ACCELERATION OF WATER UPTAKE AND GERMINATION OF SUGAR BEET SEEDBALLS BY SURFACE COATINGS OF HYDROPHILIC COLLOIDS AND NUTRIENTS

BY

TAKAO MIYAMOTO

AN ABSTRACT

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The emergence of a sugar beet seedling is slow in dry soil due to retarded water absorption by the seed. In order to improve water uptake, the seed ball was treated with hydrophilic colloids. A thin film of hydrophilic colloid on the surface of the seed ball absorbed water easily from the surrounding soil and the seed took up water from the moistened film. The water absorption by the treated seed from sand containing 0.35% water was about 50% greater than the control 24 hrs. after planting. The emergence of seedlings from treated seed was also faster than the control. The algin "Keltex", in a 0.75% water solution, was used to moisten the seed balls in most cases.

The treated seed balls were stored in the laboratory and tested one year later. The speed of water uptake and emergence of treated seed was still greater than that of the control. This indicates that the treated seeds are perfectly storable.

Treating seed with the hydrophilic colloid speeded up germination, but the effect of the treatment on seedling growth amounted to only a 6% increase in weight of individual seedlings at 5 days after planting. In order to hasten the development of the seedling, Hoagland's nutrient solution five times ordinary concentration was mixed with 0.75% Keltex. The film of Keltex accelerated water absorption, and at the same time, the nutrient solution furnished additional nutrients to the growing seedling. The average weight of seedlings from the seed balls treated with the mixture of hydrophilic colloid and nutrient solution was about 20% more than that from the seed balls treated with the colloid alone.

Calcium nitrate was eliminated from the nutrient solution because this salt tended to coagulate the colloid and was inconvenient in the treatment. The effect of this elimination on the development of seedlings was found to be statistically non-significant.

Further improvement of the development of seedlings was accomplished by adding organic nutrients to the Keltex solution containing mineral nutrients. 1% sucrose and 0.05% asparagin so added gave further weight increase of seedlings of 9% and 16% in two different tests.

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Introduction

Sugar beet seeds* require a wetter soil for germination, and seedling emergence is slower than that of many other kinds of seeds. In many cases, after prolonged storage in semi-damp soil, the seed will mold and rot. Yet, the mechanization of spring work with this crop requires a prompt and uniform emergence of seedlings.

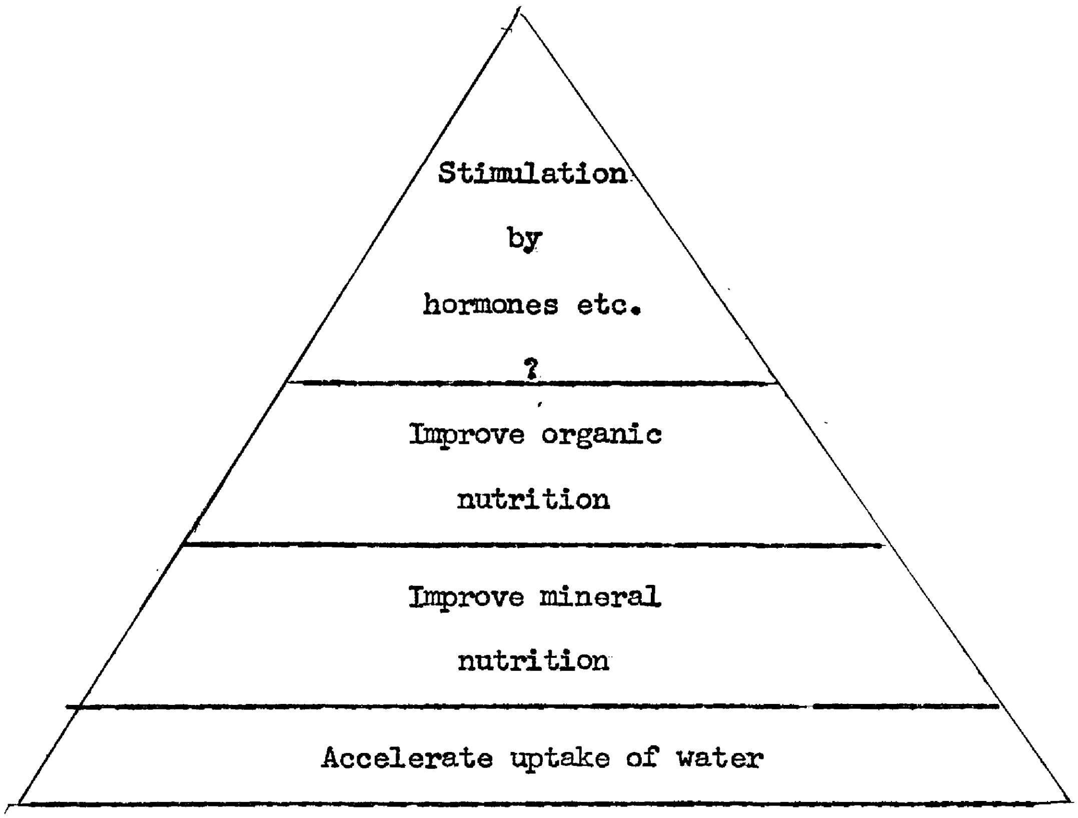
Numerous investigators (6,8,11) have reported that the removal of inhibitory substances from the seed coat promotes seedling emergence. However, it seems to be necessary to invent other ways of acceleration of emergence if the soil is rather dry. This thesis deals with the results of a study in which the author has found ways to promote seedling emergence in soils with low moisture contents.

