Influence of the Seedball on Speed of Germination of Sugar Beet Seeds[1]

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Erratic germination of sugar-beet seeds is rather common. Some varieties and progenies germinate more rapidly than others (5, 6)[3]. Inhibitory substances present in the seedball have been shown to delay or inhibit germination (1, 4, 8). In contrast, the author has observed in certain progenies of sugar beets that the seedballs do not retard germination but actually stimulate germination and early growth of seedlings. The structure of the seedball might also be expected to influence speed of germination. This is a report of observations from experiments designed to evaluate the effect of some seedball characteristics on germination.

Methods and Materials

The germination tests were conducted in closed plastic boxes at room temperature. The piece of saran plastic screen in each box was supported on five pieces of glass tubing. Twenty or twenty-five seedballs were placed in each quarter of the box in contact with the surface of approximately 180 milliliters of water or nutrient solution (Figure 1). The molar composition of the nutrient solution was as follows: $CaCl_2$, 0.0255; $Ca(NO_3)_2.4H_2O$, 0.0040; KCl, 0.0445; KH_2PO_4, 0.0740; $MgSO_4.7H_2O$, 0.0240; Na_2SO_4, 0.0295. The osmotic pressure of this solution is 10.1 atmospheres. This method of germination is designated the liquid-contact method.

Results

It is easy to demonstrate that the physical structure of the seedball of many varieties of sugar beets delays germination. Whole seedballs germinate more slowly than notched seedballs, in which a small hole is made to expose the seedcoat of each true seed (Table 1 and Figure 2). Notching the seedball apparently accelerates water uptake and decreases the imbititional force required to pry loose the "seed cap" or lid covering the ovarian cavity of the seedball. Processing or removal of some of the corky substance of the seedball will also speed up germination.

Gemma (2) has attributed non-germination of *Beta patellaris* and *Beta procumbens* to the inability of the seed to push up the seed cap, even when it absorbs enough water to germinate.

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[3] Numbers in parentheses refer to literature cited.

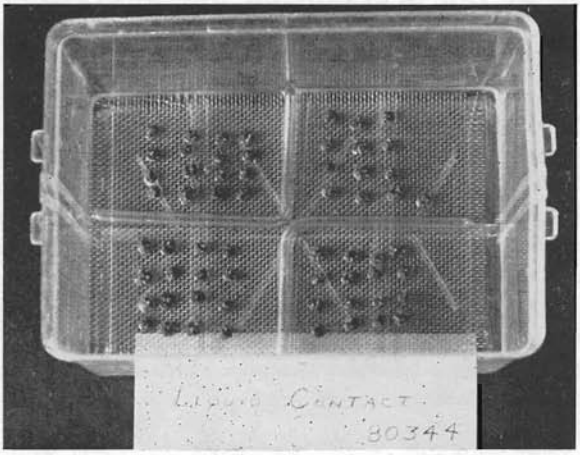

Figure 1.—View into plastic box showing general arrangement and size. Plastic box top removed. (Number of seedballs differs from experiments mentioned in text.)

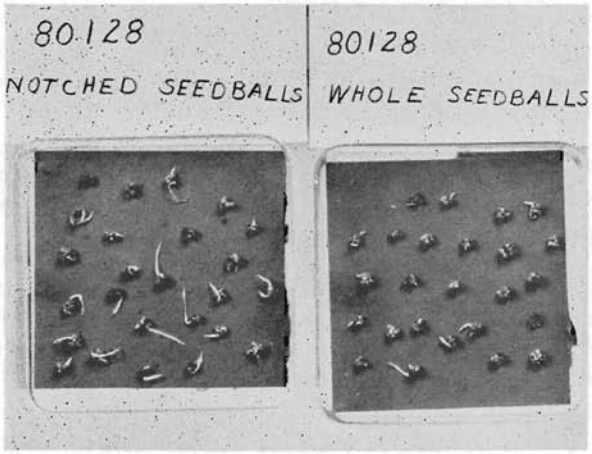

Figure 2.—Effect of notching the seedball into each true seed on the speed of germination.

