Relation of Sugarbeet Seedling Emergence to Fruit Size[1]

F. W. SNYDER[2] AND CHRISTINA FILBAN[2,3]

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In the Great Lakes area, industry personnel have observed that a higher percentage of sugarbeet seedlings emerge from plantings of large monogerm fruits than from small ones. The implications of these observations suggested the studies reported.

Previous research (1,2,3,4)[4] has shown that fruit- and seed-size are correlated. Fruit diameter of a monogerm variety was correlated (0.68**) with seed diameter (1). For a given monogerm seedlot, usually a greater percentage of the seeds in the larger-sized fruits germinate than those in smaller-sized fruits. Thus, under field conditions, when the same number of "seeds" are planted per unit length of row, fewer seedlings emerge from the smaller-sized fruits solely on this basis. However, this alone could not account for the large differences in field emergence usually observed.

The positive correlation between fruit and seed size suggests that seedlings developed from seeds in the larger fruits may be larger than those from the smaller fruits. Also, the quantity of reserve starch may be greater in larger fruits. Seedlings from the larger fruits may exert a greater force during the emergence process. Since the hypocotyl is involved in seedling emergence, hypocotyl size may influence emergence.

When seedlings from large and small fruits of sugarbeet were compared, those from the larger fruits had larger diameters of hypocotyls and a greater percentage of emergence from sand and soil, particularly as the seeds were planted deeper. Depth of planting in sand also affected hypocotyl size.

Methods and Materials

Monogerm fruits (single cavity with one viable seed) of a given variety were sized into two or three categories. When whole fruits were used, they were sized and then hand processed. For many of the experiments, commercially processed and sized fruits were used. Size categories were in inches/64. A 6½-7½ size-class indicated that all the fruits fell through a 7½ round-hole screen

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[2] Plant Physiologist, and Laboratory Technician, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, East Lansing, Michigan 48823.

[3] Now Christina Filban Andre, Technician, Department of Chemistry, Colorado State University, Fort Collins, Colorado 80521.

[4] Numbers in parentheses refer to literature cited.

but remained on a 6½ round-hole screen. For the designation "On 12", all the fruits remained on a 12 round-hole screen.

Hypocotyl size

In the initial experiments, two sizes of fruits were placed on blotters in the germinator. Approximately 10-day old seedlings which had hypocotyl lengths over 1½ cm, were selected and a 1-cm segment of the hypocotyl was removed by means of a guillotine. The segments were kept on moist paper until they were weighed and counted. The average weight per segment was calculated for each fruit-size class.

In later experiments, whole fruits of a single size-class (12-13) were planted in fine quartz sand (<1 to 0.1 mm) at ½- and 2-inch depths in covered plastic boxes. To determine the effect of depth of planting on hypocotyl size, we kept the seedlings in the dark for the 10-day experiment. The average weight of 50 of the 1-cm segments excised immediately above the transition zone was determined. The average weights of 50 of the intact hypocotyls of groups of seedlings grown in the dark and in the light in the greenhouse also were obtained.

Laboratory germination and emergence

In some experiments, the percentage germination at approximately 70 F in a germinator on two layers of blotter was compared with emergence from quartz sand at 72 to 74 F. Quartz sand, having 7½% moisture, was placed in covered plastic boxes (5×7×4 in). Approximately ¾ in of sand was placed in the box; the fruits were placed, and then covered with the moist sand to specified depths. Twenty-seven seeds of each of two size-classes of fruits were planted in each box. A minimum of three replications (boxes) per experiment was used for each depth. Other experiments involved soaking of the fruits and using sand with different moisture contents.

Since the fine quartz sand with 7½% moisture will compact, care must be taken to apply the same amount of pressure to all containers. Where close comparisons are desired for certain fruit size-classes, the experiment should be designed to place the size-classes in the same container. Reproducibility is similar to blotter germination.

