Island plants will show hybridization, thus indicating that the greater part of the seed must have been self-fertilized. There are, however, indications that foreign pollen is somewhat more active than a plant's own pollen. For instance, at five o'clock one morning several flowers of Sea Island cotton were emasculated by the writer and pollinated with their own pollen after which they were covered with bags. About four hours later the same flowers were pollinated with upland pollen. About 50 per cent of the plants from the resulting seeds were hybrids, which would indicate that foreign pollen when once applied is even more potent than the plant's own pollen.

IMPROVEMENT OF COTTON BY SELECTION.

Aside from the above experiments in the hybridization of cotton, a large number of experiments have been made by agents of the Department in the improvement of certain standard varieties by selection. It has been shown that marked improvements can be obtained in this direction, as in the case of various other plants. The fiber of Achmouni Egyptian cotton has been increased about one-fourth of an inch in length as a result of four years' selection, the production meantime having been maintained. The production, however, has not been increased sufficiently so that the cultivation of this cotton in the United States can be recommended. Experiments which have been carried on in the selection of certain common upland cottons—as, for instance Russel and King—for length of lint, indicate that it will be perfectly possible to produce strains of these varieties having a fiber length of $1\frac{3}{4}$ inches if not greater. This field of improvement is one of the most important in cotton breeding, and will certainly give much quicker results than can be obtained in hybridization. It is probable, however, that more valuable and lasting new types can be produced by hybridization.

BREEDING SOY BEANS.

By H. F. ROBERTS, *Manhattan, Kansas.*

The breeding of the soy bean (*Soja hispida*) as a grain plant for the semiarid regions was entered upon by the Botanical Department of the Kansas Experiment Station in 1902. The well-known drouth-resisting qualities of this plant have caused its introduction into the West in recent years, as a hay or forage crop, to be grown where an annual legume was desired, or where such a perennial as alfalfa for various reasons would not succeed. The question of utilizing the soy bean primarily as a grain plant, and of bringing it up to a higher standard of efficiency in this regard, does not seem to have been considered hitherto. This appears, however, to be the rational source to pursue in the breeding of the plant.

There are some marked objections to the soy bean as a hay plant from the standpoint of farm economy. It is not a plant of a remark-

ably succulent habit with a rank vegetative growth, like the cow pea. It is a stocky, erect-growing plant with a decided tendency toward the development of a large stiff heavy stem, with woody branches and a foliage mass constituting a comparatively minor portion of the entire body. One is impressed at once with the fact that the plant is a heavy seed bearer. On individuals from 1 to 2½ feet high there will be developed from 20 to 30 pods or more, carrying from 1 to 3 seeds each. These seeds constitute 30 per cent of the entire dry weight of the plant, the remainder being largely the cellulose of the stems.

The present status of the soy bean as a seed bearer is indicated in the following table. Eighty plants taken at random from a group of selected individuals, in which the air-dry weight of the entire plant lay between 30 and 40 grams, gave the following results per plant:

Average weight of whole plants (air-dry)	grams 33.8
Average number of pods per plant	50.56
Average number of seeds per plant	73.88
Average weight of seed per plant (air-dry)	grams 10.30

From this it is at once apparent, as already stated, that about one-third of the entire dry weight of the plant is found in the seeds. In the above case, the average number of seeds per pod is but 1.4, whereas, in the best developed pods on all plants and on nearly all the pods of some plants, two or three seeds are borne. If the average number of pods per plant can be raised from 50 to 60 or 70, bearing in the neighborhood of 200 seeds, we shall have made a decided advance. As much and more has been accomplished in the breeding of other plants in domestic use.

It was necessary in the first place to discover what was possible and what was impossible with the soy bean. Accordingly, in 1902, from a field of beans grown as a farm crop, two groups of individuals were selected by careful inspection as they stood growing in the drill rows, one for apparently greater prolificacy, and the other for apparently superior stature and the vigor of the vegetative parts irrespective of the pod-bearing tendencies of the plants. It is, of course, true that such selection has a purely relative value, and, not being based upon fixed standards, the results are the outcome of personal judgments. Nevertheless, one must begin somehow, and this seemed the only way of arriving at the desired statistics with the very large number of individuals necessary to secure a safe average on which to base future calculations. The two groups mentioned were tagged in the field before the end of the growing season, and were then sacked to prevent loss of seeds or pods, and were harvested separately. Owing to the fact that the shattering habit, whereby the pods early after their maturity, begin to lose their seeds, is characteristic of most of the races of soy beans, it was deemed best to arrive at the question of relative prolificacy by counting the pods on each plant, rather than by counting or weighing the seeds. The pods are long retained on the plants, and constitute a safe basis for comparison.

