

THE EFFECT OF SOIL AGGREGATION AND SEED TREATMENT ON
GERMINATION OF SEGMENTED SUGAR BEET SEED
AND EMERGENCE OF THE SEEDLINGS.

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by
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TABLE OF CONTENTS

	Page
I. INTRODUCTION	1
II. REVIEW OF LITERATURE	2
III. EXPERIMENTAL PROCEDURE	5
Laboratory	5
Germination tests I, II, and III	6
Greenhouse Experiments	6
Planting I	7
Plantings II, III, IV	7
Plantings V, VI, and VIII	8
Planting VII	9
Field Experiments	9
Plantings I and II	10
IV. DISCUSSION AND RESULTS	10
Laboratory Experiments	11
Germination tests I and II	11
Germination tests III	12
Greenhouse Plantings	12
Planting I	12
Plantings II, III, and IV	13
Plantings V, VI and VIII	14
Planting VII	16
Field Experiments	16
Planting I	16
Planting II	18

	Page
V. SUMMARY AND CONCLUSIONS	19
Table I. Germination test of sugar beet seed used in experiments.	21
Table II. Germination test of seed treatment	21
Tables III & IV. Germination tests of seed treatments.	22
Table V. Percent germination in greenhouse planting I.	23
Table VI. Percent seedling emergence in greenhouse planting I.	24
Table VII. Percent seedling emergence in greenhouse planting II.	25
Table VIII. Percent seedling emergence in greenhouse planting II.	26
Table IX. Percent seedling emergence in greenhouse plantings III & IV.	27
Table X. Percent seedling emergence in greenhouse planting V.	28
Table XI. Percent seedling emergence in greenhouse plantings VI & VIII.	29
Table XII. Percent seedling emergence in greenhouse planting VII.	30
Table XIII. Percent seedling emergence in field plantings I and II.	31

	Page
Table XIV. Air permeability determinations of greenhouse planting VIII.	32
Table XV. Volume weight determinations of field plantings I and II.	33
Table XVI. Porosity and pentiometer determina- tions on field planting II.	34
Table XVII. Statistical analysis of field planting I.	35
Table XVIII. Statistical analysis of field planting II.	36
Figure I. Pictures showing effect of mulch treat- ments on emergence of sugar beet seed- lings.	37
Figure II. Pictures showing effect of phosphoric acid seed treatments on emergence and growth of sugar beet seedlings.	38
Figure III. Photograph to show difference in seedling emergence in various sized soil aggregates.	38
VI. LITERATURE CITED	39

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I. INTRODUCTION

The high cost of labor in the thinning and blocking of sugar beet seedlings is one of the greatest difficulties encountered in the sugar beet industry.

Various advancements have been adopted to reduce this cost, such as mechanical means of blocking and thinning, the use of adapted varieties of seed to obtain vigor and resistance to diseases, and the use of segmented seed to obtain single germ seeds.

One of the greatest advancements in lowering the cost of sugar beet production has probably been by the use of segmented or sheared beet seed. This segmented seed is advantageous in lowering seed cost, reducing competition between seedlings prior to thinning, reducing disturbance of beets on thinning and blocking, and increasing the rate of thinning and blocking. The greatest disadvantage in the use of the segmented seed is in securing and maintaining a desired stand of sugar beet seedlings.

This paper presents a study of some factors thought to influence the germination of sugar beet seeds and emergence of the seedlings.

II. REVIEW OF LITERATURE

Investigations of the germination of sugar beet seed and emergence of the seedlings have centered mainly on seed treatment, seed bed preparation, and manner of planting.

Cox (2) stated that the yield of sugar beets depends very largely on the stand obtained, and a uniform stand can only be obtained by planting on a well fitted seed bed. The seed bed is the foundation of a good stand. The use of a cultipacker after planting and before beets are up is recommended for ground which has tendency to bake over or crust. He recommends spacing plants 10-12 inches apart, fall plow to good depth, and plant early to middle of May.

Gormany (1) gave evidence that beets planted at 1" depth gave 88.09% emergence; at 3-1/2" depth 3 plants appeared in 185 feet of row, and no beet seedlings emergence at depth of 4-5".

Satchell (13) showed that sheared sugar beet seed as a general rule should be planted as shallow as moisture will permit. Aeration of the soil was also found to be a very important factor in sugar beet seedling emergence. The use of pelleting seed gave a better seed distribution but lengthened the emergence period. The use of salt solutions was found to offer a possible means of separating perfect and imperfect sheared sugar beet seed. This worker experienced difficulty in coverage of the seed when planted at 1/2 inch or less in depth.

Tolman and Stout (15) presented evidence that free ammonia released during germination of the seed balls produced toxic effects when sugar beet seed was germinated in the presence of the seed ball extracts. The removal of water soluble nitrogen fractions from the pericarpal tissue afforded an explanation of the beneficial effects of washings or soaking seeds prior to germination tests.

Hsuef and Lou (5) have shown that 2,4-D at low concentrations of 0.01% promotes germination in barley and rice seeds but at higher concentrations of 0.1% it begins to inhibit aerobic respiration and checks germination.

