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CROSS AND SELF-FERTILIZATION OF PLANTS.*

This is a valuable contribution to the literature of plant culture and improvement, containing, as it does, the results of the author's experiments in the cross and self-fertilization of plants during a period of nearly twelve years. Starting from the obvious and now generally recognised fact that most plants are adapted by diversified and effective means for occasional cross-fertilization, it might have been inferred from this alone that some great advantage was derived from such a process; and it is the object of Mr. Darwin's book, as he tells us himself, to "show the nature and importance of the benefits thus derived." The adaptation of flowers for cross-fertilization has occupied the author's attention for the last thirty-seven years, and the experiments recorded in the volume now before us were suggested by his having raised, for other purposes, two large beds of cross and self-fertilized seedlings of the wild Linaria vulgaris. "To my surprise," says the author, "the crossed plants when fully grown were plainly taller and more vigorous than the self-fertilized ones;" but as bees are necessary to the due fertilization of this Linaria, so that the wild plants from which these seedlings had been raised must have been inter-crossed during previous generations, it seemed incredible that the difference in vigour could be due to a single act of cross-fertilization, and the result, although apparent enough, was attributed to other causes. Further experiments, however, made with cross and self-fertilized seeds of Mimulus luteus and Ipomœa purpurea, a plant better known in gardens as Convolvulus major, both of which, unlike the Linaria and Dianthus, are highly self-fertile. In all these preliminary experiments, the apparent superiority was so much in favour of cross as against self-fertilized plants, that a more extensive and careful series of experiments was decided on, and these, as we have before observed, occupied nearly twelve years to carry out. It is essential to notice here that all the plants were artificially fertilized, the one set with their own pollen —seedlings of these being called "self-fertilized," and the other series with pollen from other individual plants, their seedling offspring being termed "cross-fertilized." The manner in which the experiments were conducted, as well as real or apparent sources of error, are carefully gone into, but the results obtained are uniformly in favour of the cross-fertilized seedlings, and especially so in the case of the plants fertilized with pollen from an entirely fresh stock grown under conditions of soil, air, heat, or moisture which had caused their characteristics or constitutional peculiarities to vary in different proportions from those with which they were cross-fertilized. This cannot be shown better than by reproducing the accompanying Table.

	Plants from a Cross with a fresh stock.	Intercrossed Plants of the same stock.	Self-fertilized plants.
Mimulus luteus—the intercrossed plants are derived from a cross between two plants of the 8th self-fertilized generation. The self-fertilized plants belong to the 9th generation.	100	4	3
Eschscholtzia californica—the intercrossed and self-fertilized plants belong to the 2nd generation.	100	45	40
Dianthus caryophyllus—the intercrossed plants are derived from self-fertilized of the third generation, crossed by intercrossed plants of the 3rd generation. The self-fertilized plants belong to the 4th generation	100	45	33
Petunia violacea—the intercrossed and self-fertilised plants belong to the 5th generation . . .	100	54	46

N.B.—In the above cases, excepting in that of Eschscholtzia, the plants derived from a cross with a fresh stock belong on the mother-side to the same stock with the intercrossed and self-fertilised plants, and to the corresponding generation.

* "The Effect of Cross and Self-fertilization in the Vegetable Kingdom." By Charles Darwin, M.A., F.R.S., &c. London: John Murray, 1876.

As the author observes at page 15 that he has met with no observations on the effects of crossing and self-fertilizing the individuals of the same variety, we may here the more fittingly allude to Mr. Gower's interesting experiments, made some years ago, and published in Williams's "Choice Stove and Greenhouse Plants," p. 31, where, under the head of "Fertilization," we are informed of the astonishing results obtainable by cross-breeding, especially in the case of spring, autumn, and winter flowers, which, being to a great extent deprived of insect agency, require artificial impregnation. The experiments here alluded to have especial reference to the larger production of seed and increased vigour in the resulting plants. "For example," says the author, "we found that the stigma of one flower fertilized with pollen from a separate flower, but growing on the same plant, yielded four times as much seed as when left to fertilize itself, and above one-half more than when artificially impregnated with its own pollen. Carrying the experiment still further, and bringing pollen from another plant of the same species, but which had not originally sprung from the same stock, we found that the produce was three times the quantity yielded under the most favourable circumstances of the other experiment, namely the fertilization by pollen from a separate flower of the same plant. The contrast was, however, greatest with the flower which received no aid whatever; for with the foreign pollen applied artificially, the yield of seed was finer in quality, and twelve times as much in quantity, while in the respective cases of fertilization with foreign pollen (that is, pollen from a different plant) and with its own pollen, the yield was five times greater in favour of the foreign pollen. This will be seen more clearly by the following Table:—

Experiment 1.	Experiment 2.	Experiment 3.	Experiment 4.
Produce of a flower not receiving artificial aid in any way.	Produce of a flower fertilized with its own pollen.	Produce of a flower fertilized with pollen from a separate flower grown upon the same plant.	Produce of a flower fertilized with pollen from a different plant of the same species.
25 Seeds.	60 Seeds.	100 Seeds.	300 Seeds
Yield of Seeds one-twelfth that of Experiment 4.	Yield of seeds, one-fifth that of Experiment 4.	Yield of Seeds, one-third that of Experiment 4.	Yield of Seeds highest both in quantity and quality.

