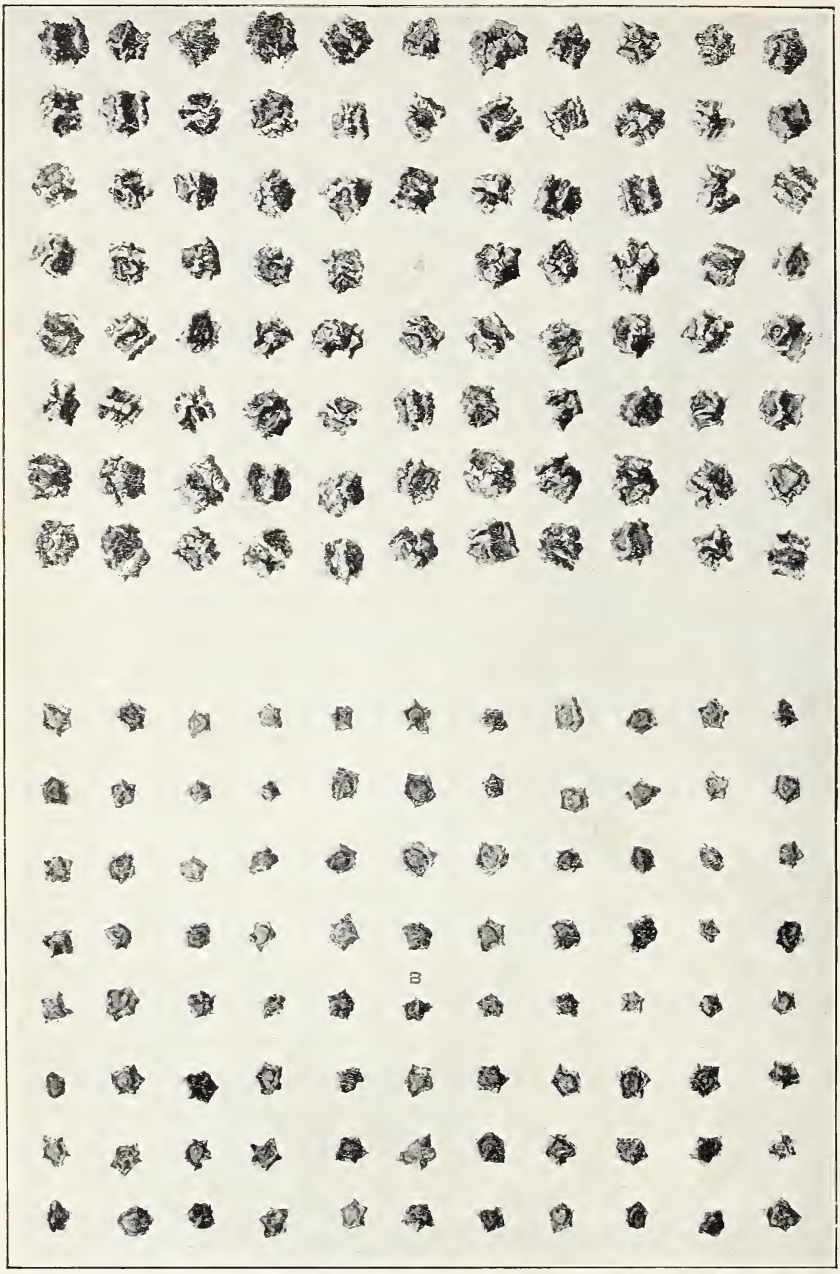

A.—MULTIPLE-GERM BEET-SEED BALLS. B.—SINGLE-GERM BEET SEEDS.
Natural size.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 73.

B. T. GALLOWAY, *Chief of Bureau.*

THE DEVELOPMENT OF SINGLE-GERM BEET SEED.

BY

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AND

E. C. RITTUE, Assistant.

VEGETABLE PATHOLOGICAL AND PHYSIOLOGICAL INVESTIGATIONS.

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Pathologist and Physiologist, and Chief of Bureau.

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LETTER OF TRANSMITTAL.

U. S. Deparment of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., January 26, 1905.

Sir: I have the honor to transmit herewith the manuscript of a paper submitted by the Pathologist and Physiologist, entitled "The Development of Single-Germ Beet Seed," by Dr. C. O. Townsend, Pathologist in Charge of Sugar-Beet Investigations, and Mr. E. C. Rittue, Assistant, Vegetable Pathological and Physiological Investigations, and recommend its publication as Bulletin No. 73 of the series of this Bureau.

The accompanying eight plates are necessary to a clear understanding of the subject treated in the text.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

Efforts to produce a single-germ beet seed have created considerable interest among sugar-beet growers, and numerous inquiries have been received in regard to the progress of the undertaking. It has been considered advisable, therefore, to present at this time a preliminary report relative to this work, giving a brief description of the sugar-beet flower, single and multiple germ seed balls, and the methods employed in carrying the work forward from its inception two years ago until the present time.

It is encouraging to know that some progress has been made toward the solution of this problem and undoubtedly it is only a question of time when beets will be grown commercially from single-germ seed.

Acknowledgment is hereby made to Mr. T. R. Cutler, manager; Hon. George Austin, general agricultural superintendent, and Mr. Parley Austin, local agriculturist for the Utah Sugar Company, for their assistance in carrying forward this work.

A. F. Woods,
Pathologist and Physiologist.

Office of Vegetable Pathological
and Physiological Investigations,
Washington, D. C., January 20, 1905.

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THE DEVELOPMENT OF SINGLE-GERM BEET SEED.

INTRODUCTION.

