# Processing Sugar Beet Seed by Decortication, Burr Reduction, and Segmentation

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Fifteen to 20 million pounds of sugar beet seed have been used during the past 4 years in the preparation of segmented seed. Most of the machines used for processing the seed were built along the lines of the one used in the early experiments *(1) (2)*[2] at the California Agricultural Experiment Station. The rapid adoption of segmented seed was due primarily to the war and its attendant labor shortage, resulting in a demand for processed seed developing at a greater rate than the techniques of processing methods. Actually there was little basic information available for use in the early design of equipment capable of producing seed of optimum quality. This information, in many respects, is still not available even though much experience has been gained from processing large quantities of seed.

Experience in the field and laboratory has revealed certain characteristics of segmented seed behavior that are related to the segmenting process. Among these principally are viability, singleness of germ, and recovery. In addition some seed units produce abnormal seedlings as a result of receiving mechanical injury during the segmenting operation. Low viability in the segmented product is related to the quality of the original whole seed and is due to the inability of separating germ-containing units from non-germinating pieces without sacrificing too much good seed. The production of multiple germ units is probably related to the size, variety, and locality of production of the original seed, the extent of pre-grading, and the setting of the shear bar on the machine. Recovery of segmented seed is influenced by the relation of the germination of the segmented to the original sample and to the nearness of approach to a single germ unit. Fn fact all three are closely related so that a change in one affects the others. In addition the recovery may be affected by the size, variety, and moisture content of the whole seed as well as by type of seed segmenting equipment used.

Whole sugar beet seed varies from 8/64ths to 18/G4ths of an inch in size and may produce from one to as many as five or six seedlings per germinating unit. Because of the extreme range in size it cannot be planted in a uniform manner with present planting equipment. Several planters now available will handle seed in a uniform manner provided the variation in size does not exceed 2 or 3 sixty-fourths of an

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[2]Italic numbers in parentheses refer to literature cited.

inch, depending- somewhat upon the shape of the units. The nearer they approach a sphere in shape, the greater can be their variation in size.

Three methods are available for controlling: the size range of the seed; namely, grading whole seed, processing whole seed or combinations of the two, and pelleting-. Further reference to the latter does not come within the scope of this paper. Whole seed may be graded into three divisions of 3/64 inch size range each. Immediately the difference between the characteristics of each grade presents certain problems. First, the three grades call for three sizes of planter- plates for handling- the seed; second, the germination will vary considerably between grades; and third, the seedlings produced per viable seed ball will vary for the different grades. Certain grades may be in demand more than others, making it difficult to dispose of all the seed.

Some methods of processing whereby the seed is reduced to a narrow range of size fits in well with a, precision planting program. The degree to which it is necessary to carry the processing operation in the production of single germ units has never been fully determined. It would seem evident thai seed balls capable of producing more than two seedlings are undesirable if too numerous in the sample. On the other hand, seed that produces one and two seedlings per unit may give a greater factor of safety in obtaining a stand under adverse field condit ions.

Plantings made during the past 2 years at Davis have included graded whole seed and large segmented seed. Each had a higher seedling count per viable unit than is commonly regarded as optimum for segmented seed. The plantings were made under a variety of field conditions, giving varying degrees of germination. The plantings were made with planters capable of giving uniform distribution of seeds. Table 1 shows that the percentage of inches having single plants varies inversely with field germination. For example, graded whole seed (12-10)[3] having a potential germination of 1.84 seedJ'ngs per viable seed ball gave 45.7 percent singles at a field germination[1] of 70.4 percent, while at 30.1 percent field germination the percentage of inches with single plants amounted to 72.7 percent. Segmented seed (10-8) having a potential germination of 1.38 seedlings per seed ball produced singles on 82.8 percent and 70.1 percent of the beet-containing inches at field germinations of 30.5 percent and 53.9 percent respectively. From these comparisons it appears that further investi-

[3] 12--10) indicates size of seed. Tn this ease the seed passed through a 12/04 inch screen and over a 10/(64 inch screen.

[4]Field germination refers to Hie emergence of seedling's in the field as a percentage of the total seedlings per *100* seed units as shown by laboratory or greenhouse germination trials.