Several possible ways were considered to improve seedling emergence. These were: (a) stimulate enzymes (b) improve mineral nutrition (c) improve organic nutrition (d) overcome dormancies (e) take up water faster (f) accelerate elongation.

In this study, the acceleration of water uptake was tested first because it seemed the most important factor for rapid emergence. The acceleration of water uptake and germination were accomplished by seed treatment with hydrophilic colloids, to give a thin surface layer of colloid.

In the next study, the acceleration of growth of seedlings by addition of mineral nutrients was attempted. The following diagram of a pyramid illustrates the approach used to improve the emergence and vigor of sugar beet seedlings.

*In this paper the terms "seed" and "seedball" are used almost interchangeably.


Stimulation
by
hormones etc.
?
Improve organic
nutrition
Improve mineral
nutrition
Accelerate uptake of water

Review of Literature

The relationship between sugar beet seed germination and soil moisture has been shown by many investigators. Doneen and MacGillivray (3) showed the moisture requirements of various seeds for germination using a Yelo fine sandy loam soil at different moisture contents. They found that most vegetable seeds gave good germination in the soil with more than 9% water, but beets required more than 11% water for good germination. Hunter and Erickson (5) reported, at 25°C, that a soil should have a moisture tension of not more than 12.5 atmospheres for corn kernels to germinate; 7.9 atmospheres for rice kernels; 6.6 atmospheres for soybeans; and 3.5 atmopheres for segmented sugar beet seeds. Hunter and Dexter (4) showed that sugar beet seeds did not germinate in relative humidities of 100% and must be in contact with some source of free water.

Direct contact of relatively dilute solutions of mineral salts to sugar beet seed has been recognized to slow down germination. Synder (10) reported that banding 100 pounds per acre (28-inch rows) of 10-10-10 fertilizer in contact with the seed at 14.7% soil moisture resulted in emergence of less and 50% of the potential stand in twenty days. He showed that the emergence was substantially delayed when seeds were placed one-half inch above the band of fertilizer as compared with seeds placed one inch to the side and one-half inch above the fertilizer. However, he did not test the effect of a very small amount of fertilizer in contact with the seed on emergence.

The effect of sugar on the growth of the seed embryo was studied by some investigators. Bulard (2) studied the embryo culture of Ginko biloba. He reported that normal growth of the excised embryo was obtained only when the cotyledons were in contact with the nutrient media and that the presence of sugar in the media was indispensable to growth. Brown and Gifford (1) cultured embryos of Pinus lambertiana. The basic medium was a modified Knop's solution to which 2% sucrose and 1% agar were added. Embryos grown with the radicle embedded in the sucrose medium exhibited immediate growth of all organs; the roots, however, grew only 1 to 2 cm in length during the first two to three weeks and thereafter became completely inhibited. In contrast, when the cotyledons were placed in the sucrose medium, leaving the radicle end free in air, growth of the root was rapid, reaching 5 to 8 cm in length before dying or desiccation.

There results might be interpreted to mean that a mixture of mineral salts and sugar is absorbed by the cotyledon and accelerate, especially, the growth of roots.

Materials

Sugar beet whole seed: U. S. -- 401, Lot No. 808.

Sugar beet decorticated seeds: U. S. -- 401, Lot No. 808, Size 7/64-10/64".

Sugar beet monogerm seeds: Size 8/64-9/64".

All sugar beet seeds were furnished by the F & M Beet Sugar Association.

Vegetable seeds were furnished by the Horticulture Department.

Field crops seeds other than sugar beets were furnished by the Farm Crops Department.

Keltex, Kelcogel, Kelcoloid L V and Kelgin L V were furnished by the Kelco Company.

Keltex is the trade name of algin (7).

Carbopol 934 was furnished by B. F. Goodrich Chemical Company.

Experimental Procedure

The surfaces of air dry seeds were dampened by immersion in dilute "solutions" of the various colloidal materials or the mixtures of colloidal matter and nutrients. The seed absorbed about one third its weight of solution. The treated seeds were redried for several days before use.

In the water absorption tests, weighed lots of treated and untreated seeds were placed in sand dampened to specific moisture contents. After various intervals the seeds were removed from the sand by screening, and reweighed to determine the uptake of water.