Owing to the importance that the beet-sugar industry has attained in the United States, and to the possibilities of the extension of sugar-beet growing and beet-sugar production in this country, it is desirable that every effort be made to improve to the fullest extent the quality of the beets and to cheapen in every way possible the cultural processes involved in sugar-beet growing, so that the largest returns per acre may be obtained at a minimum cost. The first part of this proposition—the improvement of the quality of the beet—depends to a large extent upon the proper selection of beets for seed production, upon improved methods of cultivation, and upon the proper relation of the plant to soil and climate. The second part of the proposition—the cheapening of the cultural processes relating to sugar beets—may be accomplished either by skill acquired by practice in performing the various hand operations so that a greater amount of work of a given kind may be done in a definite time, or by the employment of labor-saving machinery, or by so changing the beet or the seed that certain operations are no longer necessary.

The Department of Agriculture has in view the accomplishment of the improvements above outlined, and it is believed that the production of single-germ beet seeds on a commercial scale will do much toward reducing the cost of sugar-beet production, and will possibly improve the quality of the beets in one or more directions. It is the purpose of this preliminary report to show to those interested in the subject the progress that has been made in the development of a single-germ beet seed during the two seasons that the work has been under way.

Mr. Truman G. Palmer, secretary of the Beet Sugar Manufacturers' Association, in a contribution to the annual report on the progress of the beet-sugar industry in the United States[a] discusses the advantages and disadvantages that would result from the use

[a] See Progress of the Beet-Sugar Industry in the United States in 1902.—Report No. 74, United States Department of Agriculture, pp. 141–152.

of single-germ beet seeds, and while the obstacles in the way of employing single-germ seeds on a commercial scale are of sufficient importance to demand consideration. there is no reason to suppose that these obstacles can not be overcome, as Mr. Palmer has suggested. At any rate, the only satisfactory way to determine the practicability of the single-germ seed for beet production is to produce such seed in sufficient quantity so that it can be tested on a commercial scale in comparison with multiple-seed balls under the same conditions of soil and climate.

SINGLE AND MULTIPLE GERM BEET SEED.

The term "seed ball," as applied to beet seeds, implies a combination of seeds into a mass having a more or less rounded appearance (Pl. I, A); hence, the term "ball" can not properly be applied to the single-germ beet seed (Pl. I, B). Each germ arises from a single floret, and when the flowers are in clusters of two or more (fig. 1) a multiple-germ seed arises; whereas, if the flower stands by itself on the stem (fig. 2) a single-germ seed results. If two or more single flowers stand very close together but do not arise from the same point as in the case of flower clusters, each will produce a single-germ seed (Pl. II). Even if the flowers are so close together that the seeds slightly adhere in the process of development, they are easily separated and readily distinguished as single-germ seeds (Pl. III, flower stalk on right hand, end of second branch at left). On the other hand, the component parts of a multiple-germ seed ball adhere so firmly that they can not be separated by any known process without great danger of injuring the germs. It appears, therefore, that the arrangement and distribution of the flowers on the seed stalk determine whether the seeds are to be single-germ seeds or whether they are to be parts of multiple-seed balls. One can determine in practically all cases, even before the flowers are open, whether they will produce single-germ seeds or whether they will be parts of a multiple-seed ball.

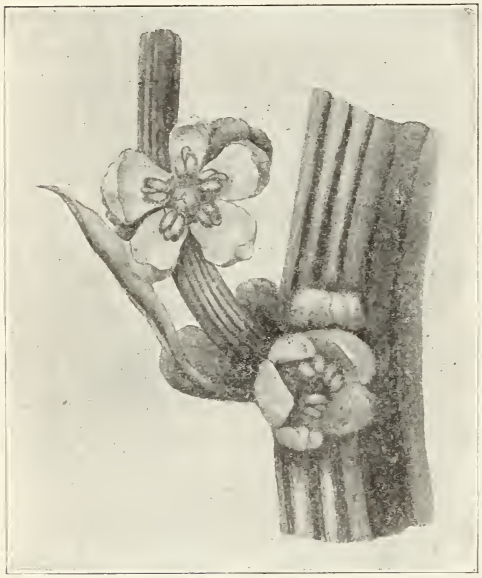

FIG. 1.—Clusters of closed and partly open beet flowers.

A typical single-germ beet seed is a five-pointed star possessing a somewhat flattened appearance (Pl. I, B). As a rule, these are easily distinguished from the multiple-germ seed balls, as shown in Plate I, A. Frequently the points of the star are broken off, when a more careful examination is necessary to determine whether the seed in question contains one or more germs. A close examination of a number of these seeds and a comparison of them with multiple seeds will soon make the selection of single-germ seeds comparatively easy.

There is a false single-germ seed against which it is necessary to guard in making selection of the single-germ seeds. This false single-germ seed arises usually from what would have been a double-germ seed (Pl. VIII, fig. 2) had not one of the seeds failed to develop. A more or less close examination will invariably enable one to determine which is the false and which is the true single-germ seed.

The careless observer often makes the mistake of supposing that the small seeds are all single germs and that all multiple seed-balls are large. Some seedsmen have made the assertion that 60 per cent of the seeds produced by beets have single germs and that these seeds are sifted out and discarded from the commercial seed. The writers obtained a sack of the siftings from a quantity of commercial beet seed, as they had been informed that these siftings were composed of nearly all single-germ seeds. A careful examination of this seed was made and the different sizes were separated by means of sieves having 6, 8, 10, 12, and 14 meshes per inch. (See Pl. IV, B to G.) The results are tabulated for convenience to show the percentage of singles that were caught in each sieve, while in Plate IV the percentage of single-germ seed is roughly indicated by the number of singles at the end of the second row in each set. (See Table I, p. 12.) A study of this table shows how erroneous is the common impression with reference to the number of single-germ seeds that are present in commercial seed. Many of the single-germ seeds are larger than many of the multiple-germ seeds, as shown by Plate IV, D, compared with singles shown in groups A, B, and C. In practically all commercial seeds there are a few single-germ seeds, but an examination of a large quantity of commercial seed and a study of many seed beets in the field show that the number of singles produced by the ordinary beet-seed plant is very small. (See Table III, p. 22.)

