Seed Size in Relation to Development and Yield of Sugar Beets

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Size of seed was one of the early standards used in the sugar beet seed trade in Germany and other European countries. Large seed balls were recognized as giving a higher percentage of germination than seed balls of medium and small size. The minimum size or diameter of seed balls acceptable was 2.5 millimeters. The German seed standards served as a guide in the early sugar beet seed contracts in this country when commercial seed growing was started 12 years ago. Later, interest in seed size arose among the directors of the West Coast Beet Seed Company and in 1938 the senior author was requested to supply sized seed for experimental purposes. Seed of the variety U.S. 12 grown at Kernel, Calif., was separated into four sizes by using screens of 4, 3.5, 3, and 2 mm. diameters. Seed of each of the four sizes was shipped to six sugar companies for experimental purposes. One of the field tests, conducted near Salinas, Calif., by the Spreckels Sugar Company, was observed several times during the season. It was noted first that in the plots planted with the smallest seed the seedlings were slower in emerging than those in the plots planted with the larger seed. Later, it was noted that the plots planted with large seed had thick stands and those planted with small seed had very poor stands. Interest in the question of seed size lagged after those tests.

Interest was revived in 1942 after segmented seed had been introduced into widespread use. Number of seed per seed ball decreases with size of seed ball so that seed balls less than 2.5 mm. in diameter are practically all single seed. This fact has led to the suggestion that very small seed could be saved and, without being segmented, used alone or combined with seed that had been segmented. Furthermore, it was noted that with some cleaned but unsized seed lots high in average germination the very small seed removed in the standard sizing process could be blended back in without lowering the germination below the contract standard of 75 percent. An average of 3.5 percent of the totals passed through a 2.5 mm. screen and the germination varied from 50 to 75 percent. According to contract size standard these very small seed should have been discarded.

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This interest in seed ball size led us to start greenhouse and laboratory studies on size in relation to percentage and vigor of germination. Results of these tests led to field investigations of the matter.

Materials and Methods

The seed used in these investigations was produced in southern California, and western Oregon. Most of the seed lots used had been commercially cleaned according to contract standards, while one lot was used as it came from the thresher and without being commercially cleaned. The separation of the seed lots into different sizes was accomplished by passing them over screens with round holes of given sizes and then taking off in each case the seed that remained on top of the particular screen. The diameters of holes in the screens were 4 mm., 3.5 mm., 2.5 mm., and 2 mm. In one case a sixth size of seed was used, that passing through a 2 mm. screen. The sized seed was tested for germination on blotting paper so that the amounts of different sizes planted could be adjusted to the potential numbers of sprouts. The very small seed balls gave low percentages of germination and also relatively low numbers of sprouts per seed ball. Therefore, with the very small seed balls, many more were planted in a given length of row than with the large seed balls.

Greenhouse germination tests were made in soil in flats 14 inches wide, 16 inches long, and 31/2 inches deep. Some of the seedlings from these flats were compared as to weight.

A field test was conducted at King City, Calif., using seed produced at Hemet, Calif., of the two varieties U.S. 22 and U.S. 33. Two sizes of seed of each variety were used : The larger seed was that remaining on a 4 mm. screen, the smaller seed was that passing through a 3 mm. screen and remaining on a 2.5 mm. screen. The plots were 65 feet long. There were four rows in each plot. The planting was on 2-row beds and the distance between the rows were 14 and 26 inches. The two entire center rows of each plot were harvested for yield data. Sucrose percentages and purity determinations were made by the usual standard methods. The plots were not replicated in this test but the soil was exceptionally uniform.

A field test at Riverside, Calif., involved U.S. 15 produced at Medford, Ore., and U.S. 33 produced at Hemet, Calif. Three seed sizes of each variety were used: The seed remaining on a 4 mm. screen ; that passing through a 4 mm. screen and remaining on a 3.5 mm. screen ; and that passing through a 3 mm. screen and remaining on a 2.5 mm. screen. The quantity of the smallest seed planted was increased in the effort to compensate for its lower germination. The plots consisted of two rows 65 feet long. The beets were thinned to

single plants 10 inches apart. Each treatment was replicated eight times.