It was found that the pods on 651 individuals were distributed in the following manner:

Plants bearing 1 to 10 pods.....	6
Plants bearing 10 to 20 pods.....	79
Plants bearing 20 to 30 pods.....	220
Plants bearing 30 to 40 pods.....	196
Plants bearing 40 to 50 pods.....	110
Plants bearing 60 to 70 pods.....	23
Plants bearing 70 to 80 pods.....	14
Plants bearing 80 to 90 pods.....	2
Plants bearing 90 to 100 pods.....	0
Plants bearing 100 to 110 pods.....	1
Total	651

The largest number of individuals—220 out of 651, or 34 per cent—fall into the 20 to 30 group as a mean. The curve platted seems to follow Quetelet's law in a rough way.

Of the plants selected for greater stature and vigor of development of the vegetative parts, it should be said, as of the preceding group, that exceptional individuals were not chosen, and that the plants selected were in all cases as closely planted in the drill rows as were those of less vigorous growth and of inferior development. Their superior stature, therefore, was not due, as far as could be seen, to ampler space left for root or stem development, or to better cultural conditions. The plants of this selected group numbered 715, and were graded for stature and development of body on the basis of the air-dry weights of the entire plants, a more certain test in the case of a widely-branching plant like the soy bean, than the measurement of the height would be. It was found that the individuals weighed fell into groups as follows:

Plants weighing from 1 to 10 grams.....	6
Plants weighing from 10 to 20 grams.....	163
Plants weighing from 20 to 30 grams.....	465
Plants weighing from 30 to 40 grams.....	72
Plants weighing from 40 to 50 grams.....	7
Plants weighing from 50 to 60 grams.....	2
Total	715

It appears that in this case the mean lies in the 20 to 30 gram class, in which 465 individuals, or 42 per cent of the whole, are found grouped. The curve appears likewise to follow Quetelet's law. In the same group of individuals the number of pods per plant was also counted, with the following results. There were:

Plants bearing 10 to 20 pods.....	7
Plants bearing 20 to 30 pods.....	100
Plants bearing 30 to 40 pods.....	300
Plants bearing 40 to 50 pods.....	245
Plants bearing 50 to 60 pods.....	65
Plants bearing 60 to 70 pods.....	13
Total	730

Through some undiscoverable error in tabulating there appear in this table 15 more individuals than were actually counted, but this error can in no way affect the general result. From the above it appears that 300 individuals or 41 per cent are found in the class bearing 30 to 40 pods per plant. It will be remembered that of the 651 individuals selected in the field for apparent prolificness the laboratory examination showed the mean to lie in the 20 to 30 class. It would appear from this, perhaps, that so far as the mere rough process of selection of plants in the field is concerned, the method of selection of individuals with greater apparent vegetative vigor would yield more satisfactory results so far as discovering more heavily bearing plants is concerned, than the method of selecting those plants which seem from optical inspection to carry the most pods: This is not necessarily to be expected, since vegetative luxuriance is usually correlated with diminished seed production.

The whole question, however, lies in whether improvement in seed-bearing capacity can be secured by selection of the highest bearing plants from year to year, by whatever method. To ascertain facts bearing on this point, the seeds borne by the plants especially selected for seed production were planted this season (1903). The progeny used for this purpose were those from parents near the extremes of both maximum and minimum of pod production. The groups included in the planting of the progeny plats were those bearing from 1 to 10 pods and 10 to 20 pods on the one hand, and those bearing 40 to 50, 50 to 60, 60 to 70, 70 to 80, and 80 to 90 on the other, leaving out those near the mean—20 to 30 and 30 to 40.

The progeny of each mother plant was sown in drills under field conditions similar to those under which the mother plants themselves had grown the previous year, and on similar soil. All of these plants, amounting to 4892, were tabulated for pod-bearing capacity, with the result shown in the following tables:

Pod-bearing record of first generation of progeny, in relation to pod-bearing record of the mother plants.

