Influence of Inhibitors in Sugar Beet Fruits on Speed of Germination at 50 and 70 Degrees Fahrenheit[1]

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In most areas where sugar beets are grown, planting as early as possible has been most profitable. Thus, the seeds (fruits) are planted in cold, moist soil. Soil temperatures below 50 F may delay germination and emergence a number of days during which diffusion of inhibitors may take place. Therefore at this low temperature, rapid water absorption and presence of inhibitors in the fruit may not be significant factors in the speed of germination. On the other hand, at 70 degrees the germination processes are initiated so rapidly that slow water absorption and inhibitors in the fruit may exert a considerable delaying action on germination.

Smith (2)[3] demonstrated that seeds of sugar beet varieties differ in their ability to germinate at 43 F and that this ability is a heritable trait. Sedlmayr (1) also demonstrated that speed of germination at room temperature is heritable. Snyder (3) and Sedlmayr (1) observed that speed of germination at room temperature is largely controlled by the fruit (maternal tissues) which surrounds the true seed. Speed of germination at room temperature has been causally related to the concentration of inhibitory substances in the fruit of the sugar beet[4]. Chemical inhibitors in the fruits of commercial varieties seem to control speed of germination more than does the physical nature of the fruit (3). Miyamoto and Dexter[5] removed the inhibitors by washing in water and inactivated them by soaking fruits in a solution containing mercury ions; however, emergence from cold soil was accelerated only slightly in comparison with untreated fruits.

This investigation was undertaken to determine whether (a) sugar beet strains could be selected that would emerge rapidly from soil at 70 and at 50 F, (b) the retarding effect of inhibitors

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[3] Numbers in parentheses refer to literature cited.

[4] Unpublished data of F. W. Snyder, J. M. Sobeson, and J. L. Fairley.

[5] Unpublished data of T. Miyamoto, and S. T. Dexter, Michigan Agricultural Experiment Station, East Lansing, Michigan.

in the fruits on germination and emergence would be completely dissipated in moist soil at 50 F, and (c) the relative growth activity of the embryos of strains of US 401 differed at 50 and 70 F.

Methods and Materials

Samples of open-pollinated seed (fruits containing the seeds) harvested from 538 plants of sugar beet variety US 401, previously indexed for speed of germination, were available for this study. Fifty whole seedballs of the 13 most rapid and the 13 slowest samples were again germinated by the blotter method. The 10 most rapid and the 10 slowest samples were chosen for the tests in soil.

Sandy loam was steam-sterilized, air-dried, and then moistened uniformly to contain approximately 17.5% moisture at planting time. Plastic dishes ($10\frac{3}{4} \times 7\frac{1}{2} \times 2\frac{1}{2}$ inches) were filled to a depth of $1\frac{7}{8}$ inches with soil, which was leveled and then compacted with a board ($10\frac{1}{2} \times 7\frac{1}{2}$ inches) having 10 cleats $\frac{1}{2}$ inch in depth to form the rows. A pressure of 150 pounds was applied to the board for approximately 15 seconds.

The seedballs (previously treated with a fungicide) were planted in a randomized block design. Each row contained 5 seedballs of a given entry. Thus with 10 rows, each dish contained 50 seedballs. Two dishes were required for one replication. Ten replications or 50 seedballs per entry were planted. After the seedballs were placed, they were coverd with $\frac{5}{8}$ inch of loose soil of the same moisture content. The dishes were immediately placed in plastic bags to minimize evaporation. The dishes for the higher temperature phase of the experiment had been placed at approximately 70 F about 5 hours before planting. Those for the lower temperature were maintained at approximately 60 F until planted and then were placed at a mean temperature of 53 for the first 2 days, 49 for the next 6 days, and then maintained at 50 from the eighth day until the experiment was concluded.

The percentages for germination and emergence were corrected for germination failures whenever a seedball contained all defective seeds. Only the first seedling from a seedball was counted, since the seedball was considered as a single unit. Each entry was ranked according to an accumulated score based on speed of germination or emergence.

Results

Speed of germination by the blotter method and speeds of emergence from soil at approximately 50 F and 70 for the rapid

Table 1.—Speed of germination and emergence percentages of 10 rapid and 10 slow entries of US 401 sugar beets.

Method and length of test period (days)	Averages for		Ranges for	
	Rapid	Slow	Rapid	Slow
Blotter germination at approx. 70 F				
2	40.2	0.0	22-71	-
2½	82.2	7.9	62-94	0-20
3	95.6	28.4	86-100	4-67
3½	98.6	50.8	94-100	12-90
4	99.8	69.7	98-100	32-98
5	100.	87.8	-	52-100
10	100.	96.4	-	-
Emergence from moist soil at approx. 70 F				
3	5.4	0.8	0-14	0-6
3½	54.4	12.7	34-88	0-33
4	96.8	51.2	90-100	4-90
4½	99.4	83.3	92-100	14-100
7	99.4	98.4	-	-
Emergence from moist soil at approx. 50 F				
11	19.0	8.8	6-36	2-18
12	53.4	25.3	30-84	2-44
13	87.2	60.3	70-100	20-84
14	99.0	86.2	96-100	60-98
19	99.8	97.0	-	-

Table 2.—Time required to attain 75 percent germination and emergence for the 20 entries of US 401.

Test	Temp. F	Number of days required		Range in time
		Minimum	Maximum	
Blotter germination	70	2	10+	8+
Emergence from soil	70	3½	5½	2
Emergence from soil	50	12	15	3

and slow entries are given in Table 1. The time required to attain 75% germination or emergence was determined for each test (Table 2).

