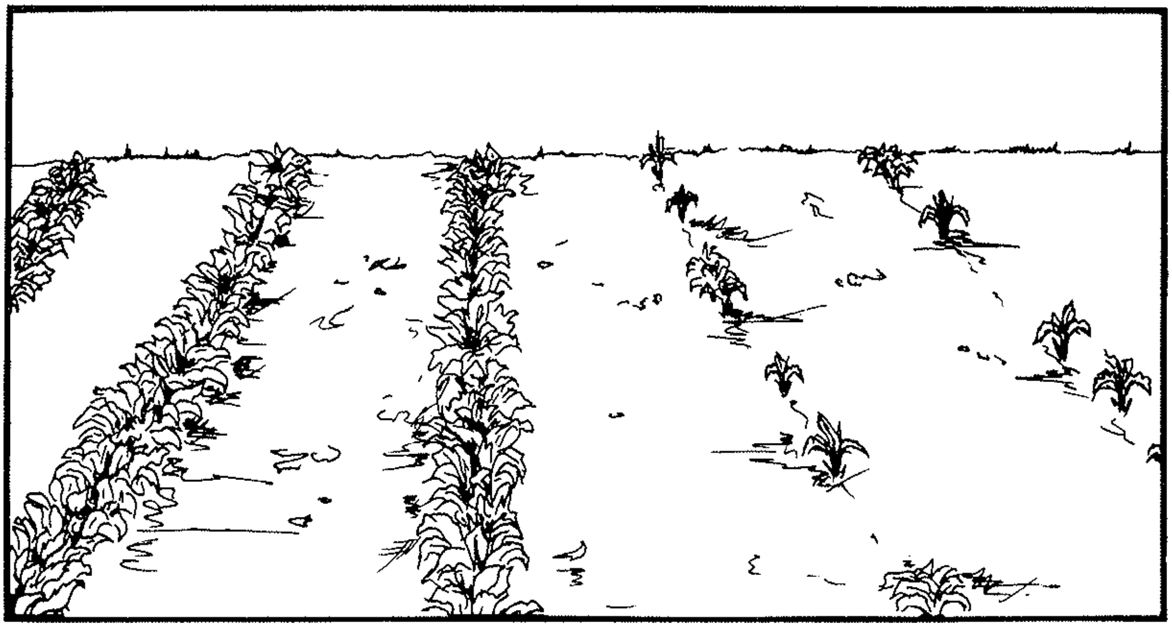
Seed Research Circular No. 2

PREDICTING...

.... FIELD STANDS OF TABLE BEETS



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FOREWORD

THE SEEDLING PRODUCTION potential of 100 seedballs of table beets may vary from one seed lot to another from fewer than 100 seedlings to more than 200. Thus, in order to obtain desired stands of plants, it is necessary to adjust planting rates in accordance with seedling production potential.

A sand test for determining seedling production potential of individual seed lots provides a good basis for a reasonably accurate prediction of field germination under favorable planting conditions. Under such conditions, seedballs planted in field trials have produced about 0.7 times as many plants as seedballs from the same lot planted in sand tests. Therefore, sand test results can be used to adjust planting rates to obtain desired stands of plants.

Adjusting planting rates in accordance with seedling production potential will not necessarily help to avoid poor stands of plants resulting from too little soil moisture, damping-off, crusting of the soil, or other adverse field conditions. However, there is no disadvantage to having adjusted planting rates under such conditions and there may be a considerable advantage when field germination conditions are favorable.

This circular has been prepared partly to provide a sufficiently detailed description of the sand test to guide others in using it, partly to present research data concerning the accuracy of the sand test in in predicting field stands of table beets, and finally to illustrate the manner in which sand test results can be used to adjust planting rates to obtain desired stands of table beets under favorable field conditions.

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PREDICTING...

