Chemical Loosening of Seed Caps in Relation to Germination of Sugar Beet Seed

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The object of these studies was to find an efficient chemical method for loosening the caps of the sugar beet seedball and in that way hasten and increase seed germination.

The seed caps loosen along a definite line of cleavage, making a clean, smooth break. Figure 1-A shows a seed cap in place before germination of seed with remnants of stigmatic lobes and 1-B underside of a seed cap that shows a definite abscession layer where it joins the seed ball.

There are two materials in plant tissue that can act as cementing substances. These are pectic substances and hemicelluloses. Pectic substances occur in unlignified cell walls in the middle lamella and in the cellulose containing lamellae. They are abundant in apples and citrus fruits and in certain fleshy roots, as carrot and turnip. They are dissolved by some acids but not by alkalies. These pectic substances are readily stained red by use of the ruthenium red method. The hemicelluloses are of two kinds: (1) skeleton hemicelluloses which occur chiefly in woody cell walls and in seed coats, (2) storage or reserve hemicelluloses found mostly in the cell walls of endosperm and very young bast fibers. They are dissolved by weak NaOH or dilute mineral acids such as HCl or H_2SO_4, but not organic acids such as acetic acid. They are not stained by the ruthenium red method.

Sugar beet seedballs in different stages of development were sectioned and given the Maule test which is specific for lignin. These tests revealed that there is a progressive lignification of the seed coat, inner walls of the seed locule, and several cell layers of the seed cap and surrounding walls of the seedball locules.

Seed were treated with 4-percent NaOH for 2 to 24 hours. The seed caps were loosened to such an extent by this treatment that they could be shaken loose from the seedball. This indicated that some form of hemicellulose was the cementing substance. Treatments with 10-percent trisodium phosphate, 3-percent HCl and 3-percent H_2SO_4 showed loosening of caps and increased germination. Glacial acetic acid had no effect on the seed caps. Sodium hypochlorite in 1-to-4 dilution of the commercial 5.25-percent solution loosened caps a little but depressed germination, as did the 4-percent NaOH. The two dilute acids, 3-percent HCl and 3-percent H_2SO_4, loosened caps but not as much so as 4-percent NaOH. However, these acids increased and hastened seed germination.

It was observed how readily the seed cap loosens when a beet seed within starts to germinate. It was thought that possibly the process of

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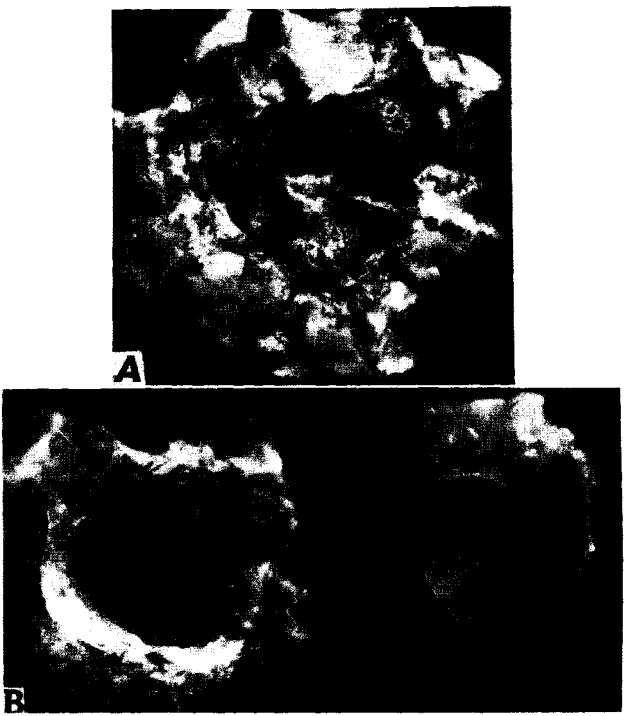

Figure 1.—Showing upper and under side of sugar beet seed cap and seedball. A. Seed cap on seedball before germination with remnants of stigmatic lobes visible in center of cap; B. Early stage germination showing seed with radicle having lifted edge of cap, and cap removed to show under side with its smooth edge where it separated from seedball by means of a clean-cut abscission layer.

germination might release some compound or enzyme which dissolves the hemicelluloses and loosens the seed caps. Therefore, to test the effect of the chemical treatments alone it was necessary to kill the seed. This was done by soaking the seed in 95-percent alcohol for 48 hours and also by treating seed 5 hours at 100° C. After this treatment some of the seed were soaked in 4-percent NaOH and 3-percent HCl and the check lots in distilled water. The caps of the seed treated with NaOH and HCl were loosened but the checks in distilled water remained unaffected.