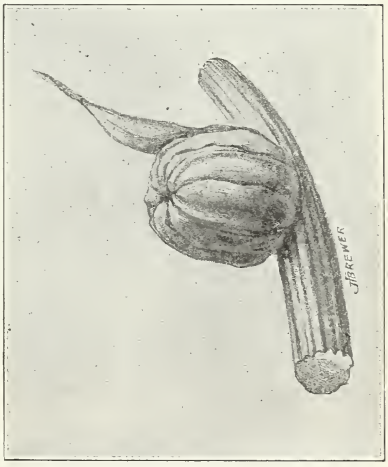

FIG. 2.—A single beet flower bud.

TABLE I.—*Percentage of single-germ seeds from siftings.*

	Number of meshes per inch.				
	6	8	10	12	14
Percentage of single germs	3	8.8	8.8	8.5	7.6

The singles that remained in sieves of 6 and 8 meshes to the inch were of normal size and well filled; those that remained in the sieve of 10 meshes were small but well filled; those left in the 12 and 14 mesh sieves were to a great extent not filled at all, while others were simply immature flowers, and, taken all together, they constituted but the small percentage of 7.34—considerably less than 8 per cent. While we have no way of determining what bulk of the cleaned seed these siftings represent, study of seeds obtained from ordinary beet plants leads to the conclusion that they do not represent more than one twenty-fifth, or 4 per cent, of the original bulk. If this be true, and on an average three seeds from the siftings are equal in weight and bulk to one commercial seed, the following conclusions can be reached:

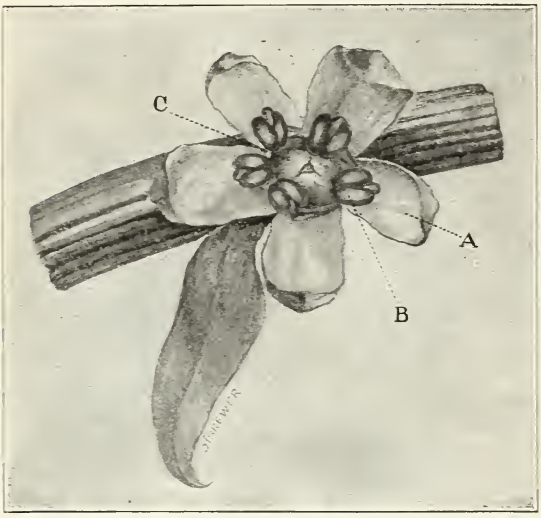

FIG. 3.—A single beet flower. A, sepal; B, anther; C, pistil.

Percentage of singles in siftings 7.34÷8⅓ (25÷3)	0.88
Percentage of singles in commercial seed	.96
Average percentage of singles in ordinary seed	1.84

This is somewhat lower than the percentage of singles on the plants selected from the field of ordinary seed beets. (See the second column of Table III, p. 22.) It must be remembered that the 2.77 per cent given in Table III is the average of singles on the ten best plants and not the average of all the plants in the field.

THE BEET FLOWER.

The beet flower consists of three sets of organs arranged in three whorls (fig. 3). The outer set is composed of five green parts, called sepals (fig. 3, A), which are attached to and form a part of the seed coat. In the early stages of the flower, i. e., before it opens, these five sepals inclose and protect the other parts of the flower (fig. 4).

These sepals are not united with each other along the edges except near the base, so that when the flower opens they form a five-pointed star (fig. 3). It is these five sepals which form the five points of the star when the seed is ripe (Pl. VIII, fig. 4). These parts, as well as the remainder of the seed coats, turn brown upon the ripening of the seeds. The second set of organs consists of five stamens, one opposite each sepal (fig. 3, B). Each stamen consists of a fine stalk, called a filament (fig. 5, D), and on the free end of each filament is a sack, called an anther (fig. 3, B, and fig. 5, B). The anthers contain the pollen grains, a few of which much enlarged are shown in figure 6. There are thousands of pollen grains produced in each anther, and as there are five anthers in each flower the pollen grains produced by each flower are almost innumerable, and when we consider that each plant produces thousands of flowers we can readily understand how it is that the air in and around a field of seed beets at flowering time is filled with these grains.

FIG. 4.—A single beet flower and a cluster of buds.

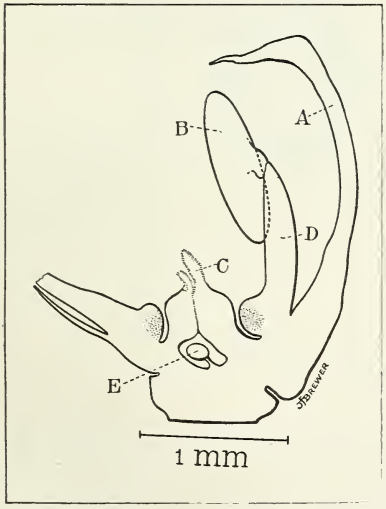

FIG. 5.—Section of a beet flower. A, sepal; B, anther; C, pistil; D, filament; E, seed germ.

The third set of flower parts is in the center of the flower, and is called the pistil or pistils (fig. 3, C, and fig. 5, C). In the beet flower the pistil is composed of three parts, as shown in figure 3, C. Just at the time the flowers are ready to open completely, the pollen grains become ripe, i. e., they reach a stage of development when under proper conditions of warmth and moisture they will produce what are called pollen tubes. At this stage of the development of the pollen grains the anthers burst, allowing the grains to escape. At the same time the three-parted pistil becomes sticky and some of the pollen grains, carried either by the wind or by some other agency, such as insects, fall upon the pistil and remain attached. This transfer of pollen from the anthers to the pistil is the process

known as pollination. Under the favorable conditions already mentioned pollen tubes are produced and grow down into the lower part of the pistil, where the contents of a pollen tube unite with the contents of the lower part of the pistil to form the germ which is destined to produce the new plant (fig. 5, E). This union of the contents of the pollen tube and of the lower part of the pistil is called fertilization.