....FIELD STANDS OF TABLE BEETS

INTRODUCTION

PROPER SPACING of plants within the row is very important in profitable production of table beets grown for processing. Some processing companies pay a premium for beets delivered early in the season and some growers attempt to obtain that premium. For early beets, a grower must have a relatively thin stand of plants--about 12 to 15 plants per foot of row. Otherwise, maturity will be delayed.

Some processing companies also pay premium prices for small-size beets. Growers attempting to obtain high prices for deliveries later in the season need uniformly thick stands of plants (about 25 to 30 plants per foot of row) because crowding keeps the roots from growing too large.

Providing a precise spacing of plants within the row is difficult for any crop. It is complicated for table beets by the fact that most varieties have multigerm seeds. That is, the seed unit is actually a seedball which may contain none to several germinable seeds. Some seed lots may have fewer than 100 germinable seeds per 100 seedballs whereas others will have more than 200. If lots with such differences in seedling production potential were planted at the same rate, widely different stands of plants would result.

In the standard procedure for testing the germination of table beet seeds prescribed by the Association of Official Seed Analysts each seedball is treated as a single seed unit and any seedball capable of producing one normal seedling is considered to be germinable. Seedballs which produce two or three normal seedlings are placed in the same category as those which produce only one.

It has been suggested by some that only one seedling per seedball is capable of producing a root large enough for processing and that the standard laboratory germination percentage, therefore, is the best guide to planting value. However, data presented below indicate that the number of roots one inch in diameter or larger that can be produced from a lot of seed is more closely related to the total number of seedlings per 100 seedballs that a lot is capable of providing than to the standard per cent germination. Therefore, a suitable method for measuring the seedling production potential of table beet seedballs appeared to be needed. This need has been met by a procedure commonly referred to as a "sand test" because sand is used as the seed germination medium.

The sand test was selected for predicting field germination after it was found to be more accurate for that purpose than tests using non-pasteurized soil mixtures. It is conducted in pasteurized builder's sand carefully adjusted to a moisture level of 25 per cent of its water holding capacity and held at a temperature of 20°C (68°F) for a ten day germination period.

A detailed description of the sand test and the manner in which it is conducted is provided in the appendix for those who want to conduct such a test on table beet seeds. Featured in the appendix is a complete set of photographs showing exactly the various steps necessary in making a sand test of table beet seeds.

USE OF SAND TEST IN PREDICTING FIELD GERMINATION

During a 4 year period, standard laboratory germination tests, sand tests, and field trials irrigated as necessary to provide good germination conditions were conducted on samples from 96 different lots of table beet seeds. These included 21 different lots in 1963, 29 in 1964, 20 in 1965, and 26 in 1966. In each of the first 3 years, two field plantings were made from each lot of seed and in 1966, three plantings were made.

A comparison of the ability of the standard laboratory germination test and the sand test to predict initial stands of plants is provided in table 1. In every one of nine plantings there was a better correlation between sand test results and field emergence than between standard germination percentages and field emergence.

During the first 3 years, records were kept not only on the initial stand of plants (total number of emerged seedlings) but also on the number of plants remaining at harvest and on the number of roots one inch or larger in diameter at harvest. Results are summarized in Table 2. Here again the sand test provided a more accurate prediction in each case than the standard laboratory germination test.

The general relationship between sand test results and initial field stands is revealed by Figure 1 in which the number of seedlings per 100 seedballs obtained in field trials is plotted against the average number of plants per 100 seedballs obtained in sand tests for each of the 96 seed samples included in the experiments. On the average, there were 74 plants produced in field trials for each 100 seedlings obtained in sand tests.

