Germination Potential of Monogerm Sugarbeet Seed As Determined by Field Emergence And Laboratory Germination[1]

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Introduction

With the discovery of monogerm sugarbeets (9) in 1948, growers and fieldmen anticipated precision planting throughout the industry. When the monogerm varieties were introduced into commercial production a decade later, there was immediate concern because of low germination in many varieties. When precision planted, these varieties germinated poorly, causing irregular stands. This forced growers to use thicker field plantings which again required thinning as with the old multigerm varieties.

A constant problem in laboratory germination tests of sugarbeet seed has been to obtain full germination potential. This problem has existed for years, but caused less concern in multigerm varieties as usually one or more of the three to four seeds per seedball would germinate. Likewise, since thinning of multigerm varieties was mandatory, excess seedballs were planted to be assured of a stand. When monogerm varieties which consist of a 1:1 seed to fruit ratio were planted, poor germination was readily detected.

There have been many laboratory germination studies on multigerm varieties however, little information has been reported on non-germinability of monogerm seed. Conflicting results have evolved from the multigerm seed studies as to possible causes of poor germination. As a result, the most common factors reported to cause low germination are: chemical inhibitors (4,7, 12,13), physical restrictions of the seedball (10,11), and underdeveloped seeds (14).

When the low germination percentages of monogerm seed were initially reported, the validity of laboratory results was often questioned. Common concerns about these results were: 1) Are laboratories getting the full germination potential from a seed lot? 2) Are laboratory results as high as field emergence results?

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[3] Number in parentheses refer to literature cited.

The objective of this study was to investigate low germination of Oregon-grown monogerm sugarbeet seed using laboratory and field methods to determine germination potential. This potential is defined as the number of fruits having seeds with sufficient embryo and perisperm development to produce a normal seedling under ideal conditions. The methods used were: 1) Standard laboratory germination; 2) Hydrogen peroxide laboratory germination; and 3) Field emergence.

Materials and Methods

Twelve hybrid monogerm sugarbeet varieties were selected to represent the principal commercial seed lines currently grown in Western Oregon. Six of these varieties were composed of natural fruits as harvested and the other six were composed of partially decorticated fruits. Decortication is a process that removes the corky maternal tissue of the fruit.

Field Emergence Study

Plots were arranged in a randomized block design with four replications. Each replication contained one row with 50 seeds for each variety.

The soil was a fine, sandy loam which was approximately the same aggregate size as Hammerton (5) found to give maximum rate of emergence and number of seedlings. The fertility level was determined by soil tests to be adequate prior to seed bed preparation. All seed was treated with Ceresan "M" and planted on August 5, 1966.

Fifty seeds for each row were hand-planted 3 inches apart at a depth of ¾ inch on moist soil. Individual seeds were marked with small stakes at planting for positive identification at emergence. Seedling emergence counts began 7 days after planting and continued for 5 weeks. During maximum emergence (7 to 14 days), daily counts were made to ascertain emergence prior to damage by insects or pathogens. Only emergence of healthy seedlings was recorded and not the survival and eventual field stand.

Laboratory Germination Studies

Laboratory germination tests using the hydrogen peroxide and standard methods were initiated concurrently with field emergence studies. Eight 50-seed replicates of each variety were germinated by each method. Germination tests, using both methods, were conducted at the same time in the same germinator for each variety. Special precautions were taken to avoid contamination during germination tests. This involved cleaning all tools with water before planting and counting, covering blotters and beets while soaking, and covering beets while drying.

Standard Method

Each 50-seed replicate was soaked in 200 ml of water at 25°C for 2 hours. Following a five-second rinse in warm water, seeds were spread on paper towels to dry for 4 hours at laboratory temperatures. Seeds were then hand planted in blotter boxes prepared from 6×10 inch blue-gray blotting material (120 pound weight). The blotters were soaked in water for 1 hour and drained for 1 hour prior to folding into boxes as excess moisture can form beads on the fruits. The boxes were formed by folding the longest section across the center, leaving one half for a lid and folding up the three edges of the other half to form a support for this lid.

Planted seeds were placed in a germinator which was maintained at a temperature of 20C for 16 hours and 30C for 8 hours. No watering of medium (blotter boxes) was necessary during the test period. Germination counts were started at 3 days and continued for 14 days after planting. Normal and abnormal seedling evaluation was in accordance with the Association of Official Seed Analyst Rules (1). Diseased abnormal seedlings were removed at the interim counts to prevent contamination of healthy seedlings, but other abnormal seedlings were evaluated at the completion of the test.