Table 1.—Comparison between field termination and percentage of inches with singles for graded whole seed mid large segmented seed.

| Seed | Size | Germination Percentage | Seedlings per viable unit | Pounds per acre | Field germination percentage | Percent inches with singles |
|---|---|---|---|---|---|---|
| Whole | 12-10 | 96.0 | 1.84 | 4.6 | 70.4 | 45.7 |
| Whole | 12-10 | 96.0 | 1.84 | 4.4 | 44.5 | 57.5 |
| Whole | 12-10 | 96.0 | 1.84 | 4.0 | 30.1 | 72.7 |
| Segmented | 10.8 | 92.6 | 1.38 | 3.4 | 53.9 | 70.1 |
| Segmented | 10.8 | 92.6 | 1.38 | 3.6 | 30.5 | 82.8 |

"rations are justified in processing seed in such a way that it can he planted in a precise manner, at the same lime maintaining or improving germination as related to the original seed and eliminating through reduction those seeds containing more than one or two germs.

A machine was built for removing the cork, leaving the seed as smooth as possible and at the same time rubbing the larger seeds hard enough to empty some of the locales of germs, thereby reducing the number of multiple seed units. The device for decorticating the seed consists of a silicon carbide stone (Norton 37C24QV) 10 inches in diameler mounted on the upper end of a vertical shaft (figures 1 and 2). The shaft is mounted in a frame with suitable bearings for taking both radial and thrust loads. Power to the shaft is furnished through a single B section V belt from a 2 h.p. electric motor. Pressure pads, consisting of $Y_2$ inch of either rubber or neoprene vulcanized to a round plate 10 inches in diameter with a 5-inch round hole at the center, were used for holding the seed against the revolving stone. The rubber Pad was cured to give a durometer reading of 65,

Figure 1. -Machine used fur decortieation and burr reduction.

Figure 2.—Decortication is accomplished through use of a iircssure pad for holding seed ugjiinst i olving grinding -wheel.

while the neoprene gave a reading of 45. The pressure pads were molded with a taper of Vs inch per *2y%* inches, converging toward the outside to facilitate feeding. This taper was lost during the processing of 200 to 300 pounds of seed because of greater wear near the outer edges where the pressure was the greatest. The pressure pads are attached to an adjustable plate immediately above the stone. Clearances of 0.125 to 0.150 inches are maintained, depending upon the size of the seed. The stone and 7i>ressure pad are enclosed in a steel case witli a hoppered bottom. A suction fan connected 1o the discharge at the bottom of the hopper removes fine dust resulting from the operation. A large hopper above the unit feeds the whole seed to the center of the wheel. The stone is operated at 775 r.p.m. which gives a peripheral speed of approximately 2,000 feet per minute. Centrifugal force moves the seed from the center to the periphery of the stone.

During preliminary trials with the machine equipped with the neoprene pad. the whole seed was pregraded over a 12/64 or 13/64 inch screen to divide the lot into approximately two equal parts. The larger size was then run through the machine twice, once at a clearance between the pressure pad and stone of 0.175 inch and again at 0.150 inch. The small seed was run, first at 0.150 inch and finished at 0.125 inch. Capacities (150 to 200 pounds per hour.) were greater if the seed was decorticated at two settings, each removing part of the cork, than if an attempt was made to remove it all at one time. Following the decoritcation the seed was aspirated and graded into two sizes: 11-9 and 9-7. Liater, wdien the rubber pressure pad was available, sack run seed was run at 0.150. inch with the rubber pad and finished at 0.125 inch clearance with the neoprene pad. After aspiration, the seed was graded 10-7.

Whole seed weighs 18 to 22 pounds per bushel. After decorticating, cleaning and grading, it weighs 35 to 40 pounds per bushel. Inasmuch as 40 to 50 percent of the original weight is lost during the process and its unit weight is doubled, the volume occupied by decorticated seed amounts to less than ⅓ that occupied by the whole seed from which it was produced.

The early seed processing studies were concentrated on one lot of seed, (U. S. 33L343) in order to make accurate comparisons of the results obtained from time to time. Before the work was started a screen analysis was made and germination tests were run on the seed. Results of this analysis are shown in table 2. Such a study is enlightening and at the same time serves as a guide to subsequent grading and processing studies.

Preliminary results showing decortication trials on several lots of seed are shown in table 3. The U. S. improved 22, used in the trial, germinated 85.25 percent in its original form, producing 1.95 seedlings per viable seed unit. A pound of the whole seed contained 25,235 units, and it weighed 18 pounds per bushel. Following decortication and aspiration the seed was graded 10-7. The germination based on normal seedlings amounted to 94.0 percent. In addition there was 1.5 percent producing abnormal seedlings as a result of the processing operation. A pound of the decorticated seed contained 34,692 units and the bushel weight amounted to 38 pounds. This seed produced 1.78 seedlings per viable seed unit. The recovery based on weight of the original sample amounted to 50.7 percent. When expressed on the basis of seed units the recovery was 69.7 percent, and when expressed in viable seed units it amounted to 76.8 percent.

