salts. When prepared composts are used for agricultural and horticultural purposes, the danger of soluble salts is minimal because or dilution in soil after the compost is incorporated and mixed, and the extent of leaching that occurs after application.

At Beltsville, composts are always leached to remove soluble salts prior to studying heavy metal effects on plants so as to avoid confounding of salt injury with heavy metal phytotoxicity. Nevertheless, even this apparent precaution cannot fully account for the results obtained in some horticultural experiments, such as those shown in Table 1. Two experimental composts were prepared using limed raw sludge from the Blue Plains Waste Water Treatment Plant in the District of Columbia, and woodchips obtained from land clearing operations in Maryland and from pilings and other waste woody materials gathered in the New York City Harbour area.

The composts were used to prepare potting mixes consisting of (a) one-third compost and equal parts of peat and vermiculite, (b) two-thirds compost and equal parts of peat and vermiculite, and (c) full-strength compost. All mixes were formulated on a volume basis. Growth response of different crops to these potting mixes was then investigated (Table 1).

Table 1

CROP RESPONSE TO LIMED RAW SLUDGE COMPOST POTTING MIXES LEACHED BEFORE CROPPING 1/

Treatment		Marigold	Tomato	Snapbean
Rate 2/	Woodchip source	(g dry shoots per pot)		
33	Beltsville	11.23ab 3/	10.84 a	8.30 a
67	Beltsville	11.83 a	9.38ab	7.32ab
100	Beltsville	9.46 b	9.54ab	5.05abc
33	NYC Harbour	11.44 a	8.25 b	3.21 c
67	NYC Harbour	10.58ab	8.36 b	4.04 bc
100	NYC Harbour	9.44 b	6.10 c	1.91 c

1/ Composted Blue Plains limed raw sludge.
2/ % by volume; remainder was equal parts of peat and vermiculite.
3/ Duncan's test, 5% level.

There was little difference in the growth of marigolds when the composts were applied at the same rates, although yields tended to decrease when plants were grown in full-strength compost. This may have been due to phytotoxicity resulting from residual salt concentrations, since marigolds are moderately salt-sensitive, or possibly from excessive amounts of organic matter decomposition products such as ammonia (NH_3). However, in the case of both tomato and snapbean, yiels were substantially lower for the compost prepared with woodchips from New York City Harbour pilings. Again, yields were lowest when the mixes consisted of 100% of either compost. Further investigations indicated that the NYC compost contained a higher level of residual soluble salts after sequential leaching than did the Beltsville compost. This is not surprising since the pilings had probably become well saturated with high salinity water over an extended period. Moreover, the pilings in some cases had been treated with preservatives, such as creosote, which could have caused some phytotoxicity. Preliminary studies suggest that full-strength use of the composts may have caused an imbalance of plant nutrients resulting in a manganese deficiency. This problem did not arise with compost that was prepared from unlimed digested sludge from Blue Plains.

ii. Toxic organic chemicals

It is possible that some sludges may contain rather high levels of toxic organic chemicals of industrial origin. The level of chlorinated hydrocarbon pesticides in most US domestic sludges is now quite low since these chemicals are no longer used. Also, there is some evidence that these pesticides are biodegraded during sewage treatment (Hill and McCarty 1967) and also during composting (Rose and Mercer 1968; Epstein and Alpert 1978). The presence of polychlorinated biphenyls (PCB's) in sludges and composts being applied to land is of concern because of possible entry into the food chain in root crops.

iii. Sludges from advanced waste water treatment

The future plans of a number of waste water treatment plants in the US calls for the production of sludges from advanced waste water treatment (AWT). Such treatment will necessitate the addition of substantial amounts of different chemicals to remove the remaining solids and some sludge borne chemicals from the effluent. Consequently, these sludges will have a considerably higher chemical content than most sludges that are available for composting today. Since there is little information on the composting of AWT sludges, some pilot studies were conducted at Beltsville to characterize limitations in composting these sludges (Willson et al 1976).

Several small batches of synthetic AWT sludges were prepared by adding various combinations of chemicals to a mixture of orimary and waste activated sludges. The final analyses of these sludges are shown in Table 2.

Table 2 PERCENTAGE ANALYSES OF SOME SYNTHETIC ADVANCED WASTE WATER TREATMENT SLUDGES

Component	Combined primary and waste activated secondary sludges %	Combined sludges from nitrification & denitrification treatment %	Sludge from nitrification treatment Sample 1 %	Sludge from nitrification treatment Sample 2 %
Organics	81 1/	39 1/	36 2/	36 1/
$AlPO_4$	14	-	-	-
$CaCO_3$	3	35	37	37
$Fe(OH)_3$	1	4	-	-
$Mg(OH)_2$	1	4	4	4
$Al(OH)_3$	-	12	17	17
Lime inerts	1	3	4	4
Polymer	1	3	2	2
pH	5.8	8.0	12.0	5.9

1/ Raw primary sludge
2/ Lime-stabilized primary sludge

The sludges were mixed with different bulking materials, including woodchips, and incubated in 10-liter laboratory composters. Except for the pH 12 lime-stabilized sludge, which seemed to be nearly inert, the sludges exhibited an oxygen demand and a temperature rise indicative of microbiological activity and compostability. Moreover, sludge odours were not detected after 3 weeks of processing in the composters. Indications are that at least some of the AWT sludges can be composted successfully. Perhaps a more pertinent question is whether or not after composting they will be acceptable for land application in view of their high chemical content which could exceed 50% by weight, and which could cause adverse effects on both plants and soils, or reduce the benefits ordinarily achieved in the use of composts as fertilizers and soil conditioners.

Moreover, sludge odours were not detected after 3 weeks of processing in the composters. Indications are that at least some of the AWT sludges can be composted successfully. Perhaps a more pertinent question is whether or not after composting they will be acceptable for land application in view of their high chemical content which could exceed 50% by weight, and which could cause adverse effects on both plants and soils, or reduce the benefits ordinarily achieved in the use of composts as fertilizers and soil conditioners.

When AWT sludges are actually available, larger scale experiments are planned at the Beltsville Composting Facility to determine the effects of various chemicals in these sludges on the composting process, and how they affect product quality. If AWT sludges are slow to stabilize during composting, they may have to be blended with other sludges that have received less rigorous chemical treatment. Moreover, if after composting some AWT sludges are deemed potentially hazardous to plants, because of their high chemical content, they may have to be diluted with composts produced from primary and secondary sludges prior to marketing.

iv. Heavy metals

The application of sludges and sludge composts on agricultural land will be limited primarily by their level of contamination from heavy metals. The heavy metal content will vary depending on the method of waste water treatment, and the type and amount of industrial waste effluents that are discharged into the sanitary sewers. For example, the metal contents of digested sludges based on (a) the maximum concentrations observed, (b) the maximum domestic level that would be acceptable for landspreading or composting, and (c) the attainable low levels that could be achieved through pretreatment and abatement procedures, are presented in Table 3.

Table 3

METAL CONTENTS OF DIGESTED SEWAGE SLUDGES
(DRY WEIGHT BASIS)

Metal	Attainable low level 1/	Maximum domestic 2/	Observed maximum
Zn, ppm	750	2 500	50 000
Cu, ppm	250	1 000	17 000
Ni, ppm	25	200	8 000
Cd, ppm	5.0	25	3 400
Cd/Zn, %	0.8	1.5	110
Pb, ppm	-	1 000	10 000
Hg, ppm	2.0	10	100
Cr, ppm	50	1 000	30 000

1/ Observed in sludges generated from waste water of newer suburban communities with no industrial effluent. Sources of these metals are assumed to be from deterioration of domestic plumbing fixtures and storm sewers.

2/ Typical of sludge from communities without excessive industrial waste sources or with adequate source abatement. Sludges which exceed any of these metal concentrations are not recommended for landspreading or composting.

It is generally accepted that the cadmium to zinc (Cd:Zn) ratio should not exceed 0.015, i.e., that the Cd content of sewage sludges or sludge composts should not exceed 1.5% of the Zn content. This would help to ensure that where sludges and their composts are applied to land, Zn will accumulate in the plant to toxic levels before sufficient Cd can be absorbed to endanger the food chain. Excessive amounts of some heavy metals such as copper, zinc, nickel, and cadmium, can cause phytotoxic effects on agricultural and horticultural crops (Chaney and Giordano 1977). However, crop species will vary considerably in their relative tolerance to heavy metal toxicity as shown in Table 4.

Table 4 RELATIVE TOLERANCE OF VARIOUS CROPS TO HEAVY METAL TOXICITY

Degree of tolerance	Crop
Very sensitive	Swiss Chard, sugarbeet, redbeet, kale, mustard, turnip, tomato, lettuce
Sensitive	Snapbean, cabbage, collards
Moderately tolerant	Small grains, soybean
Tolerant	Corn (maize) and most grasses: fescue, Bermudagrass, perennial ryegrass, orchardgrass
Very tolerant	Certain ecotypes of grasses

Leafy vegetables such as lettuce are very sensitive to heavy metals while most grasses are very tolerant. In 1976, USDA proposed certain guidelines to limit the accumulation of heavy metals on agricultural land from the application of sewage sludges and their composts. The purpose of these guidelines (Table 5) was, and still is, to encourage the proper use of good quality sludges (low heavy metal content) while limiting the use of bad sludges (high heavy metal content) for land application. The guidelines are based on the best available information from scientists at state universities, agricultural experiment stations, and USDA. Two categories of land were delineated: (a) privately-owned land and (b) land dedicated to sludge application, i.e. publicly-owned or leased land. Heavy metals are more phytotoxic and available to plants when soil pH falls below 6.0. Thus, where sludges and composts are applied, soil pH should be maintained in the range of 6.2 to 6.5 by liming if necessary.

Annual application rates of sludge or sludge compost should be based on the nitrogen or phosphorus requirements of crops. Table 6 illustrates the effect of the metal content of different sewage sludges, and a raw sludge compost, on the maximum amounts of sludge (dry weight basis) that can be applied at N fertilizer rates according to the USDA guidelines (Table 5). For example, if a soil has a cation exchange capacity (CEC) of 5 to 15 meq/100 g, the total allowable cumulative zinc loading would be 500 kg/ha. Then if the sludge contained 4% N, and was applied at a rate equivalent to 100 kg of N/hectare/year, sewage sludge from the Piscataway Waste Water Treatment Plant in Prince Georges' County, Maryland could be applied for 370 years. Because of their progressively higher zinc contents, sludges from the Blue Plains Waste Water Treatment Plant (Washington, D.C.), Baltimore, Maryland and Grand Rapids, Michigan could be applied for 112, 39 and only 5 years, respectively.

Table 5 RECOMMENDED MAXIMUM CUMULATIVE SLUDGE METAL APPLICATIONS FOR PRIVATELY-OWNED CROPLAND

Metal	Soil cation exchange capacity (meq/100g)		
	0-5	5-15	15
	Maximum addition kg/ha		
Zn	250	500	1 000
Cu	125	250	500
Ni	50	100	200
Cd	5	10	20
Pb	500	1 000	2 000

Notes:
1. Annual Cd application should not exceed 2 kg/ha from dewatered or composted sludges, or 1 kg/ha from liquid sludge; sludge application should not supply more crop available N than the crop requires.
2. Sludges having Cd greater than 25 ppm should not be applied unless the Cd:Zn 0.015. If sludge Cd/Zn exceeds 0.015, an abatement programme to reduce sludge Cd to an acceptable level should be initiated.
3. These recommendations apply only to soils that are adjusted to pH 6.5 when sludge is applied, and are to be managed to pH 6.2 thereafter.
4. Leafy vegetables or tobacco should not be grown on sludge-treated cropland.
5. The CEC designation is for unamended soils.

The Piscataway and Blue Plains sludges are good quality sludges for land application, either directly, or after composting. With some abatement of Zn, Cu and Ni, the Baltimore sludge would be suitable for land application. The Grand Rapids sludge is a good example of a bad sludge, and it should not be applied to private land until the metal contents reach the "maximum domestic" levels shown in Table 3. While the Blue Plains digested sludge could be applied for 112 years before the soil Zn level would approach the USDA guidelines, Blue Plains raw sludge compost could be used for almost as long, i.e. 104 years. The reason for this is that although the digested sludge has a higher N level, the metal content of sludge is diluted in the composting process.

Table 7 shows the extent to which heavy metals are concentrated on the dilution of metals in both raw and digested Blue Plains sludges. Because of this dilution principle, an obvious question is: "Can a bad sludge be transformed into a good compost?" This question is answered, at least in part, by Table 8 which shows the extent of heavy metal dilution in Baltimore and Philadelphia digested sludges after composting with woodchips. While the Zn and Cu content of the Baltimore sludge was considerably higher than the recommended maximum domestic levels (Table 3), after composting the concentrations of these metals were within the acceptable range for land application. Although composting caused considerable dilution of heavy metals in the Philadelphia sludge, the concentration of Zn and Cd remained unacceptably high. Thus, in the case of "borderline" sludges, composting can produce a reasonably good product; however, when sludges contain excessive amounts of heavy metals it is most unlikely that composting will provide sufficient dilution for safe and acceptable use on agricultural land. It is also noteworthy that in addition to heavy metals, the levels of N and P in the sludge are also diluted by composting, thus reducing the fertilizer value od the compost.

Table 6

EFFECT OF THE METAL CONTENT OF SEWAGE SLUDGES FROM DIFFERENT MUNICIPALITIES ON THE MAXIMUM ALLOWABLE CUMULATIVE AMOUNT OF DRY MATERIAL THAT CAN BE APPLIED TO SOIL AS NITROGEN FERTILIZER ACCORDING TO THE USDA GUIDELINES

Metal and cumulative amount	Piscataway sludge	Blue Plains 1/ sludge	Blue Plains 1/ compost	Baltimore sludge	Grand Rapids sludge
		Level in sludge			
Zn, ppm	540	1 780	770	5 100	20 500
Cu, ppm	240	486	300	1 760	3 140
Nu, ppm	33	42	55	280	7 850
Cd, ppm	5	15	8	21	165
Cd/Zn, %	0.9	0.8	1.0	0.4	0.8
		Cumulative amount 2/			
Ton/acre	413	125	290	44	6
Mt/ha 3/	926	281	649	98	13
Fertilizer, yr 4/	370	112	104	39	5

1/ Column 1 reports the analysis of Blue Plains digested sludge, while column 2 reports data on compost made from Blue Plains raw (undigested) sludge.

2/ Cumulative loadings calculated from USDA and EPA recommendations; first limiting element is underlined.

3/ Assumes a soil CEC of 5 to 15 meq/100 g.

4/ Based on sludge or compost application of 100 kg N/ha/yr; sludge N = 4.0%, Compost N = 1.6%.

Table 7

METAL CONTENT OF PLAINS SLUDGES AND THEIR COMPOSTS

Material	Zn	Cd	Cu	Ni
		mg/kg dry wt.		
Raw sludge (RS)	980	10	420	85
(RS) Compost	770	8	300	55
Digested sludge (DS)	1 760	19	725	50
(DS) Compost	1 000	9	250	300 1/

1/ Samples were contaminated with fragments of nickel-containing serpentine rock from an unpaved composting pad.

Table 8

DILUTION OF HEAVY METAL CONTENT OF
BALTIMORE AND PHILADELPHIA DIGESTED SLUDGES
AFTER COMPOSTING WITH WOODCHIPS

Source	Material	Zn	Cd	Cu	Heavy metal dilution %
		mg/kg dry wt.			
Baltimore (Back River Treatment Plant)	Sludge	5 100	20	1 570	-
	Compost	1 730	7.5	619	60
Philadelphia (Northeast Treatment Plant)	Sludge	7 520	226	1 090	-
	Compost	4 100	100	1 000	50

4. CONSIDERATIONS FOR IMPROVING THE QUALITY OF SLUDGE COMPOST AFTER COMPOSTING

There are a number of ways in which sludge composts can be conditioned or modified to improve their quality and marketability. These include (a) selective screening, (b) leaching to remove soluble salts, (c) blending with sand or soil for potting mixes or synthetic topsoils, (d) enrichment with additional nutrients, particularly nitrogen, and (e) granulating or pelleting. An example of how the chemical properties of a sludge compost can be changed through selective screening into different sized fractions is shown in Table 9 (Tester et al 1978). The N content tends to increase with fine screening because of the greater removal of residual woodchips. This results in a much lower C:N ratio. The P content was also increased with fine screening. Pot tests showed that plants responded readily to the increased N and P levels in the finer fractions. The potential for using selective screening, in producing specially compost products is being thoroughly investigated.

Table 9

SOME CHEMICAL PROPERTIES OF BLUE PLANTS
RAW SLUDGE COMPOST AS AFFECTED BY SCREENING

Sieve fraction	pH	Total N	Total P	Carbon	C:N
		mg/g dry wt.			
Coarse (passed through a 6mm mesh)	6.8	12.3	14.7	180.6	14.7
Medium (1-6 mm sized fraction)	6.9	11.6	11.5	215.6	18.6
Fine (1 mm mesh or less)	6.8	13.5	18.0	140.5	10.4

5. SUGGESTED MONITORING PROGRAMME FOR A MUNICIPAL SEWAGE SLUDGE COMPOSTING FACILITY

To ensure (i) that proper conditions of moisture, temperature, and aeration are achieved during the composting process, and (ii) that a safe and acceptable high quality product is marketed, a comprehensive monitoring programme, as outlined in Table 10, is absolutely essential. The frequency of analysis for heavy metals and pathogens, either before or after composting, will depend on (a) the sludge volume and production schedules, and (b) the methods of marketing and utilization. For example, a facility that composts 50 tons of sludge per week will require less frequent analysis for heavy metals than one which is composting 500 tons per day. Moreover, if most of the compost is to be utilized for land reclamation or on agricultural soils, standards for pathogen survival should be less stringent than if the product is bagged for wholesale and retail marketing, or distributed directly to the public. Site monitoring, including health of personnel, odours, and dust, requires continuous surveillance. Until more is known about the possible significance of air-borne spores, monitoring programmes should periodically assess the numbers that are generated and transported from the site.

Table 10 SUGGESTED MONITORING PROGRAMME FOR A MUNICIPAL SEWAGE SLUDGE COMPOSTING FACILITY

Activity/time	Component	Analysis	Frequency
Before composting	Sludge bulking material	Heavy metals PCB's	Monthly
During composting	Aerated pile or windrows	Acceptable time/temperature relationships e.g. 55°C for 3 to 5 days	Temperature measurements on at least 6 days during first 2 weeks
After composting	Compost prior to marketing	Heavy metals pathogens Bioassay in growth chamber or greenhouse to characterize plant response, metal uptake, and phytotoxic effects	Monthly/bimonthly depending on use of compost
Site monitoring	Personnel	Physical examination prior to employment and periodically thereafter	Annually
		Protective equipment and clothing as needed	Continuously
	Odours	Regular monitoring of odour strength	Continuously, but especially during wet periods
		Regular maintenance of odour filter piles; log of complaints	Continuously
	Dust	Assessment of particulate concentrations	Continuously but, especially during dry periods
	Leachate & runoff	Analysis of BOD, suspended solids and pathogens	Monthly
	Air-borne spores	Determine numbers generated/ transported	Monthly

Preliminary plans for design of sewage sludge composting facilities should include assessments of numbers of air-borne spores (particularly _Aspergillus fumigatus_) prior to the start of composting so as to establish reliable background levels for possible future reference.

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Paper 8

RESOURCES OF ORGANIC WASTES IN EGYPT

by

Mohiy-Eldin Abdel-Samie
National Research Centre, Doki, Cairo, Egypt

Organic wastes are considered to be one of the renewable materials resulting from the synthesis of different compounds in plants by utilizing solar energy, water, CO_2 and other dissolved nutrients from the soil.

Organic wastes comprise the following:

i. the residues left on the land after harvesting the crops (maize and cotton stalks, etc.);

ii. the residues left after separating grains (maize cobs, rice and wheat straw, etc.);

iii. the residues resulting from grain milling and grinding (husks and brans, etc.);

iv. the agro/industrial residues resulting from extractive and transformative industries such as sugarcane, oil, starch, dairy products, and vegetable, meat and fish canning industries. These residues comprise bagasse, maize steep liquor, maize germ cake and gluten, cotton seed cake, whey and meat and fish wastes, etc.;

v. land and aquatic weeds resulting from clearing waterways and cultivated lands.

Upon the advancement of the different branches of science it has been feasible to utilize organic wastes to produce enzymes, proteins, antibiotics, organic acids and solvents, as well as non-fossil fuels such as methane and hydrogen through microbial fermentation processes. On the other hand, the production of petro-chemicals from petroleum fractions and natural gases (fossil fuels) has been a competent technology to fermentation industries.

However, the consistent rise in petroleum prices might imbalance this situation favouring microbiological utilization of organic wastes to produce industrially important chemicals.

In rural areas of Egypt most of the crop residues are used as animal fodder. Even maize stalks and cobs have been used for this purpose upon the abrupt rise in the prices of roughages such as wheat straw. Cotton stalks are used for energy production through direct burning. Obviously, this means the loss of a great proportion of the organic matter needed to be recycled to keep soil productivity at a high level.

The competition between burning the organic wastes for energy production and its utilization in a manner suitable for the adequate recycling of organic matter should be handled seriously to preserve and increase our soil productivity.

A good compromise is to adopt the technologies of biogas production by anaerobic digestion of organic wastes. Only the carbon component will be consumed to give mainly methane and CO_2. Macro and micronutrients will be reserved in the digester as a stabilized sludge.

The use of cotton residues for biogas production has not been tried extensively.

Rizk et al (1968) actually made preliminary trials for combustible gas production from the anaerobic digestion of cotton, maize and rice stalks. Their data show that the amount of combustible gases produced from cotton stalks digestion was half that produced from maize stalks.

Cotton stalks are known to resist degradation when compared with other crop residues such as barley (Abdel-Malik et al 1965). This relative resistance to biodegradation was also met in the work done at the National Research Centre (Kamel et al 1966). Laboratory and field experiments were carried out to obtain bast fibers and cotton stalks, which proved to be resistant to the conventional retting practice, if stagnant water was used. Investigations proved that the stalks contained compounds inhibitory to the anaerobic retting organism, Clostridium felsenium. This problem was solved by soaking the stalks for 2 to 4 days in plain water and subsequent transfer of the stalks to the retting basins. This soaking was sufficient to overcome the inhibitory effect of the constituents of the cotton stalks. In the field, this problem was solved by using the waterways (drainage or irrigation canals) for retting, since the slow flow of water would take care of removing the inhibitory compounds from the immersed stalks. The inhibitory substances, although not fully identified, might be of the polyphenolics known to be present in cotton leaves (Abdel-Wahid 1969).

The above mentioned work might lead to the anticipation of a similar situation in the anaerobic digestion of cotton plant residues for methanogenesis. Investigations concerned with biogas production from such a residue should take into consideration such inhibitory compounds, in addition to the problems of degradation of ligno-cellulosic materials in the initial stages of anaerobic digestion.

A potential source of organic waste, that deserves the attention of an investigator, is the collected cotton leaves infested by the cotton leaf worm. Another similar residue is the infested cotton bolls. The anaerobic biodigestion of these residues, not only serves the purposes of combustible gases and manure production, but also breaks the cycle of reinfestation of the subsequent cotton crop. Abou-El-Fadl et al (1958) studied the impact of composting the infested cotton bolls into organic manure as a control of the pink boll worm, Pectinophora gossypiella.

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GREEN MANURE

by

S.A.Z. Mahmoud and M. El-Sawy
Agric. Microbiology Dept., Fac. of Agriculture
Ain Shams Univ., Cairo, Egypt.

1. INTRODUCTION

It is well known that organic matter influences the physical, chemical and biological properties of soils, which in turn affect the growth and development of plants. Organic matter improves the physical structure, soil aggregation stability, and water holding capacity. From the chemical point of view, organic matter increases cation exchange capacity and supplies plants with a stream of nutrients through its decomposition by micro-organisms.

Organic matter, including green manure, is generally of great importance to soil fertility and hence productivity. The permanent fertilization experiments at Rothamsted Experimental Station, England (150 years), and at Bahteem, Egypt (80 years) showed that organic matter treatments gave the highest yields as compared with other treatments receiving inorganic fertilizers. The use of organic manures is inevitable especially in tropical and subtropical soils and also in sandy soils where the rate of degradation of organic matter is very high, due to the presence of optimal environmental conditions for microbial activities.

Nowadays, apart from the hazard of the use of inorganic fertilizers due to water pollution and the effect of nitrogen oxides produced as a result of nitrate reduction on the ozone layer, mineral fertilizers became so expensive due to the high increase of oil prices. Consequently, organic manures are now regaining their popularity, especially with the advancement in technology of waste recycling to avoid mainly environmental pollution, and increasing agricultural production to meet the high rate of increase in world population.

Factors influencing the rate of decomposition of soil organic matter have been the target of many investigators: Jensen 1929; Starkey 1924; and Whiting 1926; found that organic materials with wide C/N ratios decomposed slowly, and that younger plants decomposed more rapidly than older ones. Also Waksman (1929) reported that the nature amd rapidity of decomposition of different plant materials, were markedly influenced by their chemical composition, provided that conditions for decomposition were the same. The rate at which organic matter decomposes, increases with increasing moisture and also with rise in temperature (Waksman & Gerreston 1931). It appears that temperature is a more important factor than moisture, but obviously a combination of both is most effective on the organic matter decomposition.

Green manuring is a very old practice. It is well known since the Romans. Both leguminous and non-leguminous plants are utilized for this purpose. Because of the importance ascribed to soil organic matter, interest has been created in developing practical methods for maintaining or increasing organic matter content of our soils. Green manures and crop residues had been the chief means whereby this maintenance or increase has been attempted.

Green manuring is a good means of preserving soil nutrients from leaching, fixing or trapping them in an insoluble organic form which, when mineralized by soil micro-organisms, supplies the plants with a gentle stream of nutrients throughout their life period in the soil. Further, green manures in addition to fixing available nutrients in the soil in the organic form, increase soil nitrogen and organic matter, gained from nitrogen fixation and photosynthesis.

2. COMMON GREEN MANURES

i. The best known green manures are legumes associated with fixation of atmospheric nitrogen. These can be incorporated in the rotation as green manures such as berseem (Trifolium alexandrinum) which is ploughed under after taking one cut or more before cultivating cotton. Other plants, such as soybean and cowpea yield a food crop before being ploughed under as green manure.

ii. In view of the fact that the rate of decomposition of organic matter in our soils is high, Sesbania and Crotalaria legumes, which grow as shrubs containing a high content of cellulotic material, can be used as green manures. The rate of decomposition of these shrubs is slow and they add ample amounts of organic residues and nitrogen to the soil.

iii. Water-hyacinth, a weed which is a nuisance by obstructing irrigation canals and open drainage systems, in addition to absorbing considerable amounts of nutrients from water, can also be used as green manure or feed stuff. It is either composted, or added directly to the soil after being dried and chopped to small pieces.

iv. Blue-green algae, green algae, and also water-hyacinth can be grown in ponds of sewage enriched waters. Such organic materials can be used to enrich animal or poultry feeds or as manure in addition to its effects on the purification of sewage water.

v. The fern Azolla in association with the blue-green algae Anabaena azolla fixes atmospheric nitrogen and can be used as green manure in rice fields. This symbiosis can produce almost 1 ton of green manure/hectare/day, having 3 kg of fixed nitrogen. In Egypt, we should pay more attention to this plant. Also, inoculation of rice fields with blue-green algae is of considerable importance, especially in Egypt, where we can make use of the solar energy and N_2 assimilated by algae. In addition to N_2-fixation, the algae also supply the plants with growth promoting substances, but we need to have a percolating system especially when the plants grow older and shade the algae from the direct sunlight.

3. THE USE OF GREEN MANURE IN EGYPT

Quite a lot of work has been done on the effect of green manuring on the fertility of sandy soils in Tahreer Province, Egypt. Reclamation of these virgin sandy soils could be achieved by organic manuring, addition of mud, and proper management. These soils are sandy in general and are almost destitute of clay and humus.

Results of experiments carried out on Tahreer Province soils (Tables 1, 2 and 3), showed that the rate of decomposition of added organic material depended primarily upon its chemical composition and C/N ratios. The rates were in the following descending order: groundnut, Egyptian clover, compost, Sudan grass and barley. It was also found that soil organic matter, soluble nitrogen, and microbial contents were greatly affected by the added organic matter.

In other experiments (Tables 4 and 5), results showed that the addition of winter or summer green manures or compost to the soil, in equal quantities, resulted in increasing the soil contents of organic matter and total nitrogen as compared with the control.

The rate of decomposition of added organic materials, as well as the extent of increase in soil nitrogen depended on the nature of the plant to be ploughed under, its age, and the period during which the green manure was left in the soil to decompose, before cultivating the succeeding crop.

Table 1

ORGANIC MATTER, TOTAL NITROGEN AND C/N RATIO OF SOIL, GREEN MANURE AND COMPOST USED FOR INCUBATION EXPERIMENTS

Material used	Total nitrogen %	Organic matter %	C/N ratio
Soil	0.016	0.12	4.3
Green manure: 1/			
Barley	1.42	74.00	30.4
Sudan grass	1.84	73.84	23.3
Egyptian clover (Berseem)	2.28	72.00	18.3
Groundnut	2.46	71.60	17.1
Compost	2.01	51.00	14.8

1/ Green manure was used just at the beginning of the flowering stage.

Table 2

CHEMICAL ANALYSIS OF SOIL SAMPLES TREATED WITH GREEN MANURE AND COMPOST

Soil analysis	Incubation period in days					
	0	7	15	30	60	120
Barley						
pH	8.10	8.20	8.30	8.30	8.45	8.50
Organic matter %	0.64	0.55	0.51	0.49	0.47	0.46
Total N, ppm	560	550	560	560	560	560
Soluble N, ppm	1	5	11	19	30	34
Sudan grass						
pH	8.20	8.30	8.30	8.35	8.40	8.40
Organic matter %	0.66	0.55	0.50	0.47	0.43	0.42
Total N, ppm %	600	600	610	610	600	600
Soluble N, ppm	1	8	16	22	35	40
Egyptian clover						
pH	8.80	8.75	8.70	8.60	8.45	8.40
Organic matter %	0.66	0.50	0.40	0.36	0.32	0.29
Total N, ppm	630	730	710	720	700	700
Soluble N, ppm	10	60	100	130	200	220
Groundnut						
pH	8.50	8.40	8.35	8.35	8.30	8.20
Organic matter %	0.70	0.60	0.50	0.42	0.33	0.28
Total N, ppm	800	800	820	810	780	770
Soluble N, ppm	10	70	120	160	240	260
Compost						
pH	8.10	8.00	7.90	7.90	7.90	7.90
Organic matter %	0.66	0.54	0.48	0.44	0.39	0.35
Total N, ppm	160	700	710	700	680	680
Soluble N, ppm	6	40	70	92	130	146

Table 3

BACTERIAL CONTENT OF SOIL SAMPLES
TREATED WITH GREEN MANURE AND COMPOST

Material added	Incubation period in days					
	0	7	15	30	60	120
	Total bacterial count, millions/g dry soil					
Barley	14	30	50	60	70	65
Sudan grass	15	40	60	65	75	70
Egyptian clover	20	70	90	100	115	110
Groundnut	20	80	100	110	120	115
Compost	15	60	75	85	110	105
	Sporeformers, millions/g dry soil					
Barley	1.0	3.0	5.0	6.0	7.5	7.5
Sudan grass	1.2	4.0	6.0	6.5	8.0	8.0
Egyptian clover	1.6	6.4	9.0	10.0	12.0	12.0
Groundnut	1.5	7.0	10.0	11.0	12.5	12.0
Compost	1.1	5.0	7.0	8.0	11.0	11.0

Table 4

EFFECT OF EGYPTIAN CLOVER GREEN MANURING AND COMPOST
ON SOIL CONTENTS OF ORGANIC MATTER AND TOTAL NITROGEN
AND ON GRAIN YIELD OF SESAME

Organic manure added	Cultivation time days 1/	Organic matter %		Total nitrogen %		Yield 1/ kg/acre
		Initial	Final	Initial	Final	
Clover green manure						
Old	1	1.54	0.74	0.08	0.07	520
	15	1.46	0.70	0.08	0.07	520
	30	1.37	0.62	0.07	0.06	462
Young	1	1.52	0.64	0.09	0.07	462
	15	1.40	0.55	0.08	0.07	434
	30	1.26	0.45	0.08	0.07	405
Compost						
(11 ton/acre)	-	0.84	0.63	0.06	0.05	482
None (control)	-	0.14	0.29	0.02	0.02	289

1/ Time of cultivation of sesame after ploughing the green manure.

Table 5

EFFECT OF GROUNDNUT GREEN MANURING AND COMPOST
ON SOIL CONTENTS OF ORGANIC MATTER
AND TOTAL NITROGEN AND ON GREEN YIELD OF MAIZE

Organic manure added	Cultivation time days 1/	Organic matter %		Total nitrogen %		Yield 1/ ton/acre
		Initial	Final	Initial	Final	
Groundnut green manure						
Old	1	1.37	0.49	0.07	0.06	2.12
	15	1.24	0.48	0.07	0.06	2.08
	30	1.11	0.44	0.07	0.06	1.93
Young	1	1.34	0.39	0.08	0.07	1.54
	15	1.11	0.36	0.07	0.06	1.35
	30	0.92	0.31	0.07	0.06	1.08
Compost (11 ton/acre)	-	0.84	0.84	0.06	0.05	2.04
None (control)	-	0.14	0.20	0.02	0.02	0.81

1/ Time of cultivation of maize after ploughing under the green manure.

It was also found that in addition to mineral fertilizers, treating the soil with clover green manure, with groundnut green manure or with compost, in equal quantities, resulted in increasing significantly the sesame and maize yields as compared with the control treatment. Green manuring with clover or the addition of compost, in equal quantities, was found to have nearly the same effect on sesame yield (Table 4). On the other hand, the use of younger groundnut green manure, gave a significantly lower yield of maize than compost or older groundnut green manure (Table 5).

Regarding the added plant materials which vary in their chemical composition, it is natural to expect that there will be differences in the rates at which they decompose. Evidently the rate of decomposition of added materials depended upon their C/N ratio. The wider the C/N ratio, the larger the period required to decompose (Waksman 1942). Leguminous green manures were found to be more rapid in decomposition than non-leguminous green manures. Compost added was found to be slower in decomposition than leguminous plant materials, although its C/N ratio was lower. This could be due to the fact that the added compost had reached a certain degree of stability, where the more easily available portions of the organic matter were decomposed. The remainder consisted of rather resistant materials, where decomposition processed more slowly and with much more difficulty as stated by Brown and Allison (1916).

It was found that the incubation period had no effect on the soil total nitrogen. The soil total nitrogen did not vary in the soil manure-mixtures from the commencement to the end of the experiment, within the limits of accuracy of the method of analysis. This was confirmed by Hibbard (1919), who explained that on the basis that aerobic conditions were continuous in the experiment, hence no loss of nitrogen was to be expected. No doubt, there were considerable changes in the form and combinations of the nitrogen. Even, there may have been some losses of gaseous nitrogen as a result of denitrification, which might have existed under aerobic conditions, yet such loss was compensated by the fixation of atmospheric nitrogen by the non-symbiotic nitrogen-fixers, as indicated by Hutchinson (1918) and Ibrahim (1964). Consequently, the total nitrogen was found to remain nearly constant.

The decomposition process was at first rapid, where the increase in microbial numbers had reached its maximum after 60 days of incubation (Table 3). After this period, the process was gradually slowed down where microbial numbers slightly decreased till 120 days of incubation, the duration of the experiment. This was due to the fact that the development of micro-organisms during the first 60 days of incubation exhausted the supply of most available nutrients resulting in subsequent decrease in numbers.

Composts and leguminous plants gave higher densities of microbial population than non-leguminous plants. This is simply due to the presence of more nitrogen in the former than in the latter. In the last case, nitrogen will be the limiting factor for the development of soil microflora. Besides, the presence of more resistant forms of organic matter in non-leguminous plants such as cellulose and legnin, would cause the slow decomposition of the added organic materials as reported by Waksman and Starkey (1924) and Waksman (1952).

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Paper 10

USE OF ORGANIC MATERIALS AS SOIL AMENDMENTS

F. Gati
Sandy Soil Department, Research Institute for Soil Science
and Agricultural Chemistry of the Hungarian Academy of Sciences
Budapest, Hungary

Summary

Organic materials can be considered as humus supplying and soil improving agents. The maintenance of a balanced humus regime is of particular importance in soils of the arid and semi-arid regions. The improvement of soil physical and chemical properties and of the nutrient status depends to a great extent on the rational use of organic materials as amendments.

The formation of a deep fertile layer is a basic condition of improving light-structured sandy soils, poor in nutrients and colloids. The improvement can be carried out by:

i. the ploughing of organic materials into the upper 0–40 cm layer of the soil;

ii. the carpet-like placement of these materials at depths of 40–60 cm.

Some of the materials and methods discussed are at present only of scientific importance, for example the clay-humus complex and organic materials activated with polymers. Fossil organic materials such as lignite and brown coal are already applied in practice as composts; but the use of some of their derivatives, for instance, lignite disaggregate with liquid manure, would solve serious problems of environmental conservation. The efficiency of humic acid preparations and fertilizers on brown coal base was justified by the experiments.

Some products and by-products of the petroleum industry can be regarded as organic amendments, e.g. acid-resin originating from petroleum refinery, and different types of bitumen emulsion.

1. INTRODUCTION

Soil organic matter means the bulk of materials of plant and animal origin decomposed in the soil, the living and dead mass of micro-organisms and the perfectly decomposed end-product called humus. The soil's physical, chemical and biological properties are influenced by the humus fraction, which also plays an essential role in the nutrient supply for the plants. It follows that the conservation of soil organic matter is an important factor in soil fertility. The type and texture of the soil and the climatic conditions determine the humus level of the soil.

The present paper deals with the use of traditional organic materials of plant and animal origin from the aspect of soil improvement. Information is also given on some recent organic amendments, methods, and trends in research. We tried to consider the soil problems of arid and semi-arid regions where the conservation of humus is considerably influenced by climatic and soil conditions.

2. MAINTENANCE OF SOIL PRODUCTIVITY WITH ORGANIC MATERIALS

The maintenance of soil productivity requires a certain constant level of organic matter. This is a special problem in soils with low humus content, e.g. loose-structured sands. These soils have an unfavourable nutrient and water regime.

Egerszegi et al (1972) stated that the humus and $CaCO_3$ content of sandy soils had a significant influence on crop yield and efficiency of fertilizers. High $CaCO_3$ (above 10%) and low humus (about 0.5%) are limiting factors for the soil fertility. According to Sarkadi (1958) nitrogen is the main influencing factor in sandy soils.

The principal sources of soil organic matter are crop residues, e.g. stubble, roots, etc., but also of importance are organic materials of animal origin, e.g. liquid manure, farmyard manure, etc.

The conservation of humus in soils of arid and semi-arid regions is impossible without organic materials, the most important of which are dealt with in the following paragraphs.

2.1 Green Manure

Green manuring is the incorporation of plant material before maturity while green into the soil. This method of manuring was known to the Romans; Cato (234-149 BC) and Vergilius (70-19 BC) suggested ploughing under leguminous crops such as bean, lupin or vetch to enrich the soil.

In the case of leguminous crops, not only the organic matter content but also the N reserve of the soil is increased. Nutrients in the subsoil become available and the soil surface is protected from drying by the shadowing effect. For increasing the productivity of sandy soils, low in humus, vigorous leguminous forages are preferred. By applying green manure plants, average amounts of 200 to 300 q fresh green mass and about 50-100 kg N are incorporated into the soil per hectare and it is only the P and K that have to be supplemented.

The developed root system of green manure plants improves the soil structure and enriches the humus content (Alekseev, 1948).

The yield increasing effect of green manure is mainly due to its N-supplying capacity. According to Barnes and Clarke (1963), clover as a green manure increased the yield of barley and sugar beet grown in a light Woburn soil.

In Hungary, where the average annual precipitation is 550 mm, experiments on green manure in crop rotation, conducted by Westsik (1965) since 1928, proved that green manure plants, especially lupin, were successful for the improvement of blowing sand. Between 1955 and 1961, Antal (1968) carried out green manuring experiments with rye, hairy vetch and white flowered Melilotus in three kinds of crop rotations in sandy soils (pH 7.0-7.2; humus 0.4-0.7%). Potato, maize and rye received mineral fertilizers in amounts of 35 kg P_2O_5 and 55 kg K_2O per ha. Nitrogen was not applied. The cumulative data of six-year experiments are shown in Table 1.

2.2 Straw Manure

In traditional small-scale agricultural production, the straw of cereals is usually used for making farmyard manure. In large-scale production, a part of the straw is used in industry (e.g. cellulose production), but a considerable amount is returned into the soil after composting and fermentation.

Simon (1963) observed that the adsorption capacity of the soil increased with straw manuring and with nitrogen application; permanent well-absorbing humus forms were developed. According to Erofeev and Vostrov (1964), straw manuring favourably influenced the soil structure and water regime; further, it had a protecting effect against water and wind erosion.

Table 1 EFFECTS OF HAIRY VETCH-RYE MIXTURE AND WHITE FLOWERED MELILOTUS ON THE YIELDS OF POTATO AND MAIZE AND THEIR RESIDUAL EFFECT ON RYE IN ROTATION (Antal 1968)

Crop / Green manure	Potato 1955–1957 q/ha	Potato 1955–1957 Relative number	Maize 1958–1961 q/ha	Maize 1958–1961 Relative number	Rye 1956–1961 q/ha	Rye 1956–1961 Relative number
Control	83.8	100.0	18.6	100.0	12.3	100.0
Hairy vetch-rye mixture	126.9	150.7	25.8	138.7	21.9	178.0
White-flowered melilotus	117.1	139.9	29.9	160.7	19.3	156.9

Soils with a low nutrient status can also be enriched by straw manures. As reported by Bergman et al (1966), 50 q/ha straw supplies the following macro and micro-element amounts to the soil:

Macro-elements	Micro-elements
20–35 kg N	28 g B
5–7 " P	15 " Cu
60–90 " K	150 " Mn
10–15 " Ca	2 " Mo
4–6 " Mg	200 " Zn
5–8 " S	0.5 " Co

Sauerlandt and Gierke (1961) reported on the increase of available P, K and Mg content in the examined acid soil due to straw manuring.

In Hungary, Westsik (1955) prepared straw manure by fermentation and compared it with raw straw, this fermented material gave about 10 to 20% more yield in rye-potato-rye rotation. Westsik stated, however, that green manure and farmyard manure cannot be substituted by straw material.

2.3 Farmyard Manure

Farmyard manure is the most ancient organic matter source used to conserve soil productivity. By the intensive use of mineral fertilizers, it is possible to reach high yields but humus content cannot be increased this way.

Cooke et al (1958) compared fertilizers and farmyard manure in long-term experiments. In the first half of the century, relatively low fertilizer rates were used. Today, fertilizer doses are multiplied and crop yields are considerably higher. However, experimental data demonstrated that there were no marked differences between mineral fertilizers and farmyard manure in crop yields using a poor calcareous loam soil (Table 2).

Table 2 YIELD DATA OF LONG-TERM EXPERIMENTS AT SAXMUNDHAM, SUFFOLK, ENGLAND AVERAGE OF THE YEARS 1901-1956 (Cooke *et al* 1958)

Treatment	Yield/acre average of the years 1901–1956				
	Wheat grain bu	Mangolds roots ton	Barley grain bu	Beans grain bu	Clover hay cwt
Control	18.2	4.3	16.6	20.8	39.4
Farmyard manure 1/	33.4	18.6	32.8	39.8	77.7
NPK 2/	34.0	18.8	35.5	37.2	60.2

1/ Applied FYM: 6 ton/acre
2/ $NaNO_3$: 2 cwt/acre, Superphosphate: 2 cwt/acre, and potassium salt: 2 cwt/acre.

Table 3 INSTABILITY FACTORS AND WATER PERMEABILITIES OF CLAYS AND SANDY SOILS (Williams and Cooke 1961)

History and treatment	Instability factor per cent	Permeability to water after slaking ml/hr/cm^2
	Clay soils	
Arable		
Fallowed for several years	15	20
FYM annually	00	130
Grass	00	520
Ploughed before sampling	5	360
	Sandy soils	
Arable		
Cereals continuously	42	30
FYM each year	46	50
Grass	0	2.600

Instability factor: Loss in pore space on slaking.

The influence of farmyard manure on soil structure was studied by Williams and Cooke (1961). Loss in pore space and permeability of the slaked soil were measured (Table 3). Stable structures were observed after the use of farmyard manure as well as under grass in the clay soils. In the latter case water permeability increased. In the sandy soils, the structure was not stabilized by using farmyard manure in the course of 18 years. In contrast, grass growing for 3 years resulted in structural stability and good permeability of these sandy soils (Table 3). In long-continued rye cultivation on a diluvial loamy sandy soil at Halle (German Democratic Republic), Kullman (1962) reported data on the formation of water stable aggregates, the changes in the bulk density, volume weight and water permeability (Table 4 and Fig. 1). These experiments started in 1898 with (a) 120 q farmyard manure/ha, annually, (b) 40 kg N, 56 kg P_2O_5 and 90 kg K_2O/ha, annually and (c) unfertilized.

These data indicate decidedly the direct and positive effect of farmyard manure on the soil structure. This influence, however, depends considerably on the compaction and the duration of the continuous organic matter supply.

2.4 Industrial and Urban Wastes

World-wide industrialization is accompanied by the accumulation of industrial and urban wastes in large amounts. The utilization of these materials in agriculture is important due to their nutrients content and for reasons of environmental conservation. The main forms of these wastes are:

i. by-products of food and fermentation industries;

ii. liquid manures produced by large-scale animal husbandry and,

iii. urban wastes, e.g. sewage, activated sludge, composts from urban and slaughter house wastes.

In certain cases, these materials are used as ameliorants. Their significance as nutrient supplier is discussed by Varga et al (1975) and Raychaudhuri (1977).

Table 4 CHANGES OF SOIL PHYSICAL PROPERTIES IN LONG-TERM RYE CULTIVATION EXPERIMENTS AT HALLE (Kullmann 1962)

	With FYM	NPK	Unfertilized	LSD 5%
Volume weight g	127.83±0.72	131.60±0.74	136.37±0.83	3.12
Pore space %	51.56	50.34	48.54	
Water permeability ml/min	6.26±0.43	5.15±0.32	5.10±0.30	1.56

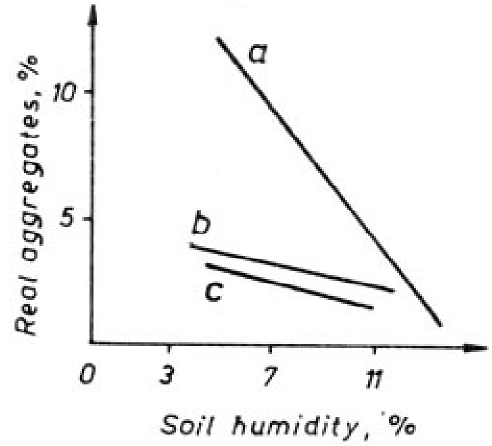


Fig. 1 Aggregate Stability as a Function of Soil Humidity
Regression lines: (a) FYM; (b) NPK; and (c) Control
(After Kullmann 1962)

2.5 Mulching and Minimum Tillage

Light structured soils are usually exposed to the influence of wind erosion upon desiccation. Massoud (1975) emphasized that due to the low water storage capacity of sandy soils, evaporation losses are high. This can be reduced through the use of surface mulch.

Plant residues applied or left on the soil surface from the preceding crop are used to reduce soil loss and weed growth and to conserve moisture. Different plant materials such as straw, leaves, sawdust and stubbles are highly effective. In general, a 50 to 80 percent saving of water may be effected depending on the thickness of the mulch layer and the nature of the mulching materials. But mulching is not applicable to field crops requiring frequent intertillage. The combination of mulching with minimum tillage on sandy soils would have beneficial results. It promotes organic matter accumulation in the soil, increases water storage capacity and improves soil structure. No-tillage was introduced with success on Hungarian sandy soils by Egerszegi (1972). The soil surface was protected with rye which is destroyed with "Gramoxone", and served as a mulch during the spring-summer period. Into rows made in the mulch cover, maize was sown and corn stalk was equally used for mulching. In the case of minimum and no-tillage, ploughing was not necessary and root mass was left undisturbed. By this method soil structure can be improved by time.

3. IMPROVING LOOSE STRUCTURED SOILS POOR IN NUTRIENTS AND COLLOIDS

On sandy soils, high crop yields can only be reached if the physiological requirements for crop production are considered. This means that the special demands of the plants and the chemical and physical soil properties are to be taken in account. This comprises a deep fertile layer, ensuring the continuous nutrient and water supply for the plants through improving the absorption properties of the soil by using organic and inorganic colloids and protection against water and wind erosion.

Research and experiments of Egerszegi (1953), Klimes-Szmik (1954), Antal (1956), Muller and Rauhe (1959), Dvoracsek and Dvoracsek (1961), Makled (1962, 1967), Kozak (1971) and Balba (1975) contributed to a large extent to the realization of these aims in sandy soils.

The improvement of sandy soils of low colloid and humus content cannot be imagined without organic materials of sufficient quality and quantity, which once incorporated into the soil, promote the continuous nutrients supply and improve the water regime.

Farmyard manure, peat, lignite and their composts are the traditional amendments used in large-scale farming in Hungary. To promote the formation of a deep fertile layer, these materials are uniformly ploughed into the upper 0-30 or 0-40 cm soil layer. They can serve as a barrier if deep placed.

3.1 Improvement of Sandy Soils with the Use of Organic Materials

Organic materials, especially peat and farmyard manure as amendments, are mainly used on sandy soils to increase their fertility. The deeper the fertile layer can be formed the more the colloid characteristics are improved and the nutrient supplying capacity and water retention are increased.

Peat is formed in marshes under favourable climatic, geomorphological and biological conditions. According the Domsodi (1977), the composition of some Hungarian peats are given in Table 5. The neutral, darker fen peats, containing humificated components, are generally preferred to high-moor peats originating from acid sphagnum poor in nutrients. Peat is composted with farmyard manure or only with NPK mineral fertilizers. Nowadays, the production of artificial composts on peat base is going on at an industrial scale. Peat composts are used, primarily, as amendments in Hungary, Poland, and the Soviet Union for improving sandy soils. Ninikov et al (1962) studied the yield of potato as affected by highmoor, fen peat and their composts fermented with mineral fertilizers and established the superiority of fen peat. According to their data, the water retention capacity of the soil was improved and the amount of water stable aggregates in the 0.25 - 10 mm fraction increased.

Table 5 QUALITY OF SOME HUNGARIAN PEAT AND PEAT-SOIL (Dömsodi 1977)

Site	Volume weight 1/ t/m^3	Ash content 1/ %	Organic matter %	pH
Osli peat	0.16	16.1	53.9	6.2
Peat-soil 2/	0.4	35.9	34.1	6.4
Kecel-Kiskoros peat	0.2	22.5	47.5	6.9
Peat-soil 2/	0.4	38.2	31.8	7.2
Nádasladany peat	0.2	20.0	49.8	6.7
Peat-soil 2/	0.4	36.7	33.3	7.1

1/ Related to 30% humidity
2/ Top-layer

THE CHEMICAL COMPOSITION OF THE ORGANIC MATTER WITHOUT ASH

Carbon (C)	53.01 - 57.00%
Hydrogen (H)	5.50 - 5.90%
Oxygen (O)	34.01 - 38.00%
Nitrogen (N)	2.01 - 3.50%
Sulphur (S)	0.06 - 2.66%

Table 6 AMENDMENT DOSES USED FOR SAND IMPROVEMENT

Humus content of the soil %	Amendment doses q/ha		
	Peat-soil	Farmyard manure	Mineral fertilizers
			Arable land
0 - 0.5 0.5 - 1.0	700 600	200 200	NPK: According to the requirements of the crop 1/
Ploughing at minimum 35 cm depth			
			For vineyards and orchards
0 - 0.5 0.5 - 1.0	900 700	300 300	NPK: According to the requirements of the plant
Ploughing at minimum 60-70 cm depth			

1/ Minimum 75 kg N, 50 kg P_2O_5 and 120 kg K_2O/ha

Source: Soil Laboratory of the Centre for Plant Protection and Agrochemistry Budapest (Hungary)

On calcareous sandy soils the following amendments are used: mixtures of fen peat, farmyard manure and mineral fertilizers. On acid sand the acidity of the soil has to be neutralized by liming. Table 6 presents some amendment doses suggested by the Soil Laboratory of the Centre for Plant Protection and Agricultural Chemistry, Hungary. Further amendment combinations are:

i. fen peat, farmyard manure and pulverized lignite completed with NPK fertilizers,

ii. fen peat and pulverized lignite completed with NPK fertilizers, and

iii. pulverized lignite completed with NPK fertilizers.

3.2 Sand Reclamation by Deep-placed Organic-mulch Layer

Sand amelioration and the applied agrotechnics have to be adjusted to the soil type and the biological requirements of the cultivated plant. Considering these as aspects, Egerszegi (1953) elaborated the system of placing deep layers for lasting amelioration. In contrast with the traditional methods of soil cultivation and fertilization, deep ploughing and deep-placement of organic materials achieved:

i. an improvement in the physical properties of highly compacted sandy soils,

ii. the formation of a wet local nutrient zone,

iii. the regeneration of the organic material by the roots penetrating into the barrier, and

iv. a decrease in the rate of mineralization and of microbial activity (Szabo and Egerszegi 1969).

The deep placement of organic materials resulted in an increase in the water and nutrient amounts and, when undisturbed, remained effective for several years. This is supported by the development of a voluminous and physiologically active root mass which penetrates into the deeper layers. The development and shape of the root system is illustrated in Fig. 2. A long-term experiment lasting 7 years (Table 7) shows the effect of deep placement in comparison to traditional manuring. The ploughing depth varies according to crop, so the organic mulch layer is placed for vegetables 35 cm deep, for field crops 45-64 cm deep, and for orchards and vineyards 70-110 cm deep.

When compared with the traditional deep cultivation at 20 cm the field increases were 40-60% with fodder crops, 20-40% with cereals and 60-90% with potato with the use of deep-placed mulch layers. Results obtained by Makled (1962, 1967) proved the favourable effect of deep-placed organic materials on yield under the climatic conditions of both Hungary and Egypt.

4. SPECIAL AMENDMENTS OF ORGANIC ORIGIN

In the past decades increasing interest has been shown in soil amendments of organic origin. Recently, investigations were carried out to fit the inorganic colloids into the clay-humus complex system and the application of linear and cross-linked polymers. Organic materials of fossil origin (e.g. brown coal and lignite) as the basic material of amendments are nowadays manufactured in technological processes of the fertilizer industry.

4.1 Clay-humus Base Activated with Linear Polymers

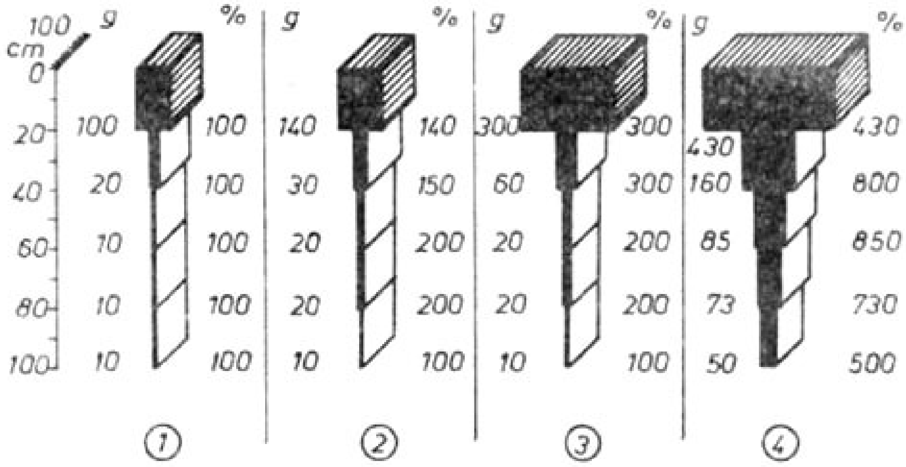
Fluvial silt and organic materials are used to enrich sandy soils in Egypt. Ahmed and Mahmud (1968) obtained valuable results for agricultural practice in this respect, the importance of which was emphasized by Balba (1973) and Sabet et al (1971). Ziegler (1957) suggested the improvement of sandy soils with amendments produced from mixtures of montmorillonite-type clay minerals and neutral organic materials such as peat.

The development of amendments on clay-humus base is the homogenization and activation of clay mineral and clay mineral organic material mixtures by linear polymers. The produced clay-humus-polymer (AHP) complex materials are essentially transformed from a colloidic aspect. Linear polymers can be, for example, hydrolyzed polyacrilic nitryl (HPAN), vinyl acetate maleic acid anhydride copolymer (VAMA), etc. In this system a clay mineral of the montmorillonite type, usually bentonite, is the inorganic component and the organic material consists of peat of lignite. Gàti and Mikes (1964), Gàti and Kazo (1965), Makled and Gàti (1968) and others studied the different effects of clay-humus systems activated with HPAN, AHP on the cation exchange capacity (Table 8).

Also, clay-humus complexes activated with polymers (AHP) improve soil physical properties (Gàti and Kazo 1965). AHP preparations have significant fertilizing effect as well. The technology of the AHP preparation was elaborated by Gàti et al (1960).

4.2 Organic Materials with Activity-retarding Effect, Treated with Cross-Linked Polymers

It is well known that farmyard manure and composts have only a short-lasting effect. Their nutrient supplying and improving capacities in sandy soils are limited to a maximum of two to four vegetative periods because of their rapid decomposition and mineralization in the soil. Natural organic materials (corn stalk, straw, etc.), due to their unfavourably wide C/N ratio, often cause yield decreases (pentosane effect). To double these materials, partly contrasting aims were set:



① Shallow cultivation
② Deep ploughing
③ Shallow cultivation and surface manuring
④ Sand reclamation by layering organic mulch

Fig. 2 Distribution of Medicago Sativa L. Root System
(After Egerszegi 1972)

Table 7 COMPARATIVE RESULTS OF A SAND IMPROVEMENT LONG-TERM EXPERIMENT
(Egerszegi 1971)

Treatment	1960 corn air dry	1961 wheat grain	1962	1963	1964	1965	1966
				Alfalfa green manure			
				Yield q/ha			
Control	15.5	12.9	9.2	159	138	127	57
FYM incorporated in surface layer	21.5	17.5	9.8	235	195	268	125
Turned sand	17.8	13.5	23.6	162	130	118	58
Deep placed FYM	41.9	27.1	50.6	249	257	529	344

Table 8 CHANGES IN THE ADSORPTION CAPACITY OF SANDY SOIL AS AFFECTED BY COMPLEXES OF CLAY-POLYMER (AP) AND CLAY-HUMUS-POLYMER (AHP), (Makled and Gati 1968)

Treatment	C.E.C. meq/100 g soil
Untreated	2.25
(A) Bentonite	3.25
(H) Peat	4.70
(AH) Bentonite + 50% peat	5.94
(AP) Bentonite + 5% HPAN	3.29
(AP) Bentonite + 10% HPAN	3.52
(AP) Bentonite + 15% HPAN	3.75
(AHP) Bentonite + 50% peat + 5% HPAN	6.45
(AHP) Bentonite + 50% peat + 10% HPAN	6.79
(AHP) Bentonite + 50% peat + 15% HPAN	7.23

i. the mobilization of nutrients in the organic materials, and

ii. the increase of their long-lasting effect.

The organic materials are soaked with a suitably chosen condensation solution of synthetic resin to release and mobilize nutrients. Through the N content of the resin the wide C/N ratio of the preparation can be considerably decreased. The adsorption capacity of the organic material increases due to the active sites of the resin and the effectivity of the organic material becomes long-lasting at the same time due to the formation of surface coating. The ion exchange groups, linked to the resin structure, ensure the chemical function and the adsorption capacity is influenced by the other polar groups too (Gàti and Mikes 1964).

Field experiments were conducted with different organic material combinations: Sorghum + corn stalk, Peat + farmyard manure, "Agrofix" a soil improving material on clay-humus base, and "Trass" a mixture of organic materials and inorganic fertilizers (Gàti et al 1963). The experiments were carried out on sandy soil poor in humus; the studied materials were placed carpet-like at depths of 45 cm. The rate of decomposition (Fig. 3) gives information as to the lasting effect of the preparations. The crop yields proved the favourable residual effect in the second year due to polymer treatments (Table 9). The main advantage of treating organic materials with cross-linked polymers is the activity-retarding effect, i.e. more favourable nutrient mobilization and the slowing down of decomposition.

4.3 Soil Amendments on Fossil Organic Material Base

4.3.1 Lignite and brown coal disaggregates and their derivatives

Hungarian lignite and brown coal complexes in their native state, as identified by Barna (1974, 1978), contain mineral and organic materials; the mineral part is aluminium hydrosilicates and the organic part is humic acid derivatives in different proportions. By mechano-chemical activation, Barna (1973, 1976) succeeded in decomposing the lignite and brown coal into the colloidic state whereby the functional radicals became loosened by hydration to produce an active and stable clay mineral-humus suspension of larger surface. These peptized and decomposed natural organic complexes are called disaggregates. According to Barna, the mechanical stability of the soil

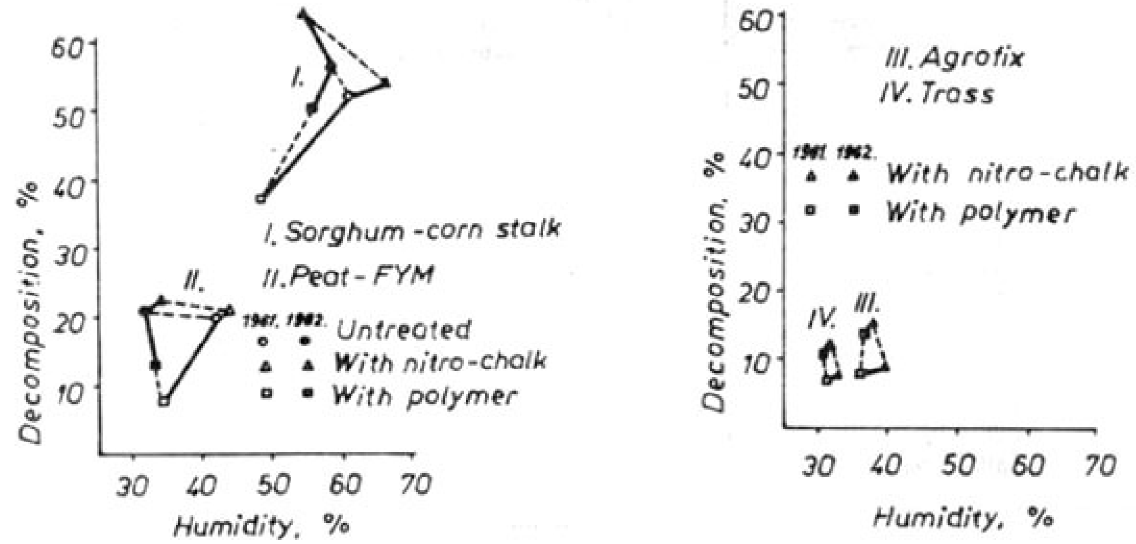


Fig. 3 Decomposition of Polymer-Containing Organic Materials and Inorganic-Organic Mixtures in the Soil
After Gàti et al, 1963

Table 9 YIELD DATA IN FIELD EXPERIMENTS WITH POLYMER TREATED ORGANIC MATERIALS (Gati et al 1963)

Treatment	Maize green mass 1961		Rye green mass 1962	
	Dry matter kg/100 m^2	Relative number	Dry matter kg/100 m^2	Relative number
Control	46.4	100	11.3	100
Sorghum + corn stalk (1:1)	46.1	99	15.3	135
same + nitro-chalk	59.9	129	37.4	331
same + 10% polymer	50.0	108	35.4	313
Peat + farmyard manure (1:1)	51.7	111	17.8	157
same + nitro-chalk	53.0	114	18.1	160
same + 6% polymer	48.6	105	23.8	210
Agrofix	64.2	138	23.0	203
same + polymer instead of nitro chalk	64.9	140	23.3	206
Trass	63.2	136	18.0	150
same + polymer instead of nitro-chalk	76.0	164	26.6	235

surface is successfully increased by disaggregates. The thin, film-like layer formed there does not prevent infiltration but markedly decreases evaporation losses from the soil. Water retention is increased as well. Incorporated into the upper 0-30 cm soil layer, the disaggregates can be considered as a humus supplying, nutrient and water retaining medium. Placed carpet-like at depths of 40-80 cm, it can serve as a barrier.

Kazo (1977) used liquid manure instead of water for mechano-chemical disaggregation. By this method a bio-active substance was introduced into the colloid suspension system of disaggregates, producing a material with similar effect to that of farmyard manure. This method of preparation is very important from a sanitary point of view.

4.3.2 Humic acid preparations on brown coal base and carbo-mineral materials

Humus formation in the soil is the result of very complicated biochemical processes. On the basis of solubility in acids and alkalis, humus is thought to be made up of three classes: fulvic acid, humic acid and humin. In spite of differences in the chemical and physical make-up, the three classes are similar in cation adsorption and nutrient release. Humic acids can be taken as polyanions of three dimensions. The active groups of polyanions (mainly phenolic hydroxyl-groups and -COOH) may react with cations so that coordinated complex or chelate-bound compounds are formed (Scheffer and Ulrich 1960). The developed alkali humates are readily soluble, whereas, the Ca, Mg, and Al-humates are of poor solubility (Puri 1949).

The stimulating effect of humates on plant growth is well known (Barbier 1943; Chaminade and Blanchet 1951; Kristena 1951). Tomko (1973) examined the effect of humic acid preparations obtained from brown coal on different soils. The examined humic acid preparations were magnesium humate, urea humate, ammonium humate and calcium humate. The structure-forming effect (the quantity of water stable crumbles characterized by the medium measured diameter) of ammonium humate was of an excessively high degree on all the four soils (Fig. 4). The cation adsorption increase was the highest in case of ammonium humate, while the hygroscopicity was increased by calcium humate and magnesium humate to the largest extent.

The technology of preparing alkali humates was elaborated at the Coal Mines of Tatabanya, Hungary (Dzsida 1977). The potassium and ammonium humate preparations produced in this way proved to be good in practice (Fig. 5).

From mixtures of coal wastes and fossil humus, carriers or other organic materials (Carbo-mineral materials) can be produced. They can be homogenized and enriched with nutrients to obtain different compositions such as Carbovit-k 21 and Carbovith-Kh.

4.3.3 Fertilizers on lignite and brown coal base

There are several methods for the production of fertilizers on a lignite and brown coal base. One of the best known is simple ammonization by which compost-like products are obtained. Brown and Berkowitz (1967), Sarma et al (1967) described the production of humic nitrogeneous fertilizers by oxy-ammonization of brown coal in a fluid bed reactor. Korbuly and Takács (1974) studied the treatment with nitric acid. In this procedure, nitric acid is used for the digestion of ash components. It can be substituted by sulphuric acid and phosphoric acid. Sulphuric acid, as hydrolyzing agent, accelerates oxidation and promotes nitration. Phosphoric acid, besides its digesting effect, solves the problem of introducing P nutrient. The product is neutralized by aqueous ammonia solution and potassium salt is added. By this method, an artificial compost on a nitro-humic acid base can be produced. It contains plant nutrients in a very effective form.

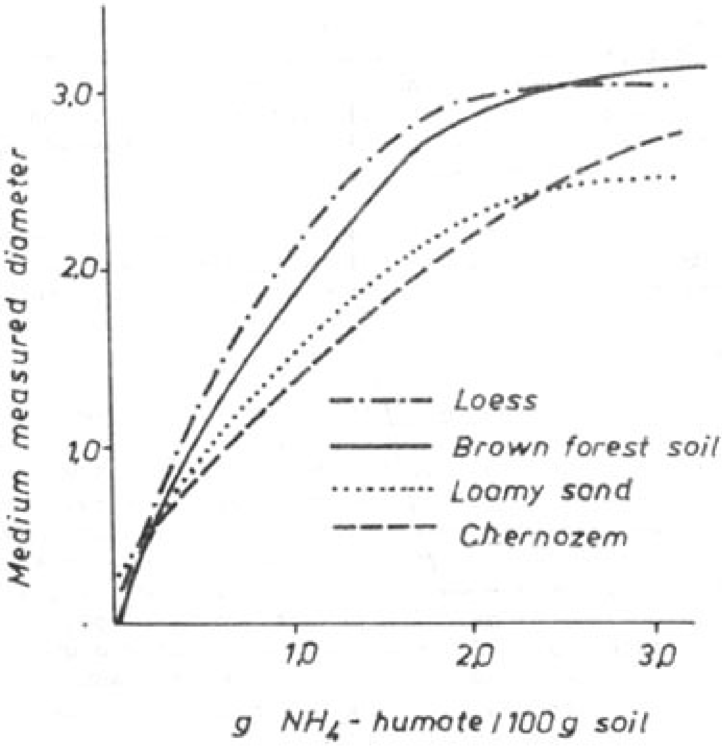


Fig. 4 Structure Forming Effect of Ammonium Humate
After Tomkő, 1973

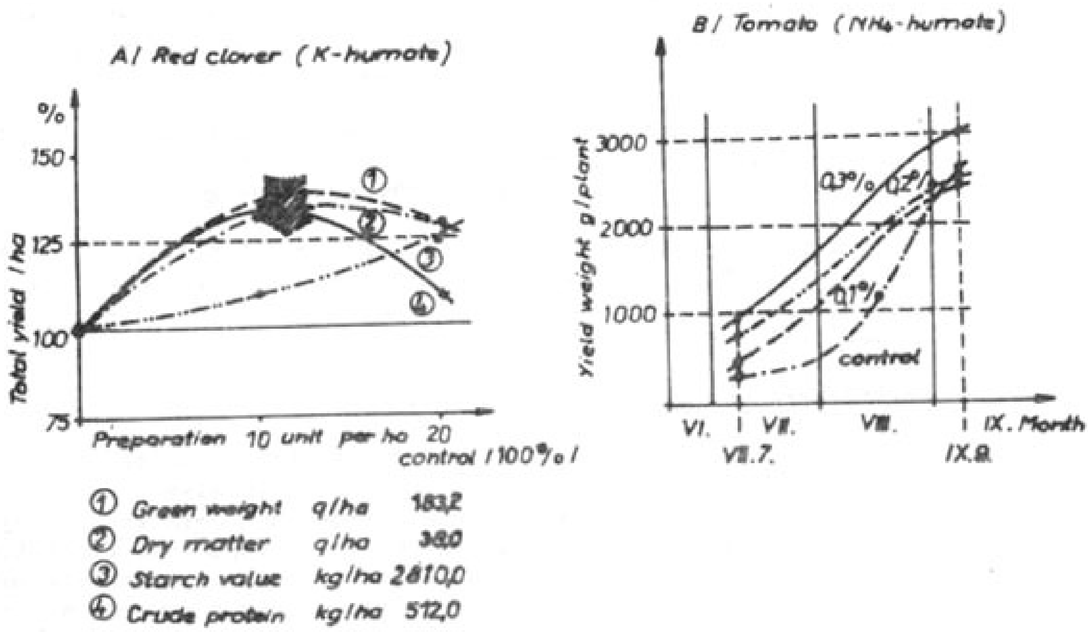


Fig. 5 Foliar Application of K-Humate for Red Clover (A)
and of NH_4-Humate for Tomate (B)
After Dzsida, 1978

At Pét in Hungary, a plant was established to produce artificial composts on a nitro-humate base, the characteristic composition of which is:

Humidity	37.0%
Total N	3.5
Citrate soluble P_2O_5	2.5
Citrate soluble K_2C	2.7
Humic acid	20.5
Other organic and mineral substances	33.8

Field experiments proved the beneficial effect of artificial humic acid compost. On an acid sandy soil with forest characteristics significantly higher yields were obtained than with NPK fertilizers of the same nutrient content (Table 10).