This brief description of the flower parts and their function will, it is hoped, serve to make clear the terms pollination and fertilization, without some knowledge of which the methods employed in our

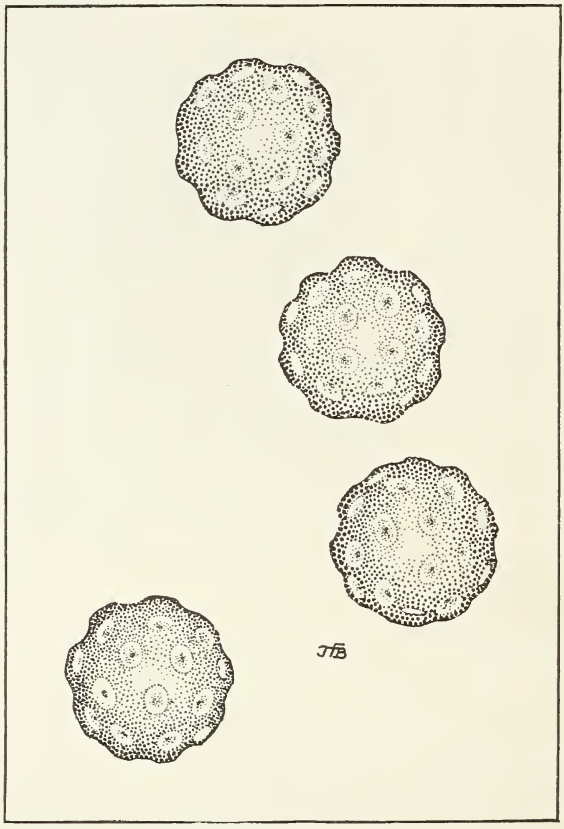

FIG. 6.—Pollen grains. × 750.

flower selection and treatment would be meaningless. It should be clearly understood that it is through the union of the contents of a pollen tube with the contents of the lower part of a pistil that the germ which is to produce the new plant is formed. The pollen grain thus utilized may originate in the same flower which it fertilizes, or it may originate in one flower and be transferred by some agency to the pistil of another flower. In the former case we speak of this process as close-pollination or close-fertilization, as the case may be, while in the latter case we speak of it as cross-pollination or cross-fertilization.

THE FIRST SEED SELECTION.

As soon as the work of producing single-germ beet seed was taken up, the various methods by which the desired results might be reached were considered and the writers arrived at the conclusion that the most satisfactory results could be attained by the production of a plant that should bear only single-germ seeds rather than by any process which should have for its aim the separation of the multiple-germ balls into the several seeds of which they are composed. Accordingly, samples of about 4 pounds each of eight of the leading varieties of commercial sugar-beet seeds were obtained, and all the single-germ seeds were carefully separated from the multiple-germ seeds in these samples. The single and multiple germ seeds were counted and the percentage of singles computed, whereupon it was found that the number of single-germ seeds consisted of a little less than 1 per cent (0.96) of the entire number of seeds in the 32 pounds examined. This calculation does not determine the percentage of single-germ seeds produced by beets of different varieties, but serves to show the percentage of single-germ seeds that are present in our ordinary commercial seed of the first grade. Subsequent selections and calculations along the same line served to confirm the results given above. The first single-germ seeds selected were used for two purposes: (1) For comparison in regard to germination and vitality with multiple-germ seeds, and (2) for the production of seed beets in the greenhouse, with the hope of gaining one season toward the solution of the problem of single-germ seed production.

GERMINATION AND VITALITY.

A comparison of the germination and vitality of single-germ seeds as compared with multiple-germ seeds is best brought out by means of Table II, which shows a distinct difference in favor of the single germ seeds.

TABLE II.—*Comparison of germination.*

Kind of seeds used.	Number of seeds used.	Number of germs in seeds used.	Date of planting.	Number of seedlings produced each 24 hours after planting for 10 days.										Total number of seedlings.	Percentage of germination
			1903.												
Single-germ seeds	400	400	Mar. 26	0	0	6	32	73	94	76	31	10	7	329	82¼
Multiple-germ seeds	100	400	....do ...	0	0	0	5	9	27	39	70	37	12	199	49¾

The seedlings from the multiple-germ seeds were thinned as carefully as possible, but the difference in growth was distinctly in favor of the plants produced from the single-germ seeds, and this difference held good during the growth of the plants. Further experiments of this kind confirmed the results shown in the table, viz, that the single-

germ seeds sprout in a shorter time than the seeds in the multiple balls; that the percentage of germination is higher, and that the plants produced from the single-germ seeds possess greater vitality than those produced from multiple-seed balls. The single and multiple germ seeds used in these comparative experiments were taken from the same lot of commercial seeds.

GREENHOUSE EXPERIMENTS.

Several hundred plants from single-germ seeds were started in the greenhouse in December, 1903, with the hope of obtaining a crop of seed the following summer. The plants made a luxuriant growth and, when they had attained a weight of from 1 to 2 pounds, water was withheld and the beets were left to ripen. After two weeks of ripening, nearly all the beets were taken up and siloed. At intervals of several weeks some of the siloed beets were replanted, but the results were uniformly negative, so far as the production of seed stalks is concerned. Etherizing and other methods of inducing the plants to produce seed stalks were resorted to, but likewise with negative results. It was therefore necessary to depend upon field planting for the first crop of seed beets.[a]

SEED BEETS IN 1903.