An analysis of the data presented in Figure 1 indicated that about 75 per cent ($r^2 = .746$) of the difference among seed lots in the number of plants produced per 100 seedballs in field trials was related to differences in seedling production potential as revealed by the sand tests. The other 25 per cent of the variation was caused by other factors which were not identified but which probably included

Table 1.--Accuracy of Standard Laboratory Germination Test and Sand Test in Predicting Relative Initial Stands of Table Beets in 4 Years of Trials

Year of trial	*Coefficient of correlation*	
	Standard laboratory germination test vs. field emergence	*Sand test vs. field emergence*
1963 First Planting	0.753	0.954
'' Second Planting	0.744	0.931
1964 First Planting	0.729	0.846
'' Second Planting	0.818	0.927
1965 First Planting	0.704	0.920
'' Second Planting	0.560	0.902
1966 First Planting	0.639	0.812
'' Second Planting	0.689	0.770
'' Third Planting	0.528	0.843
Overall (combined planting dates)	0.651	0.864

Table 2.--Accuracy of Standard Laboratory Germination Test and Sand Test in Predicting the Relative Number of Plants at Harvest and Relative Number of Roots 1 Inch or More in Diameter for Table Beets in 3 Years of Field Trials

Year of trial	*Standard laboratory germination test vs. field performance*	*Sand test vs. field performance*
	Number of Plants at Harvest	
1963 First Planting	0.788	0.957
" Second Planting	0.725	0.925
1964 First Planting	0.729	0.856
" Second Planting	0.812	0.920
1965 First Planting	0.675	0.896
	Number of Roots 1 Inch or More in Diameter	
1963 First Planting	0.641	0.823
" Second Planting	0.785	0.971
1964 First Planting	0.675	0.790
" Second Planting	0.750	0.790
1965 First Planting	0.667	0.773

differences in seed vitality, seed treatment, and soil conditions in the field.

The general relationship between initial field stands and sand test results suggested that field stands could be predicted conservatively by multiplying sand test results by a field factor or 0.7. In 1965, two separate plantings were made, one in June and one in July, to test that possibility. Samples from 20 different lots of seed were used in the first planting and from

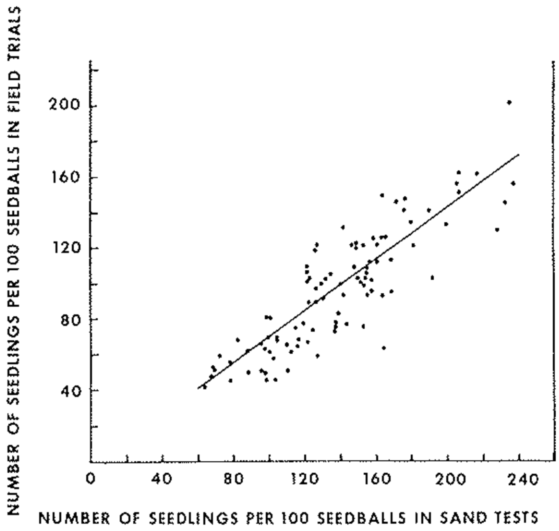


Fig. 1--The relationship between seedling emergence in field trials and sand tests. The number of seedlings obtained in field trials was equal to -6 plus 0.74 times the number of seedlings in the sand tests.

17 of the same lots in the second planting. There were not enough seeds in the samples from three lots to include them in both plantings. The planting rate for each sample was adjusted by means of sand test results and the field factor of 0.7 to provide an initial stand of 20 plants per foot of row.

Results are summarized in Table 3. The variation from the desired stand for the individual lots of seed ranged from 0 to 9 plants per foot and averaged 3.2 plants per foot in the first planting and 3.4 plants per foot in the second. Although variation from the desired stand occurred in both directions, for most of the seed lots a few more plants were obtained in the field trials than were predicted by multiplying sand test results by 0.7. That would not be a serious disadvantage for late planting in which thick spacings are desired. It might be objectionable in early

Table 3.--Plant Stands Obtained in 1965 Field Trials When the Number of Seedballs Planted per Foot of Row was Adjusted in Accordance with Sand Test Results to Provide 20 Plants per foot

	Plants per foot obtained		*Variation from 20 plants per foot*	
Sample number	*First planting*	*Second planting*	*First planting*	*Second planting*
1	24	23	4	3
2	24	25	4	5
3	24	23	4	3
4	24	24	4	4
5	26	--	6	-
6	22	24	2	4
7	28	--	8	-
8	21	--	1	-
9	19	17	1	3
10	26	25	6	5
11	22	24	2	4
12	25	24	5	4
13	20	20	0	0
14	15	11	5	9
15	21	21	1	1
16	23	24	3	4
17	20	19	0	1
18	25	25	5	5
19	17	19	3	1
20	21	22	1	2
Average	22	22	3.2	3.4

plantings where early maturity is important, but under the less favorable conditions normally encountered in early plantings such a surplus of plants would be less likely to occur.