Table 10 EFFECT OF ARTIFICIAL COMPOST ON A NITRO-HUMIC ACID BASE ON THE YIELD OF OAT AND VETCH PLANT MIXTURE

Treatment	Green mass q/ha	relative
Basic fertilizer 1/ + 100 q artificial compost	377.7	262.3
Basic fertilizer + NPK adequate with the artificial compost 2/	191.3	132.8
Basic fertilizer	144.0	100.0

1/ 180 kg PK
2/ 791 kg NPK nutrient

Source: Information of the Hungarian Chemical Trust and Chemical Work of Pét (Hungary) 1973.

5. AMENDMENTS FROM MATERIALS AND BY-PRODUCTS OF THE PETROLEUM INDUSTRY

Products and by-products of the petroleun industry can be used as organic materials for soil. Crude oil and bitumen emulsions are successfully used in practice. An asphalt layer can also be applied as a barrier. The use of acid resin (a waste-product of petroleum refineries) on salt affected soils, is justified by Overstreet et al (1955), Schoonover et al (1957) and Bocskai (1968, 1969, 1970).

The method of a bitumen-bentonite emulsion barrier combined with subsurface irrigation (Terrakliv-BR system) in sandy soils was eleborated by Sarosi et al (1970). The emulsion is produced from a mixture of activated bentonite and bitumen. It is injected into the soil at a depth of 40-60 cm to form a carpet-like layer. The perforated plastic irrigation tubes are laid above the semi-previous layer at intervals of 3-6 metres.

Applied in loose sandy soils, the system prevents deep leaching of water and nutrients. Fertilizers can be added to irrigation water.

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Paper 11

ORGANIC MATERIALS AND IMPROVEMENT OF SOIL PHYSICAL CHARACTERISTICS

by

J.N. Im
Institute of Agricultural Science
Suweon, Korea

Summary

The effects of organic material applications on soil physical properties are reviewed in relation to soil productivity.

The beneficial effects of organic matter additions on soil physical conditions include (1) better aeration and increased infiltration for silty and clayey soils, (2) increased water holding capacity and moisture availability for sandy soils, (3) decreased soil erodibility, and (4) increased resistance to compaction.

It is concluded that continuous application of organic materials could greatly improve the various soil physical properties and favour the growth and yield of crops.

1. INTRODUCTION

Among the soil characteristics, organic matter content is the most important factor determining soil productivity. It has long been recognized that organic manuring often increases crop yield. In general, the expected beneficial effects of incorporating organic materials are (a) improved soil structure through aggregation, (b) increased water holding capacity, and (c) increased supply of available plant nutrients. Accordingly, farmers in Korea are advised to use about ten tons of organic compost per hectare for all crop establishment, in addition to such mineral fertilizers, lime, etc., that the specific soils may require.

Although compost usually has very beneficial effects on crop yield, the physical and chemical properties of soil altered by the incorporation of organic materials, and how the growth and yield of crops are influenced by such changes of soil characteristics, are not fully understood.

The decomposition and humification of organic materials in soil, and the resulting influence on soil characteristics and plant growth is complex. Fig. 1 is a schematic diagram of the humification and its effects on plant growth, in general terms given.

Recently, considerable attention has been given to the direct effects of humus substances. Flaig (1975) pointed out that some substances released or formed during decomposition helped minimizing the risk of yield depression caused by abnormal environmental conditions. But some other substances can occasionally be detrimental.

The indirect effects may be defined as crop responses that are secondarily influenced by the change of the soil characteristics from use of organic materials. The indirect effects are partly due both to the improvement of soil physical properties, and to chemical properties such as availability of nutrients, reaction, and cation exchange capacity.

One can hardly say that either one plays a more important role in improving crop yields. Some data have shown that beneficial effects merely come from the additional supply of plant nutrients, mainly the nitrogen which is contained in

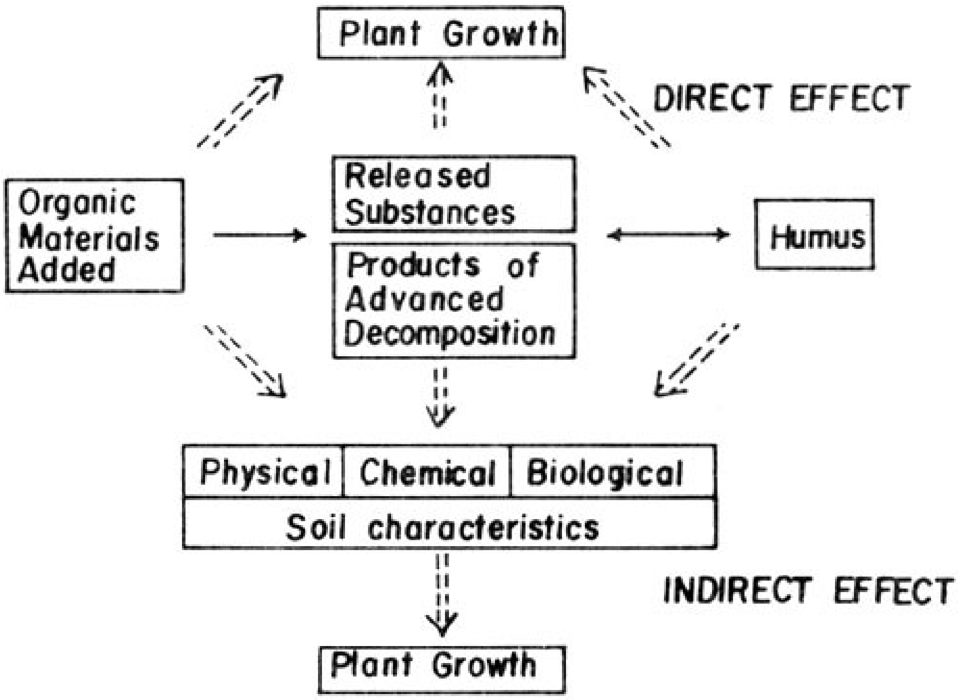

Fig. 1 The decomposition of organic material and its effect on plant growth

organic materials. This opinion seems to hold true only if soil is free of physical limitations on rooting depth, and weather conditions, especially rainfall distribution, are nearly optimum. But such ideal conditions seldom occur in farmer's fields.

Many researchers have reported beneficial effects of increasing levels of soil organic matter upon soil physical properties up to certain levels. In general, there is substantial evidence relating organic matter content to increased aggregation, water holding capacity, and percolation, and to decreased erodibility and compactibility of the soils.

The improved physical condition of soils from organic matter additions often significantly increases crop yield over unmanured plots at the same rate of fertilizer. Higher organic matter levels may increase the efficiency of fertilizer used. From this viewpoint the use of organic materials is thought to be a practical method to increase soil productivity and stabilize crop production where soil and weather conditions are not favourable, and chemical fertilizer is limited.

The results of long and short-term field, and laboratory experiments are reviewed and discussed in relation to the growth and yield of crops.

2. SOIL AGGREGATION

The structural condition of soil can be a dominant factor influencing crop yields. Well-aggregated structure provides favourable soil physical conditions for root elongation and plant growth by supplying sufficient water and improving aeration.

Aggregates between 3 and 0.25 mm are used as a guide to the interpretation of aggregation data because they are most effective in developing good tilth, resistance to dispersion, and moisture holding capacity (Nijhawhan and Dhingra 1947). Numerous researches show positive correlation between soil organic matter and aggregation.

In a study of the effects of various levels of organic matter additions upon the degree of aggregation of several cultivated soils, Rost and Rowles (1940) found that aggregation was significantly increased as soil humus content increased (Table 1). But the initial large linear response was followed by a tapering off, with the latter increments producing little effect. They concluded that the critical level of effective humus was approximately 2 to 2.5%.

Table 1

CHANGES IN AGGREGATION INDUCED BY ADDING INCREASING AMOUNT OF HUMUS IN SEVERAL SURFACE SOILS
(Rost and Rowles 1940)

Original humus, %	Soil humus content added, %					
	0.0	0.25	0.5	1.0	2.0	3.0
0.84	47.5	-	-	80.9	87.2	90.8
1.13	67.5	73.5	78.7	80.2	80.8	84.0
1.90	58.4	67.7	68.6	72.4	73.4	-
2.16	73.3	77.0	-	78.7	84.8	88.2

A similar result was reported by Wilson and Fisher (1946). They stated that the aggregation of soils seemed to be approaching maximum level at about 1.7 to 2.0% carbon.

The effect of organic matter on aggregation varies with soil condition. The addition of organic materials has a more pronounced effect on soils low in organic matter content and poorly aggregated (Wilson and Fisher 1946). There was a significant positive correlation between aggregation and organic matter content only for medium and heavy textured soils. In lighter soils, organic matter had little or no effect upon aggregation (Baver et al 1972). The effect also varies with the type of organic materials added. According to Browning and Milam (1944), organic materials which decompose easily in soil are more effective on granulation of soil particles for a short period (Table 2). They found that some materials that decompose slowly require a longer time to exert their binding influence; however, it extends over longer periods.

The most productive soils usually have high stability of aggregation, i.e. they maintain aggregate size distribution throughout the crop season. The difference is mean weight-diameter (Δ MWD) between dry-sieving and wet-sieving for aggregate size distribution is used as an index of the aggregation stability. The dotted area is related to Δ MWD (Fig. 2). The greater is Δ MWD, the less is the stability of aggregates. It was realized that the use of wheat straw (12 tons per hectare) increased the aggregate stability of silt loam soil during two months of decomposition (Im 1978).

Table 2 EFFECT OF DIFFERENT ORGANIC MATERIALS ON SOIL AGGREGATION IN GILPIN SILTY CLAY LOAM SURFACE SOIL, ONE MONTH AFTER TREATMENT (Browning and Milam 1944)

Material	% Aggregates greater than 0.25 mm		
	Before shaking	After shaking	Stable aggregates
Check (non added)	30.7	13.9	45.2
Peat moss	39.5	12.2	35.4
Wheat straw	41.4	20.4	49.4
Alfalfa	55.1	36.1	65.5
Sucrose	74.4	47.2	63.5

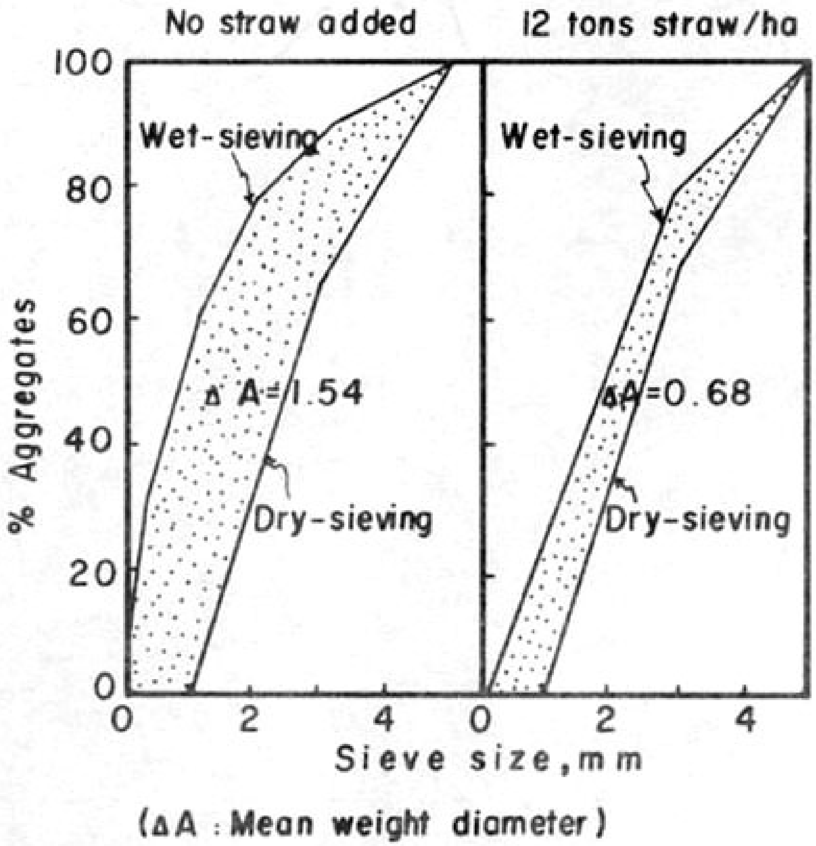

Fig. 2 Effect of straw application on aggregate stability of silt loam soil (Im 1978)

3. PERMEABILITY

Good aeration encourages root growth and consequently increases crop yield. Rapid drainage after rainfall and continuous exchange of soil air with atmosphere are desirable during the growth period. Permeability to water and/or air is a function of pore size distribution, especially the non-capillary pores. Since organic matter additions can increase the aggregates of large size as discussed previously, the permeability of soil can be improved resulting in an increase in non-capillary pores.

Peele (1937) reported the effect of differential rates of organic material additions upon the percolation rate of a Cecil clay subsoil. The percolation rate increased throughout the range of organic matter level (0 to 12 tons/acre). The heavily manured soil had a percolation rate nearly double that of the unmanured plot.

Im (1978) determined the saturated hydraulic conductivities of soils treated with and without straw (12 tons/ha) and plotted it against the normal load applied for compression (Fig. 3). He concluded that the addition of organic materials improved the soil permeability to water even if the soil was severely compacted. The improvement of permeability was entirely due to the increase in total porosity.

Infiltration is a very important factor in irrigation. Miller and Aarstad (1971) investigated the furrow infiltration rate with different additions of straw annually. The infiltration rates of the straw treated plot were maintained at a high level throughout the irrigation period, while that of the control decreased rapidly with time (Fig. 4). Such a high level of infiltration makes it possible to utilize rainfall more efficiently and control soil erosion on sloping land.

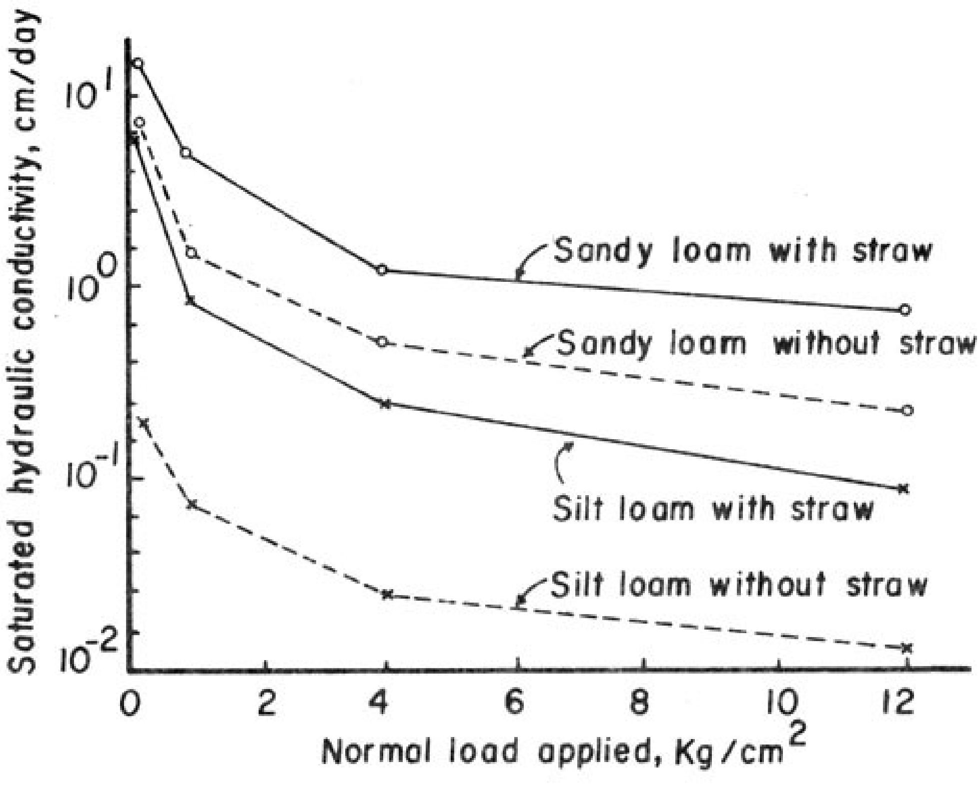

Fig. 3 Saturated hydraulic co ductivity as affected by straw application (12 tons/ha) after 2 months of decomposition (Im 1978)

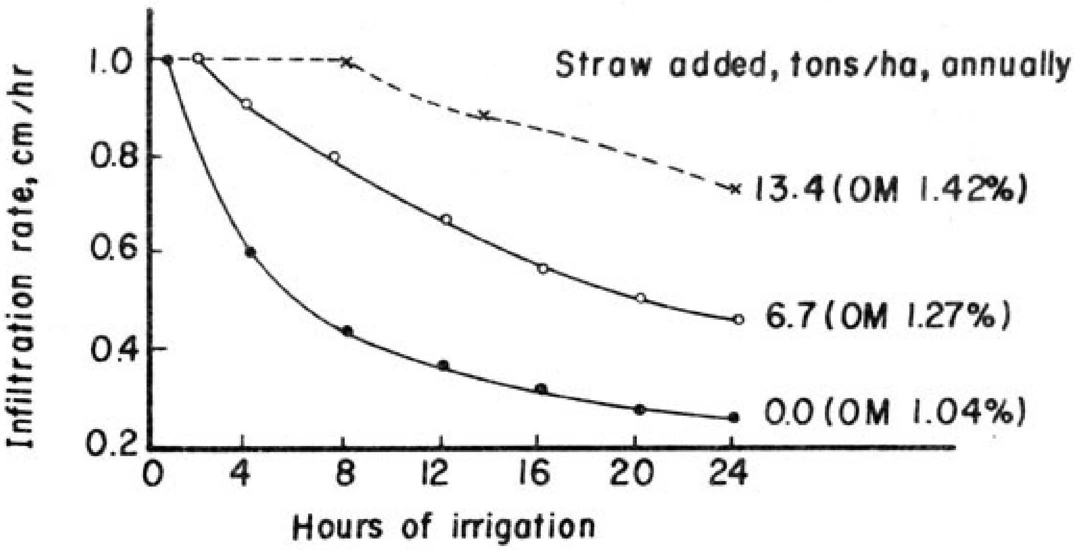

Fig. 4 Effects of straw incorporation on furrow infiltration (Miller and Aarstad 1971)

4. WATER HOLDING CAPACITY

Since organic matter has high water holding capacity, its addition to soil should increase the amount of water available to plants. There are so many different opinions about this that it is hard to say if the addition of organic materials has a significant effect on the increase in available water capacity of soil in all cases. Some workers insist that this effect is negligible. Although available water capacity is somewhat increased, there is no agronomic significance. But there are also many opposite opinions.

After a study with a hundred loamy textured soils, Oh and Im (1967) concluded that organic matter did not appear to affect available water capacity when lower than 2.0% (Fig. 5). It was suggested that 2.0% may be the critical level above which organic matter plays an important role in increasing water holding capacity in these soils. Up to now there is no evidence why organic matter can exert an effect above this level.

Russell et al (1952) found that there was a significant positive correlation between the organic matter content and moisture retention. Moisture equivalent was increased by organic matter addition, but the 15 atmosphere percentage increased at a lesser rate (Peterson et al 1968 and Russell et al 1952). Thus, the available water capacity increased. This conclusion was supported by a study of the relationship between organic matter and moisture holding capacity in Korean soils (Toha and Park 1973). It appeared that field capacity (1/3 atm) and wilting point (15 atm) increased by 1.13 and 0.4%, respectively, for each incremental increase of 1.0% organic matter content.

The effect of organic matter on water holding capacity seems to depend upon soil texture. Available moisture capacity usually increases with organic matter in course textured soils, but as texture becomes finer, the increase in available moisture capacity is influenced by texture more than by organic matter (Im 1978; Peterson et al 1968; Salter and Williams 1963)

Some data suggest that organic matter additions improve the availability of soil moisture to plants. Salter and Williams (1963) reported that annual applications of farmyard manure resulted in a significant increase not only in available water capacity of a sandy loam soil, but also in volume of water released at low tensions. The differences between available water capacity of the manured plots were not large (Fig. 6). A similar result was also obtained in a short-term laboratory experiment (Im 1978). However, the soil matric suctions of the manured plots were almost always lower than that of the un-manured plots. The lower suctions prevailing in the manured soil could be a factor contributing to the higher yield (Salter <u>et al</u> 1967).

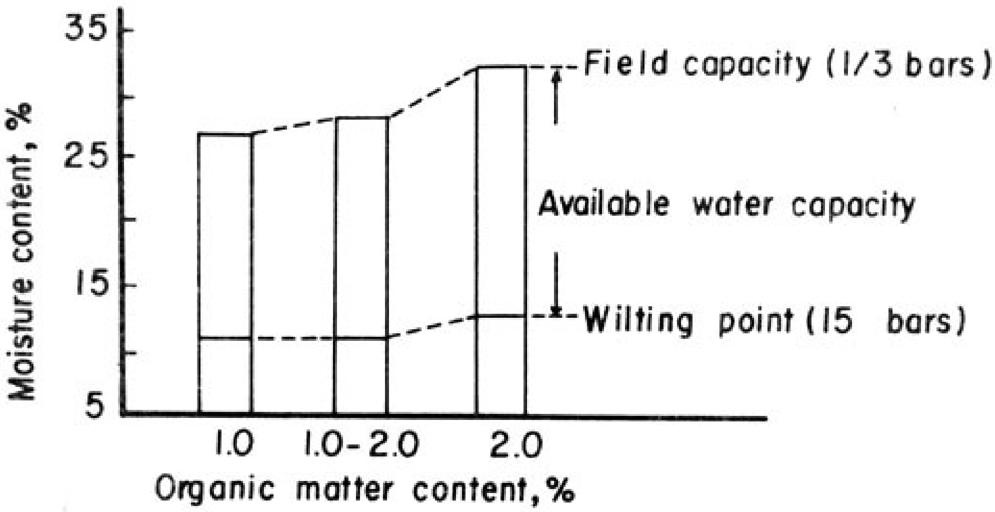

Fig. 5 Relationship of water holding capacity of Korean loamy textured soils to organic matter content (Oh and Im 1967)

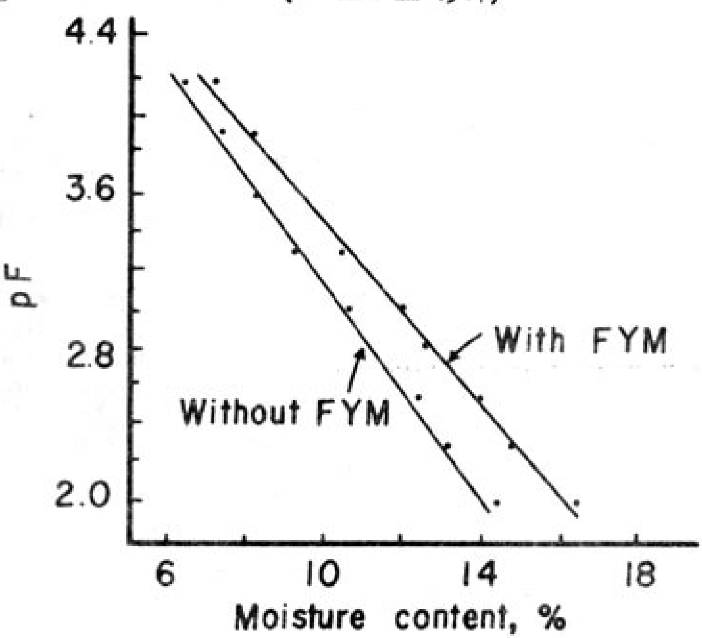

Fig. 6 Moisture characteristics of sandy loam soil as affected by farmyard manure (5 kg/m^2) (Salter et al 1967)

McIntosh and Varney (1972) reported the variation in the effect of organic matter according to weather conditions. Manure application significantly increased yields of maize grain and stover during years of normal or less than normal rainfall, but manure had no beneficial effect on maize growth and yield during relatively wet years. The fact that addition of organic matter has a good effect in dry years is of agronomic importance because it is possible to reduce the hazard of drought.

5. SOIL ERODIBILITY

Soil erosion control is particularly important in respect to maintenance of productivity on sloping land. The amount of soil erosion on any given area is affected by soil properties, provided other conditions are the same. The difference in erosion, due to soil properties alone, is referred to as the soil erodibility. Among the soil properties influencing erodibility, infiltration rate and dispersibility are of great importance.

Runoff during rainfall is largely determined by the infiltration rate of soil. As infiltration rate increases, runoff tends to decrease.

The effects of organic matter addition on dispersibility were studied with several surface and subsoils containing different initial levels of organic matter (Table 3). Browning (1937) reported that organic materials decreased the ease of dispersion of soil particles and thereby decreased soil erosion.

The soil erodibility factor (K), proposed by Wischmeier et al (1971), for Korean soils was correlated with organic matter content (Fig. 7). Jung et al (1976) reported that K-values were inversely correlated with organic matter in a range of 3 to 13%, but there was no relationship at organic matter levels under 3%. This suggests that soil erodibility was affected more significantly by texture than by organic matter at low level of organic matter. A high rate of applied organic materials could decrease the soil erodibility.

6. COMPACTIBILITY

The tendency to use heavier and more powerful machines on the farm has invariably resulted in increased mechanical loads on soils. Soil compaction, induced by heavy loading, is responsible for the deterioration of the physical conditions of many soils, decreasing their productivity.

The amount of compaction of soil at a given loading depends upon its moisture content and compactibility. Compaction studies indicate that organic matter not only determines the moisture content at which maximum compaction occurs for a given soil, but also has a pronounced effect upon the susceptibility to compaction. Soils with relatively high organic matter content have higher moisture contents at maximum compaction, and manifest lower compactibility (Free et al 1947; Russell et al 1952).

Compaction tests for sandy and silt loam soils treated with straw (12 tons/ha), compared with non-treated soils, are shown in Fig. 8.

The total porosity, as an index of the degree of compaction, was plotted against the normal load applied to water-saturated soils. It was concluded that the application of organic materials had a marked effect on preventing soil compaction induced by mechanical loading. Thus use of organic materials might contribute to reducing the possible detrimental effect of farm mechanization on soil productivity.

Table 3 RELATIONSHIP BETWEEN ORGANIC MATTER AND DISPERSIBILITY OF SOIL (Browning 1937)

Soils	Initial organic matter content %	Dispersion ratios, %		
		Check	OM	OM + Lime
Dekalb surface	2.0	41.5	17.7	13.2
" subsoil	0.6	52.4	30.1	30.6
Hagerstown surface	2.2	44.5	28.6	-
" subsoil	1.5	33.3	17.1	7.1
Upshur surface	4.4	19.7	13.8	15.7
" subsoil	1.1	13.7	13.4	13.4

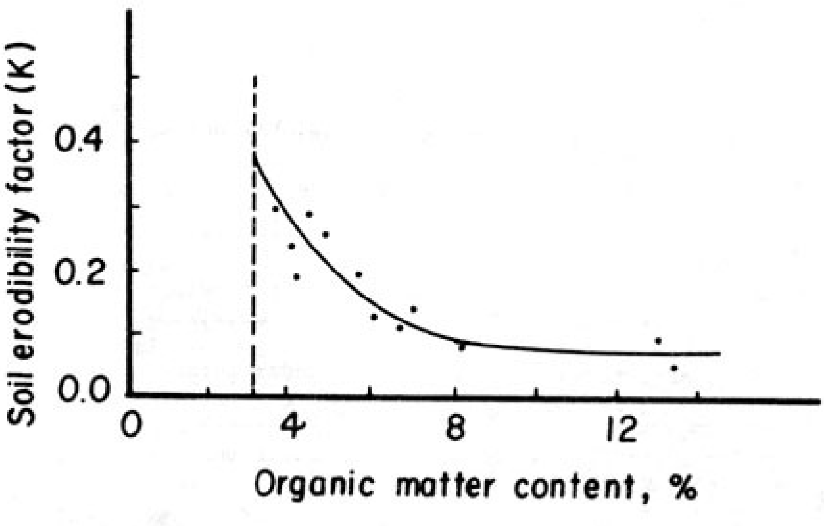

Fig. 7 Relationship between soil erodibility factor and organic matter content of Korean Soils (Jung 1976)

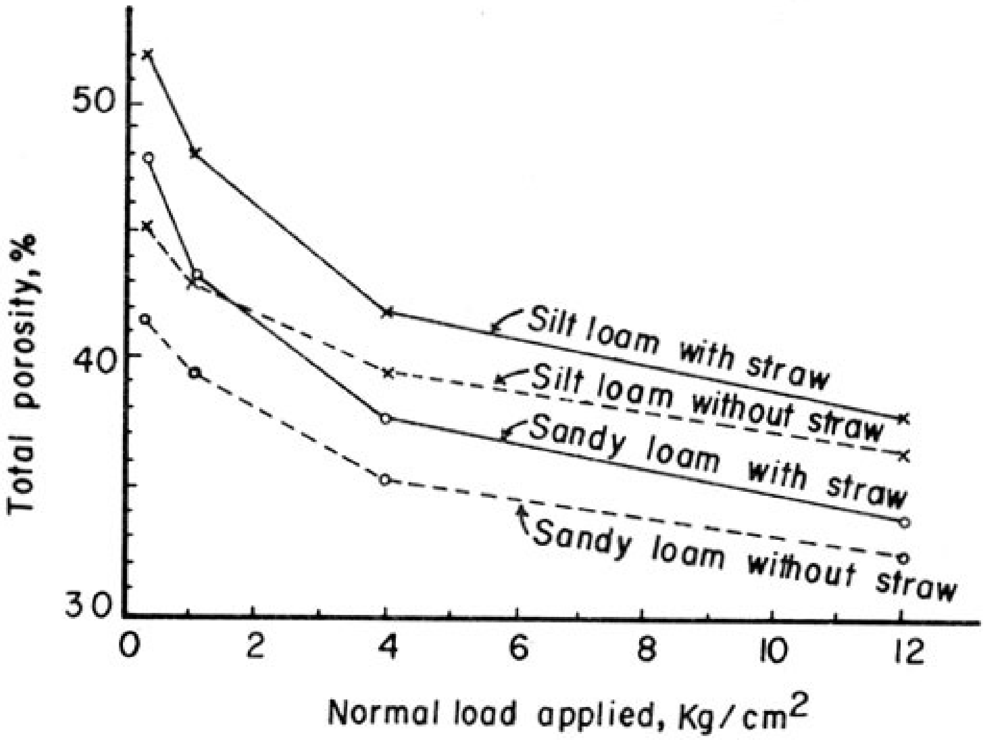

Fig. 8 Total porosity of soils as a function of loading (Im 1978)

7. CONCLUSION

The physical conditions of soils are invariably deteriorating rather than improving in most cases in agricultural lands. Therefore, soil should be managed in a proper manner so that its physical properties are favourable for plant growth.

Organic matter has been recognized as an important key for increasing soil productivity. Voluminous research supports the proposition that continuous application of organic materials greatly contributes to improving various soil physical properties related to yield potential. It is still doubtful that crop yield always responds positively to such improvement. The effect of organic matter on crop yield often depends upon the environmental conditions under which experiments are conducted.

Better aeration and increased permeability through aggregation, induced by organic matter addition, probably exert great effects on heavy soils. An increase in water holding capacity and moisture availability are of significant importance in light soils. Also the decrease of soil erodibility can play a very important part in maintaining higher soil productivity on sloping lands.

It is concluded that judicious application of organic materials is urgently desired for the increase of soil productivity, continuation of stabilized high productivity, and soil conservation.

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LIGNITE: A POTENTIAL SOURCE OF ORGANIC MATTER AND A SOIL CONDITIONER

by

I.A. Zein El-Abedine and I. Hosny
Soil Science Department, Faculty of Agriculture
Cairo University, Cairo, Egypt

Summary

The microbiological and micromorphological studies show that lignite is an organic material which is highly resistant to microbial attack and loss through decomposition. It remains in the soil over a long period of time. However, it is subject to physical breakdown through wetting and drying.

Lignite is an efficient soil conditioner which improves the major physical and chemical properties of the soil. The improvement is significantly correlated to the amount of added lignite. Its use in sandy soils requires an alternation in the mineral fertilization programme to include an initial and economical application of available N and K.

1. INTRODUCTION

Lignite is a decomposed organic material, an intermediate state between peat and coal. It is generally considered a low grade coal whose calorific value is too low for economic use at present.

There are several types of lignite in nature, and although they differ somewhat in their chemical composition, yet they are all characterized by their high total organic content, very low nitrogen content and, therefore, extremely high C/N ratio. They are rich in lignified materials and contain varying amounts of humic and fluvic acids, as well as different amounts of Ca, Mg, Na, K, I, Mn, Cu, and Zn (McLaren 1976). Lignite was found to possess an appreciable cation exchange capacity, to improve water retention properties and to reduce the hydraulic conductivity of sands.

Under arid and semi-arid conditions, soils generally suffer from rapid decomposition of organic matter which necessitates continuous supplementation with organic manures to maintain optimal physical and chemical properties required for high crop production. Continuous additions of organic manures are not only costly, but are also in many cases impossible because of the unavailability of the material. Furthermore, addition of fresh or partially decomposed manures may entail the hazards of nitrogen immobilization, and contamination of the newly reclaimed soils with weeds and nematode worms. In this respect, lignite, being a chemically and physically active and sterile material, becomes a potentially suitable and economic source of organic matter for use in agriculture particularly as a soil conditioner in the sandy soils of the arid and semi-arid regions.

The present work was undertaken to study the resistance of lignite to degradation and to evaluate its conditioning properties when used in desert sandy soils under field conditions.

2. THE EXPERIMENT

2.1 The Soil

The trial area is located in the newly reclaimed area of Wadi El-Mulak, which is a desert plateau of sandy soils, south west of the city of Ismailia, Egypt. The virgin soil of the area is composed of 76% course sand, 14% fine sand, 10% silt + clay, and 5% precipitated carbonates. It has a CEC of 4 to 5 meq/100 g, a field capacity of 16 to 20%, a total soluble salt content of 2 meq/l, an infiltration rate of 6 cm/min, a pH of 8 and an organic matter content of 0.06%.

2.2 The Lignite

The material used is an English lignite known commercially as "Kapag". It is a non-fibrous material with an approximate analysis of 4% resins and tannins, 4% fats and waxes, 14% humic acid, 72% lignite, 10% mineral matter, less than 1% cellulose, and a C/N ratio of 75.

This study used three lignite treatments:

i. lignite in its basic form;

ii. modified lignite in which the C/N ratio was lowered to 30 by the addition of a sufficient amount of mineral fertilizer;

iii. lignite-farmyard manure mixture, composed of 80% basic lignite and 20% local farmyard manure (17% organic matter).

Three levels of each were used: 3.57, 5.95 and 8.33 ton/ha.

For comparison the local farmyard manure was used at the rate of 57 ton/ha in addition to the control which received no organics. The farmyard manure was mixed in a base of alluvial sediments.

2.3 The Experimental Design

The experiment was carried out in the field with a winter potato crop. Three replicates for each treatment were used and were laid out at random distribution. The area of each plot was 100 m^2.

Lignite and farmyard manure were spread and ploughed in. The soil was then farrowed mechanically (20 cm deep) and seeded manually with potato at a depth of 15 cm. All treatments as well as the control received mineral fertilizers (70 units N, 54 units P and 72 units K).

Soil samples were collected after 1, 6, 12 (harvest) and 14 weeks (residual) from seeding. The collected soil samples were tested for: organic matter, soluble salts, cation exchange capacity, available N, P and K, infiltration rate and soil moisture characteristics according to Jackson (1958), Olson et al (1954), and Shawky (1967).

2.4 Counting of Soil Micro-organisms

A laboratory experiment was conducted to study the availability of lignite to soil micro-organisms. Either course (20 mesh) or fine (more than 80 mesh) lignite was mixed with the soil and distributed in plastic cups (100 g soil/cup). Ammonium nitrate (35 ppm), superphosphate (300 ppm) and potassium nitrate (100 ppm) were added as solutions and the soil moisture was kept at 60% WHC for 14 weeks at 30°C. At 2 weeks intervals, total bacteria, fungi and actinomycetes were counted according to Allen (1957).

2.5 Micromorphological Changes in Lignite Grains

Undisturbed soil samples were collected in steel boxes (4 x 6 x 10 cm), the inside of which were coated with thin films of parafin wax and lined with aluminium foil. The samples were slowly impregnated with unsaturated polyester (Rohne paulance, France) dissolved in elestrol (monostyrene). It is a non-polar, isotopic plastic with an R.I. close to that of Canada Balsam. It polymerises at room temperature with the help of cyclohexanone peroxide as a catalyst and cobalt octate as an accelerator, according to Brewer (1964).

3. RESULTS AND DISCUSSION

3.1 Availability of Lignite to Soil Micro-organisms

Following the changes in microbial densities gives a clear picture about the availability of the added organic material to soil microflora. In comparison with the control soil, the addition of both basic and modified lignite had only a slight effect on the development of soil microflora. There were slight increases in counts of fungi, actinomycetes, and total bacteria due to lignite addition during the first four to six weeks. However, the counts in these treated soils hardly exceeded four times those in the control. There is a constant trend for lignite to favour these soil micro-organisms, but it could be considered of little importance.

After the 6 weeks period, counts of all microbial groups in the lignite treated soil became more or less similar to those in the control. Differences during the earlier period of the experiment might be due to the presence of trace amounts of organic material in lignite which were rapidly consumed.

The insignificant changes in microbial counts due to lignite additions point out that lignite, in basic or modified form, is a carbonaceous material highly resistant to microbial degradation. Even in the presence of the fine particles of lignite ($<$ 80 mesh), which is a more preferable fraction to soil micro-organisms, the microbial counts did not increase significantly. It is expected that under field conditions, lignite may resist microbial degradation and remain in the soil for a long time.

3.2 Micromorphological Changes in Lignite Grains in the Field

Examination of thin sections of samples collected from the virgin soil of the experimental area shows the soil particles to be mainly of quartz. Horneblend and plagioclase are present in very small amounts. The soil grains are very smooth, rounded, subrounded and elipsoidal in shape, and range between the lower limit of course sand and upper limit of fine sand in size. They are randomly distributed in wavy bands and equant clusters of fine sand grains between loosely packed coarse grain (Fig. 1). Nearly 10% of the area occupied by thin sections is characterized by the occurrence of a powdery matrix of light red, yellow and light brown carbonates impregnated with iron gels. The carbonates appear as cutans, bridge, clusters and nodules. In localities high in fine sand the carbonates act as a cementing agent, occupying wider areas and producing patches of intertextic fabric. Localities rich in course sand show granular fabric, in which the grains are coated with carbonate cutans of about 15 μ thickness. The voids are mainly of the simple packing type, and approximately 10-15% of the total cross section of pores are of large and very large chamber type, up to 2 mm in diameter. The changes in soil structure with depth only appear as increases in thickness of carbonate clusters and cutan.

No organic matter or gypsum could be traced in the thin sections of the virgin soil.

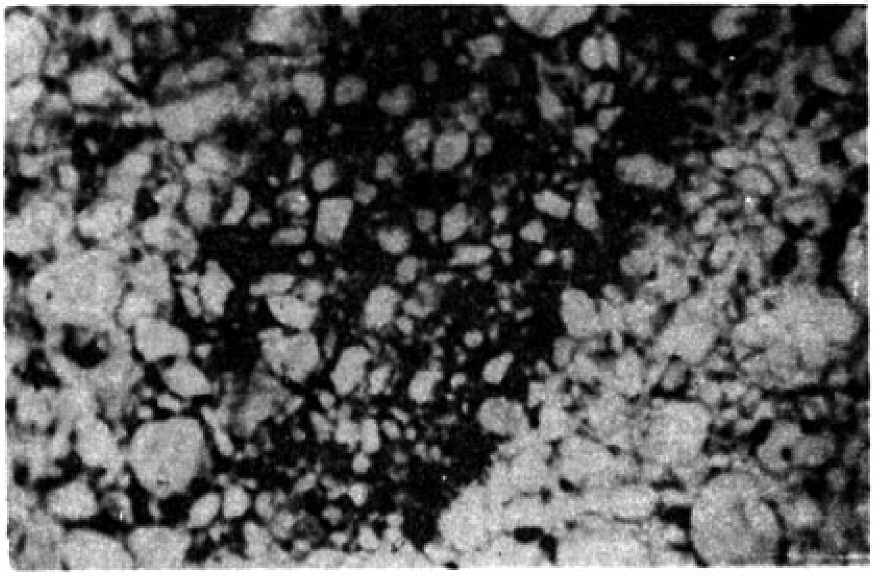

Fig. 1 Virgin soil (0-10 cm depth). Fine sand band cemented by carbonates in a course sand soil. Dark rings are brown carbonate cutans around skeleton grains (X 12 ordinary light).

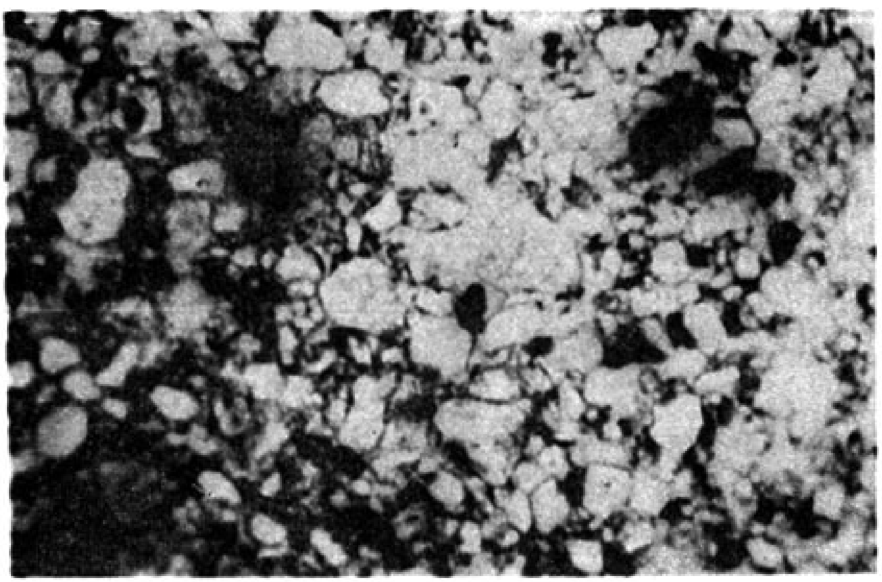

Fig. 2 Basic lignite (0-10 cm depth). Lignite grains mixed with sand grains with no definite inter-relationship, but with a greater tendency to accumulate in carbonate rich localities, left hand side of photo (X 12 ordinary light)

In lignite treated soil, examination of the thin sections of samples collected immediately after the addition and mixing of lignite with soil, showed the lignite grains as black, opaque, rigid, mostly subangular and occasionally angular or elongated particles, with well defined smooth outer edges (Fig. 2). They are mostly in the range of fine sand. Very few grains appear "soft" enough to be able to adhere to sand grains, and the homogeneity of sizes of both lignite and sand grains minimizes the possibility of modification of the packing system, or the cementation of sand grains. However, some of the finer subrounded grains of basic and modified lignite show a tendency to accumulate near the carbonate rich localities, and to adhere to the cutans around the surfaces of course sand grains. Very rare adhesion to barren sand grains is observed. This phenomenon may be due to chelation between the iron gels impregnating the carbonates and some active component of the lignite. Lignite has the advantage of being more evenly distributed in the soil than the organic matter of farmyard manure origin in the top 20 cm of soil; and only fine lignite grains reach the depth of 30 cm when well mixed with soil.

Mixtures of basic lignite and farmyard manures show the clay base of the local farmyard manure to be more effective than lignite in filling the medium sized void and partial occupation of large voids, and in cementing sand grains.

After 12 weeks of seeding and a total of 17 irrigations the most obvious feature was the complete cracking and breakdown of the majority of lignite grains, especially of small sized grains, along their natural weak points (Fig. 3). The developed cracks run in two or more directions, the resulting fragments being spaced apart and some adhering to sand grains. Cracking and breakdown appear to be mainly of physical nature and resulting from wetting and drying. The extent of cracking appears to be more pronounced in the grains of modified lignite than in those of basic lignite. The cracking of modified lignite grains is as strongly manifested at the depth of 10–20 cm as it is in the surface 10 cm of soil, whereas the breakdown of basic lignite grains is mainly confined to the soil surface layer. This seems to imply that the physical breakdown of modified lignite is easier than that of basic lignite, possibly because of a more pronounced contribution of microbial decomposition. Furthermore, a rare but definite fraying of edges of some lignite grains is observed, and powdered lignite haloing the original grains is recorded. The powder is in the range of 10–15 μ in size. This type of disintegration appears to be more of a microbial nature.

The cracking and breakdown of basic lignite mixed with farmyard manure follows exactly the same patterns described for basic lignite. A mixing of lignite grains with the organo-mineral complexes of farmyard manure origin is also observed in some localities (Fig. 4).

The micromorphological study indicates that lignite grains are strongly subject to physical breakdown into smaller sized grains due to the cyclic wetting and drying associated with perennial irrigation. This breakdown is beneficial in that it increases the active specific surfaces of the grains with time.

It would be expected that some of the finer fragments and powdery material would be translocated downwards in the soil profile, causing losses from the surface to the subsoil. Complete removal from the root zone is not expected under controlled irrigation.

3.3 Changes in Organic Matter

The organic matter content of the soil increases with time under all levels of treatments with basic lignite, modified lignite and mixtures of basic lignite + farmyard manure (Fig. 5 and Table 1). The maximum is reached in 6 weeks, after which the organic content diminishes again. At harvest, organic contents of all lignite treated soils are almost equal to those determined immediately after the addition of lignite. The increase appears to be due to residues of crop roots.

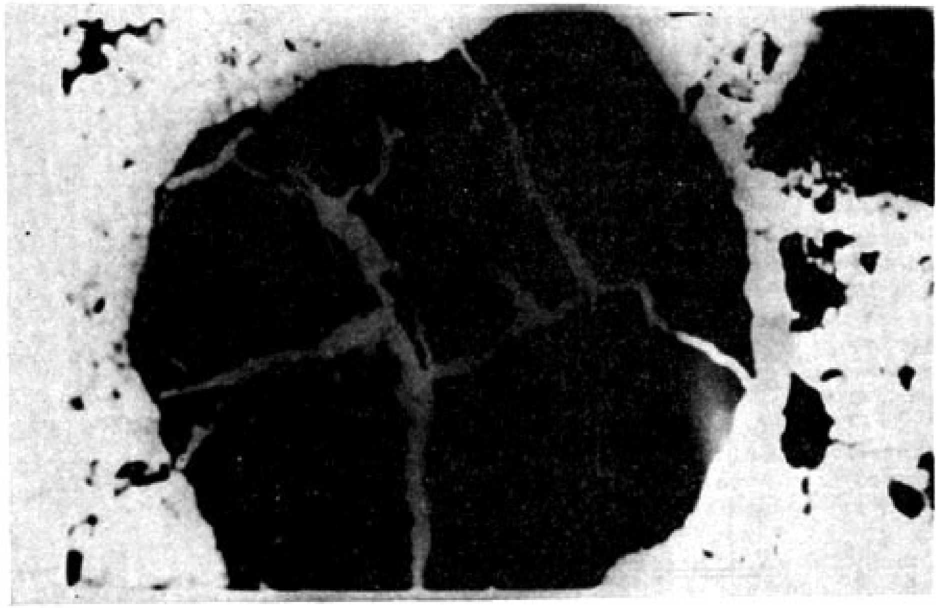

Fig. 3 Modified lignite (0-10 cm depth). Severe cracking of lignite grains (X 50 polarized light aided by gypsum plate

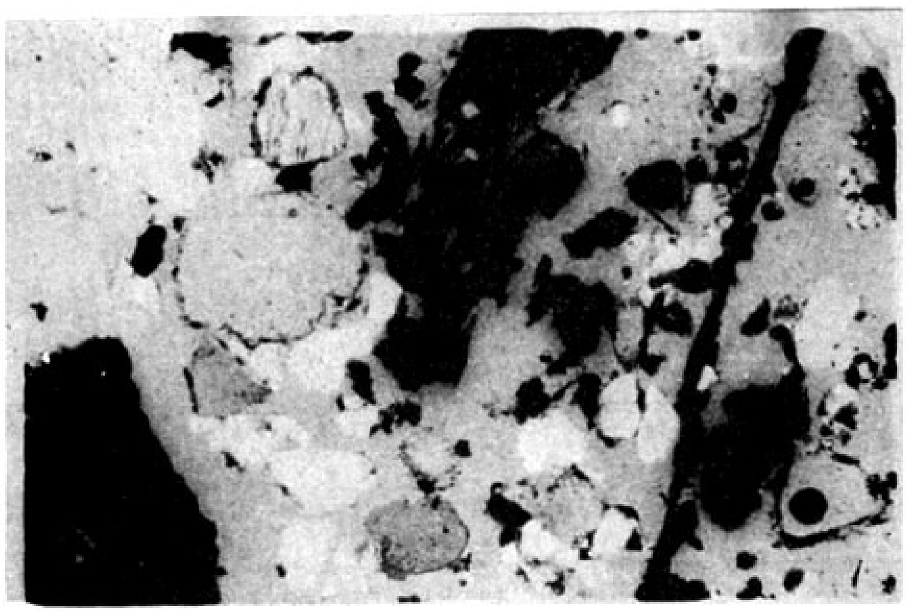

Fig. 4 Mixture of lignite and organic residues of farmyard manure (0-10 cm depth). (X 12 polarized light aided by gypsum plate)

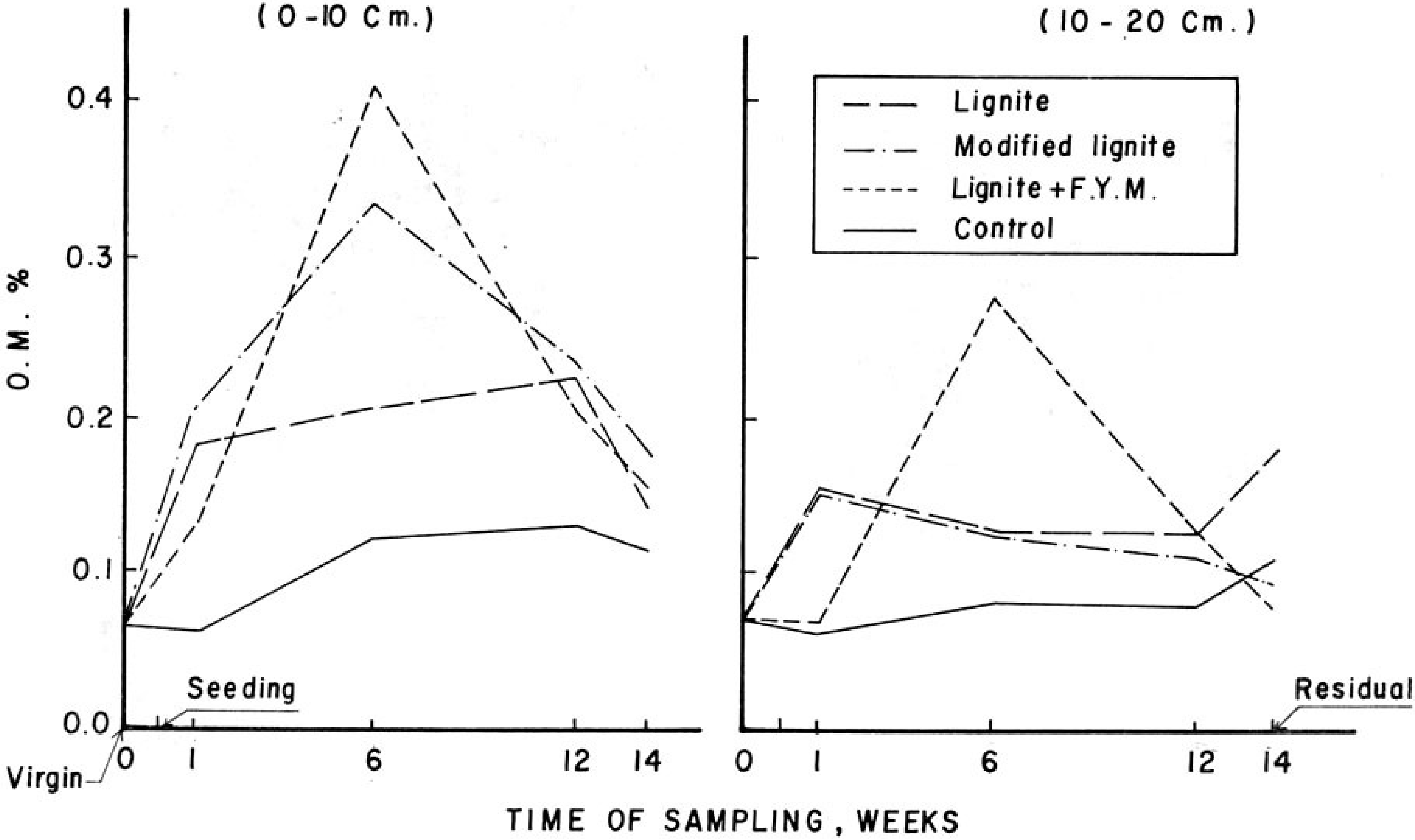

Fig. 5 Changes in organic matter with time under 3.57 ton lignite/ha

Table 1 EFFECT OF LIGNITE AND FARMYARD MANURE ON PERCENTAGE OF ORGANIC MATTER, 2 WEEKS AFTER HARVESTING POTATO CROP (14 WEEKS AFTER SEEDING)

Treatment	Depth 1/	Level of addition, ton/ha				
		0	3.57	5.95	8.33	57
Lignite	A	0.11	0.18	0.21	0.20	-
	B	0.11	0.14	0.10	0.18	-
Lignite, modified	A	0.11	0.17	0.17	0.31	-
	B	0.11	0.09	0.11	0.10	-
Lignite + FYM	A	0.11	0.15	0.27	0.26	-
	B	0.11	0.08	0.09	0.06	-
FYM	A	0.11	-	-	-	0.21
	B	0.11	-	-	-	0.09

1/ A = 0–10 cm
B = 10–20 cm

The soil treated with farmyard manure only shows continuous losses of organic matter with time, and reaches its minimum values at harvest.

The values of organic matter 14 weeks from seeding or 2 weeks after harvest provide information about the residual effect of the added organic materials.

The results indicate that, in the surface layer (0–10 cm), there is an actual loss of 26% of both basic and modified lignite, 28% of the mixtures of basic lignite and farmyard manure, and 82% of farmyard manure. In the second layer (10–20 cm) losses were 38% under low and medium levels, while a gain of 100% occurs under the high level of basic lignite. Under modified lignite the loss averages 35% under all levels. In mixture treatments, increasing losses with increasing levels of addition occur showing values of 40% and 82% under medium and high levels, respectively. Under farmyard manure, 82% of the added organics are lost. The results also indicate the possibility that basic lignite is washed down from the soil surface to the 10–20 cm layer in plots treated with 8.3 ton/ha.

Statistically, ANOVA tests show significant inter-treatment differences at each separate time interval, these differences being maintained throughout the season. Neither intra-treatment differences, nor differences with time are significant.

3.4 Changes in Cation Exchange Capacity

An increase in the CEC of the top 20 cm of the soil occurs immediately after addition of lignite, and the increase is directly related to the amount of lignite added (Fig. 6). The ANOVA test shows that inter-treatment differences are significant at the 1% level in both layers. There are no inter-treatment differences. The actual increases of CEC in the 0–10 cm layer average 9% under low levels, 40% under medium levels, 87% under high levels of lignite, and 93% under farmyard manure. In the 10–20 cm layer the increases average 15% under both low and medium levels and 33% under high levels of lignite, and 11% under farmyard manure.

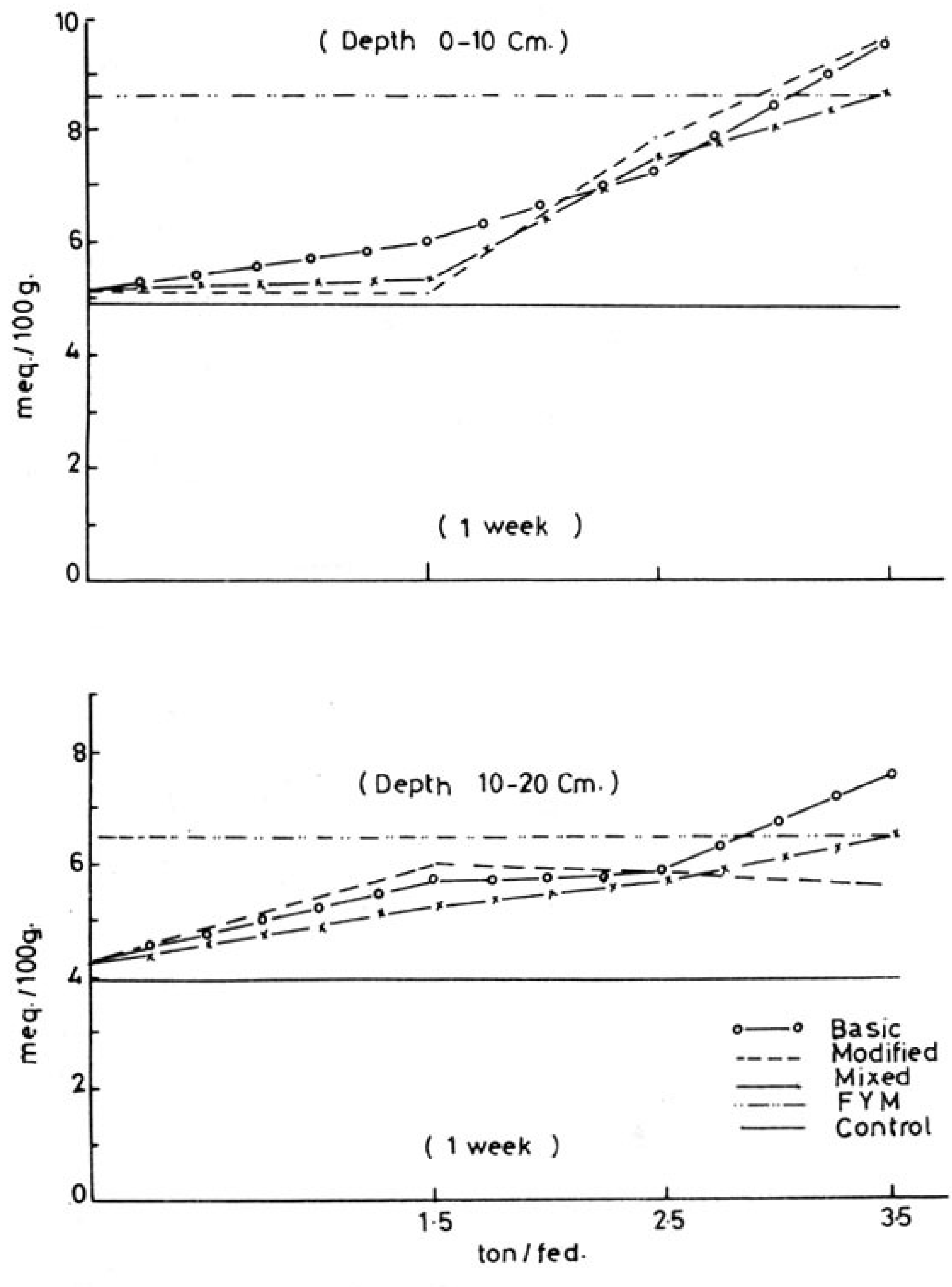

Fig. 6 Changes of cation exchange capacity with levels of lignite in 0-10 and 10-20 cm layers

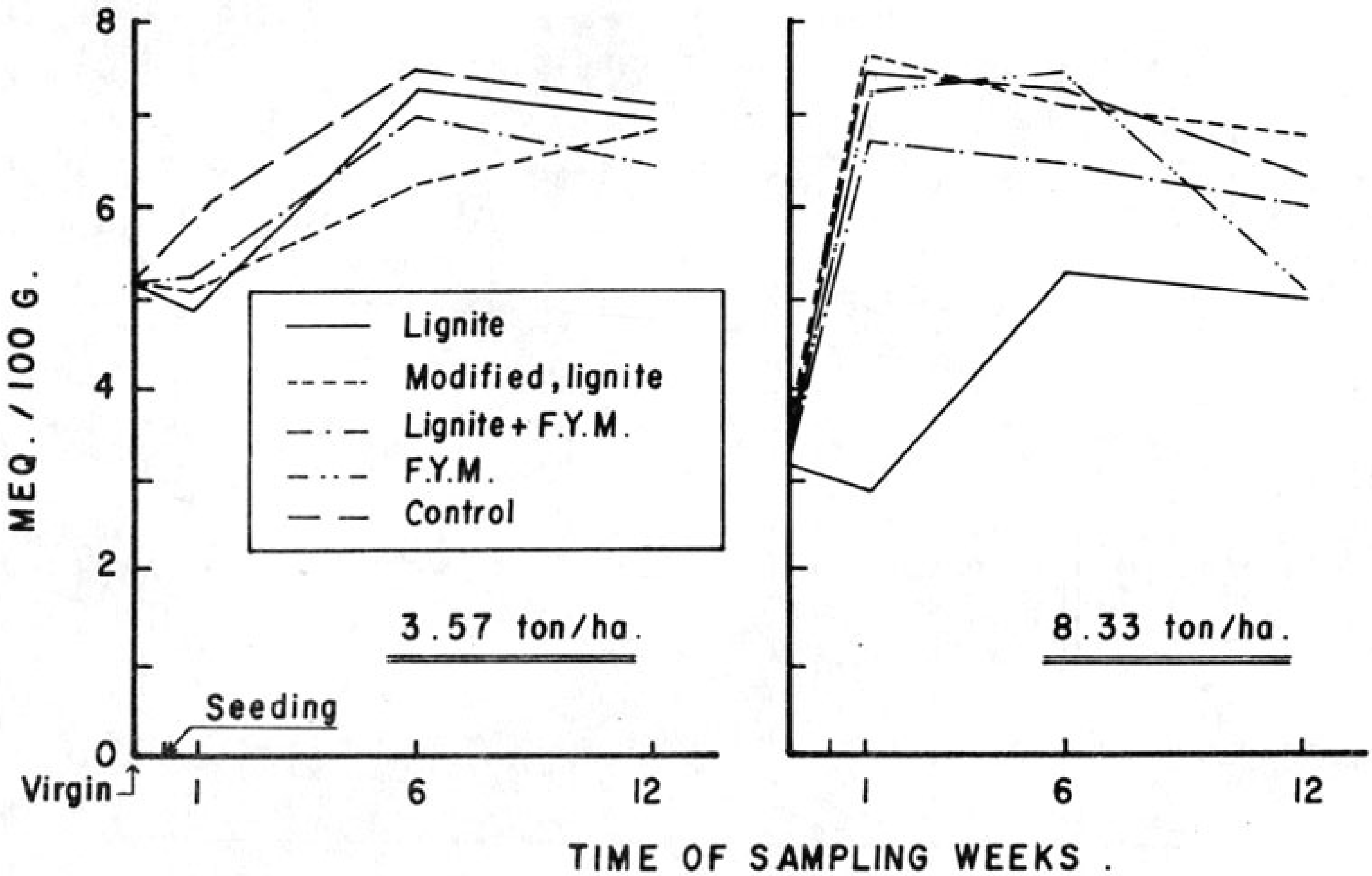

Fig. 7 Changes in cation exchange capacity with time under different levels of lignite

The changes in CEC with time (Fig. 7) are directly related to the organic matter content of the soil. Simple correlation analyses, show that CEC and organic matter are significantly correlated at the 1% level at all time intervals, and throughout the whole experiment. All lignite treatments retain fairly constant values with time, whereas under farmyard manure the CEC drops after 12 weeks to that of control.

3.5 Surface Infiltration Rates

Surface infiltration rates increase under all treatments including the control because of mechanical breakdown through ploughing (Table 2). However, the increase in lignite treated soils is much more pronounced, and amounts to 1.3 to 3.4 times as much as that observed in the control plots. The most important observation at this early stage is that the least amount of improvement was that recorded for soils treated with farmyard manure only.

Table 2 EFFECT OF LIGNITE AND FARMYARD MANURE ON MOISTURE CHARACTERISTICS AND INFILTRATION RATES, 1 AND 2 WEEKS AFTER SEEDING POTATOES

Level of addition	Sampling time,	Moisture % at 0.1 bar		Moisture % at 15 bar		Infiltration rate, cm/min	
ton/ha	weeks	A 1/	B	A	B	A	B
0 (Control)	1	20.53	22.99	2.11	2.00	10.23	9.04
	12	19.02	17.94	2.05	2.41	18.59	24.16
				Lignite			
3.57	1	21.98	27.89	1.86	2.03	20.58	12.19
	12	19.10	20.96	2.63	2.61	27.38	35.57
5.95	1	23.85	25.03	2.03	2.35	34.88	25.00
	12	18.71	22.57	1.88	1.96	20.84	29.76
8.33	1	22.61	22.66	2.51	2.34	31.07	27.98
	12	16.58	18.40	1.76	1.82	24.07	34.39
				Lignite, modified			
3.57	1	22.08	23.00	2.63	2.59	17.22	7.22
	12	20.11	19.50	2.00	1.89	25.63	16.99
5.95	1	34.78	21.86	2.26	2.35	13.85	13.00
	12	21.78	22.69	2.05	2.15	26.30	29.63
8.33	1	27.46	26.71	2.00	1.73	17.46	10.19
	12	17.93	18.21	1.67	2.00	36.29	37.80
				Lignite + FYM			
3.57	1	21.81	18.98	2.79	2.10	31.25	18.58
	12	28.51	19.80	3.35	2.00	28.96	38.89
5.95	1	23.69	26.06	3.06	3.10	21.37	16.28
	12	18.28	14.60	2.05	1.86	20.18	20.63
8.33	1	24.33	25.02	2.92	3.83	12.81	9.74
	12	24.10	21.75	2.31	2.23	24.44	24.76
				FYM			
57	1	24.94	18.64	2.23	1.82	12.64	16.67
	12	25.32	27.30	3.42	3.05	41.60	31.60

1/ A = 0–10 cm, B = 10–20 cm layer depth

Statistically, ANOVA test shows that after 1 week of seeding the inter-treatment differences are significant only under basic and modified lignite treatments. The significance is maintained for 6 weeks under basic lignite only. After 12 weeks all inter-treatment differences and changes with time are not significant. Furthermore, simple correlation analysis between the infiltration rates and the amount of organic matter in the soil recorded throughout the experiment shows no significant correlation.

3.6 Total Soluble Salts, SAR and pH

Leaching of TSS, and subsequent changes in SAR and pH values of the soil solution are related to the soil infiltration rate, and to the nature of added organics. The results, presented in Fig. 8, show that within 1 week of seeding, an appreciable drop of soluble salts occurs under all levels of treatments. The drop also occurs in control plots but to a smaller degree. All low and medium levels within all lignite treatments appear to show no further change with time. Under high levels, the leaching of salts appears to be gradual with time.

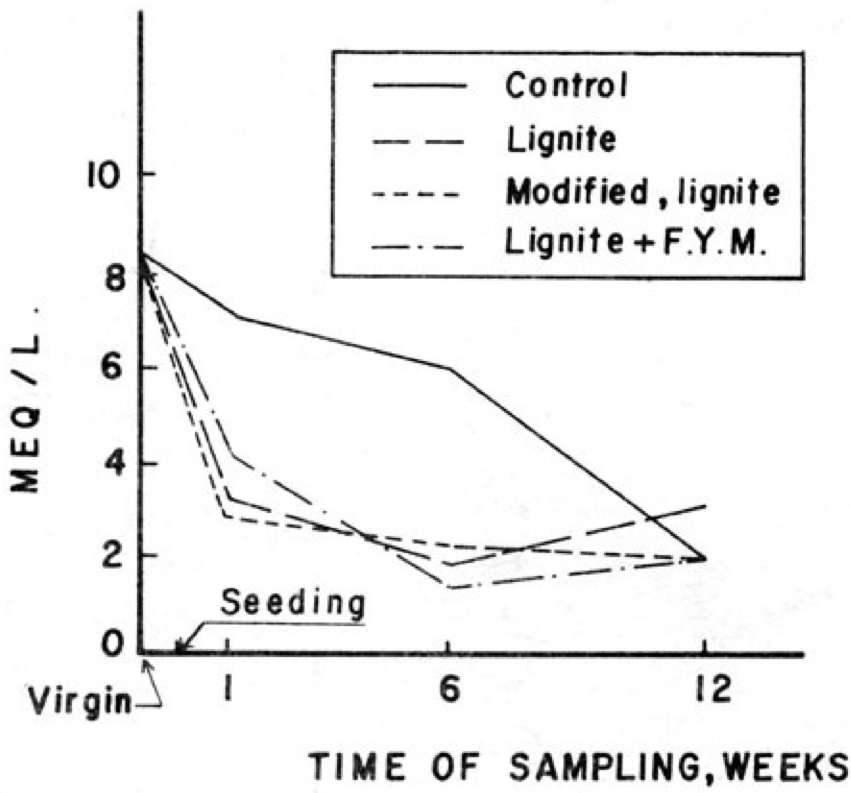

Fig. 8 Changes of total soluble salts in soil under 5.95 ton lignite/ha (0-10 cm)

The results show that in the first 6 weeks of cultivation under basic and modified lignite treatments the surface infiltration rates and leaching of salts are more efficient than under mixtures, or farmyard manure treatments.

3.7 Soil Moisture Characteristics

The average values (Table 2) show certain indicative tendencies. After 6 weeks of cultivation and complete settlement of soil, the changes in the field capacity became directly and significantly correlated to the organic content of the soil. After 12 weeks of cultivation there is a general drop in moisture retention under all basic and modified lignite treatments and in control, whereas under mixture treatment and farmyard manure the field capacity increases. The difference in behaviour is probably due to the nature of the organic material in the soil rather than to its amount. Actual values determined for field capacities in the first week of cultivation show approximate increases of 6%, 21% and 24% over control plots in the 0–10 cm layers of soils under low, medium and high levels of addition, respectively. A 25% increase is recorded under farmyard manure. After 12 weeks the recorded values show approximate increases of 34%, 6% and 2% under low, medium and high levels of lignite addition, and 61% under farmyard manure.

Statistically, the ANOVA test shows that inter-treatment differences in the moisture content at field capacity are insignificant for the first and sixth week. In the 12th week inter-treatment differences are significant in the 10–20 cm layers of soils under mixture treatment only.

3.8 Crop Yield

It was found through field observations that germination was completed 10 days earlier, growth rates were higher and plant sizes bigger, under all levels of modified lignite and under farmyard manure, than under basic lignite or mixture. This was reflected in the crop yield (Table 3). The increase in yield is about 20–30% under modified lignite and farmyard manure.

Table 3 EFFECT OF LIGNITE AND FARMYARD MANURE ON YIELD OF POTATO IN TON/HA

Treatment 1/	Level of addition, ton/ha				
	0	3.57	5.95	8.33	57
Lignite	7.62	8.57	7.38	8.33	–
Lignite, modified	7.62	9.76	10.00	10.95	–
Lignite + FYM	7.62	7.62	8.57	8.57	–
FYM	7.62	–	–	–	10.71

1/ All treatments received NPK fertilizers

Statistical analyses show that the crop yield is not correlated to the organic matter content, cation exchange capacity, total soluble salts, field capacity or infiltration rate. However, it is correlated to the amount of organic matter in the soil in the first week of cultivation and to the surface infiltration rates at the end of the season.

A positive correlation between yield and the available N and K at the first week of cultivation was found. Thus, the only variable affecting crop yield appears to be the initial nutrient content of the added organic. In the case of modified lignite, the large amount of mineral nitrogen mixed with lignite (C/N ratio 30) was not immobilized by the organic and remained in an available form in the soil. In the case of farmyard manure its available N and K contents are responsible for the high yields.

The increases in yield with increasing levels of lignite are attributed to the improvement of soil properties.

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EFFECTS OF LONG TERM APPLICATION OF FARMYARD MANURE ON SOME SOIL PROPERTIES

by

A.T. Moustafa
Institute of Soil and Water Research
Agriculture Research Centre, Egypt

Summary

The prolonged use of farmyard manure increased significantly the organic matter content of the soil and slightly affected soil permeability and exchangeable sodium percentage.

1. INTRODUCTION

Hunger is not new to the world. The problem lies in the rapid rate at which the population is increasing. Experts predict that the world's population will be between 6 and 7 billions by the year 2 000, double that of today. Furthermore, more than 90% of this increase will occur in the developing nations, where food supply is already critical and where the technology for increasing food production is wholly inadequate.

Intensification of production on lands already under cultivation is one of the routes which can be followed to increase land productivity. Incorporation of organic matter into the surface of the soil is considered one of the managements needed for increasing crop production.