In the spring of 1903, about four thousand single-germ seeds were selected from commercial seed of different varieties and planted on the Arlington Experimental Farm of the Department of Agriculture. Previous to planting, the seeds were photographed in natural size (Pl. I, B), and each seed was given a number which corresponded to the number given the plant after it came up. The rows in which the seeds were planted were 20 inches apart and the seeds were dropped and covered by hand at intervals of about 10 inches in the row. Conditions for germination were favorable and fully 90 per cent of the seeds germinated. Beets grown for another purpose in the same field from multiple-germ seeds were planted with a hill dropper. The stand in both cases was about the same, but the additional labor necessary to hand-thin the seedlings from the multiple-germ seeds was in marked contrast to the rows planted with the single-germ seeds, where no hand-thinning was required.

In actual practice it is not proposed to plant the single-germ seeds at intervals of 8 or 10 inches, but rather 2 or 3 inches apart, so that those not desired can be cut out with a hoe, and the planting

[a] The term "mother beet," commonly applied to beets used for seed production, implies that the beet flowers borne on the seed stalks possess only female organs, while, as a matter fact, each flower bears both the male and the female organs, as shown in figure 3, page 12. It is therefore suggested that in the place of the expression "mother beet" the more accurate and simple term "seed beet" be used.

will be done by the aid of a planter and not by hand. In the experimental plat it was desired to give every beet the best possible chance to develop without destroying any of the plants. Unfortunately for the experiment, a part of the ground where the single-germ seeds were planted had been previously scalped, i. e., the sod had been removed and with it practically all the fertile soil. The natural result was that the seeds planted on this spot merely germinated and the seedlings died from starvation. As this poor strip of ground extended across one end of the rows only, most of the plants from each variety used came to maturity. At the close of the season about one thousand beets grown from the single-germ seeds were selected and siloed for the next season's seed production.

BEET SEED IN 1903.

Since the production of sugar-beet seed had not been previously undertaken on the Arlington Farm, it was considered advisable to plant a few seed beets in the spring of 1903, in order to be better prepared to deal with the first crop of seed beets from single-germ seeds during the season of inflorescence in 1904. The two principal objects in growing the trial lot of seed beets were (1) to determine whether or not beet seed could be grown in this locality, and (2) to give an opportunity for studying the arrangement of the single and multiple flowers and their distribution on the flower stalks.

Accordingly a number of seed beets were obtained from the New York Experiment Station at Geneva, through the kindness of Professor Churchill. These beets were received at Washington in good condition and were planted on the Arlington Farm. Practically all of them developed seed stalks, flowers were produced in great abundance, the patch swarmed with insects during the flowering season, and the weather seemed to be all that could be desired for the proper pollination and fertilization of the flowers; but when the seed was ripe it was found upon close examination that less than 5 per cent of the hulls contained germs. Plate V shows two types of the seed stalks produced. For some reason the seeds had failed to fill, and it was considered inadvisable to undertake an experiment that depended for its success upon seed production in a locality where the probabilities were that only a very small percentage of the seeds would fill, even under the most favorable conditions. However, the flowers that were produced upon these plants enabled us to study their arrangement and to consider the methods best suited to the accomplishment of seed selection.

The first of these plants to bloom (Pl. V, plant on right hand) showed flowers thirty-one days after planting, and produced nearly all two-seeded balls, the exceptions being a few single-germ seeds which were

formed at the intersection of the spikes (Pl. II), and near the tips of the spikelets. In fact, this arrangement prevailed in all the plants, as follows: On all spikes that bore two-seeded balls there were found at the bases of most of the spikelets a two-seeded ball on one side at the intersection and a single-germ seed on the other side (Pl. II), and later in the season when these spikelets were farther advanced numerous single-germ seeds formed throughout the limb, while in a few instances the tips were thickly studded with singles for several inches. But these flowers seldom produced seeds, as they developed too late in the season. The spikes that bore multiples of 4 or 5 seeded balls seldom produced singles even at the bases of the spikelets, but the spikelets invariably produced balls of fewer seeds than were found on the main spike. If the spikelets again divided, double-seeded balls and single-germ seeds were found at the bases and sometimes at the tips of these secondary spikelets.

CHANGE OF LOCATION OF EXPERIMENTS.

As soon as it was found that the production of sugar-beet seed in the vicinity of the District of Columbia was very uncertain it became essential to select a suitable location for the continuation of the work. At this time it became necessary for one of the writers to visit a large number of the sugar-beet sections in connection with some other beet work, and while in Utah he learned that sugar-beet seed had been grown by the Utah Sugar Company at Lehi for nine consecutive years without even a partial failure, and that each succeeding year the area had been increased with good results. This company very cordially invited the Department of Agriculture to conduct its single-germ beet-seed work and such other sugar-beet experiments as it might see fit to make on one of its farms located near the outlet of Lake Utah. The soil there is a deep rich loam and is irrigated from warm springs which supply an abundance of water. The conditions thus offered for the growth of sugar beets and for the development of sugar-beet seed seemed to be all that could be desired, and the invitation to locate the experiments at this point was gladly accepted. The results obtained indicate that no mistake was made in the selection of this location for the continuation of the sugar-beet work.

PROGRESS OF THE WORK IN 1904.

PLANTING AND GROWTH OF THE SEED BEETS.

In April, 1904, several hundred seed beets were shipped to Lehi and carefully planted under the supervision of the Utah Sugar Company's experienced agriculturist, Hon. George Austin. Only two of the plants that were set out failed to live and less than 1 per cent failed to produce seed stalks. The beets were planted in rows 3 feet apart and

the space between the plants was 3 feet. The seed stalks were numerous, strong, and well supplied with flowers that eventually developed well-filled seeds. Early in June the writers were notified, in accordance with a previous arrangement, that the flowers were nearly ready to open. Accordingly, they left at once for Lehi, where the flowers were found in the best possible condition for the work.

