THE CROSS FERTILIZING OF CEREALS.

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Although most of the papers presented before an association of this kind are naturally of a somewhat advanced character, it is surely unnecessary to apologize for the introduction of a paper of an elementary nature.

Cross fertilizing in cereals is an essential operation, if we are to make much progress in the improvement of these important grains. No one doubts the great value of selection as a means of improvement, but for my part I am strongly convinced that selection is of comparatively little value unless preceded by cross fertilization. One cannot expect great advances by selection (during any short term of years) unless the material to be selected shows great variations. Great variations follow cross fertilization, but are seldom otherwise to be found.

The actual manipulations in performing this simple operation, are differently carried out by different workers. The methods I have adopted are perhaps original in some respects and may be of interest to this Association, especially as the amount of work done has been large and the measure of success obtained has been greater than that resulting from the use of some of the older methods of manipulation.

For the work of cross fertilizing, no elaborate outfit of surgeon's instruments is necessary, however effective such a display may be in a photograph intended to excite the wonder of the public. The tools which I use are as follows: One small pair of forceps, a very small sable brush (usually No. 1), and a pair of scissors. In addition to these, two or three small wooden boxes for pollen are required as well as some string and a small quantity of some light cotton material (such as cheesecloth) with an open mesh.

The most suitable weather appears to be that which is bright and sunny, but not excessively hot. Almost any time of day seems satisfactory in favorable weather, but the afternoon seems preferable when the weather is very warm. In regard to both of these points, however, many more observations will be necessary before definite statements can be made.

It is not wise to use in cross fertilizing any plants grown in an ordinary field plot, as there is usually some slight element of uncertainty in regard to such plants. The plan I have adopted is to sow all the varieties to be used either as male or female in the form of very small groups of a dozen or two seeds each, all the groups being comparatively near together and located in some place not freely accessible to the public.

When the heads have reached the proper stage for cross fertilizing, it is perhaps best to begin by collecting the pollen from the variety to be used as the male. It is important, however, that pollen should

not be collected long in advance. While exhaustive experiments covering this point have not been made I have found that, as a rule, better results are obtained from fresh pollen than from pollen which has been gathered for even as short a time as two or three hours. For collecting the pollen, the most convenient method is to pick half a dozen or more heads and then to look these over carefully, using the forceps to remove all the anthers which are seen to be sufficiently mature, as well as any which have just recently burst and have not lost all of their pollen. The anthers are picked out of the heads and are put into a small wooden pill-box. The type of box used is about $1\frac{1}{2}$ inches in diameter and made of one piece of wood, being so hollowed inside as to avoid any sharp corners or angles. This box is prepared for use by being blackened and then coated heavily with shellac varnish, so that the pollen may be easily seen and easily removed. When sufficient anthers have been gathered, the box containing them should be set aside in the shade, while the female flowers are being prepared.

It is well to put in a stake before commencing operations on the plant to be used as female. One should then with the scissors remove from the head selected for the operation the spikelets near the base and tip, as these generally produce kernels of somewhat less than average size. From each of the remaining spikelets, I usually remove with the forceps all but the two principal flowers. The anthers are then removed from all the flowers left on the head. In performing this operation one needs to be very careful not to break off or to injure any of the glumes belonging to the flowers operated on. The glumes should spring back into their natural position, enclosing the pistil, after the anthers have been taken out. Those flowers in which when forced open the anthers are seen to have burst are of course removed at once, care being taken to avoid shaking out any of the loose pollen into the air. It unfortunately happens very often that the grasping of the anthers by the forceps for the purpose of removing them, causes them to burst if they are fully ripe. In such cases the flower in question should be cut off for fear that some of the pollen may have fallen on the pistil. When all flowers have been prepared, the pollen from the box is applied. Of course there might be advantages in tying up the head and leaving it a day or two for the flowers to become more fully mature and then applying freshly gathered pollen. This, however, would involve extra work and, as a matter of fact, good success can be had by applying pollen immediately after the anthers have been removed. Before putting on the pollen, the anthers in the little black box should be picked out, two or three at a time with the forceps, and tapped against the side of the box in order to remove the pollen from them. In this way a fair quantity of pollen can usually be obtained without much difficulty. It should then be brushed together at one side of the box and applied to the flowers in small quantities lifted out on the brush. It may be necessary to very slightly moisten the brush between the lips in order that the pollen may adhere

readily to it. This method of dealing with the pollen is not only very convenient, but has proved particularly successful, perhaps owing to the fact that the pollen applied to each flower, is the mixed product of many different anthers.