To study the beneficial effects on soil properties of adding organic matter to the soils, it was found necessary to establish some long term field experiments.

In Egypt, the Bahtim permanent field experiments were established in 1912 and modified in 1919 to study the effect of using farmyard manure, known locally as Baladi manure, on crop yield and soil properties under different rotations.

2. EXPERIMENTAL LAYOUT

The permanent field experiments at Bahtim (10 km North of Cairo) were established, by the Royal Agricultural Society (now the Egyptian Agricultural Organization) in 1912 to determine the effect of the continuous application of mineral fertilizers (N, NP and NPK) on crop yields and on the physical and chemical characteristics of Egyptian soils. Originally, the experiments followed a three year rotation on the main crops: berseem (Egyptian clover), maize, wheat and cotton, but later in 1919 certain modifications were made to include one-year and two-year rotations as well as farmyard manure treatments.

The FYM comprised 15 tons of Baladi manure per feddan (36 tons/ha) for each crop of cotton, wheat and maize. This is beside other plots left unmanured. The average chemical analysis of this farmyard manure was: 10% organic matter, 0.3% total nitrogen, 0.5% phosphoric acid, and 1% total potash (Aladjem 1952).

3. STUDIES CARRIED OUT

With respect to soil properties, there were four main studies. The earlier one was carried out by Mahmoud (1934) covering the period extending from 1912 to 1933. The second study was carried out by Aladjem (1952) based on samples taken in

November 1947. After that El-Seidy (1967) did the third study on samples taken in February 1958. Heggi (1976) did the fourth study on samples taken in January 1972.

In all these studies, different soil properties were studied and the analyses included: mechanical analysis, bulk density, real density, total porosity, permeability, aggregation, calcium carbonate, pH, cation exchange capacity, exchangeable sodium percentage, and organic matter.

4. RESULTS

In 1934, Mahmoud did not observe significant differences in the physical or the chemical characteristics of the various plots. This study was carried out on samples taken in 1933, 14 years after the establishment of the modified layout of the experiments. However, the results of Aladjem (1952), El-Seidy (1967), and Heggi (1976), which were carried out on samples taken 29, 39 and 51 years after the establishment of the experiments in 1919, showed certain changes in soil properties.

4.1 Mechanical Analysis

There is similarity between the data of the mechanical analysis of the surface and subsurface soil up to 60 cm, especially in the percent of clay fraction which was 48 to 53% (Aladjem 1952), 47 to 53% (El-Seidy 1967), and 41 to 52% (Heggi 1972). This means that there was no marked change in the mechanical analysis of the soil for 51 years.

4.2 Bulk Density and Real Density

The determination of both bulk and real densities was only done by Heggi (1976). He concluded that neither farmyard manure nor crop rotation had any effect on the values of bulk and real densities. In general, he found that the values for bulk density ranged from 1.20 to 1.45 g/cm^3 for the surface layer and from 1.50 to 1.70 g/cm^3 for the subsurface layer. The values of the real density varied from 2.20 to 2.50 g/cm^3 and from 2.50 to 2.60 g/cm^3 for the surface and subsurface layers, respectively.

4.3 Total Porosity

Both El-Seidy (1967) and Heggi (1976) reported that the farmyard manure had no effect on porosity, in comparison with the other soil treatments. They gave the same conclusion regardless of the great difference between their mean values. El-Seidy (1967) reported mean values of 34.66% and 29.54% for surface and subsurface layers, respectively. Heggi (1976) reported that porosity values ranged between 40.00 and 48.00% for the surface layer and 30.50 to 40.00% for the subsurface layer.

4.4 Permeability

Aladjem (1952) stated that no reduction in soil permeability was noticed in the plots treated with nitrate of soda alone or in conjunction with other fertilizers. Later, Heggi (1976) found that the values of infiltration rate were higher in the organic manure plots than in any mineral fertilizer treatment. Also, crop rotation had its effect in infiltration rate due to crop residues.

Laboratory studies of soil permeability were also made by El-Seidy (1967) and Heggi (1976). The former found that the permeability coefficients of the plots treated with farmyard manure were almost double those of the plots treated with mineral fertilizers as well as the untreated plots (0.133 cm/hr) as shown in Table 1. The latter stated that the permeability coefficients of the organic manure plots were higher than those of the mineral fertilizers.

Table 1 EFFECT OF PROLONGED USE OF FARMYARD MANURE AND MINERAL FERTILIZERS ON CERTAIN PROPERTIES OF SOIL AT BAHTIM (El-Seidy 1967)

Soil property	Control	Farmyard manure	Mineral fertilizers
Permeability	0.133	0.277	0.144
CEC, meq/100 g soil	53.3	53.2	-
ESP	7.9	6.7	9.1
Organic matter %	0.9	1.3	0.7

4.5 Aggregation

El-Seidy (1967) stated that the degree of aggregation and the aggregation index were not influenced by the application of either farmyard manure or mineral fertilizers. Heggi (1976) came to the same conclusion. He stated that the effect of organic manure was statistically almost equal to that of NPK treatment with respect to the diameter of aggregates and aggregation.

4.6 pH

The results obtained from the three studies indicated that there was no effect from the different treatments on the pH values of the soil. All the figures fluctuated within a limited range which was between 8.36 and 8.65 (Aladjem 1952), 7.40 and 7.56 (El-Seidy 1967), and 7.86 and 8.15 (Heggi 1976).

These workers agreed that the soils were highly buffered by the presence of appreciable amounts of $CaCO_3$ (about 3%) and its high content of clay. This is the general case in the normal alluvial Egyptian soils.

4.7 Cation Exchange Capacity

It was found that, in general, no significant difference was detected between the treatments. The cation exchange capacity was about 45.6 meq/100 g soil in the untreated plots as indicated by Aladjem (1952). El-Seidy (1967) reported that it was about the same for both manured and unmanured treatments (Table 1).

However, Heggi (1976) stated that the organic manured plots had higher cation exchange capacity than the unmanured ones, but upon calculating the mean values, it was 54.51 and 51.39 meq/100 g soil for the manured and unmanured plots, respectively.

4.8 Exchangeable Sodium Percentage

From the data presented by both Aladjem (1952) and El-Seidy (1967), it could be stated that the farmyard manure lowered the exchangeable sodium percentage (Table 1).

4.9 Organic Matter

The addition of farmyard manure increased significantly the organic matter content of the soil as compared with the other treatments (Table 1). Also Heggi (1976) stated that mineral fertilizers decreased the organic matter content of the soil. In general, the figures presented by Heggi (1976) were relatively very low in comparison with the figures reported by El-Seidy (1967) even though both of them used the same method of analysis.

4.10 Crop Yield

Although mineral fertilizers, whether nitrogenous, phosphatic or potassic, and farmyard manure were used in doses which would provide these elements in equal quantities, the farmyard manure resulted in higher crop yields of cotton, wheat, maize, and berseem (Aladjem 1952; El-Damaty and El-Baradi 1956; and El-Damaty and El-Baradi 1959).

It seemed that the effect of farmyard manure on increasing crop production was mainly through other factors such as its effect on soil moisture characteristics, trace elements, and the activity of different soil micro-organisms.

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MAJOR HUMUS COMPONENTS OF EGYPTIAN SOILS

by

M. Kadr and K. Khalaf
Soil and Water Science Dept., Faculty of Agriculture
Alexandria University, Alexandria, Egypt

1. SOILS EXAMINED

An investigation was carried out to study the distribution of organic carbon and humus components in Egyptian soils:

i. alluvial soils from Giza, Banha, Kafr El-Zayat, Damnhour and Edfina in the Nile Delta (clay : 21.4–59.0%, CEC : 25.5–60.1 meq/100 g, and pH : 7.8–8.1);

ii. lacustrine soils from Abis near Alexandria;

iii. sandy soils from south Tahreer (Sand : 84.6–92.4%);

iv. calcareous soils from Nahda, North Tahreer ($CaCO_3$: 28.3–44.2%):

v. alkali soils from Ferhash, Middle Nile Delta (pH : 8.6–10.6).

2. ORGANIC CARBON

The organic carbon varied from 0.35 to 0.93% with an average of 0.59% and standard deviation of 0.14%. It tended to be relatively higher in the alluvial and calcareous soils and lower in sandy soils. Also, it declined consistently but gently with the depth of profile down to 150 cm in all investigated soils.

3. HUMIC ACID

Humic acid constituted from 1.45 to 66.65% of the organic carbon with an average of 28.2% and a standard deviation of 15.4%. It attained the higher values in the lacustrine (40.26%) and alluvial (32.12%) soils and the lower values in the alkali (8.61%) and calcareous (7.06%) soils. With profile depth, the humic acid was invariable in alluvial soils, tended to decline rapidly in sandy, calcareous, and alkali soils, but increased slightly in the lacustrine soils.

4. FULVIC ACID

The fulvic acid fraction varied from 6.49 to 57.44% of the organic carbon with an average of 30.67% and a standard deviation of 16.4%. Its value was relatively greater in lacustrine soils (42.5%) and least in calcareous soils (11.9%). The other soils were similar (about 30%). With the depth of the soil, it varied inconsistently in alluvial and lacustrine soils, declined in alkali and calcareous soils but increased in sandy soils.

Paper 15

THE EFFECT OF ORGANIC MATERIALS ON SOIL AGGREGATION

by

A.M. Gomah
Department of Soil and Water Science, Faculty of Agriculture
University of Alexandria, Egypt

Summary

Aggregate stability usually increases when soils are amended with organic materials. The addition of clover and wheat straw as well as cotton stalks to a silty clay loam and a calcareous sandy loam soil resulted in a significant increase in aggregates of more than 4.76 mm in diameter, and a decrease in those of 0.21 - 1.0 mm in diameter. The maximum effect was observed ater 1-2 weeks incubation. Clover straw was more effective than either cotton stalks or wheat straw. A logarithmic increase in the calculated structure coefficient (C_r) followed the addition of these organic materials to the soil.

Marked increases in total bacteria, fungi and microbial gums were observed in soils treated with different plant residues.

1. INTRODUCTION

The binding of single soil particles into water stable aggregates is necessary for optimum soil tilth. A well aggregated soil does not form crust easily and it has an air moisture regime favourable for plant growth and microbial activities. In addition, soil aggregation improves water infiltration and resistance to erosion.

Many factors are known to affect aggregate formation and degradation. Harris et al (1966) stated that cropping system, micro-organisms, organic material, earthworms, cultivation and climate control aggregate formation and stabilization. Organic matter, polysaccharides, and aluminium were found to be the most important factors (Chesters et al 1957 and Saini et al 1966). In Egyptian alluvial soils, Hamdi et al (1965) showed that the aggregation index was correlated to soil texture and soil organic matter. Inorganic ions, water availability, temperature, aeration and pH were also found to affect aggregate formation and degradation, since they influence the activity of soil micro-organisms (Acton et al 1963; Harris et al 1966; and Kaila and Kivinen 1952).

It has been shown that aggregate stability usually increases when soils are amended with organic materials and that the aggregating power of such materials is related directly to their rate of decomposition (Browning and Milam 1944; Kaila and Kivinen 1952). The increase in soil aggregation following the application of organic materials could be explained by one or more of the following:

i. mechanical binding of the soil particles by microbial filaments or cells;

ii. organic cementing substances found in the added materials or formed during its decomposition;

iii. organic binding compounds synthesized by soil micro-organisms.

In pure culture studies and in the presence of a suitable energy source, many fungi, streptomycetes, bacteria and yeasts were found to be capable of forming water stable aggregates (Gilmour et al 1948; Gupta and Sen 1962; Martin et al 1959; McCalla et al 1957 and Swaby 1949). This effect was attributed to particle binding by living cells rather than cementation by microbial mucilages (Harris et al 1966). In certain South Australian soils, many of the sand grains were bound together by strong filaments and finer grains were entangled in the filament masses. Furthermore, many workers showed that microbial polysaccharides and fungal mycelia play a major role as soil aggregating agents (Aspiras et al 1971; Chesters et al 1957; Greenland et al 1962; Harris et al 1964; and Rennie et al 1954). This paper discusses the work conducted in the Department of Soil and Water Science, Alexandria University, on the influence on water stable aggregates of adding different organic materials to two Egyptian soils.

2. EFFECT OF ORGANIC AMENDMENTS ON AGGREGATE STABILIZATION

Using a clay loam soil and a calcareous sandy loam soil, it was found that the addition of wheat and clover straws as well as cotton stalks, at the rate of 1, 2 and 4% (w/w) caused marked increases in aggregates with diameters of more than 4.76 mm and decreases in those with 0.21-1.0 mm diameter (Fig. 1). The maximum effect on aggregate stabilization was observed after incubation for 1-2 weeks; slight changes were detected thereafter. Clover straw at the 3 levels studied was more effective than either cotton stalks or wheat straw.

In order to find out the aggregating capacity and to compare quantitatively between different treatments, the structure coefficient (C_r), as suggested by El-Shafei and Ragab (1976), was calculated. This coefficient is the ratio between the percentage of the total amount of fractions more than 0.25 mm in diameter and the percentage of fractions less than 0.25 mm. In this study, aggregates of 0.21 mm in diameter were used instead of 0.25 mm. Figures 2 and 3 illustrate the logarithmic increase of the C values for the two soils amended with the different organic materials. It is clear that a marked increase in C_r resulted from the addition of the different plant residues. In the silty clay loam soil, this increase ranged from 52 to 156, 36 to 1620, 42 to 380 times the control, in the soil treated with clover and wheat straws and cotton stalks respectively (Fig. 2). In the calcareous soil these increases ranged from 1.5 to 272, from 31.8 to 318 and from 1.5 to 227 times the control (Fig. 3). In addition, the amount of the added organic material affected C_r values indicating that more binding materials seemed to be formed under higher levels of addition. The more marked effect in the case of clover straw additions could be due to either its higher rate of decomposition (Browning and Milam, 1944), or to the increase in microflora counts (Table 1). The more noticeable effect in silty clay loam soil than in calcareous sandy loam could be due to the higher content of clay fraction in the silty clay loam soil than in the calcareous.

However, in untreated soils, higher Cr values were found in the calcareous (0.11) than in the silty clay loam soil (0.046). This might be due to the $CaCO_3$ content which affects the aggregate stability in the absence of added organic matter (Greenland et al 1962).

3. EFFECT OF ORGANIC AMENDMENTS ON MICROBIAL COUNTS AND GUM FORMATION

The aforementioned results indicated an increase in water stable aggregates following the addition of different organic materials. Such an effect could be due to either the increase in microbial mass which is accompanied by mechanical binding of soil particles or to the formation of microbial gums which could act as a soil binding agent. These two assumptions were taken into consideration when conducting this experiment. A great increase in the total number of bacteria and moulds occurred during the first week of incubation following the addition of plant residues (Table 1). The increase in the total bacteria reached 3 to 8 times the control in the silty clay loam soil and 1.7 to 24.7 in the calcareous soil. Also, the number of moulds increased from 1.5 to 3.0 times the control in the two soils. A greater effect on the number

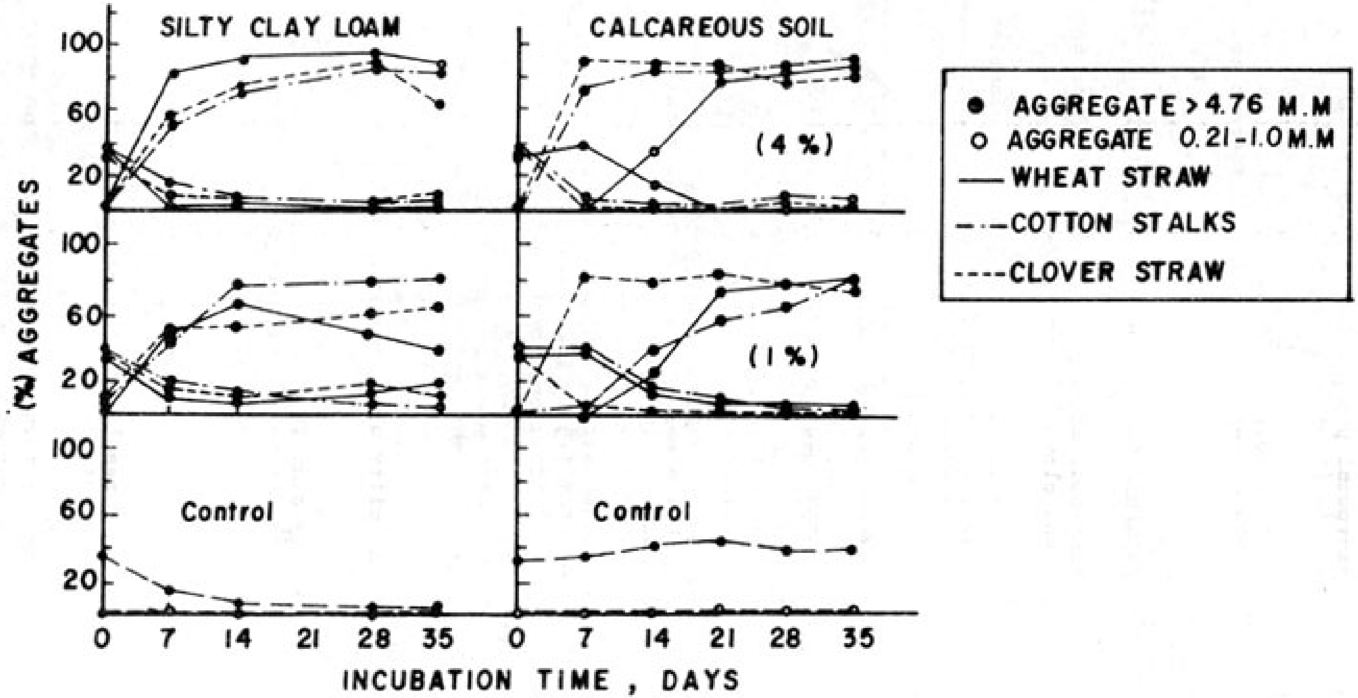

Fig. 1 Changes in percentage aggregates of the diameter > 4.76 mm and 0.21 - 1.0 mm in two soils amended with different plant residues

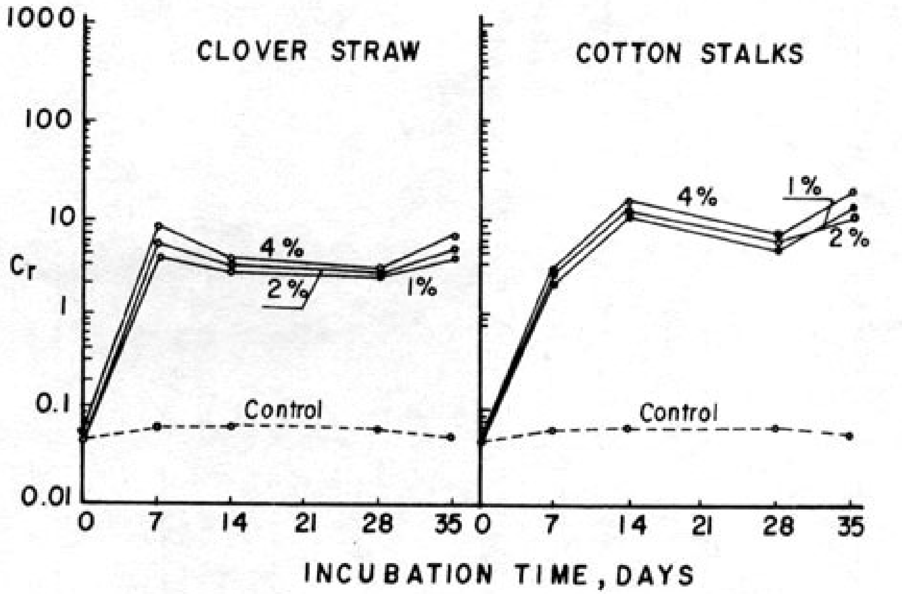

Fig. 2 Structure coefficient (C_r) of the differently amended silty clay loam soil

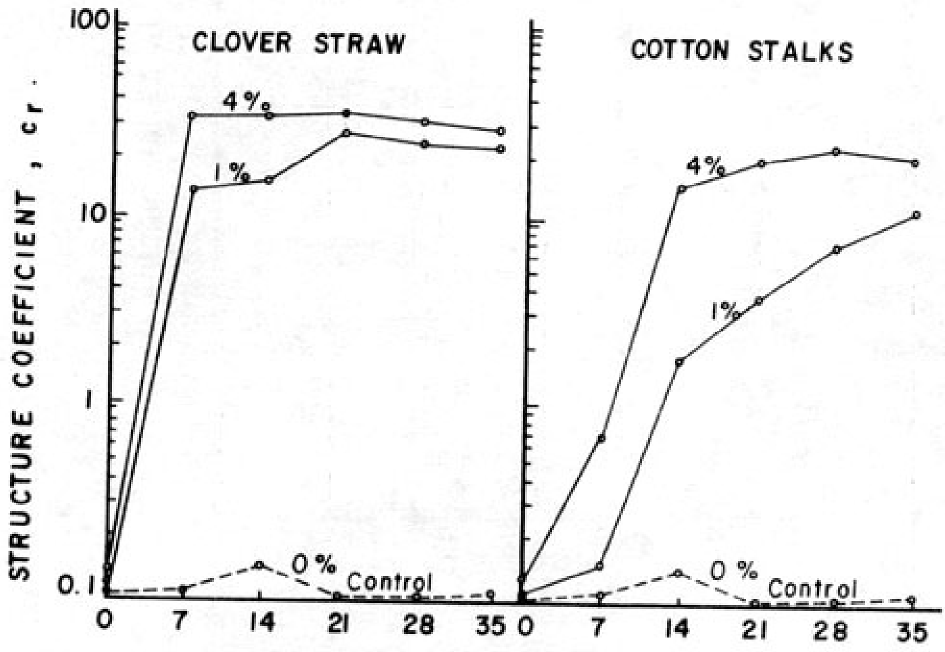

Fig. 3 Structure coefficient (C_r) of the differently amended calcareous soil

of total bacteria and moulds was observed with clover straw than with either cotton stalks or wheat straw (Table 1). This could be due to the higher nitrogen content and the more easily decomposable constituents of clover straw than the other two residues. Also microbial gums extracted from the soils treated with the different organic materials increased greatly after 7 days incubation and changed slightly thereafter (Table 2). In the treated silty clay loam soil, the gum material increased from 17.5–20.0 at the start, to 26.0–350.8 mg/100 g soil. On the other hand, this increase ranged from 11.5–14.5, at the beginning of the experiment, to 13.1–137.4 mg/100 g soil in the treated calcareous soil (Table 2). Again, more effect was observed from the clover straw addition than from either wheat straw or cotton stalks.

Table 1 NUMBERS OF TOTAL BACTERIA AND MOULDS IN THE TWO SOILS TREATED WITH DIFFERENT ORGANIC MATERIALS (1%)

Treatment	Type of organisms	Numbers/g dry soil after days			
		0	7	14	28
		Silty clay loam soil			
Control	Total bacteria x 10^6	29.4	77.1	75.2	72.5
	Moulds x 10^3	48.7	65.4	66.5	63.2
Clover straw	Total bacteria x 10^6	30.7	229.8	225.6	188.4
	Moulds x 10^3	49.7	109.9	147.9	294.8
Wheat straw	Total bacteria x 10^6	27.4	134.6	94.3	84.3
	Moulds x 10^3	44.3	93.4	138.0	269.9
Cotton stalks	Total bacteria x 10^6	26.3	153.7	105.9	157.4
	Moulds x 10^3	42.5	153.7	160.2	159.7
		Calcareous sandy loam soil			
Control	Total bacteria x 10^6	10.2	17.2	16.4	12.3
	Moulds x 10^3	49.6	66.5	67.8	64.8
Clover straw	Total bacteria x 10^6	15.2	297.3	255.1	108.3
	Moulds x 10^3	50.1	88.9	79.9	86.4
Wheat straw	Total bacteria x 10^6	11.5	31.3	29.6	21.1
	Moulds x 10^3	51.4	77.6	75.9	79.5
Cotton stalks	Total bacteria x 10^6	11.4	32.6	31.1	22.8
	Moulds x 10^3	53.5	78.1	73.1	70.8

In conclusion, the increase in large aggregate formation and stability following the addition of organic materials could be attributed to physical binding by microbial cells and/or gum formation during the microbial decomposition of added organic materials. In addition, the mechanism of aggregate stability could involve the formation of physico-chemical bonds between the active surfaces of clays by some polar organic compounds.

Table 2 MICROBIAL GUMS EXTRACTED FROM THE TWO SOILS TREATED WITH DIFFERENT ORGANIC MATERIALS

Treatment	Gum mg/100 g dry soil after days			
	0	7	14	28
		Silty clay loam soil		
Control	17.5	29.0	26.0	28.2
Clover	19.4	247.4	350.8	275.5
Wheat straw	18.5	146.8	159.6	163.3
Cotton stalks	20.0	220.4	310.4	215.5
		Calcareous sandy loam soil		
Control	12.8	15.6	13.1	14.2
Clover straw	11.5	137.4	135.3	127.4
Wheat straw	13.3	58.3	46.4	50.2
Cotton stalks	14.5	78.4	75.3	70.5

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Paper 16

LOCAL ORGANIC MANURES AND THEIR EFFECT ON SOIL MICROFLORA AND WHEAT YIELD

by

A.A.M. Makawi
Faculty of Agriculture, Cairo University
Fayum, Egypt

1. INTRODUCTION

The organic matter content of Egyptian soils varies from less than 1% in sandy soils to 2% in cultivated alluvial soil. Frequent and high applications of organic manures are necessary to maintain soil fertility. In Egypt, farmyard manure is the basic organic fertilizer while sheep dung, horse manure, city waste compost, dried sludge and poultry and pigeon manure are used in small amounts. These organic fertilizers vary greatly in their composition (Riad and Anwar 1944; Hamissa 1959; Makawi 1960, 1970; Saber 1966).

This work was carried out in pot experiments using a clay loam soil to study the effect of the different organic fertilizers on soil micro-organisms and activities of certain soil enzymes, using the methods outlined by Allen (1959), Conrad (1940) and Casida et al (1940). In addition, the effect of farmyard manure, with and without mineral fertilizers, on wheat yield was studied under field conditions at the farm of the Faculty of Agriculture, Minia University, Egypt.

2. CHEMICAL COMPOSITION OF THE ORGANIC MANURES

The chemical composition of the six month old organic manures is shown in Table 1. In general, total nitrogen varied from 1.03% to 1.65% and organic matter from 24.78% to 30.27% with C/N ratio from 9.8 to 14.6. Sheep and poultry manures were the richest in inorganic nitrogen (NH_4+NO_3-N), while pigeon manure was the highest in total nitrogen content and also in phosphorus.

Table 1 CHEMICAL COMPOSITION OF THE DIFFERENT ORGANIC MANURES

Organic manure of	NH_4+NO_3-N %	Total N, %	Organic matter %	C/N ratio	Humus %	P %
Poultry	0.54	1.34	27.78	12.00	9.58	0.59
Pigeon	0.18	1.65	27.90	9.80	11.97	0.63
Horse	0.17	1.04	26.15	14.60	6.65	0.39
Sheep	0.76	1.49	30.27	11.75	11.47	0.21
Cow	0.34	1.14	24.63	12.57	7.19	0.27
Buffalo	0.36	1.14	25.12	12.36	7.36	0.57
Dried sludge	0.36	1.13	24.78	12.69	8.41	0.23

3. CHANGES IN ORGANIC MATTER CONTENT OF THE TREATED SOIL

In pot experiments, the clay loam soil was treated with the organic fertilizers at the rate of 2% and kept at 60% WHC for three months. No marked changes were detected in total nitrogen during the 90 day incubation period. The organic matter content decreased gradually during the incubation period (Table 2). The losses in organic matter were about one third of initial values.

Table 2 CHANGES IN ORGANIC MATTER CONTENT OF THE SOIL UNDER VARIOUS ORGANIC MANURE TREATMENTS (2%)

Incubation time, days	Organic matter % with manure treatment					
	Control	Dried sludge	Poultry	Cow	Horse	Sheep
0	1.72	2.13	2.31	2.05	2.44	2.57
7	1.55	1.98	2.09	1.87	2.14	2.38
15	1.48	1.93	1.82	1.84	2.02	2.02
30	1.28	1.62	1.78	1.78	1.86	1.92
60	1.91	1.57	1.76	1.55	1.70	1.83
90	1.02	1.35	1.46	1.43	1.46	1.51

4. CHANGES IN MICROBIAL POPULATION AND ENZYME ACTIVITIES

The obtained data indicate that the microbial content of the soil varied according to the kind of organic fertilizer applied and incubation time. The highest counts were recorded with poultry manure treatment followed by sheep, horse and cow manure and dried sludge (Table 3). However, the microbial counts showed fluctuations during the incubation period.

As shown in Table 4, maximum activity of dehydrogenase enzyme occurred with poultry manure followed by sheep and horse manures. Dried sludge showed the lowest dehydrogenase activity. Dehydrogenase activity increased during the first 15 days then decreased gradually with time. Also, El-Shimi (1976) found that dehydrogenase activity tended to decrease upon incubating the moist soil for two weeks.

Urease activity varied according to the type of organic fertilizer used. Dried sludge showed the maximum activity of urease, while poultry manure showed the lowest values (Table 4). The untreated soil had a higher initial urease activity than the poultry and horse manure treatments. Galstyan and Astvatsatryan (1958), found that urease did not depend on humus content. Generally, the data obtained showed that after fifteen days of treatment the urease activity tended to be constant.

Table 3 THE EFFECT OF VARIOUS ORGANIC FERTILIZERS ON MICROBIAL CONTENTS OF THE SOIL

Organic manure treatment	Incubation time, days	Number/g dry soil				
		Total bacteria	Actinomycetes	Fungi	Azotobacter	Cellulose decomposes
Control	0	$81x10^6$	$5x10^6$	$32x10^4$	$234x10^4$	$3x10^4$
	15	84 "	5 "	14 "	14 "	28 "
	30	156 "	12 "	20 "	39 "	47 "
	90	201 "	14 "	54 "	40 "	1 "
Dried sludge	0	$89x10^6$	$11x10^6$	$45x10^4$	$132x10^4$	$2x10^4$
	15	52 "	6 "	14 "	14 "	138 "
	30	129 "	10 "	17 "	87 "	62 "
	90	206 "	22 "	17 "	17 "	2 "
Poultry	0	$110x10^6$	$7x10^6$	$42x10^4$	$290x10^4$	$4x10^4$
	15	213 "	8 "	44 "	18 "	87 "
	30	184 "	13 "	39 "	31 "	86 "
	90	222 "	7 "	31 "	29 "	2 "
Cow	0	$92x10^6$	$11x10^6$	$61x10^4$	$270x10^4$	$2x10^4$
	15	91 "	8 "	14 "	14 "	216 "
	30	60 "	3 "	11 "	18 "	63 "
	90	169 "	5 "	11 "	18 "	15 "
Horse	0	$90x10^6$	$10x10^6$	$43x10^4$	$250x10^4$	$8x10^4$
	15	116 "	18 "	17 "	14 "	420 "
	30	73 "	12 "	18 "	26 "	63 "
	90	76 "	13 "	18 "	13 "	5 "
Sheep	0	$107x10^6$	$9x10^6$	$36x10^4$	$280x10^4$	$2x10^4$
	15	199 "	16 "	27 "	14 "	332 "
	30	143 "	6 "	37 "	22 "	98 "
	90	294 "	19 "	31 "	18 "	24 "

5. **EFFECT OF FARMYARD MANURE ON WHEAT YIELD**

The effect of two levels (2% and 4%) of farmyard manure with and without N and P fertilizers is shown in Table 5. The addition of organic fertilizers increased the wheat yield. Application of mineral fertilizers (ammonium nitrate and superphosphate) caused further increases in the crop yield.

C. **CONCLUDING REMARKS**

i. The organic manures vary greatly in their organic matter, humus and nitrogen contents.

ii. Generally, the organic manures used can be divided according to their quality and fertilizing into:

a. manures with fair quality and quick availability: poultry, pigeon, and horse manures;

Table 4 THE EFFECT OF VARIOUS ORGANIC FERTILIZERS ON SOIL DEHYDROGENASE AND UREASE ACTIVITIES

Organic manure treatment	Incubation time, days				
	0	7	15	30	90
	Dehydrogenase activity, mg TPE/g soil/24 h				
Control	57.6	103.7	73.7	69.4	23.8
Dried sludge	110.7	46.4	29.8	44.1	20.1
Poultry	760.9	314.6	101.1	102.5	51.0
Cow	70.7	92.1	70.5	85.2	26.2
Horse	141.6	224.5	229.5	156.2	47.3
Sheep	171.0	251.0	277.1	192.6	44.2
	Urease activity, mg urea utilized/g soil/24 h				
Control	83.3	74.1	67.7	72.7	73.4
Dried sludge	93.4	76.1	60.8	63.4	65.6
Poultry	69.8	76.1	72.8	69.9	69.5
Cow	86.7	79.0	66.4	72.8	72.6
Horse	79.9	84.9	74.0	71.6	70.7
Sheep	88.3	78.0	56.5	71.8	70.0

Table 5 EFFECT OF FARMYARD MANURE ON WHEAT YIELD

Treatment 1/	Average yield (kg/20 m^2)
Control	8.040
Farmyard manure, 2% + N+P	13.132
Farmyard manure, 4% + N+P	11.822
N + P	13.050
Farmyard manure, 2%	10.982
Farmyard manure, 4%	9.272

1/ N: ammonium nitrate, 500 kg/ha
P: superphosphate, 250 kg/ha
LSD at 5% : 3.335
LSD at 1% : 4.549

b. manures with moderate quality and availability: sheep and cow manures;

c. manures of low quality and slow availability: dried sludge.

iii. Poultry and pigeon manures are the richest organic manures. They contain higher percentages of organic matter, total nitrogen, available nitrogen and phosphorus. Their decomposition in the soil is very high.

These manures could be recommended for fertilizing soils cultivated with short quick growth period plants such as vegetables, melon and water melon.

iv. Horse manure is always richer than farmyard manure (cow and buffalo). Its decomposition is quicker in the soil. It can be used for gardens and vegetable farms.

v. Sheep dung manure also contains a high percentage of organic matter as well as fair amounts of nitrogen. It decomposes quickly in the soil, while cow and buffalo manures and dried sludge decompose at a slower rate.

vi. Generally, the addition of organic manures to the soil encourages the growth of soil micro-organisms.

vii. Field experiments showed that the addition of organic manures increased wheat yield. The addition of organic manures together with mineral fertilizers (ammonium nitrate and superphosphate) had more effect in increasing wheat yield.

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Paper 17

SOIL LIFE WITH HYDROSORB: AN EFFICIENT, EFFECTIVE ORGANIC FERTILIZER AND SOIL BUILDER WITH UNIQUE WATER HOLDING CAPACITY

by

B. Welborn
The Hydrosorb Corporation, Fort Worth, Texas

1. INTRODUCTION

During man's time on earth he has made barren almost 5½ billion acres (an area of 2 000 million hectares). In other words, a territory the size of a continent has disappeared on which all the ploughed fields of our time could fit easily. This cannot be blamed on our remote ancestors; the bulk of the losses were registered in the past 100 years. Natural soils took thousands upon thousands of years to develop; meanwhile, careless cultivation destroys the soil in a matter of years.

"Soil Life" was developed as a means of increasing soil fertility by accelerating the growth of soil organisms and providing humus, which has the ability to absorb the soluble plant minerals and to hold them in the surface layer of the soil available for plant assimilation.

It should be pointed out that due to the complexity of the material we are working with, it is very difficult to establish clinically some of the results that have been obtained. However, as in the early days of vitamin nutrition study, the beneficial results can be determined only by observing their results when fed to animals.

To date there have been outstanding results in tests throughout the world where "Soil Life" has been used, and there are many farmers who greatly increased the tilth and productivity on what was once submarginal land.

Soil Life marine organic fertilizer is composed principally of humus "Hydrosorb", humates and fulvates, humic and fulvic acids, and life-giving trace minerals. Humates, fulvates, humic and fulvic acids (hereinafter called Soil Life) are probably the most important natural constituents of fertile soils. They have been used with great success in many agricultural applications, such as mixed fertilizers, various peat products, commercial nursery soils, and potting soils.

Soil Life helps growing plants to utilize better the available plant nutrients. It increases the efficiency of fertilizer utilization. It stimulates germination, root formation, especially elongation, plant growth, and respiration. It stabilizes soil structure and improved tilth, workability, and water holding capability. Soils are made more friable by the addition of Soil Life. Sandy soils are made more cohesive and water retaining. Soil Life increases the important ion-exchange capacity of soils.

Soil Life reduces the amount of water-soluble fertilizers that are leached or washed out of soils and into streams or other bodies of water, thus reducing pollution as well as saving fertilizer. The agricultural methods advocated for today's increased crop yields tend to deplete the soil life from soils and to build up mineral fertilizer residues, which are counter-productive. Good soil management calls for replacing the humus that is so important to soil health and productivity.

Dr. Everette Burdick (1965) in his article titled "Commercial Humates for Agriculture and Fertilizer Industry", asks this question "Why haven't the agricultural and fertilizer industries developed the humates commercially?" The answer to Dr. Burdick's question is that (a) mineral fertilizer prices have been kept unreasonably low for many years by U.S. Government regulation of oil and gas prices; (b) the chemical companies have had a vested interest in promoting mineral fertilizers, and (c) farmers have concentrated on short-term goals of added yield and have ignored the fact that they are depleting their soils and poisoning them with chemicals which have long-term disastrous consequences.

Now that the prices of oil and gas have escalated so much, prices of mineral fertilizers have gone up tremendously, thus making organic fertilizers much more attractive, price-wise, and much better for long-term soil health. Dr. Burdick's predictions as to the value of humates may now be realized.

Soil Life is a marine organic fertilizer that is nature's own organic fertilizer, millions of tons of which were deposited from marine life 50 million years ago in the Big Bend Country of Texas. Not only is the fertilizer high in organic content, but it contains the trace elements which are not a part of the mineral fertilizers that have been customarily used in agriculture.

ORGANIC MATTER

Organic matter is derived from the waste materials of living organisms and from the decomposition of dead bodies of plants and animals. The greater part of the organic materials of soils originates from plants, and is primarily from dead roots. Organic matter consists of dead leaves, roots, stems, fruits or other plants, bodies of worms, insects and animals, bacteria, fungi and protozoa, and the various chemical products of dead and living micro-organisms.

The chemical composition of organic compounds consists of cellulose, lignins, proteins, and fats. These compounds are decomposed by various species of fungi, bacteria, and other organisms, and are reduced to simple inorganic compounds in the soil such as ammonia, phosphates, water, carbon dioxide, etc. The remaining, partially decomposed, usually dark-coloured materials of the soil are known as humus and soil proteins.

Part of the humus further oxidizes and forms humic acid. These humus compounds are highly important to the soil fertility, and their supply in the soil must be maintained. Humus acts similarly to clay in that it is colloidal. Humus, when added to clay, changes the physical structure of the clay and makes it act similarly to organic matter. The clay swells, becomes darker, more porous and pliable, enabling the soil to retain more water, improves drainage, and increases the amount of air in the soil. The same thing is true when humus is added to sand - the sand reacts as if it is clay.

A good soil should have between 3% and 5% organic matter. The build-up of higher levels of organic matter is not necessary for economic production. Therefore, the quality of soil organic matter is more important than excessive quantities.

Organic matter is a major storehouse of plant nutrients in soil and provides the natural home for the millions of microbial creatures which are necessary to plant life.

While organic matter is being broken down by micro-organisms, the digestive action produces humic acids which make mineral nutrients soluble. Without it, the rate at which minerals will be made available to the plant's roots will be seriously reduced.

Organic matter serves as a spongey mass to retain water and increases water infiltration. When it rains, soils with humus soak up the water. According to the USDA, humus is so porous, it can hold at least its own volume in water. A four-inch rain on humus-rich soil causes little or no runoff, whereas half an inch on humus-poor land will cause erosion and some flooding in lower areas.

Organic matter improves the physical condition of the soil by increasing its permeability and permitting greater aeration. Organic matter also helps to stabilize soil temperature and prevents rapid changes in soil acidity or alkalinity.

3. TYPES OF FERTILIZER

True fertilization is the addition to the soil of that which is conductive to increasing soil life. Fertilizers are generally recognized in two groups: organic and inorganic. The organics are made up of organic matter and microbes. Inorganic fertilizers are basically comprised of minerals and are available in two major types. One type is made up simply of ground up minerals such as rock phosphate, rock potassium, limestone, and rock salt as they are found in their natural state. This type of fertilizer is not generally dissolved by water, but is gradually changed into plant food by the action of microbes, earth worms, and organic acids that are formed by the decomposition of organic matter. The other type of inorganic fertilizers consists of mineral fertilizers sometimes called chemical fertilizers. These are soluble in water and can cause corrosive action. Manufactured mineral fertilizers commonly advertise their quick results without warning you that when used without organic fertilizer, the soil medium may become rapidly depleted.

In nature there is no need for artificial fertilizers. Plants and animals live together and their litter accumulates on the surface to decompose and decay, thus making a health-sustaining, humus-rich soil. The whole life cycle in the soil becomes a self regulating system as long as it is undisturbed by outside forces.

When man enters the picture, however, it becomes another story. He ploughs up virgin land to grow crops. The increased oxygen made available by ploughing stimulates the bacteria into breaking down the organic matter more rapidly. Then man removes his crops from the soil, further taking from its reserves. He has thus mined the soil of its humus. The humus must be returned to the soil in order to continue producing efficient, productive crops.

3.1 <u>How Mineral Fertilizers became Popular</u>

Baron von Liebig is considered to be the father of chemical fertilizers. He began his experiments with plants in the 1840's. About the same time an Englishman, Lawes, was experimenting along similar lines. It was found that when nitrogen, phosphorus, and potassium were added to depleted soil in the form of water-soluble chemicals, production was increased like magic. Soon, farmers the world over were adopting this method as a shortcut to soil fertility - or so at least they thought.

There is no question that humus-rich soil can provide what is needed to maintain and build soil fertility. It should be noted that the early advocates of mineral fertilizers only intended that these fertilizers supplement the use of organic matter. Mineral fertilizers add only a part of the mineral portion of the critically important soil mixture essential to good health. They might be compared to vitamin pills; neither are intended to replace natural foods. But because of economic pressures, large scale specialized farming developed. Industry, through intensive advertising, urged the farmer to believe that artificial fertilizers were his panacea.

Under these conditions, the use of chemical fertilizer increased, and many farmers forgot about organic matter.

3.2 What Mineral Fertilizers Can and Cannot Do

Mineral fertilizers are like shots in the arm to the soil. Like an addictive drug, nitrogen fertilizer (and synthetic pesticides) literally create increased demand as they are used; the buyer becomes hooked on the product. They stimulate a much greater plant growth, but upset the vitally needed balance of minerals, organic matter and soil life. For example, under the impact of heavy use of inorganic nitrogen fertilizer, the nitrogen fixing bacteria originally living in the soil **may** not survive, or if they do, they may **mutate into non-fixing forms.**

There is some evidence that heavy use of NPK inhibits the uptake of certain trace elements. Superphoshates, for example, impede the uptake of zinc, copper, and iron. It is not known with any certainty why they should, but one theory which might account for the phenomenon suggests that the soil may be seriously unbalanced. In the soil solution, nutrients exist in anionic and cationic form, as small molecules carrying a positive or negative electrical charge. The outer membrane of the cells of the root hair is also charged and so it attracts molecules bearing the opposite charge. Each time one passes through the membrane, its own charge is reduced until it becomes neutral, when it will take up no more nutrients. Now if concentrated doses of particular nutrients are applied in the region of the root hair, the number of trace ions and cations as a proportion of the whole will be reduced. In effect they are being diluted, and since the mechanism by which they enter the plant is only partially selective, and since there is an upward limit to the total amount that can be taken up at one time, the root is likely to receive fewer trace minerals.

The use of mineral fertilizers means a speeded up consumption of organic matter. Recently, at Wright, Kansas, a very perceptive farmer took a soil audit before his first application of anhydrous ammonia. He took a second audit before the second application. In one season, 0.7% or 14 000 pounds of the organic matter content had been burned away. The crop was excellent, to be sure, but the capital reserve of the soil system was moving downhill rapidly. In a strict sense of accounting, this farmer burned up more value in humus than the entire worth of his crop.

Further, manufactured fertilizers alone cannot supply what the soil needs to produce abundant, healthy crops. Plants need much more than NPK. As previously pointed out, they need many other secondary and trace elements - all in the proper balance.

3.3 Results of Mineral Fertilization without Organic Matter

Dr. Barry Commoner is an eminent scientist who brought us forcefully to an awareness of certain chemical "kickbacks". He noted that more than 75 years ago, research stations such as the Missouri Agricultural Experiment Station began long-term experiments to study the effects of different agricultural practices on crop yield and on the nature of the soil. When this 50 year Sanborn Field Study was published, it showed that nitrogen was an effective means of maintaining good crop yields, but the report also showed that the soil suffered important changes. The organic matter content and the physical conditions of the soil on the chemically treated plots declined rapidly. These altered conditions prevented sufficient water from percolating into the soil, where it could be stored for drought periods.

Another major problem in farming land depleted of its organic matter was the inability of the soil to hold soluble fertilizer nutrients long enough for the plant to make maximum use of these expensive materials. Most of the nitrogen not used by the crop was removed from the soil by leaching.

As crops are grown in soil with the aid of increasing quantities of chemical fertilizers, the crops become deficient in proteins, vitamins, and minerals. According to Kansas surveys by the USDA between 1940 and 1951, while total annual State wheat yields increased during this period, protein content dropped from a high of nearly 19% in 1940 to a high of 14% by 1951. By 1969, the protein content of wheat had dropped to an average of 10.5% in the U.S. Midwest.

3.4 Pollution

This Sanborn Field study also focused attention on pollution caused by excess nitrates, the chemical salt of nitrogen. In humus-depleted soil, fertilizer nitrate tends to break out of the natural containment system. Some 7 million tons of nitrogen fertilizer are used annually in the U.S. alone. Roughly half of this fertilizer leaves the soil in some way. Much of what is leached out drains into water supplies.

In heavily farmed areas, the nitrate level of surface waters and wells often exceeds the public health standard for acceptable potable water, resulting in a risk to human health from nitrate poisoning. Also, when large amounts of nitrogen and phosphorus drain into surface water, they create an algal build up that can and does destroy entire bodies of water. The oxygen in the water is depleted; fish and other animal life forms begin to die.

Excessive nitrates is plants cause similar problems. It is important to recognize in this discussion of nitrogen that recent experiments have indicated that the presence of excess nitrates in foods might be detrimental to the health of man and farm animals. This is based upon the fact that nitrates may be reduced by intestinal bacteria to nitrites; and this form, in large quantities, will be poisonous to the blood stream. The investigation has covered many leafy vegetables and plants, including maize. Some vegetable products in the U.S. often exceed the recommended nitrate levels for infant feeding. Other effects mentioned are abortion in cattle, hay poisoning, grass tetany, and reduction of heamoglobin content in the blood. This suggests a new aspect of the importance of controlling nitrates in soils.

4. THE ALTERNATIVES

The above discussion points out that two avenues are open to the farmer: continued heavy use of artificial chemicals or the natural organic method of fertilization. We believe that the latter represents a safer ecological and more economic approach, while preserving the land's fertility. Our conclusions have been verified by scientific test results and the experience of farmers growing diversified crops around the world.

4.1 Ecological Considerations

Some of today's problems are:

i. pollution caused by the drain-off of toxic residues into water systems;

ii. the presence of harmful chemicals in the organs of farm animals that have eaten chemically fertilized grains and forage;

iii. continued applications of mineral fertilizers without the addition of organic matter will eventually leave a dead compacted soil vulnerable to erosion;

iv. in the soil system, organic matter has been extracted from the cycle at a rate that has exceeded the natural rebuilding rate of humus.

The far-sighted farmer is beginning to change his attitude toward the soil. Instead of only taking from it, he is giving to the soil by replacing and building up its supply of humus. As earth renews itself from top to bottom, and biological activity takes place somewhat in layers, the renewal process must not be interrupted; thus, natural humus must be added to the soil surface. The natural approach takes time but represents the only solution to these problems.

4.2 Economic Considerations

Even before the recent price jump of raw materials used in manufacturing mineral fertilizers, many farmers could see that their dependence upon ever increasing applications of NPK was leading beyond the point of diminishing returns. Because of the world oil and gas situation, mineral fertilizers generally are in short supply and what is available has been selling at a multiple of four to five times the price of a few years ago. And given the shortage of hydrocarbons coupled with continuing demand, there is little reason to expect reductions over the long term. Consequently, farmers are now faced with negative returns where increased yield values cannot equal the high cost of chemical inputs. Beyond this, higher prices are also being demanded for farm fuels, lubricants, and pesticides.

Whereas increasing quantities of mineral fertilizers are required to maintain yields, fortified humus with its high organic and mineral content brings yields up within a reasonable period of time, and then its application decreases. In other words, the cost curves will cross, with chemical fertilizers still heading upwards and humus continuing downward. Moreover, the price of a natural soil conditioner/fertilizer is not subject to worldwide fluctuations of oil and gas prices. Due to the vast extent of these natural organic and mineral deposits, they will remain stable and predictable. Marine humus with "Hydrosorb" is the way today's farmer can maximize his profit per acre.

5. HYDROSORB

i. Hydrosorb is a special blend of organic materials which absorbs and retains from 500 to 2 000 times its weight in water. The water is then held in place until the plant takes the water into its root system.

When in contact with water, Hydrosorb particles swell and absorb water until they become saturated. Hydrosorb has the unique ability of holding water while providing organic matter essential for efficient plant growth.

The absorption capacity of Hydrosorb varies according to water hardness, ionic strength, and pH values. The water saturated particles can be broken up into even smaller particles and still retain the water and have greater dispersion ability. After the water is taken into the plant via the root system, the particles dry and then are prepared to accept new water to be again held for the plant's benefit.

ii. Soil Life with Hydrosorb combines the required organic fertilizer and the ability to absorb and retain extremely large quantities of water.

These combined attributes enhance all the soil medium and are ideally suited for the sandy soils and extreme temperatures of the Near and Middle East. The basic ingredients of Soil Life were formed under extreme pressure and temperatures, and therefore are not adversely affected by hot arid climates.

6. WATER FILTRATION TEST

The purpose of conducting a water filtration test was to determine the amount of water savings that could be accomplished by adding Soil Life to sand.

The author recognizes that all sand does not have the same chemical analysis or the same structure (looseness, compactness, weight density, etc.); however, most sandy soils do have very similar water holding characteristics and hence a significant water loss due to filtration. Water loss from evaporation is not dealt with in this test (see FAO paper, "Evapotranspiration and Irrigation Requirements of Some Vegetable Crops in Kuwait").

Efficient use of available water is believed to be a significant agricultural problem in the Near and Middle East. A proposed solution to this problem is the utilization of Soil Life With Hydrosorb as an organic fertilizer which has the ability to eliminate water filtration.

6.1 Conditions

In order to accurately simulate the filtration loss for a particular soil, the soil's chemical analysis, structure, granular size, weight density, temperature, wind conditions, evaporation rate, saturation value must be known. Since each country, hectare, and even square metre is in fact different, one must make some basic assumptions of several of these conditions and properly analyse other conditions in order to obtain results that are meaningful. The following are some of the assumptions that were considered for the purpose of conducting the test:

i. Temperature range from 80-90° F or 27-32° C. The temperature was not allowed to rise above this range in order to minimize evaporation and thus measure the filtration rates unaffected by other conditions (i.e. evaporation, transpiration, etc.).

ii. Sand used in the experiment was washed, dried, and filtered through a 16 mesh screen prior to mixing.

iii. A variety of water conditions were considered in the test due to the variation of the saline content of the water sources in each country. Well water and distilled water were both utilized in the test. Laboratory grade sodium chloride was then added to the water in varying quantities beginning with 1 000 ppm, 2 000 ppm and up to 10 000 ppm.

iv. Six-inch clay pots were used to hold the sand while the water was applied over a 4, 12 and 24 hour period simulating a 5 cm rain or a 500 ml water irrigation in a 1 000 gram soil medium. The pots were painted with a clear sealer to prevent water absorption from affecting the test results.

6.2 Results and Conclusions

The filtration readings were taken from five identical pots and then averaged to establish a value that should be representative for a given Soil Life mixture and water salinity factor. By the nature of sand and its variation in physical structure, the water would seek "flow channels" as paths to flow through (paths of least resistance and gravitational pull). Therefore, some data points were not in the overall trend line statistically, and should not be considered as valid in establishing a statistical forecasting equation. Further research will be conducted to determine the least squares curve fit for each of the sand, Soil Life, and saline water combination. However, the obtained trend lines will suffice for an estimate of the Soil Life required to eliminate water filtration in sandy soil.

It is noted that as the amount of "Soil Life with Hydrosorb" increases, the filtration decreases (Figs. 1 and 2). The amount of water saved with increased application of "Soil Life with Hydrosorb" is shown in Tables 1 and 2.

It was determined that "Soil Life with Hydrosorb" has the ability to hold all the water in the soil medium that is required for plant growth. Obviously, there must be a proper design of an application rate consistent with soil conditions and rainfall and/or irrigation rates in order to preserve the water. At the same time, the application rate must consider the particular crop to be planted and its water intake rate, transpiration and evaporation rates, and the salinity in the soil and water. Since all these factors are readily calculable, a "Soil Life with Hydrosorb" blend can be recommended for any particular application.

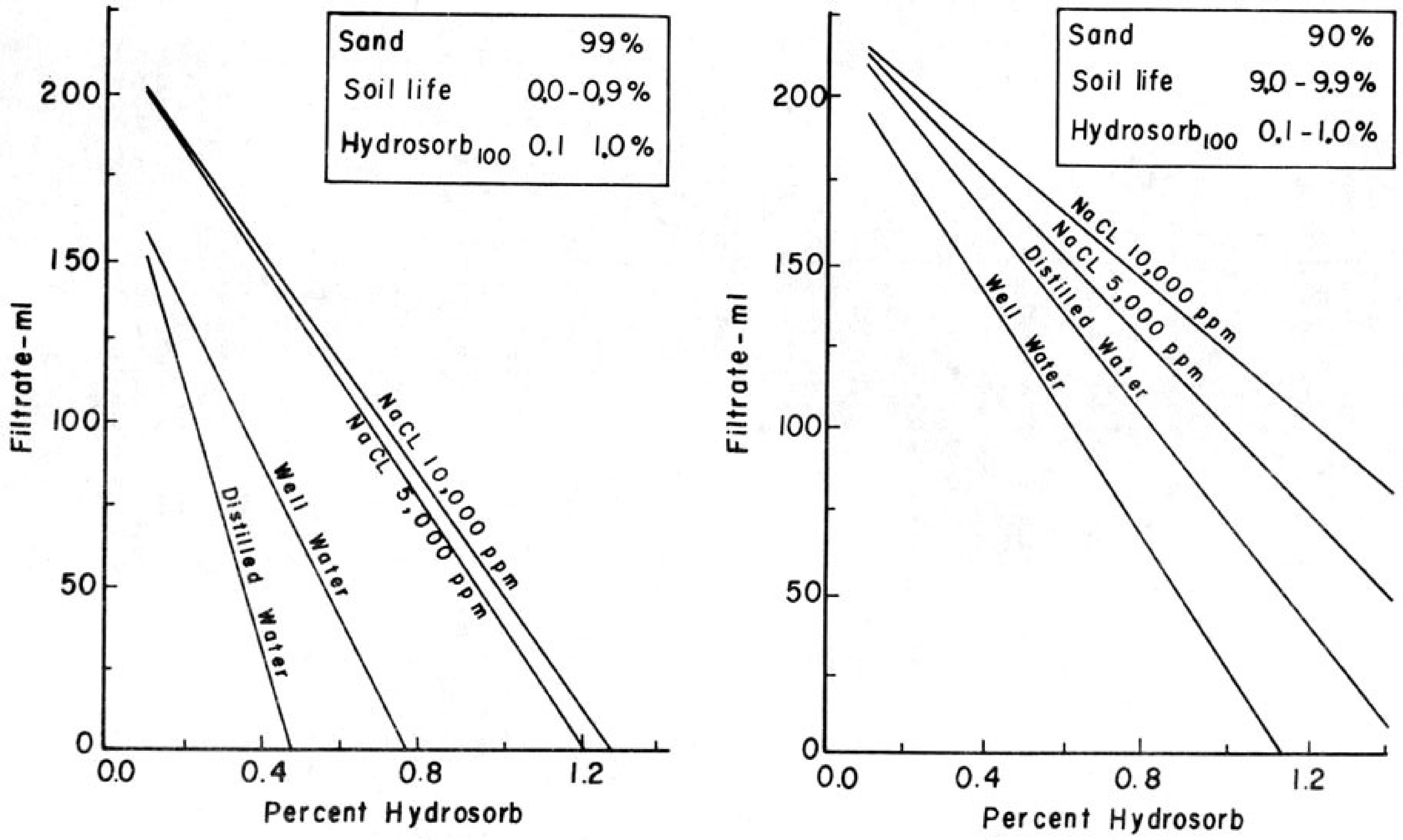

Fig. 1 Water filtration curve, filtration vs. Soil Life with Hydrosorb 100

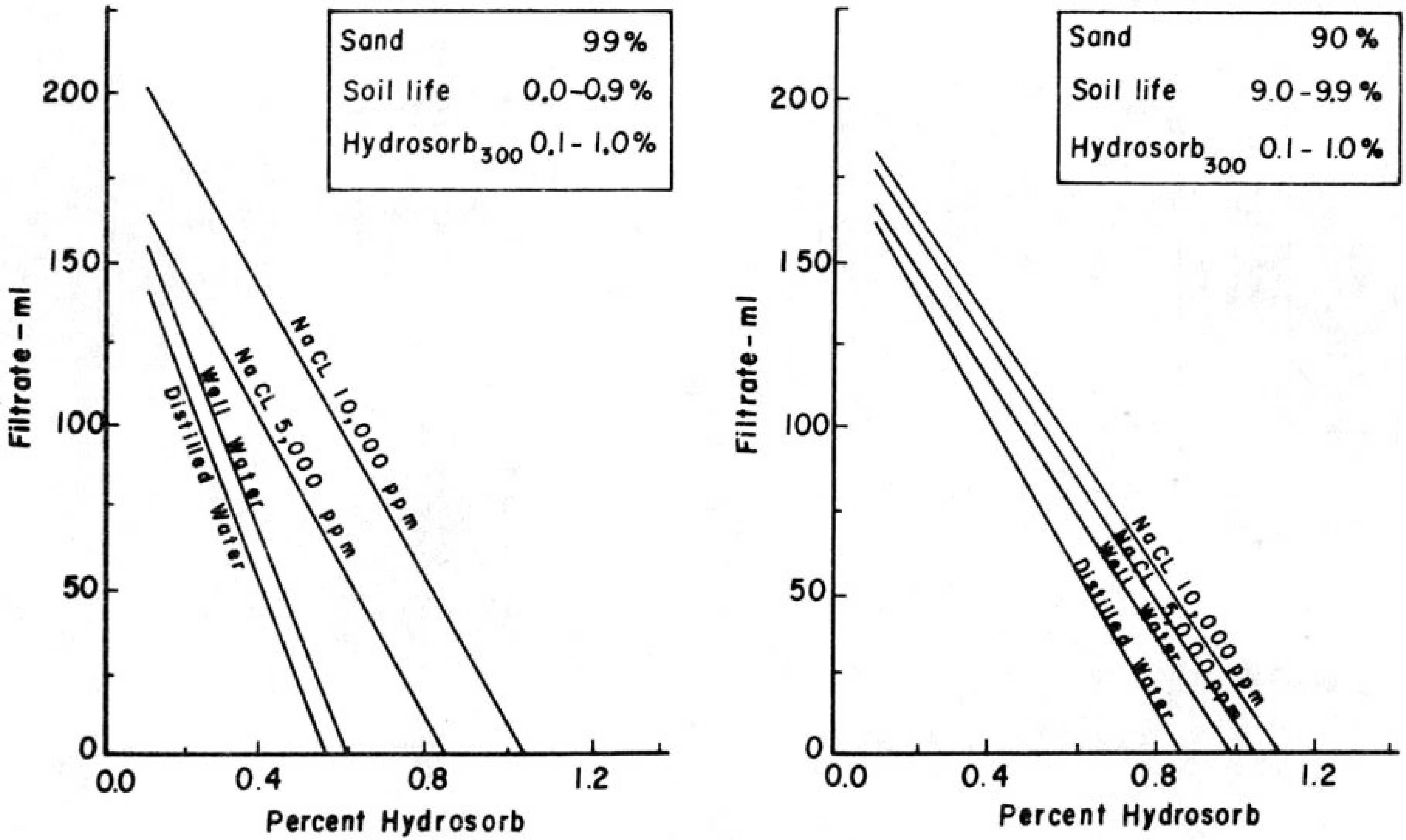

Fig. 2 Water filtration curve, filtration vs. Soil Life with Hydrosorb 300

Table 1

SAND, SOIL LIFE WITH HYDROSORB100 FILTRATION TEST
(500 ml H_2O APPLIED TO SOIL MEDIUM)

Distilled water + NaCl in ppm	Sand 90 % Soil Life 9.5% Hydrosorb 0.5%			Sand 90 % Soil Life 9.0% Hydrosorb 1.0%		
	Filtrate, ml	Water held, ml	Water saving %	Filtrate, ml	Water held, ml	Water saving %
1 000	64	436	87.2	5	495	99.0
2 000	65	435	87.0	23	477	95.4
3 000	70	430	86.0	32	468	93.6
4 000	85	415	83.0	38	462	92.4
5 000	84	416	83.2	50	450	90.0
6 000	82	418	83.6	65	435	87.0
7 000	97	403	80.6	73	427	85.4
8 000	95	405	81.0	65	435	87.0
9 000	100	400	80.0	83	417	83.4
10 000	104	396	79.2	90	410	82.0

Table 2

SAND, SOIL LIFE WITH HYDROSORB300 FILTRATION TEST
(500 ml H_2O APPLIED TO SOIL MEDIUM)

Distilled water + NaCl in ppm	Sand 90 % Soil Life 9.5% Hydrosorb 0.5%			Sand 90 % Soil Life 9.0% Hydrosorb 1.0%		
	Filtrate, ml	Water held ml	Water saving %	Filtrate, ml	Water held, ml	Water saving %
1 000	38	462	92.4	1.7	498.3	99.7
2 000	45	455	91.0	2.8	497.2	99.4
3 000	52	448	89.6	3.9	496.1	99.2
4 000	56.3	443.7	88.7	4.6	495.4	99.1
5 000	61.2	438.8	87.8	5.0	495.0	99.0
6 000	64.0	436.0	87.2	5.8	494.2	98.8
7 000	65.1	434.9	86.9	6.3	493.7	98.7
8 000	70.4	429.6	85.9	6.5	493.5	98.7
9 000	76.5	423.5	84.7	7.6	492.4	98.5
10 000	82.6	417.4	83.5	8.6	491.4	98.2

Paper 18

ORGANIC RECYCLING PRACTICES IN ASIA AND THE FAO/UNDP INTERCOUNTRY PROJECT RAS/75/004

by

P.R. Hesse
Regional Project Coordinator for Organic Recycling
in Asia and the Pacific

1. INTRODUCTION

During the past twenty years the assistance given to member countries by FAO and UNDP in the field of soil fertility has been largely on the use and effects of mineral fertilizers. This was due partly to the fact that experiments using easily handled inorganic compounds gave relatively quick and positive results, but also in order to keep abreast with the world tendency to increase crop yields by means of mineral fertilizers. It was realized that optimum soil fertility could result only from a balanced use of mineral and organic fertilizers together, but interest in organic manures had waned, even in countries where such fertilizers were traditional, owing to the increased availability, convenience of use, and low cost of commercial mineral fertilizers.

However, these conditions did not endure and, primarily due to the world energy crisis, availability of mineral fertilizers decreased and their cost increased. In 1974 at the FAO Committee on Agriculture, the Commission on Fertilizers, the FAO Council and the World Food Conference, better and increased use of organic materials was urged in order to improve soil fertility and food production.

Among the follow-up activities of FAO was a regional workshop on the agricultural use of organic materials in Asia and the Pacific which was held in Bangkok in December 1976. This workshop was attended by thirteen countries from the region and resulted in many specific proposals concerning the agricultural use of rural wastes, biogas, peat soils, city and industrial wastes and biological nitrogen fixation. Great emphasis was laid upon the need to share and exchange knowledge and experience between countries.

Some of these recommendations have already been followed up by FAO and all such activities, past, on-going and planned, have now culminated in an intercountry project "Improving Soil Fertility Through Organic Recycling". The project will have the overall purpose of coordinating all activities in the region related to the use of organic materials to improve soil fertility. In addition, the project will collect and disseminate information, and help with the transfer of technoligies by means of consultants, seminars, workshops and study tours. It will also assist in the training of individuals or groups by means of training courses, fellowships and consultants.

A preparatory assistance phase of the proposed project was approved by UNDP for a six month period commencing 1 February 1978. The preparatory assistance was primarily a fact-finding mission during which the Coordinator visited each potential participating country. In addition UNDP approved funds for a Study Tour in China for about twenty participants from Asia in order to study techniques of azolla propagation and use, and of small-scale biogas unit construction.

2. FINDINGS

2.1 Research Programmes

Research programmes in organic recycling vary greatly in extent, subject and efficiency from country to country. In some countries, notably India and Vietnam, there is a considerable research programme covering nearly all aspects of organic recycling, whereas in others - Lao and Afghanistan for example - there is no relevant research.

Interest in Azolla and blue-green algae had, in several countries, been stimulated by an FAO training mission in late 1977 and investigations into its propagation have been commenced. Thus, generally speaking, research in this subject is not far advanced; the exception is at the International Rice Research Institute in the Philippines where the recent findings on temperature tolerance of different species are of great interest to all concerned, especially in Vietnam and China. Three species of Azolla are under investigation, A. pinnata (the most commonly occurring species in Asia), A. filiculoides (from California) which grows best at temperatures below 25°C, and A. mexicana which can resist high temperatures. Ten strains of these species are being examined for nitrogen fixation, temperature effects and nutrient requirements. An attempt is being made to establish a world collection of Azolla.

One problem is that of the most suitable method of phosphorus application, and trials are being done on this. Results to date indicate that from 5-7 kg P/ha (10-15 kg P_2O_5) in split application every 1-2 days is best; superphosphate is being used. Thus the current advice is to add 2.5 kg P every two days, five times in all. Economic factors show that 0.5 kg P represents a fixation of 2 kg N. Experiments are also being made to find the minimum P content permissible in the water for satisfactory growth of Azolla.

A second problem is that of transportation of Azolla to other districts or countries. This problem does not arise with blue-green algae for example, which can be dried; Azolla must be fresh, as drying kills it. Thus distribution of promising strains is limited. Research is under way on the technology of spore formation. If spores can be produced artificially, then not only can dormant spores be transported but it would be possible to experiment with hybridization. Meanwhile a successful method of transporting Azolla is to grow it in Agar jelly in test tubes, where it will live for one week.

Research is also being done on algae at IRRI. The problem here is to know if any of the fixed N becomes available to plants and if so, how much. It is suspected that the good effects of blue-green algae may be due to growth promoting hormones rather than nitrogen.

Although research on biogas is said to be active in many countries, only in India is there a well-established and planned programme involving actual biogas research stations. Work in other countries is largely confined to isolated investigations into design or temperature or nature of inputs. Most designs are variations of the floating metal gas holder type but interest in the cheaper, Chinese-type is increasing. The main problems to be overcome are how to continue use of biogas units in cold weather and how to reduce cost. Some countries are researching into problems already solved in other places and this emphasizes the need for sharing information.

At the Indian Biogas Research Station at Ajitmal, many different forms of unit are under investigation, including seven variations of the basic Chinese model. In the laboratory, which is run entirely on biogas, the various factors affecting gas production and quality are being studied. Gas analyses are made and also analyses of the N P K balances involved. Many different organic wastes are being examined and at present great expectations are held for using water hyacinth. Ratios of water to solids, temperatures, organic additives and so on are all being studied. The laboratory, which is simple, uses biogas directly when possible, i.e. for heating, lighting, glassblowing etc. and electricity is made from biogas-run generators. Research into improved gas-using appliances is under way and especially its use for running engines. A full scale workshop with drills and lathes is operated by biogas.

Laboratory results are tested in large units. Water hyacinth is proving a good material to use, especially when mixed with cattle manure. A special method of loading the unit is needed and this has been designed; for best results roots must be eliminated.

To be able to use plants in colder weather, temperature control experiments are made. One successful model has a steam-lagged outer chamber and a very successful technique is to instal solar-heaters and circulate hot water round the unit.

The Chinese type of unit is preferred as it is simple, easily constructed, cheap (about Rps. 1 500 as compared to Rps. 7 000 for metal tank models) and more easily run and maintained. The floating tank type needs emptying and re-painting every year (Rps. 500) and very soon corrodes. It is thought that by 1979, it will be possible to recommend a specific variation of the Chinese form.

In Korea, a joint research project is being conducted by the Korean Institute of Agricultural Engineering and the United Kingdom Government. In an experiment on the cold weather running of biogas units, PVC bags are used as digestion chambers and gas holders. The bags are supported in stone-lagged trenches and have double plastic covers like small greenhouses.

Nearly every country experiences difficulty in preparing good quality compost, but research on this is limited to a few centres (e.g. Indian Agricultural Research Institute; Institute of Agricultural Sciences Korea). A subject of common interest is the use of bacterial concentrate to hasten composting processes. Other relevant research is limited to specific investigations in individual research stations. For example at MARDI in Malaysia, and at ICRISAT in India, research is particularly active on leguminous nitrogen fixation and cover crops, in Pakistan interest is high in the green manuring of saline-alkali soils and in Korea, the Suweon Institute of Agricultural Sciences has a well-established programme of research concerning the effects of organic recycling on the physical properties of soils.

Research on improved methods of composting is going on at the Indian Agricultural Research Institute. Some very basic research is on decomposition of organic materials in soils and in composts, including nutrient supply and micro-organisms.

The use of fungi and bacteria to hasten the composting process of farm wastes is being examined, because if 3-4 crops are grown per year, little time is available to decompose plant residues. A special study is being made of cellulose-decomposing organisms, and studies on composting of city waste are being planned.

Another subject is enrichment of compost by adding azotobacter and phosphorus-solubilising organisms together with rock phosphate. Other studies include the effect of organic materials on plant growth, the detoxication of pesticides and herbicides, and also the combined effect of organic/mineral fertilizers on nematodes.

2.2 <u>Field Practices</u>

Although nearly every country in Asia practises some form of organic recycling, many have no knowledge of what can be done in related fields. For example, in Malaysia, although green manuring is well advanced, composting of the considerable quantities of rural and urban wastes is neglected and biogas is unknown. Similarly, although many countries practise green manuring in connection with rice production, they are completely unaware of the value (or even the existence) of azolla.

Few countries make, or attempt to make, agricultural use of human waste, although in some cases this is due to public unacceptance of the practice, rather than lack of technology. In some countries (e.g. Afghanistan) use of night soil is either inefficient or unhygienic. In most countries however, sewage is disposed into waterways and the sea. City garbage is sometimes composted (e.g. Thailand) and sometimes used directly without any treatment (Indonesia) but in most countries it is dumped as land-fill.

Animal wastes are recognized as being valuable manure, but the efficiency of their use is variable. In India, even though the tendency is toward use of cow dung for biogas and manure production, the larger part of the material produced in the country is still burnt as fuel. Where pig dung is available, it is efficiently used as fertilizer for soils and fish ponds although, in places such as Singapore and Hong Kong, scarcity of agricultural land necessitates wasting the dung by dumping it as land-fill or into the sea; everywhere chicken dung is valued as fertilizer and used on vegetable plots.

Biogas plants suitable for small farming communities are restricted to a few countries such as China, India, Korea and the Philippines. Each country has its own model, or models, of unit although all, with the exception of China, are variations of the metal gas-holder type. Thus the common complaint and restraint is that of high cost: the average cost is about $500 and the unit needs expensive maintenance. Even so, several hundred units are in successful operation, the initial cost being subsidized by governments. As the average cost of the Chinese design is about $25, considerable experimentation with this type of unit is expected.