In the 1965 plantings, as in most of the other field plantings, samples from a few seed lots did not fit the normal pattern of behavior. Sample 14, for instance, provided considerably fewer plants than were predicted especially in the second planting. A check into the history of the seed lot involved revealed that it was 3 years old and, although it had sufficient vitality to germinate fairly well in sand tests, it apparently did not have enough vitality to perform as well as other samples in field plantings.

An investigation of another sample which did not germinate as well as expected in the 1966 plantings indicated that it was not treated well enough with a fungicide to protect it from soil fungi. A few other samples such as sample 7 used in the first planting in 1965 produced more plants than expected in the field trials. Such samples apparently were well treated with a fungicide and had especially good vitality.

An attempt was made to identify seed lots which would perform better or poorer than the average in field trials by subjecting samples from various lots of seed to accelerated storage tests (5 days storage at 104°F and about 80 per cent relative humidity) and then testing them in sand tests to determine the effect of the hot humid storage on their ability to germinate. This procedure did not satisfactorily detect lots which varied from the usual performance pattern.

More research is needed not only for table beets but also for other crops in developing procedures for identifying seed lots with unusual behavior in field plantings. However, until such methods can be developed, the sand test appears to be the best procedure available for providing the information needed to adjust planting rates in accordance with seedling production potential in order to obtain desired stands of table beets.

ADJUSTING PLANTING RATES TO COMPENSATE FOR DIFFERENCES IN SEEDLING PRODUCTION POTENTIAL

The number of seedballs that need to be planted per foot of row to obtain a specified plant stand can readily be determined from sand test results by using the following formula:

$$\text{No. of seedballs needed/ft. of row} = \frac{\text{No. of plants desired/ft. of row}}{\text{No. of seedlings/100 seedballs} \times 0.007}$$

If a lot of seed produced 120 seedlings per 100 seedballs in the sand test and 25 plants per foot of row were desired, the number of seedballs that should be planted per foot of row would be calculated as follows:

$$\text{No. of seedballs needed/ft. of row} = \frac{25}{120 \times 0.007} = \frac{25}{0.84} = 29.8$$

In this case, therefore, the planter should be adjusted to drop approximately 30 seedballs per foot

Table 4.--Approximate Number of Table Beet Seedballs Needed per Foot of Row to Provide Specified Stands of Plants

Seedlings per 100 seedballs produced in sand test	*Seedballs needed per foot of row to produce indicated number of plants per foot of row:*				
	12	*15*	*20*	*25*	*30*
70	24	31	41	51	61
80	21	27	36	45	54
90	19	24	32	40	48
100	17	21	29	36	43
110	16	19	26	33	39
120	14	18	24	30	36
130	13	16	22	28	33
140	12	15	20	26	31
150	11	14	19	24	29
160	11	13	18	22	27
170	10	13	17	21	25
180	10	12	16	20	24
190	9	11	15	19	23
200	9	11	14	18	21
210	8	10	14	17	20
220	8	10	13	16	19
230	7	9	12	16	19
240	7	9	12	15	18
250	7	9	11	14	17

of row at its normal operating speed.

The number of seedballs that would be needed per foot of row to provide various stands of plants from seed lots with different seedling production potentials is indicated in Table 4.