ARRANGEMENT OF SINGLE FLOWERS.

The writers had previously learned that the single and multiple flowers were distributed over the seed stalks with more or less regularity (Pl. III). As a rule the single flowers destined to produce single-germ seeds were located at the joints, i. e., at the points on the stem where the branching takes place. That there is a great difference in seed stalks with reference to the number of branches produced is shown in Plate V, which illustrates some of the types of seed stalks found in fields of commercial seed. It is evident that the seed stalks shown in the plant on the right-hand side of this plate are much more frequently branched than are those shown in the plant on the left-hand side, and consequently have more points at which single-germ seeds would naturally form. However, if single-germ seeds were produced only at the bases of the branches the total number would be small compared with the number of seed balls produced on the ordinary seed stalks.

Not infrequently on the commercial beet-seed stalks single flowers are found, and later single-germ seeds extending out on the branches, even to the tips. This arrangement of the single-germ seeds along the sides of the seed stalks was found to be still more common on the seed stalks produced by beets grown from single-germ seeds (Pl. III). This is an encouraging indication of the possibility of a plant producing single-germ seeds on all the branches throughout their entire length, in which case we would have a plant producing only single-germ seeds and at the same time bearing seed in commercial quantity.

METHODS OF POLLINATION.

It is entirely possible for single flowers to be cross-fertilized with pollen from flower clusters in the natural process of fertilization. This would give to the plant produced from the single-germ seed a tendency to produce flower clusters and consequently multiple-germ seeds. In order to avoid the danger of contaminating the single flowers which were selected for seed production with the pollen of multiple-germ seeds all multiple flowers were carefully trimmed away before they were open and before the single flowers which were left on the stalks had opened. Plate VI, figure 1, shows one of the selected plants after the multiple flowers were removed.

In order to prevent the single flowers from receiving the pollen that might be floating in the air from other plants, they were covered

with paper bags, as shown in Plate VI, figure 2. If it was desired to cross-fertilize the single flowers they were carefully opened by means of a needle or scalpel, the anthers removed before the pollen was ripe, and they were then covered with the paper bags. It was necessary to uncover the flowers from time to time to see when the pistil was ready to receive the pollen.

To protect the flowers at such times against stray pollen that might be floating in the air the operator covered himself and the plant that he was pollinating with a cloth tent. This tent was supported by an iron rod fastened to the back of the operator. Plate VII, figure 1, shows one of the tents as it is being placed in position and Plate VII, figure 2, shows the tent in position. When the pistil was in condition to receive the pollen it was pollinated by means of a camel's-hair brush and the paper bag was again placed over the pollinated flower. This operation was carried on under the cloth tent.

If close-fertilization was desired, each flower to be pollinated was covered with a paper bag and the anthers were not removed, since it was desired that the pistil should receive the pollen from the same flower. The same precautions were taken in excluding other pollen as in the preceding case.

Another method, which, for want of a better term, may be called "bunch pollination," consisted in covering the single flowers with paper bags, inclosing several flowers in the same bag and not removing any of the anthers. When the pollen became ripe it was set free from the anthers but could not escape from the bag. An occasional shaking of these flower stalks caused the pollen to lodge upon the pistils, and thus the flowers were pollinated. It was certain by this process that the flowers, which were in all cases covered with the bags before any of them opened, were pollinated with pollen from single flowers only and from the same plant upon which the seed was to be produced, but it was not possible to determine whether a flower had been pollinated with its own pollen or with that from another flower on the same stalk. However, the process is much more rapid than either the cross-pollination or self-pollination previously described.

By utilizing these various methods of pollination, about 15,000 single flowers, produced by 50 of the plants that possessed the highest number of single flowers, were treated. It was impossible to cut away the multiple flowers on any plant without removing some of the single flowers; hence, the 15,000 flowers treated do not represent the total number of single flowers on these plants.

After the flowers were treated and covered with the paper bags, the plants were protected from the wind, so that the paper bags would not be blown off, by covering the entire plant with a cloth bag made for this purpose. These bags were supported by four strong stakes driven into the ground until they were firm. The number of flowers

handled was limited by the progress they made in opening; i. e., as soon as the flowers opened so that there was danger of pollination taking place before they were covered with the paper bags, it was necessary to abandon the work. The period that elapsed from the time the buds were large enough to work until the flowers had opened so that further work was impossible was about three weeks—from June 15 to July 4.

It was now necessary simply to go over these 50 plants from time to time and remove the superfluous growth that was forced from the nodes as a consequence of the excessive trimming due to removing the multiple flowers and the branches that bore them. As soon as the seeds had set, the paper bags were removed, but the plants were still protected by the cloth bags, which remained over the plants until the seed ripened.

GATHERING THE SEED.

Early in August the seed was ready to be gathered, and that from each of the 50 plants was kept separate and a record made of the plant from which it was obtained. The seeds were also kept separate with reference to the method of pollination. Of the 15,000 single flowers treated, about 10,000 set their seed and reached maturity. These will be carefully planted by hand at the proper time for the production of the second crop of seed beets, from which the writers hope to obtain their second crop of seeds. These single-germ seeds are larger than similar seeds that were selected for the first planting, as shown in Plate VIII, figure 4. Plate VIII shows the comparative sizes of multiple seed balls (fig. 1), double seed balls (fig. 2), and single seeds from the same plant (figs. 3 and 4). The larger growth of the seeds shown in figure 4 is probably due in some measure to the trimming that the branch that bore these seeds received, thus throwing more of the growth and vigor of this branch into the seed.

PERCENTAGE OF SINGLE-GERM SEEDS.