Table 1.—Effect of Notching Sugar Beet Seedballs on Speed of Germination by the Liquid-Contact Method.

	Accumulated Percentage Germination by Days[1]			
	1	1.5	2	5
Whole Seedballs	0.0	2.0	12.5	62.1
Notched Seedballs	31.6	65.4	76.5	----

[1] Based on 800 seedballs.

The role of seed-cap tightness in the physical hindrance of the seedball to germination has not been evaluated in commercial varieties. Some qualitative data on seed-cap tightness are available. These data were obtained from seedballs that had been in contact with water or nutrient solution for at least seven days. The caps over ovarian cavities containing ungerminated seeds were pried loose and placed into categories of tightness according to the estimated force required to loosen them. The results for five varieties of sugar beets are presented in Table 2. These qualitative data clearly indicate varietal differences in the tightness of seed caps and permit an approximate classification of

Table 2.—Tightness of Seed Caps Over Ungerminated Sugar Beet Seeds in Contact with Water or Nutrient Solution for at Least Seven Days.

Variety	Approximate Germination 5th Day	Seed Caps Examined	Tightness of Seed Caps Over Ungerminated Seeds		
			Tight	Intermediate	Loose
	%	No.	%	%	%
SP 5377-0 Monogerm	3	238	94.5	1.7	3.8
US 400, Acc. 1329	44	252	77.4	10.3	12.3
US 400, Acc. 1329	34	329	55.3	24.6	20.1
Acc. 32 (Kohls)	15	112	33.0	49.1	17.9
US 401	60	153	41.2	26.1	32.7
SP 53B9-3	75	241	16.6	27.0	56.4

varieties on this basis. Data reported by the author (5) in a preliminary report on tightness of seed caps of variety US 400 were evaluated on a somewhat different basis and so are not strictly comparable, especially with respect to loose caps. The loose caps can be determined much more precisely than the tight or intermediate ones; therefore, emphasis should be directed toward this category. Relatively little is known about the influence of environmental factors on the tightness of seed caps. However, when cloned seed-bearing plants were grown at mean temperatures of 66° and 76° F. a greater proportion of the loose seed caps occurred on seedballs of plants grown at the higher temperature (7).

In variety US 400, the seed caps of a seedball may differ in relative tightness. Of 528 seedballs examined, 60 percent had all seed caps of the seedballs in a specific tightness category. The remaining 40 percent were in the mixed-tightness category, and nearly half of this mixed category contained both tight and loose seed caps on the same seedball.

Seeds of sugar beet have germinated more rapidly after periods of soaking followed by thorough drying prior to planting (3).

It is not known whether the improved germination results from (a) removal of inhibitory substances from the seedball, or (b) from loosening of the seed caps by the stresses induced by alternate wetting and drying. Soaking had no significant effect on loosening the seed caps covering ungerminated seeds of variety US 400. Soaking the seedballs of varieties US 400 and US 401 prior to germination by the liquid-contact method under osmotic stress did not alter the percentage of germination in any consistent manner in comparison with unsoaked seedballs. Coe[1] has observed that soaking of seedballs of different varieties prior to germination may be beneficial, may have no effect, or may even be detrimental to germination of seeds. It appears that soaking may be beneficial only when seedballs contain an abundance of inhibitory substances that must be diluted to a concentration that permits germination.

Three substances that may affect germination adversely have been isolated from the seedballs of sugar beets (1, 4, 8); however, only ammonia (8) and oxalic acid (4) have been identified as to their chemical nature. A qualitative test has indicated the presence of oxalic acid in the seedballs of variety US 400. Acidulation and calcium added to counteract the presence of ammonia and oxalic acid, respectively, failed to improve germination of US 400 in the liquid-contact method using nutrient solution of 10.1-atmosphere osmotic pressure.

