Maturity Effects on Fruit Characteristics, Germination, and Emergence of Sugarbeet[1]

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The role of maturity in germination performance of sugarbeet seed is beginning to be evaluated. Harvesting seeds before maturity may lower the germination (1, 3)[3]. However, at any given number of days after first bloom, cultivars may differ appreciably in germination percentages. Germination also varies inversely with fruit moisture at harvest (1). The quantity of water required for maximum germination and emergence of sugarbeet seeds has been defined under certain conditions (2). When water is available in excess of that required for germination, sensitive seedlots may have markedly lower germination than do the less sensitive ones. Since a highly sensitive seedlot will absorb more water and germinate less than will a less sensitive one, the sensitivity appears to be related to the ability to control the rate and quantity of water absorbed by the fruit during germination (2).

The effect of degrees of immaturity on fruit characteristics, germination, and emergence needs to be established for single plants and for cultivars. The objectives of this study were: 1) Determine the effect of degrees of immaturity on a) water absorption by sugarbeet fruits, b) loss of fruit weight by soaking, c) loss of fruit weight by hand processing (rubbing fruits to remove all corky material), d) germination, and e) emergence; 2) relate water absorption by the dried fruit to fruit moisture at harvest; and 3) determine the effect of fruit treatment on germination.

Methods and Materials

Experiment I: Immature fruits of three plants of monogerm sugarbeet cultivar (SL129×133)ms × SP5822-0, grown near Salem, Oregon, were hand-harvested 18 days before commercial maturity. Fruits of two plants were harvested 3 days before commercial maturity and designated as mature. Water absorption for 75 samples (20 fruits per sample) was compared in all combinations of untreated, hand-processed, and soaked fruits. Soaked samples were immersed for 2 hours (h) in 20 ml of either distilled water or 0.1% hydrogen peroxide

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[3]Numbers in parentheses refer to literature cited.

and then air-dried to equilibrium. All samples were weighed and placed on uniformly moistened double blotters in a germinator. After 48 h, the samples were removed and rapidly weighed. Percentages were calculated as follows:

$$\% \text{ water absorption} = \frac{\text{Wet wt} - \text{Air-dry wt}}{\text{Air-dry wt}} \times 100$$

Experiment 2: Sugarbeet mother roots of five monogerm cultivars were harvested at East Lansing, Michigan in November 1970. They were stored at about 4°C until they were planted in soil (25.4-cm pots) in the greenhouse in January 1971 for seed production. Fruiting branches from 11 plants were harvested at 40, 50, 60, and 70 days after first bloom and from 10 plants at 40, 45, 50, 55, 60, 65, 70, and 75 days. Fresh weights of the whole fruits were obtained at each harvest to determine moisture content. The fruits were air-dried in the laboratory.

Part 1: Fruits from 11 plants were separated by plant and by the four times of harvest ($11 \times 4 = 44$ lots). Fruits from each lot were divided into six samples of 40 fruits each (five samples had lesser numbers). Two samples were untreated; two were soaked in 50 ml tap water for 2 h, quickly rinsed, and air-dried to equilibrium; two were hand-processed to remove the cork. Each sample was weighed and placed on a double layer of moistened blotters in an uncovered Petri dish in a germinator at about 21°C for 40 h. Water was added twice during the 40-h period to replenish that lost by evaporation and absorption by the fruits. After the absorption period, samples were weighed and then returned to the germinator for 10-day germination data. Water absorption was calculated as in Experiment 1. Percentage weight losses in water-soluble substances and in removal of corky material were calculated by weighing the fruit samples before soaking and processing and again at air-dried equilibrium after treatment.

Part 2: Fruits from 10 plants (five cultivars), separated by plant and by time of harvest, were hand-processed. For each plant and each time of harvest, 80 fruits were used for blotter germination and 96 for sand emergence. The fruits were planted in plastic boxes at a depth of 3.8 cm in fine quartz sand at 4% moisture. After 12 days at about 70°F, all of the fruits were accounted for by categories, i.e., seedlings emerged, germinated in sand but not emerged, not germinated, and judged to be nonviable. All germination and emergence percentages were calculated on the basis of the number of viable seeds.