The results of sand tests can also be used to calculate the approximate number of pounds of seed needed per acre to provide a desired stand of plants. That calculation can be made through use of the following formula:

$$\text{Lbs. of seed required/acre} = \frac{272 \times \text{No. of plants desired/sq. ft.}}{\text{No. of seedballs/oz.} \times \text{seedlings/100 seedballs} \times 0.0007}$$

If 20 plants per foot of row were desired in rows 24 inches apart and if the seed to be used contained 1,250 seedballs per ounce and produced 80 seedlings per 100 seedballs in the sand test, the approximate number of pounds of seed required per acre would be calculated as follows:

$$\text{Lbs. of seed required/acre} = \frac{272 \times 10}{1,250 \times 80 \times 0.0007} = \frac{2,720}{70} = 38.9$$

Approximate quantities of seed required per acre to provide various stands of plants with two different sizes of seedballs and different seedling production potentials are indicated by the figures in Table 5. These figures were calculated by using 1,875 seedballs per ounce as the number for seedballs which would pass through an 11/64 inch screen and over a 9/64 inch screen and 1,250 seedballs per ounce for seedballs large enough to pass over an 11/64 inch screen. More accurate estimates, of course, can be made by using the actual number of seedballs per ounce in the seed lot being planted.

If the figures in Table 5 are used to make approximate settings of planters, the actual rate of seed delivery of the planters should be subsequently determined to verify the accuracy of the approximate settings.

As the data presented in this

Table 5.--Approximate Number of Pounds of Table Beet Seed Needed per Acre to Provide Specified Stands of Plants when Seeded in Rows 24 inches Apart*

Seed size	*Seedlings per 100 seedballs produced in sand test*	*Pounds of seed per acre needed to provide the indicated number of plants per foot of row:*				
		12	*15*	*20*	*25*	*30*
Over 9/64 inch (Approximately 1,875 seedballs per oz.)	70	18	22	30	37	44
	80	16	19	26	32	39
	90	14	17	23	29	35
	100	12	16	21	26	31
	110	11	14	19	24	28
	120	10	13	17	22	26
	130	10	12	16	20	24
	140	9	11	15	19	22
	150	8	10	14	17	21
	160	8	10	13	16	19
	170	7	9	12	15	18
	180	7	9	11	14	17
	190	7	8	11	14	16
	200	6	8	10	13	16
Over 11/64 inch (Approximately 1,250 seedballs per oz.)	80	23	29	39	49	58
	90	21	26	34	43	52
	100	19	23	31	39	47
	110	17	21	28	35	42
	120	16	19	26	32	39
	130	14	18	24	30	36
	140	13	17	22	28	33
	150	12	16	21	26	31
	160	12	15	19	24	29
	170	11	14	18	23	27
	180	10	13	17	22	26
	190	10	12	16	20	25
	200	9	12	16	19	23
	210	9	11	15	19	22
	220	8	11	14	18	21
	230	8	10	13	17	20
	240	8	10	13	16	19
	250	7	9	12	16	19

* For rows 12 inches apart multiply above figure by 2.00
" " 14 " " " " " " 1.72
" " 16 " " " " " " 1.50
" " 18 " " " " " " 1.33
" " 20 " " " " " " 1.20
" " 22 " " " " " " 1.09
" " 24 " " " " " " 1.00
" " 26 " " " " " " 0.92
" " 28 " " " " " " 0.86
" " 30 " " " " " " 0.80

The estimates provided in this table were calculated in accordance with the formula on Page 6 using the approximate number of seeds per ounce indicated in the table. A more accurate estimate could be made for an individual seed lot by using the formula and inserting in it the number of seeds per ounce that the lot actually contains.

circular have indicated, sand test results served quite reliably as a basis for predicting field germination in irrigated field trials at the Geneva Experiment Station in 9 separate plantings over a period of four years. Nevertheless, the trials were all conducted on an Ovid silt loam soil and different results might be obtained on other soils.

If other soil types are found to provide different results, it may become necessary to use different field factors for different soils. Some soils may require a factor of 0.6 whereas a factor of 0.8 may be best for others. If different field factors are found to be needed for varying soil conditions, they can be incorporated into the basic formulae that have been developed for calculating planting rates.