	Progeny of seed from mother plants with pod-bearing records of—							Total.
	1-10	10-20	40-50	50-60	60-70	70-80	80-90	
Plants bearing 1 to 10 pods...	4	125	183	199	119	35	10	675
Plants bearing 10 to 20 pods...	8	207	337	324	194	56	25	1151
Plants bearing 20 to 30 pods...	14	283	298	245	185	52	28	1105
Plants bearing 30 to 40 pods...	8	271	272	144	73	34	32	834
Plants bearing 40 to 50 pods...	4	188	189	82	27	7	13	510
Plants bearing 50 to 60 pods...	0	134	133	30	18	4	7	326
Plants bearing 60 to 70 pods...	2	58	77	11	6	2	1	157
Plants bearing 70 to 80 pods...	1	29	43	6	1	0	.....	80
Plants bearing 80 to 90 pods...	.....	11	16	4	.....	0	.....	31
Plants bearing 90 to 100 pods...	.....	1	8	0	.....	1	.....	10
Plants bearing 100 to 110 pods...	.....	3	5	1	.....	.....	.....	9
Plants bearing 110 to 120 pods...	.....	2	2	.....	.....	.....	.....	4
Total	41	1312	1563	1046	623	191	116	4892

Progeny of first generation arranged in two groups, according to whether they descend from mother plants of high- or low-bearing record.

	Progeny of seed from mother plants--	
	Low-bearing (1 to 20).	High-bearing (40 to 90)
Plants bearing 1 to 10 pods...	129	546
Plants bearing 10 to 20 pods...	215	936
Plants bearing 20 to 30 pods...	297	808
Plants bearing 30 to 40 pods...	279	555
Plants bearing 40 to 50 pods...	192	318
Plants bearing 50 to 60 pods...	134	192
Plants bearing 60 to 70 pods...	60	97
Plants bearing 70 to 80 pods...	30	50
Plants bearing 80 to 90 pods...	11	20
Plants bearing 90 to 100 pods...	1	9
Plants bearing 100 to 110 pods...	3	6
Plants bearing 110 to 120 pods...	2	2
Total	1353	3539

These tables may be analyzed in a summary as follows: Of the progeny numbering 41 individuals, coming from mother plants bearing from 1 to 10 pods each, 14, or 31 per cent, bore from 20 to 30 pods each, while only 10 per cent fell in the 1 to 10 class of the parents.

Of the progeny, numbering 1312 individuals, coming from mother plants which bore from 10 to 20 pods each, the highest number of individuals, 283, fell in the 20 to 30 pod class, making 22 per cent of the total progeny from these parents. Individuals to the number of 271, or 21 per cent, of the progeny of the same group of mother plants, bore from 30 to 40 pods each, while the number of individual progeny falling into the 10-20 class of the mothers was only 17 per cent.

From this it appears that individual mother plants selected as having a low-bearing record did not yield progeny with a correspondingly low-bearing record. On the contrary, the mean of the progeny from mother plants of both the 1 to 10 and 10 to 20 classes fell into the general mean of the race, the 20 to 30 pod class of plants.

Inspection of the progeny from mother plants of the higher bearing records shows a like result. From mother plants bearing from 40 to 50 pods each, the progeny planted and harvested amounted to 1563 individuals. The mean bearing capacity of these fell into the 10 to 20 class, where we find 337 individuals, or 21 per cent of the whole. Of the progeny from mother plants bearing from 50 to 60 pods each, the mean of the 1046 progeny fell also in the 10 to 20 class, with 324 individuals, or 30 per cent. Of the progeny from mother plants bearing from 60 to 70 pods each, amounting to 623 individuals, the mean lay in the 10 to 20 class likewise, where we find 194 individuals, or 31 per cent. Of mother plants bearing from 70 to 80 pods, the progeny numbered 191, and their mean fell into the 10 to 20 groups, with 56 individuals, or 29 per cent.

Finally, from those mother plants bearing 70 to 80 pods each, there came 116 descendants of which the mean fell in the 20 to 30 class with 28 individuals, or exactly 25 per cent.

The second table shows that all of the 4892 individuals descended from mother plants selected and tabulated for pod production grouped in two general classes for comparison. First, there is an assemblage of 1353 individuals that came from mother plants of low-bearing capacity, or, perhaps better said, of low-bearing record. *i. e.*, those which were found to have borne from 1 to 20 pods each. There is, in the second place, an assemblage of 3539 individuals that came from mother plants having a high-bearing record, from 40 to 90 pods each.