Results

Water absorption by fruits

Experiment 1: Immature fruits of this cultivar absorbed much more water than mature fruits (Table 1). Neither plant source nor fruit size significantly affected water absorption for a given maturity. Soaking and processing fruits substantially decreased the quantity of absorbed water, particularly in immature fruits.

Table 1.—Effect of maturity, processing, and soaking on water absorption by air-dried sugarbeet fruits in 48 h.

Fruit	Fruit age	% increase in weight[a]		
		No soak	H_2O_2 soak	H_2O soak
Whole	Immature	160.6	89.3	80.4
	Mature	81.0	56.3	54.4
Processed	Immature	102.6	72.7	75.3
	Mature	49.6	42.4	43.6

[a]Air-dry basis.

Experiment 2, Part 1: As sugarbeet fruits matured, they usually absorbed progressively less water (Fig. 1). Water absorption after the soaking treatment did not follow this pattern consistently. Two cultivars (five plants) averaged 115% water absorbed at 40 days after first bloom and increased to 138% absorbed at 60 days. The soak treatment increased the quantity of water absorbed by fruits in 14% of the samples by at least 10% over that absorbed by untreated fruits. Thus for some cultivars, the soak treatment appears to induce changes in the fruits at specific stages of maturity that enhance rather than suppress water absorption.

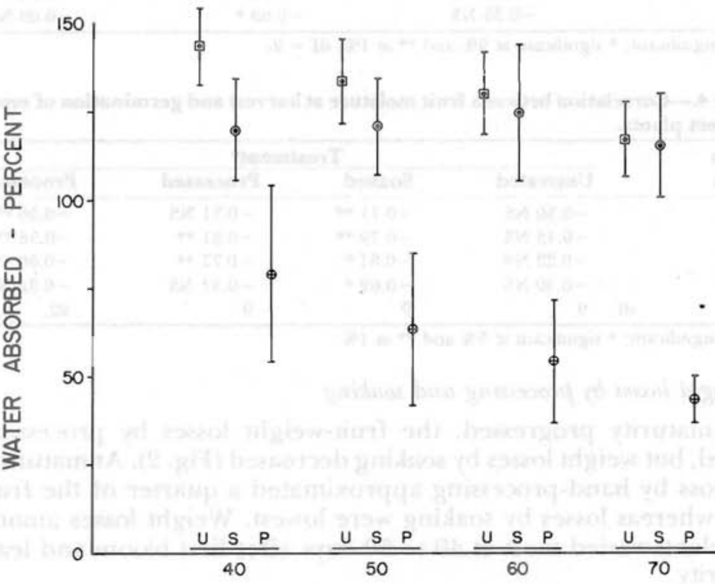

Figure 1.—Effect of maturity and treatments (U—untreated, S—soaked, P—processed) on water absorption by air-dried sugarbeet fruits (air dry basis). Means and standard deviations for 11 plants.

Water absorption by the processed fruits of the 11 plants was correlated with fruit moisture at harvest ($r = 0.74^{**}$ to 0.91^{**}) (Table 2). Germination percentages correlated inversely with water absorption, and significantly for processed fruits at 40, 50, and 60 days after first bloom (Table 3). Germination also correlated inversely with fruit moisture at harvest (Table 4).

Table 2.—Correlation coefficients between fruit moisture at harvest versus subsequent water absorption by air-dried sugarbeet fruits from 11 plants.

Days from 1st bloom	Treatment[a] Untreated	Soaked	Processed
40	0.07 NS	0.13 NS	0.91 **
50	0.63 *	0.17 NS	0.87 **
60	0.83 **	0.90 **	0.88 **
70	0.76 **	0.75 **	0.74 **

[a]NS = not significant; * significant at 5% and ** at 1%; df = 9.