For use in the field, 10 pounds of segmented seed were treated by the author with a 0.75% solution of Keltex. Another 25 pounds of seeds were so treated by the research staff of the F & H Sugar Beet Association. These 35 pounds of seed were distributed to the research staffs of the Michigan Sugar Company, the Monitor Sugar Company, the Canada and Dominion Sugar Company, and the F & M. The seed was planted in many replicated plots throughout the sugar beet growing area in Michigan and Ontario. Results of counts to establish speed of emergence were furnished by this group.

In the laboratory emergence tests, seeds were planted in a screened Brookston clay loam taken from the plow layer of a field on the University farm. In order to make the soil moisture content uniform, an appropriate amount of water was added to 4.5 kg of the soil, and the the soil and water were well mixed and screened. The uniformly moistened soil was put into a metal tray of 4 x 8 x 12" dimensions.

Four or five plots were laid out in the tray and twenty seeds were planted in each plot at 1/2 inch depth. The tray was covered with a sheet of plastic to prevent rapid evaporation of water. After emergence took place, numbers and weights of seedlings were determined. Seedlings were dug up, the soil was removed from the roots and the weight of seedlings was determined. Tests were replicated five or six times, and the results were statistically analyzed.

Results

I. Acceleration of water absorption by means of seed treatment with hydrophilic colloids.

A. Water absorption by sugar beet whole seeds treated with various hydrophilic colloids from dampened sand.

Numerous weighed samples of 10 seeds were placed in 300 ml. Erlenmeyer flasks with 300 gms. of moistened quartz sand. Tests were duplicated and the average was calculated.

TABLE 1

Percent weight increase, due to water uptake from sand at various moisture contents, of seeds buried in sand.

Sand containing 0.35% water

Treatments/time hours	24	48	72	96	120
	%	%	%	%	%
0.75% agar	56	72	76	85	110
1.5% gelatin	60	70	93	94	97
0.75% gelatin	60	71	80	78	96
Control	41	58	66	75	83

Sand containing 0.50% water

Treatments/time hours	24	48	72	96
	%	%	%	%
0.75% agar	69	83	103	130
1.5% gelatin	66	77	87	92
0.75% gelatin	74	83	92	119
Control	50	66	70	87

Sand containing 0.35% water

Treatments/time hours	24	48
	%	%
1% Kelgin LV	71	94
1% Kelcogel	69	97
0.33% Carbopol	68	76
1% Kelcoloid	60	89
1% Keltex	85	102
Control	47	67

Table 1 shows that the hydrophilic colloid treatment accelerated water absorption from sand with 0.35 and 0.50% water. In sand with 0.35% water, a rather dry condition, the treatment with 1% Keltex gave the best result.

B. The best concentration of Keltex for the treatment of sugar beet seedballs.

Whole seeds were treated with various concentrations of Keltex solution. Water absorption was tested in the same way as in the previous experiment.

TABLE 2

Percent weight increase due to water absorption by seeds treated with solutions of several concentrations of Keltex from sand at various moisture contents.

Sand with 0.35% water

Conc. of solution / time hrs.	24	48	72	96
	%	%	%	%
0.25%	64	73	107	127
0.50%	66	76	106	121
0.75%	74	80	116	125
1.00%	73	89	98	112
Control	56	65	88	110

Sand with 1.0% water

Conc. of solution / time hrs.	0.5	1	3	5	8	14	24	48
	%	%	%	%	%	%	%	%
0.25%	12	17	29	38	47	61	70	91
0.50%	14	16	32	39	49	67	81	101
0.75%	17	18	31	39	58	75	86	105
1.00%	14	18	32	40	57	70	86	108
Control	11	14	22	34	42	52	63	85

Sand with 1.5% water

Conc. of solution / time hrs.	0.5	1	2	3	8	14
	%	%	%	%	%	%
0.25%	17	23	29	36	62	61
0.50%	18	25	31	42	65	77
0.75%	19	30	42	46	68	82
1.00%	27	33	51	54	77	89
Control	12	16	23	30	42	50

Table 2 (Continued)

Sand with 3.0% water

Conc. of solution / time hrs.	0.5	1	2	3	8	14
	%	%	%	%	%	%
0.25%	23	38	46	53	70	81
0.50%	34	32	74	53	86	86
0.75%	29	50	60	56	80	97
1.00%	33	46	63	76	85	105
Control	15	33	32	32	52	66

Table 2 shows that the 0.75% and 1.0% Keltex treatment gave greater water absorption than lower concentrations from sand with various moisture contents. Differences in water uptake between 0.75 and 1.0% Keltex were slight.

Fig. 1 shows germination of the treated sugar beet seed at 5 days after planting in sand with 0.35, 0.40 and 0.50% water.