It is a common custom to tie up the head which has been operated upon in some kind of thin paper. It appears that in hot, sunny weather this form of covering produces a temperature around the head which is fatal to the setting of the seed. I have, therefore, for some years, used a cotton material, cheesecloth or something of that type, with which to tie up the heads. This material is wound around the head about twice, and tied both above and below the head and usually once loosely around the middle. It may be that in rare cases foreign pollen may be blown in through the openings in this cloth; but such an accident certainly occurs very seldom, if at all, and the advantage of this method of covering the head is great. Of course, when one has small groups of plants growing for the sole purpose of this kind of work it is a simple matter to remove any unused heads which are in a fair state of maturity and which might, if blown by the wind, strike against the heads which have been tied up or might shed pollen in their immediate vicinity.

It seems best to loosely tie the heads which have been operated on to a stake, though it must be admitted that this method is attended with some difficulties and dangers. The stem should also be loosely tied to the stake at about four different points in order that as it grows it may not bend itself at an angle, which it is quite sure to do if the tying is confined to the head only. For about a week after the head has been operated upon it is well to inspect it twice a day to prevent the occurrence of any accidents due to the rapid growth of the stalk. After this period has elapsed, the heads require no further attention until the seed is ripe. It is, perhaps, worth while, however, to remove all unused heads from those plants which are being employed as the females in the crosses, so that the full strength of the plants may go to the production of the desired seeds.

As it is by results alone that one can demonstrate the superiority of any method of work it seems desirable to summarize the results obtained in the cross pollenizing of spring wheat by the method described. This work covers the seasons of 1903-1906, the season of 1907 being omitted in making up these figures, owing to the impossibility of being quite certain at this date whether the seeds obtained in that year were true crosses or not. All crosses attempted by other methods than that here described are of course omitted in making up these figures as well as those attempted under conditions in any way distinctly abnormal. During the years mentioned, I operated by this method on 626 flowers. From these 320 seeds were obtained. The record of these particular seeds were not in all cases kept separate from those of the other seeds of identical parentage, so that exact figures in regard to germination cannot be given. The germination was, however, good: about 300 plants being obtained, of which only 10 failed to show any influence of the supposed male

parent (in either the first or second generation). These were no doubt self-fertilized by pollen of the same variety reaching the pistil at the time the operation was performed, or possibly through the cheesecloth after the head was tied up. It will be seen that the percentage of apparent success was 51, while the percentage of real success was about 46. Compared with the work of other investigators, whose operations have been performed under similar conditions of climate, these results obtained with spring wheat afford good evidence of the value of the methods of manipulation here described.

In working with barley and oats I have used the same method. With barley success has generally been easy to obtain, but with oats the results have not, as a rule, been satisfactory, only a very small proportion of the flowers operated upon producing seed.

REPORT OF THE COMMITTEE ON BREEDING FISH.

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OBJECTS: To investigate and report on the theory and practice of breeding fish, and on ways and means of promoting the improvement of fish by breeding; to indicate the relation of the breeding of fish to the breeding of other living things; and to encourage the development of the technique of fish breeding so as to increase the use of improved breeds of fish.

The following is the report of the committee as submitted by the chairman:

INTRODUCTORY STATEMENT.

The records as to results from the hybridization of fishes are so unsatisfactory that experiments are now being made in the hybridizing or crossing of various species susceptible to domestication or of domesticated fish under observation, notably the trouts. The Commissioner of Fisheries has directed all superintendents of stations in the Bureau of Fisheries to make such experiments whenever there is an opportunity to do so.

The object of such experiments is to ascertain whether any improvement can be made by producing a cross breed of economic value to the commercial fish culturist, as well as to establish principles of hybridization.

The Pacific salmons offer a remarkable field for making crosses in attempting to combine some of the very desirable qualities possessed by different species. As the progeny of any experiments with these species must go to the sea to mature and pass from