As already indicated, 50 of the plants that possessed the highest number of singles were selected for the special pollination work. Owing to the method of treatment already described, it was impossible to determine the percentage of single flowers on the 50 plants that were treated. As a consequence, it is impossible to compare accurately the number of single-germ seeds produced by these 50 plants grown from single-germ seeds with the number of singles produced by plants grown from commercial seed. However, after selecting the 50 plants for this work, 20 of the plants remaining that showed the highest percentage of singles were picked out and all the seeds from each plant were carefully saved and kept separate. From a field of 17 acres of beet seed, in which the seed beets were produced from ordinary commercial seed, 10 plants that showed the highest yield of

single-germ seed were also selected for comparison. The seed from each of these plants was kept separate and all the seed of each plant was carefully saved. These results are embodied in the following table, together with the results previously mentioned in regard to the percentage of singles in commercial seed and in siftings:

TABLE III.—*Comparison of percentages of single and multiple germ seeds from selected plants, from siftings, and from commercial seed.*

From seed beets grown from single-germ seed.	From field of ordinary beet seed.	From siftings.	From commercial beet seed.
0.25	0.018	.....	.....
.212	.047	.....	.....
.21	.018	.....	.....
.145	.028	.....	.....
.122	.029	.....	.....
.114	.046	.....	.....
.105	.037	.....	.....
.098	.011	.....	.....
.092	.015	.....	.....
.082	.021	.....	.....
Av..0.143	0.027	0.0734	0.0096

It will be seen from this table that the best plant—i. e., the one possessing the highest number of single-germ seeds that could be found in a field of 17 acres grown from commercial seed—bore 4.7 per cent of single-germ seed, or a little less than one-twentieth, of all the seeds produced by the plant, and the average for the ten selected plants was less than one thirty-fifth of all the seed produced by the plants.[a] On the other hand, the number of single-germ seeds produced by the next best plant after 50 of the best ones had been selected—i. e., from the fifty-first plant—in point of number of singles was 25 per cent, or one-fourth of all the seed produced by the plant, and the average for the ten plants, ranging from the fifty-first to the sixtieth best, was a little less than one-seventh of the seed produced by the 10 plants.

It is true that out of the total number of plants grown from single-germ seeds and used in this selection work a large number of them produced in point of numbers, so far as could be determined by casual observation, approximately the same quantity of single-germ seeds that were produced by beets grown from ordinary multiple-germ seed. It must be remembered, however, that all the seeds with which the first planting was made were selected from commercial seed, so that nothing is known in regard to the plants or the manner of the pollination of the flowers that produced the seeds. It would not be surprising if a large number of the single-germ seeds found in commercial seed were produced from flowers which were pollinated and fertilized by pollen from flower clusters instead of from single flowers.

[a] It should be noted that this proportion represents selected plants and does not show the percentage of single-germ seeds grown on ordinary plants taken at random, which would be somewhat less than one thirty-fifth.

CONCLUSION.

It is the purpose of those having this work in charge to continue their experiments along the same line during the coming season. The writers expect to produce this year a crop of seed beets from their selected single germ seed and to silo these beets in the autumn for next year's seed production. Meantime the experiments of last year will be repeated. In addition to this repetition, serving as a comparison of the results already obtained, it will give this season a crop of seed similar to the seed saved last year. The importance of this precaution appears when it is remembered that it takes two years to produce a crop of seed, and that any accident to the present supply of seed would cause a delay of two years unless a quantity of seed beets ready to produce more seed was on hand. For this reason it is planned to repeat each year the experiments of the preceding season.

As soon as a sufficient quantity of single-germ seed has been produced, the writers hope to conduct comparative experiments with single and multiple germ seeds in different localities to determine the influence of soil and climate upon beet production from single-germ seed and to test the practicability of using single germ beet seed on a commercial scale. Further reports, showing the progress of the work, which must necessarily extend over a considerable period, will be published from time to time.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. A.—Typical multiple-germ beet seeds, showing some of the variations in shape and size of commercial sugar-beet seed balls. Natural size. B.—Single-germ beet seeds selected from commercial seed, showing some of the variations in shape and size. Natural size.

PLATE II. Upper part of flower stalk from beet plant, showing method of branching, and also size and arrangement of flowers, both single and in clusters. Natural size.

PLATE III. Flower stalks from which the flower clusters have been removed, leaving only the single flowers. The branch at the right is the same as that shown in Plate II. Some of the flowers on the branch are already open; hence too late to bag for hand pollination. The branch at the left has all the flowers still closed, and is ready to bag. Some of the single flowers stand close together, as shown at the top of branch at the left, so that in the cut they appear like doubles. Natural size.

PLATE IV. Different grades or sizes of sugar-beet seed obtained by taking commercial seed as shown in *A* and by separating the so-called siftings into the grades *B*, *C*, *D*, *E*, *F*, and *G*, by means of sieves having 6, 8, 10, 12, and 14 meshes per inch, respectively. *F* shows the material too coarse to pass through the sieve having 14 meshes per inch, and *G* shows the material that passed through the sieve. *B* and *C* are good grades of small seed. *D* contains a large amount of seed not filled. *E* and *F* contain only a few seeds that are filled, and numerous immature florets. *G* is composed mostly of broken florets, leaves, and stems. An attempt is made in each case to represent the percentage of singles. This can be done only approximately. The percentage in *A* is nearly 1; in *B*, 3; in *C*, 8+, in *D*, 8+, and in *F*, 8—; so that for 25 seeds the percentage of single seeds is only approximately correct.

PLATE V. Two types of beet-seed stalks. The one at the right is much more branched than the one at the left and possesses many more single-germ seeds.

PLATE VI. Fig. 1.—Flower stalks with multiple flowers removed, leaving only the singles ready to be bagged for hand pollination. Fig. 2.—Single flowers covered with paper bags to protect them from foreign pollen.

PLATE VII. Fig. 1. Cloth tent being adjusted to cover the operator and the plant upon which he is to work. Fig. 2.—Tent in position, covering the operator and plant in order to protect the flowers from foreign pollen.