The systematic use of azolla is confined to China and Vietnam at present, but now that its value is more widely recognized, its use is expected to spread to every participating country providing climatic conditions are suitable.

Many countries have their own particular example of organic recycling practices. Thus in the Philippines, the Maya Farm is rapidly becoming a show piece; India has several systems of integrated farming based upon biogas production and in Malaysia, farmers are transforming unsightly and infertile tin "tailings" into highly productive farms, almost entirely by use of organic manures.

3. CONCLUSION

Organic recycling is fully recognized in Asia as an important, and even essential, practice for improving soil fertility and it is firmly established that for optimum land use, a properly balanced use of organic and mineral fertilizers is necessary.

However, knowledge and experience in this subject are confined to a few places and the intercountry project will provide a coordinating body for dissemination and sharing of this knowledge and experience.

The project will also provide for the training of individuals or groups in the various aspects of organic recycling as found necessary by means of training courses, fellowships and consultants.

Another important function will be to assist in transfering technology by means of consultants, seminars, workshops and study tours. Assistance could also be given to ongoing country programmes by provision of limited quantities of specialized equipment and supplies.

The Study Tour in China on Azolla and biogas was very successful and participants gained much valuable knowledge which they are anxious to use for the benefit of their countries. In many cases assistance in the form of materials or, more especially, practical technology, will be necessary if their new-found knowledge is to be translated into practical activities. During the study tour, it was ascertained that the Chinese Government would be willing to send technicians under the auspices of the project to help in the construction of biogas units. In view of the much lower costs of the Chinese design, this offer will be taken up - at least in a few experimental countries.

Paper 19 BIOFERTILIZERS - REQUIREMENTS AND APPLICATION

by

M.N. Alaa El-Din
Senior Researcher in Soil Microbiology
Soil and Water Research Institute
Agriculture Research Centre, Giza, Egypt

1. INTRODUCTION

"Biofertilizers" denote preparations containing living micro-organisms such as bacteria (Rhizobia, Azotobacter, Spirillum and phosphate dissolvers), fungi (mycorrhiza) and blue-green algae (free-living or in symbiosis with Azolla), which can improve the soil fertility by changing unavailable sources of nitrogen (atmospheric N_2) and phosphorus into available forms for growing crops. Biofertilizers are considered as a cheap way to recycle elements, to conserve natural resources and to act as protection against increasing pollution due to the extensive use of mineral fertilizers. Extensive use of mineral nitrogen fertilizers, e.g. ammonia, nitrate and urea, usually leads to an accumulation of nitrate which is either lost by washing out to the groundwater, causing nitrate toxicity to man and animals, or by dinitrification under anaerobic conditions to nitrogen gas (N_2), nitrous oxide (N_2O), nitric oxide (NO) and nitrogen dioxide (NO_2). The nitrogen dioxide (NO_2) converts the ozone (O_3) to oxygen (O_2), thus causing a decrease in the ozone concentration. Possible environmental hazards for plants, animals and climate are reported by the Council for Agricultural Sceinces and Technology (1976).

In developing countries, nitrogenous and phosphatic fertilizers are not only in short supply but also expensive. Pierrou (1976) calculated the P-consumption for one-third of the world population to be 10 times more than that consumed by the remainder.

The exploration of the possibilities of using inexpensive and easily available biofertilizers should, therefore, be one of the immediate tasks to meet the increasing needs for plant nutrients and for a less polluted globe.

One of the good possibilities is the effective use of biological nitrogen fixation. Nitrogen fixation in agriculture is estimated by Burns and Hardy (1975) to be 35, 9 and 45 million tons nitrogen/year for cultivated legumes, non-legumes and grasslands, respectively. An additional 50 and 10 million tons nitrogen/year are reported for forests and unused land, respectively. The total biological nitrogen fixation (149 million tons/year) represents about 63% of the total nitrogen (237 million tons/year) reaching the soil through biological and nonbiological nitrogen fixation processes, e.g. lightning, combustion and fertilizer production.

Some of the well known biological systems capable of fixing atmospheric nitrogen, their utilization as biofertilizers and the feasibility of their application are listed in Table 1 which shows that the biofertilizer preparations with potential benefits are:

i. preparations containing Rhizobium sp. to be applied to legumes, "legume inoculants";

ii. Azolla plants to be used as green manure for rice as well as for other crops, such as wheat and maize, or composted and used as fertilizer. It can also be used as animal feed after drying;

iii. water lentils, "Lemna gibba", to be applied to paddy, or to be used as feed;

iv. preparations containing nitrogen-fixing blue-green algae to be applied to paddy, "algal inoculants";

v. preparations containing free-living nitrogen-fixing bacteria e.g. Azotobacter and Spirillum.

2. LEGUME INOCULATION

There is no doubt about the beneficial effect of applying legume inoculants containing effective rhizobial strains to the legume seeds before sowing. Successful nodulation increases the legume yield without nitrogen fertilization. Moreover, the residual effect on the following crop presents an additional contribution to the nitrogen resources in the ecosystem.

In this connection, it is worth throwing light on the very efficient Sesbania-Rhizobia association. Sesbania plants are able to grow under extremely varied agroclimatic conditions, e.g. tropical, subtropical and semi-arid, and are resistant to drought, waterlogging and to soil acidity and alkalinity. The author found that nodules formed naturally by Sesbania plants in China (*Sesbania cannabina*), Egypt (*S. sesban*) and Afghanistan (*Sesbania* sp.) were highly efficient in N-fixation. Plants of 4.5 m hight and 4-5 kg fresh weight could be reached within 75 to 115 days after sowing. Combined use of Sesbania as a source of shade, wind-break, green manure, fodder and fuel could be achieved by cultivating sesbania on borders or in rows. About 15-22.5 tons/ha green material (green manure or fodder containing 82 kg of N, 11-16 kg of P_2O_5 and 23-34 kg of K_2O) could be obtained within 6 weeks. Keeping sesbania growing for a longer time (up to 6 months), the stems would provide 26-39 tons/ha wood for fuel, 3.5 - 7.8 tons/ha dry pods and the young branches could also be fed to farm animals. Values of 542 kg N/ha/year have been reported for the nitrogen fixed by *Sesbania cannabina* (Nutman 1976).

3. AZOLLA

Azolla is a small water fern of the family Salvaniaceae and contains in the cavities of the dorsal lobes of its leaflets a filamentous, heterocystous blue-green algae called *Anabaena azollae*. Proliferation of Azolla in nature and in the laboratory is an entirely vegetative reproduction. It contains 3-4% dry matter, 4-5% nitrogen, 25-32% organic carbon and a crude protein content of 1.3% in the green material (about 32.5 - 43.4% of the dry matter). Azolla can grow at a temperature of 14 to 30°C (18 - 22°C optimum) in 5 - 10 cm standing water and 85-91% relative humidity. It grows well in soils of pH 5-8 but fails to grow in acidic soils (pH 3.5). Due to its narrow C:N ratio (10:1), Azolla decomposes rapidly in the soil releasing 56% and 80% of its N as ammonia at 3 and 6 weeks respectively (Singh 1978). Azolla has long been grown in lowland rice fields in China. About 1.3 million hectares have recently been reported cultivated with Azolla in China (Chung-Chu 1978). The use of Azolla as green manure and feed for domestic animals, and composting of Azolla were recorded in 540 BC in China (Chung-Chu 1978). Azolla has also been cultivated in Vietnam and became an important practice in agriculture (Dao and Thuyet 1978). The rice area grown with Azolla in Vietnam has been increased from 5 000 ha in 1950 to more than 400 000 ha. India started in 1977, after experimentation, to cultivate Azolla (Singh 1978). In September 1978, the author carried out a feasibility study on Azolla propagation in Afghanistan and reported difficulties due to the very low relative humidity of air during the rice cultivation period.

Table 1

BIOLOGICAL SYSTEMS FOR NITROGEN FIXATION, EFFICIENCY OF BIOFERTILIZER PREPARATIONS AND FEASIBILITY OF APPLICATION

Micro-organism	Plan	kg N fixed/ha	Biofertilizer preparation	Feasi-bility
A) Symbiotic nitrogen fixation systems				
1) Bacteria (Rhizobia)	Forage legumes	34-897/year	Legume - inoculants	High
	Pulses	41-552/crop		
	Legume trees	74-542/year		
	Zygophyllaceae and Trema cannabina		Not available	-
2) Actinomycetes	Non-leguminous angiosperms Hippophae, Elaeagnus, Casuarina, Myrica, Alnus etc.	12-350/year	Not available	Probably
3) Blue-green algae	Fungi : Lichens	-	Not available	-
	Water plants : Azolla	425/100days	The plants - containing algae	High
	Lemna gibba (loose association)	60/100days		Fair
	Gymnosperms : Cycas, Zamia	-	Not available	-
	Angiosperms : Gunnera	-	Not available	-
B) Non-Symbiotic nitrogen systems				
1) Heterotrophic bacteria: Azotobacter			Available	Debatable
Spirillum		20-50/year	Under Experi-mentation	
Others e.g. Mycobacterium, Methylobacter Bacillus, Clostridium, Desulfovibrio		-	Not available	-
2) Photosynthetic bacteria e.g. Rhodomicrobium, Rhodospirillum		-	Not available	-
3) Chemoautotrophic bacteria e.g. Thiobacillus		-	Available as phosphate dissolvers	-
4) Blue-green algae e.g. Nostoc, Anabaena, Tolypothrix, Scytonema, Aulosira		5.2-77.6/crop	Algae inoc. for paddy	Fair

Azolla can be applied in several ways, i.e. green manure in general and in combination with rice cultivation, for feeding farm animals, for preparing composts, and for making biogas together with crop and animal residues. Probable benefits realized from Azolla propagation are summarized in Tables 2 and 3. More details are presented in FAO Soils Bulletin 40 (1978) and by Singh (1978), Chung-Chu (1978), Dao and Thuyet (1978), Becking (1978), Peters et al (1978) and Rains and Talley (1978). In the summer, shading the fields reduces light intensity and water temperature which improve the growth of Azolla, therefore a combination of Sesbania (2-3 m wide rows) and Azolla cultivation could be a possible way to overcome the problems raised in summer. This technique should also be tried in semi-arid climates.

Table 2 NITROGEN FIXATION RATE BY DIFFERENT AZOLLA SPECIES AND THEIR EFFECT ON YIELD OF PADDY

	Alaa El-Din et al (1978b)	Chung-Chu (1978)	Dao and Thuyet (1978)	Singh (1978)	Rains and Talley (1978)
Locality:	China	China	Vietnam	India	USA
Azolla strain	Pinnata	Pinnata	Pinnata	-	Filiculoides
Seeding rate, ton/ha	7.5	-	2.5-15.0	1-4	0.5
Fertilizers:					
P_2O_5 kg/ha	24-36	-	5-10/5days	4-8	15
K_2O "	20	-	10/10days	4-10	-
Others " (ash)	-	-	100	50	-
Growing period, days	100	-	60	7-20	35
Yield					
Green mat., tons/ha	157.5	-	30	27.7	50
rate, ton/ha/year	574.9	150.15	182.5	333.4	521
Nitrogen fixed, kg/ha	428.4	-	25.0	20-40	52
rate, kg/ha/year	1563.7	300	152.1	840	542
Nitrogenase activity					
µmole C_2H_4/g d.wt/h	66.8	-	-	-	-
mg N/g d.wt./day	9.8	7.5	-	-	-
Increase of rice yield, kg/ha	-	600-750	-	-	-
Increase of rice yield, %	-	9.9-42.7	-	9-54	25-300

Table 3 BENEFITS REALIZED FROM VARIOUS APPLICATION METHODS OF *Azolla Pinnata* IN CHINA

	Application method	Green matter tons/ha	N-fixed kg/ha
a)	In rice fields		
	Ploughing under	22.5	61.2
	Ploughing and burying once	45.0	122.4
	Ploughing and burying twice	67.5	183.6
	Ploughing and burying thrice	90.0	244.8
b)	As N-fixation factor		
	10 times harvest within 100 days	157.5	428.4

The potential uses of Azolla are numerous and FAO is helping developing countries to make use of this symbiotic system. Efforts in the immediate future are likely to concentrate on the following:

i. Research programmes on:

a. Azolla agronomic potential in supplying nitrogen to aquatic environments;

b. spore propagation of Azolla to help popularization and handling;

c. selection of strains for high temperatures and low relative humidity to be applied in irrigated paddy fields in semi-arid regions, e.g. Egypt and Afghanistan;

d. improved utilization methods to increase the fertilizing and feeding values of Azolla.

ii. Wide use of Azolla in developing countries

Mineral fertilizers are becoming too expensive for the developing countries. Even in the developed countries, the use of Azolla will become economic as a N-source for rice-growing areas, e.g. North America, in the near future.

4. LEMNA GIBBA

Lemna gibba called "water lentil" or "duck weed" is a small floating, fresh water plant associated with blue-green algae and other free-living nitrogen-fixing bacteria. Proliferation is through vegetative reproduction. However, sexual reproduction which is essential to the survival of the population during temporarily adverse conditions also occurs. Water is a fundamental requirement for the occurrence of Lemna.

On the contrary to Azolla, Lemna can grow at low relative humidity (30-50%) and during summer months at high temperatures (30-40°C). It occurs in shallow and deep waters and on the surface of permanent ponds, canals and drains. Lemna prefers an environment with a certain degree of shading. As shown in Table 4, the plant contains 3-5.5% dry matter, 1.7-2.0% N and a protein content of 10.6-12.5%. It grows rapidly, can fix atmospheric N and is easy to harvest (Alaa El-Din et al 1978a). Lemna is generally used for feeding ducks in Egypt. However, this plant could present a good substitute for Azolla in semi-arid irrigated regions, e.g. in many of the Near East countries with hot, dry summers. During preliminary experiments Lemna showed similar growth rates to Azolla. Starting with 7.5 ton/ha inoculum of Lemna, 6.6 tons fresh Lemna and 3.9-4.6 kg N/ha/week were achieved and after 7 months, the yield was 200 tons green material and 119-140 kg N/ha.

Lemna grow extremely well in drain and sewage waters. They can also be used to strip dissolved ionic pollutants as nutrients (nitrates, phosphates and other nutrients) and to remove these ions from waste waters. It is much better than green and blue-green algae used now for this purpose.

Lemna could be used, like Azolla, for feeding farm animals, making compost, green manuring and also for biogas production. Further investigations are, however, needed on the benefits realized by its application.

Table 4 MOISTURE CONTENT, TOTAL N AND NITROGENASE ACTIVITY (C_2H_2) OF *Lemna gibba* COLLECTED FROM DIFFERENT LOCATIONS (WATER WAYS) IN EGYPT

	Location	Moisture %	Total-N %	N_2-ase activity % 1/
1.	Drainage of Defrah (near Tanta)	97.42	1.77	77.3
2.	Drainage of Qoutohr	96.98	1.70	72.7
3.	Rice field at Qoutohr	97.10	1.76	74.3
4.	Maryotia irrigation canal (near Pyramids of Giza)	96.61	1.76	69.8
5.	Sewage water at Giza (El-Koum Akhdar)	94.44	1.97	23.8

1/ µg N fixed/g dry weight/h, mean of 4 replicates and 3 successive injections each.

5. BLUE-GREEN ALGAE

The popularization of blue-green algae inoculation as a very cheap source of nitrogen and organic matter provides one of the tools to increase paddy production and soil fertility. The inoculation is necessary because not every soil harbours useful nitrogen-fixing blue-green algae. In India only one third of the tested rice field soils were found to have these algae. However, their relative abundance showed a wide variation.

Results of the research work conducted in Egypt, India, Japan and the Philippines are summarized in Table 5. These data show the following:

i. in areas where commercial N fertilizers are not used algal application can give the benefits of applying 24-48 kg N/ha;

ii. the nitrogen fertilizer used could be reduced by about 30% when combined with algal inoculation;

iii. even at high N level applications, algal inoculation increases the yield per unit input besides its ecological benefits, e.g. synthesis of growth promoting substances such as amino acids which help the growth of the rice plants (Table 6).

Usually the successive inoculation with algae for 3-4 consecutive seasons sustains a high crop yield at a reduced level of nitrogen fertilization in the subsequent cropping season, providing there are no adverse ecological conditions, e.g. frost during winter time or accumulation of high salt concentrations.

The algae applied to the field are usually species of filamentous, heterocystous algae, e.g. Tolypothrix, Nostoc, Anabaena, Plectonema, Scytonema and Aulosira.

The starter inoculum containing the suitable algal strains is propagated in shallow trays of galvanized iron sheets (180 x 90 x 25 cm) or of brick and mortar structure when permanent units are desired. The size can be increased to produce more algal biomass. Nursery plots of 5-7 m long, 1 m wide and 20 cm deep could also be used. Covering with plastic sheets could help accumulation of solar energy and protection from cold.

The inoculum is applied to rice fields 1-2 weeks after transplanting at a rate of 10 kg of the soil based inoculum/ha (Egyptian and Indian methods) or 750 kg green algal material/ha (Chinese method).

In both India and Egypt, the preparation of the starter is carried out by the Agriculture Research Centers of the Ministry of Agriculture.

6. FREE-LIVING NITROGEN-FIXING BACTERIA

Nitrogen fixation by certain free-living bacteria, e.g. Azotobacter, Clostridium and Spirillum is well known. Inoculation of soil with preparations containing Azotobacter chroococcum (Azotobacterin) was attempted in Russia in the early part of this century. Since then, research has been carried out in many parts of the world including Egypt and India. In general, the benefits realized from applying Azotobacter preparations are debatable and depend on the presence of high content of organic matter in the soil.

The role of Spirillum bacteria in the nitrogen supply of tropical and subtropical grasses and crops has been recently put under investigation since Dr. Johanna Döbereiner, in Brazil, identified these bacteria. She and co-workers reported nitrogen gains of 30 kg/ha through fixation.

7. PHOSPHATE DISSOLVING MICRO-ORGANISMS

Much of the soil phosphorus is poorly available to plant roots because it occurs in insoluble mineral or organic forms or is strongly adsorbed on the clay fraction. Also, much of the soluble phosphate added as fertilizer becomes adsorbed. Certain bacteria, called phosphobacteria such as Bacillus megatherium var. phosphaticum are used as soil inoculants in Russia and other countries. Yield increments in

Table 5 NITROGEN FIXATION AND INCREASE OF YIELD OF PADDY INOCULATED WITH DIFFERENT BLUE-GREEN ALGAE

Type of experiment	Algae species	% increase over control		N-fixed equivalent to kg N/ha	Remarks	References
		Grain	Straw			
	Different	-	-	77.6-352.4	-	Mandol (1956)
Field	Tolypothrix tenuis	15.0 25.0	- -	- -	Well-drained Badly-drained	Watanabe, et al As above (1951)
Pot	Tolypothrix tenuis	4.2 7.0 16.1	19.3 56.6 67.0	- - -	-P fertilization +P fertilization +N+P fertilization	Ibrahim et al (1971)
Field	Tolypothrix tenuis	15.3	-	48	-	Abou-el-Fadl et al (1970)
Field	Tolypothrix	14.1 29.7	- -	< 24 < 24	After horse bean After wheat	Abou-el-Fadl et al (1967)
Field		0.85-21.1	-	5.2-15.2		Venkataraman (1972)
Field		15	-	-		Venkataraman and Goyal (1968)
Laboratory		600	-	-		Allen (1956)
Field	Aulosira fertilissima	114	-	-		Singh (1961)
Pot	Aulosira fertilissima	368	-	-		Singh (1961)
Field	Nostoc+ Anabaena+ Tolypothrix + Scytonema	22.2 32.6	14.1 37.6	- -	200g dry algae/ha 200g algae+1000kg lime+20kg P_2O_5 + 0.28 kg Mo/ha	Subrahmanyan et al (1965)
Field		6.7-21.4	-	20-30	Exp. 1965-1975	Venkataraman (1977)
Field	Anabaena azotica	24	-	-		
Field	Anabaena azotica var. alpina	17	-	-		Ley et al (1959)
Pot	Anabaena variabilis	18	-	-		
Field	Tolypothrix tenuis	10.2-17.9	6.2	-		Watanabe (1962)
Field		13.8	-	-		Relwani (1965)
Field	Natural	-	-	30.8-46.4/ crop season		IRRI. Ann. Report (1975)
	algal	-	-	18.5-33.3 pure soil		
	flora	-	-	2.3-5.7 Santa Domengo soil		

Table 6 EFFECT OF INOCULATION WITH DIFFERENT BLUE-GREEN ALGAE ON SOME PROPERTIES OF RICE PLANTS

Algae	% increase over control	N-fixed kg/ha	References
Tolylpothrix tenuis		112	Watanabe et al (1951
Calothrix brevissima	12.9 length of leaves cm	-	
Anabaenopsis sp.	5.5 length of leaves cm	-	
Anabaena cylindrica	1052.7 plant weight	-	Allen (1958)
Anabaena cylindrica	2000 N content in the plant	-	
Single culture	9.2-20.1 N content in the plant	-	
Mixture culture	24.8-64.9 N content in the plant	-	Khadr (1975)
Single + N	52.6-126.0 N content in the plant	-	
Mixed + N	37.7-131.8 N content in the plant	-	

the order of 5 to 18% have been reported by different investigators. The increased availability of phosphates was reported to be due to decreasing soil pH. This effect could also be reached by sulphur bacteria and other organisms decomposing organic materials. Thiobacillus thiooxidans, a sulphur bacterium, is used in Australia to inoculate a mixture of rock phosphate and sulphur. The product is called "Biosuper". The bacteria oxidize the sulphur to sulphuric acid which dissolves the phosphate and enhances phosphorus nutrition of plants.

Among soil micro-organisms that affect the uptake of P by plant roots, the mycorrhizal fungi seem to have the largest and most direct effect. Plants benefit most from mycorrhiza when phosphate is growth limiting. In some soils that are very deficient in phosphate, the plants may not be able to survive without mycorrhiza. Utilization of this beneficial fungal activity is still at research level. Results of experiments at Rothamsted Experimental Station in the United Kingdom revealed that growth of maize was improved ninefold and the utilization of added rock phosphate was increased tenfold through inoculation with the mycorrhizal fungus Stylosanthes guyanensis. According to Dr. M. Daft of Dundee, Scotland (personal contact), the yield of groundnuts was increased by 300% when inoculated with Rhizobia and mycorrhiza, while only 100% increase was reached through Rhizobia inoculation only.

More research using field experiments is needed on mycorrhizal inoculation to realize its full benefits.

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Paper 20 BIOGAS TECHNOLOGY WITH RESPECT TO CHINESE EXPERIENCE

by

M.N. Alaa El-Din
Senior Researcher in Soil Microbiology
Soil and Water Research Institute
Agriculture Research Centre, Giza, Egypt

1. INTRODUCTION

The evolution of combustible gas (methane) from marshes has been known to man for ages. However, proper understanding of this phenomenon and its application for anaerobic digestion of animal droppings, crop residues and human habitation wastes (night soil, sewage sludge) was first recognized and reported during the later part of the 19th century and has become possible only during the current century.

During the past 50 years, many cities in Europe and north America have built anaerobic digesters to produce biogas and have used it as a source of fuel for operating sewage treatment plants. Recently, the conversion of biogas to electricity has covered 60-80% of a plant's energy demand.

It is of interest to note that small and household biogas plants have been developed in the developing countries and that scientists in the industrialized countries have only become aware of the potential for such systems during the past decade - largely as a consequence of the so-called environmental crisis (Feacham et al 1977).

The construction of small biogas plants by individual families was initiated in India in 1951 (Subramanian 1977). In 1976 there were over 36 000 biogas units operating in India and the government has a construction target of an additional 100 000 by 1978.

In Korea the biogas development programme started in 1969 and by October 1975, 29 450 biogas units were operating there (ESCAP 1975), while 7 500 small biogas digesters existed in Taiwan and considerably smaller numbers in Pakistan, Nepal, Bangladesh, the Philippines, Thailand, Indonesia and Japan (Bene et al 1978).

In China, remarkable progress has been achieved in the field of biogas, although their first attempts date from 1958 and the massive campaign to popularize the technology only started in 1972.

Since then, the largest number of biogas plants has been recorded in China where there were more than 2 800 000 family-size biogas units in one province (Szechuan) at the beginning of August 1976 (Smil 1977).

The anaerobic digestion of crop residues, animal droppings, night soil and sewage sludge is a complicated microbial process involving two main stages, namely, Stage I: breakdown of complex organic material, e.g. carbohydrates, proteins and fats by a group of acid-forming bacteria existing symbiotically with the methane forming bacteria (Smith et al 1976). The products are organic acid e.g. acetic acid, lactic, propanoic and butyric acids; alcohols e.g. methanol, ethanol and butanol; gases e.g. CO_2, H_2, H_2S and other nonorganic materials.

$$\text{Complex organic} \xrightarrow[\text{bacteria}]{\text{acid forming}} CO_2 + H_2 + \text{organic acids.}$$

Stage II: the simple organic material and CO_2 that have been produced are either oxidized or reduced to methane by methane producing or methanogenic micro-organisms. This stage may be represented by the following overall reaction (Leo Pyle, 1976)

$$(C_6H_{10}O_5)_n + n\,H_2O \xrightarrow[\text{bacteria}]{\text{methane}} 3nCH_4 + 3nCO_2 + \text{heat}$$

While individual reactions include:

i. Acid breakdown into methane

$$2\,C_3H_7COOH + H_2O \longrightarrow 5\,CH_4 + 3\,CO_2$$

ii. Oxidation of ethanol by CO_2 to produce methane and acetic acid

$$2\,CH_3CH_2OH + CO_2 \longrightarrow 2\,CH_3COOH + CH_4$$

iii. Reduction with hydrogen of carbon dioxide to produce methane

$$CO_2 + 4\,H_2 \longrightarrow CH_4 + 2\,H_2O$$

This reaction must occur simultaneously and if the reaction becomes unbalanced the digestion process fails. A considerable amount of research on biogas has been conducted to improve the yield of gas and to increase the production rate. The optimum conditions vary from one system to another but for all systems they fall within certain limits of the following factors.

2. HYDROGEN ION CONCENTRATION (pH)

During the first stage of anaerobic digestion, organic wastes, acetic and other volatile fatty acids, hydrogen and carbon dioxide are produced at high rates because of the relatively fast growth of the micro-organisms involved in this stage (generation time 3-4 hours), whereas methanogenic bacteria responsible for the second stage may take ten days or more to double in number. The two stages must be monitored to prevent the build-up of excess acids from the first stage which inhibits the methanogenic bacteria. It is therefore essential to control the pH within the range of 7 - 8.5 by not overloading the system with fresh digesting materials, allowing the temperature to drop several degrees or by the addition of sodium bicarbonate solution or slaked lime (Lipinsky 1978).

3. TEMPERATURE

In China, the addition of lime solution or grass ashes is recommended for maintaining the pH between 7 and 8. Methane can be produced within a fairly wide range of temperatures. Three types of fermentation are possible, namely: thermophilic, mesophilic, and ordinary. For thermophilic fermentation 50-55°C should be maintained, while 30-35°C are suitable for mesophilic fermentation and the ordinary one occurs between 10-30°C (Leo Pyle 1976). Japan is the only country which has adopted the thermophilic digestion technique. They claim that it is possible to increase the rate of loading of their digesters by a factor of 2.5 and at the same time to reduce the retention time to 5-7 days (Bene et al 1978). The thermophilic technique, however, is a much more sophisticated operation which requires heat exchanges, insulation and much better supervision. Therefore Bene et al (1978) believe that this technique is not suitable for any but the very large units. The mesophilic process is considered as the most promising one. Generally, biogas production decreases rather drastically as temperature drops below the optimum level; 50% for every 11°C decrease in temperature below the optimum level has been reported (Stout et al 1977). The relationship between gas production from the digestion of rice straw, pig manure and grasses and temperature observed in China is indicated below:

Temperature °C	29–31	24–26	16–20	12–15	below 8
Gas production (cm^3/day)	0.55	0.21	0.10	0.07	negligible

The Chinese make use of the fact that soil temperatures at 2–3 m deep are almost constant and higher than those of the atmosphere. They construct their biogas units completely underground. When the ambient temperature in Sichuan province falls below zero, the temperature inside many biogas units remains above 10°C, so that production of methane is still maintained. Methane micro-organisms are very sensitive to temperature changes. A sudden change exceeding 3°C will affect production; therefore one must ensure relative stability of temperatures (Leo Pyle 1976).

4. CONCENTRATIONS OF SOLIDS

Concentrations of solids should not exceed 10% because of the difficulty in stirring, and the pH and ammonia toxicity become more critical with insufficient dilution. The minimum concentration may be as low as 0.1–0.5%, but at these levels micro-organisms will be washed out of the digesters with the sludge. The optimum concentration is therefore between 7–9% solid matter (FAO, 1977).

In China, common combinations of raw materials are reported to be: a mixture of urine (20%) and human excreta (30%) and water (50%); or 10% human excreta, 30% animal dung, 10% straw and grass and 50% water; or 20% human excreta, 30% pig manure and urine and 50% water; or 10% each of human and animal waste, 30% marsh grass and 50% water. Crop wastes, green grass and other vegetable materials are decomposed for more than 10 days prior to their being put into the digester.

5. RATE OF LOADING WITH THE DIGESTING MATERIAL

Increasing the rate of loading usually increases the gas generation but the yield of gas per unit weight of organic material decreases. Shelat et al (1977) showed that increasing the loading rate from 1.17 to 5.29 kg dry solids/m^3 of digester volume/day increased the total volume of biogas from 0.22 to 0.47 m^3/kg/day, but reduced the volume of gas per unit weight of organic matter from 0.22 to 0.09 m^3/kg/day. The optimal loading rate as kg of dry solids/m^3 of digester volume/day is reported to be 0.8 kg/m^3/day (Bene et al 1978). Whereas Miner and Smith (1975) indicated loading rates from 1.6 to 5.9 kg volatile solids/m^3/day as generally satisfactory for continuous flow digesters.

6. LEVELS OF CARBON, NITROGEN, PHOSPHORUS AND OTHER NUTRIENTS

The bacteria carrying out both stages of methane generation require carbon, nitrogen, phosphorus and other elements in order to live, but they use up carbon about 30–35 times faster than nitrogen and the last about 5 times faster than phosphorus. Therefore, when the ratio of C:N:P in the raw material is about 150:5:1, the digestion proceeds at an optimum rate when other conditions are favourable. Small amounts of potassium are also needed but the ratio is not critical and there is usually sufficient potassium in the feeding material. Heavy elements which might be present in the digesting material (especially in sewage sludge) are very toxic to micro-organisms but they are often eliminated by precipitation with H_2S normally formed in the digester. From the point of view of C/N ratio night soil, pig manure sewage sludge and cattle dung are almost perfect substrates (Table 1). However, if too much straw or agricultural residues are used, supplemental addition of nitrogen and/or phosphorus in the form leguminous plants and/or human and animal wastes may be necessary.

Table 1 APPROXIMATE VALUES OF C/N RATIOS OF COMMON MATERIALS USED FOR BIOGAS PRODUCTION (LEO PYLE 1976)

Material	C %	N %	C/N ratio
Dry wheat straw	46	0.53	87:1
Dry rice straw	42	0.63	67:1
Maize stalks	40	0.75	53:1
Fallen leaves	41	1.0	41:1
Soybean straw	41	1.30	32:1
Wild grass	14	0.54	27:1
Groundnut straw	11	0.59	19:1
Fresh sheep manure	16	0.55	29:1
Fresh cow ox manure	7.3	0.29	25:1
Fresh horse manure	10.0	0.42	24:1
Fresh pig manure	7.3	0.60	13:1
Fresh human manure	2.5	0.85	2.9:1

7. STIRRING

Stirring of the slurry inside the digester is desirable to stimulate bacterial action resulting in maximal gas production. Continuous feeding of fresh waste into the digester always induces some movement in the mass of material in it, helping to expose fresh undigested material to the bacteria. When digesters are not stirred the fermentation material settles into three layers: the top is scum with a high content of fresh material and very few microbes in both number and variety; much acid is produced here. The middle layer is a clear fermented material containing very little solids and also few microbes. The bottom layer is sediment and residue rich in many kinds of microbes, but low in fresh material because it is under a high hydrostatic pressure, the gas produced is dissolved in the fermenting liquid and is not easily released. This makes it impossible to achieve a high production of gas. The sediments can be brought up from the bottom by stirring; the concentration and the temperature in the pit correspondingly because they become more even, the methane-producing microbes reproduce more quickly, and greater contact between the microbes and the fermentation materials hastens their fermentation.

Stirring can also break up or prevent the formation of any scum on the surface. In the fermentation of all organic materials, the bubbles produced often contain minute particles which rise to the surface of the liquid and after a long time a thick layer of scum forms and prevents the biogas from rising up into the gas compartment and also reduces its production. Stirring will break up and make the small bubbles combine and escape more quickly from the liquid into the gas compartment. Chinese experiments revealed that in digesters fed with night soil, stirring increased gas production by 80% in comparison with non-stirring.

In China, small-scale biogas units (household) are stirred by poking a large prod or other tool into the digester through either the inlet or outlet compartment and moving it around. Other methods are also used, e.g. extraction of effluent from the outlet and then pouring back through the inlet, or by a mechanical device in large digesters.

8. DESIGN OF BIOGAS PLANTS

The basic design of biogas plants consists of an anaerobic digester and a gas chamber to collect the methane/carbon dioxide mixture. The performance, however, depends upon many factors.

Figures 1-9 present selected designs for small-scale units (household and pigeries) constructed in different countries (India, Korea, Thailand, Papua New Guinea and China). In China, the 10 m^3 capacity design is taken as the standard for household. The unique feature of the Chinese biogas plants is that the gas holder and the digester are combined in one unit. The gas holder is the brick dome shaped cover of the digester itself. In the construction of these plants local materials are used; people along rivers use mainly pebbles, those in mountain areas use stones and those in the plains use bricks. A mixture of lime and earth in the proportion 5% and 95% respectively is used in the construction. The walls of the biogas unit are thinly plastered with cement. For the standard capacity plant, the requirements for these materials are: bricks 3 000, lime 1 000 kg, and cement 100 kg. The cost of construction is reported to be us $25 excluding labour charges.

When gas is formed, it ascends towards the top of the dome and pushes the effluent down. The displaced level of the effluent provides the necessary pressure for the release of the gas from the plant. The pressure of the gas is kept constant through an automatic adjustment of water pressure. The pressure equalization is based on the principle that increased gas pressure pushes slurry up the feed inlet and the outlet chamber openings, and the decrease in pressure is balanced by return of slurry into the digester. The sizes of the inlet and the outlet chambers are stated to be important features and their design has undergone some changes over the years. The digester is below ground level. The removal of sludge and maintenance are carried out twice a year. One-third of the sludge is left in the digester to act as "seeding" material.

The advantages of the Chinese type of biogas plant compared to the Indian system are:

i. Lower construction costs since no mild steel is used. Steel is scarce and expensive, particularly in developing countries.

ii. The plants can be easily constructed by production team members who know how to work with bricks and cement.

iii. Since there are no moving parts, wear and tear and maintenance costs are almost negligible.

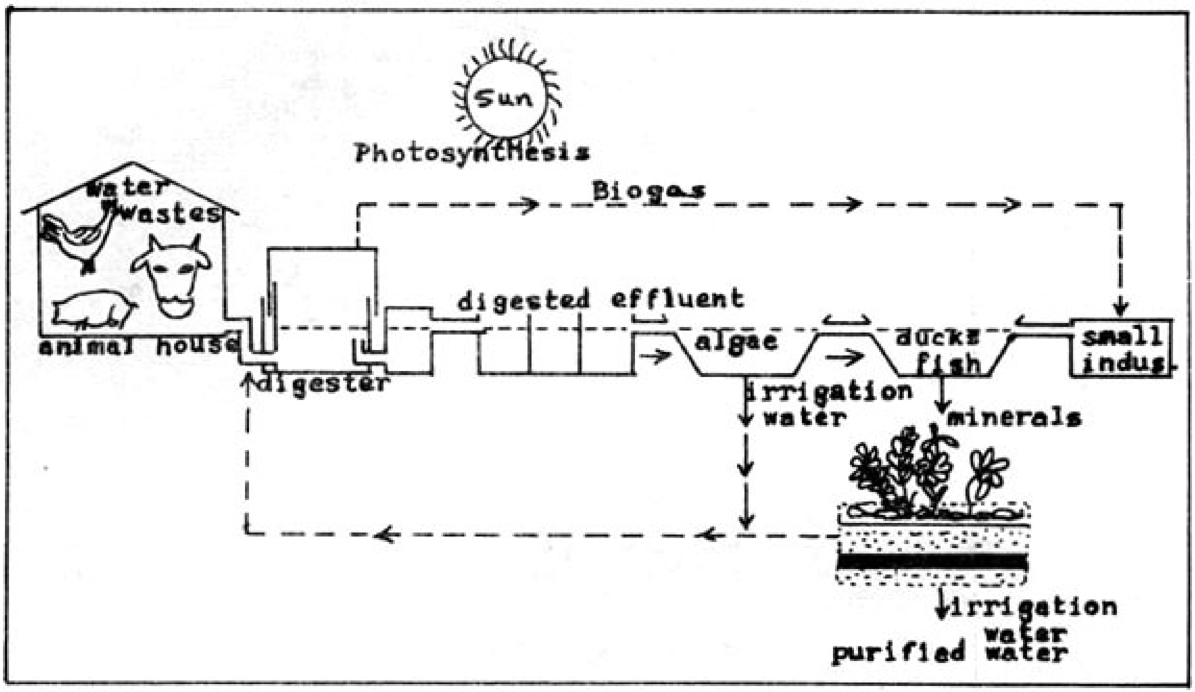


Fig. 1 Integrated biogas system for Indian farms (ESCAP 1976)

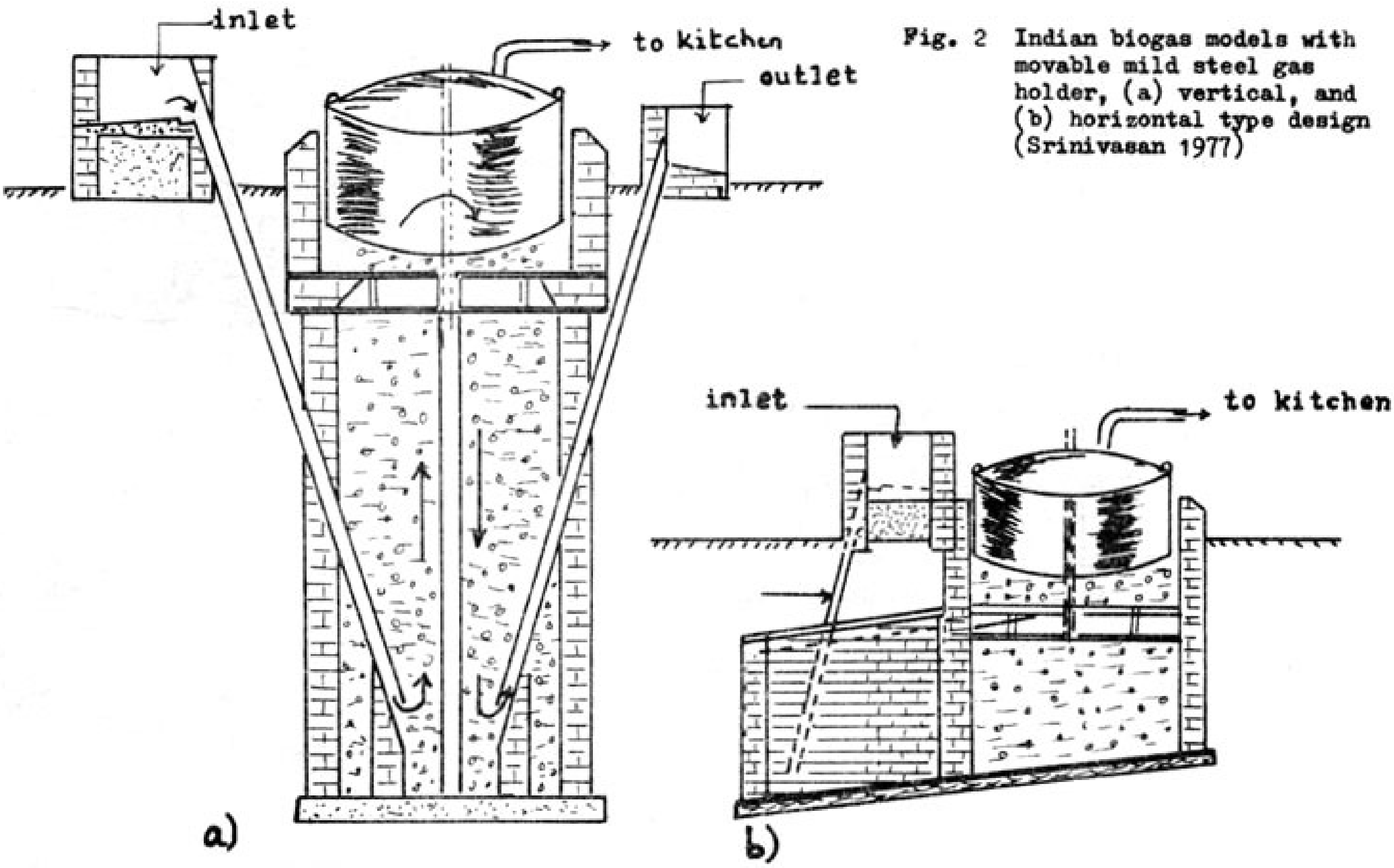


Fig. 2 Indian biogas models with movable mild steel gas holder, (a) vertical, and (b) horizontal type design (Srinivasan 1977)

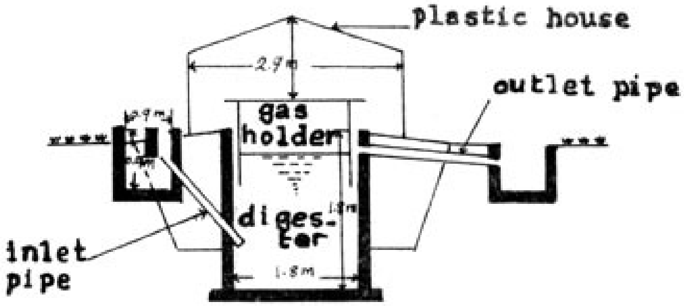


Fig. 3 Korean biogas system with movable gasholder made of wood and plastic sheets and covered with a plastic house (ESCAP 1976)

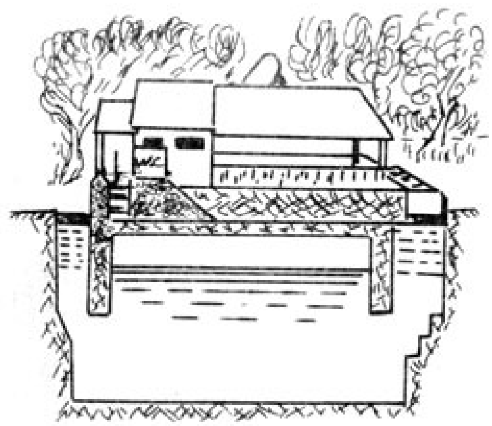
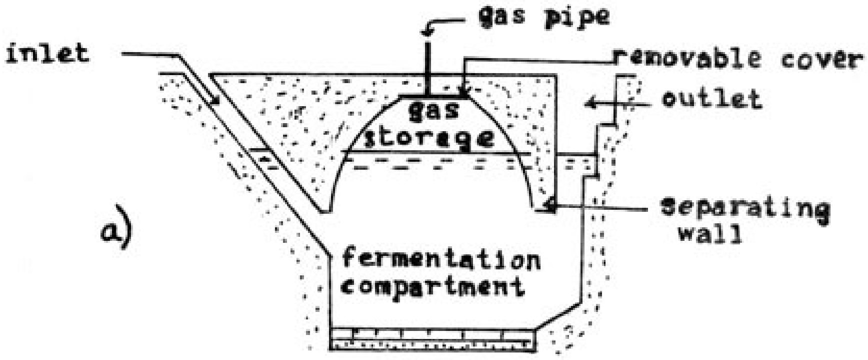


Fig. 4 Rectangular Chinese biogas unit constructed under toilet and pigsty (Leo Pyle 1976)



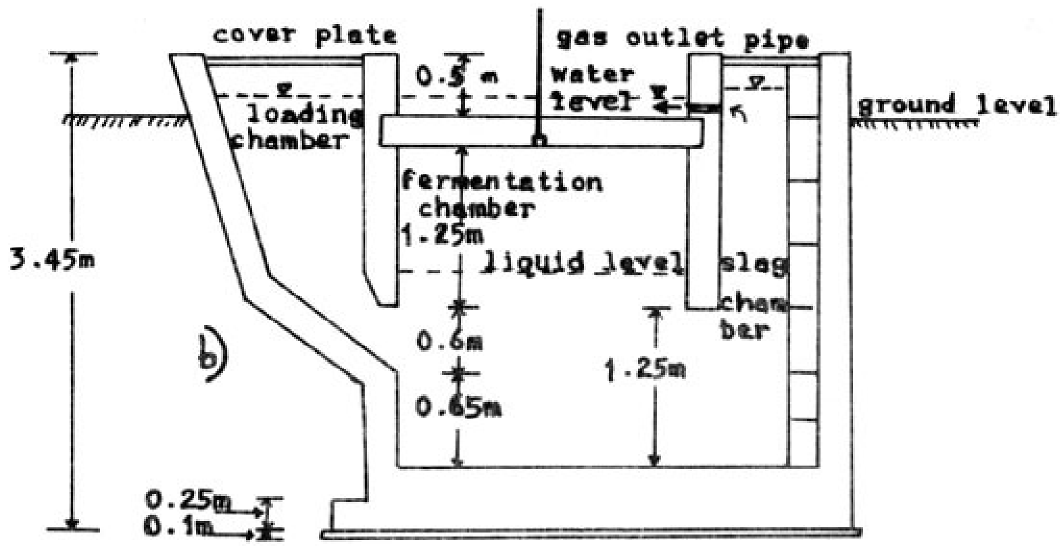


Fig. 5 Diagrams of typical Chinese biogas units, a) circular b) rectangular (Leo Pyle 1976)

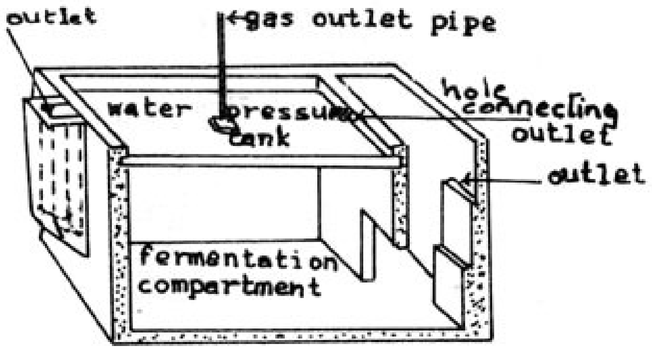


Fig. 6 Cross section of a typical rectangular Chinese biogas unit of triple concrete (Leo Pyle 1976)

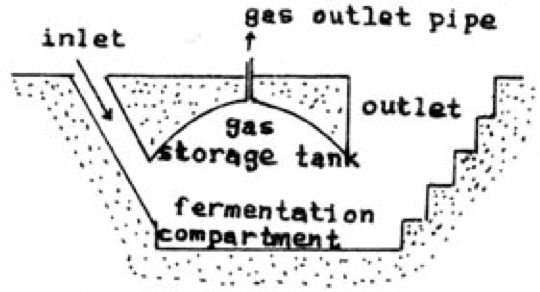


Fig. 7 Pot-shaped biogas unit popularized in Huai Lu County, Hebei Province, China (FAO 1977)

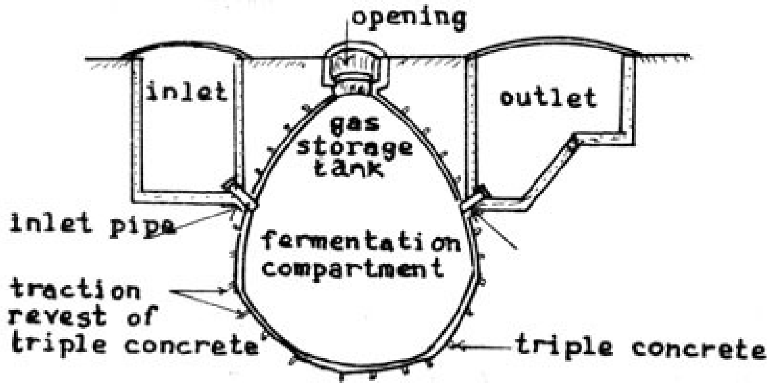


Fig. 8
Circular biogas unit constructed of triple concrete. Suitable for firm earth with low level of underground water and no water seepage (Leo Pyle 1976)

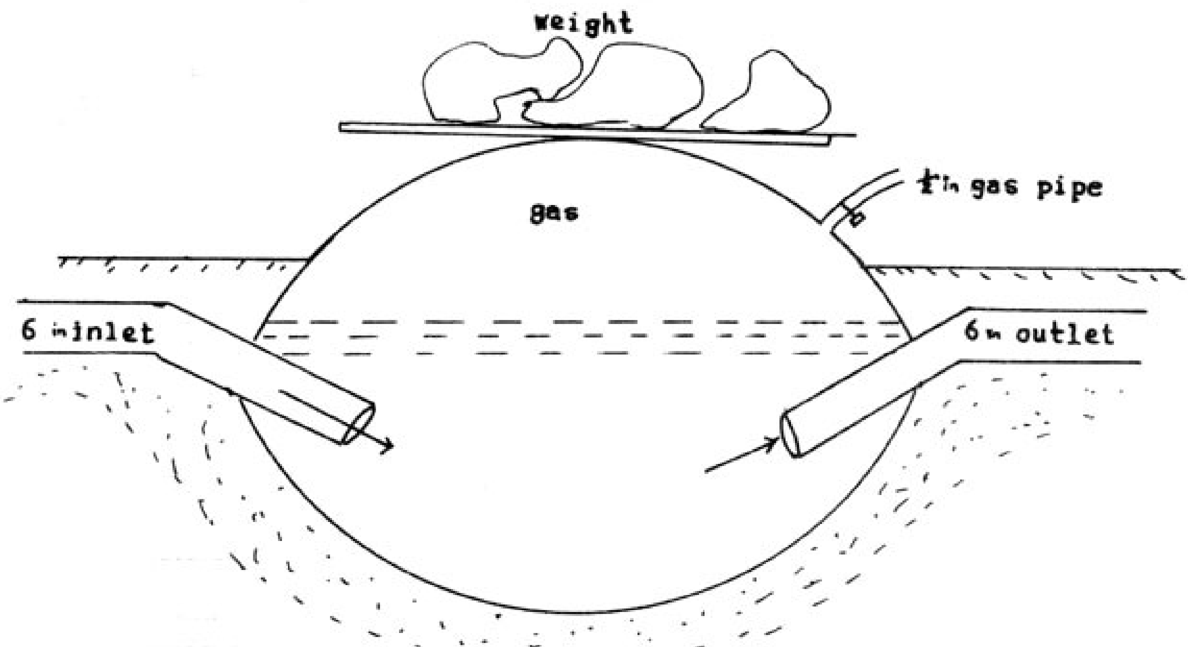


Fig. 9 Bag digester for biogas used in Papua New Guinea of 0.55 mm thick Hypalon laminated with Neoprene and reinforced with nylon sheet; has great promise of success because of low cost (one-tenth of conventional biogas units) (Panichjaroen and Deemark 1976)

iv. Maintenance of proper temperature is easier because the whole structure is underground.

The gas from biogas plants is quite similar to natural gas. It usually contains 54–70% methane, 27–45% carbon dioxide, 1.0–10% hydrogen, some nitrogen and traces of hydrogen sulphide (Fry 1973). The gas is a very convenient fuel with a high overall efficiency as shown in Table 2.

Table 2 RELATIVE FUEL VALUE OF BIOGAS AND OTHER MAJOR FUELS (SHELAT and KARIA 1977)

Fuels	Fuel (heating) value	
Coal (town) gas	4 000 – 4 445	kcal/m^3
Biogas	4 800 – 6 225	"
Methane gas	7 965 – 9 500	"
Acetylene gas	13 335 – 14 225	"
Propane gas	19 460 – 23 115	"
Butane gas	25 780 – 30 225	"
Animal dung	2 127 –	kcal/kg
Soft coke	6 200 – 6 600	"
Coal	7 550	"
Charcoal	6 950 – 7 750	"
Fire wood	3 885 – 4 700	"
Kerosene	10 800 –	"
Furnace oil	10 800 –	"
Ethanol	7 120	"
Methanol	5 340	"
Electricity	860	kcal/kWh

Bene et al (1978) compared the conventional practice of burning dried animal dung (cowdung cakes) on an open fire, which has a very low heat effeciency (5–11%), with the 50% of energy available in the original cowdung if it is converted into biogas. A conversion efficiency of 60% can be obtained if this biogas is burnt in specifically designed cookers (Fesham et al 1977). The overall recovery was calculated therefore to be 30% lower. Conversion efficiency (35%) by conventional cookers reduces the overall recovery to 21%. This still presents about twice the amount of heat available from burning cowdung in an open fire (Parsad et al 1974). In addition to the doubling of energy gains, organic manures are saved for improvement of soil fertility.

The gas produced from a 10 m^3 capacity plant is about 5 m^3/day when properly managed. This is sufficient to supply a five head Chinese family with enough fuel for cooking and lighting (using any gas lamp with a mantle).

Any internal combustion engine can be adapted to use biogas by connecting the gas to the air intake and closing the diesel oil feed. One cubic metre of gas is enough to run an internal combustion engine (one hp) for 2 hours, a three ton truck for 28 km, to light a lamp (60–100 watts) for 6 hours and to generate one kilowatt of electricity (Leo Pyle 1976 and FAO 1977).

9. BIOGAS MANURE

The manure obtained from biogas plants consists of two parts, namely, the effluent which is considered as liquid fertilizers, and the sludge, rich in nutrients and organic matter. The sludge output from a 10 m^3 Chinese plant is about 10 m^3. The sludge is used directly for basal or top dressing, and also for making humic acid fertilizers. When not directly applied, it is heaped, plastered and kept till needed. The annual output of effluent from such a biogas unit is about 14 m^3. This is either applied to the land with irrigation water or stored in a tank for application as a top dressing. The composition of sludge and effluent from Chinese biogas units has been reported to be as follows (FAO 1977):

	N ppm	P ppm	K ppm	Organic matter %
Effluent	500	15	2000	–
Sludge	650	40	9400	35

Biogas manure has been reported to increase yields by 17%. Application of effluent to wheat increased tillering rates and the number of spikelets over those obtained from ammonium chloride (FAO 1977). It has increased crops of maize, rice, cotton and wheat by 28, 10, 24.7 and 12.5% respectively, when compared to the application of the unfermented excreta (Leo Pyle 1976).

Biogas technology improves health conditions, especially in those areas where the direct application of fresh night soil, pig manure and other residues in agriculture is a common practice. Chinese experience in this field indicates that the biogas plant has relatively little impact on the viability of the roundworm ovum which is considered as the most resistant of all parasite eggs. The viability rates of ascaris (roundworm) eggs ranged from 63–93% after 10 to 90 days, decreasing to 20% after 180 days. Paratyphoid bacteria survived for 44 days and Schistosomes were observed to live up to 37 days. The disappearance of parasites and pathogenes has been attributed to both the physical separation by settling to the bottom of the digesters and to their mortality under adverse conditions.

10. ADVANTAGES OF BIOGAS TECHNOLOGY

Bene et al (1978) summarized the advantages of biogas technology as follows:

i. Biogas is a very convenient fuel with a high overall efficiency as shown in Table 2.

ii. The use of biogas provides a much cleaner and healthier environment in the home and reduces the incidence of eye diseases caused by the smoke from the traditional burning of solid wastes.

iii. The fertilizer value of the waste, which is lost if the fuel is burned, is retained with the possible exception of a loss of about 10% of the nitrogen if the residual sludge is dried. This results in a substantial saving in foreign exchange.

iv. Anaerobic fermentation is superior to composting because it permits the recovery of 50% of the fuel value. This results in saving forest land through less dependence on firewood; it is estimated at 0.3 acre for each 100 ft^3/day (2.83 m^3/day) biogas plant.

v. The process can be operated with almost any type of organic waste with solid contents up to 10%, and even on soluble materials. Using direct combustion techniques, it is not generally practicable to recover heat from wet fuels if the moisture content cannot be reduced below 60-70 (Makhijani 1975).

vi. The equipment required for anaerobic digestion is relatively simple and can be made from readily available materials as the process is operated at ambient temperature and pressure.

vii. A medium or high Btu gas may be obtained depending on the transportation and end use requirements.

viii. The process has a favourable environmental impact because it reduces smoke and improves sanitation in the villages.

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Paper 21

EFFECT OF INOCULATION WITH N-FIXING SPIRILLA AND AZOTOBACTER ON NITROGENASE ACTIVITY ON ROOTS OF MAIZE GROWN UNDER SUBTROPICAL CONDITIONS

by

N.A. Hegazi, M. Monib and K. Valssak
Department of Microbiology, Faculty of Agriculture, Cairo University, Egypt, and Faculty of Agricultural Sciences, Catholic University, Louvain, Belgium

Summary

Inoculated and non-inoculated seedlings of maize were grown in fertile clay-loam soils of Egypt and Belgium under subtropical conditions provided in a greenhouse. Acetylene reducing activity and microbial counts were determined during a period ranging from 6-12 weeks after sowing. Irrespective of soil origin, N-fixing spirilla and *Azotobacter* were common under maize cultivation. Inoculation resulted in a transitional increase in their numbers at early stages of growth. Nitrogenase activity was not detected in the rhizosphere of young plants. Maximum activities (81-1436 n moles C_2H_4 $g^{-1} h^{-1}$) occurred close to 50-70% silking stage. Inoculation with N_2-fixing spirilla, particularly in Nile Delta soil, doubled the amount of N-fixed at a late period of growth (12 weeks), while inoculation with *Azotobacter* had no remarkable effect.

1. INTRODUCTION

Recent recognition of the associative growth of particular asymbiotic N_2-fixing bacteria in the rhizosphere of certain C_4-plants, mainly in the tropics, has received the attention of many investigators all over the world (Neyra and Dobereiner 1977). *Spirillum lipoferum* Beijerinck (recently replaced in the separate genus *Azospirillum*) in particular was found responsible for nitrogenase activity in roots of field grown tropical grain and forage grasses (von Bulow and Dobereiner 1975). The present study is one of a number of investigations carried out on the occurrence of such bacteria in soils and the rhizosphere of various plants in Egypt, characterization of local isolates, methods of enumeration, and their possible contribution to nitrogenase activity in roots of major crops (Hegazi and Valssak 1977a, b; Amer *et al* 1977; Amer 1978; Eid 1978; Hegazi *et al* 1978).

2. EXPERIMENTAL METHODS

Roots of germinated maize seedlings (open pollinated cultivar Shandwill) were dipped in Ashby's N-deficient medium minus carbon source and in a liquid mixed culture of *Azotobacter chroococcum* and *A. vinelandii* or *Spirillum lipoferum* (ATCC 2945). The seedlings were transferred to pots containing 1 kg fertile clay-loam soil from Egypt (pH 7.9; total N 0.13%) and from Belgium (pH 7.2; total N 0.25%). The plants were grown in the greenhouse with supplementary lighting and heating to give 14 h/day with light at minimum 10 000 lux and temperature at 28-30°C, night temperature at 28°C).

2.1 Nitrogenase Activity

Nitrogenase activity of roots, rhizosphere soil and soil away from the roots as well as from bare pots was studied using the acetylene reduction technique during a growth period of 6-12 weeks. Checks for C_2H_2 - independent C_2H_4 production were made and results were always negative after 48 h incubation.

2.2 Microbial Counts and Enrichments

After assay, roots of the control and *Azotobacter* inoculated plants were shaken in Ashby's liquid medium minus carbon source and suitable dilutions were plated on N-deficient medium for counting *Azotobacter* (Hegazi and Niemela 1976). Washed roots were dried, weighed and the soil suspension evaporated to dryness. Numbers of *Azotobacter* were related to dry weight of roots or soil. In addition, root segments of plants of all treatments were surface-sterilized in ethanol for 2 minutes and washed twice in sterilized distilled water, then transferred to 10-ml semi-solid malate medium (Dobereiner *et al* 1976). These enrichment cultures were examined for nitrogenase activity and for the presence of characteristic pellicle and active motile cells of spirilla.

3. RESULTS AND DISCUSSION

3.1 Changes in Microbial Counts

Examination of non-inoculated pots, irrespective of soil origin, revealed that *Azotobacter* and N_2-fixing spirilla commonly occurred under maize cultivation, in appreciable densities, in soil, rhizosphere and roots throughout the growing period (Table 1).

Lowest counts of *Azotobacter* were found at the first period of analysis (6 week old plants). They were particularly enriched in rhizosphere soil and roots of 9 week old plants as their densities in the roots of such plants were 200-900 and 6-20 fold those reported at 6 and 12 weeks respectively. Similar development of N_2-fixing spirilla was found. Enrichment cultures prepared for roots of 9 week old plants, in particular, exhibited rather high acetylene-reducing activity.

Table 1 COLONY COUNTS OF AZOTOBACTER UNDER MAIZE CULTIVATION

Stage of plant growth	Egyptian soil		Belgian soil	
	Inoculated	Non-inocul.	Inoculated	Non-inocul.
6 weeks				
Soil	26.4	0.4	24.7	0.2
Rhizosphere	58.5	0.2	13.0	0.4
Roots	262.2	1.0	602.6	1.9
9 weeks				
Soil	10.3	8.3	9.7	5.9
Rhizosphere	19.7	46.8	33.0	35.7
Roots	348.6	842.2	109.1	371.2
12 weeks				
Soil	1.2	0.1	1.9	0.1
Rhizosphere	13.3	1.2	28.4	7.1
Roots	52.5	41.1	65.3	60.5

Inoculation was carried out with heavy bacterial suspensions containing 10^9 cells/ml. Counts recovered from Azotobacter-inoculated seedlings were in the range of $1-10^8$ colonies/root. Such inoculation led to a rather pronounced increase in counts reported for 6 week old plants. Such effect was diminished with prolongation of growth period particularly for 9 weeks where the roots of the non-inoculated plants harboured double the densities reported for those of inoculated ones. The persistence of bacterial inoculum was traced by following the development of A. vinelandii which were absent in soil and roots of non-inoculated pots. Their numbers constituted 18-39% of total Azotobacter occurring in the rhizosphere and roots of inoculated plants. Their appearance in free soil was delayed to the 9th week of growth where they represent 3-16% of total Azotobacter.

3.2 Pattern of Nitrogenase Activity

With both inoculated and non-inoculated pots, the amount of acetylene reduced by rhizosphere soil freed of roots as well as by free soil was relatively low and irregular (Tables 2 and 3). Rates obtained were in the range of 0.05 - 0.61 n moles C_2H_4 $g^{-1}h^{-1}$.

High rates of acetylene reduction obtained for detached roots indicated that nitrogenase activity is mainly associated with root systems and the very close surrounding. Washing of roots in distilled water remarkably enhanced acetylene-reducing activity which was further increased by prolongation of incubation period.

Roots of 6 week old plants exhibited rather low acetylene-reducing activity (0.01 - 0.4 n moles C_2H_4 $g^{-1}h^{-1}$) in both types of soil; inoculation slightly increased such activity. Further growth of maize plants encouraged asymbiotic N_2-fixation as appreciable rates of acetylene reduction were obtained for plants during the flowering stage (50-75% silking), i.e. 9 and 12 week old plants. Non-inoculated plants yielded highest activities at the age of 9 weeks. Egyptian soil supported relatively higher (62 - 1440) activities than Belgian soil (43 - 240 n moles C_2H_4 $g^{-1}h^{-1}$). At this stage, inoculation exerted no remarkable effect, in general, except for washed roots of spirilla-inoculated plants grown in Egyptian soil. Later on, a decrease in acetylene-reducing activity was detected for the roots of 12 week old non-inoculated plants. During this particular stage of plant growth, stimulated effects of inoculation with spirilla in Egyptian soil and to a less extent with Azotobacter in Belgian soil was demonstrated.

3.3 Discussion

Nitrogenase activity reported for non-inoculated plants is associated with the presence of appreciable densities of Azotobacter and with the consistent isolation of N_2-fixing spirilla. Other organisms, e.g. Enterobacter cloacae, Klebsiella and Bacillus are possibly involved (Raju et al 1972; Amer 1978).

Acetylene-reducing activity in roots results from a complementary interaction between plant and bacteria, and many factors are involved, such as photosynthetic efficiency, translocation, root anatomy and physiology, and bacterial characteristics (von Bulow and Dobereiner 1975; Brown 1976). Similar to the legume-bacterial symbiosis, the growth stage of maize plants under investigation played an important role in this respect. In agreement with the results of von Bulow and Dobereiner (1975), maximal acetylene-reducing activity was reported during the flowering stage of maize plants. The rather low activity found around the roots of 6 week old plants, including inoculated ones and which contained densities of Azotobacter comparable to those reported at other stages of growth, might be attributed to insufficient photosynthates available for bacterial growth. In addition, such activity might be inhibited by the amount of nitrogen available in soil, and only developed when plant growth had removed this nitrogen and conditions of nitrogen stress prevail (Day et al 1975; Brown 1976).

Table 2 ACETYLENE-REDUCING ACTIVITY ON ROOTS OF MAIZE PLANTED IN EGYPTIAN SOIL 1/

Incubation period (h)	Non-inoculated Non-Wash.	Non-inoculated Wash.	Azotobacter-inoculated Non-Wash.	Azotobacter-inoculated Wash.	Spirilla-inoculated Non-Wash.	Spirilla-inoculated Wash.
6 week old plants						
24	0.05	0.02	0.3	3.2	0.8	0.5
48	0.04	0.02	0.3	3.3	0.8	3.2
9 week old plants						
24	62.7	229.9	50.4	167.3	49.9	797.3
48	81.3	826.6	98.4	320.6	82.9	2027.1
72	-	1436.6	-	346.6	-	2380.9
12 week old plants						
24	6.1	28.4	27.7	210.9	109.9	2109.6
48	7.7	45.5	26.6	213.0	134.0	2193.5
72	9.8	-	30.0	-	141.0	-

Table 3 ACETYLENE-REDUCING ACTIVITY OF ROOTS OF MAIZE PLANTED IN BELGIAN SOIL 1/

Incubation period (h)	Non-inoculated Non-Wash.	Non-inoculated Wash.	Azotobacter-inoculated Non-Wash.	Azotobacter-inoculated Wash.	Spirilla-inoculated Non-Wash.	Spirilla-inoculated Wash.
6 week old plants						
24	0.1	0.05	0.8	3.4	0.4	0.03
48	0.1	0.4	0.9	6.8	0.4	0.02
9 week old plants						
24	43.3	62.7	11.9	48.3	38.2	106.9
48	145.3	61.7	20.0	80.4	53.2	166.7
72	-	238.9	-	-	-	294.5
12 week old plants						
24	33.3	53.0	67.8	353.4	38.5	99.5
48	34.3	53.0	50.9	366.5	37.3	123.1
72	64.9	-	68.4	-	58.7	-

1/ Accumulated n moles C_2H_4 $g^{-1}h^{-1}$

Values are mean of 3-8 plants.

\- Not determined.

Values of nitrogenase activity in non-washed roots of 9-12 week old plants described in this paper were much lower (max. 145 n moles C_2H_4 $g^{-1}h^{-1}$) than those reported for washed roots (max. 2380 n moles C_2H_4 $g^{-1}h^{-1}$), particularly with prolongation of incubation period. An explanation recently presented by Okon et al (1977) is that an anaerobic metabolism is established in the wet maize roots during the extended pre-incubation period which probably produces organic acids (lactic acid, etc.) that support vigorous growth of asymbiotic N_2-fixers, mainly spirilla. Therefore, to avoid overestimation of N_2-fixation based on measurements of C_2H_2 produced, values obtained at total 24 h incubation of non-washed roots are used for further discussion. Converting C_2H_2 reduction into kg of N_2 fixed is subject to criticism, and the assay used with detached roots puts further limitations. However, it is helpful in understanding the potential of N_2-fixation in maize as well as other plants. Generally, an amount of 8.05 - 9.02 g N_2ha^{-1} day^{-1} was calculated under the subtropical conditions provided in the greenhouse and irrespective of soil origin. At a late phase of growth, inoculation with spirilla doubled the amount of N_2 fixed when practised in the Nile Delta soil. This encourages further studies, including $^{15}N_2$ analysis, under natural conditions where higher estimates of fixation are expected as the light intensity, as well as other possible factors, are important for N_2-fixation in rhizosphere of plants (Dobereiner and Campelo 1971). Delayed positive effects of inoculation with members of asymbiotic N_2-fixing bacteria were reported in literature, e.g. Azotobacter paspali and Paspalum notatum (Brown 1976). However, such effect was attributed to stimulatory factors, without N_2-fixation necessarily occurring, produced in the rhizosphere of young plants and its effect manifested later.

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LEGUME INOCULANTS, LEGUME INOCULATION AND IMPROVING SOIL FERTILITY

by

Y.A. Hamdi
Soil and Water Research Institute
Agriculture Research Centre,
Ministry of Agriculture, Giza, Egypt

Summary

Legume inoculants are widely practised in different parts of the world. Response to inoculation has been confirmed in may areas but failure has been occasional.

The amounts of nitrogen fixed by different legumes varies from one host to another. Forage legumes fix more nitrogen than pulse legumes. Under Egyptian conditions, clover fixes about 100 kg N/feddan/5 cuts (238 kg N/ha). Other legumes, e.g. termis, broad bean, fenugreek, chick pea, lentils, groundnut and soybean fix between 17 to 58 kg N/faddan (40-138 kg N/ha). The residual nitrogen in soil after legumes is higher than non-legumes.

1. LEGUME INOCULATION

Inoculation is defined as the addition of effective rhizobia to legume seeds prior to planting for the purpose of promoting symbiotic nitrogen fixation. Various historical aspects of the rise and familiarity of the practice in progressive agriculture are described by different authors (Fred et al 1932; Allen and Allen 1952; Strijdom and Deschodt 1976).

Little argument exists that inoculation is necessary in the majority of agricultural soils throughout the world. Four conditions warrant the inoculation of leguminous seed with rhizobial preparations: i) when a leguminous plant has not been grown previously on the land, or is widely different from the one previously cultivated; ii) if the leguminous crop that was grown previously on the land lacked good nodulation; iii) in a rotation cycle accompanying, or following, a non-leguminous plant, and lastly, iv) when the land has been abused by lack of care or reclaimed from disastrous conditions (Allen and Allen 1952).

1.1 Legume Inoculants

Table 1 shows examples of legume inoculants applied in different parts of the world. All inoculants have the same objective, i.e. to carry the rhizobia from the laboratory where it is produced to the seeds when planted in soils. Carriers are mainly peat, specially in countries where available, but others are now used such as soil, earth, begasse, lignite, coal, composted date leaves, etc.

The efficiency of a commercially prepared inoculum depends on: i) the use of properly selected host specific rhizobial strains having high nitrogen-fixing efficiency under field conditions including competition for nodules sites, persistance and colonizing ability; ii) the availability within the inoculum of excessively large numbers of rhizobia per seed; iii) freshness in culture preparation; and iv) proper treatment of the seed with the inoculum at the time of planting.

Table 1 COMMON LEGUME INOCULANTS

Country	Inoculants
Argentina	Radibak
Australia	Nodule aid, Adlife
Bulgaria	Radiksoya, Nitrogin
Czechoslovakia	Nitrogen
Egypt	Okadin (Soil)
German Democratic Republic	Peat culture
India	Jeevankhad, Bactogin, Calcutta and TDC (Lignite), Rhizogen, Kampur (Peat), Hissar (Soil compost)
Japan	Agar cultures, soil-sand cultures
Netherlands	Peat cultures, soil-alfalfa meal
New Zealand	Legulin, Inoculaid
Poland	Soil-Peat Inoculant
Spain	Leguminal, Nodosit, Nitrogen
Uruguay	Peat culture
USA	Nodogen, Nitragin, Legume Aid, RP

1.2 Response to Inoculation

The success of inoculation as measured by the response of legume plants to inoculated rhizobia is affected by many factors: i) those related to the host and bacteria, e.g. cross-inoculation groups, host specificity, strain variation and genetics of both; ii) those related to the environment: pH, trace elements, nitrogen in soil, temperature, moisture, pesticides, rotation; and iii) biotic factors: rhizosphere organisms and bacteriophage. These factors may interfere in symbiosis through (a) inhibition or enhancement of infection and establishment of symbiosis, (b) reduction or stimulation of the efficiency of rhizobia in nitrogen fixation.