The germination of the decorticated seed was equal to or above that of the original whole seed sample for all varieties shown in table 3. Outstanding results were obtained from one sample of U. S. 15 where the original germination was only 59.5 percent. Decortication of this seed resulted in a recovery of 33.0 percent by weight and 55.6 percent by viable seed units, raising the germination to 92.0 percent. On the other hand another lot of U. S. 15 (not shown in the table), having a germination of 38.0 percent was not improved materially through decortication. The reasons for the difference in performance of these two seed lots have not been fully determined.

Following decortication, aspiration, and grading (9-7) a lot of seed germinating 89.25 percent was classified on a gravity table. The seed from each of the first three spouts germinated 97.25 percent. The combined recovery for these three spouts, on the basis of the original sample, was 42.2 percent. The seed from spouts 4 and 5 showed a germination of 94.5 percent and represented 47.2 percent of the total sample, while the seed from spout 6, representing 10.6 percent of the total, germinated 69.0 percent. When the increment from spout

Table 2.—Screen analysis and laboratory germination of sugar beet seed. Variety U. S. 33, lot 343, whole seed.

| Seed size | Recovery by weight percentage | Laboratory germination | | | | | | Seedlings per 100 seed units | Seedlings per viable seed unit | Seed units per pound |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Percent | Singles | Doubles | Triples | Quads | Quints | | | |
| Composite | 100.00 | 81.50 | 34.00 | 40.00 | 6.50 | 1.00 | 0 | 137.50 | 1.69 | 29,000 |
| 18/17 | 0.51 | 97.50 | 5.00 | 27.50 | 38.50 | 24.75 | 1.75 | 283.25 | 2.91 | 3,400 |
| 17/16 | 0.51 | 90.75 | 9.50 | 31.00 | 30.75 | 19.75 | .25 | 261.50 | 2.70 | 11,350 |
| 16/15 | 8.18 | 95.50 | 20.50 | 41.50 | 28.00 | 5.50 | 0 | 200.50 | 2.10 | 14,190 |
| 15/14 | 6.15 | 92.00 | 23.75 | 50.00 | 16.75 | 1.50 | 0 | 180.00 | 1.96 | 17,564 |
| 14/13 | 15.20 | 87.00 | 25.00 | 47.50 | 14.50 | 0 | 0 | 163.50 | 1.89 | 21,300 |
| 13/12 | 11.13 | 78.50 | 34.25 | 39.25 | 4.25 | .75 | 0 | 128.50 | 1.64 | 22,620 |
| 12/11 | 20.85 | 76.00 | 33.75 | 37.25 | 4.75 | .25 | 0 | 125.50 | 1.65 | 27,320 |
| 11/10 | 20.85 | 68.75 | 38.00 | 29.25 | 1.50 | 0 | 0 | 101.00 | 1.47 | 35,880 |
| 10/9 | 9.95 | 64.75 | 39.75 | 24.75 | 0.25 | 0 | 0 | 90.00 | 1.39 | 40,400 |
| 9/8 | 4.88 | 46.50 | 33.50 | 12.75 | 0.25 | 0 | 0 | 59.75 | 1.28 | 61,500 |
| 8/7 | 1.03 | 46.75 | 37.00 | 9.75 | 0 | 0 | 0 | 56.50 | 1.21 | 67,450 |
| 7/6 | 0.34 | 34.25 | 27.25 | 7.00 | 0 | 0 | 0 | 41.25 | 1.20 | 92,102 |
| 6/PAN | 0.34 | | | | | | | | | |

Table 3.—Sugar beet seed processed by decortication, burr reduction, and segmentation.