This experiment was repeated several times, insects of all kinds being most carefully excluded from the flowers; and though differing in some cases in the number of seeds, yet in each the proportions were about the same. Now, although we are not prepared to assert that the like results can be obtained in the case of every species or variety, yet, from other experiments we have made, we are certain that the yield of seed will be larger and finer when the flowers thus receive the benefit of a cross with pollen from a separate plant, and where insect agency is deficient, it should always be supplied by artificial means."

The different phases of cross and self-fertilization as recorded and tabulated by Mr. Darwin, are doubtless of the utmost value and form the substantial basis of this instructive work, but it is in the general results deducible from these that we may expect cultivators to be most interested, and the benefits derivable from these are collected in the last chapter, from which we cannot do better than make a few extracts. The first and most important of these conclusions is that "cross-fertilization is beneficial and self-fertilization injurious," as shown by the superior difference in height, weight, constitutional vigour, and fertility of the offspring from cross-fertilized flowers. In the case of such plants as Reseda (Mignonette) and Eschscholtzia, which are sterile with their own pollen, but fertile with that from any other individual, it is pointed out that these plants must have been cross-fertilized during a long series of previous generations, and the artificial crosses as practised by Mr. Darwin cannot have increased the vigour of the offspring beyond that of their progenitors. "Therefore," says the author, "the difference between the self-fertilized and crossed plants raised by me cannot be

attributed to the superiority of the crossed, but to the inferiority of the self-fertilized seedlings due to the injurious effects of self-fertilization."

Another important result from a practical point of view is that "after plants have been propagated by self-fertilization for several generations a single cross with a fresh stock restores their pristine vigour;" and especially is this restoration valuable since "the good effects are transmitted by plants to the next generation, and, judging from the varieties of the common Pea, to many succeeding generations;" but it would appear as if there were a slow decrease of those effects in each succeeding generation, since many of the old varieties of self-fertilizing garden Peas are greatly improved by crossing them with fresh stock. There are some plants (and, according to our present knowledge, Ophrys apifera is a notable example) which habitually are self-fertilized, and as this plant, so far as we can judge, is as healthy and prolific as its cross-fertilized compeers, at present it would be desirable to know whether cross-fertilization would not be injurious rather than otherwise in the case of this and other self-fertilizing plants. Most probably, however, much of this mysticism anent the advantages of cross and self-fertilization comes of our looking at plants from an artificial and restricted stand-point; for it seems to us to be a matter of some importance whether we consider plant growth as it exists naturally, or as managed for private ends by the cultivator; for we must never lose sight of the great fact that re-production is hurtful rather than beneficial to the plant as an individual. Mr. Darwin's experiments go to prove that but little or no good follows cross-fertilization between flowers growing on the same plant, but on this point we require further evidence, particularly in the first place, because Nature especially provides for this kind of crossing in the case of Lobeliads, Agaves of the spicate group, and Composites; and, secondly, because, as we have already shown, Mr. Gower and, we believe, also the late Professor Lecoq, to say nothing of other observers, have noticed beneficial results from this phase of cross-fertilization, although not in such a marked degree as when two individual parents were employed. One fact pointed out by Mr. Darwin strikes us as being so important that we quote it in full:—"Seeds often lie dormant for several years in the ground, and germinate when brought near the surface by any means, as burrowing animals. They would probably be affected by the mere circumstance of having long lain dormant, for gardeners believe that the production of double flowers and of fruit is thus influenced. Seeds, moreover, which were matured during different seasons, will have been subjected during the whole course of their development to different degrees of heat and moisture." By this we see that cross-fertilization between distinct or differentiated stocks may have been carried on naturally for ages, owing to the sudden exposure and germination of seeds long buried, and the same result might attend the promiscuous dissemination of floating or winged seeds, since plants so distributed would be liable to become cross-fertilized by contiguity to plants in an old colony among which they had thus, as it were, become accidentally placed. We here see how it is possible for gardeners to improve their seeds by sowing mixed seeds of a variety, a result easily attained by purchasing a quart of any Pea, Bean, or other seed from three or four seedsmen in different localities, instead of three or four quarts of any given variety from one seedsman. This may give a little more trouble, but, as Mr. Darwin so well demonstrates, the results thus obtainable are worthy of extra cultural care, and to all seed-growers, for trade purposes more especially, is this book to be recommended. The fact of different species or families of plants affecting certain localities in which the soil, moisture, or shelter is suitable to their growth, also tends to foster cross-fertilization between distinct stocks or races, since a suitable seed-bed thus furnished serves in some measure to forward the development of seeds of similar plants. In conclusion, we may truly say that the volume now under consideration is one which no intelligent cultivator can afford to be without, and especially is this the case because, apart from the immense volume of facts or direct information which it contains, set down in a plain and systematic manner, there is also a vast amount of suggestive matter which rouses the attention of the reader and which induces him to collate his own knowledge as he reads. This, as we take it, is one of the objects kept in view by the author when preparing the work, and we now leave the book to the consideration of our readers as the result of priceless labour and research extending over the sixth part of a lifetime. B.