The beneficial effects from inoculation are: (1) prevention of early starvation for nitrogen, (2) the demand of leguminous crops upon soil nitrogen is lessened, (3) crop yield, as measured in foliage or fruit is increased, (4) the quality of the crop is improved, and (5) nitrogen rich, succulent readily decomposable green manure is made available for soil improvement.

1.3 Examples of Response of Different Crop Legumes to Inoculation

i. Soybean

Inoculation of soybeans with effective strains of *Rhizobium japonicum* may increase yields and seed protein percentage when rhizobia are not already present (Abel and Erdman 1964; Caldwell and Vest 1970).

Whether inoculation is beneficial when seeds are planted in soils where effectively nodulated plants have been produced previously is sometimes in doubt. Ham *et al* (1976) reported that, in a series of studies, no significant response to inoculation was obtained when soybean was inoculated and planted in soils containing naturalized *R. japonicum*. Comparison of seed yields of the non-nodulating isolines indicated that 20-40% of the seed yield of the nodulating isoline was attributed to nodulation.

On the other hand, response of soybean to inoculation has been significant in other parts of the world. Subba Rao and Balasundaram (1971) showed a significant increase in yield between 14.3 to 235.7% according to location (Table 2). Differences in response were attributed to agroclimatic conditions characteristic of each location. Hera (1976) obtained 16 to 78% gains through inoculation of soybean in different soil types in Romania (Table 3). Similarly, Sistachs (1976) in Cuba, reported a significant response to inoculation of soybeans. Raicheva (1976) indicated that inoculation of soybeans increased yield much more than the application of 80 kg/ha of mineral nitrogen in Bulgaria. In Iraq, a significant response to inoculation of soybean was obtained (Ajam 1977).

In Egypt, the response of soybean varieties Hampton, Hill and Lee, cultivated in pots with single and composite strains of *R. japonicum* showed a different response, and some strains had a significant effect on yield (Hamdi *et al* 1968). Ashour *et al* (1969) studied the effect of inoculation and fertilizers on the soybean variety Hampton cultivated in pots containing 40 kg of Nile silt and fertilized with 6 and 12 g/pot of calcium nitrate. Inoculation alone or fertilization alone increased the dry weight and nitrogen content of soybean plants. The addition of nitrogen in combination with inoculation markedly increased several other yield components.

Table 2 YIELD OF SOYBEAN AS INFLUENCED BY *R. japonicum* (SB 16) INOCULATION AT DIFFERENT LOCATIONS IN INDIA IN 1970 (After Subba Rao and Balasundaram, 1971)

Location	Grain yield (kg/ha)		Difference from control %
	Un-inoculated	Inoculated	
Delhi	936	1583	69.1
Pantnagar	2307	2637	14.3
Jabalpur	1639	2920	78.1
Kalyani	1997	2561	28.2
Junagadh	573	1924	235.7

Table 3 SOYBEAN YIELD (kg/ha) AFTER INOCULATING WITH DIFFERENT STRAINS OF *R. japonicum* AND A BASAL DRESSING OF 64 kg N/ha + 64 kg P_2O_5/ha (after Hera, 1976)

Type of soil	Location	Un-Inoculated	Rhizobium strains				Significant differences at 5%
			SO-69	SO-75	SO-78	SO-85	
Irrigated							
Carbonated chernozem	Braila	1710	2110	2322	2344	2190	307
Chestnut-coloured chernozem	Marculesti	1460	2311	2011	2190	2077	395
Leached chernozem	Caracal	2144	2522	2480	2566	2470	209
Forest reddish brown soil	Simnic	2355	2910	2770	2770	2706	241
Exogleic podzol	Albota	2380	2560	2780	2322	2510	145
Mean		2011	2480	2480	2444	2390	141
Non-irrigated							
Forest brown	Tg. Mures	1677	1940	1810	1810	1880	146
Podzol and brown medium forest	Livada	2180	2511	2390	2333	2280	110
Mean		1913	2233	2110	2080	2080	83

ii. Cicer arietinum

Subba Rao (1976) reported a significant response to inoculation of *Cicer arietinum*; increase in yield of up to 31% under rainfed conditions (Table 4). In certain locations no significant response was observed.

iii. Lentils

Subba Rao (1976) indicated that inoculation of *Lens culinaris* increased yield at Ludhiana and Jabalpur (70.9%) but not at Rajendranagar and yield was significantly reduced at Hissar. Application of P_2O_5 with or without inoculation significantly increased yield at Sehore and Sheikpura (Table 5).

Taha *et al* (1967) reported a significant response of lentils to inoculation as the yield and total contents of nitrogen in the seeds increased (Table 6) in Egypt.

iv. Broad bean

As shown in Table 7, under Egyptian conditions, broad bean responded to inoculation (Loutfi *et al* 1966; Taha *et al* 1967).

2. NITROGEN FIXED BY DIFFERENT LEGUMES

Various reports deal with the amounts of nitrogen fixed by legumes and Nutman (1976) has summarized them. In general, pulses fix nitrogen less than forage legumes. However, this depends largely on the crop itself and the factors interfering with growth of the crop.

Rizk (1968) studied the amounts of nitrogen fixed by legumes under Egyptian conditions (Table 8). It is clear that clover, with its 4 cuts, fixes about 100 kg N/feddan (238 kg N/ha) followed by termis (pulse crop), broad bean, fenugreek, chick pea, lentils, groundnut and soybean.

3. EFFECT OF LEGUMES ON SOIL FERTILITY

Russell (1961), presented the results of a two-year rotation of legume-cereal, the cereal being either rye or barley. Table 9 shows that the yield of the following cereal crop largely depended on the amount of nitrogen added by the legume to the soil. The amount of nitrogen fixed varies from 70 to 450 lb (32 to 204.5 kg) of nitrogen. Leguminous crops grown for seed (peas, field beans, soybeans and groundnuts) tended to reduce the nitrogen content of the soil. Legumes grown for their leaf (clover, sweet clover and lucerne) increased the nitrogen content of the soil.

Rizk (1968) reported that nitrogen content of the soil varies with the crop cultivated (Table 10). The increase in nitrogen of the soil varies between 33 and 257 kg N/ha with legumes and between 7 and 38 kg/ha when cultivated with non-legumes (barley, sesame and chicory).

It is recommended that legumes should be inoculated with efficient rhizobia. Nitrogen fixation in different habitats and its role in the nitrogen cycle must be assessed.

Table 4 WINTER 1971/72 FIELD EXPERIMENTS WITH *Cicer arietinum* (after Subba Rao 1976)

Place	Treatment	Grain yield (kg/ha)	Difference from control (%)
Uninoculated		1776	-
Hissar	*Rhizobium*	1911	7.6
	25 kg N/ha	1655	-6.9
Uninoculated		1240	-
Badnapur	*Rhizobium*	1303	5.1
	25 kg N/ha	1330	7.2
Uninoculated		186	-
Akola	*Rhizobium*	191	2.7
	25 kg N/ha	144	-22.6
Uninoculated		2081	-
Sehore	*Rhizobium*	2025	-2.7
	25 kg N/ha	2113	1.5
Uninoculated		1708	
Rajendranager	*Rhizobium*	1986	16.2
Experiment 1	25 kg N/ha	1876	9.8
Uninoculated		1714	
Rajendranager	*Rhizobium* S_1	1966 *	14.7
Experiment 2	*Rhizobium* S_3	2047 *	19.4
	Rhizobium A_1	1971	15.0
	Mixture of S_1, S_3, A_1	1817	6.0
Uninoculated		1000	-
	Rhizobium	1260 *	26.0
Nagpur	25 kg N/ha	1243 *	24.3
Uninoculated		1041	-
Sheikpura	*Rhizobium*	1252 *	20.3
	25 kg N/ha	1054	1.3
	25 kg + *Rhizobium*	1650 *	58.5
Uninoculated		150	-
Jabalpur	*Rhizobium* S_1	1732 *	15.5
	Rhizobium S_3	1576 *	5.1
	Rhizobium A_1	1621 *	8.1
	Mixture of S_1, S_3, A_1	1670 *	11.3
Uninoculated		955	-
Dahod	*Rhizobium* S_1	1146 *	20.0
	Rhizobium S_3	1257	31.6
	Rhizobium A_1	1145	19.9
Uninoculated		2419	-
Raichur, Var. Chaffa	*Rhizobium* S_1	2957	22.7
Uninoculated		1841	-
Var. N 59	*Rhizobium* S_1	2113	8.9
	Rhizobium A_1	2108 *	8.6

* Significant difference from control at 5% level.

Table 5 WINTER 1971/72 FIELD EXPERIMENTS WITH *Lens culinaris* (Subba Rao 1976)

Place	Treatment	Grain yield (kg/ha)	Difference from control (%)
Uninoculated		513	-
Rajendranager	*Rhizobium* L_1	552	7.6
	Rhizobium L_4	587	14.4
	Rhizobium L_7	535	4.3
	Mixture of L_1, L_4, L_7	528	3.0
Uninoculated		354	-
Jabalpur	*Rhizobium* L_1	606 *	70.9
	Rhizobium L_4	568 *	60.4
	Rhizobium L_7	552 *	55.7
	Mixture of L_1, L_4, L_7	560 *	57.9
Uninoculated		1380	-
Ludhiana	*Rhizobium* L_4	1679 *	21.7
Uninoculated		1675 *	-
Hissar	*Rhizobium*	1256 *	-25.0
	25 kg/n/ha	1578	-5.8
	50 kg P_2O_5/ha	2121 *	26.6
Uninoculated		808	-
Sehore	*Rhizobium*	957	18.4
	50 kg P_2O_5/ha	843	4.3
	50 kg P_2O_5/ha + *Rhizobium*	1137 *	40.7
	50 kg P_2O_5/ha + 25 kg N/ha	953	17.9
Uninoculated		1095	-
Sheikpura	50 kg P_2O_5/ha	1285 *	17.3
	50 kg P_2O_5/ha + *Rhizobium*	1550 *	41.5
	25 kg N/ha + 50 kg P_2O_5/ha	1407 *	28.5
	25 kg N/ha + 50 kg P_2O_5/ha + *Rhizobium*	1600 *	46.1

* Significant difference from control at 5% level.

Table 6

EFFECT OF INOCULATION IN THE PRESENCE OF SUPERPHOSPHATE TOTAL NITROGEN CONTENT OF THE SEEDS (Taha et al 1967)

Super-phosphate (kg/ha)	Mean, yield (kg/ha)		Increase in yield (kg/ha)	Seeds, Total nitrogen, mg/g		Increase in nitrogen (mg/g)
	Uninoculated	Inoculated		Uninoculated	Inoculated	
0	1376	1638	262	40.2	50.2	9.72
117	1638	1733	95	40.6	51.2	10.60
233	1615	1873	258	41.4	52.2	10.85
350	1638	1873	136	42.5	57.0	14.46
466	1756	1872	217	44.8	58.3	13.52

Table 7

EFFECT OF CALCIUM NITRATE AND INOCULATION IN THE PRESENCE OF SUPERPHOSPHATE ON BROAD BEAN YIELD (Taha et al 1967)

Calcium nitrate (kg/ha)	Yield of seeds	
	kg/plot	kg/ha
58	21.2	2524
117	26.0	3096
175	24.0	2856
233	23.4	2786
291	24.0	2856

Table 8

NITROGEN FIXED BY DIFFERENT LEGUMES UNDER EGYPTIAN CONDITIONS (after Rizk 1968)

Crops	Nitrogen fixed	
	kg/feddan 1/	g/kg dry weight
Berseem Miskawy (4 cuts + seeds)	100	18
Termis	58	20
Broadbean	57	17
Fenugreek	44	23
Chickpea	41	23
Lentils	35	22
Groundnut	33	16
Soybean	17	14

Table 9 AMOUNT OF NITROGEN FIXED BY LEGUMINOUS CROPS, AND THEIR INFLUENCE ON THE FOLLOWING CEREAL CROP (Russell 1961)

Crop	Nitrogen harvested in		Grain or loss of N in the soil per rotation lb/acre	Total N fixed by legume, lb/acre	Yield of cereal grain, cwt/acre
	leguminous, crop, lb/acre 2/	Cereal crop, lb/acre			
Lucerne	299	66	122	450	23.2
Clover	125	51	115	260	19.4
Sweet clover	170	51	84	270	18.9
Soybean	176	29	- 8	160	11.8
Field beans	103	25	-20	70	10.6
Cereal every year	-	22	-10	-	2.7

Table 10 CHANGES IN SOIL NITROGEN CULTIVATED WITH LEGUMES AND NON-LEGUMES (Rizk 1968)

Crop	Change, 1/ kg N/feddan
(A) Legumes	
Broad bean	14
Lentil	36
Fenugreek	69
Termis	51
Chickpea	38
Groundnut	34
Soybean	24
Berseem fahl (1 cut)	42
Berseem Miskawy (4 cuts)	108
(B) Non-legumes	
Barley	3
Sesame	16
Chicory (4 cuts + seeds)	9

1/ One feddan = 0.42 ha = 1.038 acre
2/ One lb/acre = 1.12 kg/ha; 112 lb/acre = 125.4 kg/ha = 1 cwt.

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Paper 23

UTILIZATION OF RURAL AND URBAN WASTES TO IMPROVE SOIL FERTILITY

by

Myint Maung
United Nations Industrial Development Organization
Vienna, Austria

Summary

The paper describes UNIDO's experience in assisting developing countries in the production of compost from municipal solid wastes and of biogas from rural wastes. It discusses the problems and suggests the approach that developing countries may take in planning to utilize organic waste materials for soil improvement.

1. INTRODUCTION

UNIDO has been giving increasing attention to the utilization of rural and urban wastes, including agricultural residues and industrial by-products. However, this paper will be confined to their utilization to improve soil fertility in developing countries, i.e., the processing of rural and urban wastes for return to the soil.

The problems associated with the disposal of wastes from rural and urban communities have reached crisis level not only in developed countries but in many developing countries as well, partly through population growth and partly through increase in per capita waste production. Though the problem does not appear to be as critical in developing countries as in developed, it deserves serious and immediate attention owing to the generally lower standards of public sanitation found in developing countries and the imminent need to combat disease.

In this connexion, it may be worth quoting a WHO report on the incidence of faecal-borne diseases (Gotaas 1956):

"The diseases commonly transmitted by human excrement, particularly the parasitic diseases, are widespread and exact a serious toll of human lives and health. In areas where night soil is commonly used for fertilizer it is not unusual to find ninety per cent of the population infested with a single type of parasite, and the entire population affected by one or more of the several common intestinal infestations. WHO is concerned with the number of deaths arising from such diseases, which strike mainly at infants and small children, and with the general ill-health in all age-groups, which may not result in death but which does reduce vigour and working capacity.

"Much has been written about the use of community and human wastes as fertilizers. There is little doubt that they are of value, and as processes are developed to improve their competitive position, their use will be extended more and more. While recognizing the necessity of maintaining soil fertility, WHO is interested that widespread agricultural practices should be consistent with acceptable principles of public health. There is an apparent conflict between the hazards of using community wastes and night soil in agriculture on the one hand, and the need for organic fertilizers to improve crop production on the other. One possibility for a solution lies in making infectious material relatively innocuous by properly controlled composting".

It seems that in many developing countries, while the need is recognized to combine sanitary disposal with reclamation of the wastes for use in agriculture, the problem remains untackled, or only partially tackled, probably because it lies across the jurisdictions of several authorities, namely, the municipal, public health, and agricultural.

The purpose of this paper is to present the experience gained by UNIDO in assisting a number of developing countries in the production of compost from municipal solid wastes (MSW) and of biogas from rural wastes. It is hoped that this paper will provoke some thought and provide useful guidance on the planning and implementation of similar projects concerning the utilization of wastes for improvement of the soil.

2. COMPOSTING OF MUNICIPAL SOLID WASTES

2.1 Why Composting for Developing Countries?

Even while recognizing the problem of municipal solid waste (MSW) disposal, people often ask why composting should be resorted to as a method of disposal in developing countries, where cheaper alternatives exist.

There are four common methods of MSW disposal and treatment: open dumping, controlled dumping or sanitary landfill, incineration and composting. Of these, open dumping, where the wastes are merely thrown into a large heap somewhere on the outskirts of the city, is the least satisfactory and the cheapest, if the cost of damage done to the environment and the surrounding population is not taken into account.

Controlled dumping (where the wastes are deposited in layers, compressed daily by means of tractors, and then covered with a thin layer of soil or other suitable material) is a necessary method of disposal in the sense that it is applicable for those waste materials rejected by incineration, composting or recycling processes. Its apparent cheapness is offset by the need for a large land area and for certain anti-pollution measures: surface-water pollution is prevented by digging a circular ditch around the site of the controlled dump. Various measures may be introduced to restrict groundwater pollution, e.g. providing an impermeable floor and/or a final covering which prevents the penetration of rain water.

Incineration is the method of disposal whereby the organic components of MSW are destroyed in special furnaces at very high temperatures. In large installations it is possible to utilize the released heat for generating electricity, but in small installations this heat is released into the atmosphere. Besides many drawbacks such as operating problems owing to variability in waste composition and the risk of severe air pollution due to the release of toxic and noxious fumes, incineration often turns out to be a costly waste processing method. It is estimated that a 6 350 ton-per-week-plant in Baltimore would cost around $ 22 million to install and $ 4.6 million a year to operate (Niessen 1978). The unit capital cost works out to be $ 24 700/ton daily capacity, and the unit processing cost $ 14 570/ton.

The fourth alternative is composting, which if planned and carried out in the right way, should be a particularly attractive solution to the MSW disposal problem in developing countries. First, it combines sanitary disposal with reclamation of the wastes for return to the soil. Although composting is not a cure-all for fertilizer needs and compost is generally not competitive with inorganic fertilizers, there is no doubt that urban refuse composting can play an important role in the maintenance and improvement of soil fertility. The place of urban refuse composting in order of priorities set by an European agricultural experimental station is shown below (Stickelberger 1975):

Priority	Nutrients from	Comment
1	Livestock raising on farm Barnyard manure Liquid manure	Can be used without reservation
2	Mass livestock breeding Liquid manure Dried manure Manure combined with 3.	Can be used without reservation
3	Urban refuse and other organic wastes	If suited, to be used as far as possible
4	Commercial fertilizer	A substitute or complement for 1, 2 and and 3.

Secondly, the generally high organic matter content and low heavy metal content of MSW found in developing countries mean that a high quality compost which is safe for application to the soil can be obtained. Thirdly, wastes from agro-industries (e.g. meat processing, paper, saw mill, tanneries, etc.) on which many developing countries are concentrating can be incorporated in the composting process; so can digested sewage sludge. In fact, composting should be a segment of the process of wastes recycling. Finally, urban refuse compost can play an important role in land reclamation projects. An example is the project in Mexico (Golueke 1975) where the soil that constitutes the floor of a lake near Mexico City had dried up in the distant past, leaving a highly saline silt on the lake bed. When the wind blows in the direction of Mexico City, the city is subjected to a very irritating type of air pollution in the form of the suspended dust. To put an end to the air pollution and simultaneously up-grade the soil in the lake bed and thereby render it useful to agriculture, the Government plans to use the compost produced in the Mexico City recycling plant to fix and to improve the soil. Treated sewage from Mexico City's sewage treatment plant will be used to leach the salts from the soil. Because of the large land area involved, the output of compost from the Mexico City plant will be required for many years.

2.2 The Economics of Composting MSW

2.2.1 Raw material costs

Since municipal waste collection is a necessity irrespective of whether or not composting is used as a method of disposal, the refuse should be delivered free of charge at the compost plant. It is usually possible to arrange this by suitable siting of the compost plant in order to avoid unnecessary transportation costs.

Most municipalities are prepared to pay a suitable price to the compost plant for accepting the refuse which they would otherwise have to dispose of at a cost by sanitary landfill or incineration. This price is an important factor in determining the viability of the composting operation. The plants in Morocco receive the equivalent of $ 2/ton of refuse delivered at the plant site, whilst the one in Vienna receives the equivalent of about $ 12/ton.

2.2.2 Capital costs

The capital costs can vary over a very wide range depending on the degree of mechanization and the level of sophistication of the machinery used. The capital costs of a composting facility employing the Bangalore or Indore methods, which are widely practised in India, are confined to that of constructing earth trenches or pits lined with concrete, brick or masonry, and perhaps the costs of a few earth moving vehicles. At the other extreme, a really sophisticated plant with a capacity of 500 tons of garbage a day can cost around $ 10 million. On the other hand, it is possible to build a simple but perfectly adequate plant for about $ 3-4 million or even less, depending on the possibilities for local fabrication of parts for the plant. For example, the plant at Mexico City with a capacity of 500 tons/day was reported by Golueke (1975) to cost between $ 3.5 to 4 million in 1974. A plant of the same capacity designed for Fez, Morocco is estimated to cost around $ 2 million. The estimated capital costs of fairly basic mechanical composting plants planned for sixteen Indian cities are given in Table 1.

Table 1

PROJECT ON MECHANICAL COMPOST PLANTS UNDER IMPLEMENTATION IN INDIA 1/

City/town	Population (in thousands)	Refuse availability (tons/day)	Capacity of the plant (tons/day)	Estimated project cost (in thousand Rs)	Estimated cost of org.fert. (Rs/ton)
1. Allahabad	564	282	100	4 970	59
2. Ahmedabad	1 588	600	125-150	6 000	60
3. Bangalore	1 668	712	200	8 885	49
4. Baroda	467	160	125	7 000	80
5. Bombay	5 968	2 500	200	10 000	55
6. Calcutta	3 148 2/	2 600	125	6 000	89
7. Lucknow	880	440	100-125	4 970	58
8. Kanpur	1 450	725	200	9 350	60
9. Madras	2 470	1 200	435	7 064	50
10. Jaipur	680	200	100	4 500	46
11. Varanasi	700	350	100	4 970	59
12. Ludhiana	401	250	150	6 666	57
13. Amritsar	405	280	150	6 666	63
14. Jullundur	300	150	150	6 000	65
15. Jodhpur	400	120	125	2 921	50
16. Delhi	3 279	1 400	150	7 958	77

1/ Reported by G.S. Vidyarthy and R.V. Misra at the FAO/SIDA Workshop on Organic Fertilizers, held at Bangkok, 26 October-5 November 1976.

2/ Municipal area only.

Note: 1 US$ equals approximately 8 Rupees.

A pilot plant with a capacity of 10 tons/hour or a maximum capacity of about 160 tons/day, would cost approximately $ 1 million, the cost of machinery being of the order of $ 600 000.

2.2.3 Production costs

The production costs for the labour-intensive Bangalore and Indore methods of composting are best expressed in terms of man-hours required to produce one ton of finished product. This quantity will of course depend upon the different composting operations and on whether night soil is incorporated or not. The average figure is reported to be between 1¼ - 1½ man-days per ton of compost (Gotaas 1956).

At the Rabat plant in Morocco the production costs (without capital debt service) are found to be 13.50 Dirhams ($ 3.38) per ton of refuse treated, or 24.54 Dirhams ($ 6.14) per ton of compost produced.

2.2.4 Assessment of value

While the science of compost production is well advanced, the nature and magnitude of benefits to agricultural production are not understood so completely as to be quantifiable. Moreover, the benefits vary according to soil, climate and other conditions, although it is generally accepted that regions with sandy soils and an arid climate benefit most from the application of compost. Therefore, even in countries where compost application has been practised for many years and where extensive research data is available, no uniform method for economic evaluation of compost has been developed. One method of evaluation is solely on the basis of its nutrient content, and on this basis the value of compost has been estimated to be in the range of $ 15-22/ton (Rabat, Aden, Conakry).

2.3 Guidelines on Planning MSW Composting in Developing Countries

It should be recalled that the much publicized failure of compost plants in the USA and Japan was due mainly to two reasons: the use of sophisticated machinery and processes, and the insufficient market for the compost produced.

The problems encountered by developing countries, e.g. Morocco, which have ventured into MSW composting are somewhat different: these concern not only technical problems such as process adaptation, repair and maintenance of equipment, etc., but the more difficult matters related to provision of capital and working budget, selection of plant site, organization of refuse collection to serve the plant and market development. These problems are made worse by the distribution of responsibility between the municipal and agricultural authorities in these matters.

In view of these problems, it is best for developing countries to approach MSW composting in several phases. For places where there is a sufficiently organized garbage collection service and related infrastructure, the beginning should be made with the establishment of a pilot plant or a plant of low initial capacity which could be expanded later or duplicated at other suitable sites around the city or at other cities in the country. This approach would enable developing countries to find their own way to meeting the most important considerations for successful composting which are:

i. simplicity of plant design and composting process to reduce capital and production costs, increase labour-intensiveness and enhance possibility of local fabrication, repair and maintenance of equipment;

ii. good adaptation of the composting process to cope with the high organic matter content and humidity;

iii. establishment of adequate organizational and financial arrangements for the garbage collection system, compost plant operation, compost marketing and distribution;

iv. judicious selection of plant site or sites around a city; and

v. development of technical manpower for a waste management programme on a national scale.

In those places where the garbage collection service is totally inadequate, efforts should be directed to its improvement, but simultaneously, an experimental composting programme may be started using the Bangalore or Indore methods, perhaps assisted by the use of simple earth moving machinery. This will provide an opportunity to gain information on the nature of the materials, the possibilities for marketing and distribution, and the operational problems before undertaking the construction of a plant at substantial capital cost. The experience gained should ensure the most efficient final installation.

In all cases, a sanitary landfill facility should be established to absorb the surplus material from the wastes which are not suitable for composting.

The incorporation of night soil or sewage sludge in composting should be left to the second phase, as it requires an efficient process control to avoid health hazards.

Finally, it is suggested that developing countries should, as far as possible, use locally fabricated parts for the compost plant and build model designs so that the plants can be duplicated at reasonable cost throughout the country. For example, in Morocco, all the parts, except the grinder, are locally fabricated.

3. PRODUCTION OF BIOGAS FROM RURAL WASTES

3.1 Why Biogas Technology?

Energy, fertilizer and rural development are priority development objectives. Biogas technology not only supplies energy (biogas) and organic fertilizer from renewable waste materials, but also alleviates the problem of waste disposal and pollution control. Furthermore, owing to its simplicity and the possibility for local fabrication of the equipment, biogas technology is particularly suitable for rural areas.

It is hoped that the propagation of biogas technology in rural areas will have a favourable impact on their industrialization. Among the activities related to the construction of biogas plants is the manufacture of such items as gas holders, gas stoves, gas lamps, pipes, valves, welding conversion kit, engine conversion kit, etc. The availability of the gas could also increase the scope for the development of other small-scale village industries and generally encourage the development of rural entrepreneurship.

3.2 UNIDO's Demonstration Projects

Many developing countries, e.g. China, India and Korea, have long-established biogas development programmes, and complete designs of biogas plants of different capacities and types are available. However, the choice of a particular design has to be made after careful assessment of the local conditions, and the design chosen has to be demonstrated to work, and to work competitively in the poor rural areas of the country.

Other reasons why a demonstration project is essential for biogas development are:

i. the cost/benefit ratio depends largely on local conditions;

ii. the biogas plant should be managed as the core of an integrated system with many possible variations in input material and slurry utilization, and these should be incorporated in measures to promote its use, as well as in design and operation;

iii. it is not possible to force biogas development ahead of the genuine interest of the people concerned, and of their commitment to proper operation and maintenance - hence the need for demonstration projects to arouse public interest;

iv. considerable planning of infrastructure and mobilizing of financial resources (Government loans, subsidies, etc.) are needed;

v. the need to establish a sound technical advisory service to improve cost effectiveness and to promote reliability of plant design through stardardization.

Therefore, UNIDO's approach has been to assist in the transfer of biogas technology from countries, such as China. India and Korea, where it has been firmly established, to countries mostly outside the Asian region which are interested to benefit from the Asian experience. This is being done initially through demonstration projects carried out at the request of the government of the recipient country.

Demonstration projects are being started in Tanzania and Upper Volta, and request have been received for similar assistance to Afghanistan and Turkey. The Tanzanian project includes a workshop for the purpose of sharing the experience with other interested countries in English-speaking Africa. It is hoped that the Upper Volta project will also culminate in a similar workshop for French-speaking African countries. The technology being transferred in the above cases is the Indian biogas technology. It is hoped that at some future date, UNIDO will have a favourable opportunity to assist in transferring the Chinese technology to interested developing countries.

It is also envisaged that UNIDO may assist in the development of biogas technology at a somewhat larger, industrial scale, e.g. establishment of a sizable biogas plant fed by the wastes from a livestock farm and meat processing plant where the gas can be used as fuel for running the plant machinery and the slurry for growing algae to feed the fish in an integrated farming system.

4. CONCLUDING REMARKS

It should be recalled that only in recent years has emphasis been placed on the use of mineral fertilizers because they produce quick and positive results and because of their relative ease of handling and application. Yet, organic fertilizers have traditionally played, and continue to play, a vital role in the maintenance and improvement of soil fertility. The renewed interest in organic fertilizers has led to an appreciation of the fact that they possess, if properly used, a potential for increasing soil fertility which is at present very inadequately exploited. This is true of MSW composting and biogas production from rural wastes, to mention just two areas.

Although urban refuse compost and the slurry from biogas production can meet only a small portion of a country's fertilizer needs, in many cases they may provide the only fertilizer readily available. Since their utilization does not involve the large, concentrated capital investment needed for mineral fertilizers, developing countries should lose no time in taking full advantage of these organic materials to improve soil fertility. This can be achieved through careful planning and persistent effort on a national scale. UNIDO will be willing to assist developing countries in all the phases.

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Paper 24

EFFECT OF DIFFERENT ORGANIC MATERIALS ON CERTAIN PROPERTIES OF THE CALCAREOUS, SANDY AND ALLUVIAL SOILS OF EGYPT AND ON CROP YIELD

by

E.M. Abd-Elnaim
Institute of Soil and Water Research,
Agricultural Research Centre, Egypt

1. INTRODUCTION

The future expansion of agriculture in Egypt depends on the reclamation of the calcareous and sandy soils west and east of the alluvial soils of the Nile valley.

The main characteristic of the calcareous soils, in arid and semi-arid regions is the high content of $CaCO_3$ (10-60%). The pH is usually on the alkaline side. These soils are low in cation exchange capacity and lack plant nutrients and organic matter, a condition which promotes crust formation. These soils are also characterized by unfavourable structure for proper aeration and root development (Abd-El-Malek et al 1961).

Sandy soils are characterized by their poor physical and chemical properties as well as their low capacity to retain water and applied nutrients. Improvement of such conditions in these sandy soils could be accomplished by the addition of organic materials. Under arid conditions rapid decomposition would take place and frequent application seem necessary (Abd-El-Malek et al 1961). The rate of decomposition, however, depends on the nature of the organic material especially the C/N ratio (Mahmoud et al 1969).

Green manuring is also among the methods used for soil improvement because it increases the humus content as well as plant nutrients, especially nitrogen (Pinck et al 1945). The method of turning under the organic manures, implying tillage by different types of ploughs, plays a role in the effect on soil properties (Bishai 1961; Zein El-Abedine et al 1970).

Addition of aggregate stabilizers was attempted. Fuller et al (1953) reported increases in yields of many crops on calcareous soils of Southern Arizona by the addition of aggregate stabilizers. Also, many investigators recommended, especially for sandy soils, asphalt emulsion resulting from petroleum refining operations (Chepil 1955; Mildner 1963; El-Shabassy et al 1971a). Application of asphalt emulsion was found to promote soil aggregation, to reduce evaporation and excessive permeability, to protect soil against erosion and leaching, to raise soil temperature in the seed zone, to establish a good stand of certain crops and, in general, produce better conditions for plant growth and higher yields.

The following is a summary of the work published by the Sand and Calcareous Soils Research Section, Soil and Water Research Institute, Agriculture Research Centre, Giza, Egypt.

2. CALCAREOUS SOILS

2.1 A Comparative Study on Canal Spoil and Farmyard Manure as Soil Conditioner

A field experiment, at Nobaria Experimental Station near Alexandria, comprising 6 treatments in eight replicates was conducted for this purpose (Abd-Elnaim et al 1973a). The experimental soil (0-50 cm) was characterized by:

$CaCO_3$ from 26-31%, clay from 25-29%, silt 16-22%, sand from 51-53%, organic matter from 0.65-0.79%, pH from 7.7-8.1, cation exchange capacity from 8-11 meq/100 g soil and total soluble salts from 0.1-0.2%. The canal spoil contained 11.5% $CaCO_3$, 17% clay, 44% silt and 26% sand. Its organic matter content was 1.3%, pH 7.5%, CEC 34 meq/100 g and total salinity 27 mmhos/cm. The farmyard manure contained 12% moisture, 24% OM, and 0.47% total nitrogen.

Maize (hybrid 67) was planted in summer followed by wheat (Giza 155) in winter. The treatments were repeated in four replicates before wheat cultivation, the other replicates were left without addition to examine the residual effect of the first addition.

The results obtained are shown in Table 1. Maize yield increased significantly only by the mixture of canal spoil and farmyard manure. Farmyard manure or canal spoil alone at any rate did not affect the yield of maize. Wheat yield was increased significantly by most of the treatments. The residual effect of the added materials on the following crop (wheat) was clear but renewing the addition before that crop gave more pronounced effect.

Table 1 EFFECT OF FARMYARD MANURE (FYM) AND CANAL SPOIL ON MAIZE AND WHEAT YIELDS

Treatment, ton/ha		Yield, ton/ha 1/		
FYM	Canal spoil	Maize ears	Wheat grain	
			Residual	Re-addition
0	0	2.93	1.33	1.33
12	0	3.27	1.54	2.78
24	0	3.56	1.74	2.25
6	76	5.12	1.85	2.75
12	166	3.71	1.51	2.27
0	166	2.98	1.39	1.91

1/ LSD at 5% for maize ears 0.73
for wheat grain (residual effect) 0.36
for wheat grain (re-addition effect) : 0.56

2.2 Effect of Manuring and Different Ploughs on Wheat Yield

For this purpose, a field experiment including 4 types of ploughs (mould board, disc mounted, disc trailed and chisel mounted) and 4 levels of farmyard manure (0,24, 48 and 72 tons/ha) was carried at Nobaria farm (Abd-Elnaim et al 1973b). Wheat (Giza 155) was planted as an indicator crop.

The results show that organic carbon and total nitrogen increased very slightly by the application of FYM but were not affected by the types of plough. Six months from application, the organic carbon and total nitrogen had not materially changed and the C/N ratio was almost constant. With respect to the grain yield of wheat, there was a significant increase with increasing amounts of applied organic manure (Table 2). The disc trailed plough was inferior and the mould board was the best. Taking the interaction into consideration, the best treatment was the 48 tons/ha of FYM using the disc mounted plough.

Table 2

EFFECT OF DIRRERENT RATES OF FARMYARD MANURE AND DIFFERENT PLOUGHS ON GRAIN YIELD OF WHEAT

FYM ton/ha	Yield, ton/ha with plough				Aver.
	Mould board	Disc mounted	Disc trailed	Chisel trailed	
0	1.36	0.88	0.83	0.78	0.96
24	1.57	0.93	0.91	0.98	1.10
48	1.55	1.99	0.90	1.25	1.33
72	1.75	1.70	1.03	1.40	1.47
Aver.	1.56	1.37	0.92	1.11	-

LSD at 5% for manure and plough type: 0.15

2.3 Influence of Different Sources of Organic Matter on Soil Conditions and Crop Yield

A field experiment using the calcareous soil at the Nobaria farm was carried out to study the effect of different organic manures on soil and crop yield (Abd-Elnaim et al 1975a). The organic materials used in this investigation were: i) farmyard manure (24.2% OM); ii) garbage manure (13.5% OM); iii) sewage manure known as poudrette (45.2% OM); iv) maize stalks in whole form (67.4% OM), and v) maize stalks cut into small pieces, all applied at a rate of 25 ton/ha. Indicator crop were barley followed by maize. Barley was fertilized with ammonium sulphate and superphosphate at the rate of 500 kg and 250 kg/ha respectively. For maize, the same fertilizers at the same rate + 125 kg/ha potassium sulphate were used. Results are shown in Tables 3 and 4. Residual organic matter after 6 months of application was higher with all sources of manure than in the control, especially with FYM and sewage. Four months later, the organic matter content declined in all treated plots but was still higher than that of the control. Barley grain yield obtained from the FYM treated plots was higher than that from any other treatment. Next to it was that from sewage plots. Maize grain yield was higher on the plots treated with garbage than with any other treatment. The straw of barley and stalks of maize did not show any definite trend.

Table 3 ORGANIC MATTER CONTENT OF THE SOIL (0-30 cm) AS AFFECTED BY DIFFERENT SOURCES OF ORGANIC MANURING

Time of sampling after addition in months	% organic matter with treatment					
	No-Manure (control)	FYM	Garbage	Sewage	Whole maize stalks	Cut maize stalks
6	0.50	1.35	1.00	1.40	0.95	0.90
10	0.40	0.80	0.75	0.50	0.70	0.50

Table 4 EFFECT OF DIFFERENT ORGANIC MANURES ON YIELDS OF BARLEY AND MAIZE (maize planted following the harvest of barley)

Manure (25 ton/ha)	Barley		Maize	
	Grain	Straw	Grain	Stalk
	. . . . Yield ton/ha			
Control	1.77	1.94	4.74	3.89
Farmyard	3.78	2.23	4.87	4.18
Garbage	2.02	1.36	5.44	3.43
Sewage	2.86	2.03	2.82	3.01
Maize stalks, whole	2.30	1.78	5.16	3.92
Maize stalks, chopped	2.18	2.46	4.74	3.92

2.4 Effect of Different Ploughs and Organic Manuring on Properties and Productivity of Calcareous Soils

A split split plot field experiment was carried out at Nobaria Farm (Abd-Elnaim et al 1975, 1976).

The experiment included two green manuring treatments and 5 types of ploughs (native baladi plough, subsoiler + native, chisel plough, mould board plough and disc plough) as different methods for turning under the manure. The green manuring consisted of cowpea in the summer season (turned under at the age of 50 days) and fenugreek in the following winter season (turned under at the age of 75 days). At the time of turning under, the cowpea contained 24.76% OM, 2.25% TN and 2.39% ash, while the fenugreek contained 26.01% OM, 2.63% TN and 3.16% ash. The submain factor was introduced in the second season and comprised the application of different amounts of FYM (18.5 OM and 0.45% TN) to each treatment. The indicator crop was maize in both seasons. The results of the first and second seasons are shown in Table 5 and 6 respectively. Grain yield increased significantly and appreciably with green manuring (one third more than obtained with no manuring). If the green manure was turned under by the disc plough, its effect on maize yield became higher (Table 5). Results of the second season (Table 6) confirmed the previous results with respect to green manuring. The effect of disc plough did not differ significantly from the subsoiler + Baladi plough or the chisel plough, but it was superior to both the Baladi and the mould board ploughs. Also, the FYM was very effective in increasing grain yield of maize (Table 6).

Table 5 EFFECT OF GREEN MANURING (COWPEA) AND PLOUGH TYPE ON GRAIN YIELD OF MAIZE

Treatment	Maize yield, ton/ha with plough					Aver.
	Native	Subsoiler + native	Chisel	Mould bourd	Disc	
Control	0.76	0.76	0.82	0.95	0.93	0.84
Green-manure	0.97	0.87	1.13	1.30	1.40	1.13

LSD at 5% for manuring : 0.26
for plough type: 0.21

Table 6 EFFECT OF GREEN MANURING (FENUGREEK), FYM AND PLOUGH TYPE ON GRAIN YIELD OF MAIZE

Treatment		Maize yield, ton/ha with plough					Aver.
FYM, ton/ha	Green manure	Native (Baladi)	Subsoiler + native	Chiesel	Mould board	Disc	
0	–	0.70	1.05	0.76	0.81	1.10	0.88
	+	1.19	1.24	1.14	1.14	1.14	1.17
24	–	1.00	1.38	1.05	1.14	1.67	1.25
	+	1.38	1.48	1.71	1.33	1.76	1.53
48	–	1.14	1.67	1.38	1.19	1.67	1.41
	+	1.86	1.74	1.71	1.57	2.24	1.82
72	–	1.35	1.81	1.62	1.29	2.33	1.68
	+	2.00	2.38	2.43	2.19	2.67	2.33
Aver.	–	1.05	1.48	1.20	1.11	1.69	–
	+	1.61	1.71	1.75	1.56	1.95	–

LSD at 5% for farmyard manure : 0.27
for plough type : 0.29

3. SANDY SOILS

3.1 Effect of Applying Asphalt Emulsion to Sandy Soils on Crop Yield

Two field experiments were conducted in sandy soil under irrigation in the Southern Sector of Tahreer Province (Egypt) to study the effect of spraying asphalt emulsion additions over the soil surface on the growth of clover (*Trifolium alexandrinum* and flax (*Linum usitatissimum*) (Abd-Elnaim *et al* 1972).

The results obtained indicate that the asphalt emulsion had a good effect on soil moisture in sandy soils (Table 7). The moisture content of the soil increased significantly, especially in the deeper layers, as the rate of asphalt application increased up to 2 380 litre/ha.

Table 7 EFFECT OF ASPHALT APPLICATION ON MOISTURE CONTENT OF THE SANDY SOIL (% oven dry basis)

Soil depth cm	Amount of asphalt added litre/ha				
	0	1190	2380	2370	4760
Flax					
0–10	1.34	1.30	1.70	1.68	1.23
10–20	2.37	1.87	4.53	2.63	2.78
20–30	2.57	4.08	5.90	7.25	4.31
Average	2.43	2.42	4.04	3.19	2.77
Clover					
0–10	2.05	2.52	1.93	2.32	1.86
10–20	3.16	3.29	2.93	3.43	2.48
20–30	3.91	4.91	6.52	5.64	3.48
Average	3.04	3.57	3.79	3.79	2.61

LSD at 5% for flax : 0.38
for clover: 0.56

The asphalt emulsion applications were found to have no significant effect on the dry weight of flax straw or its stalk length but flax seed yield increased progressively and significantly with the increase in rate of asphalt application (Table 8). The application of 2 380 litre/ha increased the flax seed yield by 143 kg/ha. This increase was a result of increasing the capacity of the soil to retain water.

In the clover experiment, the fresh weight of clover, 80 days from sowing, was significantly increased only by the application of 3 570 and 4 760 litres of asphalt emulsion per hectare (Table 8). The application of 3 570 litre/ha increased clover yield by about 2.4 ton/ha. In addition, El-Shabassy *et al* (1971a) found that asphalt application, at a rate of 1 000 kg/ha increased the moisture content of sandy soils by 16–24% and the yield of groundnut yield by 538 kg/ha.

Table 8 EFFECT OF ASPHALT APPLICATION ON YIELDS OF FLAX AND CLOVER

Crop	Amount of asphalt added, litre/ha				
	0	1190	2380	3570	4760
Flax					
Dry straw, kg/plot	4.68	5.08	5.20	4.92	4.68
Stalks length/cm	55.50	59.90	53.40	55.70	59.10
Seeds, kg/plot	1.30	1.51	1.72	1.74	1.82
Clover					
Fresh wt, kg/plot	12.70	14.15	15.05	15.88	16.65

LSD at 5% for flax seeds: 0.12
for clover : 2.32

3.2 Effect of Sewage Water on Properties of Sandy Soils

A farm know as El-Gabal El-Asfar, about 25 km north east of Cairo has been continuously irrigated with sewage water since 1911. The soil is sandy desert and it contained 7.7% clay, 2.2% silt and 82% sand. The sewage water contained 400 ppm of suspended material and 250 ppm chlorides. Since then, periodical soil analyses have been carried out to follow the changes taking place (El-Shabassy et al 1971b). Some of these data are reported in this paper, i.e. the analyses after 8, 23, 33, 50 and 55 years (Table 9). As may be noticed from the table, the pH declined and the organic matter increased to a stable percentage, around 2%. Calcium carbonate dropped remarkably perhaps due to the solution effect from organic acids in the sewage water. Cation exchange capacity dropped at first, probably due to washing out the amorphous materials contained in the sand, but tended to rise again due to the increase of organic matter content.

Table 9 EFFECT OF IRRIGATING WITH SEWAGE WATER ON CERTAIN PROPERTIES OF SANDY SOIL (0-30 cm) AT EL-GABAL EL-ASFAR FARM

Date of sampling	pH	Organic matter %	$CaCO_3$ %	TSS %	CEC meq/100 g soil
1911 (Initial)	7.6	0.30	5.06	0.129	8.93
1919	6.8	0.83	3.79	0.087	5.83
1934	6.7	1.38	3.87	0.076	-
1944	6.3	1.45	2.21	0.125	-
1961	5.9	2.03	1.30	0.066	11.31
1966	6.4	1.93	0.29	0.057	-

4. EFFECT OF ORGANIC MANURING ON NUTRIENT UPTAKE AND CROP YIELD

Bayoumi et al (1978) carried out a pot experiment using two types of soils (sandy loam and clay loam) adjusted at different levels of ESP (6-30) and treated with organic manures (Poudrette and FYM). The results are summarized in Tables 10 and 11.

Loss of organic matter in 6 months was greater in the sandy loam than in the clay loam soil, probably due to excess aeration (Table 10). Although the loss of organic matter was treater with lower ESP, it did not vary with kind or rate of applied manure.

The grain yield of wheat was better on the sandy loam soil, and increased with the increase in rate of application of either poudrette or FYM but decreased as the ESP increased (Table 11). Total uptake of NPK was a little bigger in the clay loam soil and increased as the rate of manure application increased but declined steadily with increasing ESP. Sodium uptake only increased with increasing ESP.

Table 10 EFFECT OF ORGANIC MANURING AND LEVEL OF ESP ON ORGANIC MATTER CONTENT OF THE SOIL UNDER WHEAT (pot experiment)

Variable	Organic matter, %		Loss
	Initial	After 6 months	%
Soil			
Sandy loam	1.79	1.00	44
Clay loam	2.03	1.31	36
ESP			
6.3	1.99	1.12	44
14.4	1.95	1.24	36
19.2	1.91	1.28	33
24.9	1.89	1.33	30
29.9	1.85	1.37	26
Poudrette (ton/ha)			
0	1.20	0.79	34
20	2.10	1.36	35
60	2.36	1.57	34
Farmyard manure (ton/ha)			
0	1.20	0.79	34
35	2.22	1.56	34
105	2.40	1.59	34

Table 11 EFFECT OF ORGANIC MANURING AND LEVEL OF ESP ON GRAIN YIELD OF WHEAT AND UPTAKE OF NUTRIENTS BY WHEAT PLANTS (pot experiment)

Variable	Grain yield g/pot 1/	Nutrient uptake, mg/pot 1/			
		N	P	K	Na
Soil					
Sandy loam	6.98	518	131	134	8.6
Clay loam	5.62	533	158	157	8.6
ESP					
6.3	6.93	661	187	182	3.9
14.4	6.45	625	158	159	6.6
19.2	6.20	539	153	147	9.1
24.9	5.99	385	139	134	11.1
29.9	5.79	451	126	115	12.9
Poudrette (ton/ha)					
0	5.16	310	85	103	8.7
20	5.90	557	167	149	8.2
60	7.59	757	170	191	10.1
Farmyard M (ton/ha)					
0	5.16	310	85	103	8.7
35	6.39	680	188	164	8.3
105	7.60	756	198	161	8.0

1/ Each figure is the average of all other variables.

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Paper 25

RESPONSE OF MAIZE TO FARMYARD MANURE AND ZINC

by

H. El-Attar, M. El-Halfawi and E. El-Haddad
Soil and Water Sci. Dept. Faculty of Agriculture
University of Alexandria, Alexandria, Egypt

Summary

The addition of 10 tons/acre of farmyard manure increased the maize yield by 13% in the clay loam soil of Abis and by 19% in the calcareous sandy clay loam of Nubaria over the control. In addition the farmyard manure improved the response of maize to ZnO and $ZnSO_4$. Zinc application increased the leaf content of zinc but reduced both copper and manganese with uncertain effect on iron. Larger response to organic matter and zinc was found in Abis than in Nubaria showing the effect of carbonates on micronutrient availability and uptake.

1. INTRODUCTION

The production of acids and chelating compounds as a result of soil organic matter decomposition, plays a vital role in the availability of essential plant nutrient elements (Grunes et al 1961 and Wallingford et al 1975).

On neutral to alkaline and specially on calcareous soils, the zinc availability is generally low. Zinc defficiency of maize is world wide. Zinc oxide is suggested as a cheap material that can slowly release zinc and is not easily converted to $ZnCO_3$ as in the case of $ZnSO_4$.

2. EXPERIMENTAL METHODS

Effects of zinc sources and farmyard manure on maize grain yield and the contents of maize leaves from Zn, Cu, Fe, and Mn elements were determined.

Maize was cultivated on a highly calcareous soil of marine origin at Nubaria and on a soil of lacustrine deposits at Abis. The chemical and textural analysis of the two soils are presented in Table 1.

Table 1 SOME PROPERTIES OF THE ABIS AND NUBARIA SOILS

	Abis	Nubaria
EC mmhos/cm	1.90	4.30
pH (paste extract)	8.10	8.30
$CaCO_3$ %	9.10	33.20
Organic carbon %	0.98	0.49
Organic nitrogen %	0.25	0.13
DTPA-extractable Zn (ppm)	3.49	1.09
EDTA-$(NH_4)_2CO_3$ extractable Zn(ppm)	0.062	0.022
Texture	clay loam	Sandy clay loam

The farmyard manure contained 1.2% total nitrogen, 39% organic carbon and the C/N ratio was about 31. It was added before sowing at the rate of 0 and 10 ton 10 ton/acre.

The two zinc sources, ZnO and $ZnSO_4$, were used at the rate of 0, 5 and 10 kg/acre.

3. RESULTS AND DISCUSSION

Organic matter addition increased the grain yield (Table 2). The corresponding increases were 13% and 19% over the control at Abis and Nubaria, respectively. This increase is attributed to improvement of soil fertility (Herron and Erhat 1965; Garner 1966; Abdou et al 1969; and Hensler et al 1970). Also FYM may improve soil structure (Williams and Cooke 1961) and subsequently have a positive effect on soil permeability and water holding capacity. Maize grain yield responded to the addition of ZnO as well as $ZnSO_4$ specially in the presence of FYM.

This result means that the addition of organic matter improved the efficiency of the added zinc and rendered it more available to maize plants. This could be attributed to the chelation which takes place between the organic molecules and zinc ions. The activity of soil micro-organisms was probably increased following the application of FYM resulting in several favourable reactions.

The analysis of variance of the obtained data (El-Haddad 1978) showed that the yield of grain/acre was not significantly increased by the addition of zinc at Nubaria, while a significant increase in grain yield was found only in the presence of FYM at Abis.

Table 2 MAIZE GRAIN YIELD (kg/acre) IN RESPONSE TO THE ADDITION OF FARMYARD MANURE AND ZnO or $ZnSO_4$

Treatments	Zn source	Zn rate kg/acre	Grain yield (kg/acre) at	
Farmyard manure			Abis	Nubaria
Without FM	ZnO	0	1943	1318
" "	"	5	2074	1492
" "	"	10	1745	1281
" "	$ZnSO_4$	0	1943	1318
" "	"	5	1930	1619
" "	"	10	1955	1496
With FM	ZnO	0	2029	1590
" "	"	5	2157	1685
" "	"	10	2347	1876
" "	$ZnSO_4$	0	2029	1590
" "	"	5	2352	1586
" "	"	10	2151	1845

The data presented in Table 3 shows that the increase in added zinc from 0 to 10 kg Zn/acre, on average organic matter and zinc source treatments, generally increased the Zn and decreased both Cu and Mn concentrations in leaves while iron behaviour was not clear. This imbalance in the mineral content of the leaves might be due to an interaction between zinc and the other elements (Fuehring and Soofi 1964; and Ohki et al 1967).

It may also be noted that the response to organic matter and zinc additions was more clear on ear leaf than on the recently matured leaf mineral content at both sites. A larger response to these treatments was noticed at Abis. This result might reflect the effect of the high carbonates at Nubaria. The carbonates immobilize the studied elements through chemical precipitation, antagonism and reduction of the acidifying and chelating effects of organic matter.

Table 3 EFFECT OF ZINC APPLICATION ON MICRONUTRIENT CONTENT OF EAR LEAVES AND RECENTLY MATURED LEAVES

Zn added kg/acre	Abis				Nubaria			
	Zn	Cu	Fe	Mn	Zn	Cu	Fe	Mn
	ppm							
Recently matured leaves								
0	44.6	22.8	163.4	57.3	38.1	26.9	184.6	86.5
5	46.9	24.9	162.7	57.5	44.7	25.1	212.9	86.8
10	48.1	25.9	155.3	56.7	44.9	22.1	212.3	88.6
Ear leaves								
0	34.4	20.4	200.8	61.1	30.2	19.0	198.9	109.8
5	38.1	18.5	207.6	63.8	35.4	19.1	194.1	105.8
10	38.6	16.6	208.1	65.9	36.8	15.8	192.6	93.4

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Editor's Note: the word 'corn' in these references refers to maize which is the expression that has been used throughout the text.

Paper 26

CROPPING SYSTEMS AND EFFECT ON SOIL PRODUCTIVITY

by
A.M. Balba
Department of Soil and Water Science, College of Agriculture
University of Alexandria, Alexandria, ARE

Summary

Cropping systems differ according to climatic conditions, soil characteristics, needs and habit of the population and the economic and social level of the region.

The effect of the cropping systems on soil productivity is the result of the cropping operations and plant growth: i) tilling operations activate the decomposition of organic residues; heavy machinery increases soil compactness; ii) plants deplete soil content of nutrients; legumes enrich the soil with N; loss of N in gaseous forms takes place as a result of cropping; plant growth and the roots remaining in the soil change the soil fertility pattern; iii) irrigation might cause soil salinization if not accompanied by an efficient drainage system; soluble nutrients might be lost by leaching with irrigation water in coarse textured soils; and iv) application of fertilizer N increases the absorption of soil N and other nutrient elements.

In rainfed areas, clean tilled fallow land after wheat exposes the land to wind erosion. Wheat followed by fallow in summer and the following year is practised in the middle east region. Attempts to improve soil productivity are made by growing lentils in the fallow year.

In irrigation regions cropping systems are intensive and the effect of the above-mentioned operations is intensified because of the number of crops planted each year. Cropping systems to suit newly reclaimed salt-affected soils and $CaCO_3$-rich and sandy soils are discussed. Crop associations are also presented. The cropping system which suits a specific region can be selected by field experiments in the region.

1. INTRODUCTION

Cropping systems differ from one region to another. Several factors cause these differences, among which are climatic conditions, soil characteristics and population needs and habits as well as the social and economic status of the region. Other systems prevail under irrigation. Several crops are grown in variable successions. The soil productivity under each system might differ. Also, the soil productivity after each system differs from its original productivity due to the effect of plant growth and cropping operations.

Cropping is a complex operation. It starts with clearing the land if it is covered by woods or other naturally growing plants. It might be preceded by other preparatory operations such as drying of swamps or water bodies, desalination, introducing irrigation and drainage in the area etc. Cropping procedures, like tilling, levelling, seeding, fertilizing, cultivating, irrigating, and harvesting effect changes in the condition of the soil. Also biological activities which occur in the soil during the plant growth, or as a result of it, induce changes in the soil condition as a medium for plant growth. All these activities are reflected in the soil productivity.

2. EFFECTS OF THE MAIN OPERATIONS PRACTISED IN CROPPING

Before discussing the effect of cropping systems on the soil productivity, the effects of the main operations practised in cropping on the soil must be mentioned. These operations affect the soil physical, chemical, and biological conditions which reflect on the soil productivity.

2.1 Effect of Land Preparation Operations

In places where the land has to be cleared from its natural vegetative cover of trees, grasses, or other plants, the soil surface is subjected to the atmospheric elements. As the soil dries, the proportion of air increases in the soil system and oxidation is activated. The decomposition of organic matter is thus hastened. This dryness and oxidation are enhanced when ploughing is carried out at a suitable time. The soil structure should be improved for the soil to become more suitable as a seed bed. However, use of heavy machinery may cause soil surface compaction. A ploughing depth of 20-25 cm using a mould board plough followed by a chisel plough in a perpendicular direction has been recommended for maniplating the calcareous soils west of Alexandria. On the contrary, under certain conditions, ploughing may enhance wind erosion. This is especially true in rainfed agriculture.

2.2 Effect of Plants on Soil Nutrients Content

Plants absorb the necessary nutrient elements from the soil. For example, the amounts of elements absorbed by maize in one acre in kilograms are: N:60, P:50, Ca:17, Mg:15, P:10, S:10, Mn:0.15, Fe:1 in addition to small amounts of B, Cl, Zn, Cu and Mo. Thus nutrient elements are usually depleted from the soil by successive cropping, especially if the soil does not contain reserve amounts of these elements. The unavailable soil reserve forms of nutrient elements usually need a long time to be transformed to forms available to plants (Bray 1944).

As legumes have the ability to fix atmospheric nitrogen, growing these plants eventually enriches the soil with N instead of depleting it as occurs with other crops unable to fix atmospheric nitrogen. Over the years, several workers have tackled this point, and their estimates of the N gained by using leguminous plants differ from one plant to another and according to other conditions. However, most figures reported show that the gained N is about 100-150 kg N/acre. Leguminous crops such as soybean, field beans (Vicia faba) and peas harvested for grains, according to Russell (1962), fix about 50-100 kg N/acre but all N appeared in the harvested material.

Cropping was found to be a factor increasing loss of N from the soil in gaseous forms. Allison (1955) has shown, from studies in lysimeters, that the loss of N in gaseous forms was about 12% without cropping and it increased to 20% when the lysimeters were cropped. Dilz and Woldendrop (1960) used ^{15}N and showed that the denitrification was enhanced in the vicinity of the plant roots. He stated that the roots excrete H-donors in addition to the anaerobic conditions. Stefanson and Greenland (1970) used tight growth chambers to determine the evolved gases and showed that N_2O was greater than N_2. The gas evolved from cropped pots was always greater than that from uncropped ones. They applied water equal to 50-80% of the maximum water-holding capacity to eliminate the effect of anaerobic conditions due to excess water. Balba and Ata (1974) showed that 1.254 g of gaseous forms of N per pot were lost from cropped pots.

According to Barber (1971), several changes occur in the amount of soil directly contacting the root hairs. An increase in plant transpiration brings to the rhizo-cylinders, through mass flow, an excess of several elements, such as Ca, which might react with P decreasing its availability and might affect the absorption of K and Mn due to competition or other mechanisms.

Cropping also affects the soil nutrient contents and distribution as a result of the growth of the root system and its subsequent decomposition. Taking the maize plant as an example, a successful maize crop yield from one acre produces about 3 tons of maize seeds, and 2.5 tons of roots. If all the above-ground parts are removed from the soil, the roots at least remain in it. This considerable amount of organic material effects extensive biological activity in the soil. From the nutritional point of view, the contents of nutrient elements in the roots are liberated and the soil depth containing the major part of the roots is enriched with nutrients. Actually the roots are a factor in changing the fertility pattern of the soil.

2.3 Effect of Irrigation

Irrigation of arid regions is a necessity for cropping. However, salinity hazards are closely associated with irrigation in these regions. Salinity results from waterlogging which can be caused by applying water without an efficient drainage system. The ground water table approaches the soil surface and the soil water reaches the surface by capillarity and consequently evaporates leaving its salt content on the soil surface. Also, because plants absorb water, leaving cations and anions in the root zone, an accumulation of salts takes place in time. This is especially clear when sub-irrigation is utilized. In this case, movement of water upwards is not interrupted by the surface application of water or rain which moves downwards dissolving the salts and pushing them further down. Balba and Soliman (1978) showed that the salts accumulated where the density of the roots increased under sub-irrigation.

In practice, an amount of water over and above that needed by the growing crop is usually applied in order to ensure leaching the salts from the root zone. Irrigation might cause leaching of nutrients from coarse-textured soils. Bizzell (1926), Benson and Barnette (1939) and Balba and Sayed (1969) reported that NO_3^- is the form which moves most readily with water. In the latter work, the leached N from the soil columns fertilized with NH_4^+ or urea was in the form of NO_3^-. Broadbent el al (1958) showed that urea moved less rapidly than NO_3^-. The results of Balba and Sayed (1969) showed that 14, 8.5 and 67% of applied N as $(NH_4)_2SO_4$, urea and $Ca(NO_3)_2$, respectively, were accounted for in the filtrates. Cooke and Cunningham (1957) and Balba and Sayed (1969) reported that migration of soluble substances with water depends also on the water-holding capacity of the soil.

The loss of fertilizer P by leaching is not a problem in most soils. Phosphorus is usually immobilized upon incorporation in the soil, but because of the low content of clay and organic matter fractions in the sandy soils, a limited movement takes place of applied phosphatic fertilizers by convection with irrigation water. The writer has shown that 12.4% of P added on sandy columns 15 cm long was in the filtrate. The situation of potassium in coarse-textured soils is similar to that of phosphorus. The problem of losing applied K fertilizers by leaching with irrigation water is not serious in sandy soils.

2.4 Effect of Fertilization

Fertilization is an important practice in crop production. About half of the wheat, maize and rice produced in Egypt is a result of this practice.

Application of fertilizer N was shown to increase the uptake of N from soil sources; this was shown using ^{15}N-enriched fertilizer. Balba and Shabana (1971) showed that the uptake of fixed NH_4^+ by barley seedlings increased when the plants were supplied with NO_3^-. An increase in soil N uptake upon the application of fertilizer N was explained by Broadbent as being due to enhancing the nitrification of soil N as a result of excess energy sources from the root hairs. In the opinion of the writer, the root system is extended due to N application in the soil. Thus immobile soil N forms are reached and absorbed as has been demonstrated by the increase in the absorption of fixed NH_4^+ which is easily nitrified (Balba and Nasseem 1967).

Fertilization affects the absorption of nutrients other than the one applied as fertilizer.

Intensification of plant growth, because of applying fertilizer, results in an increase in the root system and, consequently, greater absorption of the other nutrients. Balba and Bassiuni (1968), using ^{32}P, showed that the application of fertilizer N increased the uptake of soil and fertilizer P by tomato plants. The increase in soil P absorption, however, was greater because of N fertilization than the increase in the absorption of fertilizer P. They showed that the correlation coefficient between the weight of the root system and the absorbed soil P was + 0.897, while the same correlation with fertilizer P was + 0.341. Again, Balba and Sayed (1969), using a mathematical method, showed that the application of 30 mg N/kg soil in a pot experiment increased the P absorbed from the soil 9 times more than without N application. The increase in the absorption of fertilizer P due to the same N application was only 3.0 times.

3. CROPPING SYSTEMS

3.1 Rainfed Regions

In rainfed areas, wheat yields are controlled by the amount of precipitation. In these areas, summer fallow is generally practised on the basis that the fallow land conserves moisture, thus better crops are obtained. This practice was once widespread in US Prairies where in order to conserve soil moisture in the summer, the land was kept free of weeds. This system proved to be a failure because wind blew the dry, bare soil causing enormous damage to vast areas in the Midwest of USA. Soil conservation measures such as leaving stubble on the land, or covering it with growing vegetation, and ploughing and seeding along the contours should be applied.

In the semi-arid region of the Middle East, fallowing is also adopted. It raises contradictions. In Syria, as in other countries of the region, the land is left fallow the summer after the wheat is harvested and the whole following year after which wheat is again grown on the same land. Loizidis (1968) compared the following rotations in Syria: i) wheat continuously every year without fallowing; ii) wheat after fallow; iii) wheat followed by lentil, and iv) wheat followed by Vicia.

His studies showed that differences in wheat yields could be related to the soil moisture content, and the yield of wheat after fallow was better than continuous wheat without fallow. He concluded that the net return of wheat, followed by lentil, was greater than wheat after fallow.

Rainfed agriculture is an extensive system of cropping but when supplementary irrigation is possible, cropping becomes more intensive. A rotation including legumes accompanied by appropriate fertilizers is required to conserve the soil fertility and its productivity.

3.2 Irrigated Regions

Intensive cropping in irrigated regions requires balanced rotations. The effect of cropping operations, summarized above, is intensified because of the number of crops usually planted each year in a specified piece of land. Attention should be given to several points in order to maintain soil productivity:

i. the nutrient requirements for the crops in the rotation: a fertilizer programme should be applied to conserve the soil fertility;

ii. the amount of water applied: the method and frequency of its application should be suited to each crop in the rotation;

iii. the quality of the applied water should not increase the soil salinity or sodicity or adversely affect plant growth;

iv. efficient drainage is necessary to avoid waterlogging and subsequent soil deterioration;

v. crops should differ in their rooting pattern: some (such as various grass types) can bind soil particles together into crumbs, and some roots are such strong growers that they can penetrate even compact subsoils, e.g. some legumes. A succession of such crops can improve the drainage and aeration of the subsoil;

vi. the length of the crop growth period: shorter periods from seeding to harvesting permit the succession of more crops in a year; for instance, a vegetable rotation could permit 3 crops to follow each other;

vii. the needs of the population might indicate rotations of subsistence crops rather than fibre or cash crops.

Cropping systems to suit soils with special conditions are necessary in newly reclaimed salt-affected soils, sandy or calcareous soils.

3.3 Newly Reclaimed Salt-affected Soils

The crops selected should require ample amounts of water at short periods and, at the same time, be salt tolerant. Growing plants which do not fulfil these requirements would only increase soil salinity. Attention should be paid to the water quality and efficiency of the drainage system. A popular rotation of crops in areas with these soils is clover followed by rice and temporary clover followed by cotton. Suitable fertilizers should be applied.

3.4 $CaCO_3$-rich Soils

Crops that tolerate excess Ca, like legumes, are usually preferred for these soils. Some vegetables, especially Cucurbitaceae and Solanaceae, and fruits such as olives, vines, and figs have proved successful in calcareous conditions. Care should be taken to minimize the loss in gaseous forms of applied N fertilizers. A fertilizer programme including ample applications of P and micronutrients is necessary. Green manure, and organic fertilizers, if economical, are recommended. Irrigation should be at short periods and drainage should be kept efficient.

3.5 Sandy Soils

These soils should be cropped to minimize the loss of water and nutrients by leaching. Crops yielding highly priced products should be selected in order to compensate the relatively high costs of production. A technological package including the most suitable crops, the method of irrigation and the kind and method of application of the fertilizers and other nutrients is necessary to maintain the productivity of sandy soil. The most popular crops on these soils are groundnut, sesame, barley, citrus, mango, tomato and strawberry.

3.6 Other Cropping Systems

i. Continuous cropping with one crop for several years used to be considered harmful to the soil and to decrease its productivity, but now, with vigorous fertilization and pest control it has become possible to grow continuous maize for several years. However, Russell (1962) stated that land continuously cropped with clover becomes 'clover-sick', and the lower the soil in organic matter the sooner clover-sickness sets in.

ii. Two crops are grown in association in several regions in the world. In general, no annual crop has its yield per acre increased by being grown with another, although the land productivity, the total yield per acre, may be increased.

iii. Growing two-non legumes simultaneously on the same piece of land has been practised in many regions. Wheat and barley or oats and barley associations are ancient practices. The mixed crop usually gives a higher yield of grain per acre than that of either of the two components.

iv. A non-legume and a legume are grown in association on the premise that the non-legume can utilize nitrogenous components synthesized by the legume. However, it could be interpreted that the legume makes no demands on the soil nitrogen and hence that the reduced number of non-legume plants present in the association, as compared with a pure crop, has a larger N supply to draw on (Russell 1962).

4. SELECTION OF A CROPPING SYSTEM

Field experiments with several crops in varying successions should be carried out. The results of these experiments will show the most suitable cropping system for the soil under the climatic conditions of the area. It might be possible to use mathematical equations to select the most profitable system for the area.

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Paper 27

ENVIRONMENTAL HEALTH ASPECTS OF WASTEWATER AND REFUSE APPLICATION TO LAND

by

Olfat D. El-Sebaie and H. Mitwally
High Institute of Public Health
Environmental Health Department
University of Alexandria

Summary

Land application of wastewater, liquid sludges and refuse is considered as the best solution to disposal problems. For health reasons however, it is recommended not to use raw sewage. As a rule, field crops that are normally consumed in a raw state, should not be irrigated with sewage of any kind. Preliminary treated or undisinfected sewage effluent is usually allowed for field crops, such as cotton, sugar beets, and vegetables for seed production. To minimize health risks, refuse has to be composted and sludge should be digested before application. Also it is recommended that the people applying wastewater, compost, or refuse to land should attend health education programmes.

1. LAND APPLICATION OF WASTEWATER

The advantages of applying wastewater to land are summarized, in Agricultural Research Service (1974) and Thomas and Harlim (1975), as recycling of some nutrients back to the land.

The three main types of application, namely "irrigation, infiltration-percolation, and overland flow" are used successfully under different conditions of climate and soil characteristics in Canada, USA, Europe and Australia (EPA reports 1973, 1975). In wastewater irrigation, the traditional methods of application are spraying, ridge and furrow, and flooding. Other application methods may be introduced depending upon local circumstances.

In developing countries, wastewater is often disposed of either raw or partially treated by primitive methods such as by dilution into usable water bodies, with its consequences on public health and associated economic losses. This problem is more obvious in urban communities where considerable quantities of domestic and industrial wastewater are encountered (Farag 1973). Oxidation ponds and trench tile fields are two possible alternatives for treatment and final disposal which have been tried successfully in rural areas and isolated communities in the Middle Eastern countries (UNRWA Report 1968). As regards land application of wastewater with its established technique in this part of the world, it is considered non-familiar and has not been practised before. New elaborate treatment methods are not advisable, not only because of shortage of funds, but also because of the lack of technical personnel who can take care of operation and maintenance problems.

Land application of domestic and industrial wastewater could be resorted to in desert as well as cultivated areas in Egypt. A considerable part of the desert area could be cultivated if water and nutrients were available. On the other hand, the already cultivated areas could be irrigated with wastewater wherever possible (Mitwally 1959).

Although land application of wastewater and sludge as fertilizer has been practised locally in many areas, little research was conducted by its handlers on its effects on soils, crops and groundwater. Some work aimed at improving the quality of wastewater before final disposal through coagulation was reported by El-Sebaie and El-Sharkawi (1976). Disposal of raw wastewater directly into the River Nile or its tributaries is prohibited by law. However, disposal by dilution is practised indirectly in inland cities. In communities where no water bodies are available, land application is resorted to in a primitive manner. This technique is hazardous and the need for an elaborate study is becoming a mandatory assignment.

In Egypt, exploration of the effects from land application of wastewater on environmental health is required. The most important effects are listed in the next subsections.

1.1 Environmental Effects

a. On soil: physical and chemical characteristics, soil flora and fauna.

b. On crops and vegetations: growth and production characteristics.

c. On groundwater: quality and depth of water table, and on surface water quality.

d. On animal and insect life: propagation and vitality.

e. On air quality: bacteriological and chemical composition.

1.2 Public Health Effects

a. On workers: those participating in activities on the land. Special emphasis would be on the parasitic, bacterial, and skin diseases.

b. On groundwater quality: continuous monitoring for nitrates, other dissolved salts, heavy metals, trace elements and pathogens.

c. On crops and vegetation: biological contaminants and chemical pollutants as trace elements in different crops.

d. On propagation of insects and rodents: controls especially for flies and mosquitoes.

1.3 Economic Effects

a. On the value of land: change in value of the land used and adjacent lands as a result of introduction of this system.

b. On income: loss of tax revenues as a result of governmental use, and gain of additional income as a result of more crops.

c. On sources of water: an available inexpensive source of water for irrigation.

d. On cost of water treatment: change in cost of wastewater treatment compared with traditional treatment systems giving the same efficiency.

1.4 Social Effects

a. On green areas: increase of greenbelts, parks, open space and recreational areas.

b. On community growth: Stimulation or encouragement of growth of a community, both in terms of economy and population.

c. On residence: relation of residence and allotment of land for different purposes.