| | | Germination percent | | Soedlli IgH per viable unit | Seeds per pound | Recovery percent | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Normal | Abnormal | | | Weight | Number | Viable units | per bushel |
| | | | | *V.* Fi. Improved 22 | | | | | |
| Original | Siick run | 85.25 | | 1.95 | 25,235 | 100.0 | 100.0 | 100.0 | 18.0 |
| Decortication | 10-7 | f>40 | | 1.78 | 34,002 | 50.7 | 60.7 | 76.8 | 38.0 |
| Burr reduction | 11-8 | | | 1.70 | 33.014 | 50.9 | 08.4 | 75.8 | 27.0 |
| | | | | 215 x 216 | | | | | |
| Original | Sack run | | | 1.80 | 30,.7.)7 | | | 100.0 | 20.0 |
| Decortication | 10-7 | | | 1.08 | 30,443 | | | 68.8 | 39.0 |
| Burr reduction | 11-S | | | 1.80 | 30,700 | | | 60.2 | 26.0 |
| | | | | MM-west 4 | | | | | |
| Original | Sack run | 01.0 | | 1,01 | 28.304 | 100.0 | 100.0 | 100.0 | 21.5 |
| Decortication | 10-7 | 07.2.1 | | 1.87 | 33.53S | 56,0 | 60.0 | 71.5 | 36.0 |
| Burr reduction | 11-S | 94.75 | | 1.83 | 31.220 | 75.0 | 82.6 | 86.0 | 27.0 |
| | | | | G. W. 267 | | | | | |
| Original | Sack run | 7R.T0 | | 1.71 | 27.574 | 100,0 | 100.0 | 100.0 | 18.5 |
| Decortication | 10-7 | SO.75 | | 1.51 | 34.25)0 | 43.8 | 54.5 | 63.2 | 35.0 |
| Burr reduction | | 82.no | | 1(15 | | | 73.0 | 76.S | 24.5 |
| | | | | **r. s.** | | | | | |
| Original | Sack run | 85.5 | | 1.83 | 34.S02 | 100.0 | 100.0 | 100.0 | |
| Burr reduction | 11-8 | 01.0 | | 1.70 | 37.505 | 71.fi | 77.0 | 82.0 | |
| | | | | **r. s.** 15 | | | | | |
| Original | | jifi.no | | 1.53 | 30,071 | 1(50.0 | 100.0 | | 21.0 |
| Decortication | | | | 1.51 | 30.358 | 33.0 | 36.0 | | 39.0 |
| | | | | A. ('.. K | | | | | |
| Original | S: | 80.2") | 0.25 | 2.0S | 27,202 | 100.0 | 100,0 | 100.0 | 19.5 |
| Decortication | | 02.0 | 1.0 | 1SO | 30,581 | 44.3 | 59.3 | 68.1 | 36.0 |
| | | | | **r. s.** 33 | | | | | |
| Original | Sf | 842,"> | 1.75 | 1.00 | 28,040 | 100.0 | | 100.0 | 20.0 |
| Decortication | | 91.0 | 2.25 | 1.51 | 35,858 | 51.8 | | 71.6 | 34.0 |
| Burr reduction | 11-8 | | | 1.50 | 32.0! :0 | 08.0 | 77,7 | 82.6 | 26.0 |
| Segmentation | i)-7 | 74.75 | 10.0 | 1.13 | . 40.130 | 32.0 | 57.7 | 50.6 | 24.5 |
| Combined burr ajtd decortication | | 83.75 | 4.5 | | | 4S.8 | | | |

6 was reduced to 7.6 percent of the total by aspiration, the germination amounted to 81.25 percent.

In some localities there is a trend toward supplying graded whole seed. The sizes usually furnished are either 12-9 or 11-8. This leaves approximately one-half of the seed to he reduced mechanically and blended back in order to keep within the selected size range. If the small graded seed is used alone there is some likelihood of the germination being lower than for the original sample. By referring to table 2 and considering the 11-8 size of this particular lot of seed it will be found that 1his increment contains 35.68 percent of the original sample by weight, 53.6 percent by number, and 42.3 percent by viable seed units. This size shows a germination of 64.4 percent and produces 1.49 seedlings per viable seed unit, as compared with a germination and seedling count of 81.5 percent and 1.69 respectively for the original sample. By selecting the 12-9 size the germination would be raised 1o better than 70 percent. Other lots of seed would show different results; therefore these figures pertain only to this specific sample.

Because of the trend Towards planting graded whole seed, a machine was built to reduce the oversize seed to the size of the graded product. The machine built for decorticating seed was modified for this work, (fig. 3). A Kadiac stone (9716NV2) was substituted for the Norton stone. The grit size in the Radiac stone is larger and arranged to give a lower density. The bond strength of the stone was too weak for this particular job, resulting in excessive pitting while processing only 1,000 pounds of seed. .Further work with other stones is contemplated. The pressure pad was replaced by a Letz feed grinder burr plate (No. AA 230). A minimum clearance of 0.125 inch is used between the burr plate and stone. Whole seed is fed into the machine in the same manner described for

Figure 3.-Burr reduction is accomplished by passing seed between a burr-plate and coarse stone.

the decorticator. The capacity of the unit varies from 600 to 800 pounds per hour. Follow-ing the burr reduction the seed is aspirated and graded 11-8. Usually 5 to 10 percent of the seed will not pass the larger screen on the first grading and must be re-run through the machine for further reduction.