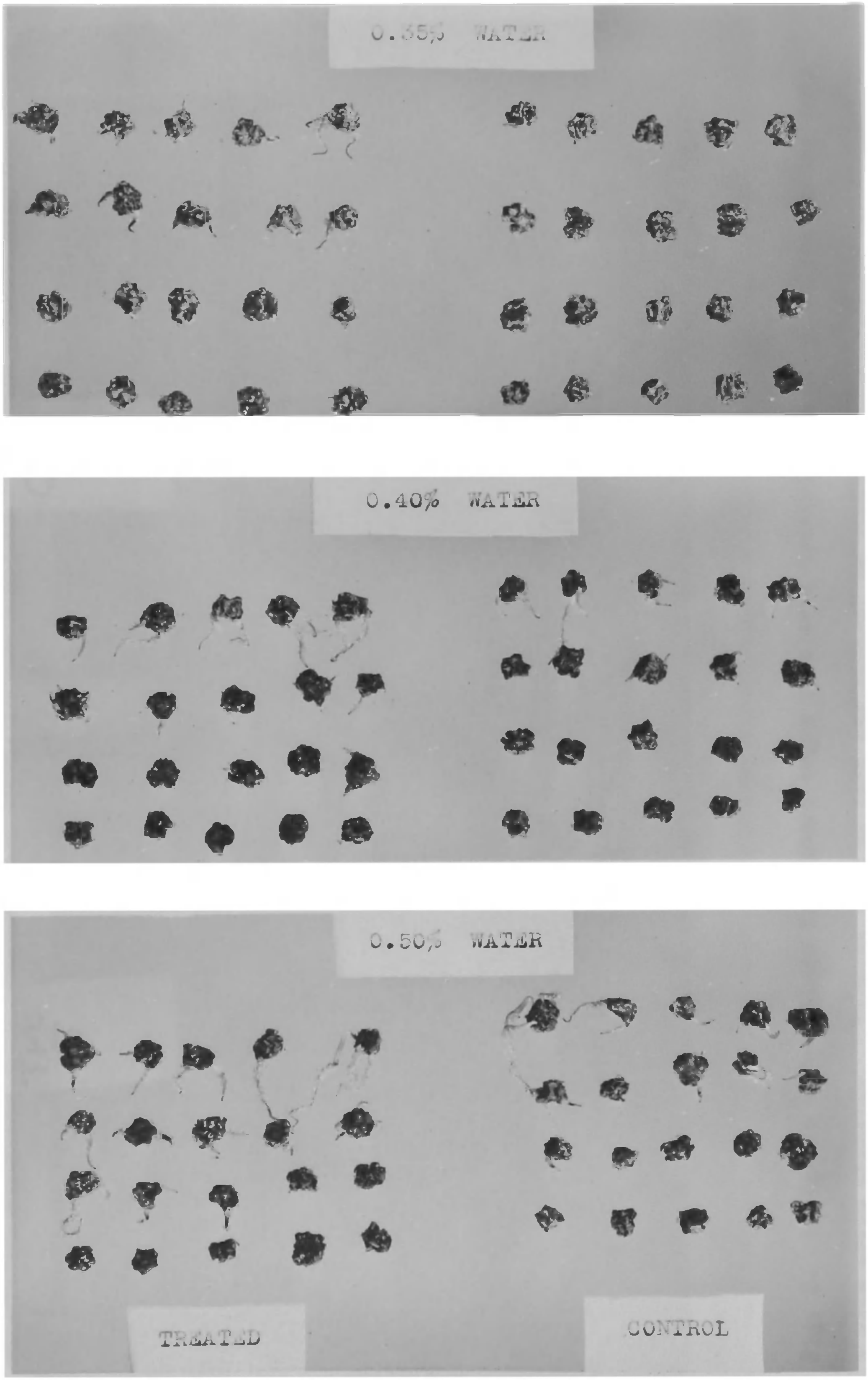


Fig. 1. Germination in sand of seed treated with 0.75% Keltex with various water content.