After the final count (14 days) ungerminated fruits were hand-cut with razor blades and evaluated for firm ungerminated or underdeveloped seeds. Firm ungerminated seeds filled more than half of the fruit cavity and had white, chalky perisperm and firm white embryo. Underdeveloped fruits had either completely empty cavities or partially developed seeds. The seeds classified as underdeveloped (shrunken) were either discolored and watery or filled less than half of the fruit cavity (14).

Hydrogen Peroxide Method

Fifty seeds were soaked in 200 ml of a 0.1% hydrogen peroxide solution for 16 hours. After the soak period, the solution was drained off and the seeds were rinsed in warm running water for 5 seconds. They were then placed on paper towels and allowed to dry for 2 hours. The seeds were carefully rinsed and dried to prevent any injury to protruding radicles which may be present at the end of the soak period. The remainder of the test, including planting, counting, evaluation of seedlings, and cutting was conducted as described for the standard method.

Results

Mean germination results of all methods are summarized in Table 1. This table includes germination percentages of each variety as determined in laboratory (columns a and b) and in

Table 1.—Germination results of two laboratory methods and field emergence for 12 varieties of mougerm sugarbeet seed.

Variety	Laboratory results H_2O_2 method	Laboratory results Standard method	Difference between laboratory results (a - b)	Field emergence	Difference between laboratory and field (d - a)	Difference between laboratory and field (d - b)
	(a)	(b)	(c)	(d)	(e)	(f)
1	77.75	64.50	13.25**	79.50	1.75	15.00**
2-D[1]	72.75	71.00	1.75	79.00	6.25	8.00
3	89.50	81.75	7.75	82.00	(7.50)[3]	0.25
4-D	85.50	81.75	3.75	88.00	2.50	6.25
5-D	85.50	81.00	4.50	84.00	(1.50)	3.00
6	81.50	81.25	0.25	87.00	5.50	5.75
7	69.50	52.50	17.00**	77.50	8.00	25.00**
8-D	81.50	72.25	9.25*	82.00	0.50	9.75*
9	87.00	74.50	12.50**	94.50	7.50	20.00**
10	84.00	76.50	7.50	88.50	4.50	12.00**
11-D	89.00	90.00	(1.25)[2]	88.50	(0.50)	(1.50)
12-D	75.50	72.50	1.50	73.50	(2.50)	1.00
Mean	81.58	74.87	6.71*	83.67	2.09 ns	8.80*

* Significant difference at the 5% level as determined by Duncans Multiple Range Test.
** Significant difference at the 1% level as determined by Duncans Multiple Range Test.
[1] Partially decorticated varieties are indicated by (D).
[2] Brackets indicate standard results are higher than H_2O_2 results.
[3] Parentheses indicate laboratory results are higher than field results.

field studies (d). Differences between laboratory methods (c) and between the laboratory and field (e and f) are also shown.

The hydrogen peroxide method produced consistently higher results than the standard method for all varieties examined except 11-D. This difference (column c) was significantly higher at the 1% level for three varieties and at the 5% level for one variety. The laboratory methods differed less for those varieties with partially decorticated seed except variety 8-D. When comparing the mean of all varieties for each method, the hydrogen peroxide results were significantly higher than the standard method results at the 5% level. This difference was 6.71%.

The hydrogen peroxide results were not significantly different from field emergence results (column e) for the 12 varieties examined. The standard germination results were consistently lower than the results of field emergence for all varieties except 11-D and significantly lower for five of 12 varieties tested (column f). Four of the five varieties that were significantly lower had natural (not decorticated) fruits. When comparing the mean results of all varieties, the difference between the standard method and field emergence was 8.8% (significant at the 5% level); whereas, the difference between the hydrogen peroxide method and field emergence results was 2.09% (not significant).

Correlation coefficients comparing associations between the three methods are presented in Table 2. The standard and hydrogen peroxide methods were significantly associated (r = 0.862**). The hydrogen peroxide method was significantly associated with field emergence (r = 0.735**); but, the standard method and field emergence were not significantly associated (r = 0.546).

Table 2.—Simple correlation coefficients (r) for laboratory germinations and field emergence of 12 monogerm sugarbeet seed varieties[1].

	Field emergence	Standard method
Standard methods	.546	
Hydrogen peroxide method	.735**	.862**

[1] Values of r necessary for significance: .576 at 5% level, .708 at 1% level.