Seed processed by burr reduction has the appearance of whole seed except for size. The units are more spherical in shape than segmented seed. The results of the runs employing burr reduction are shown in table 3. As an example, U. S. Improved 22 shows that the results were almost identical with those obtained from decortication, except that the seedlings produced per viable seed unit and the bushel weight were lower. In other lots of seed processed the seedling count per viable seed unit was slightly higher than for decorticated seed.

Segmented seed was produced from U. S. 33 for use in comparative field trials. Segmented seed producing, as nearly as possible, one seedling per viable seed unit was desired. Therefore, the process was carried out, to produce 9-7 seed. The segmented seed showed a total germination comparable with the original seed, but 10 percent of the seeds produced abnormal plants to give a normal germination of 74.75 percent as compared to 84.25 percent for the original (table 3). Recoveries of 32.0 percent by weight, 57.7 percent by number, and 50.6 percent, by viable seed units were obtained. Segmenting to this size was too drastic for this particular lot of seed.

One size of decorticated seed (9-7) was produced by first reducing all whole seed over 12/64ths in size by burr reduction, then running it through the decorticator with the whole seed that passed the 12 screen. This combination on U. S. 33 (table 3) produced seed in which the original germination was practically maintained. The seedlings per viable seed unit were reduced from 1.87 to 1.46 as a result of the process. The recovery amounted to 48.8 percent by weight and 69.0 percent on the basis of viable seed units. The next step in this combination is to produce 10-7 or 11-8 seed in an endeavor to raise the percentage of recovery.

Decorticated seed averages between 33,000 and 40,000 seed units per pound for the 10-7 size as compared to approximately 50,000 or more units for segmented seed of the 9-7 size. A pound of seed reduced by burr reduction and graded 11-8 contains 30,000 to 38,000 seed units, as compared to 25,000 to 35,000 seed units per pound of whole seed. Seed produced by decortication or burr reduction has characteristics superior to segmented seed in every respect except one, namely, singleness of germ. Seed processed by combining burr reduction and decortication approached the upper limit found in segmented seed produced by some of the western sugar companies in re-

gard to singleness of germ units.

The speed of operation of the processing equipment influences to a considerable degree the number of abnormal seedlings produced. Seeds upon leaving the wheel are thrown against the wall of the steel case surrounding the unit. One lot. decorticated when the stone was operating at 3,500 feet per minute (peripheral speed), produced a high percentage of abnormal germination. A large part of the damage consisted of broken roots. The same lot when processed at a speed of 2,000 feet per minute produced 7.5 percent abnormal seedlings. The percentage of abnormal seedlings was reduced to 2.0 percent by padding the inside of the steel case with a piece of rubber floor mat. A further reduction in abnormal seedlings was obtained through the use of a half-inch layer of sponge rubber. Additional tests are needed to determine the relation of the speed ol' operation, and possibilities of cushioning the impact, on the production of abnormal seedlings.

A planter development program has been carried along simultaneously with the seed processing investigations. Tn order to get a true picture of the behavior of the seeds processed in different ways, it is necessary to plant them one at a time in a uniform manner and spaced far enough apart to determine the seedlings produced by each seed unit. A .John Deere horizontal plate planter with certain modifications was used. Greased board tests were used during the development period to check the distribution of seed as the improvements were made. Plates -were made to fit the seed processed in different, ways (table 4). Smooth tubes (chrome-molly seamless steel tubing i/2-inch O. D.) described by Bainer *(3)* were attached to the false plate. The cut-off was changed in shape to conform more to that of a plow. The spring pressure on the cut-off and knock-out wheel was doubled to prevent seeds from lifting the cut-off up and lodging under it. This made il necessary to increase the pressure against the bottom of the false ring by a similar amount. The relief in the false ring, immediately below the knock-out wheel, was milled to the radius of the wheel plus the thickness of the plate. The teeth on the knock-out wheel were dressed down slightly to give freer entrance and exit to the cell.

The performance of the planter for the differenl types of seed used is shown in table 4. At the theoretical spacing of 2.92 inches the data from a perfect planter would show all of the seeds in column marked " 1 " under seeds per inch, and 92 percent of the figures under inch spaces without seeds would be in the 2-inch column and 8 percent would be in the 1-inch column. An arrangement of data as just described would give a dispersion coeficient of "0". The method used for determining the dispersion coeficient was developed by Brooks and Baker (4).