Table 3.—Correlation between water absorption by air-dried sugarbeet fruits and germination of the seeds from 11 plants.

Days from 1st bloom	Treatment[a] Untreated	Soaked	Processed
40	−0.57 NS	−0.04 NS	−0.66 *
50	−0.60 *	−0.27 NS	−0.75 **
60	−0.35 NS	−0.62 *	−0.84 **
70	−0.33 NS	−0.60 *	−0.09 NS

[a]NS = not significant; * significant at 5% and ** at 1%; df = 9.

Table 4.—Correlation between fruit moisture at harvest and germination of seeds of sugarbeet plants.

Days from 1st bloom	Treatment[a] Untreated	Soaked	Processed	Processed
40	−0.30 NS	−0.71 **	−0.51 NS	−0.56 **
50	−0.43 NS	−0.79 **	−0.81 **	−0.58 **
60	−0.22 NS	−0.61 *	−0.77 **	−0.66 **
70	−0.40 NS	−0.62 *	−0.37 NS	−0.32 NS
df	9	9	9	22

[a]NS = not significant; * significant at 5% and ** at 1%.

Fruit-weight losses by processing and soaking

As maturity progressed, the fruit-weight losses by processing increased, but weight losses by soaking decreased (Fig. 2). At maturity, weight loss by hand-processing approximated a quarter of the fruit weight, whereas losses by soaking were lowest. Weight losses among the 11 plants varied most at 40 to 50 days after first bloom and least at maturity.

For the 40-, 50-, and 60-day harvests, losses in weight by soaking correlated significantly with fruit moisture ($r = 0.79^{**}$ to 0.87^{**}), but losses in weight by processing correlated with fruit moisture only for the 40- and 50-day harvests ($r = -0.94^{**}$ and -0.80^{**}, respectively).

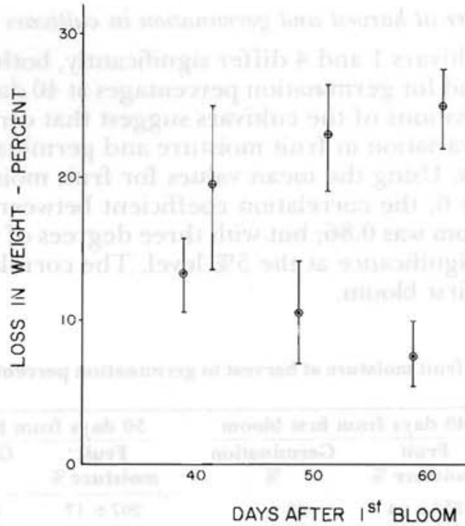

Figure 2.—Relation of weight loss in processing and soaking to time of harvest of sugarbeet fruits. ⊕Process, ◉Soak treatments. For the consecutive harvests, mean fruit moisture percentages were 206±35, 144±58, 75±58, and 37±27.

Germination response by time of harvest

The germination percentages for the five cultivars (Table 5) indicate that at full maturity it is very difficult to select the cultivars with the most desirable germination. If we examine the data under columns "P" in Table 5, four of five cultivars germinated in excess of 90% when harvested at 60 days after first bloom, but at 50 days only three, and at 40 days only one.

Table 5.—Relation of germination percentage to time of harvest and treatment of sugarbeet fruits.

Cultivar	No. of plants	Treat.[@]	40 U	40 S	40 P	50 U	50 S	50 P	60 U	60 S	60 P	70 U	70 S	70 P
			No. days from first bloom											
1	2		47	42	46	57	68	72	80	87	84	78	90	95
2	3		92	94	87	93	96	97	92	97	99	97	98	100
3	1		100	100	96	97	99	97	100	100	100	100	100	100
4	2		72	94	83	69	95	93	86	99	96	86	99	97
5	3		57	79	60	80	89	82	84	95	92	93	96	99

[@]U is untreated; S is soaked, see text; P is processed.

Germination response to fruit treatment

Cultivars differed in germination patterns and in their response to the fruit treatments. These differences were more striking with progressively greater immaturity (Table 5). Individuals within a cultivar tended to follow a pattern for a given set of treatments; thus data could be averaged to indicate cultivar performance.