Tolman and Stout (16) showed that water soluble substances present in the seed ball were found to produce a toxic effect on germinating sugar beet seed both retarding germination and killing of radicles. These investigators discovered that water soluble toxic substance of sugar beet seed balls can be removed by either soaking or washing in running water for a six hour period. The substances in sugar beet seed that produce the toxic effect on germination are thought to accumulate in the pericarp during seed development and the amount present vary with variety, climate, soil, and maturity stage.

On treatment of sugar beet seed with sulfuric acid, Gardner and Sanders (4) gave evidence of an increase in both rate of germination and total germination. They attribute the increase in germination to a greater permeability of the

hard seed balls which allows the processes connected with germination to take place more rapidly.

Other work by Tolman and Stout (14) indicated that 20-25% of sheared seed units have exposed seeds and one half of these will not produce a seedling when planted more than 1/2 inch in depth. Blotter tests in germination gave an erroneous impression of percentage seed recovered in the shearing process unless care was taken to differentiate between normal and abnormal germination. Approximately 12 to 15 percent of sheared seed and naked seeds germinated abnormally but perfect sheared seed gave a good germination and 100% of seedlings of perfect sheared and whole seed balls reached surface from the deepest planting.

On applications of common salt upon yield and quality of sugar beets and upon composition of the ash, Lill (10) noted beneficial effects of NaCl on the stand or the number of commercial roots secured.

Farnsworth (3) concluded that if the soil has an air capacity of 12 percent, aeration should no longer be a limiting factor for growth of sugar beets.

Leach, Bainer, and Doneen (9) working on moisture requirements found that beets would germinate at a water content just slightly over the permanent wilting percentage, pelleted beet seeds required a longer emergence period than either whole or segmented seed. These workers noted that

seed required a longer emergence period at the lower temperatures.

Rudolfs (12) reported that the rapidity of germination varied with the kind of seed and that some seeds were benefited by dilute solutions of various salts.

In development of unilocular seed, Owens, Smith, and Musser (11) report some progress. Russian workers have also reported the development of single germ strains.

Jones (6) working with liquid phosphoric acid as a fertilizer, gave evidence that an increase of over 800 lbs. of beet seed per acre was produced with an application of 200 lbs. of phosphoric acid. Evidence has accumulated which indicates that seeds germinate better when crops are irrigated with water containing liquid phosphoric acid.

III. EXPERIMENTAL PROCEDURE

The seed used in all experiments was obtained from the Farmer and Manufacturers Beet Sugar Association. Germination tests were made by A. P. Anderson of the Michigan Sugar Company laboratory and the seed type and tests are shown in Table I.

A. LABORATORY

These experiments were conducted to determine the effects of various seed treatments on germination of segmented sugar beet seed under laboratory conditions by the use of the blotter test method.

The seed treatments of this first germination test were conducted by the soaking of the sugar beet seed in various solutions of sugar, magnesium chloride, starch, and water. The germination tests were made in December, 1947 and results are shown in Table II.

The second germination test was similar to the first one with the addition of seeds soaked in various solutions of sucrose, dext, and calcium chloride. These tests were made in January, 1948 and the treatments and results are shown in Table III.

The third germination test consisted of soaking seeds in various diluted solutions of phosphoric acid for thirty minutes, allowing them to dry, and determining the percent germination. These tests were completed on March 16, 1948 and the results are recorded in Table IV.

B. GREENHOUSE EXPERIMENTS

The soil used in the following experiments consisted of Wisner, Brookston, and Miami silt loam. All plantings were made in flats of various sizes with soil depth of approximately six inches. All seed was dusted with ceresan before planting and countings were made until a constant number of seedlings were obtained. Watering was accomplished by use of a sprinkling can with exceptions as mentioned in the following experiments.

Experiment I was begun January 9, 1948 to determine the effects of the previous seed treatments on germination of beet seed and emergence of seedling in soil at various moisture content. The effect of saw dust mulch and packing of soil on emergence of the beet seedlings was also studied. The various moisture contents of the soil were obtained by addition of a certain percent of water to air dry screened Brookston and Wisner silt loam soils. Falts 7, 8, and 9 contained a low moisture content of approximately 16% and flats 10, 11 and 12 a higher moisture content of 24%. All plantings of 100 seeds per flat were made at one inch depths with similar packing in all cases. The treatments and results are shown in Table V.

To show the effects of packing and mulch treatments, soil in the remaining flats contained the same moisture content of approximately 30%. 100 seeds were planted in each flat at one inch depth. The treatments and results are shown in Table VI.

Experiment II, a replicate of experiment I, was started January 23, 1948 with the addition of starch treated seed. The results are tabulated in Tables VII and VIII.

Experiments III and IV begun on February 20, 1948 and March 3, 1948 respectively were undertaken to determine the influence of soil aggregation on sugar beet seed germination and seedling emergence. The soil used was Wisner silt loam.

Planting III consisted of beets being seeded in soil aggregates of three different sizes, those screened above 4 mm., between 4-1 mm., and below 1 mm. Watering in this case was accomplished by capillary action in which a water saturated soil was covered with the varying sized aggregates with the seeds planted one inch in depth.

Planting IV was similar to III except water was added from the top with a sprinkling can to provide a hard crust on the soil surface. Results of both plantings are given in Table IX.