Field emergence

In order to correlate laboratory germination and emergence from sand with emergence under field conditions, we used two fruit sizes, small (6½-7½) and large (9½-10½), of commercially processed "seed" of Lot 7334 of variety US H20. The "seed" was treated with a fungicide.

Field plantings were made by two industry cooperators. Precautions were taken to avoid any bias of individual planting units of the commercial planters.

Results

Hypocotyl diameter was positively correlated with fruit size for each set of data listed in Table 1. In experiments involving emergence from sand, the hypocotyls of seedlings from commercially-processed, large fruits averaged larger than those of seedlings from small fruits.

Table 1.—Relation of seedling hypocotyl diameter to fruit diameter in monogerm sugarbeet.

Variety	Fruit size		Hypocotyl segments*	
	Whole	Process.		Avg weight
	In./64	In./64	No.	Mg
Hybrid	On 12		30	4.6
	8½-9½		50	4.1
US H20	On 13		33	4.5
(Lot 6369)	8-9		22	3.1
US H20	On 12		159	4.3
(Lot 6452)	8-9		222	3.6
(SL126 × 128)ms ×	On 12	On 12	127	4.1
SP5822-0	10-11	8½-10½	172	3.7
(Lot 4504)	7½-8½	6½	205	3.0

* 1-cm segments.

For seedlings emerging in light, the hypocotyls from "seeds" planted 2 in deep in sand weighed more than those from "seeds" planted ½ in deep (37.4 versus 21.4 mg per hypocotyl). This weight differential occurred even though the seedlings from the shallow planting emerged earlier and photosynthesized more. For seedlings emerging in the dark, the hypocotyls from "seeds" planted 2 in deep also weighed more (59.4 versus 52.9 mg per hypocotyl). The 1-cm hypocotyl segments of seedlings grown in the dark from "seeds" planted 2 in deep in sand also weighed more than those from "seeds" planted ½ in deep (8.2 versus 6.9 mg per segment; t-test significance at 2% level). The length of hypocotyls was more variable for the deep planting than for the shallow.

Repeated experiments revealed that germination percentages on blotters were nearly identical to percentages of emergence from quartz sand when the fruits were covered with ½ in of sand, thus the percentage values can be used interchangeably.

Emergence of sugarbeet seedlings from quartz sand (seven experiments, total of 24 replications involving different varieties and seedlots) showed that: 1) Fewer seedlings emerged (18 to 65% fewer) when fruits were planted 2 in deep than when planted ½ in deep; and 2) Proportionately fewer seedlings emerged from the smaller fruits than from the large, when planted 2 in deep.

When small and large fruits of US H20 were placed in sand at ½-, 1-, 1½-, and 2-in depths, progressively fewer seedlings emerged, but the percentage emergence declined more sharply between the 1½- and 2-in depths. When large, processed fruits (either soaked in water for 20-30 min before planting or planted in the air-dried condition) were planted 1 in deep in sand having moisture contents of 3, 5, or 7½%, seedlings emerged most rapidly from sand at 7½% moisture. Soaking the fruits hastened emergence from sand at 3% moisture. The final percentages of emergence did not indicate any distinct trends or effects. However, when whole and processed fruits were planted (1 in deep in sand at 7½% moisture) either in the air-dried condition or after soaking in water for 20-30 min, the percentage of seedlings emerging from the soaked fruits averaged 10 to 15% below that of the dried fruits.

Emergence of seedlings has been compared in firmly packed and relatively loosely packed sand. The fruits (9½-10½ size-class) were placed at a depth of 2 in. Firmly packed sand reduced seedling emergence to 46% of that from the loosely packed sand.

Field emergence study

Both size-classes of fruits contained at least 98% fully developed seeds. Percentages for blotter germination and emergence through ½ in of sand averaged 95% for both size-classes. Seventy-six percent of the seedlings from large fruits emerged through 2 in of sand, but only 53% of those from small fruits.