Germination percentage at the first count (7 days) in the field and at an early count (4 days) for both laboratory methods is shown in Figure 1. These results indicate that the hydrogen peroxide method closely followed the early field emergence for all varieties; whereas, the standard method was generally lower than the other two methods.

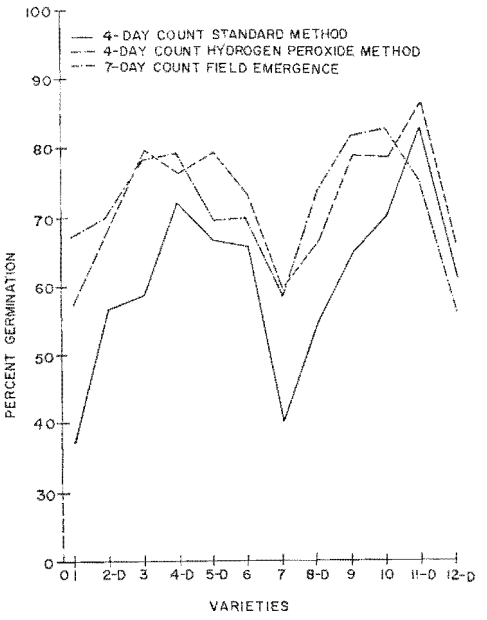

Figure 1.—Initial emergence of seedlings comparing the first count in the field and early laboratory counts of two methods.

Primary factors causing low laboratory germinations are shown on Table 3. Underdeveloped seeds ranged from 4.7 to 20.2% with a mean of 9.5%. The percentage of abnormal seedlings was consistently lower when using the hydrogen peroxide method than the standard method. Six varieties having natural (not decorticated) fruits had significantly higher abnormal seedlings at the 1% level when using the standard method. The mean of abnormal seedlings for all varieties using the hydrogen peroxide method was 4.9%. This was significantly lower at the 1% level than the mean of abnormal seedlings for the standard method which was 11.0%. The laboratory methods did not differ significantly in the number of firm ungerminated seeds at the final count except for variety 8-D. There was also no significant difference between the means of all varieties for firm ungerminated seeds when comparing the two laboratory methods.

Table 3.—Primary factors lowering the laboratory germination results for 12 varieties of sugarbeet seed.

Variety	Underdeveloped seeds[1]	Abnormal seedlings		Firm ungerminated[1] seeds	
		H_2O_2	Standard	H_2O_2	Standard
1	13.0	3.2	16.0**	6.5	4.5
2-D[2]	20.2	4.7	6.0	0.5	3.5
3	6.9	1.7	9.2**	2.0	1.0
4-D	8.5	2.7	6.0	3.0	3.7
5-D	6.9	3.0	5.0	4.0	5.5
6	7.4	4.0	10.5**	3.5	2.2
7	11.7	13.5	28.7**	5.5	6.7
8-D	9.0	6.0	9.7	2.7	8.0*
9	4.7	5.2	16.7**	2.0	4.5
10	5.7	7.0	12.5**	4.0	4.2
11-D	7.0	1.7	3.0	0.2	1.5
12-D	12.9	5.5	8.0	5.2	5.2
Mean	9.5	4.9	11.0**	3.2	4.2

[1] As determined by cutting test.
[2] D = indicates partial decortication of fruits.
* Significantly higher than H_2O_2 method at the 5% level.
** Significantly higher than H_2O_2 method at the 1% level.

Discussion

Contrary to previous speculation, field emergence results compared favorably to the laboratory results when using the hydrogen peroxide procedure. This hydrogen peroxide method was significantly associated with field emergence at the 1% level (Table 2) and did not differ significantly from field emergence results for any varieties examined. Early laboratory counts using the hydrogen peroxide method compare very favorably to the initial seedling emergence in the field (Figure 1). Also, those varieties which germinated poorly in the laboratory (1, 7 and 12-D) follow the same trend under field conditions. Therefore, the hydrogen

peroxide method should provide an accurate indication of germination potential for field planting purposes. Every effort was made in the field emergence study to have ideal soil and moisture conditions and positive identification of emerged seedlings. Due to these precautions, the field emergence results were higher than previously expected. Under other soil types and environmental conditions, field emergence of these varieties may be lower than reported in this study.

Laboratory results re-emphasized the complex problems involved when attempting to gain accurate estimates of germination potential for sugarbeet seed. Underdeveloped seeds, abnormal seedlings, firm ungerminated seeds and decortication of fruits are among the factors found to influence or lower the germination results (Table 3).