Of the former group, the mean is found to lie, not in the group bearing pods from 20 downward, but in the 20 to 30 group, where the mean of the race seems to lie, and in this class we find 297 individuals, or 22 per cent. Of the 3539 individuals descended from mother plants of high-bearing record, we find the mean not to lie in any one of the groups bearing from 40 pods upward, but actually to lie in the 10 to 20 group with 936 individuals, 26 per cent of the whole. As a matter of fact, only 694 individuals, or 16 per cent were found bearing from 40 or more pods per plant.

It is evident, therefore, that selection of high and low bearers as mother plants, while it gave progeny that was both high and low in each class, did not result in any shifting of the mean downwards in the progeny from low-bearing mother plants, or upwards in the progeny from high-bearing mothers.

The conclusion—if any can safely be drawn from statistics of but two generations—is that, in the case of soy beans, the mean bearing capacity of the plant seems to follow Quetelet's law, and that improvement in bearing capacity cannot be obtained by annual selection of the highest bearing plants.

It should be stated that the experiment is being continued on the same lines for further verification.

Mention should be made of the attempt which is being made to find mothers for a race of non-shattering soy beans, an absolute essential to success in breeding the plants for grain-bearing purposes exclusively. Out of the great number of individuals thus far handled in the breeding plats, a few show remarkably retentive pods, and it so happens that these particular plants in all cases ripened much earlier than the others. Naturally, these will be carefully isolated as mother plants for this season's planting. Here and there among the progeny from the same mother plant, decidedly aberrant forms appeared among descendants of an otherwise uniform cast. These "sporting" individuals (possibly they are "mutation forms" in the sense in which de Vries uses that term) have been retained for further experiment. If de Vries' theory of the origin of species by mutation be correct, the improvement of the bearing capacity of the soy bean would seem to lie in the discovery of such "mutation forms" as display a high-bearing capacity. Our experiments thus far have not certainly revealed such individuals.

As a final word, it should be said that the general vegetative growth and vigor of development of the plants of the second generation was in every way satisfactory and fully equal to that of the

parents so far as the seasonal and cultural factors are concerned, and there was certainly no falling off in pod-bearing capacity due to untoward conditions.

BEAN BREEDING.

By R. A. EMERSON, *Lincoln, Nebr.*

TYPES AND CONDITIONS INVOLVED.

Beans are grown for so many purposes that the objects sought in breeding them can scarcely be indicated in a general way. It should be pointed out at once that a general-purpose bean is an impossibility. Beans illustrate the value of special types for special purposes as well as any crop known to the writer. In the following account, some idea will be given of the many uses to which beans are put and the particular types which should be kept in mind when breeding beans for these particular purposes.

ADAPTATION TO CLIMATIC CONDITIONS.

Adaptations to local conditions is one of the first things to receive attention. A race of beans may be very good in one locality and worthless in another. The Yosemite Mammoth, for instance, is doubtless an excellent sort in rich soils in mild moist climates, but if we had to depend on this variety in Nebraska, we should go without snap beans. Plant habit is important from the standpoint of locality. Climbing beans are out of the question in a windy country, unless the climate be very dry so that the plants can trail upon the ground. Bush beans, for whatever purpose grown, should be erect and strong enough to hold their pods well above the ground to avoid rust and discoloration if not harvested promptly when mature. This character is not often found in either garden or field beans. It is probably more important in moist than in rather dry climates.

SNAP BEANS.

Several types of garden beans are needed in any locality. The ideal main crop snap bean for home use, in addition to being productive and resistant to disease, must have good quality. The immature pods are the crop. Above all they should be tender; that is, without the development of cross-fibers in the pod walls. Stringlessness, or the non-development of fibers along the sutures, is important, but less so than tenderness, for, in breaking snap beans, the strings can be pulled out, but the cross-fibers cannot be removed and will never cook tender. Fleshiness of pod is a character of prime importance. Most pods are tender and almost stringless when young, and some races are almost perfect in this respect even when their pods are full grown, but without fleshiness they lack substance. An agreeable flavor when cooked is a character not commonly regarded, but there are considerable differences in the flavor of beans. A yellow or