Table 4.—-Greased board tests of horizontal plate planter used for segmented, decorticated, and burr-reduced seed. Planter equipped with14-inch length of 1/2-inch O. D. crome-molly tube. Theoretical spacing 2.92 inches. Board speed $2^1/_4$ m.p.h. Total of four 8-foot boards.

| | Seeds per inch | | | Inch spaces without seeds | | | | | | | Dispersion coefficient |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 2 | 1 | 0 | 1 | 2 | 3 | 1 | 5 | 6 | |
| Decorticated (11-0) through 12/04" cell. Plate thickness 0.137 inch | | | 132 | 1 | 27 | 93 | 13 | | | | 0.020 |
| Decorticated (0-7) through 9.5/04 cell. Plate thickness 0.110 inch | | 2 | 133 | 2 | 38 | 77 | 10 | 1 | 1 | | 0.100 |
| Segmented (9-7) through 0.5/(5-1 cell. Plate thickness 0.110 inch | | 13 | 125 | S | 10 | 56 | 28 | 1 | | | 0.323 |
| Burred (11-9) through 12/04" cell. Plate thickness 0.137 inch | | 3 | 127 | 11 | 28 | 00 | 23 | 4 | 2 | 1 | 0.225 |
| Burred (11-8) through 12/04" cell. Plate thickness 0.137 inch | 6 | | 129 | 5 | 30 | 82 | 17 | 1 | | | 0.184 |

Seed processed by burr reduction and graded 11-8 gave slightly belter planter performance than that graded 11-9. This was probably due to slightly better cell fill. Better performance was shown for the decorticated seed than for the seed processed in other ways. This was due to their smooth exterior and uniform shape. The test showed no inches with doubles for the 11-9 seed and only 2 for the 9-7 seed in 32 feet of greased board.

Recent modifications of the International Harvester Company planter, along the same lines as described for the Deere unit, gave similar results. Both the Lindeman-Cobbley and Rassmaim vertical plate planters are capable of similar performance.

Following the laboratory tests two units of the John Deere planter were mounted on a sled for planting on beds. The units were geared to be driven by the power take off of the tractor. This type of drive eliminated slippage as far as possible. A revolution counter on the final drive gave the turns of the plate so that the opportunities for seeds to be dropped could be calculated for a known distance. The machine was set for as near the spacing used on the greased boards as possible. The discrepancy was 0.1 inch between seeds (theoretical). A field speed of $2^1/_4$ m.p.h.', the same as for the greased board, was used.

One field planting was put in before the winter rains set in. It was made with the planter set to sow 4.27 (theoretical) seeds per foot.

Three additional plantings were put in at a slightly higher seeding rate during March 1946. A tabulation of the stand counts is given in table 5.

The November planting (table 5) resulted in field germinations of 70.4, 88.2, and 69.0 percent for segmented, decorticated, and burred seed, respectively. Under these conditions segmented seed with 87 percent singles (greenhouse germination) produced a stand with 85.9 percent of its inches containing singles in the field. Decorticated seed having 42 percent of its seeds containing single germs produced a stand with 54.8 percent inches with singles, while the burr-reduced seed with 36 percent of its seeds containing single germs produced a stand with 53 percent of its inches containing singles.

With 4.25 seeds planted per foot there were no skips exceeding 10 inches for either the burr reduced or decorticated seed. On the other hand at a seeding rate of 5.07 seeds per foot the segmented seed planting showed skips of 13, 16, .17, 21, and 42 inches in the twenty-four 100-inch counts.

When the stand was recalculated on the basis of 100 seed units planted (table 5), the decorticated seed produced 47 inches with singles as compared to 50.2 for the segmented seed. In addition there were 37 inches with doubles as compared to 9 for the segmented planting.

Plantings made under less favorable germinating conditions gave an entirely different result. The percentage of field germination for the March 15 planting (table 5) amounted to 20.4, 44.8, and 40.7 percent for segmented, decorticated, and burred seed, respectively, while the percentage of inches with singles amounted to 90.0, 75.1, and 70.2 percent for the three types of seed. When the data was recalculated on the basis of 100 seed units planted there were over twice as many inches with singles for either the decorticated or burred as compared with segmented seed. Decorticated and burred seed gave 35.62 and 34.82 inches with singles for each 100 seeds planted, as compared with 16.4 inches with singles from 100 units of segmented seed.