In conclusion, land application of wastewater could be a reliable approach to meet the following requirements, providing that the environmental health effects were controlled:

- treatment and final disposal of wastewater applied,
- increasing the productivity of already cultivated land,
- gaining more cultivatable land from desert areas,
- control of sandy storms and stabilization of sandy soils,
- groundwater recharge.

2. LAND APPLICATION OF SLUDGE

Application of liquid sludges to land provides a useful way of disposing of them, it enriches the soil with plant nutrients in addition to the conditioning and stabilizing effects on the soil. Canadian workers have reported that the application of liquid sludges improved harvest quality and quantity, reduced the consumption of expensive commercial fertilizers and helped solve the problem of sludge disposal.

In Egypt, there are a few wastewater treatment plants in big cities which produce sludge in ever increasing quantities and numerous water treatment plants that produce large quantities of sludge. The sludge from the latter is usually regarded as poor in nutrients, compared to wastewater sludge. However, the sludge from water treatment plants throughout Egypt contains Nile river silt which renovates soil fertility. Thus, by combining sludge from water and wastewater treatment plants for land application, the unique characteristics of each type of sludge can be used to increase soil fertility and to improve the soil condition.

The effects on environmental health from applying sludge to land are similiar to those mentioned for wastewater. Therefore, it is advisable to consider these effects when using sludge as soil fertilizer or conditioner.

2.1 Land Disposal

The most common methods of land disposal include:

i. Spreading on soil: wet digested sewage sludge is spread over farm lands and ploughed under when dry. The humus in the sludge conditions the soil and improves its moisture characteristics.

The digested sludge may either be heat dried, ground in a mill and fortified with nitrogen, or air dried. Air dried sludge may also be used as a soil conditioner.

ii. Lagooning: lagooning is another popular disposal method because it is simple and economic if the treatment plant is in a remote location. If the lagoon is used only for the digested sludge, the nuisances produced, such as odour or flies, would not be a problem.

Sludge may be stored indefinitely in a lagoon, or removed periodically after draining or drying.

iii. Dumping: dumping is suitable for sludges that have been stabilized so that no decomposition or nuisance will result. Digested sludge, clean grit, and incinerator residues can be disposed of safely by this method.

iv. Landfill: a sanitary landfill can be used for disposal of sludge, grease and grit whether or not stabilized if a suitable site is available. This method is also suitable for the disposal of refuse and other solid community wastes. In a true sanitary landfill, the wastes are deposited in a designated area, compacted in place with a tractor or roller, and covered with a 30 cm layer of soil. With daily coverage of the newly deposited wastes, nuisance conditions are minimized. After several years during which the wastes are decomposed and compacted, the land can be used for recreational or other purposes where gradual subsidence would not be objectional. In selecting a site for a dump or landfill, consideration must be given to the nuisance and health hazards that they may cause.

Trucks carrying wet sludge and grit should be able to reach the site without passing through populated areas. The site should have good drainage so that runoff would not create boggy conditions that would interfere with vehicular movement. Drainage from the site would cause pollution of the groundwater supplies or surface streams and must be guarded against.

3. LAND APPLICATION OF REFUSE

Solid wastes vary throughout the world in quantity and constituents and these are determined by social customs and living standards. They are heterogeneous and consist of fermentable organic wastes which decompose rapidly, and non-fermentable wastes which resist decomposition or decompose very slowly.

Harm from wastes and their products can arise from inflammation, disgusting or nauseating smells during fermentation in the open, the scattering of paper, plastic and dust by the wind and the breeding of flies and rodents, which are of great importance in the spread of disease. Therefore proper refuse disposal is essential. Many methods of refuse disposal are used in various localities, but selection of the best method should always be based on public health requirements.

3.1 Sanitary Landfill

Sanitary landfill is the best disposal method and it is basic to any other solid waste programme. Incineration is a volume reduction process and produces residues which should be sanitary landfilled. Open burning and open dumping are not solutions to the disposal problem. Feeding hogs on garbage is a form of reuse. Composting is a form of processing organic wastes, such as garbage, to form a humus-like material and a soil conditioner. Such a recycling process may be incorporated in the system to handle a small percentage of solid wastes, but local governments should not base any solid waste management system predominantly on salvage or compost programmes.

Sanitary landfill is frequently a versatile and economical disposal method. Almost any solid waste can be disposed of in a sanitary landfill, and the unusable land can often be reclaimed for community use. Major elements in the sanitary landfill process are proper placing of refuse, effective compaction and adequate cover.

A properly operated sanitary landfill produces no objectionable odours, vector problems, or blight and is especially suited to the reclamation of marginal land.

3.2 Composting

Composting, according to a WHO technical report, is a method of handling and processing solid wastes to produce a humus-like material which may be used as a soil conditioner. The process requires separation of non-compostable materials. Technically, composting is biological degradation of organic matter under controlled conditions of aeration, temperature, and moisture.

Composting of solid wastes may take place in the presence or absence of oxygen. Odours produced under aerobic decomposition are less objectionable. The aerobic process is quicker and achieves higher temperatures, thus guaranteeing a relatively germ-free product, free of live weed seeds and insect larvae. The anaerobic process is slow, smelly and does not achieve temperatures high enough to destroy all pathogens. Anaerobic decomposition also produces noxious gas by-products such as hydrogen sulphide.

In most cases, it is difficult to control the oxygen balance throughout the wastes. Thus, it is possible to have aerobic and anaerobic decomposition taking place simultaneously in different parts of the wastes.

Problems of marketing compost restrict the use of this method, particularly in Europe and in USA, although it is practised on a wide scale in some of the developing countries. It is worth mentioning here, that application of immature compost to soil results in adverse effects on crops because micro-organisms may rob the mineral nitrogen from the soil. So, it is advisable not to use the material before it is mature.

Finally, a health education programme on the aspects of applying wastewater, sludge, and refuse to land would be of great benefit. People who are going to handle or apply these wastes must be aware of the health aspects in order to avoid the hazards, especially in developing countries.

3.3 Solid Wastes of Alexandria City

Table 1 presents the relative composition of the different types of solid wastes in Alexandria City. These results were obtained in a study carried out in 1978, by the Department of Environmental Health. Sanitary landfill is recommended as the best method to dispose of the solid waste in the city. Because of the low content of organic matter in Alexandria's wastes, composting becomes more expensive than landfilling.

Table 1 RELATIVE COMPOSITION OF DIFFERENT TYPES OF SOLID WASTES IN ALEXANDRIA CITY, 1978

Type	Combined solid wastes %	Domestic solid wastes %	Pure street solid wastes %
Food wastes	41.8	78.1	-
Paper	3.5	12.6	3.6
Rags	1.5	2.0	0.1
Wood	4.8	-	-
Plastics	1.3	0.4	0.2
Weeds	8.8	-	33.1
Bones	0.8	1.8	-
Glass	0.4	0.7	-
Stones	6.4	-	-
Metals	0.5	0.7	-
Dust	30.2	3.7	63.0

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Paper 28

ORGANIC MATERIALS IN RELATION TO ENVIRONMENTAL PLANNING

by

L.T. Kadry
Land and Water Development Division, FAO, Rome

Summary

Organic materials are the products of human activities and result in the generation of residues (waste) which are discharged to the natural environment. These discharges result in changes in environmental quality and have adverse effects on people. A common example is found in the rural areas of the developing countries where people obtain their drinking water from irrigation canals, thus accentuating the already prevailing problems of human hygiene, sanitation and spread of disease. Accordingly, environmental assessment and management in relation to environmental planning for the control of organic material residues is an activity of vital importance to the eradication of disease in developing countries.

This paper covers a listing of the sequence of operations for environmental planning for control of organic material residues. These cover twelve functions, namely: establishment of goals; establishment of policy, programme and actions; preliminary assessment; decision to delay or proceed with the study of selected alternatives, detailed environmental impact assessment, recommendations for action, decision making, implementation and post audit or evaluation.

The paper concludes by proposing main action points for environmental assessment and management of organic material residues which can serve as a supplement to a regional programme on the use of organic materials for improving soil productivity.

1. INTRODUCTION

Organic materials, whether their source is rural or urban city areas, are the products of human activities resulting in the generation of residues (wastes) which are eventually discharged to the natural environment. These discharges often result in changes in environmental quality, which in turn have adverse impacts on people particularly if these discharges contain deleterious materials in the form of pollutants. Residue management must therefore maintain the levels of environmental quality that are desired by society.

On the other hand, the commonly accepted practice of the rural populations, in those areas of the developing countries that lack the availability of potable water supplies, is to obtain their drinking water from irrigation canals thus accentuating the already prevailing problems of human hygiene, sanitation and the spread of disease. This will in turn reduce the capacity of farm labourers to perform efficiently and do productive work in agriculture. It is therefore necessary thaat all processing and handling of organic materials and of the disposal of their residues be subject to regular and systematic controls through Environmental Impact Assessment (EIA). The lines of action of this system will have to be modified to suit the particular conditions in the developing countires.

The present trend in high fertilizer and energy costs points to an expanded use of organic materials as mineral fertilizer supplements and sources of fuel energy.

This paper covers certain principles of environmental assessment and management in relation to environmental planning for the control of organic material residues. There follow the Focal Points on the Environmental Assessment and Management of Organic Residues Control which can be adapted as a Supplement to the proposed Regional Programme on the Use of Organic Materials for Improving Soil Productivity.

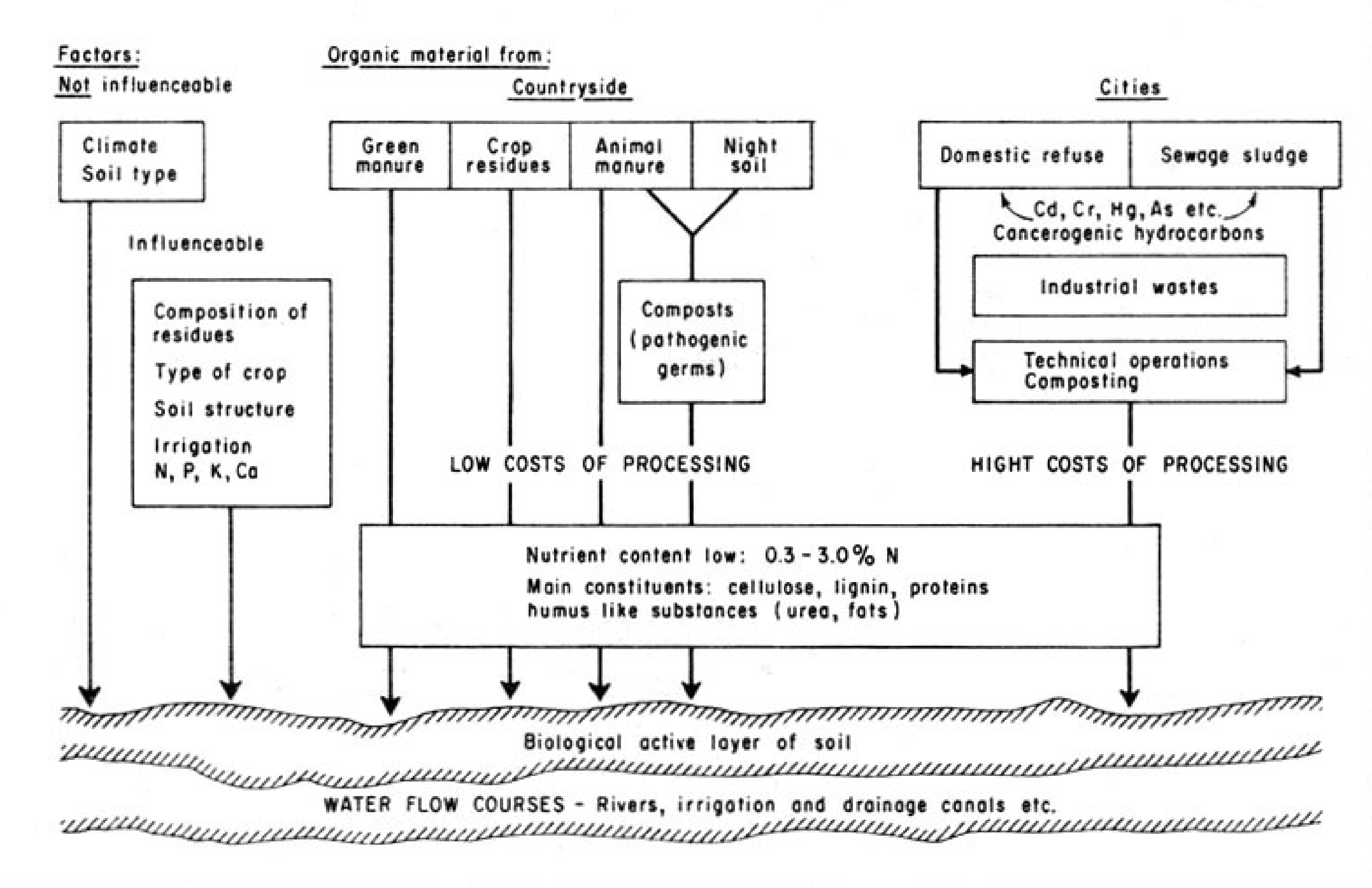
2. ENVIRONMENTAL PLANNING FOR THE CONTROL OF ORGANIC MATERIAL RESIDUES

Environmental planning can be considered as part of comprehensive planning on all activities involved in regional and national planning for the future. Specifically, environmental planning is defined as planning for those activities concerned with assessing the quality of the environment in both the natural and a disturbed state (examples would include water pollution in a river or lake; pollutant effect of livestock manure on an irrigation canal, etc.). Environmental Impact Assessment is the identifying and predicting of the impact on man's health and wellbeing, of legislative proposals, policies, programmes, projects and operational procedures and the interpreting and communication of information about the impacts which serve as guiding elements for improving the environmental management process. Thus, an Environmental Impact can be defined as the net change (good or bad) in man's health and wellbeing (including the wellbeing of the agro-ecosystem on which man's survival depends) that results from an environmental effect of organic material residues as pollutants and is related to the difference between the quality of the environment as it would exist "with" and "without" the same action, i.e. organic material residues as pollutants and/or productive waste.

An environmentally positive effect of the use of organic materials, provided they are adequately processed, is their application in the form of organic manure to improve the physical condition and fertility of soil. On the other hand, the utilization of organic materials can have a major negative pollutory effect on the human environment, both in rural and urban areas, when improperly processed and/or handled, in the form of spreading pathogenic organisms and toxins in the water courses and the potable water supply and storage installations. Fig. 1 depicts the sources and eventual destination of organic materials. It can be seen that account must be taken to identify and enlist the specialized government and public services dealing with land and water development and conservation, in order to prevent disease and improve sanitation control.

3. SEQUENCE OF ENVIRONMENTAL PLANNING FOR THE CONTROL OF ORGANIC MATERIAL RESIDUES

In Fig. 2 individual functions in the decision-making process of environmental planning for controlling organic material residues are numbered 1 to 12. These are not necessarily separate operations in time or place, nor are they necessarily performed by separate individuals or institutions. It is emphasized that the detailed way in which the environmental planning system operates depends upon the approach taken by the regular governmental planning procedures in the country concerned. The diagram is presented mainly to show the relationship of one function to the next, particularly the relationship of the assessment procedure to the overall decision-making process. The focus of this paper is on functions 5 to 9, but it is necessary to consider the entire sequence in order to appreciate fully the link and relationships between the functions.



Economics

Additional nutrient supply from natural sources of former waste products	Improved utilization of nutrients from added fertilizer	Maintenance of production level	Increase of net income by stabilization of yield potential

Fig. 1 Organic materials as fertilizers and soil productive agencies (after Flaig, November, 1974)

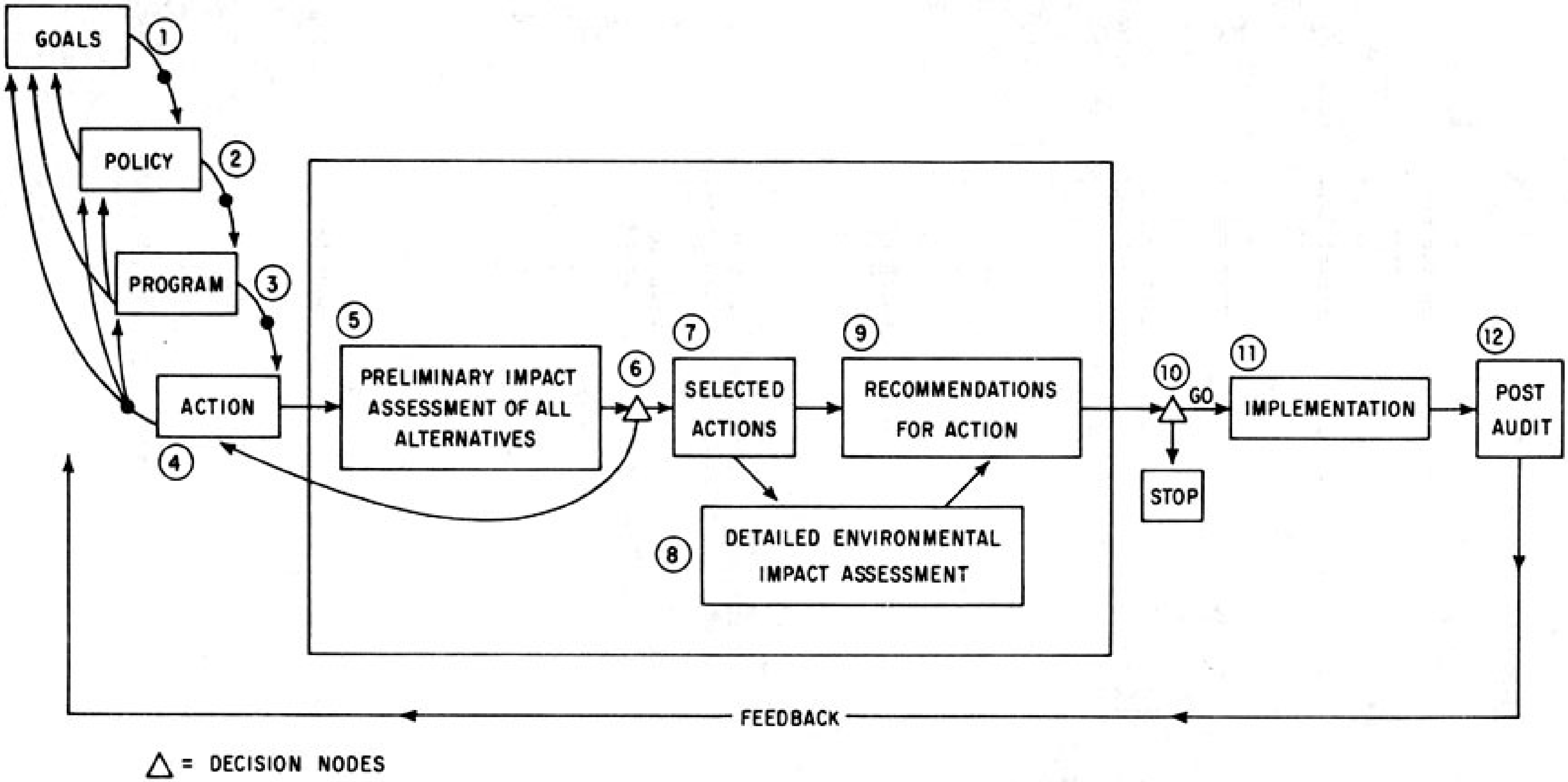


Fig. 2 Sequence of environmental planning

3.1 **Function 1 - Establishment of Goals**

The government sets goals for its comprehensive national plan, a major item of which is the attainment of human welfare through the control of pathogens and toxins derived from using organic materials.[1] These goals as a rule establish the framework within which policies, programmes and actions are implemented.[2]

If one goal is to ensure that the environmental considerations of organic materials receive adequate attention in the planning and implementation of actions, an environmental assessment procedure is a way in which this can be achieved.

3.2 **Functions 2, 3 and 4 - Establishment of Policy, Programme and Actions**

It can be noted from Fig. 2 that the goal-setting process must be translated into action through the policy and programme activities. It is important to provide for a feedback system within Functions 1 to 4 to ensure that environmental considerations are raised and taken into account by the decision-maker as early as possible in the planning and not almost as an afterthought, just before a final decision is taken (in Function 10).

After an action has been implemented (Function 11), it is equally important that the results of post audit (evaluation) be fed back to the decision-maker, indicating how the action has contributed to the original goal. In Fig. 2, note the feedback arrow from Function 12 to Functions 1 to 4. This procedure assists in the development of subsequent goals and in the refinement of actions to achieve them. Additionally, a catalogued archive system provides a sound reference system available to future assessors and all other participants.

3.3 **Function 5 - Preliminary Assessment**

The preliminary assessment is, in effect, a first screening of the proposal to determine whether or not a detailed environmental impact assessment of the use of organic materials and their handling will be required, and to ensure that the entire spectrum of alternatives is examined. This function may be a simple determination by the responsible official, or it may be a formal document, brief but relevant, prepared by a small group of specialists.

Should the magnitude of the potential impact of organic material residues upon the public health be such that the initiation of a detailed environmental impact assessment is warranted, a preliminary study should be made on the alternative proposals of the control measures to give guidance to the assessor on the depth of the analysis that will be required in Function 8.

3.4 **Functions 6 and 7 - The Decision to Refer Back or to Proceed with the Study of Selected Alternatives**

Once the preliminary environmental assessment has been used to screen the proposal and all possible alternatives, it is necessary to determine whether those that are environmentally acceptable should be carried forward or should be referred

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1/ Organic materials as referred to above covers the whole spectrum of countryside (rural) and city (urban) fluid and residue uses.

2/ An action may be the authorisation for a very preliminary feasibility study for a project.

back to Function 4 in the light of non-environmental factors such as economics or engineering feasibility.

3.5 Function 8 - Detailed Environmental Impact Assessment

Where the need has been established, a detailed environmental impact assessment is undertaken. Administrative and technical organizational procedures are available in the literature to guide this detailed activity.

3.6 Function 9 - Recommendations for Action

The preliminary or detailed environmental impact assessment contains recommendations which will, after review, be forwarded to the decision-maker. Usually, the substance of the recommendations is to:

GO: 1. Proceed with the original action, sometimes with minor amendments to the proposal.

or

2. Proceed with an alternative, which the assessment has shown to be environmentally more desirable as well as being acceptable on political and socio-economic grounds.

STOP: 3. Do not proceed with the project.

The recommendations may also include measures to be taken to mitigate anticipated environmental problems.

3.7 Function 10 - Decision-making

The decision-maker may range from a President or Prime Minister down to a designated official in a particular department or agency. Whoever he may be, he will wish to make a wise decision, although his task is not easy because of the large number of economic, sociological, political and environmental factors which often are in conflict with one another. If the penalty to be paid for preservation of environmental quality is not too great, the decision-maker will probably accept the recommendations of the assessor. If the penalty is large, he may have considerable difficulty in reaching a decision. This is why an independent review of the assessment is so helpful.

The study of the assessor is not to persuade the decision-maker to cast his vote always on the side of the environment. However, the assessor has a responsibility to bring the environmental issues into focus, providing a significant input into the development of later native management strategies, and thus into the decision-making process.

Sometimes the environmental impact assessment itself will contain conflicting objectives, e.g., the maintenance of water quality at the expense of air quality. The assessor will usually assign a system of weights when he makes his recommendation. However, the various components should be clearly separated in order that the reviewer and the decision-maker may change these weights to accommodate other considerations such as the relative political sensitivities of neighbouring countries to releases of air and various water pollutants.

3.8 Function 11 - Implementation

Implementation involves several functions: design, construction and operation. Implementation may be carried out by a designated government agency or by others. In the case of non-governmental implementation, there is still a responsibility by the government to ensure compliance with regulations and standards.

3.9 Function 12 - Post Audit

The whole implementation process - planning, initiation and operation - should remain under review to ensure that the designated environmental quality standards are achieved, for example, by continued monitoring of certain features of the environment. Not only may such data be used to verify the predictions made for the selected alternative, but also they may contribute to the improvement of future assignments. The continuing review may improve the goal-setting and decision-making processes by providing information on the environmental effectiveness of each action.

4. ACTION FOCAL POINTS FOR THE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT OF CONTROL OF ORGANIC MATERIAL RESIDUES - SUPPLEMENT TO A REGIONAL PROGRAMME ON THE USE OF ORGANIC MATERIALS FOR IMPROVING SOIL PRODUCTIVITY

4.1 Environmental Assessment

Environmental assessment is one of the basic activities which will underlie and facilitate the implementation of a regional programme on organic materials for Improving Soil Productivity.

The identification of the present quality of the human environment, the factors currently affecting its quality and having an impact on human health, and the assessment of future trends will be given priority.

Due to lack or inadequacy of available data on the human environment, a coordinated basic and applied regional organic material residues and pollution control programme will be formulated as a first step towards the protection of the human environment of the region. In formulating the operational detail of these programmes, the recommendations of the national and regional programmes, whether in progress or planned, will be taken into account.

The following components are recommended for inclusion in the coordinated environmental assessment programme:

i. Survey of national capabilities of the region in the following areas as they relate to organic material residues and pollution control:

   a. scientific and administrative institutions,

   b. information centres and data sources,

   c. research facilities and equipment,

   d. manpower,

   e. activities in progress or planned,

   f. publications.

ii. Assessment of the origin and magnitude of organic material residues and pollution in the region, including:

   a. development of applicable methods providing comparable data on the extent of pollution of irrigation canals and river waters by pathogenic organisms and toxins.

   b. survey of sources discharging organic material residues and pollution into irrigation canals and river waters,

   c. establishment of a coordinated network of observation stations along selected irrigation canals and rivers to provide data on pollution trends by organic material residues and pollutants,

d. conduct of regular surveys of organic material residues and pollution.

iii. Assessment of the origin and magnitude of organic material residues and/or pollution from industrial production and agricultural application, including:

a. preparation of a detailed survey of land-based pollution sources of industrial effluents and agricultural run-off discharged directly or indirectly into irrigation canals, river courses and the sea,

b. initiation of baseline studies on the levels and effects of selected industrial and agricultural organic material residues and/or pollutants in the potable water supply installations.

iv. Assessment of the origin and magnitude of organic material residues and/or pollution from domestic wastes, including:

a. preparation of a survey of present sewage treatment and disposal practices in the region,

b. monitoring of biological and microbiological (sanitary) quality of recreational waters, shellfish-growing waters and seafood,

c. initiation of epidemiological studies on the relationship between the sanitary quality of water courses (including edible organisms) and the incidence of water-borne diseases.

v. Training of local scientists and technicians in:

a. analytical techniques for measuring organic material residues and/or pollutant concentrations,

b. techniques used to measure effects of organic material residue pollutants on human health, fishery resources and marine and coastal ecosystems,

c. methods for establishing environmental quality criteria and waste discharge.

The programmes listed in points i - iv are interdisciplinary and interrelated in nature. Therefore, while preparing the operational details of each programme, due attention should be paid to their close coordination in order to avoid duplication.

The priorities to be assigned to the listed activities will be determined by the governments concerned, taking into account the present level of development in the region and the pressing need to provide reliable and comparable data on which sound management decisions can rest.

The agreed programme will be executed primarily through existing national institutions within the framework of regional cooperation, keeping in mind that for some projects a training programme should be formulated and that the assistance of experts from outside the region might be required in the initial phase of some projects.

4.2 Environmental Management

Continuous socio-economic development can best be achieved on a sustainable basis if environmental considerations are taken into account. To achieve the objectives of the Regional Programme on Environmental Assessment and Management for the control of organic material residues, the following preparatory activities should be undertaken:

i. preparation of a directory of institutions available in the region and active in fields related to the environmental management of organic material residues;

ii. assessment of present and future development activities and their environmental impact in order to evaluate the degree of their impact on the human environment and to find appropriate means to either eliminate or reduce any possible damaging effects;

iii. identification of relevant national, regional or internationally supported development projects in progress which demonstrate sound environmental management practices, the environmental sanitation activities of the World Heath Organization, the United Nations Environment Programme and the assistance in industrial waste handling provided through the United National Industrial Development Organization and the Arab League's Industrial Development Organization. Some of these projects may be appropriately strengthened or expanded to serve as demonstration and training models on a regional basis.

In view of the priorities and needs of the region, the following cooperative programmes may be undertaken:

a. assistance to governments for the establishment of national coordinating mechanisms to deal with environmental affairs;

b. formulation of regionally and locally applicable guidelines and standards for management and control of industrial, agricultural and domestic wastes;

c. development of principles and guidelines for sewage disposal practices, including locally applicable effluent standards based on the evaluation of the waste-receiving capacity of the receiving waters.

The control of organic material residues through protection and enhancement cannot be achieved without the full support and cooperation of all those concerned. Therefore, adequate resources should be devoted to systematic and regular campaigns for public awareness of environmental issues in the region.

IX. COUNTRY REPORTS

1. COUNTRY REPORT - AFGHANISTAN

by

M.H. Paiman and Lal M. Zurmati

1.1 Introduction

The Democratic Republic of Afghanistan covers an area of 647 497 km^2. Its estimated population is over 15 millions including more than 2 million nomads.

Afghanistan is predominantly an agricultural country and the majority of its people are either peasants or pastoralists. Agriculture, therefore, is the main sector of the nations's economy and social development. More than 80% of the country's manpower resources are in agriculture. The major export commodities are fresh and dried fruits, Karakul pelts, cotton, wool and rugs. The principal agricultural products are wheat, maize, fruits and barley, rice, cotton, karakul pelts and wool. Afghanistan is a land-locked country in Central Asia lying approximately between 30 and 37° N latitude and 61 to 72° E longitude. The country has high mountain ranges extending from north-east to south-west. There are desert plains on the south-west and in the north. The country, in general, is characterized by arid and semi-arid climatic conditions. Out of the total geographical area of 62.23 million hectares, more than 70% are mountains, desert, and pastures. The cultivable land is limited to 8 million ha but the cultivated area is only 4.9 million ha of which about 2.586 are irrigated and the rest is rainfed. Neither all the rainfed nor all the irrigated land is seeded every year to crops. Some areas are invariably left fallow. On the average, an area of 3.88 million ha is effectively cropped every year.

Lower Productivity of Soils and Affecting Factors

Afghanistan is an agricultural country with more than 80% of the total national revenue derived from agriculture. Wheat is the most important crop and is responsible for about one-third of the agricultural economy. Maize, cotton, rice, sugarbeet, fruits and livestock are other sources of agricultural income. However, the average yields of the principal crops (Table 1) are one of the lowest in the world. A number of natural and human factors have exhausted most of the farm land down to a low level of productivity.

Table 1 YIELDS OF PRINCIPAL CROPS IN AFGHANISTAN (AVERAGE OF FIVE YEARS ENDING 1976) [1]

Crop	Production (1 000 tons)	Yield (kg/ha)
Wheat	2 739	1 185
Maize	765	1 606
Rice	425	2 031
Cotton	130	1 394
Barley	374	1 177
Sugarbeet	80	16 020
Sugarcane	59	15 050
Oil seeds	39	830
Vegetables (in terms of potato)	697	7 643
Fruits	861	6 155

[1] Yields of crops, except wheat, pertain to irrigated crops.

i. Soils

Soils of Afghanistan have developed under arid and semi-arid conditions. The majority of the soils are derived from wind-borne material (loess) or from alluvium (alluvial or colluvial deposits). From the published reports and the meagre observations on soil studies made so far, it appears that many of the soils are relatively young from the geological point of view and have not been weathered extensively as in other tropical countries. Data on some physical and chemical properties of the soils representative of different climatic zones of Afghanistan are presented in Table 2. These and other published reports (Survey of Land & Water Resources - Afghanistan, Vol. IV. FAO: 1965. Some physical properties of certain soils of Afghanistan - Salem and Hole, Soil Sci. 116: 179-190) show that the soils of Afghanistan are alkaline in reaction and contain an excess of free calcium carbonate. In fact, most of the soils have a pH above 7.5 and contain more than 10% free calcium carbonate. Soils of Darulaman (Kabul Province), Darweshan (Helmand Province), and Sher Abad (Mazar-i-Shariff) contain as high as 20.24 and 25.6% calcium carbonate (Table 2).

Table 2

SOME PHYSICAL AND CHEMICAL PROPERTIES OF REPRESENTIVE SOILS IN AFGHANISTAN

Name and place	Depth (cm)	pH	Organic carbon %	Total N (kg/ha)	Availa-ble N (kg/ha)	Bulk density (g/cc)	Calcium carbonate equivalent %	Particle size analysis: Sand %	Silt %	Clay %
1. Shisham Bagh sandy loam (Nangarhar)	0-33	7.5	0.75	1774.4	28.8	1.6	7.23	56.50	32.56	10.21
	33-52	7.7	0.25	443.6	33.3	1.7	6.12	64.75	26.23	8.70
2. Darulaman sandy clay loam (Kabul)	0-15	8.5	0.66	347.2	22.4	-	18.78	52.40	24.00	23.60
	15-30	8.7	0.51	271.6	13.2	-	20.24	54.00	24.00	21.60
3. Charka sandy clay loam (Wardak)	0-30	8.4	1.40	-	18.8	-	6.20	47.20	20.00	32.80
4. Naknam clay (Paktia)	0-30	7.9	0.18	274.0	8.0	-	17.10	28.92	23.64	47.44
5. Rochani sandy clay loam (Paktia)	0-30	8.5	0.04	70.0	8.0	-	10.10	72.92	3.64	23.44
6. Turnak sandy clay loam (Kandahar)	0-15	7.7	1.03	115.0	5.2	-	12.15	65.12	7.28	27.60
7. Nadi Ali sandy loam (Helmand)	0-20	7.8	0.74	1552.6	19.96	1.9	16.47	57.80	28.45	13.82
	20-75	8.1	0.20	221.8	11.09	-	15.88	57.60	21.20	21.29
8. Best gravelly loam (Helmand, desert)	0-3	-	Desert pavement							
	3-8	8.3	0.25	665.4	4.44	-	18.69	49.40	35.40	15.00
	8.13	8.2	0.43	887.2	4.44	1.8	24.01	47.95	32.09	19.85
9. Darweshan silt loam (Helmand)	0.10	8.6	0.68	-	4.44	1.7	26.80	56.70	14.80	16.77
	10-30	8.6	0.35	-	2.22	1.4	11.40	69.30	16.70	17.51
10. Ordookhan loam (Herat)	0-6	8.2	0.59	243.6	trace	-	7.20	39.60	35.00	25.35
	6-21	8.2	0.57	260.4	trace	-	11.60	44.95	30.00	25.05
11. Ghorbandi sandy clay loam (Baghlan)	0-30	8.3	0.59	302.4	6.00	-	16.20	52.00	29.20	18.00
12. Angoor Bagh clay (Kunduz)	0-30	8.5	0.84	370.05	24.80	-	19.40	28.00	29.20	44.80
13. Sher Abad sandy clay loam (Mazari-Shariff)	0-30	8.5	0.78	294.78	24.80	-	25.60	73.20	10.00	16.80

As might be expected from the age of the soils and the climatic conditions, most of the soils are low in organic matter content. Data in Table 2 show that most contain less than 0.70% organic carbon and only a few contain more than 0.75%. With the high pH and low organic matter content deficiency of a number of essential nutrients is widespread in these soils. In most of them, the total or available nitrogen content is low; similar is the case of phosphorus. The free calcium carbonate present in the soil quickly converts the phosphorus that is present, or added, into insoluble phosphate compounds of tricalcium phosphate, octocalcium phosphate etc. making it unavailable to crops. In calcareous soils, with high pH, the availability of other nutrients that are essential for plant growth is also greatly affected. Deficiencies of micro-elements such as iron, zinc and manganese, become evident in fruit and ornamental trees, grapevines and in forest plantations.

ii. Farming practices

The problems of natural soil deficiencies have been aggravated by the centuries old farming practices. Because of the feudal conditions and in the absence of proper land reforms until recent times, the exploited small farmer had to follow a soil management system that exhausted the soil's productivity. Continuous cropping with soil depleting crops such as wheat, rice, barley, etc., little rotation of crops and little or no production of legumes and application of manures were the vanguards of most of the farming practices. Soil improving practices were limited by the economic conditions of the farmers. A farmer having small holdings of one or two jeribs of land could not afford green manuring of crops and the application of mineral fertilizers, apart from the lack of crop residue left on the land and the use of animal manure as fuel. Due to economic constraints, the poor farmer had to collect every bit of straw and stalk from the field to use as feed for his livestock or as fuel. Such farming practices, instead of enriching the soil, have resulted in the tremendous reduction of its already scanty organic matter status. The inevitable result has been lower production from most of the farm lands.

Continuous use of the country plough combined with the low soil organic matter content has made the plough-sole compact with an increase in soil bulk density (Table 2). Crusts are often formed on the soil surface restricting the emergence of seedlings and their proper growth. In several parts of the country, the poorly structured sandy loam soils, deficient in organic matter, have been subjected to severe wind erosion and also water erosion following floods.

Thus, it can be said that farming in Afghanistan is still very traditional. For instance, organic manure is made from animal wastes, dry earth and ashes which are brought to the animal shed to absorb the urine, then mixed and heaped outside the house under sunshine, in this case the nitrogen is lost and the value of the organic manure is lessened. Preparation of organic manure from human wastes is common. In this case, the farmer utilizes his own night soil which is usually in a thick slurry form, and in most cases the night soil is not sufficient to meet his demands for fertilization. However, farmers near cities collect night soil from the storage chambers. This practice involves very substantial health hazards to the people at the collection sites, to the agricultural workers and to the consumers of the crops grown.

1.3 Improvements in Soil Productivity

Not much research work has been carried out in Afghanistan for improving soil productivity. The meagre information available from existing literature, the attempts taken recently in this direction and the possibilities of future lines of work are briefly discussed below.

1.3.1 Soil management practices

Experiments have shown that the soils of Afghanistan are very responsive to better management practices. Adoption of such practices as green manuring, deep ploughing, addition of farmyard manure etc. result in quick improvement in the crop production potential.

i. **Utilization of green manure**

Experiments conducted at Aliabad Farm in Kabul showed that a crop of alfalfa added enough nitrogen to soil to improve significantly the following cereal crop. The soil being low in available and total nitrogen, the process of symbiotic fixation of nitrogen is accelerated by growing legumes. Turning under a green manure crop of clover was also found to meet the phosphorus requirement of the succeeding maize crop. This was possible because phosphorus, accumulated by the leguminous crop after green manuring, was returned to the soil in readily available forms for the following crops. Moreover, the organic acids liberated by decaying plant material might have changed some of the unavailable soil phosphorus to available forms.

ii. **Improved tillage**

Other experiments at Aliabad showed that deep ploughing with a mould board plough relieved to a considerable extent the phosphorus deficiency in following maize as compared to the previous year. Deep ploughing broke up the shallow plough scale allowing the crop roots to grow deeper and into a larger volume of soil, and thereby extracting a larger amount of phosphorus. Recent work at Darulaman Experimental Station by the Department of Soil Science, Ministry of Agriculture and Land Reform, showed that this practice of deep ploughing conserved a large amount of snow water in the deeper layers of the soil profile which would be very useful for the growth of winter and spring wheat.

iii. Addition of manures, compost and night soil

Experiments conducted on yellow Spanish onion in the experimental farm of the Faculty of Agriculture during 1973-1975 showed that the combined application of 7 tons of farmyard manure (FYM) + 100 kg N and P_2O_5/ha did not significantly increase the yield over the use of only 7 tons FYM/ha. Yields were significantly increased in plots receiving 14 tons FYM/ha as compared to plots receiving 7 tons FYM/ha in 1974 and 1975. Thus FYM has great influence on the yields of onion. Experiments are conducted by the Department of Soil Science, Ministry of Agriculture and Land Reform, on the effect of FYM on availability of phosphorus. Preliminary results showed better growth of wheat plants where FYM was added in combination with phosphate fertilizer. While such studies are in progress, it may be stated that the Afghan farmer, in spite of his constraints as mentioned earlier, is aware of the beneficial effects from the addition of manures to his crop. Composting of waste materials, a well known practice in other countries, has been initiated.

Near large cities farmers regularly collect and use night soil as a fertilizer, particularly for vegetable crops. The main problem lies in the fact that the supply of such materials is small in comparision with the needs of the total farm land and that for so long there has been no organized agency to help the farmers in proper utilization of these materials. Projects on recycling of organic wastes and biogas will be launched during the Five Year Plan. It would be doubly advantageous to supply a good quality organic manure on one hand, and on the other to supply fuel thereby reducing the pressure on meagre organic materials available to the local people.

iv. Use of industrial wastes

Recently, limited attempts were made to recycle industrial wastes such as beet pulp from sugar factories and cotton seed cake and cotton seed hulls from cotton mills. There is good potential for the use of dried blood, slaughter house wastes and animal bones (bone-meal) to improve the soil nutrient status and other soil properties. Efforts will be made during the Five Year Plan to make full use of all industrial wastes to augment soil fertility.

1.3.2 Crop rotation

The importance of suitable crop rotations to improve soil productivity is being increasingly realized in Afghanistan. In advanced agricultural areas, such as in the Logar and Helmand Valleys, Baghland and Kunduz, a fairly satisfactory system of crop rotations is practised in which leguminous crops are included. Winter wheat-clover-maize-winter wheat is an example. Peas or vetch may be substituted for clover and rice may be substituted for maize in this rotation. Inclusion of deep rooted crops in the rotation should receive due consideration. Comprehensive studies have been or are being initiated on scientific cropping patterns and rotational treatments and rotations involving legumes. A series of studies will be commenced on intercropping of widely spaced row crops, like maize with legumes.

1.3.3 Increasing the level of soil organic matter

In addition to those mentioned earlier, there are other means of increasing the organic content. Straw from wheat, barley and other small grains, stalks of maize and beans and roots of different kinds of crops and leaves of sugarbeet etc. are some sources of organic matter. With the availability of alternative sources of energy for fuel, these crop residues may be left in the field and incorporated into the soil.

1.3.4 Integrated approach

While no accurate figure is available, it is beyond doubt that the use of nutrients per hectare of cropped area in Afghanistan is very low and this must be stepped up to increase crop production. While our present efforts to increase the consumption of mineral fertilizers should continue, improving soil and crop productivity calls for greater emphasis on the use of organic materials. We feel that a system of integrated supply of plant nutrients by judicious and proper balancing of mineral fertilizers and organic manures would be a real asset for Afghanistan. We are making efforts to undertake an integrated programme to exploit the potential of our local manurial resources including rural compost, urban compost, sewage and sullage. Exploitation of organic wastes resources would also result in economizing on the use of expensive mineral fertilizers in our country. Efforts for pilot studies for biogas plants, which make use of agricultural and organic wastes and serve as sources of both fuel and fertilizers, in several parts of our country, would be a worth while proposition.

1.4 Conclusions

Soil is an important natural resource of the country. In Afghanstan, improvement of soil productivity is the basic requirement for increasing agricultural production. Unfortunately due consideration was not given earlier to the necessary steps for soil improvement and maintenance of soil fertility. The present Democratic Government is aware of this situation. Recently, necessary land reforms were introduced as a first step so that effective management practices can be adopted by the real tillers to improve the productivity of their lands. Efforts are in progress for research and study of the manurial resources of our country, the potential availability of nutrients from these resources and their judicious and scientific utilization for improvement of soil and crop productivity.

2. COUNTRY REPORT - CYPRUS

by

C. Koundounas and I.N. Papadoupoulos

2.1 Introduction

Cyprus is an island situated at latitude 35° North and it has an intense Mediterranean climate with the typical seasonal rhythm strongly marked in respect of temperature, rainfall and weather. Hot dry summers from June to September and rainy, rather changeable, winters from November to March are separated by short autumn and spring seasons of rapid change in October, April and May. The average annual rainfall for the country as a whole is nearly 500 mm, but it was as low as 182 mm in 1972-73 and as high as 750 mm in 1968-69. In the plain areas, however, which constitute the bulk of the agricultural land, average annual rainfall is only 350 mm. Under such climatic conditions, plant residues decompose fast. In the plain irrigated soils, organic matter is between 1-2% in the plough layer (Ap) and much lower further down. In the same areas under dry farming conditions, organic matter content in the top soil is around 1%. In mountain areas under vines and deciduous fruit trees, organic matter content in the plough layer generally lies within 2-3%, significantly declining with depth. Thin organic layers (Aoo, Ao) and A horizon with much higher amounts of organic matter do occur in the highest areas of the Troodos mountains (1000 - 1800 m altitude) under forest, especially pines.

In Cyprus, the organic matter content of the cultivated soils is very low, normally below 2%. This is mainly due to the hot and dry climate and also to the intensive cultivation of the soil.

The low soil organic matter content leads farmers into purchasing farm manures (sheep, goat, pig, chicken) for use as a soil amendment, particularly for irrigated land. However, this trend is decreasing due to the high cost of such manures. Experiments carried out at Fassouri on the south coast indicated that the application of manure was not effective as nitrogen fertilizer for oranges. By contrast, preliminary results at the Morphou Station of Agricultural Research Institute, before 1962, indicated some response to manure. However, the value of manure is based not only on the supply of nutrients but also on the improvement of soil physical, chemical and biological conditions, which may be of great importance particularly for light or heavy soils.

2.2 Experiments with Orange

In 1962, the Agricultural Research Institute established an experiment aimed at comparing mineral fertilizers with sheep manure. A Valencia orange orchard, planted in 1956 at Morphou near the north west coast, was used. A randomized complete block design consisting of 8 treatments was established in the spring of 1962. Each plot consisted of 3 trees with a guard row between experimental rows. The fertilizers and manure were distributed in the area contained by the drip-line of the trees and worked into the soil.

The NPK content of the sheep manure used throughout the experiment varied widely as follows:

	N	P	K
	% (dry weight basis)		
1964	2.57	0.68	3.18
1965	1.20	0.56	1.62
1966	1.22	0.39	2.30
1967	1.74	0.34	1.34
1968	1.34	0.24	1.28
1969	1.52	0.38	2.05
1970	1.49	0.55	1.59

This shows how difficult it is to interpret the results of the experiments and to compare organic manures with mineral fertilizers.

The yields over the period 1964–1972 are given in Table 1. The yields up to and including the 1972 harvest varied widely from year to year. However, the combined statistical analysis indicates that lower levels of application of mineral fertilizers appeared to have a slightly greater effect than organic manure. The higher rate of sheep manure, in combination with both nitrogen levels, was clearly superior to the other levels. These results suggest that the beneficial effect of manure is mainly due to supplying more nutrients. However, this increase in yield would hardly pay for the extra cost to buy and apply sheep manure.

Table 1 EFFECT OF MINERAL FERTILIZERS AND SHEEP MANURE ON YIELD OF VALENCIA ORANGES OVER THE PERIOD 1964–72, MORPHOU

	Amount of Fertilizer, kg/tree				
Code	N	P_2O_5	Sheep manure (dry weight)	Mean number * of oranges/ tree/year	Mean weight * of oranges/in kg/tree/year
M_2C_2	0.4	0.30	30	683 a	117.3 a
M_2C_1	0.2	0.15	30	668 a	114.0 a
M_1C_2	0.4	0.30	15	596 b	99.7 b
M_1C_1	0.2	0.15	15	608 b	102.4 b
C_2	0.4	0.30	0	589 b	99.1 b
C_1	0.2	0.15	0	567 b	99.6 b
M_2	0	0	30	498 c	90.1 c
M_1	0	0	15	420 d	75.2 d

* Figures accompanied by a common letter are not statistically different at the 5% level of probability.

Quality characteristics, like juice content of the fruit, the sugar/acid ratio and the peel thickness were not affected by the different treatments.

The NPK contents in leaf dry matter fluctuated widely from year to year. The nitrogen content ranged from 2.15 to 2.69%. The phosphorus content was about 0.12% all through the experimental period. In contrast, leaf potassium declined considerably from 1.04 in 1962 to 0.49% in 1970, which is considered low by California standards.

Micronutrients were not affected by the fertiliser treatments, but it was found that manganese and zinc remained within the low-deficient range. This fact was confirmed later to be generally the case in orchards of the Morphou area.

From the above data it is possible to conclude that 30 kg manure per tree per year has a positive effect on yield, but such application is hardly economical.

2.3 Experiments with Tomatoes

Another experiment including manure was carried out in 1975-76 with tomatoes. In it, the plants (hybrid F_1-Multicross 12 A) were grown in individual 10 litre plastic pots filled with either "forest soil" (2.47% organic matter, medium texture) or a 2:1 mixture of this soil and farmyard manure.

Three irrigation regimes were tested, namely three fractions of the amount of water required to bring the potting medium to field capacity. These fractions were: 1.0, 0.87 and 0.75. Irrigation was applied daily through drippers, one for each pot. In addition, nine fertilizer treatments were tested consisting of the combinations of three rates of nitrogen and three of potassium. The nitrogen rates were: 42, 84 and 126 g sulphate of ammonia per pot, while the potassium rates were 0, 53 and 106 g sulphate of potash per pot. A basal dressing of 30 g/pot triple superphosphate was mixed with the soil prior to planting, while the nitrogen and potassium fertilizers were applied in solution during the growing season.

Only irrigation affected yields significantly (Table 2), fertilization did not affect (Table 3), however, at the highest amount of water, the soil plus manure indicated a tendency towards increasing yields (Table 4). Fruit quality was better at high levels of fertilization, presumably as a result of higher salt concentration in the soil.

2.4 Concluding Remark

In line with the above results it is felt that for Cyprus soils manure can do little or nothing more than mineral fertilizers.

Table 2 YIELDS OF GLASSHOUSE TOMATOES GROWN IN POTS IRRIGATED DAILY WITH THREE AMOUNTS OF WATER, ATHALASSA, 1975-76

Irrigation regime: fraction of amount required to bring the pot to field capacity	Yield	
	kg/plant	tons/ha y
0.75	3.56	111.5
0.87	3.91	122.5
1.00	4.62	144.7
	SE = ± 0.48	

y Calculated on the basis of the spacing of the pots.

Table 3 YIELD (kg/plant) OF GLASSHOUSE TOMATOES GROWN IN POTS UNDER THREE LEVELS OF N AND THREE LEVELS OF K FERTILIZER, ATHALASSA, 1975–1976

$(NH_4)_2SO_4$/pot (g)	K_2SO_4/pot (g)			Means for N treatments (SE = ± 0.12)
	0	53	106	
42	4.19	4.25	3.82	4.09
84	4.10	4.16	4.00	4.08
126	3.79	3.77	4.21	3.93
Means for K treatments (SE = ± 0.12)	4.03	4.06	4.01	4.03

Table 4 YIELD (kg/plant) OF GLASSHOUSE TOMATOES GROWN IN POTS UNDER THREE LEVELS OF N, THREE LEVELS OF K, AND WITH OR WITHOUT MANURE, ATHALASSA 1975–1976

Amounts of fertilizer (g/plot)			Potting medium	
Code	N	K	Soil	Soil + measure
N	42	nil	4.08	4.91
N_1K_1	42	nil	4.21	5.18
N_1K_2	42	nil	4.26	4.66
N_2	84	53	4.39	5.76
N_2K_1	84	53	4.60	4.84
N_2K_2	84	53	4.88	4.98
N_3	126	106	3.70	4.13
N_3K_1	126	106	4.16	4.48
N_3K_2	126	106	3.90	6.08
Mean			4.24	5.00

3. COUNTRY REPORT - EGYPT

by

Y.A. Hamdi and M.N. Alaa El-Din

3.1 Organic Matter Level of Egyptian Soils

It is generally accepted that Egyptian soils are poor in contents of organic matter; it seldom exceeds 2%. Table 1 illustrates this point in more than 5 000 soil profiles collected from different parts of the country.

3.2 Sources and Potential Resources of Organic Matter in Egypt

3.2.1 Agricultural residues

Based on the 1968 statistics, about 11.5 tons/year are produced by different crops (Table 2). Most of these residues are rice and wheat straw and cotton, maize and sorghum stalks. At the moment they are used largely for burning, industry or animal feed. Little is composted as artificial organic manure. It is estimated that if these residues were composted they would give about 5 million cubic meters of compost.

3.2.2 Animal manure

Table 3 summarizes the number of animals in Egypt and the expected amount of manure produced. About 88 million m^3 are produced annually. As the area of cultivated land is about 6 million feddans (2.52 million ha), accordingly it could be expected that each feddan received about 15 m^3 of this manure, but this is not the case in most areas as the number of animals varies from one place to another. The present shortage in organic manures is about 30-40 million m^3/year. By increasing the area under reclamation the need for organic manures will certainly increase. Estimates are that 40-60 million m^3 of organic manures will be required for new areas to be reclaimed.

3.2.3 Night soil

Dry latrines with a storage chamber (open back) are common in rural areas. The night soil of farmers' families is usually collected and mixed with the earth compost. In other cases, the night soil is dumped in the drains, causing harmful pollution.

In small cities, where there is no sewage system, septic tanks and the like are the usual way of disposal. The night soil is then collected and transported in lorries to the trenching ground for burial and eventual preparation of an organic manure called "Budrite".

Night soil is mainly used for manuring melons, water melons, cucumber and other vegetables because of the quick release of nutrients.

Table 1 LEVELS OF ORGANIC MATTER IN SOILS OF EGYPT [1/]

Governorate	Organic Matter, %
Quena	Trace - 2
Assuit	0.4 - 3.4
Elmenia	Trace - 2
Fayoum	Trace - 1.5
Minoufia	1.0 - 2.0
Al-Gharbia	1.0 - 2.0
Kafr El Sheikh	0.5 - 3.0
El Sharkia	0.5 - 2.5

Table 2 AMOUNTS OF AGRICULTURAL RESIDUES PRODUCED YEARLY [2/]

Crop	Area, Feddan [3/]	Residues, Tons	
		Feddan	Total
Wheat	1 412 892	1.7	2 401 916
Barley	117 063	1.2	140 476
Broad Bean	306 419	1.2	367 703
Fenugreek	28 427	1.1	31 270
Lentils	51 486	0.8	41 189
Clover (Berseem)	175 559	0.8	138 047
Cotton	1 625 969	1.1	1 788 566
Rice	1 204 336	1.4	1 686 070
Sorghum	532 603	2.0	1 065 206
Maize	1 554 219	1.7	2 642 172
Sugar cane	136 978	1.0	136 978
Groundnut	42 466	1.0	42 466
Seasame	24 188	0.9	21 769
Vegetables	708 041	1.0	708 041
Other crops (horticulture)	250 000	1.0	250 000

1/ Report of Department of Soil Survey, Ministry of Agriculture, Egypt, 1959 - 1973

2/ Based on 1968 Statistics

3/ One feddan = 4 200.033 m^2 = 1.038 acre = 0.42 hectare

Table 3 NUMBER AND KINDS OF ANIMALS IN EGYPT[1] AND THE AMOUNTS OF MANURE PRODUCED

Animals	Number	Manure Produced m^3		Losses[2] %	Net production m^3
		Animal	Total		
Cows, Buffaloes	3 111 345	35	108 897 075	30	76 227 953
Camels, Horses, Mules, Donkeys	1 257 350	15	18 860 250	80	3 772 050
Sheep, Goats, Pigs	2 428 600	5	12 143 000	35	7 892 950
Total	6 797 295	-	139 900 325	-	87 892 953

1/ Data based on 1960 statistics

2/ Losses are caused by moving the animals and using wastes for burning

3.2.4 Sludge

About 128 000 m^3 of sewage slude are produced annually. It is expected that this amount will increase as the efficiency of production improves with wider areas covered by sewage treatment plants. Sewage treatment plants are not sufficient and the present ones do not work properly. Sewage water is usually dumped in the sea, lakes, or water ways with no or very little effective treatment. Sludge from sewage treatment plants, is used for fertilizing horticulture.

3.2.5 Compost of city refuse

At the moment there is only one plant at Shubra which converts part of Cairo City refuse. The annual production of this plant is about 100 000 m^3, however, Cairo produces about 3 500 tons/day garbage which require more sufficient composting. Farmers surrounding cities are accustomed to applying fresh garbage which presents health hazards. Raising pigs on garbage is also popular in big cities.

3.2.6 Green manure

Green manuring was one of the popular practices in Egypt until the fifties. The drastic increase in population led to more intensive cultivation to meet the growing needs of man and animals. Green manuring is now practised only in newly reclaimed areas to improve soil physical, chemical and microbiological properties, specially those of sandy and calcareous soils. The use of sesbania offers good possibilities for use as wind breaks, fodder, fuel and a source of organic matter.

3.3 Biofertilizers

3.3.1 Legume inoculant

Since 1954 the legume inoculant "okadin" has been produced by the Ministry of Agriculture in quantities sufficient to inoculate 200 000 feddans (84 000 ha) annually.

3.3.2 Algalization

Research programmes initiated in the Department of Microbiology, Ministry of Agriculture, in 1966 indicated that rice fertilizers can be reduced by a quarter to a third if algal inoculation is practised.

A project is now in operation to produce algal inoculants, and large-scale production to cover 1 million acre/year will begin in 1979–1980.

3.3.3 Azolla

Azolla has been recently introduced from China and Nigeria into the Department of Microbiology, Institute of Soil and Water Research and University of Alexandria. Potentials of this fertilizer are being studied.

3.4 Biogas

Research has been conducted in the Department of Microbiology, Institute of Soil and Water Research, on the potential of producing biogas from agricultural wastes. Results were positive. A biogas unit (house model), following the Chinese system, was recently constructed in Fayoum Governorate. Another plant was built by an Egyptian expert in Afghanistan. An intensified programme for biogas production and research has been started.

3.5 Conclusion

From the foregoing discussion it can be concluded that resources are available for organic matter production under Egyptian conditions. However, these resources are not fully utilized and research must continue on:

- biogas technology,
- intensive use of sesbania as a source for nitrogen, organic matter, fodder, fuel, wind breaks etc.,
- improving soil productivity through legume inoculants,
- algalization of paddy,
- utilization of water lentils (Lemna sp.) as green manure, fodder and for biogas production,
- selection and adaptation of Azolla to the Egyptian environment,
- composting methods for solid and liquid wastes using local materials and experience,
- organic manures and soil conditioners for different soil types common in Egypt.

4. COUNTRY REPORT - JORDAN

by

Widad A. Nuri

4.1 INTRODUCTION

The total area of Jordan is about 9 806 000 hectares of which 9 255 100 ha are east of the Jordan river. Only 53 500 ha or about 0.61% of the total area of East Jordan are under irrigation and 1 196 208 ha (13%) are considered potentially productive dry land farming areas.

The organic matter content of Jordanian soils is low, ranging from 0.4% to 1.5%, because of high temperatures and very low humidity, which cause the breakdown of organic materials and necessitate their compensation.

Jordan suffers from a severe shortage of farm animals. There are only 32 000 head of cattle and one and a quarter million sheep which are scattered throughout the country in specialized farms. The cattle, sheep and goat farms are unevenly distributed, as 81% of the cattle farms and 94% of the sheep farms are situated close to the large cities. There are also numerous small farms whose owners are unable to keep animals.

Chicken manure is the most important organic manure to farmers but is not available in sufficient quantities. In view of this situation, most farmers resort to using mineral fertilizers, which give faster returns in many types of agriculture. Reliance on mineral fertilizers alone is however detrimental to soil productivity in the long term. In addition, the incorrect methods of preparing and storing the farmyard manures cause deterioration and loss of plant nutrients.

4.2 Shortage or Non-Exploitation of Other Resources

Only the Jordanian capital has a sewage system and treatment plants, while cesspools are used in other towns. Garbage is also wasted in every town of the country, although it represents a potential source of organic fertilizer. To overcome the shortage of organic fertilizer, it is recommended that a number of projects be undertaken, such as expansion of cattle, sheep and goat farms in various parts of the country, installation of sewage systems and exploitation of wastes in the large cities.

The Government installed a sewage system in Amman, and built a treatment plant in 1970, with a capacity of 60 000 m^3 per day, but farmers are reluctant to use the product of this plant, for a number of reasons. However, it is essential to install sewage systems in all the large towns in Jordan, and to encourage farmers to use the produced organic manure. The Ministry of Agriculture should use these manures on its own farms and research stations, as an insentive and guide to the farmers.

4.3 Mineral Fertilizers

Jordan exports raw phosphates, of which there are huge deposits in many parts of the country, in addition to large quantities of potassium in the Dead Sea. About 1.5 million tons of phosphates were produced in 1977; most of it was exported and the revenue used to import the required mineral fertilizers. The present Five-year Plan includes the construction of a phosphate treatment plant in Aqaba, at a cost of 120 million Jordanian dinars (US$ 370 million), scheduled to start production in five years time. This plant should produce sufficient mineral fertilizers to cover local demand and also for export to neighbouring countries.

4.4 Research and Studies

There is so far no real research work on the utilization of organic fertilizers and their effects on soil fertility and productivity. There have been some attempts to ascertain the effects of organic fertilizers on the physical and chemical properties of the reclaimed desert soils in which groundwater is used for irrigation, and which are faced with certain salinity and alkalinity problems. Green manure is used to a limited extent in some of the irrigated areas. In certain years, as a part of the cultivation cycle, legumes such as beans, peas and berseem are ploughed under and then followed by spring and summer vegetables.

In conclusion, it is noted that applied research is concentrated on the utilization of mineral fertilizers, as regards quantity, type and method of application in the irrigated areas and the rainfed areas to a limited extent.

5. COUNTRY REPORT - KUWAIT

by

A.H.M. Abdul Redo

5.1 Introduction

Agriculture in Kuwait is, basically, in the early stages of its development. In 1976, there were 471 farms with a total area of about 449 hectares. Future expansion for the coming 10-15 years is about 6 000 ha of which 3 250 ha will be irrigated with brackish water, 2 500 ha with sewage water and 300 ha with fresh water.

Availability of irrigation water is one of the main limiting factors. In addition, the scarcity of organic matter in the soil and the unavailability of organic manures make agriculture difficult.

The national income from agriculture was about KD 8.4 million in 1976. The total agricultural production represented about 10% of the total food consumed in Kuwait. Agriculture, in Kuwait, provides the following products as a percentage of the total consumption:

Fresh vegetables	20%	Fresh milk	60%
Green forage	30%	Fresh eggs	20%
White meat (chicken)	40%		

5.2 Kuwait Soils

Soils in Kuwait are mainly sandy with about 7% clay and silt, and very poor in organic matter; some have hard pans either deep or shallow. Table 1 gives some information on soil analyses in Wafra area which is considered as one of the two main agricultural areas.

5.3 Organic Fertilization

Soil fertility in Kuwait is very low and the organic matter content is limited due to the hot dry weather in summer and the scarcity of organic manures. The available sources of organic manures for agriculture are:

i. Farmyard manures: a mixture of animal excrement and bedding materials, coming from about 8 000 cattle in dairy farms, thousands of imported sheep for slaughtering and from the poultry farms. A few years ago, organic manures used to be imported from other countries.

ii. Compost from town wastes: in 1973 a small pilot plant for making compost from town garbage was established with a capacity of about 100 tons of garbage daily, to produce 40 tons of organic manure. This plant will be expanded to use 600 tons of town waste daily. The quality of organic manure from the compost is good and is used for vegetable crop production and fruit trees. The chemical analysis of the compost is:

pH in saturated paste	5.0
Moisture content	24.7%
Saturation percentage	253.0%
Total nitrogen	1.2%
Total phosphoric acid (P_2O_5)	1.2%
Total potassium oxide (K_2O)	0.6%
Total organic matter	62%

iii. Sewage and sewage sludge: this source of organic manure is well established and in process of expansion. It will provide large quantities of organic manures as well as irrigation water. The raw sewage has been used for irrigation and fertilization in some roadside planting and afforestation. However, there is a plant for sewage treatment that produces about 20 million gallons per day for irrigation. Other plants will be constructed in the near future. It is estimated that the following quantities of sludge will be available for agricultural use:

In 1980	38.6 tons per day
In 1985	73.1 " " "
In 1990	80.8 " " "

This estimation is on the basis of 60 kg per 1 000 population.

iv. Green manure: in Kuwaiti conditions, it is unprofitable to turn under green manure for the sake of increasing the productivity of the soil as it is better to grow legumes for pasture or to be fed as hay to livestock and the manure returned to the field.

Table 1

SOIL CHARACTERISTICS, WAFRA AREA

Sample depth cm	Total phosphoric acid %	Total potassium oxide %	Total nitrogen %	$CaCO_3$ cm	ECe mmhos/cm	pH (saturated paste)	meq/l Saturated Extract								Saturation %
							CO_3	HCO_3	Cl	SO_4	Ca	Mg	Na	K	
0–30	0.025	0.075	0.010	6.40	5.60	7.7	Nil	1.65	37.5	18.65	24.0	10.40	20.63	1.34	19.00
30–60	0.022	0.068	0.011	6.00	3.10	7.9	Nil	0.47	17.25	13.66	11.8	6.00	13.60	0.54	19.00
60–90	0.017	0.068	0.09	7.50	2.80	8.0	Nil	0.75	18.75	8.66	16.20	5.80	5.47	0.36	20.00
90–120	0.024	0.056	0.07	12.00	-	-	-	-	-	-	-	-	-	-	-

Organic matter percentage in different locations ranges from 0.029 to 0.416

Mean valua is 0.116

6. COUNTRY REPORT - SULTANATE OF OMAN

by

Selim Ali Rawahy

There are many sources of organic matter and each differs from the other in organic matter content.

In Oman the main organic matter that is recycled is from animal waste, mainly from cows, chickens, sheep and goats and some from donkeys and camels. The numbers estimated in 1976 were:

Goats	164 600	Camels	13 500
Cows	133 800	Donkeys	10 000
Chickens	100 000		

Depending on their availability, some farmers mix various types of waste and add them to the soil; others add only one type. Percent nitrogen differs from one waste to another; for example, chicken manure has about 3 times as much nitrogen as cow manure.

Soils are generally low in organic matter; this may be due to a combination of high temperatures during the summer, sometimes exceeding 45°C, and the dryness of soils. There is very little rainfall, except in some areas of Dhofar Province. The soils have a low degree of development because of this arid climate. Practically all soils are highly calcareous. As the rainfall in most parts is very low (about 50-200 mm/yr), irrigation is necessary for agriculture.

In the Batina plain, the principal limiting factor from the standpoint of soil productivity is soil and water salinity. Organic matter content of the soil is 0-0.8% and pH is 7.5-8.4. Available phosphorus is very low because of inhibition of calcium carbonate. Exchangeable calcium and occasionally high exchangeable magnesium concentrations are found in the absorption complex. Potassium is 0.1-0.5 meq/100 g (values over 0.3 meq are considered satisfactory). Exchangeable sodium is distributed unevenly. Cation exchange capacity ranges from 5-15 meq/100 g.

In the interior, the organic matter content of soil reaches 2.07% in some areas and soils in palm groves contain relatively large amounts of organic matter. In these areas also there is high exchangeable calcium and magnesium on the absorption complex. The soils here are infrequently saline.

Dhofar Province has some areas which are comparable to those of tropical climates, for example, the Salalah plain and the Jebel. Inland Dhofar has a desert climate with negligible rainfall. It is similar to the Batina Coast with wide variations in temperature. The Salalah plain has an annual temperature variation similar to a tropical climate but the area is extremely arid. The Jebel's southern slopes receive 500-650 mm of low intensity rainfall between July and September. It has monsoon weather. It is a cattle producing area. The organic matter content reaches 3.3%. Overall fertility is much greater than in other parts of Dhofar, but the soils are shallow over limestone, and could be "Terra rosa" type.

REFERENCES

Sir William Halcrow and Partners. Surveys and Investigation for Land and Water
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OPENING STATEMENTS

1. Mr. Salah Jum'a
Assistant Director-General, Regional Representative for the Near East,
FAO Regional Office

On behalf of Mr. E. Saouma, the Director-General of FAO, I would like to extend FAO's gratitude and thanks to the Government of the Arab Republic of Egypt for hosting this important Workshop. Thanks are also due to the Swedish International Development Authority for their generous financial support, without which this Workshop would not have materialized so soon.

It is needless for me to tell this scientific gathering about the importance of organic materials for the increase of soil productivity and hence their substantial contribution to closing the food gap, which humanity is striving to do. Organic matter improves the physical property of the soil, by increasing its water holding capacity and improving its structure and soil aeration, both of which are basic for increased soil productivity. The increase of water holding capacity of the soil has special importance for the Near East with its condition of water shortage, that has such a major effect on plant growth.

To avoid misunderstanding, we know that organic manures, because their main effect is on physical properties of soils, can provide in general, only limited quantities of soil nutrients. Experience in the Near East Region, as in other parts of the world, shows that therefore an optimal combination of organic manures with mineral fertilizers (for plant nutrients) is the answer on a short and long-term basis for increasing and maintaining agricultural productivity.

I notice with satisfaction that the programme of this Workshop reflects this important fact. I also notice the impressive variety of items you are going to deal with including compost making from different materials, biological nitrogen fixation, and last but not least, the most interesting subject of biogas production, which is interesting from the energy as well as from the soil fertility point of view.

I am glad to see that the second part of the Workshop is dedicated to group sessions to work out action guidelines for follow-up activities in your countries. I agree: the Workshop is not an end in itself, but a starting point. On this point I would like to assure you that FAO is ready to give technical and practical assistance to member countries whenever required.

I would like to end by extending my thanks to all those who contributed to the preparation for this Workshop, and in particular to the Faculty of Agriculture, University of Alexandria, to whom special thanks are due.

I wish your Workshop every success.

2. Professor Khaled El-Shazly
Dean, Faculty of Agriculture, Alexandria University

It is with great pleasure that I welcome you to the Workshop on Organic Matter and Soil Improvement.

The Egyptian population has reached 40 million inhabitants and is expected to reach 70 millions by the year 2 000. Egyptians live on 3.5 % of the total area, a sum of 6 million acres which has not increased in the past decades, in spite of efforts spent in land reclamation as a result of using equivalent good agricultural areas for industry and housing. Due to the population explosion we are becoming more dependent on imported foods and other goods.

A World Bank Report has indicated that agricultural production increased by 3.5 - 4.0% annually, from 1955-1965.[1] From 1966 onwards the agriculture sector began to falter: "The growth in production declined to about 2% and has not regained its former growth level. With the exception of cotton, the yields of most crops have not improved significantly. A large proportion of the reclaimed lands, roughly two-thirds has not been made fully productive. The groundwater level has risen seriously, as a result of the increase in water supplies, reducing the productivity of some lands and necessitating a major drainage effort".

The World Bank Report has related slow agricultural growth in Egypt during the past decade to the following reasons:

i. limitations of the natural resource base, especially land, and poor water management;

ii. shortages of financial and investment resources due to military necessities since 1967;

iii. the belief that agriculture has almost reached a plateau of productivity in old lands;

iv. suboptimal distribution of capital resources within agriculture;

v. inadequate price and incentive policies;

vi. administrative control of the cropping pattern;

vii. an inflexible institutional structure within agriculture;

viii. an inadequate organizational linkage between agriculture and the rest of the economy.

They have failed to recognize two other major constraints to agricultural development in Egypt: a) disruption and non-continuity of governmental agriculture policies; and b) silt precipitation behind the High Dam and its effect on soil fertility.

It is interesting to compare the balance of payments in Egypt since 1960 up to 1976.

In million £ E.

	1960	1965	1970	1973	1976
Exports	204	247	355	396	714
Imports	269	417	518	656	1 914
Balance	-65	-170	-163	-260	-1 200

The negative balance of payments has been accentuated by increased international prices, particularly of food.

1/ No. 931 B. EGT 1976

It is true that the present Egyptian yields appear high by world standards, e.g. compared to California:

	Egypt	California	
Rice	2 189 kg/fd	2 540 kg/fd	
Wheat	1 304 "	1 304 "	
Beans	989 "	710 "	
Potatoes	7 510 "	14 833 "	
Cotton	917 "	673–1 360 "	
Maize	1 579 "	2 540 "	(3 000 irrigated)

However, this overlooks the exceptional growing conditions found in Egypt which, permit I am sure, higher yields. If we consider maize for instance which yields 12 ardabs on an average (1 600 kg), yet some areas in Egypt have reached 30 ardabs (4 200 kg/fd). This indicated clearly that there is ample space for increased productivity from the old land over and above production from newly reclaimed areas (horizontal expansion).

This can only be achieved by good extension services and the will to do it.