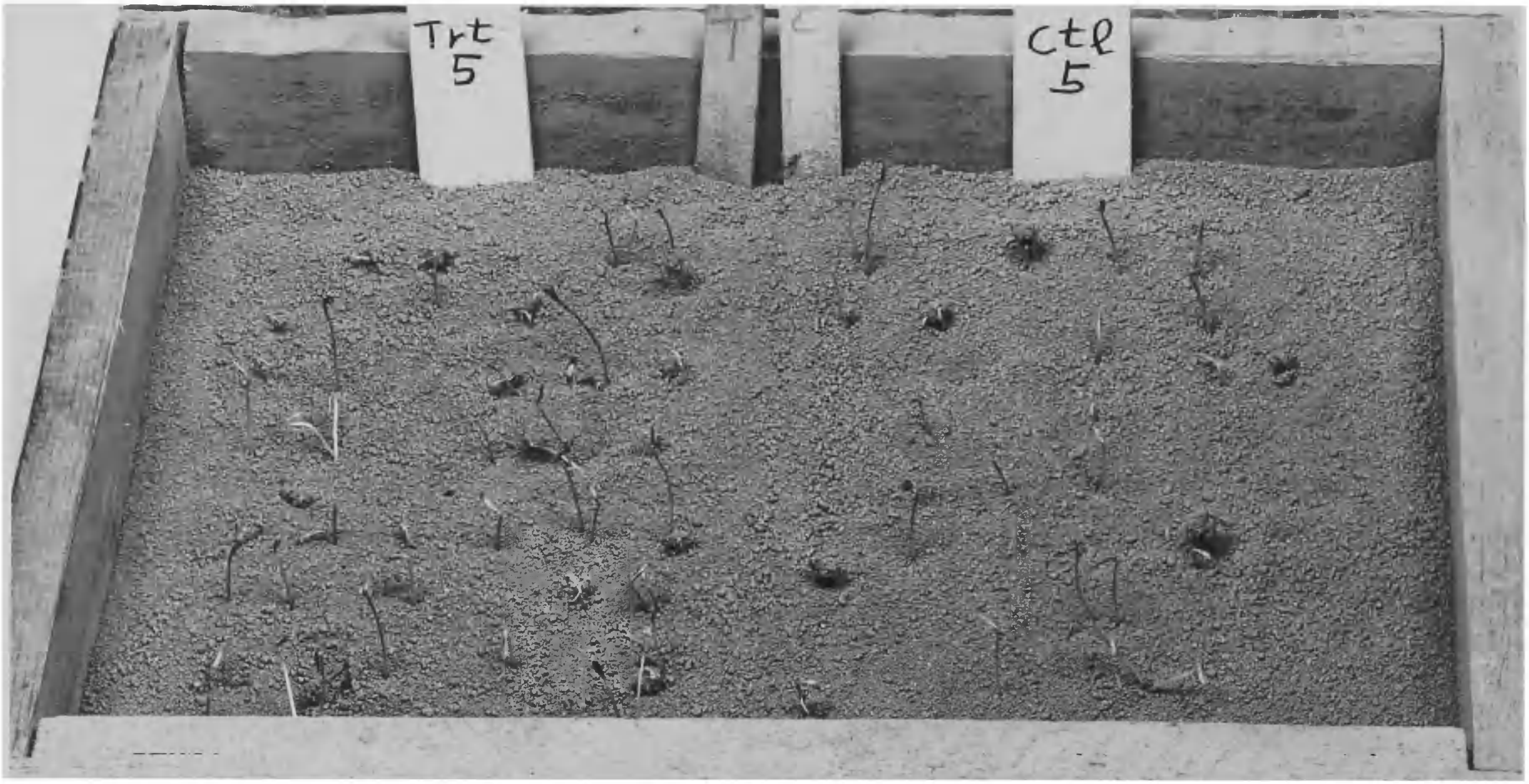


Fig. 2. Emergence of seedlings from whole sugar beet seed treated with 0.75% Keltex in the soil 5 days after planting. Treated seed on left and control on right.

C. Difference in speed of water absorption between sugar beet whole multigerm seed and monogerm seed.

Generally speaking, the emergence of seedlings from monogerm seed is slower than that of whole multigerm seed under the same conditions. In order to study the reason, water uptake by treated and untreated seeds of both kinds was tested in moist sand.

TABLE 3

Percent weight increase due to water absorption from sand with 0.35% water by monogerm and whole multigerm sugar beet seeds treated with Keltex and nutrient solution

Kinds of seeds	Treatments	Replications 1	2	3	4	5	Treat Total	Treat Average
	0.75% Keltex	79	75	76	74	78	382	76.4
Monogerm	0.75% Keltex + x5 N. S. -Ca $(NO_3)_2$	73	77	72	78	74	374	74.8
	Control	62	62	64	61	62	311	61.8
Whole seed	0.75% Keltex	79	78	85	83	81	406	80.1
	0.75% Keltex + x5 N. S. -Ca $(NO_3)_2$	80	79	79	83	82	403	80.0
	Control	67	72	64	71	70	344	68.8

Analysis of variance

Source	D. F.	S. S.	Variance
Replications	4	13.0	3.25
Kinds of seeds	1	1089.8	1089.80**
Treatments	2	246.5	123.25**
Interaction between Kinds and Treatments	2	4.1	2.05
Error	20	124.6	6.23
Total	29	1478.0	

R. E. (5% = 3.47 p = 3
(1% = 4.73

Table 3 shows that water absorption by monogerm is slower than multigerm seed, and the amount of acceleration of water uptake due to the same treatment is about the same in both kinds of seed.

D. An attempt to further improve water absorption of seed by using a wetting agent.

Monogerm and whole seeds were treated with a mixture of 0.75% Keltex and 0.1% "Tween Twenty". Water uptake of the treated seed from sand with 0.35% water was tested. Tests were duplicated.

TABLE 4

Percent weight increase due to water absorption by monogerm and whole sugar beet seeds treated with 0.75% Keltex and 0.1% "Tween Twenty" from sand with 0.35% water 24 hrs. after planting.