Plantings of decorticated and burred seed were put in with a distributed hill plate. The plate was designed and operated to place three seeds, 1.4 inches apart, in hills on approximately 10-inch centers. Decorticated seed at 2.43 seeds per hill produced 256 plants in 105 beet-containing hills per 100 feet with 75.8 percent of the inches, within the hills containing beets, with singles. Burred seed at 2.62 seeds per hill produced 229 plants in 102 beet containing hills per 100 feet with singles in 67.8 percent of the inches. This method of planting resulted in the plants emerging as if blocked and required the removal of one or two plants per hill to leave a satisfactory stand of beets.

*An* 80-acre field near Davis was planted with decorticated seed

Table 8.--Field plantings using segmented, decorticated, and burr-reduced seed. Counts made 1 month following planting. Four replications each planting. Average of twenty-four 100-inch counts each replication. U. S. 33, Lot 343, used in all plantings.

| Seed | Size | Pounds per acre | Seeds per foot | S | D | T | Q | Total inches | Total plants | Percentage inch singles | Percentage field germination |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | November 14, 1945, planting | | | | | | |
| Segmented | 9-7 | 2.62 | 5.07 | 21.1 | 3.8 | 0.26 | | 25.2 | 29.5 | 83.9 | 70.4 |
| Decorticated | 9-7 | 3.27 | 4.24 | 16.6 | 12.3 | 0.62 | 0.05 | 30.6 | 45.4 | 54.8 | 88.2 |
| Burred | 11-9 | 3.72 | 4.25 | 13.7 | 11.2 | 0.8 | 0.15 | 25.8 | 38.9 | 53.0 | 69.0 |
| | | | | | Emergence based on 100 seed units planted | | | | | | |
| Segmented | 9-7 | | | 50.2 | 9.0 | 0.50 | | 59.8 | 69.9 | 83.9 | 70.4 |
| Decorticated | 9-7 | | | 47.0 | 37.7 | 1.76 | 0.17 | 86.6 | 118.7 | 54.8 | 88.2 |
| Burred | 11-9 | | | 38.7 | 31.6 | 2.26 | 0.42 | 73.1 | 100.8 | 53.0 | 69.0 |
| | | | | | March 6, 1946, planting | | | | | | |
| Segmented | 9-7 | 4.02 | 7.00 | 13.05 | 2.66 | 0.41 | 0.03 | 17.3 | 20.74 | 81.6 | 35.2 |
| Decorticated | 9-7 | 3.72 | 4.92 | 13.15 | 6.54 | 0.29 | ..... | 20.0 | 27.10 | 65.9 | 48.4 |
| Burred | 11-9 | 4.30 | 4.87 | 14.36 | 6.98 | 0.66 | 0.16 | 22.3 | 30.90 | 64.9 | 47.8 |
| | | | | | Emergence based on 100 seed units planted | | | | | | |
| Segmented | 9-7 | | | 22.1 | 4.2 | 0.63 | 0.12 | 27.05 | 32.87 | 81.6 | 33.2 |
| Decorticated | 9-7 | | | 32.2 | 15.95 | 0.71 | ..... | 48.86 | 66.23 | 65.9 | 48.4 |
| Burred | 11-9 | | | 35.4 | 17.16 | 1.69 | 0.39 | 54.63 | 76.17 | 64.9 | 47.8 |
| | | | | | March 15, 1946, Planting | | | | | | |
| Segmented | 9-7 | 4.17 | 7.00 | 10.76 | 1.20 | ..... | ..... | 12.03 | 13.13 | 90.0 | 20.4 |
| Decorticated | 9-7 | 4.02 | 5.30 | 15.74 | 5.31 | 0.16 | ..... | 21.12 | 26.64 | 75.1 | 44.8 |
| Burred | 11-9 | 4.17 | 4.72 | 13.70 | 5.96 | ..... | 0.04 | 19.70 | 25.78 | 70.2 | 40.7 |
| | | | | | Emergence based on 100 seed units planted | | | | | | |
| Segmented | 9-7 | | | 16.4 | 1.82 | ..... | ..... | 18.22 | 20.04 | 90.0 | 20.4 |
| Decorticated | 9-7 | | | 35.62 | 11.80 | 0.36 | ..... | 47.42 | 60.30 | 75.1 | 44.8 |
| Burred | 11-9 | | | 34.82 | 14.80 | ..... | 0.10 | 49.02 | 61.82 | 70.2 | 40.7 |
| | | | | | March 25, 1946, planting | | | | | | |
| Segmented | 9-7 | 4.12 | 7.79 | 8.17 | 1.58 | 0.08 | ..... | 9.83 | 11.62 | 83.2 | 19.0 |
| Decorticated | 9-7 | 3.90 | 5.16 | 10.70 | 4.68 | 0.16 | ..... | 15.44 | 20.34 | 69.2 | 35.0 |
| Burred | 11-9 | 4.20 | 4.76 | 9.75 | 3.04 | 0.16 | ..... | 12.95 | 18.21 | 75.3 | 26.8 |
| | | | | | Emergence based on 100 seed units planted | | | | | | |
| Segmented | 9-7 | | | 12.55 | 2.43 | 0.12 | ..... | 15.1 | 17.77 | 83.2 | 19.0 |
| Decorticated | 9-7 | | | 24.8 | 10.67 | 0.37 | ..... | 35.84 | 47.25 | 69.2 | 35.0 |
| Burred | 11-9 | | | 24.6 | 7.67 | 0.41 | ..... | 32.67 | 41.14 | 75.3 | 26.8 |

