Progress Report on Sugarbeet Emergence Studies[1]

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Introduction

Commonly accepted seeding rates for sugar beets in Ohio and Michigan range from one seed every 3 cm in the row to one every 10 cm in the row. To achieve the desired minimum spacing of 20 to 25 cm apart in the row, hand hoeing or mechanical thinning is required. Field emergence of 20 to 60%[3] has not been sufficiently reliable to permit seeding at rates equal to the desired final stand. This paper describes attempts to improve the reliability of sugar beet emergence.

A first step in achieving an acceptable emergence percentage is to plant seed having potential emergence in excess of the desired value under conditions where mechanical impedence and disease are not factors. If seed cannot perform satisfactorily under such conditions, chances of satisfactory performance under less desirable conditions in the field are remote.
Improvement of seed lots should include:

a) Removal of foreign materials which might be mistaken for sugar beet seed by planting mechanisms.
b) Removal of seed without fruit or containing excessively shrivelled fruit.
c) Removal of seed with non-viable or apparently non-viable fruit or treatment of such seed to permit germination.

A second step in achieving desired emergence would be seed treatment or selection which increases the rate of seed germination and seedling emergence and/or increase the vigor of the emerging seedling. Such improved seed would allow less time in the field for unfavorable dry or crusted soil conditions to develop, or increase the severity of conditions necessary to reduce emergence.

A third step would be soil treatment or addition of amendment to the soil to reduce evaporative water loss near the seed, to increase soil temperature near the seed, and/or reduce crusting over the seed.

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[3] Estimated by sugar beet company fieldman for Ohio beet acreage.

Preliminary screening trials were conducted to select some of the more promising techniques for implementing steps 1, 2 and 3. The following techniques were selected for further study.

a) Seed separation based on density differential between empty and full seed (Dexter[4], Pauli (10)).
b) Preplant soaking of seed in dilute salt solution (1).
c) Encapsulating seed in vermiculite wafers (10).
d) Placement of vermiculite and/or asphalt over the seed row in the field.

Materials and Methods

A. *Density separation*: Commercially processed and fungicide treated monogerm seed (bulk seed) were placed in the upward moving air stream of a South Dakota seed blower[5] for five minutes. The controls were set to remove about 25% of the original sample. The fraction removed is termed the least dense quartile. The procedure was repeated with controls set to remove about 75 percent of the original sample. The fraction remaining is termed the most dense quartile. Seeds from these two fractions were photographed with X-radiography according to the method of Kriebel (5). Those seed with no apparent fruit or with excessively shrivelled fruit, as seen from the X-radiographs, were separated from the apparently healthy fruit-containing seed within each of the two density fractions (2). All seed from the resulting four classes were tested for germination on moist blotting paper at 21 C.

B. *Preplant soaking*: Seed were placed on blotting paper moistened with a solution of 1.5% KNO_3 plus 1.5% K_3PO_4, and incubated at 15 C for 6 days. After incubation, the seed were washed thoroughly in deionized water, drained, and air dried at 21 C. Seed were stored in an open container at 21 C until planted. Most of the Maneb fungicide was removed by this procedure.

C. *Seed response to density and soaking treatments*: Sand culture was utilized to test the ability of seed to germinate and emerge in a relatively loose medium. Seed were planted 1.25 cm deep in each of four grades of sand selected so that 15 percent by weight of water resulted in matric suctions of 10 cm, 80 cm, 540 cm and 2200 cm of water. Sand and half strength Hoagland's nutrient solution were mixed thoroughly and placed in a gallon size, 2 mil polyethylene bag. The bag was in turn placed in a rigid plastic container to avoid disturbing seed placement. After

[4] Dexter, S. T. Unpublished data, 1971.

[5] Model B, E. L. Erickson Products, Brookings, South Dakota. Trade names and company names are included for the benefit of the reader and do not infer any endorsement by the author or OARDC.

planting 30 seeds the bag was sealed with a rubber band and the container was placed in the appropriate controlled temperature cabinet. Constant temperatures of 7 ± 1 C, 12 ± 1 C, 17 ± 1 C and 22 ± 1 C were used to approximate mean field values from late March to late May. Seed treatments studied were bulk seed, most dense quartile, and salt soaked most dense quartile seed. All combinations of matric water potential, temperature and seed treatment were replicated 6 times. Emerged seedlings were counted daily from day of first emergence until emergence ceased. Each container was then dismantled and non-germinated seed were counted.

