such work. Such experimentation naturally devolves upon the federal government.

It is therefore hoped that at no distant date the federal government will appropriate money for one or two fish cultural experiment stations to be operated along somewhat the same lines as agricultural experiment stations. The cost of such stations will undoubtedly exceed considerably the cost of an ordinary fish cultural station as now conducted but the economic value of such experimental stations from the results which ought to be obtained is sufficient warrant for the increased expenditure.

NOTES ON BREEDING OATS.

By J. B. NORTON, *Washington, D. C.*

Oat breeding in the United States in general is a question of breeding for resistance. The pure factors leading to increased yield are of paramount importance only in those regions where the optimum conditions of soil and climate always prevail, that is, we have to consider other things besides the possible yield per plant as determined by the number of flowers and the size of grain. With these factors alone, breeding work would be a simple question of mathematics.

In actual practice these two points are crowded into the background by the question of resistance. Rust, smut, lodging, hot weather, drouth, poor soil, and a multitude of other adverse circumstances all go to influence the yield and must all be considered in selection work.

The fact that a plant or strain of plants does not succumb by adverse conditions such as disease, drouth, etc., has been interpreted as resistance. As a matter of fact this apparent resistance may be due to quite different causes in different plants. These different causes lend themselves to a somewhat fixed classification as follows:

Physiological resistance to disease and parasitic and predatory enemies is usually and probably correctly assigned to the presence in the plant of some substance, that while it does not prevent the initial entrance of the disturbing factor, yet prevents the full development of the disease or organism.

Morphological resistance includes those cases where attack is prevented by denying entrance to the parasite or disturbing factor through some structural adaptation, also where effects of injurious environment are overcome by definite structure, as in drouth resistance, resistance to lodging, etc.

A third class in which plants escape disease and adverse conditions by modification of the growth period, while of great value in breeding work, yet can hardly be included in true resistance. If an oat variety ripens before the attacks of rust can hurt it, it is not necessarily resistant and can be said to be only rust escaping. This class of phenomena is in a way related to morphological resistance and the two can be more properly grouped as avoidance rather than resistance.

In all these cases we have resistance or avoidance in varying degrees and hence the necessity of selection of the best types enters as the great problem of breeding.

SMUT RESISTANCE.

Apparent smut resistance was noticed for several seasons but not studied carefully until last year when the marked difference in resistance of strains that had been untreated for several years showed some selections to be absolutely free from smut, while others growing near them were smutted about twenty per cent. This resistance is most marked in Early Burt and some of its hybrids, one whole series being perfectly free from smutted heads. Early Champion and its selections smutted worst. In the plats last year, without considering other characters, selections and hybrids, of this variety could be easily picked out. The cause of resistance to smut is not definitely known but it is probably physiological.

RUST RESISTANCE.

Leaf rust is usually most prevalent on varieties derived from *Avena fatua*; *Avena sterilis* forms are nearly free from it. Stem rust, however, attacks the latter very badly. In breeding for resistance to smut the yield of grain is probably the best basis for selection.

The variety studies and attempts at classification of standard varieties has brought out the fact that cultivated oats have originated from more than one wild species. It has been generally accepted that *Avena fatua*, the common wild oat of Europe and Asia, is the progenitor of all our cultivated forms. Such, however, is not the case. The red oats of the South and some related forms are undoubtedly descended from *Avena sterilis* of the Mediterranean region. This is plainly shown in a habit of growth, that of a semi-winter annual the fact that in *sterilis* alone we have the firm union of the first and second grains in the spikelet, in the color of the flowering glume and of the basal hairs, also in the reversionary forms which appear in second generation hybrids when a red oat is one of the parents, in many cases the hybrid bears a striking resemblance to *Avena sterilis*. Many other points of resemblance and habit, etc., have been observed. It is probable that a third wild species is represented by the common Burt oats in the southern states.

HOT WEATHER BLIGHT.

One of the most serious conditions interfering with successful oat growing in the United States is the blighting effect of hot weather on the flower and embryonic grain. Under normal weather conditions at blooming time every flower should set a grain and if the weather remains right, all these grains should develop. Such, however, is rarely the case. To a certain extent oat varieties have a definite blooming period which is only partially influenced by the time of planting. Oats planted in Illinois about April first ripened less than a week

earlier than the same varieties planted May first. Winter varieties, like Virginia Gray, planted in the fall will be ripe before the same seed planted in the spring has bloomed. Red Texas and similar *sterilis* varieties last year behaved peculiarly on account of a prolonged drouth. Ordinarily they ripen just after Early Champion, but last year Early Champion and the other *fatua* forms matured at their proper time while the *sterilis* forms, which probably originated in a region subject to drouth, refused to bloom until nearly a month after their normal period.