Experiment V was started March 3, 1948 to determine the effect of phosphoric acid on germination and emergence of the beet seed and seedlings. The phosphoric acid was applied at various dilutions with the seed in the soil; also seeds were planted having been soaked in different dilutions for thirty minutes. These results are recorded in Table X.

Experiments VI and VIII started March 22, 1948 and April 17, 1948, respectively, were similar to plantings III and IV with the use of Miami sandy clay loam in place of the Wisner silt loam soil.

These two experiments differ in that the soil surface in VI was heavily crusted by saturating soil with water after planting and allowing to dry; whereas, in VIII the soil was kept moist and covered with oil paper to decrease the amount of soil surface crusting. The percent seedling emergence in each case is given in Table XI.

Experiment VII was a study of mulches on affecting sugar beet seedling emergence and was begun March 24, 1948. Mulches used consisted of sand, saw dust, and straw which covered beet seeds planted at 1-1/2 inch depths. All flats were saturated with moisture after plantings and allowed to dry. The percent seedling emergence is shown in Table XII.

C. FIELD EXPERIMENTS

Plantings of sugar beet seed were conducted to determine the effect of some chemical treated seeds and soil aggregation on germination of seed and emergence of the seedlings under natural existing conditions in the field.

The seed treatments were the same as those used in the green house plantings and the soil aggregation size was accomplished by varying the amount of seed bed preparation.

The plantings were made by the use of a John Deere #55 beet drill at 1 to 1-1/2 inches in depth at the rate of 67 seeds per 50 inches of row for the treated seed and 85 seeds per 50 inches of row for the control seed. The soil type was Hillsdale sandy loam. The beet drill was set for 20 inch rows for the first planting and for 28 inch rows in the second planting.

The field plots were set up in a split plot design with three replicates as prepared and shown below.

Plot I Plowed approximately 7 inches in depth.
 Harrowed with spring tooth once.
 Cultipacked once.

Plot II Plowed approximately 7 inches in depth.
Disked twice.
Harrowed with spring tooth once.
Cultipacked once.

Plot III Plowed approximately 7 inches in depth.
Disked 5 times.
Harrowed with spring tooth twice.
Cultipacked once.

In field planting # 1, started on April 30, 1948, saw dust was applied by hand at two rates to several of the plots over the seeded rows. The counting of seedling emergence was determined 21 days after planting and the averages of percent emergence of seedlings of eight 50 inches of row are given in Table XIII.

Field planting # II, made on May 28, 1948, differed from planting I in that a steel toothed harrow was used to insure a leveler seed bed. This gave greater uniformity in seed distribution and depth of planting; also no mulch was used in this planting. Countings of the seedling emergence were made 24 days after planting and the percent seedling emergence is shown in Table XIII.

IV. DISCUSSION AND RESULTS

The emergence of sugar beet seedlings may be increased by at least two methods, either to increase the emerging power of the beet seedling or to decrease the resistance of the soil to emergence of the seedlings. It was with this thought

that the experiments previously mentioned were carried out and a discussion of the results obtained is given below.

A. LABORATORY EXPERIMENTS

One of the first steps in the process of germination is the absorption of moisture by the seeds. In preliminary experiments an attempt was made to control percent available moisture by the use of dessicators having specific relative humidities for determination of the effect of seed treatments on germination of sugar beet seeds. This method failed as the seeds would not germinate at 100% relative humidity, so the germination tests were made by use of the blotter test technic.

The soaking of seeds in the calcium chloride and dreft solutions was an attempt to increase the rate or amount of water absorbed by the seeds and to increase the rate and percent of seed germination.

The seeds were soaked in the starch and sugar solutions with the possibility of increasing the food supply for the growth of the beet seedlings.

The water and magnesium chloride seed treatments were to increase the permeability of the beet seed coat and as stated by Tolman and Stout (16) to remove the toxic substances from the seed ball prohibiting germination.

As shown in Table II, considerable difference in germination was obtained from the various seed treatments. The magnesium chloride and sugar treated seeds showed depressed

germination with production of small abnormal radicles; whereas, the sucrose and water soaked seeds were approximately equal in percent germination to the control seed.

Table III shows results with a definite decrease in germination of seeds soaked in a dreft solution, with little variation of the remaining seed treatments.

As indicated by Jones (6), there was evidence that seeds germinated better when irrigated with water containing phosphoric acid. Germination test III was made to determine if similar results could be obtained by soaking the beet seed in diluted phosphoric acid before planting. As shown in Table IV, no detrimental effects were obtained from this treatment up to solutions of 5280 p.p.m. of P_2O_5 ; and that this method might be used to increase the available phosphorus for growth of small beet seedlings.

B. GREENHOUSE PLANTINGS

Believing that soil seed contact would give different results than indicated by the laboratory germination tests, the various seed treatments were continued and their effect on germination of beet seeds and emergence of seedlings determined under greenhouse conditions.

As shown in Table V, greenhouse planting I shows very little influence of seed treatment on emergence of beet seedlings. Moisture control was the big problem involved in this experiment as the large flats dried out very rapidly and water had to be added to them to maintain a uniform condition. The results show that higher seedling emergence was obtained

in the flats at low moisture. This situation indicates the possibility that the seeds had germinated in the higher moisture containing flats, but due to lack of moisture before the second addition of water, they had failed to emerge.