Germination tests were made with seed treated with each chemical which did not depress germination. The results of these tests by the blotter method with 3 percent HCl, 3 percent H_2SO_4, and 10 percent trisodium phosphate are shown in table 1. The HCl and H_2SO_4 treatments gave practically the same average germination, 93.6 percent for HCl, 94.2 percent for H_2SO_4, as compared with 84.6 percent for the distilled water checks, increases of more than 10 percent. The 10-percent trisodium phosphate gave 92.8 percent germination for a ¼-hour treatment, as compared with 87.9 percent for distilled water checks.

Table 2 shows the results of treating a lot of exceptionally hard and some ordinary or relatively soft sugar beet seed with 3-percent HCl for 2 hours with checks in distilled water. This treatment gave an increase of germination of 11.6 percent over the checks with the hard seed which were slower and more difficult to germinate than the soft seed. The softer seed showed an increase of only 5.5 percent as a result of the HCl treatment. Some lots of both kinds of seed treated with HCl were dried for 2 to 4 days before testing. These gave as good germination as those that were tested while wet.

Table 1.—Effects of seed treatments on the germination of sugar beet seed, washed for 2 hours after treatment. Readings made after 96 hours. Each test represents the average of four 100-seed replications.

	TREATMENTS				
	3% HCl 2 hours Pct.	3% H_2SO_4 2 hours Pct.	(Checks) Distilled water, 2 hours Pct.	10% Trisodium Phosphate, ¼ hr. Pct.	(Checks) Distilled water Pct.
	96.9	95.2	84.3	93.9	82.5
	95.6	93.6	93.8	90.4	87.7
	91.9	93.5	76.1	94.1	93.2
	94.7	93.3	86.4	94.9	85.5
	92.1	94.9	83.9	88.1	93.3
	95.6	96.2	81.4	94.4	89.5
	92.1	93.9	83.9	93.3	88.0
	90.3	96.2	86.1	92.1	84.3
	93.3	97.5	85.6	93.7	87.4
Average	93.6	94.2	84.6	92.8	87.9

Table 2.—Effects on germination of treating hard and soft sugar beet seed with 3-percent HCl for 2 hours and washing 2 hours in running water, compared with checks treated with distilled water 4 hours the same way. Each figure represents the results with 100 seed.

	HARD SEED		SOFT SEED	
Test No.	Germination with 3% HCl Pct.	Germination Distilled water checks Pct.	Germination with 3% HCl Pct.	Germination Distilled water checks Pct.
1	96	89	95	90
2	92	88	96	92
3	92	74	94	87
4	83	73	96	91
5	96	86	96	89
6	85	74	97	92
7	94	85	96	92
8	92	88	95	91
9	88	78	96	88
10	94	85	93	89
11	81	72	--	--
12	90	82	--	--
Averages	90.4	81.0	95.4	90.4

The 3-percent HCl treatment hastened germination in soil also. Tests were made with the hard seed treated as in table 2 except the seed were planted in soil flats in alternate rows. In 16 replications the HCl-treated seed showed an increased germination of 8.9 percent and 25 to 30-percent faster emergence 7 to 10 days after planting than the checks. Thus, the soil tests which gave 8.9 percent increase in germination showed a fairly close correlation with the blotter tests which showed an increase in germination of 11.6 percent.

Summary

Microchemical and other chemical tests indicated hemicellulose is the cementing substance holding seed caps in place on sugar beet seedballs.

The cementing substance was dissolved and the seed caps were loosened when sugar beet seed were treated with 4-percent sodium hydroxide for 2 to 24 hours. Commercial sodium hypochlorite, 5.25-percent strength, in a 1-to-4 dilution, also loosened seed caps somewhat. Both these alkaline solutions depressed germination.

A 10-percent solution of trisodium phosphate in a ¼-hour treatment loosened caps and gave 92.8-percent germination as compared with 87.9 percent in the checks treated with distilled water.

Treatments with 3-percent hydrochloric and 3-percent sulphuric acids hastened the rate and increased the percentage germination of sugar beet seed, as an average, more than 10 percent over checks treated with distilled water.

One lot of exceptionally hard beet seed and some ordinary, relatively soft sugar beet seed were treated with 3-percent HCl for 2 hours. This treatment gave an increase in germination of 11.6 percent for the hard seed and 5.5 percent increase for the soft seed over the checks. Some of the hard seed were treated with 3-percent HCl for 2 hours, washed 2 hours and planted in soil in flats. In 16 replications germination was increased 8.9 percent and emergence of seedlings hastened 25 to 30 percent as compared with distilled-water checks in 7 to 10 days after planting.

Some lots of seed treated with 3-percent HCl were dried 2 to 4 days before testing and showed as good germination as the lots tested wet.