Selection in this case is rather easy as it involves two quantitative variants, the per cent of filled grain and the weight of grain per plant. The factor of earliness seems to be connected closely with any resistance to this hot weather blight but many hybrids between late and early varieties indicate that this is only an accidental relation and not true correlation.

In conducting breeding work, the first point to be considered is the climatic region for which the new strains are to be produced. In corn growing, the earliest varieties come from the north, while in oats the reverse is true. This is due to the fact that the growth limit in oats is determined by hot weather instead of by frost, as in corn. A late oat, such as White Russian or Black Tartarian, which might outyield all others in the north, when transferred to Kentucky, would not fill on account of the hot weather. In view of this important point, it seems advisable to carry on oat breeding work as a local proposition. While one central station for general work in hybridization and methods can be established, the final testing of selections, etc., must be done under the definite local conditions to reach the best results.

To secure pure strains of high average yield intended for any definite locality, it is not necessary to keep an extensive set of descriptive notes. Take for example, the conditions found in Central Illinois and Iowa where oats are grown as a rotation crop with corn. The one factor to consider here is the net average yield of the marketable threshed grain. In planning for this work the following points should be considered:

First, foundation stock. As many so-called varieties as possible should be tested in small rows for general adaptability to regional conditions. The most popular local varieties can be used to start preliminary selections. The breeder will not be far wrong in using these as a basis for preliminary work. They are probably composed of mixtures of several distinct types, many of which will outyield the original mixture.

In carrying out pure selection work, it is essential for the best results to work with large numbers. This is especially true in self-fertilized crops where no great change can be expected from continued selection. Unless a race varies, the value of continued selection is lost and we find ourselves selecting plants that are large through some effect of local conditions, size of parent grain, etc. Any increase obtained by this *maxima* selection will be lost as soon as selection ceases, as it must in the case of small grains. It is of great import-

ance, then, that we look for the original good plants in the field of the parent variety.

It is not necessary that a foundation bed be established with the grains planted a definite distance apart. The one requirement is that the original selections be made from plants grown under as near field conditions as possible.

The best criterion of a good oat is that it will do well under the conditions that it will have in the field. We do not know what the characteristics of a good breeding plant are. The ability to produce the greatest average *value* per acre is the criterion of the best strain of oats for any given set of conditions. Value is made up of a combination of *quantity* and *quality* where quantity counts about 90 points. Quality can be definitely measured and its factors determined, but quantity is made up of so many varying factors that we are at sea when it comes to general directions for selection. Where we desire a definite type of plant, as a Black Side oat, Swedish Select, or Sixty Day, the problem is easier. The typical plants in these varieties are closely related and any two type plants will give about the same progeny yield and will agree in their general form and behavior under different conditions. In making original selections for breeding work, the regular field is just as good as a few thousand plants in a foundation bed. In picking out several hundred of the best plants from a half acre you are sure to get just as good stock as if you picked from your foundation bed.

The next year plant the grains from the best head of each of your select plants in a series of short drilled rows of equal length, say five feet long and twelve inches apart. When these progeny rows mature, discard those that are least resistant to drouth, rust, smut, lodging, etc., harvesting only the best. This should be threshed and judged for quality, and if desired, for yield in a general way. No accurate estimate can be made but many rows can be eliminated on account of their poor yield. If any row shows lack of uniformity in type, it should be discarded at once. The seed not saved for the next season's planting can be used for an increase plot for home seed, as it would be better than the general field average and of reasonably pure type. Any selections from this increase field in the future will probably result in a waste of time and hence should not be made.

The seed for the second year's crop is planted in rows 17 feet long and one foot apart for a yield test. This is such a fraction of an acre that by multiplying the yield of the row in ounces by five, we obtain the approximate yield per acre of the selection. This system of yield estimate gives much better comparative values on a uniform field than half acre or acre plots. The conditions can be more closely controlled, rows influenced by extra good soil conditions can be more easily noted, and if necessary thrown out. The experimental plot is smaller and can be more easily cared for. With the amount of seed at our disposal, the results can be checked up by duplicate plantings.