In a second laboratory experiment beet seed were exposed to physical pressure during germination and early growth in a triaxial pressure cell (4). Pressures of 0, 70, 140, 280, and 560 g cm^{-2} were applied to separate sets of 30 seed from the least dense quartile, most dense quartile, and salt soaked most dense quartile fractions. The pressure was applied to the soil fabric only, with the pore air space vented to the atmosphere. Each of the resulting 15 combinations was replicated six times. All samples were incubated at 16 C for 7 days at water suction of 20 cm, at which time the cells were dismantled. Seed having a detectable radicle (length of 1 mm or more) were counted as germinated, and the lengths of radicles of all germinated seed were measured.

D. *Field testing of seed treatments and amendments to or over the seed.* The following four seed treatments were incorporated into two field experiments in 1971.

1) Bulk seed
2) Most dense quartile
3) Most dense quartile, salt soaked according to section (B) above.
4) Most dense quartile, salt soaked, encased in the center of a 0.5 cm thick x 2 cm diameter disk of pressed vermiculite. The disk (wafer) consisted of 1 g of No. 3 vermiculite plus 0.1 g of clay as a binder.

The first experiment was performed on Hoytville silty clay loam, a Mollic ochraqualf soil. Each of the following three tillage treatments was planted on each of the three dates: 25 March, 12 April, and 4 May.

1) Plowed in fall 1970
2) Plowed in fall 1970 plus spring operation with a Lilliston cultivator to produce 10 to 15 cm high ridges in the row prior to planting.
3) Spring plowed shortly before planting plus 2 to 4 times over with a disk.

In addition the following four amendment treatments were applied over the row of each seed treatment, in each tillage treatment and on each planting date:

1) Check, no treatment
2) Vermiculite band applied over the seed in the planting furrow with a special applicator attached to the planter. The wafered seed treatment did not receive the vermiculite band.
3) Asphalt emulsion applied with a hand-held sprayer in a 12 to 15 cm wide band over the row.
4) Vermiculite followed by asphalt spray.

Each treatment combination was replicated three times. All treatments except wafers were planted with a John Deere 71 planter, with No. 33 vegetable seed hoppers at about 2 cm depth in rows 70 cm apart. Seed treatment-amendment combinations were 12 meter long, single row split plots within planting date-tillage treatment combination whole plots. Two hundred seed were put into the planter for each row. The remaining seed were removed at the end of the row and counted later. Exact seed drop was obtained by differences. Eighty wafers per row were planted by hand so that seed were at approximately 1 cm depth, and the top of the wafer even with the soil surface. Soil water content was monitored from the date of first emergence to date of final emergence by collecting samples from the row of each treatment at 0-1.25, 1.25-2.5, 2.5-5.1 and 5.1-10.2 cm depths and making gravimetric water determinations. Soil strength in the row was measured at the same time with a spring-loaded penetrometer having a flat-end probe 0.47 cm in diameter pushed into the soil to a depth of 0.5 cm.

The second experiment was performed on Wooster silt loam, a Typic fragiudalf soil. The only treatments were the four seed treatments plus three dates of planting: 9 April, 20 April and 10 May. Each seed treatment was replicated twice. Row length and seed counting were the same as in the first experiment. Seedbed preparation consisted of plowing prior to 1 April and one or more times over with a disk shortly before each planting date.

Results and Discussion

A. *Density separation*: At least two mechanisms apparently operate in an air flow density fractionation to separate faulty seed from viable seed. The explainable mechanism is removal of empty seed. Seed classed by X-radiography as empty or without fruit (seedballs 3 and 4 of figure A, for example) had less than 10% germination (Table 1), which indicates excellent ability to detect empty seed. Only two empty seed remained in the most dense quartile.