Experimental Results

A test was conducted in the greenhouse with thresher-run seed of U.S. 33 produced at Hemet, Calif., and separated into six sizes. The sizes were: 4, 3.5, 3, 2.5, 2, and less than 2 mm. Enough seed balls, based on blotter germination tests, were planted in each row to give the same number of seedlings. In this soil test decrease in num ber of seedlings emerging and in vigar of seedlings become evident with the seed balls separated out by the 3 mm. screen. The smaller sizes were progressively poorer (figure 1).

A greenhouse germination test was conducted with three sizes of seed of U.S. 15 produced at Medford, Ore., and of U.S. 33 produced at Hemet, Calif. Each lot was separated into three sizes: 4, 3.5, and 2.5 mm. In both varieties the largest seed gave the highest germina-lion and the seedlings were the most vigorous and most nearly uni-form (figure 2). The seed were planted on April 11, 1944. On May 2 (21 days after planting) seedlings of each treatment were removed from the soil and carefully washed and weighed in lots of tens. Eleven such lots were weighed and the average weight per seedling, as given in table 1, was calculated from these weight determinations. The percentage germination decreased as seed size decreased. Seed-lings from the, 4 mm. seed balls were only slightly heavier than those from the 3.5 mm. seed balls but much heavier than those from the 2.5 mm. seed balls. Such seedlings when transplanted to pots and grown in the greenhouse continued to show the differences in size and vigor.

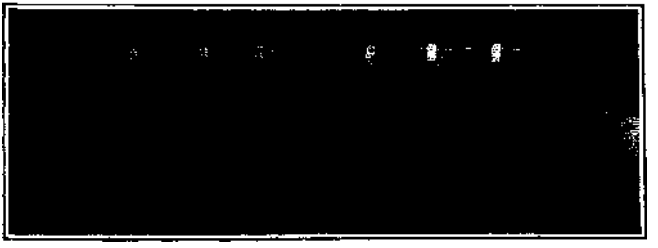

Figure I. —Seed size in relation to germination and vigor with U.S. 33 grown at Hemet, Calif. Sizes, left to right: 4, X.5, 3. 2.5. 2, and less than 2 mm. On basis of blotter tests, enough seed were planted in each row to give the same number of seedlings. Drop in germination and vigor begins with 3 mm. size.

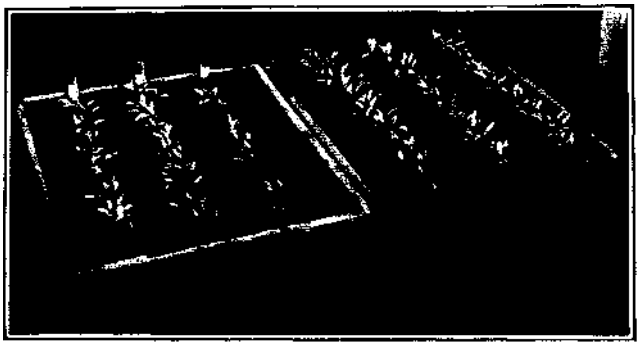

Figure 2.—Commercial seed of U.S. 15 grown at Medford. Ore-., and U.S. 33 grown at Hemett, Calif., each separated, left to right, into three sizes: 4, 3.5, and 2.5 mm. U.S. 33 on right, U.S. 15 on left. Lowest germination and lowest vigor in smallest size in both varieties.

A field test was conducted at King City, Calif., in 1943. Seed of U.S. 22 and U.S. 33 produced at llemet, Calif., were used. Two sizes, 4 mm. and 2.3 mm., of each variety were used. During the growing season it was noted that the plants from the smaller seed were very irregular in size while those from the larger seed averaged larger and were comparatively uniform. There was practically no difference in sugar percentage within the varieties but in both cases there was a noteworthy increase in yield from the larger seed, about 6 and 7.5 percent, respectively (table 2).

Table 1.—Seed size, germination, and vigor.

Variety and source	Seed size*	Average weight per seedling**	Germination
	Mm	Mgm	Pct
U. S. 15 (Oregon)	4	265	02
U. S. 15 (Oregon)	3.5	240	84
U. S. 15 (Oregon)	2.5	104	75
U. S. 33 (Calif.)	4	255	98
U. S. 33 (Calif.)	3.5	228	81
U. S. 33 (Calif.)	2.5	116	37

*Seed passed through round-meshed screens and then that remaining on respective screens used.