APPENDIX

PROCEDURES FOLLOWED IN CONDUCTING SAND TEST

A coarse grade of builder's sand is used for sand tests. It is pasteurized by the "flash flame" method which removes most of the moisture and thereby permits adjusting the moisture content to almost any desired level by adding water. After pasteurization, the sand is stored in pallets with plastic liners to prevent a change in moisture and to provide some protection against contamination.

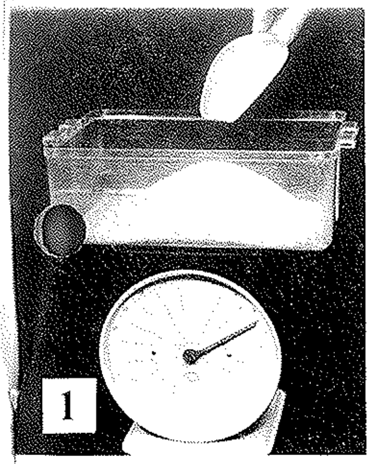
Because the moisture content of the sand when it is used as a germination medium is critical, considerable care is taken to insure the same moisture condition for each test. Both the moisture content and the water holding capacity of each lot of sand are determined before it is used.

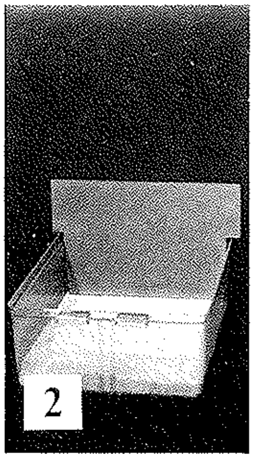
These determinations are relatively simple. Determining the moisture content involves taking representative samples of the sand in a suitable container such as a coffee can. The empty container is weighed and then the weight of the container plus the sand is taken. The container of sand is then placed in an oven at about 105°C (221°F) for 16 to 24 hours after which it is weighed again and the per cent moisture in the sand is calculated as follows:

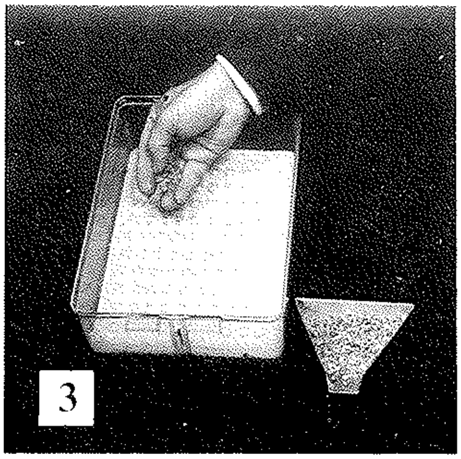
A.	Weight of dry container	=	100 gms.
B.	Weight of sand plus container before drying	=	1130 gms.
C.	Weight of sand plus container after drying	=	1100 gms.
D.	Weight of moisture loss	=	30 gms.
E.	Dry weight of sand = C-A	=	1000 gms.
F.	Per cent moisture in sand (based on dry weight of sand)= D ÷ E x 100	=	3%

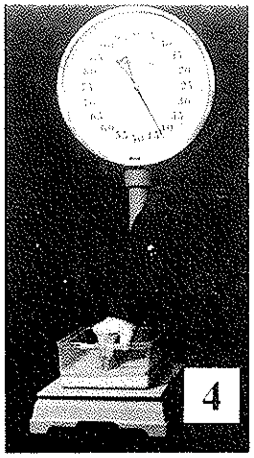
The procedure used for determining the water holding capacity of the sand is quite similar. The sample is taken in the same way but the container used has small holes in the bottom to allow water to drain.