Kinds of seeds	Treatments	
	0.75% Keltex	65%
Monogerm	0.75% Keltex & 0.1% T. T.	68%
	Control	58%
	0.75% Keltex	78%
Whole seed multigerm	0.75% Keltex & 0.1% T. T.	73%
	Control	64%

Table 4 shows that the addition of 0.1% "Tween Twenty" to the treatment did not improve the water absorption appreciably.

E. Water absorption of sugar beet whole seeds treated with Keltex from atmospheres of various relative humidities.

Before the Keltex treatment was recommended for practice, water uptake from atmospheres of different relative humidities was investigated. Saturated solutions of barium chloride, sodium chloride and manganese chloride were used for controlling relative humidities at 91.2, 75.8 and 54.0% respectively. A 2 gm sample of seed was put in a desiccator with the saturated solution. After equilibrium was reached (one month), water absorption was determined. Tests were duplicated.

TABLE 5

Percent weight increase due to water uptake from atmospheres at various relative humidities after equilibrium was reached.

Treatments/Relative Humidity %	91.2	75.8	54.0
	%	%	%
0.1% Keltex	10.2	5.0	0.7
0.3% Keltex	10.8	5.4	1.1
0.5% Keltex	10.9	5.8	1.2
1.0% Keltex	16.5	6.0	1.0
3.0% Keltex	12.2	5.9	1.1

Table 5 shows little increase in moisture uptake from the atmosphere as a result of the seed treatment.

F. Storage of segmented sugar beet seed treated with 0.75% Keltex.

An attempt was made to test the effect of treatment on the longevity of the seed. Segmented seed was treated with 0.75% Keltex in April 1958. The treated seed was put into a bottle with a loose cover on top and stored in the laboratory for one year.

Water absorption by the stored seed from sand with 0.35% water was tested by duplicated tests. Treated seeds absorbed 56.7% of their original weight and the control took up 46.4% of water during the first 18 hrs. This indicates that the treatment was still effective for the acceleration of water uptake after storage for a year.

The germination capacity of stored seed in the dry soil was tested. Eighty seeds were planted in each tray. Tests were duplicated and the average was calculated.

TABLE 6

Emergence capacity of decorticated sugar beet seed a year after being treated with 0.75% Keltex. Tested in soil with 9.3% water.

Treatment/Time after planting days	4.0	4.5	5.0	5.5
	%	%	%	%
0.75% Keltex	15.0	60.1	83.7	85.0
Control	3.7	37.5	57.5	65.2

Table 6 shows that the treatment was still effective after one year and storage did not shorten the longevity of treated seed.

G. Emergence of seedlings from "decorticated" (7/64-10/64) sugar beet seed balls treated with 0.75% Keltex in the field in 1958.

TABLE 7

Germination in the field

Investigators	Days after planting	Seedlings/100 ft. Treated	Control	No. of replications or locations	Condition of soil
Frakes	9	347	50	10	very dry
Nichol	14 17	1434 1968	1440 2016	2	good
Reinsch	13 16	489 574	294 341	2	
Van Driessche	14	834	606	2	
F. & M. Assoc.	10 13 17	228 540 712	106 376 586	6	good
F. & M. Assoc.	10 20	780 792	592 664	3	

Table 7 shows that both field stand and speed of germination of the treated seed was greater than that of the control. Nichol observed little difference between the treated seed and control. The reason for this might be the good field condition.

H. Water absorption by treated seeds other than sugar beet from moistened sand.

Water uptake of seed from sand during the first 24 hrs. after planting was tested. Tests were duplicated.

TABLE 8

Percent weight increase due to water absorption by various seeds treated with 0.75% Keltex solution from sand with 0.35% water.

Kinds of seeds/water uptake	Treated	Control
	%	%
Buckwheat	40	33
Cabbage; Chieftain Savoy	61	59
Carrots; Danvers 126	73	59
Cauliflower; Burpenna	70	60
Celery; Goldenplume	146	77
Chewings fescue	67	55
Chinese cabbage; Michihli	65	59
Domestic ryegrass	56	50
Emmer; Spring speltz	31	29
Field peas	24	23
Flax	122	98
Hairy vetch	8	10
Lettuce; Empire	79	57
Millet; White proso	37	29
Oats; Jackson	45	38
Okra	34	36
Pepper; Sunnybrook	78	62
Radish; Burpee white	71	69
Rape	55	46
Reed canarygrass	50	43
Rye; Rosen	42	37
Rye; Tetrapetkas	36	30
Soybean	27	31
Spelt	30	26
Spinach; califlay	64	43
Sudangrass; Sweet	39	26
Tomato; Sunray	75	56
Wheat; Seneca	31	27

Table 8 shows that the treatment accelerated water absorption of all seeds except those of the Leguminosae, Brassica and Raphanus. Legume seeds often absorb water through the hilum area, and the water uptake by Brassica and Raphanus seeds is very rapid regardless of treatment.