Relation of fruit moisture at harvest and germination in cultivars

The means of cultivars 1 and 4 differ significantly, both for fruit moisture at harvest and for germination percentages at 40 days (Table 6). The standard deviations of the cultivars suggest that certain ones may have much less variation in fruit moisture and germination performance than others. Using the mean values for fruit moisture and germination in Table 6, the correlation coefficient between these at 40 days after first bloom was 0.86; but with three degrees of freedom, 0.88 is required for significance at the 5% level. The correlation was less at 50 days after first bloom.

Table 6.—Relation of fruit moisture at harvest to germination percentage for five cultivars of sugarbeet.

		40 days from first bloom		50 days from first bloom	
Cultivar	No. of plants	Fruit moisture %	Germination %	Fruit moisture %	Germination %
1	4	254 ± 4	43 ± 6	207 ± 17	80 ± 13
2	6	218 ± 15	79 ± 11	139 ± 23	97.5 ± 2.6
3	3	205 ± 15	87 ± 14	139 ± 35	97 ± 2
4	4	167 ± 22	87 ± 7	82 ± 4	95 ± 3
5	7	214 ± 15	71 ± 18	140 ± 59	91 ± 12

Relation of blotter germination to sand emergence on given days after first bloom

On the basis of the germination data, seeds of these plants had attained physiological maturity 40 to 55 days after first bloom (Fig. 3). However, on the basis of sand-emergence data, complete physiological maturity was not attained for an additional 5 to 15 days.

The sand-emergence test revealed that certain seedlots emerged rather poorly and that emergence was poor in fully matured seed (Fig. 3). Seeds of two plants emerged only 70%, regardless of when they were harvested after first bloom.

Discussion

The correlation studies indicate that the amount of water absorbed by sugarbeet fruits is closely related to fruit moisture at harvest and the degree of maturity, and these, in turn, influence germination. Also, processed fruits apparently have more predictable relationships between fruit moisture at harvest, subsequent water absorption, and seed germination than either untreated or soaked fruits. Since growers plant unsoaked, processed seeds in the field, seeds treated similarly should provide more reliable estimates of germination potential, as well as eliminate the time-consuming soaking procedure.

The evidence seems clear that at full maturity, sugarbeet fruits and seeds (for cultivars or individual plants) differ much less in a given characteristic than at the more immature stages. Thus, further studies

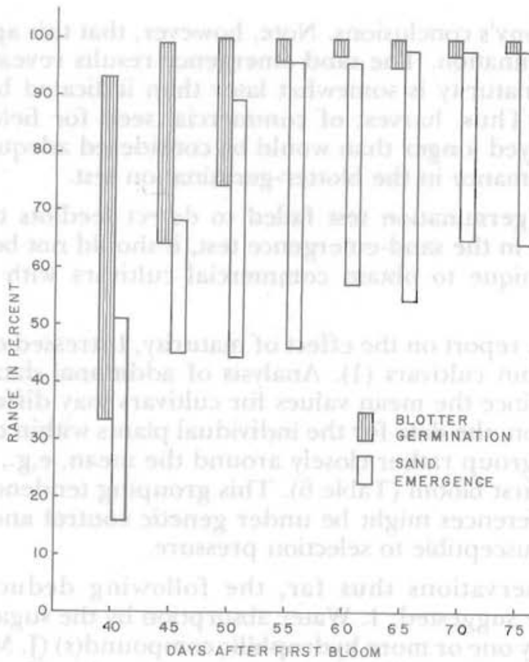

Figure 3.—Effect of maturity on germination and emergence of seedlings from 10 sugarbeet plants. At full maturity, a sizable range occurs in percentage of emergence, but not in percentage germination.

to determine the significant fruit and seed characteristics that influence germination performance should be made on immature fruits and seeds, probably around 40 days after first bloom. As presently conceived, any system of testing for and isolating superior germination performance would require the following: 1. Date of first bloom for each plant, 2. determination of time interval between first bloom and the seed's physiological maturity, and 3. fruit moisture at harvest coinciding with physiological maturity. Although a single, fixed time of harvest would minimize the time required to harvest and the number of samples for germination, two harvests at about a 10-day interval would probably be better to isolate the superior plants.