Field emergence data (Table 2) reveal the same trends that were obtained in the laboratory. With the exception of 1¼-in depth on the Adelsperger Farm, for any given planting depth, fewer seedlings emerged from the small than from the large fruits. Also, fewer seedlings emerged as the fruits were planted deeper and proportionately fewer seedlings emerged from smaller fruits planted deeper. J. L. Brown, Farmers and Manufacturers Beet Sugar Association, Saginaw, Michigan planted the two size-classes of fruits 1 in deep[5]. Seedlings emerged from 58% of the large fruits and from 37% of the small fruits.

Table 2.—Field emergence of sugarbeet variety US H20 as affected by planting depth in northern Ohio.*

	Fruit size (inches/64)	6½ - 7½		9½ - 10½	
Farm	Depth planted (inches)	1¼	2	1¼	2
Adelsperger		46	28	47	42
Havens		18	13	36	34
Damschroder		47	—	70	—

* Data of P. Brimhall, Northern Ohio Sugar Co., Fremont, Ohio.

[5] Helmerich Farm, Bay City, Michigan.

Discussion

The technique of planting sugarbeet fruits at different depths in moist sand offers a simple procedure for differentiating the emergence potential of seedlots and particularly for various size-classes of fruits. It should be possible to standardize the emergence from sand so that the various size-classes could be given an emergence potential rating which then could be used by growers to minimize emergence problems.

The data from Ohio (Table 2) indicate the difficulty of trying to predict possible emergence for a given seedlot. However, where emergence tends to be a problem, seed with high emergence potential should be made available to the grower. If the grower employs space-planting to get the desired stand without thinning, the following guide lines should be useful: 1. When smaller "seeds" are space-planted, at least one-third more should be planted than when larger "seeds" are planted; 2. Since depth of planting affects the percentage of emergence much more for small "seeds" than for the large, smaller "seeds" should be planted shallow (probably always less than 1 in deep); and 3. Where lack of moisture may limit germination, particularly for later plantings, "seeds" probably should be planted somewhat deeper. In such cases, larger "seeds" should be planted because they have greater emergence potential.

In the future, sugarbeet varieties may have larger fruits and greater emergence potential, however, each seedlot will still have a range in emergence potential which is related to fruit-size. Also, the micro-environment in which the seed develops and matures may effect the emergence potential of the seed.

The erratic germination and emergence performance of soaked "seeds" seems to be related to the differential needs of individual seeds for oxygen and sensitivity to limited diffusion of oxygen through the moist fruit. Small increases in the moisture content of the fruit may impede the rate of diffusion of oxygen into the seed below that required for germination. Thus, in repetitive experiments, the inherent small differences in moisture content may lead to relatively large differences in percentages of germination.

The effect of depth of planting on the hypocotyl was unexpected. Since energy is expended during the emergence process, the hypocotyls from a deep planting logically might be expected to be smaller than those from a shallow planting. The data suggested that the expenditure of energy was not sufficient to reduce the size of the hypocotyl. Perhaps the increased diameter of the hypocotyls from a deep planting is related to the increased impedance during emergence. The restriction on elongation might exert greater turgor pressure on the lateral walls than would occur with unrestricted cell elongation, thus enlarging cell-diameters and concurrently the hypocotyl diameter. The depth of planting affected the length of time the seedlings grew in the dark and could affect the size of the hypocotyls, since light retards elongation.

Summary

Sugarbeet fruits were separated into large and small size-classes and placed on blotters for germination. Approximately 10 days after germination, 1-cm segments of hypocotyl were excised. The segments of hypocotyls from the large fruits weighed more than those from small fruits. The size differential could also be observed macroscopically.

The percentage emergence of seedlings from moist quartz sand was determined when fruits were placed at ½- and 2-in depths. As the fruits were planted deeper, fewer seedlings emerged. Significantly, at the 2-in depth, proportionately fewer seedlings emerged from the small fruits than from the large when compared to the ½-in depth.

The trends in emergence potential obtained in sand in the laboratory were confirmed by emergence from soil under field conditions. The results indicate that seeds in large sugarbeet fruits have a greater emergence force and emergence potential than seeds in small fruits.

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