In general, the data as shown in Table VI indicates that compaction of soil over seedlings is detrimental to emergence of sugar beet seedlings. This agrees with work done by Satchell (13).

Ridging of soil over the sugar beet row seemed beneficial with the problem being in removing the ridge before seedlings would be damaged.

The mulch treatments increased emergence slightly except in cases where the mulch was applied in the row with the seeds. This had the tendency to dry out the soil and decrease the seed germination.

Greenhouse planting II was a replicate of I, with an attempt to reduce evaporation of moisture by covering of flats with oil paper. Again water had to be added to obtain seedling emergence and very little variation is shown from seed treatments, as shown in Table VII. Data in Table VIII shows that less emergence from the ridge plantings was obtained, which is attributed to removing of ridges at a later date than was in planting I, which destroyed some of the beet seedlings; also packing of soil and saw dust in the rows decreased the seedling emergence.

Greenhouse plantings III and IV were made to study the influence of soil aggregation size on emergence of beet seed-

lings and as shown in Table IX, very little variation was obtained from the different treatments. In most cases, the rate of seedling emergence was greater from the flats containing the smaller aggregates which was probably due to faster rise of capillary moisture and closer soil seed contact for absorption of moisture. Planting IV differed from III in that water was added to the surface in an attempt to produce a soil surface crust. However, due to the stability of the soil aggregates no crust was obtained. Again, as in planting III, no correlation in emergence from the different sized soil aggregates was obtained. This indicates that at sufficient moisture and optimum growing conditions, soil aggregate size has very little influence on emergence of beet seedlings.

In greenhouse planting V, most of the flats showed excessive cracking and drying out of the soil and, as shown in Table X, very little correlation between the replicates of the phosphoric acid treatments was obtained. In some of the flats, the percent emergence from the phosphoric acid soaked seeds was greater and most of the plants were larger, showing signs of a more vigorous growth.

Greenhouse plantings VI and VIII were similar to plantings III and IV replacing Wisner silt loam soil with Miami sandy clay loam in an attempt to get a break down of aggregates on addition of water to form a soil crust or to produce an adverse condition with respect to emergence of sugar beet seedlings. These results are shown in Table XI.

Considerable variation is apparent in seedling emergence in planting VI but no correlation between replicates was obtained. This is explained by the fact that a heavy soil crust was obtained in all flats with emergence of the seedlings only through the cracks in the soil formed. Also the flats were set on the green house floor and several were saturated by moisture from floor washings. These flats showed a high percent of seedling emergence.

Planting VIII was different from planting VI because the flats were set on boards slightly above the floor and were covered with oil paper to decrease moisture evaporation and the forming of any impermeable soil crust to seedling emergence. Correlation between emergence and aggregate size was obtained from this planting with a greater percent seedling emergence from the flats containing the small soil aggregates. In an attempt to determine the cause of this effect, air permeability determinations were made on the soil 45 days after planting. The apparatus used was constructed by Walter Carelton, graduate student in agriculture engineering, and modeled after that used by Kirkham (7). The rate of air permeability as shown in Table XIV, was greatest through the medium sized aggregates and the slowest through the smallest sized soil aggregates. The slow rate of air permeability through the large soil aggregates in comparison with the medium was probably due to the break down of the large aggregates by continuous

watering of the flats. The large soil particles were broken down on the surface decreasing the rate of air flow but not soon enough to affect germination and seedling emergence.

As shown by Klute (8), air permeability through soil was dependent considerably upon non-capillary porosity at certain tensions. This indicates the possibility of soil seed contact being of greater importance than the porosity of aeration of a soil with respect to germination of beet seeds and seedling emergence. To insure the fact that all of the soil aggregates were of the same texture, a mechanical analysis of each flat was made using the hydrometer method. In each case the texture was a sandy clay loam.

In the mulch treatments of green house planting VII, less cracking and drying of soil was noticed. As shown in Table XII, the 1/2 inch seed depth with straw mulch gave the highest percent beet seedling emergence. The 1-1/2 inch seed depth with sand and saw dust mulch also gave a higher seedling emergence than the control seed. This indicates that benefits might be obtained by use of mulches to obtain higher beet seedling emergence, in that less crusting and drying out of the soil on the surface is obtained.

C. FIELD EXPERIMENTS

In field planting I seedling emergence in all plots was sufficient to insure a good stand of beets. Considerable moisture was present in the soil throughout this

experiment and the saw dust mulch was washed away giving no results.

A statistical analysis was made of the results from this planting and significance was found for both seed and soil treatments, as indicated in Table XVII.

Of all soil treatments, the lightly worked seed bed gave the greatest significance in seedling emergence with the medium worked seed bed the least. Sixty days after planting, the beet plants showed a higher rate of growth and maintained a better stand in the lightly worked plots. To determine what physical difference might exist between the plots, volume weight measurements were taken. As shown in Table XV, the volume weights were slightly lower in the lightly worked plots. These data indicate that under high moisture conditions a heavily worked seed bed is not necessary to produce an adequate stand of beet seedlings and the compact soil in the heavily worked plots reduces growth of the seedlings.

With respect to seed treatments, the phosphoric acid treated seed gave the greatest significance for seedling emergence. The calcium chloride and water soaked seed treatments were also significant when compared with the control seed. These results agree with investigations of workers previously mentioned with respect to the water soaked seed. This significance in seed treatment could

have been due to the increase in resistance to dampening off of the beet seedlings which often occurs during wet springs, plus the nutritional value of the elements present from the phosphoric acid and calcium chloride seed treatments.