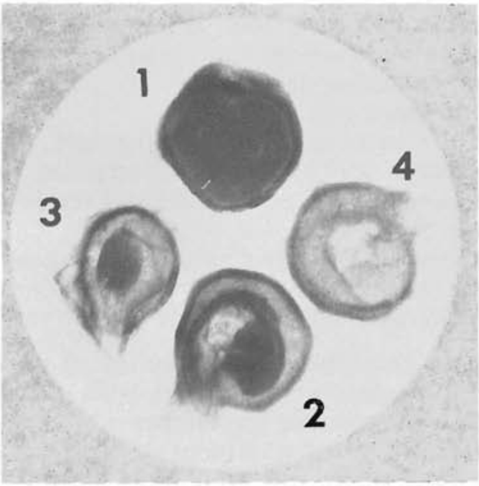

Figure A.—X-ray photograph of 4 sugarbeet seeds. Seed 1 has an apparently full-size, healthy fruit. Seed 2 has a shrivelled fruit of questionable viability. Seeds 3 and 4 are nearly or completely empty.

Table. 1.—Sugarbeet germination as a function of density separation.

Density Fraction	X-Ray Detection	Number of seed not germinated	Number of seed germinated
Least dense quartile	Empty seed	112	9
	Full seed	116	273
Most dense quartile	Empty seed	1	1
	Full seed	19	576

The unexplainable mechanism(s) is associated with the large number of apparently full seed in the least dense quartile which did not germinate (Table 1). This may represent an incorrect X-ray classification. It may be associated with damage to full seed carried upward and striking the top retaining screen of the seed blower, as reported by Kunze (6). In any case, these nonviable seed were removed by the density separation procedure.

Air flow density fractionation does not have the additional potential advantage of leaching or washing germination inhibitors from the seed, as may occur during water flotation separation procedures.

B. *Seed response to density and soaking treatments*: Results of the sand culture study are reported in Table 2. In general, the

Table 2.—Sugarbeet germination and emergence in sand culture.

		Germination*			Emergence*			Time to 50% emergence*		
Temper-ature	Matric suction	Bulk seed	Dense quartile	Dense plus salt soaked	Bulk seed	Dense quartile	Dense plus salt soaked	Bulk seed	Dense quartile	Dense plus salt soaked
°C	cm	%	%	%	%	%	%	days	days	days
7	10	68 e	72 e	93 b	61 g	63 g	92ab	29.2 de	28.6 d	15.1a
	80	79 d	84 c	98a	75 f	82 de	95a	24.1 bc	21.2 b	15.0a
	540	57 f	79 d	94ab	50 h	78 ef	89 bc	32.2 e	23.8 bc	15.8a
	2200	80 cd	85 c	91 b	74 f	81 de	86 cd	26.2 cd	28.5 d	17.5a
	Mean	71	< 80	< 94	65	< 76	< 90	27.9	> 25.5	> 15.8
12	10	62 f	80 e	92 bc	57 h	77 fg	91 bc	12.8 d	11.4 cd	7.5a
	80	86 d	91 bc	97a	82 ef	88 bcd	97a	10.6 bcd	10.5 bcd	7.1a
	540	80 e	91 bc	93abc	73 g	83 de	92 b	11.5 cd	11.5 cd	8.0ab
	2200	81 e	95ab	90 cd	76 g	90 bc	86 cde	12.6 d	11.9 cd	9.1abc
	Mean	77	< 89	< 93	72	< 85	< 91	11.9	= 11.3	> 7.9
17	10	73 i	85 fg	93 bcd	68 g	83 d	93a	7.0ab	5.8ab	4.5a
	80	81 gh	93 cd	99a	75 f	89abc	93a	5.5ab	5.4ab	4.5a
	540	87 ef	97abc	93 bcd	81 de	90ab	84 cd	7.0ab	6.1ab	5.2ab
	2200	79 h	97ab	91 de	75 f	86 bcd	78 ef	7.8 b	6.4ab	5.8ab
	Mean	80	< 93	= 94	75	< 87	= 87	6.8	= 5.9	= 5.0
22	10	71 g	82 de	96abc	68 f	79 cde	95a	5.2ab	4.6ab	3.0a
	80	77 f	98a	98ab	73 ef	95a	94a	4.4ab	3.6ab	3.0a
	540	83 d	97ab	92 c	79cd	78 cde	85 b	4.6ab	5.4ab	4.5ab
	2200	78 ef	92 c	94 bc	68 f	75 de	82 bc	6.5 b	5.8 b	4.5ab
	Mean	77	< 92	= 95	72	< 82	< 89	5.2	= 4.8	= 3.8
Error Mean Square†			6.2692			9.1774			2.8816	

* All values within a data class x temperature grouping (12 values) followed by the same letter are not significantly different at the 5% level of probability, according to the Duncan's Multiple Range test.