After weighing the container it is filled with the sand and then flooded with water until the water runs out the bottom and there is obviously more water in the container than the sand can hold. The container is covered to prevent loss of moisture from the surface of the sand through evaporation and it is allowed to drain for 16 to 24 hours after which it is weighed and placed in an oven at 105°C and dried for









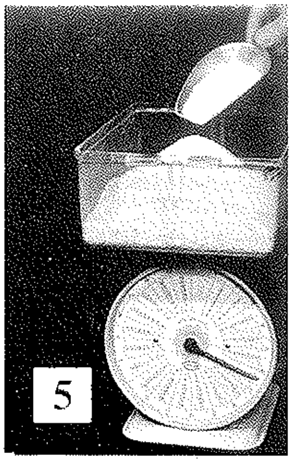
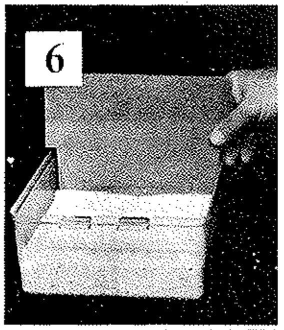
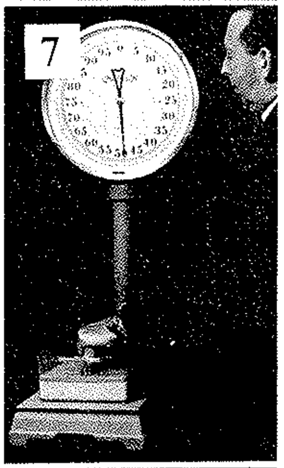
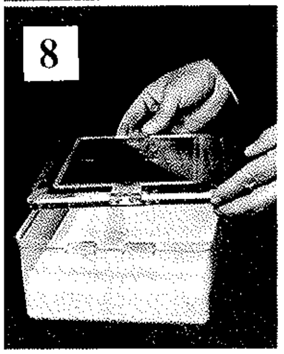


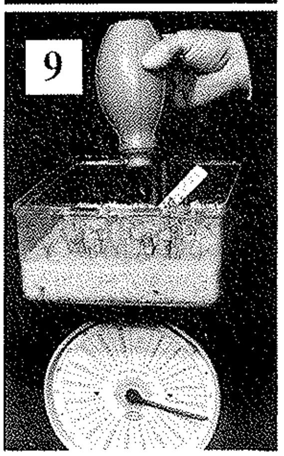
Figure 2.--Steps in Making a Sand Test of Table Beet Seeds

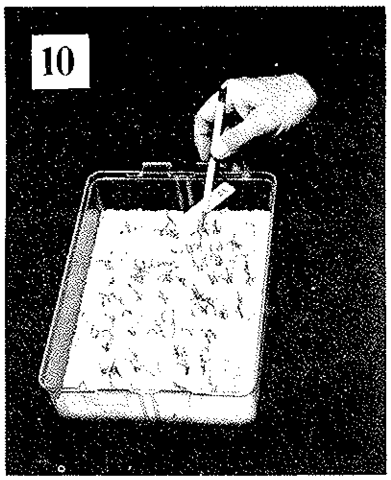
1. Weighing enough sand into a plastic box to provide about a three-fourths inch layer on the bottom of the box.
2. Leveling sand with a piece of composition board cut to the proper size and shape to ride on the top of the plastic box and reach to within about three-fourths inch of the bottom.
3. Planting seeds with the help of a plastic board with 100 holes in it for counting and spacing seedballs.
4. Compacting seeds and sand to provide good contact between the two. The piece of plywood is pressed down on the seeds and sand until a weight of 50 pounds is registered on the dial of the scale.
5. Weighing an additional amount of sand (equal to the amount placed under the seeds) into the plastic box over the seeds.
6. Leveling the sand over the seeds with another piece of composition board cut to the proper size to reach to within about one and a half inches from the bottom of the box.
7. Compacting the sand over the seeds with a pressure of 50 pounds.
8. Cover is placed on plastic box and it is put in a chamber at 20°C (68°F).
9. After seedlings begin to emerge (about the fourth day) the cover is removed from each container and every day after that each container is weighed and water is added as necessary to replace water lost through evaporation.
10. The number of emerged seedlings per 100 seedballs is counted and recorded on the tenth day.