The objective of field planting II was to determine the affect of time of planting and possibly a change in the environmental conditions in comparison with the earlier plantings of field experiment I by use of the same seed treatments and seed bed preparation.

Less moisture and warmer weather prevailed during this experimental period and, as shown from the table of statistical analysis XVIII, a significance in soil treatment only was obtained. Greatest emergence occurred on the heavily worked seed bed. This is the reverse of the results obtained in field planting I. As in planting I, volume weights were determined in each plot and, as shown in table XV, the lightly worked seed beds gave lower values. Capillary and non-capillary pore space were also determined at a 60 cm. tension and the results in Table XVI indicate that the capillary pore space was slightly higher and the non-capillary pore space was considerably lower in the heavily worked small aggregated soil particles. Pentimeter readings were also taken to show the extent of compaction of the soil. These results are shown in Table XVI and indicate the greatest compaction of soil particles was found in the fine aggregated soil seed beds.

The increase in seedling emergence might be attributed to the fact that under dry conditions the heavily worked seed beds, having greater capillary pore space and less non-capillary pore space with compaction of soil particles, would retain more moisture than the seed beds containing larger soil aggregates, greater aeration, and less soil compaction. With the larger supply of available moisture for seed absorption, this soil treatment would give a higher percent of beet seed germination and seedling emergence.

V. SUMMARY AND CONCLUSIONS

As a result of the work conducted in this investigation, of the influence of soil aggregation and seed treatment on beet seed germination and seedling emergence, the following conclusions may be drawn:

1. Moisture seed contact was essential for germination of sugar beet seed.
2. Seed treated with magnesium chloride and dreft solutions showed depressed and abnormal germination in blotter tests and greenhouse conditions. Similar tests with water, phosphoric acid, calcium chloride, and sucrose solution treated seeds gave normal germination and, in some cases, an increase in seedling emergence.
3. Packing of soil over seeds depressed seedling emergence and ridging of soil over seed rows with proper removal of ridges was beneficial to seedling emergence.

4. Mulches were beneficial to seedling emergence when applied over shallow planted beet seeds. If a mulch was covered over seeds in the row, it was detrimental due to drying out of soil and loss of moisture.
5. Fine screened soil aggregates increased beet seed germination and seedling emergence under controlled green house conditions.
6. Soil seed contact was of greater importance than aeration in germination of beet seeds.
7. Under field conditions, where excessive moisture persists, seeds treated with calcium chloride, water and phosphoric acid solutions gave a higher percent of seedling emergence. A heavily worked soil seed bed was not needed to obtain a sufficient stand of sugar beet seedlings.
8. Under field conditions, where there was a shortage of moisture, a heavily worked soil seed bed increased beet seedling emergence and no benefits were obtained from the mentioned seed treatments.
9. A heavily worked soil seed bed increased capillary pore space, decreased non-capillary pore space, increased the compaction of the soil particles, and decreased seedling growth after emergence.

TABLE I

GERMINATION TEST OF SEED USED IN EXPERIMENTS

	Replicates			
	no. 1	no. 2	no. 3	average
	percent germination			
total germination	90	89	90	89.6
singles	65	59	60	61.3
doubles	22	28	29	26.3
triples	3	2	1	2.0

Tests were made by Michigan Sugar Company.

TABLE II

PERCENT GERMINATION OF SEED TREATMENT

time in hours	seed treatments*					
	1	2	3	4	5	6
	percent germination of 100 beet seeds					
72	34	21	25	46	40	49
96	39	40	45	50	53	54

Indicates seed treatment

1. Seed soaked 2 hours in 10 % sugar solution.
2. Seed soaked 2 hours in 10 % magnesium chloride solution.
3. Seed soaked 2 hours in 5 % magnesium chloride solution.
4. Seed soaked 2 hours in water.
5. Control seed.
6. Seed soaked 2 hours in 10 % solution of starch.

TABLE III

GERMINATION TESTS OF SEED TREATMENTS.

time in hours	Seed treatments*					
	1	2	3	4	5	6
Percent germination of 100 seeds						
48	29	44	42	42	2	40
72	56	60	70	64	8	65

*Seed treatments

1. Seeds soaked 2 hours in 10 % sugar solution.
2. " " 2 " " 10 % magnesium chloride sol.
3. " " 2 " " 5 % " " "
4. " " 2 " " water.
5. " " 2 " " 10 % dreft solution.
6. " " 2 " " 10 % calcium chloride sol.

TABLE IV.

GERMINATION TESTS OF SEED TREATMENTS.

time in hours	Seed treatments*				
	1	2	3	4	5
Percent germination of 100 seeds					
48	15	12	15	13	19
72	45	44	45	46	44

*Seed treatments

1. Beet seed soaked in solution of 5280 ppm. of I_2O_5 .
2. " " " " " 528 " " "
3. " " " " " 210 " " "
4. " " " " " 53 " " "
5. " " " " " 21 " " "

TABLE V

PERCENT GERMINATION IN GREENHOUSE PLANTING I

Seed treatment*	Days after planting		
	8	12	14
Percent emergence of 100 seeds			
1	64	110	112
2	112	132	128
3	30	58	92
4	34	64	100
5	108	130	123
6	112	126	122
7	97	101	104
8	108	102	96
9	33	68	79
10	73	99	97
11	109	96	98
12	95	93	97

*Seed treatment

1 & 7. Seeds treated in 5 % calcium chloride solution.