PLATE VIII. Various forms of sugar-beet seed. Fig. 1.—Multiple beet-seed balls obtained from a selected plant grown from single-germ seed. Natural size. Fig. 2.—Double beet-seed balls from the same plant. Natural size. Fig. 3.—Single-germ beet seed from a branch of the same plant, not trimmed and not hand pollinated. Natural size. Fig. 4.—Single-germ beet seed from a branch of the same plant that was trimmed and hand pollinated. The larger size may be due to the trimming away of the multiples, or to the hand pollination, or to both. Natural size.

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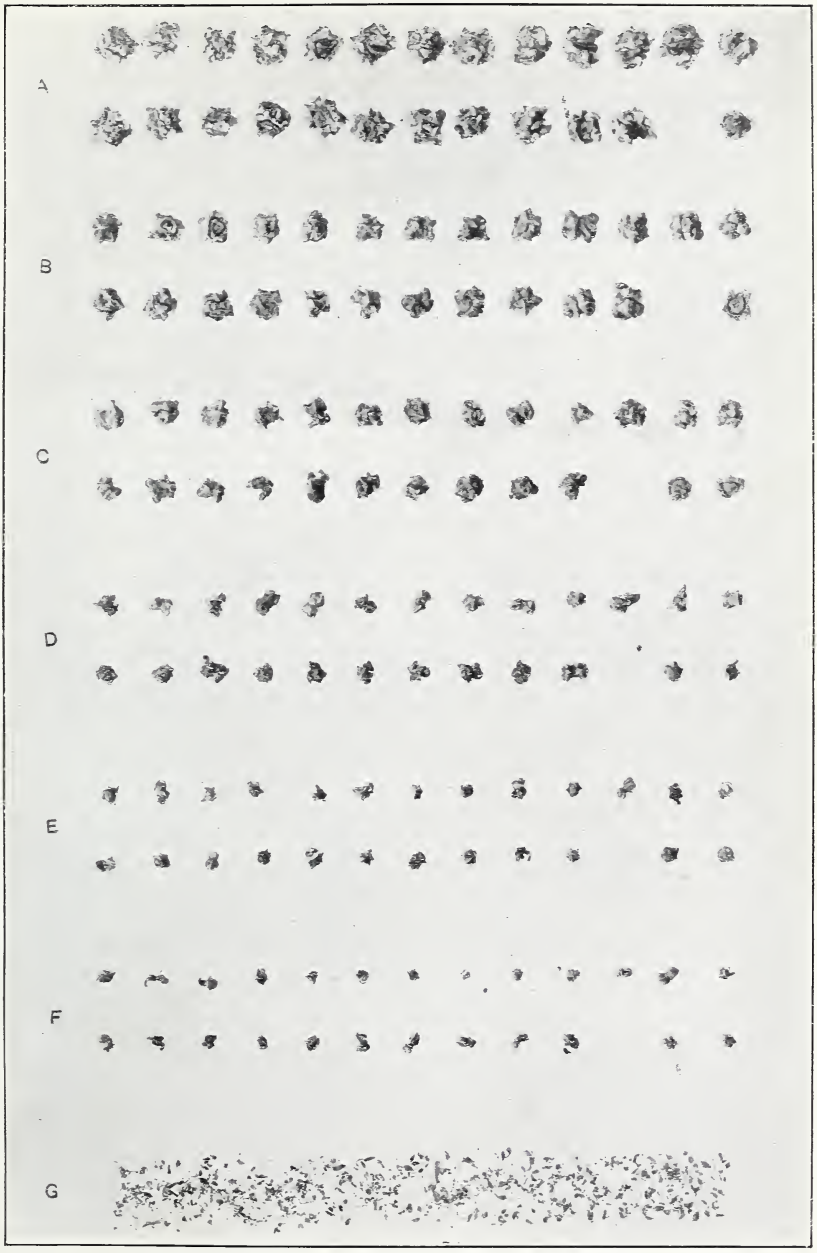
UPPER PART OF FLOWER STALK FROM BEET PLANT.

Natural size.

UPPER PARTS OF FLOWER STALKS, WITH ONLY SINGLE FLOWERS REMAINING.

Natural size.



A.—COMMERCIAL BEET SEEDS. B, C, D, E, F, G.—SIFTINGS.
Natural size.

TWO TYPES OF BEET-SEED STALKS.

FIG. 1.—FLOWER STALKS WITH MULTIPLE FLOWERS REMOVED.

FIG. 2.—FLOWER STALKS POSSESSING ONLY SINGLE FLOWERS, COVERED WITH PAPER BAGS.

FIG. 1.—PLACING CLOTH TENT IN POSITION.

FIG. 2.—CLOTH TENT PROPERLY ADJUSTED.

FIG. 1.—MULTIPLE-GERM BEET-SEED BALLS.

FIG. 2.—DOUBLE BEET-SEED BALLS.

FIG. 3.—SINGLE-GERM BEET SEED, NATURALLY POLLINATED.

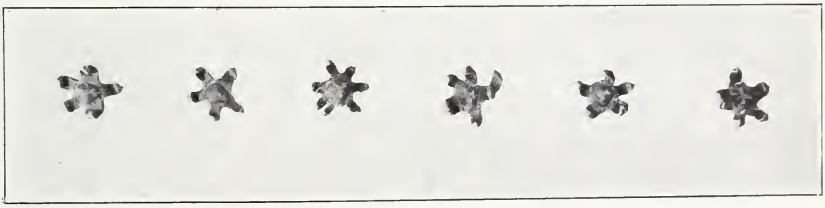


FIG. 4.—SINGLE-GERM BEET SEED, HAND POLLINATED.

VARIOUS FORMS OF SUGAR-BEET SEED.

Natural size.