An attempt was made to find a seed treatment with a mixture of hydrophilic colloid and mineral nutrient in order to get a combination effect of both acceleration of water uptake and mineral nutrients on emergence.

II. Acceleration of seedling development by means of seed treatment with a mixture of hydrophilic colloid and inorganic nutrients.

A. Water absorption from moistened sand by sugar beet whole seeds treated with mineral nutrients alone.

In the first trial, the concentration limit of nutrient solution for treatment was determined. Hoagland's nutrient solution without minor elements was used. Tests were duplicated.

TABLE 9

Percent weight increase due to water absorption by sugar beet seeds treated with nutrient solution of several concentrations from sand with 0.35% water.

Concentration/time hours	24	48	72
	%	%	%
X 1	69	—	95
X 3	65	—	102
X 5	64	89	100
X 10	65	88	103
X 25	67	85	87
X 50	68	80	90
X 75	63	—	86
X100	65	78	78
Control	64	88	101

Table 9 shows that nutrient solutions below 25 times concentration did not slow down water absorption.

B. Water absorption of sugar beet whole seeds treated with a mixture of mineral nutrient and hydrophilic colloid from moistened sand.

TABLE 10

Percent weight increase in 24 hours due to water absorption by sugar beet seeds treated with mixtures of hydrophilic colloids and nutrient solutions of several concentrations from sand with 0.35% water.

Treatments	%	Treatments	%
1.0% Keltex	89	1.5% gelatin	74
0.75% Keltex & x 5 N. S.	90	1.5% gelatin & x 5 N. S.	75
0.20% agar	82	1.5% gelatin & x 10 N. S.	75
0.30% agar & x 5 N. S.	76	1.5% gelatin & x 25 N. S.	76
0.30% agar & x 10 N. S.	73	1.5% gelatin & x 50 N. S.	72
0.30% agar & x 25 N. S.	73	1.0% gelatin & x 75 N. S.	67
0.30% agar & x 50 N. S.	70	Control	70

Table 10 shows that the addition of concentrated nutrient solution to the hydrophilic colloid for seed treatment generally reduced water uptake of seed to some extent in comparison to the use of hydrophilic colloid alone. The treatments with 0.75% Keltex and x 5 nutrient solution gave the most promising result.

C. Acceleration of sprout growth by treating seed with a mixture of Keltex and x5 nutrient solution.

TABLE 11

Germination of sugar beet whole multigerm seed treated with Keltex and nutrient solution in the soil with 11.5% water. 6 replications.

Treatments	3 days seedballs with emerged seedlings	4 days seedballs with emerged seedlings	4 days No. of seedlings	5 days No. of seedlings	5 days Total weight of seedlings gm.
0.75% Keltex	6.7	17.8	36.4	41.2	1.24
x5 N. S.	4.0	14.2	24.0	34.2	1.30
0.75% Keltex & x5 N. S.	8.6	18.0	34.8	41.6	1.50
Control	3.5	15.0	25.2	37.8	1.08

Average weight of individual seedlings in mgs 5 days after planting

Treatments/Replications	1	2	3	4	5	6	Treat. Total	Treat. Average
0.75% Keltex	33	32	27	26	30	32	180	30.0
x5 N. S.	40	38	36	36	33	34	217	36.2
0.75% Keltex & x5 N. S.	37	38	32	34	40	35	216	36.0
Control	30	28	27	29	28	28	170	28.3

Analysis of variance

Source	D. F.	S. S.	Variance
Total	23	418.0	
Treatments	3	295.8	98.60**
Replications	5	56.7	11.34
Error	15	65.5	4.36

R. E. (5% = 2.77 / (1% = 3.83   P = 4

Table 11 shows that the treatment with Keltex and x5 nutrient solution gave better results than other treatments i.e. faster emergence, thicker stand and larger seedlings.

D. Elimination of calcium ion from the nutrient solution which was used for mixing with Keltex.

The calcium ion tends to coagulate Keltex somewhat when used with x5 nutrient solution making seed treatment more difficult. Therefore the effect of seed treatment with a mixture of Keltex and x5 nutrient solution without calcium nitrate on sugar beet seedling emergence was tested.

TABLE 12

Germination of monogerm sugar beet seeds treated with Keltex and nutrient solution in the soil with 10.9% water.

Average weight in mgs of 10 best seedlings from 20 seed 6 days after planting.