The time interval between first bloom and harvest is required as a reference for fruit moisture, because the mean fruit moisture of different cultivars may vary markedly at a given interval after first bloom (Table 6), as well as when the seed first become physiologically mature (1). Data (Table 6) suggest that early loss of fruit moisture in healthy plants may be related to early seed maturity.

TeKrony (3) reported that individual flowers produced seeds that germinated 20 days after anthesis, and that all seed in the field was physiologically mature about 45 days after peak anthesis. Peak anthesis would occur 10 to 15 days after first bloom; thus these results generally confirm TeKrony's conclusions. Note, however, that this applies only to blotter germination. The sand-emergence results reveal that true physiological maturity is somewhat later than indicated by the germination test. Thus, harvest of commercial seed for field planting should be delayed longer than would be considered adequate on the basis of performance in the blotter-germination test.

Since the germination test failed to detect seedlots that would emerge poorly in the sand-emergence test, it should not be used as a selection technique to obtain commercial cultivars with improved emergence.

In my first report on the effect of maturity, I stressed diversity of the plants within cultivars (1). Analysis of additional data confirms the diversity, since the mean values for cultivars may differ appreciably. In addition, the data for the individual plants within certain cultivars tend to group rather closely around the mean, e.g., cultivar 1, 40 days after first bloom (Table 6). This grouping tendency suggests that these differences might be under genetic control and, if this is true, may be susceptible to selection pressure.

From observations thus far, the following deductions and hypotheses are suggested: 1. Water absorption by the sugarbeet fruit is influenced by one or more hydrophilic compound(s) (J. M. Sebeson, Sr., now deceased, unpublished data). 2. Based on the effect of processing on water absorption (Fig. 1), much of the compound(s) is in the corky material. 3. Since water absorption generally decreases as maturity approaches and is least when fruits are completely air-dried while attached to the plant, the quantity of the active compound(s) should decrease in a similar manner. 4. As maturity progresses in fruits attached to the plant, at least some of the compound(s) must be altered to a non-hydrophilic entity. 5. Soaking fruits of certain plants (Experiment 2) decreased the effect of the hydrophilic compound(s), while in others soaking enhanced the effect; thus a number of modes of action may occur, such as diffusion of the compound(s) from the fruit into the water, and possibly hydrolysis to either more or less active entities. The complexity of the effects is apparent.

Summary

Dried immature sugarbeet fruits grown in Oregon absorbed significantly more water than mature fruits.

Sugarbeet fruits from 21 plants (five cultivars) grown in the greenhouse were harvested periodically, beginning 40 days after first bloom, and air-dried in the laboratory. Untreated and hand-processed fruits harvested at 40 days absorbed significantly more water than fruits harvested at 70 days, but fruits that had received a 2-h soak in water and were re-dried were less responsive and more inconsistent. A hydrophilic compound(s) in the fruit is postulated as the causal agent.

Weight losses by processing were inversely related, and losses by soaking were directly related, to fruit moisture at harvest.

Germination responses at full maturity were very similar for all five cultivars, but with progressively greater immaturity, they differed markedly. Germination responses to fruit treatment differed among cultivars, particularly for the 40-day harvest, but at full maturity, treatments had minimal effect.

Fruit moisture at harvest and subsequent water absorption correlated significantly for processed fruits on all four dates. Fruit moisture at harvest correlated negatively with germination, and significantly for some times of harvests and treatments.

The sand-emergence test evaluated seed performance more critically than did the blotter-germination test. The blotter test failed to indicate seedlots that would emerge poorly from sand, and it was less accurate in determining when the seed was truly physiologically mature.

Acknowledgments

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