The Association of the Official Seed Analysts Rules for Seed Testing (1) recommend the standard method (a water soak or wash period) for germination of sugarbeet seed. In this study, the hydrogen peroxide method gave consistently higher laboratory germination results than the standard method (Table 1). Differences between the two laboratory methods were greatest at the initial counts (Figure 1). These differences decreased with time although four varieties were significantly lower at the final count when using the standard method (Table 1). The close correlation between the two methods (Table 2) indicates that the same germination response was measured although the hydrogen peroxide method was usually higher than the standard method.

The chemical action of the hydrogen peroxide on germination of sugarbeet seed was not determined in this study. Stimulation of germination by hydrogen peroxide in other kinds of seed was attributed by Ching (3) to increased respiratory rate. In this study, a stimulus was indicated by the faster germination at the early counts (Figure 1) and some radicle emergence from fruits during the 16-hour hydrogen peroxide soak period. This early emergence of the radicle can be detrimental, however, as additional caution must be taken to prevent radicle damage while planting.

Other researchers (2, 6) have reported the effects of seedborne pathogens on sugarbeet germination. These pathogens usually attack the young seedlings just at emergence from the seedball and cause abnormalities in laboratory tests. The primary reason for lower germinations with the standard method in this study were abnormal (diseased) seedlings. The principal pathogens causing the abnormalities were *Phoma betae* Frank and *Peni-*

cillium spp. The number of abnormal seedlings was consistently higher for the standard method (Table 3) than for the hydrogen peroxide method. This difference was significant for six of the 12 varieties examined. The hydrogen peroxide apparently surface-sterilized the fruits, thereby reducing abnormalities due to surface pathogens.

A decortication process is often used by sugarbeet companies to aid in sizing monogerm seed for precision planting. This mechanical process has also been used to increase germination (2). In these studies there was less variation between the laboratory methods for those varieties having partially decorticated fruits. One reason for this was that the number of abnormal seedlings occurring in decorticated varieties (Table 3) was much lower than varieties having natural fruits. There were no significant differences in number of abnormal seedlings between the laboratory methods for those varieties having decorticated seed. This confirms other results (2, 6), that the seedball maternal tissue is a primary carrier of seed-borne pathogens, and that if portions of this tissue are removed, the effect of pathogens on germination is reduced.

Underdeveloped seeds have been reported as a primary cause for low germination of Oregon-grown monogerm sugarbeet seed (14). Underdeveloped seeds found in these varieties ranged up to 20% (Table 3). These underdeveloped seeds have a direct effect on the germination of a seed lot whether planted in the field or laboratory. As a result germination potential for lots having underdeveloped seeds will always be something less than 100%.

Specific chemical analyses were not conducted to determine the amount and kind of chemical inhibitors present. A good indication of the presense of inhibitors is the number of firm ungerminated seeds at the final count (Table 3). Except for variety 8-D there was little difference in number of firm ungerminated seeds remaining between the hydrogen peroxide and standard methods. Mean percentages of firm ungerminated seeds for all varieties was 3.2% for the hydrogen peroxide method and 4.2% for the standard method. Hence, the role of inhibitors was of less concern than that of abnormal seedlings or underdeveloped seeds.

Summary and Conclusion

Field and laboratory investigations were conducted on the low germination of Oregon-grown monogerm sugarbeet seed. Two laboratory methods (hydrogen peroxide and standard) and field emergence were compared for 12 varieties.

The standard laboratory method, using a water soak, had a slower speed of germination and lower total germination than the hydrogen peroxide method. Differences were less pronounced between the two methods for those varieties having partially decorticated seed.

Field emergence results compared favorably with laboratory germination results when using the hydrogen peroxide method. Standard germination results followed the same trend as the field emergence but were consistently lower. The germination potential measured by the hydrogen peroxide method gave an accurate indication of field emergence.

Primary factors contributing to low laboratory germination were: 1) underdeveloped seed, 2) abnormal seedlings, and 3) firm ungerminated seeds. Underdeveloped seeds, including empty fruits or fruits having shrunken seeds, directly affected the germination potential. Abnormal seedlings were caused primarily by seed-borne pathogens and were highest in those varieties having natural seedballs. Abnormalities were higher when using the standard method than with the hydrogen peroxide method. The number of firm ungerminated seeds was small and the role of inhibitors was considered minor.

No single laboratory method gave an accurate measure of the total germination potential. The hydrogen peroxide method, however, provided an accurate estimate of germination potential, provided a cutting test was conducted after the final count of the germination test. The number of underdeveloped seeds and firm ungerminated seeds determined by the cutting test aided in determining the total germination potential of a seed lot.

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