2 & 8. " " " 2 % " " "

3 & 9. " " " 5 % dreft solution.

4 & 10. " " " 2 % " "

5 & 11. " " " tap water.

6 & 12. Control seed.

TABLE VI
PERCENT SEEDLING EMERGENCE IN GREENHOUSE PLANTING I.

Soil treatment*	Days after planting		
	6	8	10
Percent emergence of 100 seeds			
1	72	92	96
2	68	109	111
3	94	108	105
4	75	86	90
5	26	34	33
6	35	62	68
7	46	70	71
8	34	44	49
9	16	40	38
10	25	47	40

*Soil treatment

1. Packed soil rows and ridging.
2. Unpacked soil rows and ridging.
3. Control unpacked soil.
4. Rows and soil over seeds packed.
5. Rows packed, no mulch covering.
6. Rows packed, mulch covering over row.
7. Mulch in row and soil packed.
8. Seeds, mulch, and soil packed in rows.
9. Rows, seed, mulch, and soil packed.
10. Rows, seed, and mulch packed.

TABLE VII

PERCENT SEEDLING EMERGENCE IN GREENHOUSE PLANTING II

Seed treatment*	Days after planting		
	8	12	14
Percent emergence of 100 seeds			
1	4	30	76
2	7	36	71
3	1	10	32
4	0	6	44
5	5	21	60
6	10	39	73
7	28	61	82
8	31	55	85
9	37	68	75
10	54	93	99
11	11	39	70
12	1	26	57

*Seed treatment

1 & 7. Seeds soaked in 10 % solution of calcium chloride.

2 & 8. " " " 10 % " "magnesium "

3 & 9. " " " 10 % " "starch.

4 & 10. Control seed.

5 & 11. Seeds soaked in 10 % solution of dreft for 30 minutes.

6 & 12. Seeds soaked in 10 % solution of dreft for 60 minutes.

TABLE VIII

PERCENT SEEDLING EMERGENCE IN GREENHOUSE PLANTING II.

	Days after planting		
	8	12	14
Soil treatment*	Percent emergence of 100 seeds		
1	28	51	58
2	21	42	63
3	24	29	28
4	19	50	74
5	15	42	68
6	30	56	81

*Soil treatment

1. Rows ridged, no compaction of soil.
2. Rows ridged, soil compacted before ridging.
3. Rows packed, mulch placed in row, soil packed.
4. Rows packed, no mulch.
5. Rows packed, soil cover packed.
6. No packing of soil.

TABLE IX.

PERCENT SEEDLING EMERGENCE IN GREENHOUSE PLANTINGS III & IV.

Planting III.

Soil treatment*	Days after planting	
	7	11
Percent emergence of 100 seeds		
2	97	120
5	123	135
8	93	120
4	28	73
7	5	70
1	46	103
3	131	131
6	102	115
9	106	114

Planting IV.

2	71	114
5	48	94
8	58	93
4	93	115
7	88	124
1	73	105
3	65	101
6	63	110
9	70	112

*Soil treatment

2, 5, & 8 includes soil aggregates above 4 mm.
 4, 7, & 1 " " " between 1-4 mm.
 3, 6, & 9 " " " below 1 mm.

TABLE Y.

PERCENT SEEDLING EMERGENCE IN GREENHOUSE PLANTING V.

	Days after planting				
	7	9	12	16	21
Seed treatment*	Percent emergence of 100 seeds				
1	10	27	38	38	37
2	60	78	81	80	79
3	16	23	27	25	24
4	114	116	107	108	109
5	32	43	55	52	40
6	26	33	38	40	39
7	27	45	40	53	40
8	18	22	23	27	27
9	6	12	19	18	17
10	33	51	59	60	59
11	33	41	46	52	50
12	--	--	--	--	--
13	8	27	46	45	45
14	1	8	22	22	21
15	14	20	20	21	20

*Seed treatment

1, 2, & 3. Seeds soaked in 5280 ppm. of P_2O_5 .

4, 5, & 6. " " " 210 " " "

7, 8, & 9. " " " 21 " " "

10, 11, & 12. Control seed.

13, 14, & 15. Seeds treated with diluted phosphoric acid in soil row.

TABLE XI.

PERCENT SEEDLING EMERGENCE IN GREENHOUSE PLANTINGS VI & VIII.

Planting VI.

Soil treatment*	Days after planting				
	6	9	12	15	18
Percent emergence of 100 seeds					
2	0	3	3	3	3
3	1	9	9	9	9
9	2	7	8	9	10
4	1	6	11	12	12
6	41	64	98	102	98
8	0	13	14	14	12
1	0	10	14	14	14
5	0	7	8	7	7
7	4	51	52	53	51

Planting VIII.