† Error mean square has 210 degrees of freedom.

system adequately maintained uniform sand water content with time and space. Some condensation occurred on the bag and ran down into the outer edge of sand which affected some of the seed. Spot checks of oxygen content of air in the bags revealed no shortage at any time. However, CO_2 was inadequate for sustaining growth of seedlings once emerged, so this technique is useful only for germination and emergence studies.

Mean germination and emergence percentages of the dense quartile exceeded those of bulk seed in all but two water content x temperature combinations each. The average differences were 12% germination and 11% emergence. The time to 50% emergence was the same for bulk and dense seed.

In general, temperature and sand water content did not affect response differences between these two seed treatments. Therefore, the main effect of air density sorting must be removal of completely non-viable seed. For if the effect weie culling of weak seed, greater differential response between these two seed treatments would be expected at unfavorably low temperature or at extremes of sand water content.

On the other hand, the effects of salt-soaking appears to be growth rate stimulation under certain adverse conditions. Salt-soaked seed achieved a uniform 94 ± 4% germination, regardless of sand water content or temperature. This resulted from stimulation of seed in cold (7 C) and wet (10 cm suction) conditions, while maintaining germination percentage in the other sets of conditions. Salt-soaking maintained percent emergence of nearly all germinated seed except at the lower two sand water contents (higher two suctions) at each of the higher two temperatures. Reasons for this observation are not apparent. Salt-soaking greatly increased rate of emergence at the lower two temperatures. The stimulation mechanism was not studied.

The influence of pressure on sugarbeet germination and early growth is shown in Table 3. Germination of seed from the most dense quartile, with or without salt-soaking, was reduced as pressure increased. Radicle growth of those seed that did germinate was unaffected by seed treatment and declined rapidly with small increases in pressure. The relative growth of sugar beet radicles was reduced to a much greater extent at pressures from 70 to 280 g/cm² than in the case of corn (4). Hence, even seed from the best seed treatment are still susceptible to small applied pressures, which may easily be accomplished with improper planter function or severe rainfall.

C. *Field trials*: Results from the trial on Hoytville soil are summarized in Table 4. Effects of seed treatment and row amendments were similar for most combinations of planting date

Table 3.–Influence of pressure and seed treatment on germination and early radicle growth of sugarbeets at 16 C and 20 cm. water suction.

Pressure	Germination			Radicle Length*		
	Least dense quartile	Most dense quartile	Dense + salt-soaked	Least dense quartile	Most dense quartile	Dense + salt-soaked
(g/cm²)	%	%	%	mm	mm	mm
0	43 ef †	93a	92a	19.0 b	28.7a	24.9a
70	48 def	84ab	92a	7.4 cd	9.9 c	12.7 c
140	38 efg	68 bc	81ab	5.3 cd	5.3 cd	5.8 cd
280	43 ef	57 cde	67 bcd	2.5 d	2.5 d	3.3 d
560	22 g	41 efg	36 fg	2.0 d	2.0 d	2.0 d
Error mean square		113.586			11.82	

* Each value represents the mean radicle length for those seed which germinated.

† All values followed by the same letter within each date class are not significantly different at the 5% level of probability, according to Duncan's Multiple Range test.

Table 4.—Effect of seed treatment and row amendment on sugarbeet emergence on Hoytville silty clay loam.

Seed treatment	Emergence*			
	No amendment	Asphalt	Vermiculite	Asphalt + vermiculite
	%	%	%	%
Bulk	21 c†	28 bc	31 bc	31 bc
Dense quartile	21 c	30 bc	29 bc	36 b
Dense + salt-soak	27 c	30 bc	35 b	37 b
Dense + salt-soak + wafer	36 b	45a	-----	-----

* Each value is the average from 3 replicates x 3 planting dates x 3 tillage treatments.