SAFFRON CULTURE IN THE ABRUZZI.

AT the Pharmaceutical Conference at Bristol, Mr. H. Groves narrated a botanical tour in the Abruzzi, a sea of mountains where the Apennines present their grandest chain. On the lower spurs of these mountains, at a height of from 2000 ft. to 3000 ft., the cultivation of Saffron has been carried on for many generations. The mountains are calcareous, and, except to the botanist who has roamed them, present a very barren aspect, only relieved by the Beech thickets which straggle up their flanks as far as the tree limit. The cultivated ground commences below the Beech thickets, and is but a little less stony than the ground above; however, Corn and Potatoes thrive well, and a little lower down the Saffron plots are established. Here the stones are removed as much as is possible in a soil that consists of little else, and the ground is well trenched to the depth of half a metre and prepared in August with animal manure, preferably that of sheep, so as to be ready for the planting of the bulbs in the following October. The bulbs are planted in ridges with intervening furrows, which for economy of soil are sown with Corn, as this crop is gathered before the Saffron flowers appear, and the furrows remain free as pathways for the gatherers; besides which they are so disposed as to drain the plot. In the latter part of October and the whole of November the crop is gathered. Women gather the flowers early in the morning, and remove the stigmata at their leisure. Several flowers usually grow from one bulb, in some instances as many as ten to twelve. Once planted the Saffron plots remain good for two years, at the end of which time they are dug up, and in the third year are planted with Corn, after which they may be used again for Saffron, although they seek to keep the plots shifting as much as possible. Cows are lovers of Saffron bulbs, and field mice would commit great havoc were they not looked after by the peasants, who keep small guns and traps constantly in the fields. Many of the wealthy landowners owe their position to Saffron dealing, which in reality is speculation, as the price per kilo ranges from 100 to 300 lire. The poorer cultivators sell at the price of the year, but the richer dealers set aside their Saffron in tins if the price does not suit them. Some seasons have yielded such profits that one year's harvest has surpassed the value of the land under cultivation; at others the cultivation would have ceased were not the beds of two years' duration, and consequently no expense entailed to wait the result of a second season. The adulteration of Saffron is carried out in various ways, the chief one being by mixing with it boiled and shredded beef, the shreds being stained with Saffron water and afterwards dried. The filaments of the stamens are also dyed in the same manner and intermixed. Another adulterant is an almost impalpable yellow earth found occasionally in the mountains; and finally, before taking the product to market, it is damped with wine or water. Dealers accustomed to buying Saffron avoid these adulterated specimens, so that the Aquilan or Abruzzi quality rules higher than any other kind, not excepting that of Spain.

NOTES AND QUESTIONS ON TREES AND SHRUBS.

Pimelea decussata in Ireland.—At Ballygiblin, near Mallow, Co. Cork, the seat of Sir Henry Becher, Bart., is a plant of this Pimelea growing in the open air. It has stood in the same situation for the past four years, and has never received the slightest protection during winter. It is in perfect health, and produces its flowers freely in the month of June each year. It is in a very sheltered position, but, nevertheless, it has withstood some 14° of frost.—E. R. Q. P.

Hydrangea paniculata grandiflora.—So much has been said of this new Japanese shrub during the past year that little need be added now. It has, according to "Moore's Rural," stood 26° below zero unharmed. It begins blooming early in August, and continues until after hard frosts. The thyrses of flowers, first greenish-white, then white, then rose, often measure 1 ft. in length and 20 in. in circumference. Every stem being thus terminated, the striking appearance of an entire plant may be conceived. There can be no doubt that this is one of the most valuable of all perfectly hardy shrubs.

Pruning Fir Trees.—Does the Spruce Fir suffer from cutting? Will you kindly inform me which is the best time for pruning this description of tree?—M. W. [Conifers are seldom injured by judicious pruning, that is when pruning is absolutely required, and done at a proper time, viz., between September and November, according to the season. In all cases, the cut points should be sloped, cutting outwards and upwards, so as not to expose the cut surface to the sun or frost. In a dry summer pruning can be done at a much earlier period than during a cold, wet one. Extensive ranges of Spruce Fir hedges along the roadside in several parts of Perthshire are cut every autumn, and look as well and quite as compact as a hedge of Yew.—M.]