at 3.03 pounds per acre (3.82 seeds per foot). The seed used was graded 10-7 and was classified over a gravity table following the processing operation. The laboratory germination on this lot of seed was 95.6 percent and it produced 1.75 seedlings per viable seed ball. The bushel weight was 39 pounds. The planting was done on beds with the new John Deere No. 66 smooth tube planter operating at 3 m.p.h. Depth of planting was $1^1/_2$ inches. Following planting, the field was irrigated to insure germination moisture. Under an average field emergence of 49.4 percent, stand counts showed 17.85 inches per 100 inches with a total of 24.75 plants. Of the 17.85 inches with plants, 11.42 inches, or 64 percent contained singles, 6.06 inches had doubles, and 0.4 inches contained triples. Under the field germination (49.4 percent) of this trial, seed showing approximately 25 percent singles in a laboratory germination produced a stand in which 64 percent of the inches contained single beds. No doubt some of the seedlings growing in adjacent inches came from the same seed ball; nevertheless they appeared as separate plants. Thinning of this field was combined with the first hoeing for weeds. The resulting stand amounted to 119 beets per 100 feet.

Field plantings made under a wide range of germinating conditions will no doubt furnish further important information on this subject.

## Summary

1. Fifteen to 20 million pounds of sugar beet seed have been used during the past 4 years in the preparation of segmented seed.

2. The demand for processed seed has developed at a greater rate than the techniques of processing methods.

3. Experience in the laboratory and field has revealed certain characteristics of segmented seed behavior that are related to the segmenting process. Principal among these are viability, singleness of germ, and recovery.

4. Size range of either whole or processed seed must be controlled to 2/64 or 3/64 if used with good results in precision planters.

5. Beet seed may be reduced to a narrow size range by grading, segmentation, decortication, or burr reduction.

6. Seed processed by decortication or burr reduction gives germinations comparable with the initial whole seed.

7. Decorticated seed weighs 35 to 40 pounds per bushel as compared with approximately 20 pound per bushel for w^hole seed. It

occupies about $^{1}/_{3}$ of the volume of the whole seed from which it is produced.

8. The recovery of decorticated seed varied from 55.6 percent to 76.8 percent on the basis of viable seed units in the original seed. Seed reduced by burr reduction sliowed a recovery of 69.2 percent to 86.0 percent on the basis of viable units. Segmented, reduced to give 87 percent, single germ units, showed a recovery of 50.6 percent on the basis of viable units.

9. Seed processed by combining burr reduction and decortication was reduced to 9-7 size with a germination comparable with the original seed. The seedlings produced per viable unit amounted to 1.46 as compared to 1.87 for the original seed. The recovery was 69.0 percent on the basis of viable seed units.

10. Horizontal plate planters equipped with proper platen and small smooth tubes in place of the usual spiral ribbon tubes are capable of doing precision planting with graded whole or processed seed.

11. Segmented, decorticated, and burr-reduced seed produced stands with 83.9. 54.8, and 53.0 percent of the inches with single plants when their respective field germinations were 70.4, 88.2, and 69.0 percent. Under field germinations of 20.4, 44.8. and 40.7 percent, respectively, segmented, decorticated, and burr-reduced seed produced stands with 90.0, 75.1, and 70.2 percent of the inches with single plants.

12. Stand counts made on the basis of 100 seed units planted in replicated plantings of segmented, decorticated, and burr-reduced seed showed 16.4, 35.6, and 34.8 inches containing single plants under field germinations of 20.4, 44.8, and 40.7 percent, respectively.

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