**Results are averages from 11 ten- seedling samples for each seed size. Planted April 11, 1944. Weighed May 2, 1944.

Table. 2.—Large and small seed tost. King City, Calif. **1943.**

Variety	Seed size*	Gross sugar per acre	Beets per acre	Sucrose
	Mm.	Tons	Tons	Percentage
U. S. 22	4	4.877	27.4	17.8
U. S. 22	2.5	4,858	25.9	17.9
U. S. 33	4	4.514	24.4	18.5
U. S. 33	2.5	4.222	22.7	18.6

*Seed passed through round-meshed screens and then that remaining on respec tive screens used.

A replicated field test was conducted at Riverside in 1944. U.S. 15 seed produced at Medford, Ore., and U.S. 33 produced at Hemet, Calif., were used. Three sizes of seed balls were used of each variety: 4, 3.5, and 2.5 mm. Even though a heavier rate of planting was used with the smallest seed the seedlings did not. emerge as thickly in those plots as they did in plots from the two larger sizes. This thinner stand in the plots from the smallest seed resulted in less competition during pre-thinning stage than was the case with the thicker stands of more vigorous seedlings in the other plots. If there was any considerable effect from the difference in competition before thinning, the advantage was in favor of the smallest seed. The difference between size of tops of plants from the 4 mm. and the 2.5 mm. seed was obvious until late summer (figure 3). The harvest data from this test are given in table 3. There were no significant differences in

Table 3.—Seed size in relation to yield of sugar beets. Riverside, Calif., 1945.*

Variety and source	Seed size**	Sugar per acre: Available	Sugar per acre: Gross	Beets per acre	Sucrose	Purity	Beets per 100 feet of row
	Mm.	Tons	Tons	Tons	Percentage	Percentage	
U. S. 15 (Oregon)	3.5	4.549	5.280	32.94	15.98	86.49	114
U. S. 15 (Oregon)	4	4.483	5.175	32.97	15.70	86.66	116
U. S. 15 (Oregon)	2.5	4.264	4.918	30.65	16.97	88.52	114
U. S. 33 (Calif.)	4	3.905	4.570	31.25	14.65	85.49	115
U. S. 33 (Calif.)	3.5	3.886	4.600	32.35	14.24	84.47	114
U. S. 33 (Calif.)	2.5	3.747	4.399	29.71	14.83	85.16	114
Diff. for Sig. (19:1)		.141	.186	.832	.06	ns.	

*Data are averages of eight replications for each seed size.
**Seed passed through round-meshed screens and then that remaining on respective screens used.

Figure 3.- U.S. 33 plants from two seed sizes: Two rows on left from 4 mm. seed, two rows on right from 2.5 mm. Seed produced at Hemet, Calif. Planted at Riverside. Calif., MARCH 27. 1945. Photographed May 16, 1945.

sucrose percentages and purities and no significant differences in yield between the 4 mm. and the 3.5 mm. sizes in either variety. However, the yields in both varieties were significantly lower in the 2.5 mm. sized lots, 7 percent in U.S. 15 and 6 percent in U.S. 33.

Discussion and Conclusions

Rapid germination is a very important characteristic of sugar beet seed because seed bed conditions favorable at the time of planting may soon become unfavorable. The larger seed balls are preferable because the seed in them germinates faster than that in the small seed balls. Vigorous seedlings, such as The larger seed balls afford, are advantageous under many circumstances, as, for example, when there is soil crusting or insect attack.

Gains in yields of beets and sugar accruing from use of the larger seed far more than offset losses involved in discarding the smallest and weakest seed. Where seed is to be segmented it would seem obviously advantageous to size tbe seed first, discard the smaller seed, and segment only the larger seed.

If the indicated advantages justify a higher standard for seed size an increase in the amount of seed grown will become necessary.

The evidence presented in this paper suggests that the size standards that ought to be applied may differ for different seed-growing re gions.

Summary

Sugar beet seed size studies in the greenhouse and field revealed that seed balls remaining on 4 mm. and 3.5 mm. round-hole screens had faster germination and gave more vigorous seedlings and higher yields than did seed balls remaining on a '2.5 mm. round-hole screen. Under critical greenhouse and laboratory examination and with seed of the variety U.S. 33 grown at Hemet, Calif., it was found that seed balls remaining on a 4 mm. round-hole screen had higher germination and gave more vigorous seedlings than did seed balls passing through the 4 mm. and remaining on the 3.5 mm. screen. The one replicated field test involving these two sizes and from two varieties did not bring out a statistically significant difference in yield between these two sizes.