† All values followed by the same letter are not significantly different at the 5% level of probability, according to the Duncan's Multiple Range test.

x tillage treatments, so these factors have been absorbed in the averages. All seed treatments achieved at least 97% germination in the laboratory at 12 C and 17 C though the rate of germination was faster with salt-soaked seed than bulk or dense quartile seed (data not shown). At 7 C, bulk seed averaged 60% germination, dense quartile 78% and salt-soaked seed 94%.

Despite the trends toward improved emergence through use of row amendments and wafering (a concentrated form of row amendment), no treatment produced a high stand of beets consistently enough to warrant recommendation for planting to final stand.

Perhaps the overriding environmental effect on seedling emergence was lack of rainfall and subsequent dry soil conditions. A total of 3.4 cm of rain fell during the 51 day period of 16 March to 5 May. Soil water content at seed depth averaged about half of available capacity regardless of row amendments (Table 5). Even though the data in table 5 represent soil water content after germination has probably occurred for those seed which were going to germinate, the soil most probably was too dry at or shortly after planting time to support a reasonable rate of germination. Under dry conditions, no treatment explored in this study, not even salt-soaking, could be expected to achieve desired results.

Table 5.—Average soil water content from date first seedling emerged to date of last emergence on Hoytville silty clay loam.*

Depth	Water content in percent (dry basis)† No amendment	Asphalt	Asphalt + vermiculite
cm			
0-1.25	16.4a§	16.7a	16.7a
1.25-2.5	22.3 b	22.6 b	21.9 b
2.5 -5.1	25.3 c	25.4 c	25.2 c
5.1 -10.2	27.9 d	27.6 d	27.7 d

* Permanent wilting is ~ 17%; Field capacity is ~ 28%.

† Each value is the average from 3 replicates x 3 planting dates x 3 tillage treatments.

§ All values followed by the same letter are not significantly different at the 5% level of probability, according to the Duncan's Multiple Range test.

At no time was soil crusting considered detrimental to seedling emergence. The greatest average penetrometer value for any treatment combination at any time was 3.7 kg/cm², with most values half that or less.

Results from the trial on Wooster silt loam are summarized in Table 6. The wafered, salt-soaked seed had satisfactory emer-

Table 6.—Effect of seed treatment on sugarbeet emergence in Wooster silt loam.

Seed Treatment	Final emergence Planted April 9	Planted April 20	Planted May 10
	%	%	%
Bulk	66 bc*	77abc	38 d
Dense quartile	66 bc	79ab	54 cd
Dense + salt-soak	74abc	71abc	79ab
Dense + salt-soak + wafer	91a	90a	85ab

* All values followed by the same letter are not significantly different at the 5% level of probability, according to the Duncan's Multiple Range test.

gence for all three planting dates. Non-salt soaked seed tended to have lower emergence percentage, particularly for the 10 day planting date.

Conclusion

The principle of combining several practices into a package or system for providing adequate sugarbeet emergence under a wide range of soil and climatic conditions is considered valid, despite the failure of any combination tested so far to produce the desired results with unusually dry soil. Sorting seed lots to remove empty seed should become standard practice if it is not already. The 1971 seed lot was much freerer of empty seed than 1969 seed lots tested (compare bulk and dense quartile in Table 2 with statements made concerning seed used in the Hoytville soil field trial), which was a direct result of this study and that of Dexter[4]. Treating seed to stimulate rate of germination and emergence, particularly under wet, cold conditions, is highly desirable, whether by the salt treatment of Ells (1) as used here, or some other, subsequently developed successful treatment.

Unless some seed treatment is developed to stimulate germination under dry or relatively dry soil conditions, the approach to field amendments must be different from that used in this study. We planted seed at a relatively shallow depth (2 cm), and treated the soil directly over the seed to reduce the rate of drying and/or crust formation. This did not help when seed were planted in relatively dry soil, and rainfall was limiting after planting. Even with such circumstances, examination of soil water content from Table 5 shows sufficient water at or below 4 cm depth for more normal sugarbeet germination. Planting at such relatively deep depths may require very positive methods of reducing crusting over the seed and/or reducing soil pressure applied to the seed. Perhaps some means of inducing soil cracking over the seed would be a suitable combination with deep planting of dense, treated seed. That is one aspect of our current research program.

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