In your Workshop you will have to answer some of the important questions and points relating to organic matter and soil improvement. They might well be the following:

1) How do you make the best use of organic wastes (human, or animal) for the improvement of the soil?
2) What necessary processing or preserving conditions are required for the use of organic wastes (including garbage)?
3) What type of soils should benefit more from organic matter?
4) You may, perhaps, wish to consider the question of recycling animal wastes into animal feeds in comparison to using them for land fertilization.
5) What type of interactions with soil elements, good or bad, one may wish to promote or prevent, as the case may be.
6) The specific requirements of the different crops for organic matter.
7) The interrelation of organic matter supply and soil management policies to cope with many of the still only partially solved problems of high leaching, high soil temperatures, high loss of organic matter, etc.

These and many other questions will be answered in your meetings today and during the following days.

May I wish you all a very successful and stimulating meeting, and a happy stay in Alexandria. If the Faculty can be of any help to the meeting or to any member of the Workshop please do not hesitate to ask.

3. Professor Ali Reda El-Henidi
President of Alexandria University

It gives me great pleasure and honour to welcome you to Alexandria University.

I wish to express my thanks to our distinguished guests who are participating in this meeting.

Your Workshop on Organic Materials and Soil Productivity in the Near East is very important as more food is needed in the Near East, and more food is needed in the immediate future. There is a population explosion in this area. Measures for family planning have not been successful to the present. If you talk about Egypt, our population is now 40 million. We are increasing in an astronomical way.

We need revolutionary scientific methods to increase soil productivity, and the recent development in the use of organic materials is an important measure in this field.

I am sure that your discussions and researches will add much to our objective.

I wish to thank the Food and Agriculture Organization of the United Nations and the Swedish International Development Authority for sponsoring this Workshop.

I wish you a pleasant stay in our beautiful City.

4. Mr. Abd-El-Latif Essa
Deputy Minister, Ministry of Agriculture

It is a great honour and privilege to be delegated by H.E. Dr. Mahmoud Mohamed Dawood, Minister of Agriculture, to deliver the statement of the Egyptian Government.

On behalf of the Egyptian Government, I wish to welcome you all to the Workshop on Organic Materials and Soil Productivity in the Near East, held by the FAO in cooperation with the Swedish International Development Authority (SIDA) and the Faculty of Agriculture, Alexandria University.

Farmers for many centuries have observed that the capacity of soils to produce crops is more or less directly related to their content of organic matter. Ancient Egyptians recognized the role of soil organic matter in soil fertility. Organic matter exerts a controlling influence on soil properties, including soil productivity. Many factors determine the agricultural productivity of a soil such as water, seeds, disease and pests, tillage methods, mineral nutrients, cultivars and soil properties.

In the arid and semi-arid regions the most important two factors are water and organic matter which indeed are the limiting factors in large areas.

In the light of the present world food crisis, a large number of the developing countries do not have money either to purchase costly food from abroad or to buy mineral fertilizers in sufficient quantity needed for modern agriculture. Therefore the situation demands that they should utilize organic materials as fertilizers on a large scale.

I am sure that we will benefit from the discussions on different subjects put under study in this meeting and we will benefit from your wide knowledge and experience in the field of soil organic matter.

It is a real pleasure for us to act as the host country for such an important Workshop. I wish you a very successful meeting and a pleasant stay in Egypt and safe trip back home.

PROGRAMME

Monday, 9 October

- Registration
- Official opening of the Workshop
- Organic recycling to improve soil productivity
  F.W. Hauck
- The significance of organic materials to Egyptian agriculture and maintenance of soil productivity
  A.S. Abdel-Ghaffar
- Organic fertilization problem in rural environment and remedial measures
  John S. Davis

Tuesday, 10 October

- Sources of organic materials and techniques for their use in improving soil productivity
  J.F. Parr
- Resources of organic wastes in Egypt
  M. Abdel-Samie
- Lignite: A potential source of organic matter
  Ingy Zein El-Abedine
- Green manures
  S.A.Z. Mahmoud
- Environmental health aspects of wastewater and refuse application to land
  Olfat El-Sebaie

Wednesday, 11 October

- The role and importance of organic materials and biological nitrogen fixation in the rational improvement of agriculture production
  G.S. Vidyarthy
- Use of rural and industrial wastes to improve soil productivity
  M. Maung
- Biogas technology - Experience from China
  M.N. Alaa El- Din
- Organic recycling practices in Asia and the FAO/UNDP Introductory Project RAS/75/004
  P. Hesse
- Comparative study of the effect of local organic manures on chemical, microbial and enzymatic activities of the soil and on wheat crop
  A.A.M. Mokawi
- Cropping systems and effect on soil productivity
  A.M. Balba
- Blue-green Algae, Azolla, Lemna and Phosphate dissolving bacteria
  M.N. Alaa El-Din
- Legume Inoculation and improving soil fertility
  Y.A. Hamdi

- Inoculation of Zea Maize with nitrogen-fixing spirilla and azotobacter
  N.A. Hegazi

Thursday, 12 October

- Use of organic materials as soil amendments
  F. Gati
- Organic materials and improvement of soil physical characteristics
  Jeong Nam Im
- Use of lignite as soil conditioner
  I.A. Zein El-Abedine
- Long term application of Baladi manure as affecting physical properties of the soil
  A.T. Moustafa
- Soil life with "Hydrosorb": an efficient, effective organic fertilizer and soil builder with unique water holding capacity
  B. Welborn
- The effect of organic materials on soil aggregation
  A. Gomah
- Effect of different organic materials on certain properties of calcareous soils and crop yield : E. Abdel-Naim
- Humus in Egyptian soils
  M. Kadr
- Response of maize to farmyard manure and zinc
  H. El-Attar
- Organic materials in relation to environmental planning
  L.T. Kadry

Friday, 13 October

- Excursion to North Tahrir Agricultural Company (Reclamation of sandy calcareous soils - organic matter recycling operations)

Saturday, 14 October

- Potential sources of organic materials in Egypt
  A. Riad
- Films from Hungary:
  1. Twentyfive years devoted to soil amelioration in Hungary
  2. Reclamation of sandy soils
  3. Improvement of the water management of sandy soils
- Country Reports

Sunday, 15 October

- Country Reports (Continued)
- Discussion and formulation of guidelines for action programmes in the countries

Monday, 16 October

- Visits to the Soil and Water Science Department and the University of Alexandria Research Center
- Recommendations and Closing of the Workshop

Tuesday, 17 October

- Excursion to Fayoum Governorate, Biogas unit
- Return to Cairo

Wednesday, 18 October

Excursion: - Visit to El-Gabal El Asfar farm fertilized with sludge
- Visit to the Garbage Composting Plant

LIST OF PARTICIPANTS

I. PARTICIPANTS

Afghanistan	Paiman, Mohammad Hassan Ministry of Agriculture, Kabul
Cyprus	Koundounas, Christos Assistant Agricultural Research Officer Agricultural Research Institute, Nicosia
	Papadoupoulos, Ioannis Nicou Assistant Agricultural Research Officer Agricultural Research Institute, Nicosia
Egypt Director of the Workshop	Abdel-Ghaffar, Ahmed Sabry Head, Soil and Water Science Department, Faculty of Agriculture, Alexandria University, Alexandria
	Abdel-Malek, Yousef Professor, Faculty of Agriculture Cairo University, Giza
	Abdel Samie, Moheie El-Din Researcher, National Research Centre Ministry of Higer Education and Scientific Research, Cairo
Liaison Officer of the Workshop	Alaa El-Din, Mohamed Nabil Senior Researcher, Soil and Water Research Institute Agricultural Research Centre, Ministry of Agriculture Giza
	Makawi, Ali Dean, Faculty of Agriculture Cairo University, Fayoum
	Hamdi, Yousef A. Chief Researcher, Soil and Water Research Institute Agriculture Research Centre, Ministry of Agriculture Giza
	Moustafa, Ahmed Taher Senior Researcher, Soil and Water Research Institute Agriculture Research Centre, Ministry of Agriculture Giza, Cairo
	Riad, Ahmed Ex. Director, Chemical Section Ministry of Agriculture, Cairo
	Zein El-Abedine, Ingy A. Associate Professor, Faculty of Agriculture Cairo University, Giza
Iran	Gheissi, Javad Head, Soil and Water Management Soil Fertility and Survey Institute, Shiraz
	Hekmat, Manouchehr Director General, Plan and Budget Department Ministry of Agriculture and Rural Development, Teheran

Jordan	Nuri, Widad Abdulhamid Research Officer, Agricultural Research and Extension Department, Ministry of Agriculture, Amman
Kuwait	Abdul Reda, Abbas Hussain Muhammad Department of Agriculture Ministry of Public Works, Kuwait
Oman	Rawahy, Salim Ali Department of Agriculture Ministry of Agriculture, Fisheries, Petroleum and Minerals, Muscat
Yemen Arab Republic	Awad, Ahmed Chief, Soil and Water Research Section Central Agricultural Research Station, Taiz

II. LECTURERS AND OBSERVERS

	Atia, Mohamed Hammad Faculty of Agriculture Cairo University, Fayoum, Egypt
Lecturer	Abd Elnaim, Ezzat M. Institute of Soil and Water Research Ministry of Agriculture, Egypt
Lecturer	Balba, A.M. Professor, Soil and Water Science Department Faculty of Agriculture, Alexandria University, Egypt
	Barakat, M.A. Ministry of Agriculture, Egypt
Lecturer	Davis, Joan International Research Centre for Waste Management WHO, Dubendorf, Switzerland
Lecturer	El-Attar, H.A. Associate Professor, Soil and Water Science Department Faculty of Agriculture, Alexandria University, Egypt
Lecturer	El-Sebaie, Olfat High Institute of Public Health Alexandria University, Egypt
Lecturer	Gomah, A. Associate Professor, Soil and Water Science Department Faculty of Agriculture, Alexandria University, Egypt
Lecturer	Gati, F. Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences, Budapest, Hungary
Lecturer	Hegazi, Nabil Department of Bacteriology Faculty of Agriculture, Cairo University, Giza, Egypt
	Hussein, Yosr, A. Agricultural Research Centre Ministry of Agriculture, Giza, Egypt

Lecturer	Im, Jeong Nam Institute of Agricultural Science, Suweol, Korea
	Ishac, Y.Z. Faculty of Agriculture, Ein Shams University, Cairo, Egypt
	Ismail, Abdel-Samad S. Faculty of Agriculture, Ein Shams University, Cairo, Egypt
	Makled, Fathy Faculty of Agriculture, El-Azhar University, Cairo, Egypt
	Mahmoud, Saad Zake Dean, Faculty of Agriculture Ein Shams University, Cairo, Egypt
Lecturer	Maung, Myint Industrial Development Officer UNIDO, Vienna, Austria
	Mitwally, H. Professor, High Institute of Public Health Alexandria University, Egypt
	Moursy, Ahmed Sayed National Research Centre, Cairo, Egypt
Lecturer	Moustafa, Moustafa Khadr Professor, Soil and Water Science Department Faculty of Agriculture, Alexandria University, Egypt
	Nahal, Ibrahim Senior Regional Adviser UNEP Regional Office, Beirut, Lebanon
	Nasr, Fayza Ali National Research Centre, Cairo, Egypt
	Nierhaus, D. WHO/IRC Dubendorf, Switzerland
Lecturer	Parr, James Agricultural Research Centre Beltsville, Maryland, USA
	Safwat, Mohammed Said Ali Department of Mircrobiology, Faculty of Agriculture El-Minia University, El-Minia, Egypt
	Shehata, Samy Mohamed Institute of Soils and Water Research Ministry of Agriculture, Giza, Egypt
Lecturer	Vidyarthy, G.S. Commissioner, Fertilizer Promotion Department of Agriculture Ministry of Agriculture and Irrigation, New Delhi, India
Lecturer	Welborn, Byron Soil Fertility Consultant Texas, USA

III. FAO

Jum'a, Salah
ADG, Regional Representative for the Near East
FAO Regional Office for the Near East, Cairo, Egypt

Co-Director of the Workshop

Hauck, F.W.
Chief, Soils Resources, Management and Conservation Service, Land and Water Development Division, FAO, Rome

Technical Secretary of the Workshop

Massoud, Fathy I.
Technical Officer, Soil Resources, Management and Conservation Service, Land and Water Development Division
FAO, Rome

Arar, Abdullah
Regional Land and Water Development Officer
FAO Regional Office for the Near East, Cairo, Egypt

Mustafa, A.
Disbursing Officer
FAO Regional Office for the Near East, Cairo, Egypt

Saleh, Amr
Translator
FAO Regional Office for the Near East, Cairo, Egypt

Eldarwish, Mona
Secretary
FAO Regional Office for the Near East, Cairo, Egypt

IV. LIAISON

Dessouki, M.
Director, Foreigh Relations Department
Ministry of Agriculture, Cairo, Egypt

Al-Sarki, Adel
Foreign Relations Officer
Ministry of Agriculture, Cairo, Egypt

ARABIC SUMMARY

الندوة المشتركة بين منظمة الأغذية والزراعة والسلطة السويدية للتنمية الدولية

وكلية الزراعة ـ جامعة الأسكندرية

عـن :

المواد العضوية وانتاجية الأراضى فى اقليم الشرق الأدنـــى

الأسكندرية (جمهورية مصر العربية) ٩ ــ ١٨ اكتوبر (تشرين الأول) ١٩٧٨

المقدمـــة

تستخدم المادة العضوية للمحاصيل النامية ولتحسين انتاجية الأرض فى منطقة الشرق الأدنى منـذ قرون عديدة ، وحتى منتصف القرن التاسع عشر ـ حيث ظهرت صناعة الأسمدة المعدنية ـ كانت تضـاف المواد العضوية الى الأرض فى صورة أسمدة محضرة من المخلفات الحيوانية والنباتية كمصدر وحيـد للعناصر الغذائية لكافة المحاصيل فيما عدا بعض البقوليات • ومنذ عشرون عاما "أى عند بدء الثـورة الخضراء " أخذ استعمال المادة العضوية فى الهبوط ، حتى فى البلدان التى اعتادت عليها منـذ آماد بعيدة ، وازداد استعمال الأسمدة المعدنية بدرجة كبيرة •

ونظرا لأزمة الطاقة العالمية وللزيادة المستمرة فى أسعار الأسمدة المعدنية ـ التى يتوقع معـها ندرتها فى المستقبل ـ عاد الاهتمام بالاضافة الدورية للمادة العضوية لتحسين خصب الأرض وانتاجيتهـا الى المسرح من جديد •

أصدر المؤتمر العالمى للأغذية عام ١٩٧٤ قرارا يحث فيه على الاستزادة من استخدام المـواد العضوية لتحسين خصب الأرض بهدف زيادة انتاج المحاصيل الى الحد الأقصى • وكنتيجة لهذا المؤتمـر أخذت منظمة الأغذية والزراعة الدولية والهيئة السويدية للتنمية الدولية موقفا رائدا فى هذا الشأن حيـث قامت بتنظيم مشاورة للخبراء عن " استعمال المواد العضوية كمخصبات " فى روما (١٩٧٤) وندوة عـن " اعادة استخدام المواد العضوية فى آسيا " (بانكوك ١٩٧٦) ويدبر حاليا لاقامة ندوات مماثلة فـى البلدان النامية بأمريكا اللاتينية والجنوبية وآسيا وافريقيا وجميع هذه الندوات واللقاءات تطالب بضـرورة استخدام المواد العضوية لزيادة الانتاج الزراعى واستعمال الأسمدة العضوية والأسمدة المعدنية جنبـا الى جنب • وتكثف منظمة الأغذية والزراعة مجهوداتها لمساعدة الدول الأعضاء فى ايجاد برامج عمل لزيادة خصب أراضيها ورفع قدرتها الانتاجية من خلال الاضافات المتوازنة من السماد العضوى والسماد المعدنى •

وتهدف هذه الندوة الى بحث الاهتمام باستخدام المواد العضوية فى تحسين انتاجية الأراضى فى بلدان الشرق الأوسط والأدنى ومساعدة البلاد الأعضاء فى وضع برامج للعمل على تحقيق هذه الأهداف.

وقد تولت عقد هذه الندوة منظمة الأغذية والزراعة بالاشتراك مع السلطة السويدية للتنمية الدولية وقسم الأراضى والمياه بكلية الزراعة ـ جامعة الأسكندرية .

وقد اشترك فى الندوة ١٩ عضوا من ٨ دول أعضاء هى: افغانستان وقبرص ومصر وايران والأردن والكويت وعمان والجمهورية العربية اليمنية . كما حضر الندوة ٢٥ مراقبا ومحاضرا و ٣ أعضاء من برنامج الأمم المتحدة للبيئة ومنظمة الأمم المتحدة للتنمية الصناعية ومنظمة الصحة العالمية . بالاضافة الى ممثلى وموظفى منظمة الأغذية والزراعة .

برنامج الندوة وسماتها الرئيسية

القيت فى حفل الافتتاح بيانات من كل من السيد صلاح جمعه (المدير العام المساعد للمنظمة والممثل والممثل الاقليمى للشرق الأدنى) والسيد الاستاذ الدكتور على رضا الهنيدى (رئيس جامعة الأسكندرية) والسيد الاستاذ الدكتور خالد الشاذلى (عميد كلية الزراعة) والسيد الوزير عبد التواب هديب (محافظ الأسكندرية) والسيد عبد اللطيف عيسى (وكيل وزارة الزراعة المصرية نائبا عن السيد وزير الزراعة الاستاذ الدكتور محمود داود) .

وخلال جلسات العمل قدم المحاضرون الذين وجهت اليهم الدعوة من كل من الولايات المتحدة الأمريكية والهند والمجر وكوريا ومنظمة الأمم المتحدة للتنمية الصناعية ومنظمة الصحة العالمية ومنظمة الأغذية والزراعة وجمهورية مصر العربية ٢٨ بحثا .

وقد اشتملت الموضوعات التى جرت مناقشتها على الآتى :

١ــ دور المواد العضوية فى خصوبة الأراضى .

٢ــ مصادر وأساليب استخدام المواد العضوية .

٣ــ المواد العضوية واستخدامها كمصلحات للأرض .

٤ــ تثبيت النتروجين بيولوجيا وانتاج الغاز البيولوجى .

٥ــ النظم المحصولية وانتاجية الأرض .

٦ــ المواد العضوية وعلاقتها بالصحة العامة والتخطيط البيئى .

٧ــ التقارير القطرية.

وقد نظمت رحلتان لزيارة عمليات اعادة استخدام المواد العضوية (شمال مديرية التحرير) ووحدة الغاز البيولوجى (الفيوم).

واختتمت الندوة اجتماعاتها بتقديم تقرير نهائى عن نتائج الندوة والتوصيات .

الاستنتاجات

١ـ ليس هناك من شك فى ضرورة الأسمدة المعدنية لمعظم النظم المحصولية اذا كان الهدف هو تحقيق زيادة انتاج المحاصيل الى الحد الاقصى • ومع هذا فان التجارب طويلة الأمد تشير الى تدهور بناء الأرض والنقص المستمر فى غلة المحصول عند الاقتصار على استعمال هذه الأسمدة ، كما أن المحتوى العضوى لهذه الأراضى ــ وهو المقياس الحقيقى لخصوبة وانتاجية الأراضى يأخذ بدوره فى النقصان •

٢ـ أفضل وسيلة للحفاظ على مستوى عالى لخصوبة وانتاجية الأرض هو الاضافة الدورية للمادة العضوية المجهزة بطريقة مناسبة مع استعمال الأسمدة المعدنية • فهذه المواد العضوية تمد المحاصيل النامية بكميات جوهرية من العناصر المغذية الكبرى (ن ، فو ، بو) والصغرى (نح ، ب ، زن ، من ، مو) فضلا عن تحسينها لخواص الأرض الطبيعية ومنها على سبيل المثال قابليتها للخدمة ، بناءها وسعتها الحافظة للماء •

٣ـ نتج عن أزمة الطاقة العالمية الحالية والارتفاع المستمر فى أسعار الأسمدة المعدنية الاتجاه الى الأسمدة العضوية ولكن توجد بعض الصعاب التى يجب التغلب عليها حتى يمكن التحقيق الكامل لهذا الاتجاه ــ منها على سبيل المثال استخدام المخلفات الانسانية الذى قد يؤدى الى اضرار بالصحة العامة مالم تكن مجهزة التجهيز المناسب •

٤ـ بالرغم من القيمة الاقتصادية العالمية لبعض مصادر المادة العضوية فان بعضها مازال لم يستغل على النطاق التجارى •

٥ـ من بين المعوقات التى تحول دون الاستغلال الأمثل للمواد العضوية فى تحسين انتاجية الأرض فى بلدان الشرق الأدنى الافتقار الى مايلى :

- الوعى والاهتمام بنوع وكمية المواد العضوية المتاحة •
- ايجاد البنية الأساسية اللازمة لجمع المخلفات العضوية ومعاملتها فى المناطق الريفية والحضرية •
- استخدام التكنولوجيا المناسبة •
- الاحساس بالقلق ازاء ماقد يترتب عليها من آثار معاكسة محتملة على الصحة العامة •
- وضع سياسات وبرامج محددة لاعادة استخدام المتخلفات العضوية فى الانتاج الزراعى •
- توفير الأموال الكافية لاتخاذ الاجراءات العلاجية •

٦ـ لاينبغى أن ينظر الى عملية جمع ومعالجة المواد العضوية بغرض اضافتها الى الأرض على انها من العمليات التى تعود بالربح بل يجب أن تقدر قيمتها الحقيقية من فوائدها الجمّة على المدى الطويل بما فى ذلك منع التلوث وحماية الصحة العامة والمظهر الأفضل للبيئة سواء فى الريف أو الحضر •

٧- من المعروف تماما انه يمكن امداد المحصول بقدر ملموس من احتياجاته من النيتروجين عن طريق عمليات التثبيت البيولوجي للنيتروجين اذا ما احسن استغلالها • ولكن هذه العمليات الحيوية الهامة لم تستغل بعد فى الدول النامية وذلك بسبب نقص الأشخاص المدربين اللازمين لاستخدام هذه الطرق والعمل على انتشارها بين المزارعين •

التوصيات

١- **توصيات عامة :**

أ - تقوم منظمة الأغذية والزراعة بتبليغ جميع البلاد الأعضاء فى اقليم الشرق الأدنى بمداولات وتوصيات هذه الندوة •

ب - ترجمة أعمال هذه الندوة الى اللغة العربية فى أقرب وقت ممكن حتى تتمكن الدول الناطقة بالعربية من الالمام بمحتواها الفنى والتوصيات والبرامج المقترحة •

جـ - عقد ندوة اقليمية مماثلة كل عامين أو ثلاثة وذلك بغرض تبادل المعلومات ومراجعة خطى التقدم واعادة صياغة التوصيات والبرامج حسبما تقتضى الحاجة •

٢- **اعادة استخدام المواد العضوية لتحسين انتاجية الأرض :**

ينبغى على كل دولة أن تقوم باجراء مسح لمواردها من المواد العضوية ومدى توفرها حاليا ومستقبلا لاستخدامها فى تحسين الأراضى • والبيانات المطلوبة لهذا الغرض تتضمن نوع هذه المواد العضوية وكمياتها المنتجة وكذلك حدود استخدامها وطريقته والصعاب التى تعترض دوام اضافتها للأرض (كتركيبها الكيميائى غير الملائم أو أفضلية استخدامها فى أغراض أخرى) وأخيرا امكانية الاستزادة من اضافتها الدورية للأرض •

٣- **تخمير متخلفات الريف والحضر (الكومبوست) :**

أ - نظرا لاحتمال أن تكون الطرق الحديثة لصناعة الكومبوست غير ملائمة فى البلدان النامية فانه يجب أن تتم صناعة الكومبوست من المتخلفات العضوية على أساس النتائج التى يتم الحصول عليها من تجارب تتم على نطاق تجريبى ترتكز على مبادئ التكيف بدلا من التكنولوجيات الجاهزة • مع دراسة حالة العمالة اليدوية والتصنيع المحلى للآلات التى قد تلزم لصناعة الكومبوست •

ب - أن تنشأ هيئات خاصة بصناعة الكومبوست تضم اخصائيين مدربين على طرق تحضير الكومبوست واخصائيين فى الصحة العامة تقع عليهم مسؤولية مراقبة صحة العمال الذين يقومون بالتجميع

والنقل والتحضير والتوزيع وكذلك المزارعين الذين يستخدمون السماد الناتج وذلك لضمان مطابقة الطرق المستعملة للطرق والمقاييس المتعارف عليها • كما تعمل هذه الهيئات الخاصة على تشجيع اعادة استخدام المواد العضوية •

جـ ـ أن لا يكون الدافع لانشاء هيئات متخصصة بصناعة الكومبوست هو الربح في المدى القصير بل يجب أن تؤخذ في الاعتبار الفوائد المتعددة على المدى البعيد كالتغلب على مشاكل تلوث البيئة وانتشار الأمراض علاوة على الحفاظ على الموارد الطبيعية وما يطرأ من تحسين في الصحة العامة وفي نظافة الريف والحضر •

٤ـ انتاج الغاز البيولوجي :

ينبغي تطوير صناعة الغاز البيولوجي :

أ ـ على مستوى القرية كمصدر للطاقة وكعامل فعال في توفير الصحة الريفية •

ب ـ وعلى المستوى الصناعي لتوفير الطاقة والأسمدة العضوية اعتمادا على الموارد المتجددة •

٥ـ التثبيت البيولوجي للنيتروجين :

توصي الندوة البلدان النامية في الشرق الأدنى باجراء البحوث وتطبيق البرامج التي تؤدي الى الوصول الى الحد الأقصى لتثبيت النيتروجين سواء كان ذلك تكافليا أو لا تكافليا ويأتي ذلك من خلال :

أ ـ ادخال البقوليات خاصة ماكان منها ذا كفاءة عالية في تثبيت النيتروجين في الدورة الزراعية •

ب ـ تلقيح المحاصيل البقولية بسلالات من بكتريا العقد الجذرية ذات الكفاءة العالية •

جـ ـ تلقيح حقول الأرز بالطحالب •

د ـ أقلمة وتعميم نباتات الأزولا في حقول الأرز حيثما ومتى أمكن ذلك •

هـ ـ التغلب على معوقات تثبيت النيتروجين الوراثية والفسيولوجية •

٦ـ المواد العضوية كمصلحات للأرض :

توصي الندوة ببرامج بحثية تهدف الى استحداث مصلحات عضوية تمتاز بشدة مقاومتها للتحلل الميكروبي في أراضي المناطق الجافة ونصف الجافة • ويلزم متابعة مثل هذه الدراسات لوقت كاف يسمح بالتقييم الاقتصادي لاستخدام هذه المواد •

٧ـ الارشاد والتدريب :

لضمان نقل نتائج البحوث الى المزارعين وتطبيقها على مستواهم فان الندوة توصي بتنفيذ برامج ارشادية وتدريبية أكثر فاعلية عن استخدام المواد العضوية لتحسين انتاجية الأرض •

على أن تشمل هذه البرامج الأتى :

أ ـ تكنولوجيا اعادة استخدام المواد العضوية والفوائد الاجتماعية والاقتصادية التى تعود من اضافة المواد العضوية للأرض.

ب ـ تكنولوجيا استخدام الأزولا والطحالب الخضراء المزرقة وغيرها من الكائنات المثبتة لنتروجين الهواء الجوى.

جـ ـ تكنولوجيا تلقيح المحاصيل البقولية ببكتريا العقد الجذرية .

د ـ نقل وتطوير تكنولوجيا انتاج الغاز البيولوجى وتدريب عمال مهرة فى اقامة وحدات انتاج الغاز وصيانتها لضمان نجاحها .

٨ ـ <u>برامج العمل :</u>

أ ـ <u>تقديم مساعدات تمهيدية لتقييم مدى توافر الموارد العضوية :</u>

نظرا لنقص البيانات الدقيقة عن نوع وكمية الموارد العضوية المتاحة وأوجه استعمالاتها المختلفة فى بعض بلدان منطقة الشرق الأدنى ولأن هذه البيانات ضرورية لنجاح برامج اعادة استخدام المواد العضوية فان الندوة توصى بأن تتخذ حكومات البلاد الأعضاء الخطوات التنفيذية فى أقرب وقت ممكن للحصول على هذه البيانات والمعلومات بمساعدة منظمة الأغذية والزراعة وبرنامج الأمم المتحدة للتنمية.

كما أوصت الندوة بضرورة صياغة مشروع اقليمى لاعادة استخدام المواد العضوية تعرض وثائقه على المنظمات الدولية والوكالات الثنائية للعمل على انجازه واتمامه .

<u>خطة العمل :</u>

يقوم منسق بزيارة الدول الأعضاء فى المنطقة لجمع البيانات الآتية :

- مصادر المواد العضوية .
- الطرق المتبعة فى اعادة استخدام المواد العضوية ومدى استعمال المواد العضوية ودرجة النجاح التى تحققت من ذلك.
- مدى توافر أفراد محليين فى المنطقة للقيام باعداد وانجاز اعادة استخدام المتخلفات العضوية.
- مدى توفر الهيئات المناسبة للبحوث والخدمات المطلوبة.
- الاحتياجات والمساهمات المطلوبة .

المطلـوب :

- منسق (متفرغ كل الوقت) لمدة قد تصل الى ١٢ شهر.
- مستشارون متخصصون فى المجالات المختلفة لاعادة استخدام المواد العضوية (قمامة المدن - متخلفات المجارى - انتاج الغاز البيولوجى ...).
- مستشارون متخصصون فى مجالات التسميد الميكروبى.
- رحلات للهند والصين وغيرها.

ب - انشاء مركز لتكنولوجيا تخمير المتخلفات العضوية (الكومبوست) ولاستعمال السماد الناتج :

لكى تتكون التكنولوجيات الملائمة لانتاج واستعمال الكومبوست فى الدول النامية لمنطقة الشرق الأدنى فان الندوة توصى بانشاء مراكز ارشادية تعمل على تبنى انتاج الكومبوست بطرق تتدرج من الاعتماد كلية على العمل اليدوى الى استعمال الآلات وتعمل أيضا على تصنيع الآلات اللازمة محليا والقيام بالدعاية الواعية اللازمة لترويج استعمال السماد العضوى المنتج.

ويجب استخدام هذه المراكز للقيام بالمهام الآتية :

١- عقد دورات دراسية قصيرة عن تكنولوجيا الكومبوست للمخططين والارشاديين ومديرى المشاريع والعاملين بمصانع الكومبوست والمزارعين.

٢- اقامة مشروعات ارشادية توضح طرق استخدام الكومبوست فى الأراضى للحصول على أكبر عائد محصولى بما فى ذلك موعد وطريقة ومعدل اضافة السماد العضوى وأفضل استعمال له مع الأسمدة المعدنية.

كذلك فان الندوة توصى بأن توفر منظمة الأغذية والزراعة ومنظمة الأمم المتحدة للتنمية الصناعية وبرنامج الأمم المتحدة للتنمية وبرنامج الأمم المتحدة للبيئة المساعدات لبرنامج العمل المذكور أعلاه وكذلك المساعدات اللازمة لوضع برامج مشاريع كومبوست جديدة والعمل على تنفيذها والتغلب على الصعاب التى تجابهها وعمل التعديلات الضرورية للمصانع الموجودة حاليا.

جـ - اقامة مشروعات ارشادية عن تكنولوجيا الغاز البيولوجى :

توصى الندوة بتنفيذ مشروعات ارشادية عن تكنولوجيا الغاز البيولوجى فى المناطق الريفية بمساعدة منظمة الأغذية والزراعة وبرنامج الأمم المتحدة للبيئة ومنظمة الأمم المتحدة للتنمية الصناعية وذلك للأغراض الآتية :

١- تحديد قدرة انتاج الغاز البيولوجى كمصدر للطاقة والسماد العضوى على التنافس مع البدائل الأخرى.

٢ـ توضيح كيف ينبغى أن تدار وحدة انتاج الغاز البيولوجي على انها نواة لنظام واحد متكامل مع امكان حدوث اختلافات كثيرة فى المتخلفات العضوية المستعملة وفى التعامل مع المواد المتبقية ويلزم أخذ هذه المفاهيم فى الاعتبار عند تصميم وحدات انتاج الغاز البيولوجي وتشغيلها •

٣ـ تنمية اهتمام السكان بانتاج الغاز البيولوجي وضمان التزامهم بحسن ادارة وصيانة وحدات انتاج الغاز•

٤ـ العمل على توفير الموارد المالية (قروض أو دعم من الحكومة) اللازمة لتكوين البنية الأساسية ولبناء وحدات انتاج الغاز•

٥ـ تكوين هيئة فنية استشارية تعمل على تحسين فاعلية وحدات الانتاج وتقليل تكاليفها ومراعاة المواصفات القياسية عند تصميم هذه الوحدات لزيادة الثقة فيها •

خطة العمل :

- اقامة برامج ارشادية على المستوى القومى والاقليمى •
- بناء وحدات مختلفة لانتاج الغاز البيولوجي تتناسب مع الاستعمالات المختلفة للغاز المنتج •
- تجهيز معامل البحث وزيادة كفاءتها •
- اقامة دورات تدريبية ورحلات دراسية وانشاء منح دراسية لمدة ثلاث سنوات•
- التعاون الوثيق مع الهيئات والمعاهد القومية •

المطلـوب :

- خبير (متفرغ كل الوقت) متخصص فى ميكروبيولوجيا الأراضى مع الالمام بتكنولوجيا الغاز البيولوجى •
- مستشارون فى المجالات الخاصة والتدريب •
- دورات تدريبية ـ رحلات دراسية ـ منح دراسية •
- تجارب معملية •
- بناء وحدات الغاز البيولوجي بالآلات المناسبة من أجل الاستعمالات المختلفة للغاز المنتج •

د ـ تثبيت النيتروجين بواسطة الأحياء الدقيقة :

توصى الندوة بأن تساعد منظمة الأغذية والزراعة وبرنامج الأمم المتحدة للتنمية وبرنامج الأمم المتحدة للبيئة فى تنفيذ برامج بحث وتطوير وتطبيق تثبيت النيتروجين بالطرق التكافلية وغير التكافلية فى المجالات الآتية :

التثبيت التكافلي للنيتروجين :

١ـ سلالات بكتريا العقد الجذرية (رايزوبيا) : حصر لأنواع الرايزوبيا المختلفة فى كل دولـــة • واختيار فاعلية السلالات (القدرة على تثبيت النيتروجين) فى مراكز تجميع المزارع الميكروبيـــة القومية والاقليمية •

٢ـ اللقاحات: ايجاد مواد حاملة لمزارع بكتريا العقد الجذرية المستعملة فى تلقيح المحاصيـــل البقولية من مصادر متاحة محليا مثـل المواد الدبالية ـ التراب ـ اللجنيت ـ مخلفات مصانـع قصب السكر وغيرها •

٣ـ طرق التلقيح: تحديد طرق التلقيح (معلق ـ مزارع سائلة ـ أقراص ـ بذور سابقـــة التلقيح وغير ذلك) •

٤ـ الاستجابة الى التلقيح : تقدير مدى استجابة المحصول البقولى للتلقيح بالبكتريا الخاصـــة بفحص الجذور للعقد وقياس الوزن الجاف والمحتوى النيتروجينى والمحصول •

٥ـ كفاءة نظم تثبيت النيتروجين: تقييم النظم المختلفة لتثبيت النيتروجين وعلى سبيل المثـــال زراعة نباتات السسبان فى حقول الأرز أو كمصدات للرياح •

٦ـ النباتات غير البقولية : بعض النباتات غير البقولية مثل الكازورينا تحمل جذورها عقد وتعمـــل على تثبيت النيتروجين • التعرف على هذه النباتات وتقدير كفاءتها فى تثبيت النيتروجين •

٧ـ الأزولا : دراسة مدى انتشار هذه النباتات المثبتة لنيتروجين الهواء الجوى بالتكافل مـــع طحالب أخضر مزرق وكفاءة هذا النظام وطرق تنميتها واستجابة المحاصيل لهذا النوع مـــن التسميد •

التثبيت غير التكافلى للنتروجين :

١ـ البكتريا : دراسة مدى انتشار البكتريا المثبتة للنيتروجين لا تكافليا وكفاءتها واستجابـــة المحاصيل لها • ومن أمثلة هذه البكتريا : الازوتوباكتر ـ البيجرنكيا ـ الاسبيريـــلام ـ بكتريا التمثيل الضوئى وغيرها •

٢ـ الطحالب الخضراء المزرقة: دراسة مدى انتشار الطحالب الخضراء المزرقة وكفاءتها فى تثبيت النيتروجين وطرق تنميتها واستجابة المحصول لها •

٣ـ أنواع أخرى: البحث عن أنواع أخرى يمكن الاستفادة بها مثل أنواع من بكتريا اسبيريلـــــم والنباتات المائية المعروفة باسم عدس الماء •

— **نقل التكنولوجيـــــا :**

يوصى بأن يؤخذ فى الاعتبار النقاط الآتية عند نقل التكنولوجيا :

١ـ عقد برامج تدريبية وندوات علمية على المستوى القومى والاقليمى •

٢ـ نشر المعلومات من خلال تعيين خبراء من داخل أو خارج المنطقة •

خطة العمــل :

- اقامة برامج قومية •
- اقامة برامج عن التسميد الميكروبى للبقوليات والأرز وغيرها على مستوى المنطقة •
- جمع واختبار سلالات الأحياء الدقيقة المثبتة للنيتروجين وارسال مزارع منها لمن يطلبهـــــا (رايزوبيا ـ الأزوتوباكتر ـ الطحالب الخضراء المزرقة ـ الأزولا) •
- تجهيز معامل البحث •
- اقامة دورات تدريبية ورحلات دراسية وانشاء منح دراسية لمدة ثلاث سنوات •
- التعاون الوثيق مع الهيئات والمعاهد القومية •

المطلوب :

- خبير (متفرغ كل الوقت) متخصص فى تثبيت النيتروجين بيولوجيا •
- دورات تدريبية ـ رحلات دراسية ـ منح دراسية •
- أجهزة معملية •

شكر وتقديـــر

تتقدم الندوة بالشكر والعرفان لمنظمة الأغذية والزراعة والسلطة السويدية للتنمية لما بذلوه مــن مجهودات لتنظيم وتدعيم هذا اللقـاء ولولا ذلك لما أمكن عقد هذه الندوة •

كما تود الندوة أن تعبر عن تقديرها وشكرها للحكومة المصرية ووزارة الزراعة ومحافظ الأسكندريـــة ومحافظ الفيوم وشركة شمال التحرير الزراعية لحسن ضيافتهم ومؤازرتهم لهذه الندوة •

كما تخص الندوة بالشكر والتقدير السيد الاستاذ الدكتور رئيس جامعة الأسكندرية والسيد الأســتاذ الدكتور عميد كلية الزراعة ـ جامعة الأسكندرية لاستضافة هذه الندوة ولما قدموه من خدمات وتسهيـلات طوال فترة انعقاد الندوة مما كان له أكبر الأثر فى انجاح الندوة •

والله ولى التوفيـــق ،،،

الملخص العربي

١ـ اعادة استخدام المادة العضوية لتحسين انتاجية الأرض

ف ٠ و ٠ هـاوك
منظمة الأغذية والزراعة ـ روما (ايطاليـا)

ان أهمية المواد العضوية لا ترجع لكونها مصدرا للعناصر المغذية للنبات فقط بل أيضا الى تأثيرها على خواص الأرض الطبيعية والكيماوية والحيوية والتى بدورها تؤثر على نمو النباتات ٠

وحتى منتصف القرن التاسع عشر ظلت المواد العضوية فى صورة كومبوست وسماد اسطبل المصدر الوحيد الذى يضاف الى الأرض بقصد امداد النبات بالعناصر الغذائية فيما عدا المحاصيل البقولية التى كان يعتمد عليها كمصدر للنيتروجين ٠ بعد ذلك بدأ استخدام الأسمدة المعدنية وأخذت تحل تدريجيا محل الأسمدة العضوية وذلك لسهولة الحصول عليها ونقلها وتداولها ورخص ثمنها وذلك علاوة على تأثيرها السريع ٠ ولكن ازدهار الأسمدة المعدنية لم يدم طويلا نظرا لأزمة الطاقة العالمية وارتفاع أسعارها مما أدى الى العودة الى استخدام الأسمدة العضوية والبحث عن مصادر جديدة لها ٠ وقد تصادف حدوث هذا التغير مع بدء الاهتمام بتلوث البيئة بسبب تزايد تراكم المتخلفات العضوية نتيجة للنمو الحضرى والصناعى ٠

مصادر المواد العضوية التى يمكن استعمالها كسماد هى متخلفات الانسان والحيوان والتسميد الأخضر والتسميد الميكروبى وخاصة مايتعلق بتثبيت نيتروجين الهواء الجوى ٠

متخلفات الانسان والحيوان غنية فى العناصر المغذية للنبات ويجب اعادتها للأرض الزراعية بدلا من التخلص منها بطرق أخرى ٠ وعلى سبيل المثال نجد أن روث البقر يحتوى على ١ـ٢ ٪ نيتروجين و ١ـ٢ ٪ فوسفور و ٨ر٠ ـ ٢ر١ ٪ بوتاسيوم أما متخلفات الانسان (بول وبراز) فتحتوى على ٣ـ٥ ٪ نيتروجين و ٢ـ٤ ٪ فوسفور و ١ـ٢ ٪ بوتاسيوم ٠

والقيمة السمادية لهذه المتخلفات تتوقف على الطريقة التى تعامل بها قبل اضافتها الى الأرض ٠ويجب تحاشى اضافة متخلفات الانسان مباشرة الى الأرض حيث أن ذلك يؤدى الى انبعاث روائح كريهة وجذب وتكاثر الذباب وانتشار الأمراض ٠ وعادة تعامل متخلفات المجارى تحت ظروف محكمة لتعطى الحمأة (سلدج) التى قد تستعمل مباشرة كسماد أو تخلط بمواد أخرى كالقمامة وتخمر (كومبوست) قبل استعمالها ٠

ويعد انتاج الغاز البيولوجي أفضل وسيلة فعالة واقتصادية لاستخدام متخلفات الانسان والحيوان • ولقد قدر أنه لو أتيح استخدام كل ماتنتجه أبقار الهند من روث لأمكن انتاج حوالى ١٧ مليون قدم مكعب من الغاز البيولوجي سنويا وهذا الغاز يمكن استعماله فى طهى الطعام والاضاءة وادارة الآلات • وعلاوة على انتاج الغاز فان المواد المتخلفة تستخدم كسماد يفضل بمراحل المادة الخام الأصلية من حيث القوام ولارتفاع نسبة مايحتويه من دبال ونيتروجين ولخلوه من الميكروبات الضارة وبيض الذباب •

البقايا النباتية الزراعية من قش وحطب وأوراق وغير ذلك وكذا مخلفات صناعة الخشب وقصب السكر وغيرها كلها تحتوى على العناصر المغذية للنبات ويجب اعادة استخدامها فى الأرض بدلا من حرقها • فمثلا فى اليابان يبلغ مقدار قش الأرز المنتج سنويا ١٩ مليون طن تحتوى على ٩٥٠٠٠ طن أزوت و ١١٠٠٠ طن فوسفور و ٢٨٤٠٠٠ طن بوتاسيوم • وفى حالات كثيرة يمكن حرث بقايا المحاصيل فى الأرض مباشرة ولكن هذا الأسلوب قد يؤدى الى فقر الأرض فى النيتروجين الصالح لاستعمال النباتات النامية وانتشار آفات المحاصيل الزراعية لذلك يفضل تحويل هذه البقايا النباتية الى "كومبوست" أو استخدامها فى انتاج الغاز البيولوجي قبل اضافتها الى الأرض •

متخلفات المدن والمصانع شديدة التباين ويمكن تقسيمها الى مواد صلبة وأخرى سائلة والمواد الصلبة يمكن تحويلها الى "كومبوست" أما الجزء السائل فيمكن استعماله فى الأراضى الزراعية كمصدر لمياه الرى وكسماد فى نفس الوقت •

أفضل المحاصيل المستخدمة كسماد أخضر هى المحاصيل القادرة على تثبيت نيتروجين الهواء الجوى كالبقوليات ويمكن ادخالها ضمن الدورة الزراعية ثم قلبها فى الأرض أو زراعتها محملة مع محاصيل أخرى أو زراعتها كسياج (السسبان حول حقول الأرز)•

وأخيرا يجدر الاشارة الى القيمة السمادية للأعشاب المائية التى تنمو بغزارة خاصة فى المناطق الحارة بالمجارى المائية وتمتص كميات كبيرة من العناصر المغذية ويمكن استخدامها فى صناعة الكومبوست أو كعلف للحيوان • ومن أمثلة النباتات المائية نبات الأزولا الذى يثبت النيتروجين بالتكافل مع طحلب أخضر مزرق وهذا النبات يمكنه أن ينتج حوالى طن من المادة الخضراء للهكتار فى اليوم تحتوى على ٣ كجم نيتروجين •

ولقد تبنت منظمة الأغذية والزراعة بالاشتراك مع السلطة السويدية للتنمية الدولية الخبرة الاستشارية فى استخدام المواد العضوية كسماد فعقدت اجتماعا للخبراء فى روما عام ١٩٧٤ وندوة عن استخدام المواد العضوية فى بانكوك عام ١٩٧٦ وتوصى هذه الاجتماعات والندوات باعادة استخدام المواد العضوية مع استعمال الأسمدة المعدنية •

كما قامت هذه الهيئات بتنظيم رحلتين الى الصين واحدة عام ١٩٧٧ والأخرى عام ١٩٧٨ لتدرس بصفة خاصة استخدام نبات الأزولا فى حقول الأرز وتكنولوجيا انتاج الغاز البيولوجي • كما عقدت دورات تدريبية فى آسيا وغرب افريقيا وغالبا مايتبع هذا التدريب اقامة مشاريع رائدة على مستوى محدود •

٢ ـ دور المواد العضوية فى الزراعة المصرية وفى المحافظة على قدرة الأرض الانتاجية

أ ٠ ص ٠ عبد الغفار
كلية الزراعة ــ جامعة الاسكندرية (ج ٠ م ٠ع)

فضل الأسمدة العضوية فى الاحتفاظ بخصوبة الأراضى الزراعية ورفع قدرتها الانتاجية من المحاصيل معروف لا ينكره أحد ٠ ولقد تحملت الأسمدة العضوية وحدها عبء امداد المحاصيل الزراعية بالعناصر المغذية الى عام ١٩٠٦ حيث بدأ استيراد سماد نترات الصودا من شيلى ٠

وتدل نتائج تجارب التسميد المستديم ببهتيم وغيرها من البحوث والتجارب التى أجريت بجمهورية مصر العربية أن الأسمدة العضوية بصفة عامة تفوق الأسمدة المعدنية من حيث تأثيرها على غلة كثير من المحاصيل مثل القطن والقمح والذرة والبرسيم وكذلك محاصيل الفاكهة والخضر ٠ كما ان اضافة السماد العضوى يؤدى الى زيادة محتوى الأرض من المواد الدبالية مما يكون له أكبر الأثر فى تحسين خواص الأرض الطبيعية والكيماوية والحيوية ٠

وأراضى مصر الزراعية فقيرة فى المادة العضوية حيث تتراوح نسبة المادة العضوية فى الأراضى الطينية بين ١ر٥ و ٢ر٥ ٪ وفى الأراضى الرملية قد لا تزيد عن ١ر٠ ٪ ويعزى فقر الأراضى الزراعية فى محتواها من المادة العضوية الى عوامل كثيرة منها اهمال التسميد العضوى بصفة عامة وعدم كفاية ماينتج من سماد الاسطبل (يعرف فى مصر باسم السباخ البلدى) بالاضافة الى رداءته بسبب قلة مايحويه من مادة عضوية وعناصر غذائية نظرا لاستعمال التراب كفرشة فى أغلب الأحيان ولأخطار عديدة تقع عند تحضيره وخزنه على أن استعمال البقايا النباتية مثل القش كفرشة تحت المواشى يزيد من القيمة السمادية لسماد الاسطبل المنتج فى مصر ٠

ويمكن توفير احتياجات الزراعة من الأسمدة العضوية بتحويل متخلفات المدن والقرى والمزارع والمصانع الى "كومبوست" وذلك بتخميرها بطريقة مناسبة ٠ كما يمكن استعمال بعض هذه المتخلفات مباشرة دون تخمير بشرط اضافتها الى الأرض قبل الزراعة بمدة كافية لانحلالها وأن تكون الأرض رطبة طوال هذه المدة أو تخلط بسماد أزوتى عند استعمالها مع الزراعة ٠

٣ ــ مصادر المادة العضوية الممكنة في مصر

أحمد ريــــاض
وزارة الزراعة ــ القاهرة (ج ٠ م ٠ع)

تبلغ احتياجاتنا من الأسمدة العضوية حوالى ١٧٠ مليون طن سنويا على ان انتاج الأسمـــــــــدة العضوية فى الوقت الحاضر تقدر بحوالى ٨٨ مليون طن فى السنة موزعة كالآتى :

٠٠٠ ٠٠٠ ٨٥	طن	سماد اسطبل أو مايعرف فى مصـــر بالسباخ البلدى
٠٠٠ ٤٠٠ ٢	طن	سماد المجارى ويعرف أيضا بسماد البودريت
٠٠٠ ٢٠٠	طن	سماد قمامة المدن
٠٠٠ ٨٠	طن	سماد الطيور الداجنة كزبل الحمام وزرق الدجاج والبط ٠٠ الخ
٠٠٠ ٥٠	طن	سماد ناتج من تخمير متخلفات المزرعة والحديقة ويعرف باسم السمـــــاد العضوى الصناعى
٣٠٠ ١٢	طن	سماد متخلفات المذابح مثل الدم المجفف

ومعنى هذا انه يوجد عجز فى انتاج الأسمدة العضوية فى مصر يقدر بحوالى ٨٢ مليون طن سنويــا ويمكن تصحيح رصيد البلاد من الأسمدة العضوية ولو جزئيا عن طريق :

١ــ تحسين طرق تحضير سماد الأسطبل وتخزينه واستخدامه ٠

٢ــ الاستفادة التامة من متخلفات المجارى فى انتاج مايعرف بسماد المجارى ٠

٣ــ تحويل قمامة المدن ومتخلفات المزرعة ومصانع حفظ الفاكهة والخضر ومصانع السكر وغيرها الى سمـــاد عضوى ٠

٤ــ استغلال كل متخلفات المذابح والمدابغ كسماد عضوى ٠

٥ــ استعمال الأعشاب البحرية بعد غسلها بالماء كفرشة لمواشى الزراعة او اضافتها الى أكوام سمـــاد الاسطبل ٠

٦ــ استغلال بقايا الأسماك كسماد بعد معاملتها ببخار الماء لاستخلاص الدهون والجيلاتين ٠

٧ــ استغلال رواسب الكفرى والماروج وجوانو الوطاويط والطيور البحرية المنتشـــرة فى مصـــر ٠

٨ــ تحويل تراب الخشب ونشارته الى سماد ٠

٩ــ توجد رواسب اللجنيت فى سيناء ويمكن استخدامها كمصدر للمادة العضوية ٠

٤ ــ أهمية المواد العضوية والتثبيت البيولوجي للنتروجين في الانتاج الزراعي

ج • س• فيد يارثي ، ر• ف • مســرا

وزارة الزراعة والري ــ نيودلهي (الهنــد)

ان استعمال المواد العضوية كسماد يؤدي الى زيادة الانتاج الزراعي نتيجة لما تضيفه الى الأرض من عناصر مغذية ولتحسين خواص الأرض الطبيعية والكيماوية والحيوية علاوة على حل كثير من المشاكل الخاصة بالصحة وتلوث البيئة • لذلك يلزم المحافظة على المواد العضوية واعادة استخدامها كسماد عضوي بعد معاملتها بالطرق العلمية المناسبة •

استعمال بقايا محاصيل الحبوب كغطاء للنباتات النامية يؤدي الى حفظ رطوبة وحرارة الأرض ويساعد على مقاومة الحشائش وينتج عن ذلك زيادة في المحصول تقدر بحوالي ١٤ـ٢٩٪ وقد وصلت في حالة البسلة الى ٧٧٪ •

اضافة تبن القمح بمعدل ٢ و ٥ طن /هكتار أدى الى زيادة محصول الفول السوداني بمقدار ٦٦٪ و ٩٦٪ على التوالي ، بينما اضافة ١٠طن /هكتار أدى الى زيادة المحصول بمقدار ٤٪ فقط• وقد زاد محصول الأرز بحوالي ٤١٪ نتيجة للتسميد بسماد الاسطبل كما وجد ان اضافة سماد الاسطبل الى حقول القمح يعمل على زيادة كفاءة الأحياء الدقيقة المذيبة للفوسفات •

وتدل نتائج الدراسات التي أجريت على تلقيح بذور المحاصيل البقولية بسلالات فعالة من بكتيريا العقد الجذرية الخاصة بكل محصول على أن هذه المعاملة تؤدي الى زيادة المحصول بمقدار يتراوح بين ١٩٪ و٣٢٪ وهذه الزيادة تعادل التسميد بمقدار ٤٠ كجم نتروجين /هكتار•

وتوضح الدراسات الحديثة أهمية الأحياء الدقيقة المثبتة لنتروجين الهواء الجوي لا تكافليا مثل بكتريا الأزوتوباكتر والكلوستريديوم وخاصة في منطقة الجذور (ريزوسفير) حيث يصل مقدار ماتثبته الى حوالي ٧٩ كجم نتروجين /هكتار•

كما وجد أن اضافة مزارع الأزوتوباكتر الى حقول الأرز والشعير والقمح يوفر حوالي ٢٥٪ من كمية النتروجين المستعمل في التسميد • كما أن اضافة السماد العضوي يؤدي الى زيادة اعداد ونشاط الأحياء الدقيقة المثبتة للنتروجين •

وتعتبر الطحالب الخضراء المزرقة مصدر هام لنتروجين الأرض وتحتل مكانا مرموقا في حقول الأرز حيث يتراوح مقدار ماتثبته من نتروجين الهواء الجوي من ٤٠ الى ٨٠ كجم نتروجين /هكتار بالاضافة الى ماينتج عن نموها من مواد منشطة لنمو النباتات •

وحديثا انتشر استعمال الأزولا في كثير من البلدان مثل فيتنام والصين وتايلند واندونيسيا والهند كسماد عضوى فى حقول الأرز ٠ والأزولا نبات سرخسى ينمو طافيا فى المياه الراكدة غير العميقة ويوجد بأوراقه فجوات يعيش بداخلها طحلب أخضر مزرق يقوم بتثبيت النتروجين ويقدر مايثبت من نتروجين الهواء بواسطة هذه النباتات بحوالى ١٠٠ ـ ١٦٠ كجم نتروجين/هكتار خلال ٣ـ٤ شهر٠

وحاليا توجه عناية خاصة فى الهند الى برامج ميكنة عملية الكومبوست واستعمال متخلفات المجارى وانتاج البيوجاز وزراعة المحاصيل البقولية واستعمال الأسمدة الميكروبية٠

٥ ـ المشاكل المتعلقة باستخدام المواد العضوية كسماد في الريف ووسائل العـــــــلاج

جوان س • دافيز
المعهد السويسري الفيدرالي لمصادر المياه والتلوث
(د • بندروف ـ سويســرا)

مازال دور الأسمدة العضوية في تحسين الانتاج الزراعي دون المستوى الممكن له • ولا يرجع ذلك الى المشاكل المصاحبة بقدر ماهو راجع الى المعايير التي تستعمل للحكم على تأثيراتها النافعة • فمازال التقييم يؤسس على معايير لا تأخذ في اعتبارها دوام انتاجية الأرض • زيادة المحصول ـ كأحد هذه المعاييـر ـ يتخذ في حد ذاته كهدف دون النظر الى الهدف الأكبر وهو الطعام للجميع • كذلك معيار الكفـــاءة الذي يعني كمية الجهد الانساني الذي يبذل لانتاج وحدة سلعية بصرف النظر عن المستهلك مـــن الموارد الطبيعية ويؤدي الى زيادة حصيلة الفرد المشترك في عملية الانتاج لكنه في نفس الوقت يستبعـــد الكثير ممن لا يشتركون في هذه العملية ويحرمهم بالتالي من الدخل ويحدّ من قدرتهم الشرائية•

ويتميز الاتجاه الحالي بزيادة تلوث البيئة وخفض قدرة الأرض الانتاجية وزيادة البطالة ونقص الموارد والاعتماد على المصادر الخارجية للطعام والطاقة • لهذه الأسباب ولكثير غيرها يجب اعادة النظر فـــي تقييم دور الأسمدة العضوية في الزراعة بمعايير تأخذ في اعتبارها المجتمع ككّل وليس بمعايير خاصة بعوامـل منفردة • وبهذه المعايير الشاملة يمكن الحكم على فوائد المادة العضوية بطريقة أكثر ايجابية •

ونحن نمر بمرحلة تتطلب أن نحصل على أعلى انتاج بأقل طاقة ممكنة وهذا لا يتأتى في البلاد الناميـــة الاّ بالاستخدام الحكيم للأسمدة العضوية والعمل الانساني في الزراعة حيث تقل التكلفة •

والحاجة الى توفير الأسمدة العضوية قد أدى الى العمل على زيادة الكميات المتاحـة عن طريــــق الكومبوست ومعاملة متخلفات المجاري وغير ذلك • كما يجب الاهتمام بالمحاصيل البقولية كمصدر أساســـي للتسميد العضوي حيث أن هذه المحاصيل تثبت من نتروجين الهواء الجوي كميات تتراوح بين ٧٣ و٥٧٧ كجم نتروجين/هكتار/سنة •

ونظرا لاستخدام بعض المواد العضوية مثل بقايا المحاصيل الزراعية وروث حيوانات المزرعة كوقود فـــي الريف فانه يلزم توفير بديل لهذه المواد العضوية مثل انتاج الغاز البيولوجي واستعمال الطاقة الشمسيـــة وأخشاب أشجار سريعة النمو • وأفضل استخدام لمتخلفات المحاصيل الزراعية هو تحويلها الى الكومبوســـت حيث أن ذلك يؤدي الى انتاج سماد عضوي جيد ويقضي على انتشار الآفات كما يمكن استعمالها أيضا فـــي

انتاج الغاز البيولوجي مع متخلفات الانسان والحيوان • كما يمكن استعمال الطحالب وبعض النباتات المائية كسماد عضوى وفى تنقية مياه المجارى من الملوثات •

ويجب أن يكون الهدف فى الانتاج الزراعى هو خفض التكاليف والاعتماد على الموارد المحلية وليس على الاستيراد • وهذا هو الدور الأساسى للأسمدة العضوية فاستخدامها يحقق توفير الطعام والانتاج الاقتصادى للمحاصيل والمحافظة على انتاجية الأرض علاوة على ايجاد فرص للعمل وحماية البيئة من التلوث• فلا شك ان الاستخدام الأمثل للموارد العضوية من شأنه أن يحل مشاكل اليوم والغد •

٦ — كومبوست متخلفات المجارى لتحسين خواص الأرض

ج • ف • بار — ج •ب ويلسون • د •كولاسيكو
وزارة الزراعة — بلتزفيل (ميريلاند — الولايات المتحدة الامريكية)

ان التشريعات الحديثة فى الولايات المتحدة الأمريكية تحدّ من عمليات التخلص من متخلفات المجارى بالحرق أو تصريفها فى نهر أو محيط أو القائها فى المناطق المنخفضة ، لذلك بدأ التفكير فى استعمال هذه المتخلفات كسماد للأراضى الزراعية• فمخلفات المجارى تحتوى على المغذيات الكبرى والصغرى مثل النتروجين والفوسفور والبوتاسيوم والزنك والنحاس والمنجنيز وغيرها من عناصر يحتاج اليها النبات فى نموه •

ويمكن اضافة متخلفات المجارى الى الأراضى مباشرة كسائل يحتوى على ٢—١٠٪ مواد صلبة أو بعد ازالة جزء من مائه ليحتوى على ١٨—٢٥٪ مواد صلبة على أن مشاكل كثيرة تنشأ من اضافة هذه المتخلفات من أخطار على الصحة العامة لما قد تحتويه من ميكروبات ممرضة للانسان ومن تلوث للبيئة لاحتوائها على عناصر ثقيلة ومواد عضوية سامة قد يمتصها النبات وتصبح خطرا على الانسان وذلك علاوة على ماتحتاجه هذه الطريقة من معدات خاصة لنقلها وعدم اقبال المزارعين على استعمال هذه المتخلفات•

ويمكن التغلب على هذه المشاكل أو التخفيف من حدتها باجراء عملية تخمير لهذه المتخلفات أو مايعرف باسم "كومبوست" والتخمير طريقة قديمة استخدمت لتحويل المتخلفات العضوية الى سماد • وفى عام ١٩٧٣ توصل مركز البحوث الزراعية بمدينة بلتزفيل بالولايات المتحدة الأمريكية الى طريقة لتحويل حمأة (سلدج) المجارى (وهى المواد المترسبة من مياه المجارى) الى سماد بتخميرها تحت ظروف هوائية لمدة ٧ أسابيع • وتتلخص الطريقة فى خلط الحمأة (تحتوى على ٢٠—٢٥٪ مواد صلبة) ببقايا ومتخلفات نباتية (مثل الورق والقمامة ونشارة الخشب) وعمل كومات من هذا الخليط وتقليبها ميكانيكيا لضمان الظروف الهوائية وقد يستعمل هواء تحت ضغط لهذا الغرض • والسماد الناتج يكون خالى من الميكروبات الممرضة نظرا لارتفاع درجة حرارة الكومة أثناء التخمير كما انه عبارة عن مادة تشبه الدبال خالى من الروائح غير المرغوب فيها • وعلى عكس الحمأة يمكن تخزين هذا السماد الناتج وسهل تداوله واستعماله •

٧ ـ تأثير بعض العوامل الكيميائية والفيزيائية على عملية الكومبوست وصفات السماد الناتج

ج • ف • بار ـ ج •ب• ويلسون ـ ر• ل • تشانى ـ ل •ج سيكورا ـ ث • ف • تستر
وزارة الزراعة ـ بلتزفيل (ميريلاند ـ الولايات المتحدة الأمريكية)

الغرض الأساسى من عملية تخمير المتخلفات العضوية (كومبوست) هو تحويل هذه المتخلفات الى سماد عضوى خالى من الروائح الكريهة والميكروبات المعدية علاوة على حماية البيئة • لذلك استحدثت وزارة الزراعة الأمريكية بالتعاون مع هيئة خدمة البيئة فى بلتزفيل بميريلاند طريقة الكومة المهواة لتحويل حمأة المجارى(سلدج) المعاملة أو غير المعاملة الى سماد عضوى صالح للاستعمال بعد ٧ أسابيع•

وتختلف حمأة المجارى اختلافا بينا فى صفاتها الكيميائية والطبيعية ويتوقف ذلك على طريقة معالجة مياه المجارى وعلى نوع وكمية مخلفات الصناعة الداخلة فيها • واذا كان المطلوب هو اتمام عملية الكومبوست بسرعة وكفاءة فانه يلزم أن تكون درجة الحرارة ونسبة الرطوبة والتهوية ونسبة الكربون الى الأزوت ودرجة الحموضة وحجم مكونات الكومة عند الدرجة المثلى لحدوث الانحلال تحت ظروف هوائية وفى درجات الحرارة المرتفعة • فاذا ما انحرفت هذه العوامل الرئيسية عن الحد الأمثل لها تأثر بذلك نمو ونشاط الأحياء الدقيقة المحللة للمواد العضوية وأصبح من غير الممكن انجاز عملية "الكومبوست" بنجاح •

كذلك فان بعض الخواص الكيميائية لحمأة المجارى (سلدج) وللمتخلفات التى تخلط بها تؤثر على حسن سير عملية "الكومبوست" وصفات السماد المنتج مثل التركيز العالى من الأملاح الذائبة ووجود مواد عضوية سامة ومعادن ثقيلة وكربونات الجير وكلوريد الحديد • هذا بالاضافة الى الخواص الفيزيائية لمكونات الكومة مثل درجة السيولة ودرجة الانضغاط • ويمكن تحسين صفات السماد المنتج بامراره فى مناخل واضافة العناصر المغذية واجراء عمليات تحبيب له •

ولضمان الظروف الملائمة من رطوبة وحرارة وتهوية أثناء عملية الكومبوست للحصول على سماد جيد مقبول فانه يلزم وجود نظام محكم للرقابة على هذه العملية •

٨ ـ مصادر المتخلفات العضوية في مصر

م• عبد السميع
المركز القومي للبحوث ـ القاهرة (ج•م•ع)

المتخلفات العضوية تعتبر مواد متجددة تنشأ من عمليات التمثيل الضوئي بواسطة النباتات الخضراء وتشمل الآتي :

١ـ بقايا المحاصيل الزراعية من جذور وأوراق وسوق التي تبقى في الأرض بعد الحصاد •

٢ـ بقايا محاصيل الحبوب مثل قش الأرز والقمح والشعير وحطب وقوالح الذرة وغير ذلك •

٣ـ مخلفات طحن الحبوب•

٤ـ مخلفات التصنيع الزراعي مثل مصانع قصب السكر والنشا والبيرة ومعاصر الذرة لاستخراج الزيت ومصانع حفظ الفاكهة والخضر ومعاطن الكتان ومتخلفات السلخانات والمدابغ وغير ذلك •

٥ـ الأعشاب المائية وحشائش الأرض •

والبقايا النباتية تستخدم كعلف للحيوان فيما عدا حطب القطن الذي يستعمل في الريف وكذا روث حيوانات المزرعة بعد التجفيف كوقود • ويجب العمل على اعادة استخدام المواد العضوية والمحافظة عليها من الضياع عن طريق الحرق • ولعل أفضل وسيلة لذلك هو انتاج الغاز البيولوجي لاستخدامه في الوقود واستعمال الحمأة المتبقية كسماد •

وقد وجد أن حطب القطن أكثر مقاومة للانحلال والتخمر عن بقايا المحاصيل الأخرى ويرجع ذلك الى وجود مركبات مثبطة لنشاط ميكروبات التخمر اللاهوائي وقد أمكن التغلب على هذه المشكلة بنقع حطب القطن في الماء لمدة ٢ـ٤ يوم•

ومن ضمن المتخلفات العضوية التي يجب أخذها في الاعتبار أوراق ولوز القطن المصابة فقد أمكن تخميرها لانتاج سماد عضوي بطريقة الكومبوست وهذا يساعد على عدم انتشار الاصابة •

٩ ـ السماد الأخضر

س ٠ أ ٠ ز ٠ محمود ـ م ٠ الصاوى
كلية الزراعة ـ جامعة عين شمس ـ القاهرة (ج ٠ م ٠ ع)

يقصد بالتسميد الأخضر زراعة محصول سريع النمو غالبا محصول بقولى وحرثه فى الأرض عادة عند الأزهار وقبل النضج ٠ وهو نظام متبع منذ القدم ومن أيام الرومان ٠ والتسميد الأخضر وسيلة فعالة للمحافظة على عناصر الأرض المغذية من الفقد بالترشيح علاوة على امداد الأرض بالنتروجين والمادة العضوية ومقاومة الحشائش الضارة ٠ وأهم المحاصيل التى تستعمل فى التسميد الأخضر :

١ ـ المحاصيل البقولية وخاصة البرسيم ويمكن أخذ حشة منه قبل قلبه فى الأرض، كما هو متبع قبل زراعة القطن ٠ كذلك البقوليات الأخرى مثل اللوبيا وفول الصويا وهذه يمكن قلبها فى الأرض بعد جمع المحصول ٠

٢ ـ البقوليات التى تنمو كشجيرات مثل السسبان وهذه النباتات بطيئة الانحلال وتضيف كميات كبيرة من المادة العضوية والنتروجين للأرض ٠

٣ ـ النباتات المائية مثل " الهياسنت " الذى ينمو فى مجارى مياه الرى والصرف ويمتص كميات كبيرة من العناصر المغذية التى توجد فى هذه المياه ٠

٤ ـ الطحالب الخضراء المزرقة ٠

٥ ـ نباتات الأزولا ٠

وفى مصر استعمل التسميد الأخضر بنجاح فى الأراضى الرملية التى توضع تحت الزراعة وقد أدى ذلك الى زيادة محتوى الأرض من المادة العضوية والنتروجين وتبع ذلك زيادة ملحوظة فى انتاجية الأرض من المحاصيل المنزرعة ٠

١٠ — استخدام المواد العضوية كمصلحات للأرض

ف • جاتى
الأكاديمية المجرية للعلوم — بودابست (المجر)

ان المحافظة على قدرة الأرض الانتاجية وضمان الحصول على انتاج وفير من المحاصيل المنزرعة يتطلب احتواء الأرض على مستوى معين من المادة العضوية • فالمعروف أن الأراضى العالية الانتاج عادة تحتوى على نسبة عالية من المادة العضوية • والحفاظ على مستوى مناسب من مادة الأرض العضوية مهم خاصة فى أراضى المناطق الجافة وشبه الجافة حيث تعانى الأراضى من فقر المواد الدباليه ونقص العناصر المغذية •

والمواد العضوية فيما يهم الأرض والنبات هى الدبال وكل ماوجد فى الأرض من مواد يعود أصلها الى النبات أو الحيوان علاوة على احياء الأرض الدقيقة • وهذه المواد تؤثر لدرجة كبيرة على خواص الأرض الطبيعية والكيماوية والحيوية وبالتالى على خصب الأرض وقدرتها الانتاجية •

وتحدد خواص الأرض والمناخ والنظم المزرعية المتبعة والمحاصيل المنزرعة والمواد العضوية المتاحة محليا الطريقة المثلى لاستخدام المواد العضوية فى كل دولة أو منطقة •

والتسميد الأخضر معروف منذ عهد الرومان وهو عبارة عن زراعة محصول غالبا بقولى مثل الترمس والفول والبسلة والبرسيم — وقلبه فى الأرض قبل مرحلة النضج • وتوضح البحوث التى أجريت بالمجر أهمية التسميد الأخضر فى الأراضى الرملية حيث يؤدى الى زيادة محتوى الأرض من المادة العضوية والنتروجين •

وعادة يستخدم قش وأحطاب محاصيل الحبوب فى انتاج سماد الاسطبل فى المزارع الصغيرة أما فى المزارع الكبيرة فتحول هذه المتخلفات النباتية الى سماد عضوى بطريقة الكومبوست • وقد وجد أن استعمال هذه الأسمدة يؤدى الى زيادة نسبة المواد الدبالية فى الأرض ويعمل على تحسين خواص الأرض الطبيعية والكيماوية علاوة على حماية الأرض ضد عمليات التعرية بالماء والرياح • كما وجد أن كومبوست البقايا النباتية يفضل استعمال هذه البقايا مباشرة دون تخميرها • ويستعمل كومبوست الرواسب العضوية المعروفة باسم " البيت " كمصلح للأراضى فى المجر وبولندا والاتحاد السوفيتى •

وقد تستعمل البقايا النباتية كغطاء للأرض خاصة فى الأراضى الرملية لحماية الأرض ضد التجريف بالماء والرياح ولمقاومة الحشائش وللمحافظة على رطوبة الأرض •

ومن أجل تحسين خواص الأراضى الرملية الفقيرة فى المواد الدبالية والعناصر المغذية فانه يلزم تكوين طبقة خصبة عميقة نسبيا ويتم ذلك اما بحرث مواد عضوية فى طبقة عمقها ٤٠ سم أو بوضع طبقة من

المواد العضوية على عمق ٤٠ـ٦٠ سم • ووضع طبقة عميقة من المواد العضوية يؤدى الى زيادة صلاحية الماء والعناصر المغذية لاستعمال النباتات النامية ويبقى تأثيرها لعدة سنوات وبالتالى زيادة انتاجية الأرض بلغت ٢٠ـ٤٠٪ فى حالة محاصيل الحبوب و ٤٠ـ٦٠٪ لمحاصيل العلف و ٦٠ـ٩٠٪ للبطاطس•

وقد يستعمل مخلوط من الطمى والمواد العضوية لتحسين انتاجية الأراضى الرملية كما يمكن استخدام بعض نواتج صناعة البترول مثل البتومين كمواد مصلحة للأرض •

١١ ــ المواد العضوية وتحسين خواص الأرض الفيزيائية

ج • ن • ام
معهد العلوم الزراعية ــ سيول (كوريا)

تؤدى اضافة المادة العضوية الى تحسين تهوية وزيادة نفاذية الأراضى السلتية والطينية وزيادة السعة المائية والماء الصالح فى الأراضى الرملية كما تعمل المادة العضوية على خفض قابلية الأرض للتعرية والانجراف وزيادة مقاومتها للانضغاط•