another 16 to 24 hours. Then it is weighed again and the water holding capacity calculated as follows:

A.	Weight of dry container	=	100 gms.
B.	Weight of saturated sand plus container	=	1350 gms.
C.	Weight of sand plus container after drying	=	1100 gms.
D.	Weight of moisture loss	=	250 gms.
E.	Dry weight of sand = C-A	=	1000 gms.
F.	Per cent water holding capacity (based on dry weight of sand) = D ÷ E x 100	=	25%

In order to make certain that no mistake is made, at least two containers are used for both the moisture content and water holding capacity determinations. If the separate containers for each determination are not in reasonably good agreement, new samples are taken and new determinations are made.

After the moisture content and water holding capacity of the sand are determined as indicated above, the amount of water which must be added to bring the sand to 25 per cent of its water holding capacity (the moisture level used in the sand test) can be determined and portions of the sand supply can be prepared for use as needed.

The necessary amount of water is usually added to the sand in a metal bushel tub and it has been found that an amount equivalent to 50 pounds of dry sand is a convenient quantity to prepare. The number of pounds needed to provide the equivalent of 50 pounds of dry sand, of course, varies with the moisture content of the sand being used. It can be calculated as follows:

A.	Moisture content of sand (determined as indicated above)	=	3%
B.	Sand needed to provide 50 lbs. dry weight equivalent = 50 lbs. dry sand + (50 x per cent moisture in sand) = 50 + (50 x .03) = 50 + 1.5	=	51.5 lbs.

The amount of sand needed is weighed on a platform scale with a 100 pound capacity which is also used later in the test for uniform compaction of the sand as described below.

The amount of water that must be added to the sand to bring it to 25 per cent of its water holding capacity is calculated as follows:

A.	Amount of water that would be needed to bring sand to its water holding capacity = 50 lbs. dry sand x 25% (water holding capacity as determined above)	=	12.5 lbs.
B.	Amount of water needed to bring sand to 25% of water holding capacity = 25% of 12.5 lbs.	=	3.1 lbs.
C.	Amount of water already in sand = 50 lbs. dry sand x 3% (moisture content of sand as determined above)	=	1.5 lbs.
D.	Additional water needed to bring sand to 25% of water holding capacity = B-C	=	1.6 lbs.

The amount of water determined to be needed is weighed out on a parcel post scale with a capacity of 20 pounds and is mixed thoroughly with the sand in the metal tub. The same parcel post scale that is used for weighing water to be added to the sand is also used as described below for weighing sand into plastic containers and for daily weighings to maintain the moisture content of the sand.

The further procedures followed in conducting the sand test are illustrated in Figure 2. A layer of sand about 0.75 inch deep is weighed into a plastic container 7½ inches wide, 10½ inches long, and 3¾ inches deep. This sand is leveled with a piece of composition board cut to ride on the rim of the plastic box and extending to the proper depth into it (Figure 2).

A ¼ inch plastic board containing 100 holes is used for counting and spacing seedballs on the leveled sand. One seedball is placed into each hole after which the board is removed leaving the seedballs in place.

Close contact between the seedballs and the sand is obtained by pushing the seedballs into the sand with a piece of plywood cut to fit into the plastic box and equipped with a handle. To assure uniform contact, the plastic box is placed on a platform scale during this process and the plywood is forced downward until a weight of 50 pounds is registered on the scale.

Additional sand equal to the amount placed under the seedballs is then weighed into the plastic box over them. This sand is leveled and compacted as described above and the cover is placed on the box which is then put into a germination chamber maintained at 20°C (68°F). Four separate boxes of 100 seedballs each are used for each seed sample tested.

After the first seedlings begin to emerge, the covers are removed from the boxes and the boxes are weighed daily during the remainder of the test period with water added as necessary to replace that lost through evaporation.

Ten days after planting, seedlings which have emerged in each box are counted and the average number of seedlings produced per 100 seedballs is reported as the seedling production potential of the sample tested.