In the third year, seed of the best selections can be sown in larger plots of uniform size for increasing the amount of seed.

In estimating yields of small rows on even ground, a check row should be planted at definite intervals. This seed should be obtained by carefully mixing equal quantities of extra seed from several or all of the selections when there is a difference in the ripening period. This will give the most reliable check, as it will be subjected to all the varying conditions of weather affecting the different selections. A check composed only of early oats would be unfair to the later strains and vice versa. In harvesting rows for yield, take only that portion of any row that would be cut by a binder, otherwise easily lodged varieties would be given an unfair advantage.

HYBRIDS.

Hybridization as a factor in breeding is now widely recognized and used by all careful workers. The object in making hybrids is to secure variations on which to base selection, to combine in one new form the desirable characters found only in two or more parent strains, to secure an accentuation of a character best represented in the two parent types, or sometimes to get a new character not found in either parent or in any of the related forms. The work in hybrid oats, as far as we can tell at present, proves the possibility of successfully carrying out any one of these propositions. The marvelous variations of second generation hybrids gives the widest field for selection. In crossing two varieties to secure a combination of desirable characters, Mendel's theory of germ purity in regard to unit characters has been of great assistance.

In a study of heredity in oat hybrids some interesting things have been noted that have a general bearing on breeding problems. Mendel's theory of heredity certainly applies in part to most of the characters of the oat plant. When the first generation hybrid plants were harvested, their inheritance of parental characters seemed to indicate a complete blending but the second year's work showed quite different results. This apparent departure from the germ purity hypothesis was found to be due to the absence of any definite dominance of one character over its alternate. Black and white oats crossed gave a brown hybrid but when the progeny of these brown hybrids were grown, it was found that one-fourth of them were as white as the white parent, one-fourth black, and one-half the hybrid brown again. Since then the black and white extracted types have come pure. Awned and awnless oats crossed gave a partially awned type which next year split up the same way into awned, awnless, and hybrid. Side oats crossed with open headed varieties gave a semi-side oat the first year but followed the same method of segregation in the future.

RED TEXAS HYBRIDS.

Hybrids between *Avena fatua* derivatives and *Avena sterilis* derivatives show many interesting reversions to the wild forms in the

second generation. Type wild awns often appear, also the hairy glumes of the wild parent. In this series of hybrids the appearance of large grained types is one of the most interesting phenomena. Some fixed types are now being grown in our selections that have much larger grains than either parent.

NAKED OAT HYBRIDS.

In the series of naked oats crossed with different hull types, a peculiar correlation was found, which has already been mentioned before this Society by Dr. H. J. Webber. The spikelet of the naked varieties usually has more than three grains while in the hulled types three grains is the limit. The first generation plants produced a head naked at the top and hulled at the bottom. In the second generation, one-fourth of the progeny were typical naked plants, one-fourth were hulled, and one-half like the first generation hybrids. The naked plants all had long spikelets with more than three grains while the hulled plants had spikelets with the usual two or three grains. In future generations no exception to this rule has been found except that one second generation plant of a cross between European Hulless and Garton's Tartar King which seems to have become fixed in the intermediate hybrid type. In this example we have an extremely rare case of the fixation of a heterozygote or hybrid type.

One of the objects of crossing naked with hulled types was to secure a large grained naked oat of high yielding power. Most of this series was discarded early, as they gave no promise. However, a cross between European Hulless and Sixty Day gave among many others one plant which had large grains and in the yield test of last year produced nearly double that of its hulless parent. The grain averages fifty per cent larger than either parent and is equal in size and weight to the hulled grain of our best Illinois varieties. This is a very good example of the possibility of securing a form with a character not found in either parent. It is all the more remarkable since crosses with none of the large grained types gave the desired size.

REPORT OF THE COMMITTEE ON SWINE BREEDING.

By D. A. GAUMNITZ, *Chairman, St. Anthony Park, Minn.*

Breeding swine should mean more than the mere reproduction of species. It should mean the mating and particularly the selection of animals so as to produce individuals which, as breeding animals, would be (1) prolific; (2) regular as breeders; (3) superior as parents, and which as meat producers would be (1) disease resistant, (2) economical converters of plant into animal products; and (3) heavy yielders of dressed carcasses which show profuse muscling and quality of flesh without too small bone.