In studies employing bulk seedlots of a given variety, whole seedballs almost without exception germinated more slowly than "naked seeds" (the true seeds freed of all maternal tissues exterior to the seedcoats) obtained from the same seedlot. When seed of variety US 401, harvested by individual plants, was compared for speed of germination, whole seedballs from a few plants actually germinated more rapidly than the "naked seeds" from seedballs of the same plants. Following classification of seedlots from 182 individual plants of US 401 for speed of germination, six of the most rapidly germinating lots were used in more detailed studies. The seeds were germinated by the liquid-contact method. The effect of the seedball on germination and growth is shown in Table 3. In these six progenies the seedball failed to retard germination, and in two progenies (50232, 50246) it actually hastened germination. Furthermore, the presence of the seedball stimulated the early growth of the seedlings.

Although seedballs of progeny number 50098 did not hasten germination markedly, it was the only progeny of these six rapid germinators with an adequate supply of seed available for further experimentation. Because of fungal contamination, experiments in which naked seeds were placed in the same

[1] Unpublished data.

Table 3.—Effect of the Seedball on Germination and Growth of Selections of Sugar Beet Variety US 401 by the Liquid-Contact Method.

Progeny Number	Percentage Germination by Hours				Fresh Weight of 50 Seedlings in 6 Days	
	24	48	72	96	Gms.	Ratio (Whole/Naked)
50086:						
Whole seedballs	14	88	89	89	1.92	2.04
Naked seeds	36	77	89	94	0.94	
50098:						
Whole seedballs	26	91	96	96	1.70	1.98
Naked seeds	25	54	69	76	0.86	
50141:						
Whole seedballs	27	92	95	96	2.60	1.82
Naked seeds	49	94	98	98	1.43	
50195:						
Whole seedballs	12	78	82	87	1.95	1.65
Naked seeds	32	74	85	89	1.18	
50232:						
Whole seedballs	83	96	98	100	1.75	1.73
Naked seeds	46	77	88	92	1.01	
50246:						
Whole seedballs	62	89	93	96	2.12	2.26
Naked seeds	21	76	78	87	0.94	

Data for each progeny are based on 100 seedballs or naked seeds except for the whole seedballs of 50232 for which only 80 were used.

plastic box with either whole seedballs or the broken portions of seedballs have been unsatisfactory. In the liquid-contact method of germination, seedlings no longer in direct contact with the seedballs developed as rapidly as those still in contact with the seedballs. On the basis of this observation, the effect of a water extract of the seedballs on germination was investigated. The extract was prepared as follows: 1.75 grams of air-dried broken portions of seedballs (maternal tissues exterior to seed coats) of progeny 50098 were soaked in 20 milliliters of distilled water for 18 hours in a refrigerator. This mixture was then kept for two hours at room temperature with occasional gentle shaking. After 20 hours of contact, approximately 15 milliliters of the extract was decanted. This extract was then placed in the freezing compartment of a refrigerator and partially frozen. About six milliliters of this concentrated extract was poured off. Five milliliters of extract was added to 200 milliliters of the nutrient solution of 10.1-atmosphere osmotic pressure. If one assumes that the extract contained no solutes, by dilution, it would lower the osmotic pressure of the nutrient solution

less than half an atmosphere. This reduction in osmotic pressure could not account for the marked increase in fresh weight observed (Table 4). The presence of the extract increased the fresh weight of the seedlings 21.7 percent, but failed to speed up germination significantly. Further experimentation is planned.

Table 4.—Effect of an Extract from Seedballs of a Selected Sugar Beet Plant of Variety US 401 on Germination and Seedling Growth by the Liquid-Contact Method.

Treatment	Percentage Germination[1] by Hours			Fresh Weight of 50 Seedlings in 6 Days
	24	48	72	
				Grams
Whole seedballs in nutrient solution	13	92	95	1.77
Naked seeds in nutrient solution	43	86	94	1.06
Naked seeds in nutrient solution plus extract from seedballs	65	93	97	1.29

[1] 100 seedballs or naked seeds per treatment.