2	45	67	66	65	65
3	45	71	77	76	78
9	46	65	63	64	62
4	20	38	38	41	38
6	18	31	44	44	41
8	29	44	59	59	54
1	8	8	9	9	8
5	12	14	16	17	16
7	14	22	22	22	22

*Soil treatment

2, 3, & 9.	Soil aggregates below 1 mm.
4, 6, & 8.	" " from 1-4 mm.
1, 5, & 7.	" " above 4 mm.

TABLE XII.

PERCENT SEEDLING EMERGENCE IN GREENHOUSE PLANTING VII.

Soil treatment*	Days after planting				
	7	9	12	16	21
Percent emergence of 100 seeds					
1	30	44	51	54	53
2	18	26	36	35	36
3	76	86	84	83	80
4	9	16	31	30	29
5	55	61	52	53	51
6	7	13	14	15	14
7	59	70	68	68	68

*Soil treatment

1. Seeds planted 1 1/2 inches in depth and covered with saw dust mulch 1 inch deep.
- 2 & 6. Seed depth 1 1/2 inches, straw mulch.
- 3 & 7. " " 1/2 inch, straw mulch.
4. Control seed.
5. Sand mulch 1 1/2 inches deep over seed and covered with soil.

TABLE XIII.

PERCENT SEEDLING EMERGENCE IN FIELD PLANTINGS I & II.

Planting I.

Seed bed treatment*									
I			II			III			
Replicates									
A	B	C	A	B	C	A	B	C	
Seed Treat.**	Percent emergence per 50 inches of row								
1	47.4	53.9	57.6	51.3	52.8	50.7	60.3	50.7	48.8
2	53.4	52.4	62.1	55.5	49.8	49.9	52.7	46.8	54.8
3	48.9	39.5	57.9	39.7	53.2	46.0	59.7	45.0	43.3
4	67.6	68.9	69.8	43.6	58.7	51.3	58.5	62.3	59.8

Planting II.

1	26.3	43.3	50.4	67.2	56.9	40.5	74.0	87.5	65.7
2	29.8	60.9	55.3	59.4	54.3	38.1	91.8	87.0	76.6
3	59.7	63.0	60.8	60.0	48.0	46.3	66.6	57.6	60.7
4	37.0	41.8	52.4	68.7	61.2	59.4	74.3	83.6	57.3

Seed bed treatment*

I. Lightly worked soil seed bed.

II. Medium " " " "

III. Heavily " " " "

Seed treatment**

1. Calcium chloride seed treatment.

2. Water soaked seed treatment.

3. Control seed.

4. Phosphoric acid seed treatment.

TABLE XIV.

AIR PERMEABILITY DETERMINATIONS OF GREENHOUSE PLANTING VIII.

Manometer readings of pressure drop in seconds			
Soil treatment*	60 mm.	140 mm.	220 mm.
2	20.6	34.5	53.3
3	22.1	42.0	63.2
9	21.0	40.8	54.6
4	11.5	22.6	32.8
6	10.8	21.5	32.2
8	19.8	22.6	27.0
1	15.3	29.6	44.4
5	15.8	30.6	41.1
7	13.3	26.3	36.6

*Soil treatment

2, 3, & 9. Soil aggregates below 1 mm.

4, 6, & 8. " " from 1-4 mm.

1, 5, & 7. " " above 4 mm.

TABLE XV.

VOLUME WEIGHT DETERMINATIONS OF FIELD PLANTINGS I & II.

Planting I.

Replicates	Seed bed treatment*		
	I	II	III
A	1.361	1.327	1.339
B	1.334	1.303	1.404
C	1.370	1.420	1.435
average	1.355	1.360	1.426

Planting II.

A	1.270	1.346	1.524
B	1.263	1.307	1.524
C	1.327	1.304	1.446
average	1.283	1.340	1.531

*Seed bed treatment

- I. Lightly worked soil seed bed.
- II. Medium " " " "
- III. Heavily worked soil seed bed.

TABLE XVI.

POROSITY & PENTIMETER DETERMINATIONS ON FIELD PLANTING II.

Seed bed treatment*			
	I	II	III
Replicates	Percent capillary pore space**		
A	34.70	33.12	35.02
B	33.22	33.26	34.73
C	30.56	31.86	34.59
average	32.82	32.75	34.78
	Percent non-capillary pore space**		
A	23.82	22.97	16.47
B	24.13	22.06	16.05
C	23.04	24.04	19.01
average	23.66	23.02	17.18
	Depth of pentimeter penetration in mm.		
A	95.7	48.7	22.7
B	70.5	43.0	21.0
C	73.2	43.2	15.7
average	79.8	44.9	19.8

*Seed bed treatment

I. Lightly worked soil seed bed.

II. Medium " " " "

III. Heavily " " " "

**Pore space expressed as percent of total volume.

TABLE XVII.

STATISTICAL ANALYSIS OF VARIANCE OF FIELD PLANTING I.

source	degrees of freedom	sum of squares	mean square	level of significance
total	35	1996.92		
soil treat.	2	279.52	139.76	*
replication	2	9.69	4.85	NS
seed treat.	3	648.50	216.17	**
seed x rep.	6	117.88	19.65	NS
soil x rep.	4	316.28	79.07	NS
soil x seed	6	250.47	41.75	NS
soil x rep. x seed	12	374.58	31.21	

*Significance

**High significance

NS. No significance

For significance between means of seed treatment 5.68

For high significance between means of seed treatment 7.69

For significance between means of soil treatment 4.01

For high significance between means of soil treatment 6.66

MEANS OF SOIL & SEED TREATMENT

soil				seed			
I	II	III	1	2	3	4	
mean	228.13	208.33	214.23	159.50	159.13	144.40	180.16

TABLE XVIII.