The data revealed the following: 1) Percentage of emergence from either 50 F or 70 soil was as good as percentage of germination on the blotter at 70. 2) The germination-time and emergence-time curves were essentially the same in shape, whether the entry was "fast" or "slow"; the difference was largely in the initial delay to first sprout. 3) In soil at 70, the variation in time to attain 75% emergence between "fast" and "slow" was about 57%, but at 50, only about 25% (based on minima). 4) The greatest range in speed of germination was on the blotters. In soil, the performance of the entries was more uniform.

The rank order of the 20 entries for performance in each of the 3 tests (Table 3) revealed three patterns of performance: 1) Maintained about the same relative rank in all three tests (entries 1,7,8,11, etc.); 2) improved rank in emergence from soil at 70 F and a further improvement in soil at 50 as compared with blotter germination (entries 12 and 19); and 3) maintained relative rank in the tests at 70, but had a slower relative speed of emergence at 50 (entry 3).

Correlation coefficients calculated from the accumulated scores for the speeds of germination and emergence were as follows: Blotter versus soil at 70 F, 0.765**[6]; blotter versus soil at 50 F, 0.522*; and soil at 70 versus soil at 50, 0.787**, while correlation coefficients calculated from the rank order data (Table 3) were 0.872**, 0.519*, and 0.462* respectively.

Table 3.—Ranking of 20 entries of sugar beet variety US 401 for speed of germination and speed of emergence from soil at 2 temperatures (F).

	Blotter germination	Emergence from moist soil	
Ranking	70	70	50
Most rapid	1	6	1
	2	1	6
	3	2	12
	4	4	10
	5	3	8
	6	7	7
	7	8	2
	8	10	19
	9	12	4
	10	11	14
	11	5	11
	12	9	5
	13	13	15
	14	19	9
	15	20	18
	16	14	13
	17	15	3
	18	18	17
	19	17	20
Slowest	20	16	16

Discussion

From the literature on sugar beets, the principal parameters of speed of germination on a blotter or speed of emergence from soil appear to be the relative concentration of inhibitors in the fruit and the relative growth activity of the embryo over a range of temperatures. The growth activity at 70 F often may be masked by the high concentration of inhibitors. At lower temperatures the interrelations are more uncertain.

[6] Significance: ** at the 1% level, * at the 5% level.

The three patterns of performance can be accounted for on the basis of these parameters. Entry 1, and to a degree, entry 6 have a low concentration of inhibitors and both have unusually active embryos at 50 F. Apparently both of these desirable characteristics can be found in a single strain. Both entries 1 and 6 emerged rapidly from soil at 70 and 50 F, and would be superior agricultural varieties on the basis of germination performance. Entries 2, 3, 4, 12, and 19 are conspicuously out of rank in speed of emergence from soil at 50 as compared with their rank at 70. The performance of 2, 3, and 4 at 70 F, presumably because of low concentration of inhibitors, would not be improved by a longer period of diffusion at 50. Their relatively slower emergence at 50 may be attributed to low embryo activity at that temperature. Entries 12 and 19 emerged relatively faster when their inhibitors were permitted to dissipate in soil at 70 or 50. However, since neither equalled the speed of entry 1 at the low temperature, they apparently had a lower embryo activity in addition to the greater concentration of inhibitors.

The performance of the entries in the three tests seems to delineate the parameters and indicate the characteristics of each entry. The various combinations of characteristics exhibited by entries used in this study are illustrated (Table 4).

Table 4.—Combinations of the two parameters which affect speed of germination and emergence of selected strains of US 401.

Entry	Concentration of inhibitors in fruit	Growth activity of embryo at	
		70 F	50 F
1, 6	Low	Fast	Fast
5	Low	Intermediate	Intermediate
3	Low	Fast	Slow
10, 12	Intermediate	Intermediate	Fast
11	Intermediate	Intermediate	Intermediate
19	High	Intermediate	Intermediate
16, 17, 18	High	Slow	Slow

The correlation coefficients calculated from the accumulated scores for speed of germination or emergence indicate a reasonably good relation between blotter germination and emergence from soil at 70 F and between emergence from soil at 70 and 50 F, but a low correlation between blotter at 70 and soil at 50. However, a sufficient number of exceptions to the general performance were noted that interpretations and extrapolations of results must be made with considerable caution. The exceptional performance of an entry, e.g. entry 1, may be of much greater value for improving germination than average performance of a number of entries.

The data (Table 3) indicate clearly that the performance of seeds cannot be predicted with certainty from a single test. However, the consistent relative performance of a number of the entries in the three tests suggests that results of germination and emergence experiments conducted at room temperature may be applicable over a wider range of temperatures than suspected. While the blotter method is the simplest and quickest germination test, emergence from moist soil at approximately 50 F appears to be a more reliable test to indicate potential performance under field conditions. The latter method may be especially useful in selecting the best germination characteristics for variety improvement.

Summary

Samples of open-pollinated "seed" of 538 plants of sugar beet variety US 401 were available for study. The 10 most rapid and 10 slowest germinators, as determined by the blotter method at approximately 70 F, were chosen. Fifty seedballs of each entry were planted in sandy loam at approximately 17.5% moisture at 2 soil temperatures, 70 and 50.

The 20 entries were ranked from the most rapid to the slowest in each test (blotter germination, emergence from soil at 70 F, and emergence from soil at 50). Three patterns of performance were found: 1) Some entries maintained the same relative rapidity in all 3 tests; 2) others germinated relatively slowly on blotters as compared to emergence from soil at 70 or 50; and 3) still others maintained relative rapidity in the 2 tests at 70, but had a slower relative speed of emergence at 50.

Speed of emergence from moist soil at approximately 50 F appears to be a more reliable test to indicate potential performance under field conditions than speed of germination on blotters at room temperature.

Strains of sugar beets which emerge rapidly at 70 as well as at 50 F can be selected.

Literature Cited

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