Discussion

If the endosperm has developed normally and the embryo is viable, then the speed of germination of the sugar-beet seed is controlled largely by physical and chemical factors in the maternal tissues (seedball) surrounding the true seeds (6). Although the physical structure of the seedball generally retards germination, presumably by impeding water uptake, some exceptions have been observed (Table 3). The tightness of seed caps and thickness of the inner layers of the maternal tissues surrounding the seed vary sufficiently among varieties to suggest heritable differences.

Where the seed itself does not possess any form of dormancy, as in the commercial sugar beet varieties, the speed of germination may be related to the rate at which water is imbibed by the seed. The tighter the seed cap the greater the delay in germination. However, because of the presence of inhibitory substances in the seedball, it is extremely difficult to evaluate separately the contribution of the physical and chemical factors to the delay in germination. Although little experimental evidence is currently available, environmental factors operating during maturation of the seedball also apparently influence the physical characters of the seedball which affect the speed of germination. The data in Table 2 suggest that even after five days in favorable conditions for germination the tightness of the seed cap may affect the percentage of germination, especially in the monogerm variety SP 5377-0.

Inhibitory substances in the seedball probably play the major role in the retarded germination observed in the sugar beet (1, 3, 4, 6, 8). Results from the present study indicate, perhaps for the first time, that the seedball of certain progenies may be nearly free of inhibitory substances. In some of these same progenies, the data (Tables 3 and 4) also indicate the presence of some substance which appears to stimulate germination and early seedling growth. In the investigation of an inhibitory substance isolated from a water extract of the seedballs of sugar beets, DeKock, et al. (1) reported that cress seeds were inhibited by a water extract of this substance. If, however, the seeds so treated were washed and set out for germination, they reported that the rate at which the seeds germinated was remarkably rapid and the hypocotyls were much stouter than those of the unwashed controls. From this observation they conclude that some phase of the growth process is being retarded whereas other phases may proceed normally or be stimulated. They did not indicate whether one or more substances may be involved. All evidence from the present investigation indicates that the inhibitory substance or substances differ from the stimulatory substance.

Since the nutrient solution employed in the present study contains a copious supply of calcium and is moderately acidic even after a period of contact with the seedballs, the soluble oxalic acid would be precipitated as calcium oxalate and the ammonia would be tied up as an ammonium salt. Thus, these two inhibitory substances probably have little effect on germination of seedballs in contact with this nutrient solution.

Speed of germination seems to be a heritable trait (6). The pattern of performance in variety US 401 suggests that a genetic mechanism is controlling the amount of these chemical substances in the seedball. At present, no information is available on the modifying influence of environmental factors on these chemical substances.

Through the technique of progeny selection, it is hoped that genetically stable progenies, that will permit identification of the chemical factors involved, can be obtained. Perhaps specific chemical tests could then be utilized to locate the desirable attributes in various progenies. By proper selection, we hope to discard the detrimental seed characters which delay germination.

Summary

Experiments were designed to evaluate some of the effects of the physical and chemical factors of the seedball of the sugar beet on the speed of germination. The liquid-contact method of germination was used.

1. The maternal tissues of the seedball usually hinder germination, since seedballs notched to expose a portion of each true seed germinate more rapidly than whole seedballs of the same variety.

2. Varieties differ in the degree of tightness of the seed cap over the true seed.

3. Soaking of sugar beet seeds in water prior to germination may reduce the percentage of germination, particularly when the seeds are germinated by the liquid-contact method under osmotic stress.

4. Seedballs from some plants of sugar beet variety US 401 apparently contain so little chemical inhibitors that germination is not delayed.

5. Whole seedballs from two plants of US 401 germinated more rapidly than naked seeds obtained from the same seedlots, indicating a stimulating effect of the seedball. The growth of the seedlings also was stimulated by the seedballs.

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