STATISTICAL ANALYSIS OF VARIANCE OF FIELD PLANTING II.

source	degrees of freedom	sum of squares	mean square	level of significance
total	35	8382.10		
soil treat.	2	3081.24	1540.62	**
replication	2	316.03	158.01	NS
seed treat.	3	86.73	28.91	NS
seed x rep.	6	216.10	36.01	NS
soil x rep.	4	1434.30	358.57	**
soil x seed	6	1747.66	291.27	**
soil x rep. x seed	12	600.04	50.00	

**High significance

NS. No significance

For significance between means of soil treatment 6.40

For high significance between means of soil treatment 8.70

MEANS OF SOIL TREATMENT

Soil treatments

	I	II	III
mean	195.23	220.00	294.23

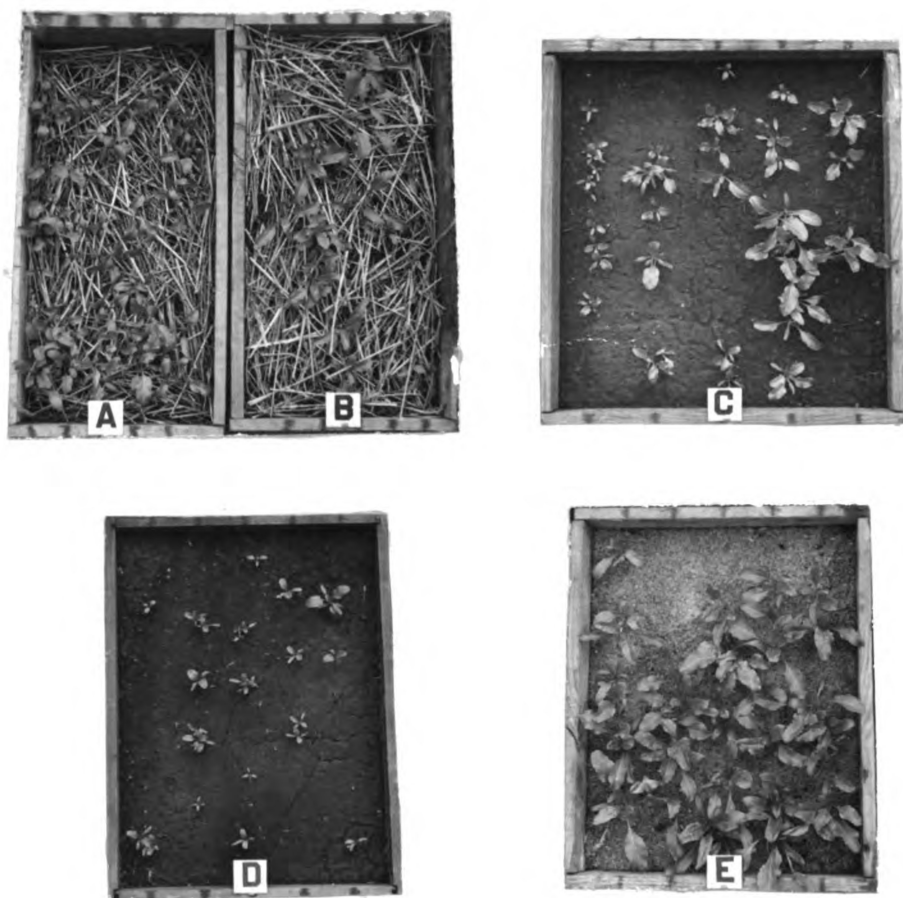


Figure I. Effect of mulch treatments on emergence of sugar beet seedlings.

- A. Straw mulch, seed depth $1\frac{1}{2}$ inch.
- B. Straw mulch, seed depth $1\frac{1}{2}$ inches.
- C. Sand mulch in rows over seed.
- D. Control.
- E. Saw dust mulch 1 inch deep over soil.



Figure II. Effect of phosphoric acid seed treatments on emergence and growth of sugar beet seedlings.

- A. phosphoric acid over beet seed in row.
- B. Control.
- C. Control.
- D. Beet seed soaked in diluted phosphoric acid solution.

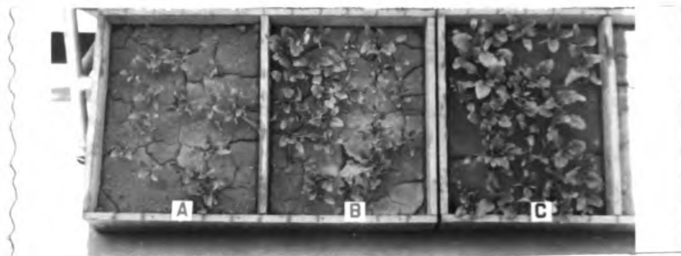


Figure III. Effect of soil aggregation on emergence of sugar beet seedlings.

- A. Soil aggregates above 4 mm.
- B. Soil aggregates ranging from 1-4 mm.
- C. Soil aggregates below 1 mm.

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