يمكن أن يكون بناء الأرض عامل محدد لقدرة الأرض الانتاجية فالأراضى ذات الحبيبات المركبة تكون حالتها الفيزيائية أكثر ملائمة لنمو النباتات لما توفره من ماء وهواء •

وقد وجد أن الحبيبات التى يتراوح قطرها من ٢٥ر٠ مم الى ٣ مم تؤثر تأثيرا فعالا فى قابلية الأرض للخدمة والتفتت وحفظ الماء•

وتوجد علاقة موجبة بين مادة الأرض العضوية ودرجة التحبب أو البناء • على أن تأثير اضافة المادة العضوية على تحبب الأرض يختلف تبعا لحالة الأرض ويكون أكثر وضوحا فى الأراضى الفقيرة فى المادة العضوية وفى الأراضى الثقيلة والمتوسطة القوام• كما أن المواد العضوية التى تتحلل بسرعة لها تأثير سريع ولكنه لا يستمر لمدة طويلة بينما تلك التى تتحلل ببطء لها تأثير بطىء ويبقى لمدة أطول •

وخاصية النفاذية للماء والهواء تحدد تهوية الأرض التى تشجع نمو الجذور وبالتالى زيادة المحصول وهى دالة للتوزيع الحجمى للمسام فى الأرض وخاصة المسام غير الشعرية • وقد وجد أن المادة العضوية تعمل على زيادة الحبيبات ذات الأحجام الكبيرة وبالتالى تزيد من نسبة المسام غير الشعرية فتزيد نفاذية الأرض وتوفر التهوية الجيدة للنباتات النامية •

وتتميز المادة العضوية بسعتها العالية لحفظ الماء وعلى ذلك فان اضافتها للأرض يؤدى الى زيادة الماء الصالح للنباتات • وترتبط انتاجية الأراضى المنحدرة على قابلية هذه الأرض للنحر والتجريف ويتوقف ذلك على صفات الأرض الطبيعية وخاصة النفاذية وقابلية حبيباتها للتفرق والتفتت • واضافة المادة العضوية لهذه الأراضى تقلل من قابلية حبيبات الأرض للتفرق ويزيد من سرعة تخلل الماء للأرض وبذلك تقل قابلية الأرض للتعرية والانجراف • وعلاوة على ذلك فان اضافة المادة العضوية تعمل على تقليل تأثير استخدام الآلات الزراعية الثقيلة على تماسك الأرض وقابليتها للانضغاط •

١٢ — اللجنايت كمصلح للأرض ومصدر للمادة العضوية

أنجى زين العابدين — أ• حسنى
كلية الزراعة — جامعة القاهرة — الجيزة (ج م ع)

اللجنايت رواسب طبيعية لمواد عضوية متحللة ذو خواص متوسطة بين الدبال (بيت) والفحم وله من الصفات الطبيعية والكيميائية مايجعله مناسبا للاستخدام فى الأرض كمصدر للمادة العضوية وكمصلح لخواصها ، خاصة فى الأراضى الرملية بالمناطق الجافة وشبه الجافة • وقد أختبرت مقاومة اللجنايت للانحلال أو التحلل عند اضافته للأرض وذلك بتقدير العدد الكلى لميكروبات الأرض من بكتريا وفطريات واكتينومايسيتات وبالفحص الميكروسكوبى لحبيبات الأرض المعاملة باللجنايت اتضح من ذلك ان اللجنايت مقاوم للانحلال بفعل الميكروبات ولكنه يتعرض للتفتت والتشقق نتيجة لعمليات الابتلال والجفاف ومن المتوقع أن يبقى فى الأرض لمدة طويلة قد تصل الى عدة سنوات •

وتدل نتائج التجارب الحقلية التى أجريت بأراضى رملية بمحافظة الاسماعيلية عوملت باللجنايت وسماد الأسطبل على أن مادة اللجنايت مقاومة لفعل الميكروبات وأن اضافتها عمل على بناء مادة الأرض العضوية أثناء موسم الزراعة وتحسين خواص الأرض المائية وشجع عملية غسيل الأملاح دون احتمال ظهور القلوية •

١٣ — تأثير التسميد المستديم بسماد الاسطبل على بعض خواص الأرض

أ • ط • مصطفى
مركز البحوث الزراعية — الجيزة (ج م ع)

نشأت فى مصر التجارب المستديمة ببهتيم عام ١٩١٢ لدراسة مدى تأثير التسميد المعدنى المستمر على غلة المحاصيل المختلفة وخواص الأرض الكيماوية والطبيعية تحت دورات زراعية متنوعة • وفى عام ١٩١٩ عدلت التجربة لتشمل دراسة تأثير التسميد العضوى (سماد الاسطبل) المستمر •

وقد قام كثير من الباحثين باجراء تحليل لعينات أراضى أخذت من المعاملات المختلفة فى أزمنة متفاوتة منذ اقامة التجربة • وتدل النتائج المتحصل عليها على أن اضافة السماد العضوى قد أدى الى زيادة محتوى الأرض من المادة العضوية بينما كان التأثير على الخواص الأخرى مثل النفاذية والنسبة المئوية للصوديوم المتبادل طفيفة • كما لوحظ أن انتاجية الأرض من المحاصيل المنزرعة كان أعلى فى حالة التسميد العضوى عنه مع التسميد المعدنى •

١٤ ــ المكونات الأساسية لدبال الأراضي المصرية

م٠ خضر ــ خ ٠ خلــــف
كلية الزراعة ــ جامعة الأسكندرية (ج م ع)

تدل الدراسة التي أجريت لتقدير الدبال ومكوناته لأراضي رسوبية (الدلتا) وأراضي بحيرية (أبيس) وأراضي رملية (مديرية التحرير الجنوبية) وأراضي جيرية (مديرية التحرير الشمالية) وأراضي قلوية بالدلتا على أن هذه الأراضي تختلف في محتواها من الكربون العضوي ومن حامض الهيوميك وحامض الفلفيك ٠

وقد تدرجت نسبة الكربون العضوي للمواد الدبالية من ٠ر٣٥٪ الى ٠ر٩٣٪ بمتوسط قدره ٠ر٥٩٪ وانحراف قياسي ٠ر١٤٪ وكانت نسبة الكربون العضوي أعلى في الأراضي الرسوبية والجيرية عنها في الأراضي الرملية كما قلت نسبة المادة العضوية مع العمق ٠

وتراوحت نسبة كربون حامض الهيوميك من ١ر٤٥٪ الى ٦٦ر٦٥٪ بمتوسط قدره ٣ر٢٨٪ وانحراف قياسي ٤ر١٥٪ وبلغت أعلى قيمة في أراضي البحيرات ثم الرسوبية وأقل قيمة في الأراضي القلوية ثم الجيرية٠ وبالنسبة للعمق فان نسبة حامض الهيوميك قد زادت زيادة طفيفة في أراضي البحيرات وقلت في الأراضي الرملية والجيرية والقلوية ولم تتغير في الأراضي الرسوبية مع عمق طبقة الأرض ٠

واختلفت نسبة كربون حامض الفلفيك من ٦ر٤٩٪ الى ٥٧ر٤٤٪ بمتوسط قدره ٣٠ر٦٧٪ وانحراف قياسي ١٦ر٤٪ وكانت أعلى نسبة له في أراضي البحيرات وأقلها في الأراضي الجيرية وقد اتجهت نسبة حامض الفلفيك الى النقصان في الأراضي القلوية والجيرية والى الزيادة في الأراضي الرملية ولم تتغير في الأراضي الرسوبية مع العمق٠

١٥ ــ تأثير المادة العضوية على تحبب الأرض

ع ٠ م ٠ جمعــــة
كلية الزراعة ــ جامعة الأسكندرية (ج م ع)

أجريت دراسة لمعرفة تأثير اضافة المادة العضوية على درجة ثبات بناء الأرض وتكوين حبيبات مركبة باستخدام تبن البرسيم والقمح وحطب القطن وأرض طميية طينية وأخرى جيرية ، وقد دلت النتائج على أن اضافة أي من هذه المواد قد نتج عنه زيادة معنوية في النسبة المئوية للحبيبات التي تزيد أقطارها عن ٤ر٧٦ مم وذلك على حساب النسبة المئوية للحبيبات التي تتراوح أقطارها بين ٠ر٢١ ــ ٠ر١ مم ٠ كما لوحظ أن التأثير الأقصى حدث خلال الأسبوع الثاني من بدء التجربة وأن تأثير تبن البرسيم كان أعلى من تأثير تبن القمح وحطب القطن ٠ وقد حسب معامل البناء وهو يساوي النسبة المئوية للحبيبات التي تزيد أقطارها عن ٠ر٢٥ مم مقسومة على النسبة المئوية للحبيبات التي تقل أقطارها عن ٠ر٢٥ مم فوجد أنه يزيد زيادة لوغاريتمية بزيادة معدلات الاضافة من هذه المواد في كلا الأرضين كما وجد أن اضافة هذه البقايا النباتية يؤدي الى زيادة كبيرة في العدد الكلي للبكتيريا والفطر وكمية الأصماغ الميكروبية المستخلصة ٠

١٦ ـ الأسمدة العضوية المحلية وتأثيرها على الأحياء الدقيقة في الأرض وعلى محصول القمح

ع • ع • مقـــــاوى

كلية الزراعة ـ جامعة القاهرة ـ الفيوم (ج م ع)

تختلف نسبة المادة العضوية في أراضي جمهورية مصر العربية من أقل من ١ ٪ في الأراضي الرمليـــة الى ٢ ٪ في الأراضي المنزرعة بالوادى ومن ثم لزم استمرار اضافة المادة العضوية للحفاظ على خصب الأرض • والسماد العضوى الرئيسى في مصر هو سماد الاسطبل أما الأسمدة الأخرى مثل سماد قمامة المدن وحمـــأة المجارى المجففة وزرق الدواجن والحمام فهى تستخدم بكميات ضئيلة كما تختلف في تركيبها اختلافا كبيرا •

وقد أظهر التحليل الكيمائى أن النتروجين الكلى في الأنواع المختلفة من المخلفات العضوية عمومـــا يتراوح من ١٫٠٣ الى ١٫٦٥ ٪ وأن المـــادة العضوية من ٢٤٫٨ الى ٣٠٫٣ ٪ وأن نسبة الكربون الـــى النتروجين (ك/ن) من ٩٫٨ الى ١٤٫٦ • أغنى هذه الأسمدة العضوية في النتروجين والفوسفور الكلـــى زرق الحمام •

وقد أجريت تجربة أصص على أرض طينية سلتية لدراسة تأثير الأسمدة العضوية المختلفة على الأحيـــاء الدقيقة ونشاط بعض انزيمات الأرض عند رطوبة ٦٠ ٪ من سعتها المائية لمدة ثلاثة شهور • وقد لوحـــظ أن كمية النتروجين الكلى في الأرض لم يطرأ عليها تغيير بينما هبطت نسبة المادة العضوية الى ثلث قيمتهـــا الأولى في خلال هذه المدة • وبالنسبة للمحتوى الميكروبى فان العدد اختلف حسب نوع المادة العضويـــة ومدة التحضين اذا بلغ العدد أقصاه في حالة زرق الدواجن وتلاه في ذلك روث الأغنام ثم الخيل والبقـــر ثم الحمأة المجففة وكان العدد يتأرجح نزولا وصعودا أثناء مدة التحضين وأخذ نشاط انزيم الهيدروجينيـــز نفس الاتجاه غير أنه ازداد أثناء الخمسة عشر يوما الأولى من التحضين ثم أخذ في التناقص بمرور الوقـــت بعد ذلك • أما نشاط انزيم اليوريز فقد بلغ أقصاه مع اضافة سماد الحمأة المجففة وأدناه في حالـــة سماد زرق الدواجن حيث كان أيضا أقل مما هو في الأرض غير المعاملة كما أن نشاط الأنزيم أخذ في الثبـــات بعد مرور خمسة عشر يوما من بدء المعاملة •

وفي تجربة أصص أخرى على نفس الأرض قورن تأثير اضافة سماد الاسطبل بمعدل ٢٫٤ ٪ منفردا أو بمصاحبة الأسمدة النتروجينية والفوسفاتية المعدنية على محصول القمح فوجد أن التسميد المعدنى ينتج عنه زيـــادة المحصول وأن الأسمدة العضوية أضافت الى هذه الزيادة •

وعموما يمكن تقسيم الأسمدة العضوية المستخدمة من حيث القيمة السمادية الى ثلاثة أنواع : أنواع ذات قيمة عالية وسريعـــة الصلاحية مثل مخلفات الدواجن والحمام والخيل وأنواع ذات قيمة متوسطة ومتوسطـــة الصلاحية مثل روث الأغنام والأبقار ثم أنواع منخفضة القيمة وبطيئة الصلاحية مثل الحمأة المجففة •

١٧ ـ " السويل لايف مع الهيد روسوب "

سماد عضوى كفء وفعال يبنى الأرض وله قدرة عالية على الاحتفاظ بالماء

ب • و لبـــــورن
شركة هيد روسورب • فورت ويـــرث
تكساس (الولايات المتحدة الأمريكية)

" السويل لايف " أو المادة التى تعطى الحياة للأرض عبارة عن رواسب الحيوانات البحرية المتراكمة منذ أكثر من ٥٠ مليون سنة بولاية تكساس حيث توجد بملايين الأطنان • وهذه الرواسب غنية فى المـــواد العضوية الدبالية وتحتوى على المغذيات الصغرى التى لا توجد فى الأسمدة المعدنية الشائعة الاستعمال • أما " الهيد روسورب " فهى عبارة عن توليفة من المواد العضوية لها القدرة على امتصاص وحفظ المـــاء حيث وجد أنه يمتص من الماء مابقدر بحوالى من ٥٠٠ الى ٢٠٠٠ مرة ضعف وزنه ويتوقف ذلك على درجـــة عسر الماء وتركيز الأملاح • وقد ثبت بالتجارب المعملية والحقلية صلاحية مخلوط هذه المواد للاستعمــــال كسماد عضوى وخاصة فى الأراضى الرملية •

الأسمدة المعدنية تذوب فى الماء وتأتى بنتائج سريعة وقد أخذت فى الانتشار منذ أيام ليبـــج ولويس عام ١٨٤٠ حين لوحظ أن اضافة الأملاح الذائبة للنتروجين والفوسفات والبوتاسيوم الى الأرض المنهكـة تزيد من المحصول • ومع مرور الوقت وتطور الصناعة والأعلام نسى المزارع أهمية الأسمدة العضوية التى كان يعتمد عليها فى المحافظة على خصب الأرض واعتمد كلية على الأسمدة المعدنية • على أن هناك من الدلائـــل مايشير الى أن الاستعمال المستمر والمكثف لهذه الأسمدة يؤدى الى استنزاف رصيد الأرض من الدبـــال فتتدهور تبعا لذلك صفات الأرض الطبيعية والكيمائية والبيولوجية • وقد قدر أن المفقود من هذا الرصيـد يفوق فى قيمته الزيادة فى المحصول نتيجة اضافة هذه الأسمدة ، كما لوحظ أيضا تدهور فى صفات المحصـول واحتواء أجزائه على عناصر كيميائية تصل فى بعض الأحيان الى حدود الضرر بصحة الحيوان والانســـان • وعلاوة على هذه الاعتبارات البيئية توجد أيضا اعتبارات اقتصادية منها الارتفاع المستمر فى أسعار الأسمـــدة المعدنية والوصول الى نقطة التحول الى العائد المتناقص نتيجة لاضافة كميات متزايدة من هذه الأسمـــدة • وهذا يدعو الى العودة الى استخدام التسميد العضوى لا لتجنب هذه الاعتبارات فحسب بل أيضا للمحافظـة على دوام خصب الأرض •

والأسمدة العضوية تتكون من متخلفات الانسان والحيوان والنبات • تقوم الأحياء الدقيقة فى الأرض بتحليلها وتحويلها الى مواد معدنية بسيطة كالأمونيا والفوسفات وينتج عن ذلك تكوين المواد الدبالية ذات الصفات الضروية المهمة من ناحية حفظ الماء والعناصر المغذية للمحاصيل المنزرعة فضلا عن كونها مأوى للمخلوقات الدقيقة التى تصنع الحياة للأرض • الأرض الجيدة تحتوى على ٣ الى ٥ ٪ من هذه المواد الدبالية المدعمة بمحتوى عضوى ومعدنى عال من شأنه أن يرفع المحصول الى حدود قريبة مما تعطيه الأسمدة المعدنية مع ثبات أسعارها وعدم الحاجة الى تصعيد الكميات المضافة منها مع الوقت كما هو الحال فى الأسمدة المعدنية •

١٨ ـ ممارسة اعادة استخدام المواد العضوية فى آسيا والمشروع الدولى لمنظمة الأغذية والزراعة وبرنامج الأمم المتحدة للتنمية

ب • ر• هيس
منظمة الأغذية والزراعة

اعادة استخدام المواد العضوية فى آسيا تعتبر من العمليات الهامة الضرورية لتحسين خصوبة الأراضى • ومن الأمور المسلم بها ان الاستعمال الأمثل للأراضى لا يتحقق الا بالاستعمال المتوازن بين الأسمدة العضوية والأسمدة المعدنية •

على أن برامج اعادة استخدام المواد العضوية تختلف كثيرا من دولة الى أخرى ففى بعض البلدان وخاصة الهند وفيتنام يوجد برنامج مكثف يشمل تقريبا كل مجالات اعادة استخدام المواد العضوية بينما فى بلدان أخرى مثل افغانستان لا يمارس بدرجة مناسبة •

ولقد قامت منظمة الأغذية والزراعة منذ عام ١٩٧٧ بتنشيط الاهتمام بالأزولا والطحالب الخضراء المزرقة وانتاج الغاز البيولوجى •

ونظرا لأن المعرفة والخبرة باعادة استخدام المواد العضوية تنحصر فى أماكن قليلة فان المشروع الدولى سوف يتيح لهيئة منسقة نشر ونقل هذه المعرفة والخبرة • كما ان المشروع سوف يهيىء الفرصة لتدريب أفراد أو مجموعات من الأفراد فى المجالات المختلفة لاعادة استخدام المواد العضوية عن طريق عقد دورات تدريبية وتوفير المنح والمستشارين •

كما يساعد على نقل التكنولوجيا بواسطة المستشارين وعقد الندوات وتنظيم الرحلات ومساندة البرامج بتزويدها بالأجهزة والمعدات الضرورية • ففى حالات كثيرة يحتاج الأمر الى مساعدة مادية أو تكنولوجية حتى يمكن وضع المعلومات الجديدة موضع التطبيق •

١٩ ــ الأسمدة البيولوجية ومقتضياتها وتطبيقاتهــا

م • ن • علاء الديــن
مركز البحوث الزراعية ــ الجيزة (ج م ع)

الأسمدة البيولوجية عبارة عن مزارع لميكروبات معينة تضاف الى الأرض أو تخلط مع بذور المحاصيل بغرض زيادة خصوبة الأرض حيث تقوم بتحويل بعض العناصر مثل النتروجين والفوسفور من صورغير ميسرة الى صورة ميسرة لاستعمال المحاصيل النامية •

ولا يوجد مجال للشك فى أهمية وفائدة تلقيح بذور المحاصيل البقولية عند الزراعة بسلالات فعالة من بكتريا العقد الجذرية (رايزوبيام) • ويجدر الاشارة هنا الى كفاءة نبات السسبان فى تثبيت نتروجين الهواء الجوى بالتكافل مع بكتريا العقد الجذرية حيث يقدر بحوالى ٥٤٢ كجم نتروجين للهكتار فى السنة • ويتميز السسبان بأنه ينمو تحت ظروف مختلفة ومتباينة فهو مقاوم للجفاف والغدق والحموضة والقلوية كما أنه سريع النمو ويمكن استخدام فروعه الخضراء فى تغذية الحيوانات •

وتستعمل الأزولا كسماد أخضر خاصة فى حقول الأرز كما يمكن استخدامها فى تغذية الحيوانات وفى عمل الكومبوست وانتاج الغاز البيولوجى • والأزولا نبات مائى سرخس يوجد بأوراقه تجويفات يعيش داخلها طحلب أخضر مزرق يقوم بتثبيت نتروجين الهواء الجوى •

وعدس الماء (لمناجبا) نبات مائى آخر ينمو فى المياه العذبة غير العميقة بمصاحبة ميكروبات مثبتة للنتروجين الهواء الجوى مثل الطحالب الخضراء المزرقة • وهذا النبات يمكن استخدامه كالأزولا فى تغذية حيوانات المزرعة وفى عمل الكومبوست وانتاج الغاز البيولوجى وكسماد أخضر • ونظرا لان هذا النبات ينمو فى جو أقل تشبعا بالرطوبة وعند درجات حرارة مرتفعة نسبيا فانه ينصح باستغلاله فى المناطق التى لا يصلح فيها نبات الأزولا •

وتستخدم الطحالب الخضراء المزرقة كمصدر للنتروجين والمادة العضوية وخاصة فى حقول الأرز • وتوضح الدراسات التى أجريت بالهند واليابان ومصر على أن استخدام هذه الطحالب يعادل التسميد بمقدار ٢٤ــ٤٨ كجم نتروجين /هكتار • كما يمكن توفير حوالى ٣٠٪ من السماد الأزوتى اذا استعمل معه التسميد بهذه الطحالب •

وتوجد ميكروبات أخرى مثل البكتريا التابعة لأجناس الأزوتوباكتر والكلوستريوم والاسبيريلام لهـا القدرة على تثبيت نيتروجين الهواء الجوى دون التكافل مع كائنات أخرى • وبعض الميكروبات لها القدرة على اذابة بعض مكونات الأرض كالفوسفات (الفطريات الميكوريزية وبكتريا باسلس ميجاثيريام) وجعلها أكثر يسرا للنباتات النامية • وتدل بعض الدراسات على أن تلقيح الأرض الزراعية بمزارع من هذه الميكروبات يؤدى الى تحسين غلة المحاصيل كما ونوعا •

٢٠ – تكنولوجيا انتاج البيوجاز نسبة الى الخبرة الصينيــــة

م٠ن٠ علاء الديــــن
رئيس بحوث قسم الميكروبيولوجيا الزراعيـــــــــة
معهد بحوث الأراضى والمياه (ج م ع)

تعتبر تكنولوجيا انتاج البيوجاز من المتخلفات عملية قديمة ، ولكن التطبيق الملحوظ لهذه التكنولوجيا بدأ فى ١٩٥١ فى الهند ، وفى سنة ١٩٥٨ فى الصين ، وفى ١٩٦٩ فى كوريا ٠

وتتلخص عملية انتاج البيوجاز فى تخمير المخلفات النباتية والحيوانية لا هوائيا حيث تنشط الكائنات الدقيقة وتعمل على تحليل هذه المواد الى احماض عضوية وكحولات وغازات ٠ ومن ثم تنشط مجموعة متخصصة من الكائنات الدقيقة لتحويل هذه المركبات وثانى اكسيد الكربون الى غاز الميثان (البيوجاز) وتتأثر عملية انتاج البيوجاز بعوامل مختلفة منها درجة تركيز ايون الايدروجين وتعتبـــــر ٧ – ٨٫٥ هى أنسب درجة ٠ وتعتمد درجة الحرارة المثلى لانتاج البيوجاز على الكائنات الدقيقة المختصة فمثلا فى حالـــــة الكائنات الدقيقة المحبة للحرارة تكون درجة الحرارة المثلى بين ٥٠ – ٥٥ م° وفى حالة الكائنات الدقيقة الميزوفيليه تكون الحرارة المثلى بين ٣٠ – ٣٥ ° م ٠ وينعدم انتاج البيوجاز عند درجة أقل من ٨° م ٠ ويتأثر انتاج الغاز بتركيز المواد الصلبة فى المخمر٠ ويقع التركيز الأمثل عند حوالى ٧–٩ ٪ مادة صلبة ٠ ويتأثر انتاج الغاز كذلك بنسبة العناصر الكربون والنيتروجين والفوسفور والعناصر الأخرى الداخلة فـــى تركيب المخلفات٠ ويجرى التخمر الأمثل عندما تكون نسبة الكربون : النيتروجين : الفوسفور هى ١٥٠ : ٥ : ١ ويتأثر انتاج الغاز كذلك بحركة التقليب فى المخمر ٠

وقد تضمن البحث تخطيطا لنماذج مخمرات انتاج البيوجاز فى كل من الهند وكوريا وتايلند والصيــــن وبابوا وغينيا الجديدة والصين ٠ وعموما يتلخص تركيب المخمر فى غرفة تخمير لا هوائية ، وحجرة لجمع الغـــاز ومدخل للمخلفات ومخرج لفائض عملية التخمير٠

تتميز مخلفات عملية التخمير بارتفاع قيمتها السمادية فمثلا يحتوى السائل على ٥٠٠ ، ١٥ ، ٢٠٠٠ جزء فى المليون من عناصر النيتروجين والفوسفور والبوتاسيوم على التوالى ٠ وتحتوى المواد الصلبة علـــــى ٦٥٠ ، ٤٠ ، ٩٤٠٠ جزء فى المليون من هذه العناصر على التوالى ٠ كما يحتوى على ٣٥ ٪ مادة عضوية ٠

٢١ ـ تأثير التلقيح بالاسبيريلا والأزوتوباكتر المثبتة للنتروجين على نشاط انزيم النتروجينيز بجذور الذرة النامي في ظروف تحت الاستوائية

ن • حجازى ـ م • منيب ـ ك • فلاشاك
كلية الزراعة • جامعة القاهرة (ج م ع) وكلية العلوم الزراعية
الجامعة الكاثوليكية بلوفان (بلجيكا)

توجد بكتريا الازوتوباكتر والاسبيريلام المثبتة لنتروجين الهواء الجوى فى الأراضى الطينية الطميية بمصروبلجيكا وفى ريزوسفير نباتات الذرة وقد زاد عددها بزيادة عمر النباتات كما أن تلقيح جذور الذرة بهذه البكتريا قد أدى الى زيادة اعدادها فى منطقة الجذور (ريزوسفير) حتى الأسبوع السادس من عمر النباتات ثم تناقص العدد بعد ذلك •

وقد وجد أن نشاط انزيم النتروجينيز ضعيف أو معدوم فى الأراضى المحيطة بجذور نباتات الذرة (ريزوسفير) وكذا الأراضى غير المتأثرة بالجذور سواء كانت ملقحة بهذه البكتريا أو غير ملقحة حيث أن خاصية تثبيت النتروجين مرتبطة بالجذور وليس بالأرض • وجذور نباتات الذرة التى عمرها ٦ أسابيع أظهرت نشاط قليل فى كل من أرض مصر وأرض بلجيكا حيث بلغ حوالى ١٠ر٠ ـ ٤٠ر٠ نانومول ك٢ يد٤ /جم/ ساعة وزاد بتقدم عمر النباتات وبلغ أقصاه ٨١ ـ ١٤٣٦ نانومول ك٢ يد٤ /جم/ ساعة فى مرحلة الازهار (٩ـ١٢ أسبوع) وتوضح النتائج أيضا أن تلقيح الأراضى ببكتريا الاسبيريلام قد زاد من معدل تثبيت النيتروجين وخاصة فى أرض مصر بينما لم يكن للتلقيح ببكتريا الأزوتو باكتر تأثير واضح •

٢٢ ـ مزارع بكتريا العقد الجذرية وتلقيح المحاصيل البقولية وتحسين خصوبة الأرض

ى٠ع٠ حمدى
مركز البحوث الزراعية ـ الجيزة ـ (ج م ع)

تلقيح المحاصيل البقولية تعبير يقصد به اضافة مزارع من بكتريا العقد الجذرية (رايزوبيام) الى بذور هذه المحاصيل عند الزراعة بغرض تشجيع التثبيت التكافلي لنتروجين الهواء الجوى٠ والمزارع البكتيرية المستعملة تأخذ أسماء مختلفة مثل نودوجين ونتراجين وليجيوم ئيد فى الولايات المتحدة الأمريكية وباكتوجين وريزوجين فى الهند ونود يول ئيد وآولايف فى أستراليا وعقدين فى جمهورية مصر العربية ٠ على أن جميعها عبارة عن خلايا حية لبكتريا العقد الجذرية ومادة حاملة ٠ وهذه المادة الحاملة قد تكون مواد دبالية أو فحم أو تراب أو لجنيت أو مواد أخرى تؤدى نفس الغرض٠

ويمارس تلقيح البقوليات ببكتريا العقد الجذرية الخاصة بكل نبات بقولى فى أنحاء كثيرة من العالم حيث من المؤكد فائدته ٠ فتلقيح بذور البقوليات قبل الزراعة مباشرة بمزارع من بكتريا العقد الجذرية ذات الكفاءة العالية فى تثبيت النتروجين يؤدى الى محصول أوفر يحتوى على نسبة أعلى من البروتين وأيضا الى زيادة محتوى الأرض من النتروجين ويقلل من اعتماد المحصول النامى على نتروجين الأرض٠

وتتوقف استجابة المحاصيل البقولية للتلقيح بهذه البكتيريا على عدة عوامل بعضها يتعلق بالبكتريا والبعض الآخر يتعلق بالمحصول البقولى أو بخواص الأرض الكيميائية والفيزيائية ٠ تحت الظروف المصرية يبلغ مقدار النتروجين المثبت تكافليا حوالى ٢٤٠ كجم /هكتار فى حالة محاصيل العلف الأخضر كالبرسيم ومن ٤٠ الى ١٤٠ كجم /هكتار فى حالة بقوليات الحبوب مثل الترمس وفول الصويا والفول والحلبة ٠

ويبلغ مقدار النتروجين المتبقى فى الأرض بعد المحاصيل البقولية حوالى ٣٣ـ٢٥٧ كجم/هكتار٠

٢٣ ـ استخدام مخلفات الريف والمدن لتحسين خصب الأرض

م. ماونج
منظمة الأمم المتحدة للتنمية الصناعية ـ فيينا (النمسا)

نظرا للزيادة في عدد السكان وفي معدل المخلفات بالنسبة للفرد الواحد فان مشاكل التخلص من هذه المخلفات سواء في الريف أو المدن تصل الى الحد الحرج لا في البلدان النامية فحسب بل أيضا في البلدان المتقدمة . والأمر يتطلب عناية جادة وعاجلة على الأخص في البلدان النامية بسبب تخلف المستوى الصحي والحاجة الملحة لمقاومة الأمراض . وفي هذا الصدد يجدر الاشارة الى ماجاء في تقرير منظمة الصحة العالمية من أن ٩٠ ٪ من سكان المناطق التي تستخدم البراز الآدمي كسماد مصابة بنوع واحد على الأقل من الطفيليات بينما كل السكان مصابة بواحد أو أكثر من الأمراض المعوية مما يتسبب عنه كثرة الوفيات خاصة بين الأطفال والاقلال من القدرة على العمل بين الكبار . والتغلب على هذه المشاكل ينحصر في تحويل هذه المخلفات الى سماد عضوي بالطرق والوسائل السليمة .

وتقوم المنظمة بمساعدة الدول النامية في انتاج السماد العضوي من القمامة في المدن والغاز البيولوجي من المخلفات في الريف . وتقدم الاقتراحات التي يمكن اتباعها في هذه الدول عند التخطيط لاستخدام هذه المخلفات العضوية .

توجد أربعة طرق شائعة للتخلص من القمامة ومعالجتها هي :

(١) التخزين في العراء خارج نطاق المدن وهي أرخص الطرق اذا لم يؤخذ في الاعتبار حماية البيئة والصحة العامة .

(٢) التخزين في طبقات متعاقبة وضغطها بجرار ثم التغطية بطبقة من التراب أو أي مادة مناسبة وهي تعتبر أيضا طريقة رخيصة .

(٣) الحرق في أفران خاصة وهي عالية التكاليف فضلا عن تلوث الهواء بالأبخرة السامة .

(٤) تحويل القمامة الى سماد عضوي (كومبوست) وتعتبر بصفة خاصة ـ اذا ما أحسن تخطيطها وتنفيذها ـ حلا مناسبا في البلاد النامية للتخلص من القمامة والمحافظة على الصحة العامة وفي نفس الوقت تحويلها الى سماد عضوي يمكن أن يلعب دورا هاما في زيادة انتاجية الأرض بجانب الأسمدة المعدنية . ويمكن ادخال مخلفات الصناعات الزراعية كصناعة حفظ اللحوم وصناعة الورق والأخشاب والأصباغ وكذلك حمأة المجاري المعاملة في هذه العملية .

ويمكن اجمال اقتصاديات تحويل القمامة الى سماد عضوى فى :

(١) تكاليف الحصول على القمامة وهذا لا يتكلف شيئا حيث أن المحليات تقوم عادة بجمعها وتوصيلها الى مقر مصنع السماد دون مقابل بل نجد أن معظم البلديات مستعدة لدفع مبلغ من المال للمصنع نظير قبول القمامة (٢ دولار فى مراكش و ١٢ دولار فى فيينا عن كل طن يستلمه المصنع)•

(٢) تكاليف رأس المال : يختلف كثيرا حسب حجم المصنع والآلات المستخدمة وطريقة التشغيل فهى اذ تقتصر فى الهند على تكاليف انشاء خنادق او حفر فى الأرض مبطنة بالأسمنت المسلح أو بالطوب بالاضافة الى تكاليف عدد قليل من ناقلات الأتربة • بينما فى أماكن أخرى عبارة عن منشآت آلية كبيرة معقدة تصل تكاليفها الى حوالى ١٠ ملايين من الدولارات • وعموما تحتاج الوحدة الانتاجية (سعة قصوى ١٦٠ طن قمامة يوميا) حوالى مليون دولار منها ٦٠٠ ٠٠٠ دولار للآلات الميكانيكية •

(٣) تكاليف الانتاج نجدها تختلف بمتوسط ١٫٢٥ الى ١٫٥ رجل / يوم لكل طن سماد كومبوست ناتج ويتوقف ذلك على طريقة التشغيل وخلط القمامة بمخلفات الانسان • وفى الرباط بالمغرب وجد أن طن القمامة يتكلف ٣٫٣٨ دولار أو ٦٫١٤ دولار لكل طن من السماد الناتج •

(٤) قيمة الناتج — بالرغم من التقدم التكنولوجى فى صناعة الأسمدة العضوية الا أن طبيعة ومدى الفائدة التى تعود على الزراعة من هذا السماد — مازالت غير محددة لاختلاف الأرض والمناخ والظروف الأخرى من مكان لآخر • وعموما فان قيمة السماد المنتج تزداد فى الأراضى الرملية بالمناطق الجافة ونصف الجافة عنها فى المناطق الأخرى ومن الناحية الكمية فقد قدرت فى الرباط بالمغرب بحوالى ١٥ — ٢٢ دولار لكل طن سماد عضوى على أساس محتواه من العناصر المغذية للنبات •

ويجدر الاشارة الى أن الفشل العام لمصانع انتاج الأسمدة العضوية من القمامة فى أمريكا واليابان يرجع الى المبالغة فى استخدام الآلات واتباع الطرق المعقدة ثم قلة التسويق ، أما فى البلدان النامية فالأمر يختلف عن ذلك ففى مراكش مثلا فان المشاكل لا تتعلق فقط بأمور فنية مثل اتباع الطريقة والمحافظة وصيانة الأجهزة بل بما هو أخطر من ذلك كمشاكل التمويل وجمع القمامة واختيار المكان المناسب والتسويق ، كما تتفاقم هذه المشاكل نتيجة توزيع المسؤولية بين السلطات المحلية وبين المسؤولين الزراعيين •

وفى ضوء هذه المشاكل يفضل فى البلدان النامية أن يجرى العمل فى هذا المجال على مراحل • ففى المناطق التى يوجد بها نظام لجمع القمامة يمكن البدء بمصنع رائد ذى كفاءة محدودة ثم تزاد سعته مع الوقت أو يقام مصنع مشابه أو أكثر فى الأماكن المناسبة حول المدينة أو فى مدن أخرى •

ويراعى فى المشاريع المقامة حينئذ بساطة التصميم وطرق التجهيز وذلك لخفض تكاليف رأس المال وتكاليف الانتاج كما تراعى ملائمة طرق التجهيز لانتاج سماد غنى فى المادة العضوية مع توفير النظم الادارية والمالية الكافية لعمليات تجهيز السماد وتسويقه ثم الاختيار الحكيم لمكان اقامة مثل هذه المنشآت حول المدينة ثم أخيرا تجهيز فريق فنى للعمل فى هذا التخصص على مستوى الدولة •

أما فى الأماكن التى لايوجد بها نظام لجمع القمامة فيجب العمل على ايجاد هذا النظام مع البدء ببرنامج تجريبى لعملية تحضير السماد العضوى باستعمال طرق البانجلور أو الاندور• والخبرة المتجمعة من مثل هذه التجارب سوف تضمن كفاءة المنشآت التى تقام فيما بعد • وفى جميع الحالات ينبغى انشاء مايعرف بالحفر الصحية لاحتواء مالا يصلح لعمل السماد من القمامة وينبغى كذلك الاستفادة بكل الامكانيات المحلية الموجودة • أما اضافة متخلفات المجارى الى القمامة فيستحسن ترك ذلك لمرحلة متقدمة•

ولصناعة الغاز البيولوجى من المخلفات فى الريف ـ وهى من الصناعات السهلة التى يمكن أن تعتمد على الامكانيات المحلية ـ وجوه كثيرة فى التنمية الريفية • فالى جانب توفيرها للطاقة والسماد العضوى فهى تخفف من مشكلة التخلص من المخلفات وبالتالى خفض أسباب تلوث البيئة كما تشجع على نشأة كثير من الصناعات المرتبطة باستخدامات هذا الغاز وتعمل على نظافة القرية•

والمنظمة تعنى بالمساعدة فى نقل صناعة الغاز من البلاد التى استقرت فيها هذه الصناعة كالصين والهند وكوريا الى البلدان خارج النطاق الأسيوى التى يهمها الاستفادة من تلك الخبرة • ويتم ذلك مبدئيا من خلال تنفيذ مشاريع رائدة بناء على طلب الحكومات المعنية • مثل هذه المشاريع يتم انجازها حاليا فى تنزانيا وفولتا العليا كما أنها مطلوبة الانجاز فى أفغانستان وتركيا • والنمط الذى يتبع هو النمط الهندى وتأمل المنظمة أن تنقل النمط الصينى للدول التى ترغب فى ذلك •

٤٢ـ تأثير المواد العضوية على خواص الأراضي المصرية وانتاج المحاصيـــل

ع • م • عبد النعيم
مركز البحوث الزراعية ـ الجيـزة (ج م ع)

ان اصلاح الأراضى فى جمهورية مصر العربية يمتد الى الأراضى المتاخمة لوادى النيل والدلتا وهـى أراضى رملية وجيرية • وهذه الأراضى تعانى من نقص شديد فى المادة العضوية والعناصر المغذية للنبات كما أن قدرتها الحافظة للعناصر وللماء ضئيلة • وعموما يتوقف تحسن انتاجية هذه الأراضى على اضافة المادة العضوية •

ويستدل من نتائج التجارب والبحوث التى أجريت على أثر التسميد العضوى على خواص هذه الأراضى وانتاجيتها مايلى :

١ـ **الأراضى الجيرية :**

يزيد محتوى الأرض من المادة العضوية والنتروجين الكلى نتيجة لاضافة سماد الاسطبل ويتوقف ذلك على معدل الاضافة • كما زاد محصول الذرة والقمح والشعير من الحبوب نتيجة لاضافة سماد الاسطبل على حدة أو مخلوطا بطرح الترع • وبمقارنة أنواع مختلفة من الأسمدة العضوية وجد أن سماد الاسطبل وسماد المجارى (البودريت) يفضل سماد القمامة وحطب الذرة من حيث تأثيره على خواص الأرض وانتاجيتها كما وجد أيضا أن التسميد الأخضر بلوبيا العلف والحلبة يؤدى الى زيادة محصول الذرة وبدراسة تأثير أنواع مختلفة من المحاريث (قلاب مقطور ـ قرص مقطور ـ قرص معلق ـ حفار مقطور) لقلب المواد العضوية المضافة وجد أن محراث القرص المعلق قد أعطى أعلى محصول •

٢ـ **الأراضى الرمليـة :**

أدى رش سطح الأرض بمعلق الأسفلت الى تحسين الخواص المائية للأراضى الرملية وانعكس ذلك على محصول الكتان والبرسيم المصرى •

وكان أفضل استعمال لمعلق الأسفلت هو ٢٣٨٠ لتر/ هكتار فى حالة الكتان و ٣٥٧٠ لتر / هكتار فى حالة البرسيم •

تروى مزرعة الجبل الأصفر بالقرب من القاهرة بمياه المجارى منذ عام ١٩١١ وتوضح الدراسات التى أجريت على أراضى هذه المزرعة أن الرى بمياه المجارى قد أدى الى زيادة محتواها من المادة العضوية وزيادة السعة التبادلية الكاتيونية وخفض نسبة الأملاح الذائبة وكربونات الكالسيوم مع تغير فى تفاعل الأرض من القلوية الى الحامضية •

٣ ــ الأراضي الطينية الرسوبية :

تبين أن المعدلات العالية من سماد الاسطبل أو سماد المجارى تؤدى الى زيادة محصول القمح خاصة عند توفر نسبة مئوية منخفضة من الصوديوم المتبادل وأن امتصاص النبات لعناصر الأزوت والفوسفور والبوتاسيوم يزداد بزيادة معدلات التسميد العضوى •

٢٥ ــ استجابة الذرة للتسميد العضوى والزنك

ح • العطار ــ م • الحلفاوى ــ أ • الحداد
كلية الزراعة ــ جامعة الأسكندرية (ج م ع)

أدت اضافة ١٠ طن / ايكر (٢٤ طن /هكتار) من سماد الاسطبل الى زيادة محصول الذرة من الحبوب بمقدار ١٣٪ فى أراضى أبيس الطينية الطميية وبمقدار ١٩٪ فى أراضى النوبارية الجيرية • وعلاوة على ذلك فان التسميد العضوى قد أدى الى زيادة استفادة الذرة من كل من أكسيد وكبريتات الزنك المضافة • وقد كان تأثير اضافة سماد الاسطبل والزنك أكثر وضوحا فى أراضى أبيس عنه فى أراضى النوبارية مما يوضح تأثير وجود نسبة عالية من الكربونات على مدى صلاحية العناصر الدقيقة وامكانية امتصاصها بواسطة النباتات النامية •

٢٦ ــ نظم الزراعة وأثرها على انتاجيــة الأرض

ع • م • بلبــع
كلية الزراعة ــ جامعة الاسكندرية (ج م ع)

تختلف نظم الزراعة تبعا للظروف المناخية وخواص الأرض واحتياجات وعادات السكان ثم المستـــوى الاقتصادى والاجتماعى لهؤلاء السكان • وتأثير نظم الزراعة على انتاجية الأرض هو نتيجة للعمليات الزراعيــة المتبعة ونوعية المحاصيل المنزرعة •

فازالة الأشجار والحشائش بقصد ادخال الزراعة يعرض الأرض للهواء الجوى فتجف وتنشط عمليـات الأكسدة وتتحلل المادة العضوية وتقل نسبتها • وعمليات الخدمة لتهيئة مهد للبذور يزيد من عمليـــات الأكسدة أيضا • واستخدام الآلات الثقيلة يساعد على تماسك وانضغاط الأرض • والرى يؤدى الى زيــادة الملوحة مالم يكن مصطحبا بنظام كفء للصرف • كما قد تفقد العناصر الغذائية مع ماء الرى بعيدا عن منطقة نمو الجذور خاصة فى الأراضى خفيفة القوام • والتسميد يساعد على امتصاص الأزوت والعناصر الأخرى مــن الأرض •

أما عن المحاصيل المنزرعة فهى تستنفذ العناصر الغذائية من الأرض بمعدلات مختلفة حسب نوعهـا وطبيعة نموها • فمحصول "أيكر" من الأذرة (٣ طن حبوب) على سبيل المثال يمتص من الأرض ٦٠ كجم نتروجين و ٥٠ كجم بوتاسيوم و ١٧ كجم كالسيوم و ١٥ كجم مغنيسيوم و ١٠ كجم فوسفور و ١٠ كجم كبريـت و ١٥ر• كجم منجنيز و ١كجم حديد علاوة على كميات صغيرة من البورون والكلور والزنك والموليبدنم • علـى أن زراعة المحاصيل البقولية عادة تزيد من النتروجين فى الأرض عن طريق تثبيت نتروجين الهواء الجوى •

ومن ناحية النظم الزراعية نجد أنها تختلف من مناطق تعتمد على المطر الى مناطق تعتمد على الرى ومن أراضى مستصلحة حديثا الى الأراضى ذات الخواص المميزة كالأراضى الجيرية والأراضى الرملية • فــى الأراضى التى تعتمد على المطر تترك الأرض بور أثناء فترة الصيف مما يعرضها للجفاف ثم التجريـــف بواسطة الرياح ومن المفضل شغل الأرض بالمحاصيل المناسبة فى هذا الفصل محافظة عليها • وفى الأراضى التى تعتمد على الرى يتبع فيها نظام الزراعة المكثفة وهذا من شأنه زيادة استنزاف خصب الأرض • ومن ثم وجبت العناية بالبرامج السمادية وكميات ونوعية مياه الرى وبالصرف وباختيار الدورة الزراعية المتزنـــة ذات المحاصيل المتنوعة خاصة من ناحية انتشار المجموع الجذرى • وفى الأراضى المستصلحة حديثـــا تختار المحاصيل ذات الاحتياج المائى العالى والتى تتحمل الملوحة كالبرسيم والأرز • وفى الأراضـــى الجيرية يراعى اختيار المحاصيل التى تتحمل الكالسيوم كبعض الخضروات والزيتون والعنب والتين ويراعـى اختيار الأسمدة المعدنية النتروجينية التى لا تفقد بالتطاير والتسميد الأخضر والتسميد العضوى وتقارب فترات الرى • وفى الأراضى الرملية يراعى الدورات الزراعية المناسبة للحفاظ على مياه الرى والعناصر الغذائية مـع الفقد مع ماء الرشح والمحاصيل ذات القيمة العالية لتغطية التكاليف العالية مثل اللوز والسمسم والموالـــح والمانجو وبعض الخضروات •

٢٧ ـ عوامل صحة البيئة فى استخدام المتخلفات السائلة والصلبة فى الأراضى الزراعية

ألفت السباعى ـ ح • متولى
معهد الصحة العالى ـ جامعة الاسكندرية (ج م ع)

يعتبر استخدام المتخلفات السائلة والصلبة فى الأراضى الزراعية الحل الأمثل لمشكلة التخلص من هذه المتخلفات • ولاعتبارات صحية يجب أن لا تستخدم مياه المجارى فى رى المحاصيل التى تؤكل طازجة • على أنه يمكن استخدام مياه المجارى المعالجة معالجة أولية أو غير المعاملة فى رى بعض المحاصيل الزراعية مثل القطن والخضروات التى تزرع بغرض الحصول على البذور •

فى بعض البلدان النامية تجرى عملية التخلص من مياه المجارى بطرق بدائية مثل خلطها بالمياه الجارية او القائها فى حفر أو خنادق ويترتب على ذلك أضرار صحية واقتصادية •

أما طرق التخلص من المواد الصلبة للمجارى (الحمأة) فهى اما باستخدامها فى الأراضى الزراعية أو تجفيفها بالحرارة أو بالهواء أو خلطها بالقمامة وتخميرها (كومبوست) • وتدل كثير من الدراسات على أن استعمال الحمأة فى الأراضى الزراعية يحسن من صفات المحصول كما ونوعا ويقلل من استخدام الأسمدة المعدنية ويعمل على تثبيت الأراضى الرملية •

وتوجد عدة طرق للتخلص من القمامة على اختلاف أنواعها وأفضلها مايقابل الاحتياجات الصحية • ويمكن تحويل المناسب من القمامة الى سماد عضوى بطريقة الكومبوست تحت ظروف محكمة من التهوية والحرارة والرطوبة •

وعموما يجب أن تكون المتخلفات الصلبة قد تم معاملتها بالطرق المناسبة قبل استخدامها فى تسميد الأراضى الزراعية كما يلزم دراسة الآثار الناشئة من استعمال هذه المتخلفات على البيئة كما يلزم أن ينظم برنامج تعليمى صحى للأفراد الذين يستخدمون المتخلفات الصلبة والسائلة فى الأراضى الزراعية •

٢٨ ـ المواد العضوية وعلاقتها بالتخطيط البيئي

ل . ت . قدرى
منظمة الأغذية والزراعة ـ روما (ايطاليا)

المواد العضوية سواء كان مصدرها ريفي أو حضرى هي نواتج لنشاط الانسان ، يلقى بها فى البيئة وغالبا ماينتج عن ذلك ضرر بالسكان خاصة اذا ماأدت هذه المتخلفات الى تلوث البيئة لاحتوائها على مايضر بصحة الانسان . وتشير أزمة الطاقة العالمية وارتفاع أسعار الأسمدة المعدنية الى التوسع فى استعمال المواد العضوية مع الأسمدة المعدنية فى الأراضى الزراعية وكمصدر للوقود . كما أن كثير من مدن وقرى البلدان النامية التى لا تصلها مياه الشرب النقية تستخدم مياه الترع وهذا يسبب مشاكل صحية ويؤدى الى انتشار الأمراض . لذلك فان ترشيد الطرق المتبعة للتخلص من المتخلفات عند اجراء أى تخطيط لحماية البيئة يعتبر ضروريا للمحافظة على الصحة العامة وللتغلب على الأمراض والاوبئة .

وتشمل خطوات التخطيط تحديد الأهداف ثم وضع السياسة والبرامج والتنفيذ ثم التقييم ودراسة البدائل الممكنة واعطاء التوصيات للتنفيذ وأخذ القرارات المنفذة . كما يجب اقتراح الأسس الرئيسية اللازمة للتحكم فى طرق التخلص من المتخلفات لتخدم البرامج الاقليمية عند استخدام هذه المواد فى تحسين انتاجية الأرض .

التقارير القطريـــــة

١ ــ أفغانستـــــــــان

(م • بايمان ، لال •م • زرماتـــــــى)

تقع جمهورية أفغانستان الشعبية بين خطى عرض ٣٠و٣٧ شمال وخطى طول ٦١ ، ٧٢ شـــــرق • وتبلغ مساحتها ٤٩٧ ٦٤٧ كم ٢ • وتتكون من سلاسل من الجبال العالية تمتد من الشمال الشرقى الــــــى الجنوب الغربى تتخللها سهول صحراوية • وهى ذات مناخ جاف الى نصف جاف• تبلغ المساحة القابلـــــة للزراعة ٨ مليون هكتار منها ٤ر٩ مليون هكتار منزرعة بالفعل (٢ر٨٥ مليون على الرى الاضافى والباقى علـــى المطر) • ولا تزرع كل هذه المساحة سنويا بل أن متوسط مايزرع هو ٣ر٨٨ مليون هكتار• يبلغ عدد السكـــان ١٥ مليون نسـمة منهم ٢ مليون على الأقل بدو رحل • كما أن ٨٠ ٪ من السكان يشتغلون بالزراعــــــة• الصادرات الرئيسية للبلاد هى الفاكهة والكاراكوك والقطن والصوف والسجاد • ويعتبر القمح أهم المحاصيــــل التى تزرع فى أفغانستان يليه الذرة والقطن والأرز وسكر البنجر والفاكهة •

انتاجية الأرض بصفة عامة منخفضة بالنسبة للمقاييس العالمية ويرجع ذلك الى عدة عوامل أهمها طبيعة الأرض وطرق الزراعة المتبعة • فالأراضى معظمها حديث التكوين من رسوبيات الرياح وتحتوى على ١٠ــ٢٥ ٪ كربونات كالسيوم ورقم التفاعل يزيد عن ٥ر٧ • وتحتوى على نسبة ضئيلة من المادة العضوية (٧ر٠ ٪ أو أقل كربون عضوى) • كما تعانى معظم هذه الأراضى من نقص فى العناصر المغذية الكبرى خاصة النتروجيـــــن والفوسفور والعناصر المغذية الصغرى خاصة الحديد والزنك والمنجنيز • والطرق المتبعة فى الزراعة كعـــدم اتباع دورة زراعية وعدم زراعة البقوليات والاعتماد على الأسمدة المعدنية بمعدلات غير كافية مع قلة اضافـــــة الأسمدة العضوية التى مازالت تصنع بطرق بدائية يتعرض معها النتروجين والكربون العضوى للفقد ، مـــع الاستخدام المستمر للمحراث البلدى كلها من العوامل التى تزيد من افقار الأرض فى خصوبتها وفى صفاتها الطبيعية وتعرضها للتعرية بواسطة الرياح أو المياه الجارية • وكثيرا مايلجأ الفلاحون الى اضافة المخلفات الآدمية مباشرة الى الأرض مما يعرضهم للمخاطر الصحية فضلا عن عدم كفايتها السمادية•

ولتحسين انتاجية هذه الأراضى فان عمل المستقبل ينحصر فى :

(١) اتباع نظم زراعية محسنة كزراعة البقوليات وقلبها أحيانا فى الأرض وقد ثبت فائدة ذلك للمحاصيـــــل التالية ، وكاستخدام الحرث العميق وقد ثبت أيضا من تجارب وزارة الزراعة فائدته لتيسير الفوسفور للنبات وتكسير الطبقة شبه الصماء الناتجة عن استخدام المحراث البلدى وللمساعدة على حفـــــظ الماء فى الأرض للمحاصيل الشتوية ، وكاضافة سماد الكومبوست والمخلفات الآدمية التى ثبتت فائدتها

أيضا وبالأخص اذا ما أستخدم معها الأسمدة المعدنية للفوسفور والنتروجين ، وكاستخدام مخلفات صناعة السكر والزيوت والسلخانات لصناعة الأسمدة العضوية وهو داخل ضمن الخطة القادمة .

(٢) اتباع دورات زراعية مناسبة تتضمن المحاصيل البقولية كالبرسيم أو البازلاء أو الحلبة مع محاصيل الحبوب وتتضمن كذلك المحاصيل عميقة الجذور .

(٣) العمل على زيادة نسبة المادة العضوية فى الأراضى كاضافة مخلفات المحاصيل الزراعية الى الأرض بدلا من استخدامها كوقود واتباع نظام المحاصيل المختلفة .

(٤) الاستفادة بمخلفات القرى والمدن فى صناعة الأسمدة العضوية لتتكامل مع الأسمدة المعدنية الى جانب انتاج غاز الميثان الذى يستفاد به كوقود .

٢ — قبرص

ج .ك كوندوناس — أ ن بابادوبلس

قبرص جزيرة تقع عند خط عرض ٣٥ شمالا ولها مناخ البحر الأبيض المتوسط بفصوله المميزة . المتوسط السنوى للأمطار ٥٠٠ مم وقد يهبط الى ١٨٢ مم أو يرتفع الى ٧٥٠ مم فى بعض السنوات وفى السهول التى تشكل معظم الأراضى الزراعية يبلغ ٣٥٠ مم . تحت ظروف الجفاف والحرارة والزراعة المكثفة تتحلل البقايا النباتية بسرعة وتصل نسبة المادة العضوية فى أراضى السهول المروية ١—٢٪ فى الطبقة السطحية وتقل عن ذلك مع العمق أما تحت ظروف الزراعة الجافة فهى حوالى ١٪ وفى المناطق الجبلية تحت الأعشاب والموالح تحتوى الأرض على مادة عضوية ٢—٣٪ ولكنها تنخفض بشدة مع العمق وفى المناطق الأكثر ارتفاعا حيث توجد الغابات الصنوبرية تتكون طبقة من المادة العضوية .

يلجأ المزارعون الى شراء سماد الاسطبل (أغنام ، ماعز ، خنازير ، دواجن) لاستعماله كمصلح للأراضى على الأخص المروية منها ومع هذا فان هذا الاتجاه آخذ فى التناقص لارتفاع أسعار هذه الأسمدة .

ولقد أثبتت التجارب التى أجريت فى فازورى على الساحل الجنوبى أن اضافة سماد الاسطبل لم يكن بالنسبة للبرتقال فعالا كالأسمدة المعدنية النتروجينية على عكس النتائج الأولية التى حصلت عليها محطة بحوث مورفو " التابعة لمؤسسة البحوث الزراعية قبل عام ١٩٦٢ والتى سجلت بعض الاستجابات لسماد الاسطبل . على أن قيمة سماد الاسطبل لا تتوقف فقط على امداد العناصر الغذائية بل أيضا على تحسين خواص الأرض الطبيعية والكيميائية والبيولوجية .

وفى عام ١٩٦٢ أقامت مؤسسة البحوث الزراعية تجربة تهدف الى مقارنة الأسمدة المعدنية بسماد الاسطبل (سماد الأغنام) فى بستان لبرتقال الفالنشيا أنشئ عام ١٩٥٦ واستخدم فى ذلك ٨ معاملات سمادية تشمل معدلين من سماد الاسطبل ١٥ ، ٣٠ كجم لكل شجرة ومعدلين من سلفات النشادر + فو $_2$ أ$_5$ هما ٢ر٠ + ١٥ر٠ ، ٤ر٠ + ٣٠ر٠ كجم لكل شجرة وأربعة معاملات أخرى هى كل التوافيق بين معدلى سماد الاسطبل والسماد المعدنى وجعل لكل معاملة ٣ أشجار وسجل المحصول من ١٩٦٤ حتى ١٩٧٢ وقد اختلف المحصول من موسم لآخر. وبصفة عامة تفوقت الأسمدة المعدنية على الأسمدة العضوية ولكن اضافة السماد المعدنى مع العضوى عند أعلى معدل أعطى أحسن النتائج • ومع هذا فان الزيادة فى المحصول لم تغط تكاليف السماد العضوى• وكان محتوى الأوراق من النتروجين بين ١٥ر٢ الى ٦٩ر٢ ٪ أما الفوسفور فكان ثابتا حول ١٢ر٠ ٪ طول المدة أما البوتاسيوم فقد انخفض من ٠٤ر١ ٪ الى ٤٩ر٠ ٪ وهو يعتبر محتوى منخفض بالنسبة لمقاييس كاليفورنيا • والعناصر النادرة لم تتأثر بالمعاملات فظلت نسبة المنجنيز والزنك فى مستوى منخفض وقد ثبت فيما بعد أن كل بساتين منطقة مورفو تعانى من هذه المشكلة • وعلى ذلك يمكن القول بأن اضافة ٣٠ كجم سماد عضوى لكل شجرة يمكن أن يعطى نتائج ايجابية ولكنها تعتبر غير اقتصادية •

وفى عام ١٩٧٥ ــ ١٩٧٦ أجريت تجارب فى أصص على استجابة الطماطم لكل من التسميد العضوى والمعدنى (ن ، فو$^-$ بو) والرى عند نسب مختلفة من الرطوبة • وقد دلت النتائج على أن المحصول تأثر معنويا بمعدلات الرى وبالأخص فى الأرض المضاف اليها سماد الاسطبل بينما لم يتأثر بالتسميد ، ومن ناحية جودة المحصول كانت الثمار الناتجة عن المعدلات العالية للتسميد هى الأجود •

ويبدو من هذه الدراسات أن سماد الاسطبل لا يفيد فى حالة أراضى قبرص أو أن تأثيره ضعيف بمقارنته بالأسمدة المعدنية •

٣ – مصـــــر

(ى. حمدى م. ن. علاء الديـــن)

أراضى جمهورية مصر العربية فقيرة فى محتواها من المادة العضوية فنادرا ماتزيد عن ٢٪ لذلك يلزم اضافة الأسمدة العضوية باستمرار.

وأهم مصادر المواد العضوية فى مصر بقايا المحاصيل الزراعية مثل الأرز والقمح والقطن والـذرة ويبلغ مقدار هذه البقايا حوالى ١١,٥ مليون طن سنويا. على أن معظم هذه البقايا تستخدم الى وقتنا الحاضر للوقود أو فى بعض الصناعات أو فى تغذية الحيوانات وقليل منها يحول الى سماد عضوى بطريقة الكومبوست.

ويبلغ متوسط انتاج مصر من سماد الاسطبل المعروف باسم السباخ البلدى حوالى ٨٨ مليون متر مكعب فى السنة فى حين أن حاجة الأراضى الزراعية من الأسمدة العضوية تقدر بحوالى ١٦٠ الى ١٩٠ مليون متر مكعب سنويا أى يوجد عجز يقدر بحوالى ٧٠ – ١٠٠ مليون متر مكعب فى السنة.

فى الريف وبعض المدن حيث لا يوجد مشروعات للمجارى العامة تجمع المتخلفات الآدمية وتجفف وتستعمل كسماد ويعرف باسم البودريت أو تخلط بالتراب قبل استعمالها كسماد وأحيانا يلقى بها فى مجرى مائى كمصرف أو ترعة وهذا فيه خطر على الصحة العامة.

وتنتج مصر حوالى ١٢٨٠٠٠ متر مكعب سنويا من متخلفات المجارى الصلبة أو الحمأة (سـلدج) ومن المتوقع زيادتها فى المستقبل مع التوسع فى معالجة متخلفات المجارى. وعادة تصرف مياه المجارى فى البحر والبحيرات أو مجارى المياه بدون معالجة.

وفى مصر يوجد مصنع واحد لتحويل جزء من قمامة مدينة القاهرة الى كومبوست وينتج سنويا حوالى ١٠٠٠٠٠ متر مكعب من هذا السماد العضوى. على أن قمامة مدينة القاهرة تبلغ فى اليوم حوالى ٣٥٠٠ طن وهذا يستدعى انشاء مصنع أكثر كفاءة لتحويل معظم قمامة القاهرة الى سماد عضوى.

والتسميد الأخضر كان شائعا فى مصر حتى الخمسينيات أما الآن فقد أصبح قاصرا على الأراضى الرملية والجيرية حديثة الاستصلاح.

وفى مجال الأسمدة البيولوجية فان وزارة الزراعة منذ عام ١٩٥٤ تنتج مزارع بكتريا العقد الجذرية الخاصة بالمحاصيل البقولية باسم العقدين. وفى عام ١٩٦٦ بدأت دراسة تأثير استخدام الطحالب الخضراء المزرقة فى حقول الأرز وقد اتضح أنه يمكن خفض تسميد الأرز بمقدار يتراوح بين ٢٥٪ و٣٣٪ اذا

لقحت حقول الأرز بهذه الطحالب • وحاليا يجرى دراسة لمعرفة مدى امكانية استخدام نبات الأزولا فى مزارع الأرز •

ويقوم قسم الميكروبيولوجيا بمعهد بحوث الأراضى والمياه بدراسة امكانية انتاج الغاز البيولوجى من المتخلفات الزراعية وقد تم انشاء وحدة لانتاج هذا الغاز فى مدينة الفيوم طبقا للنظام الصينى • وحاليا بدأ برنامج مكثف لدراسة انتاج الغاز البيولوجى •

٤ ـ الأردن

(وداد نورى)

تبلغ مساحة الأردن حوالى ٩٨٠٦٠٠٠ هكتار منها ١٠٠ ٢٥٥ ٩ هكتار توجد شرق نهر الاردن وتبلغ مساحة الأراضى التى تستخدم فيها الرى ٥٠٠ ٥٣ هكتار (٠ر٦١ ٪ من المساحة الكلية) أما الزراعة الجافة فمساحتها حوالى ١١٩٦٢٠٨ هكتار (١٣ ٪ من المساحة الكلية) • ونسبة المادة العضوية فى أراضى الأردن تختلف من ٤ر٠ ٪ الى ٥ر١ ٪ • وتعانى الأردن من نقص شديد فى الحيوانات حيث يبلغ عدد الماشية حوالى ٣٢٠٠٠ والأغنام حوالى مليون وربع •

لذلك تعتمد الزراعة الى حد كبير على الأسمدة المعدنية بالرغم من أن الاستعمال المستمر للأسمدة المعدنية يضر بقدرة الأرض الانتاجية فى المدى الطويل •

وسماد الاسطبل المنتج فى الأردن سماد عضوى ردئ نظرا لعدم العناية بتحضيره وخزنه • كما أن متخلفات المدن والقرى من مجارى وقمامة غير مستغلة ولا يعاد استخدامها • وتتمتع عمان (عاصمة الاردن) فقط بمشروعات المجارى العامة ولكن الزراع يحجمون عن استعمال نواتج معاملة مياه المجارى •

ويجب على الحكومة أن تقيم مشروعات المجارى ومعالجة مياهها فى المدن الكبيرة وأن تعمل على تشجيع الزراع على استعمال سماد المجارى الناتج واستخدامه فى مزارع وزارة الزراعة •

ولا توجد دراسة وافية توضح تأثير التسميد العضوى على خصوبة الأرض وقدرتها الانتاجية • كما أن التسميد الأخضر لا يتبع الا فى حدود ضيقة فى بعض الأراضى التى تروى •

٥ ـ الكويــــت

أ٠ح ٠م٠عبد الراضى

الزراعة بالكويت حديثة وتبلغ المساحة المنزرعة ٤٤٩ هكتار موزعة على ٤٧١ مزرعة ٠ وينتظر أن تزيد المساحة فى خلال ١٠ـ١٥ سنة الى ٦٠٠٠ هكتار ـ يروى منها ٣٢٥٠ بماء مالح ، ٢٥٠٠ بمياه المجارى و ٣٠٠ بماء عذب ٠ ماء الرى هو المحدد للزراعة ويأتى بعد ذلك نقص نسبة المادة العضوية فى الأرض ثم ندرة الأسمدة العضوية ٠ الدخل القومى بلغ فى عام ١٩٧٦ ٤ر٨ مليون دينار كويتى والانتاج الزراعى يمثل ١٠٪ من احتياجات السكان ٠

أراضى الكويت رملية تحتوى على ٧٪ طين وغرين وبعضها يوجد به طبقات صماء قريبة أو بعيدة عن السطح ونظرا لارتفاع درجة الحرارة والجفاف فان نسبة المادة العضوية ضئيلة وخصوبة الأرض ضحلة لعدم توفر الأسمدة العضوية ٠ ومصادر الأسمدة العضوية الميسرة هى : سماد الاسطبل الناتج من حوالى ٨٠٠٠ ماشيه بمزارع الألبان وعدة آلاف من الأغنام المستوردة للذبح ومن مزارع الدواجن ومكمورات مخلفات المدينة (كومبوست) ٠ وقد أنشىء فى عام ١٩٧٣ مشروع بسعة ١٠٠ طن/ يوم من القمامة يعطى ٤٠ طنا من السماد العضوى ٠ وسوف يوسع هذا المشروع لتصل كفاءته الى ٦٠٠ طن قمامة/ يوم ومواصفات الأسمدة الناتجة من هذا المشروع تعتبر جيدة ويستخدم فى محاصيل الخضر والفاكهة وهو يحتوى على ٢ر١٪ نتروجين ، ٢ر١٪ فوسفور ، ٦ر٠ بوتاسيوم ، ٦٢٪ مادة عضوية٠ ومخلفات المجارى تستعمل كسماد عضوى وجارى التوسع لتعطى كميات كبيرة من مياه الرى بجانب السماد ٠ ولكثير من المزارع على جوانب الطرق وبجوار المحطات تستخدم مواد المجارى بحالتها الطبيعية دون معالجة فى الرى والتسميد ولكن يوجد مشروع لمعالجة هذه المتخلفات بكفاءة ٢٠ مليون جالون/يوم والمشاريع الأخرى سوف تنشأ مستقبلا٠ وتقدر حمأة المجارى التى ستكون ميسرة فى المستقبل بحوالى ٦ر٣٨ طن/يوم فى ١٩٨٠ و ١ر٧٣ فى ١٩٨٥ و ٧ر٨٠ فى ١٩٩٠ على أساس ٦٠كجم/١٠٠٠ من السكان ٠ أما التسميد الأخضر فيعتبر فى الكويت غير مربح ويفضل أن يستخدم كعلف للمواشى سواء فى صورته الخضراء أو مجففا ٠

٦ ـ تقرير سلطنة عمـــــان

سليم على رواحــــى

هناك مصادر عديدة للمادة العضوية ، يختلف كل منها عن الآخر فى محتواها العضوى • وتعتبـــــر مخلفات الحيوان هى المادة العضوية التى يعاد استخدامها بصفة رئيسية فى سلطنة عمان • وتأتى هــــذه المخلفات أساسا من الأبقار ، الدواجن ، الأغنام ، والماعز ، وبعضها من الحمير والجمال • وفيما يلى بيـان بتعداد هذه الحيوانات حسب تقديرها عام ١٩٧٦ :

الماعز ٦٠٠ر١٦٤	الأبقار ٨٠٠ر١٣٣	الدواجن ٠٠٠ر١٠٠
الجمال ٥٠٠ر١٣	الحمير ٠٠٠ر١٠	

ويضيف بعض الزراع هذه المخلفات للتربة اما مختلطة مع بعضها أو بصورة مفردة ، وذلك حســـب توفرها • كما تتفاوت نسبة ماتحتويه هذه المخلفات من الأزوت من نوع لآخر • فمثلا يحتوى السماد العضوى من مخلفات الدواجن على ثلاثة أمثال الأزوت بنظيره من مخلفات الأبقار •

وتفتقر التربة فى عمان بشكل عام الى المادة العضوية ، وقد يرجع ذلك الى ارتفاع درجة الحـــرارة أثناء الصيف مع ارتباطه بجفاف التربة • وأحيانا ماترتفع درجة الحرارة لأعلى من ٤٥° م ، كما يقـــل سقوط الأمطار بدرجة كبيرة • ويبلغ المتوسط السنوى حوالى ٥٠ ـ ٢٠٠ مم ، فيما عدا بعض المناطـــق بظفار ، ولهذا كان الرى ضروريا للزراعة • وينعكس تأثير جفاف المناخ على انخفاض درجة تطور التربة • وعلى وجه الخصوص ، تعتبر كل أنواع التربة فى عمان حيوية مرتفعة •

وفى سهل الباطنه ، تعتبر ملوحة التربة والمياه العامل الأساسى المحدد لخصوبـــة الأرض • ويتراوح محتوى التربة من المادة العضوية بين صفر، ٨ر٠ ٪ ، والرقم الهيدروجينى بين ٥ر٧و٤ر٨ ، كمـــا ينخفض الفوسفور المتاح بدرجة كبيرة بسبب التأثير المثبط لكربونات الكالسيوم • أما السعة التبادلية للتربة فتتراوح بين ٥ـ١٥ للمكافىء/١٠٠ جرام تربة ، ويمثل الكالسيوم معظم الكاتيونات المتبادلة ، ولو أنـــه أحيانا ماتكون الغلبة للماغنيسيوم • والبوتاسيوم المتبادل يتفاوت بين ١ر٠ ـ ٥ر٠ للمكافىء/١٠٠ جـرام تربــة (مازاد عن ٣ر٠ للمكافىء/١٠٠ جرام تربــة يعتبر كافيا) ، أما الصوديوم المتبادل فيختلـــف توزيعه •

وفى الداخل ، يصل محتوى التربة من المادة العضوية فى بعض المناطق الى ٠٧ر٢ ٪ • وهو عـــادة مايزيد بتربة بساتين النخيل • وترتفع نسبة الكالسيوم والماغنيسيوم على معقد الامتصاص ، كما تميل التربـــة الى الملوحة بعض الشىء •

وفى بعض مناطـق ظفار يتشابه المناخ مع المناخ الاستوائى ، كما هو الحال فى سهل صلالـــه ، والجبل • وتتشابه الاختلافات السنوية بدرجة الحرارة بسهل صلاله مع المناخ الاستوائى ، ولكن مـــع زيادة فى الجفاف • وتتساقط الأمطار على الميول الجانبية للجبل بمعدل ٥٠٠ ــ ٦٥٠ مم سنويا بيـــن يوليو/تموز ــ اغسطس / آب • والطقس موسمى • ونظرا لتربية الماشيه بالمنطقة ، يزداد محتوى التربـــة مع المادة العضوية الى ٣ر٣٪ مما يؤدى الى ارتفاع الخصوبة عن مناطق ظفار الأخرى • ومع ذلك فالتربـة غير عميقة تكونت فوق صخر جيرى ويمكن أن تكون من نـــوع Terra Rosa .

أما ظفار الداخلى فمناخه صحراوى ، معدوم الأمطار ، ويشابه ساحل باطينه مع تباين أكبـــر فى درجة الحرارة •

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