Treatments/Replication	1	2	3	4	5	6	Treat. Total	Treat. Average
0.75% Keltex	37	35	34	33	33	37	209	34.8
x5 N. S.	36	37	36	35	39	37	220	36.7
0.75% Keltex & x5 N. S. - Ca $(NO_3)_2$	38	40	43	39	44	39	243	40.5
0.75% Keltex & x5 N. S.	39	38	39	38	39	40	233	38.8
Control	33	34	36	33	35	34	205	34.2
Reps total	183	184	188	178	190	187	1110	

Analysis of variance

Source	D. F.	S. S.	Variance
Total	29	236.0	
Treatments	4	170.7	42.67**
Replications	5	18.4	3.68
Error	20	46.9	2.35

F = 18.15**

(5% = 1.97
R. E. (1% = 2.68 P = 5

Table 12 shows that treatment with 0.75% Keltex and x5 nutrient solution without calcium nitrate gave the heaviest average weight of the ten best seedling though the difference between Keltex -- x5 nutrient solution treatment and Keltex -- x5 nutrient solution without calcium nitrate treatment was not significant.

A similar experiment was carried out using spinach seed. Spinach and sugar beet seeds are morphologically similar.

TABLE 13

Germination of spinach seeds treated with Keltex and nutrient solution in the soil with 9.8% water.

Average weight in mg of 10 best seedlings out of 20 seeds 6 days after planting.

Treatments/Replication	1	2	3	4	5	6	Treat. Total	Treat. Average
0.75% Keltex	55	61	60	62	55	58	351	58.5
x5 N. S.	56	62	63	59	58	62	360	60.0
0.75% Keltex & x5 N. S. - Ca $(NO_3)_2$	65	62	64	65	60	63	379	61.5
Control	54	54	56	56	52	58	330	55.0
Reps total	230	239	243	242	225	241	1420	

Analysis of variance

Source	D. F.	S. S.	Variance
Total	23	331.3	
Treatments	3	208.9	69.63**
Replications	5	66.3	13.26*
Error	15	56.1	3.74

For Treatments: R. E. (5% = 2.56 (1% = 3.55 P = 4

Table 13 shows that this treatment seems to be beneficial to spinach seeds. Spinach seeds do not require as high a soil moisture content as sugar beet seeds to germinate. This was the reason why soil with 9.8% water was used in this test.

III. Acceleration of seedling development by means of seed treatment with a mixture of hydrophilic colloid, mineral nutrients, organic nutrients and enzymes.

An attempt was made for further improvement of sugar beet seedling emergence by applying organic nutrients and enzymes in addition to the hydrophilic colloids. The addition may be beneficial if it does not slow down water uptake greatly.

A. Effect of the addition of organic nutrients and enzymes on the water absorption of sugar beet seeds from moistened sand.

Diastase, trypsin, barley malt and bean powder from sprouted beans were used for the improvement of endosperm digestion in order to accelerate the growth of the embryo and perhaps water uptake by the seedball. 4.4% of colloidal material was extracted from the surface of air dried buckhorn seed. A decoction was prepared by soaking 5 gms of air dried buckhorn seeds in 50 cc of water for 10 hrs. at 20°C and the resultant gelatinous mass through cheese cloth. Water absorption tests were duplicated.

TABLE 14

Percent weight increase of whole sugar beet seeds, treated with hydrophilic colloid and organic nutrients, due to water absorption from sand with 0.35% water.

Treatments/time hrs.	24	48	72
	%	%	%
0.75% Keltex	75	84	97
0.75% Keltex & 2% bean sprout	75	92	87
0.75% Keltex & 2% barley malt	72	82	101
10% buckhorn decoction	76	79	98
Control	58	64	75

Treatments/time hrs.	24	48	84	108
	%	%	%	%
3% starch	63	72	85	104
(3% starch (0.1% diastase (1% gelatin	69	86	92	96
(3% starch (0.1% diastase (1% gelatin (10^{-6}M trypsin	54	67	95	102
1% Keltex	64	79	94	123
Control	51	58	66	80

Table 14 (Continued)

Treatments/time hrs.	24	48	72
	%	%	%
1% Keltex	69	91	96
3% starch & 1% Keltex	64	80	96
Water	51	68	74
2% bean powder in Water	56	74	75
2% bean powder in 3% starch solution	56	82	74
2% bean powder in 1% Keltex solution	72	89	86
2% bean powder in 3% starch and 0.75% Keltex solution	67	85	89
Control	53	66	71

Table 14 shows that addition of organic nutrients and enzymes generally reduced water absorption from the sand only slightly if the organic nutrients and enzymes were used with Keltex. Treatment with the colloidal material from buckhorn seeds helped water uptake of sugar beet seedballs.

B. Germination of monogerm sugar beet seed treated with a mixture of Keltex, organic and inorganic nutrients.

An attempt was made for further improvement of the emergence or vigor of seedlings by adding sucrose and asparagin to the previous treatment with Keltex and mineral nutrient solution. Sucrose and asparagin are rather generally used in media for embryo sulture.

TABLE 15

Emergence of seedlings from monogerm sugar beet seeds treated with Keltex, x 5 nutrient solution and organic nutrients in soil with 11% water. Average weight, in mg, of 10 best seedlings from 20 seeds 5 days after planting.

Treatments/Replication	1	2	3	4	5	Total	Average
0.75% Keltex & x5 N. S. -Ca $(NO_3)_2$	36	37	34	34	38	179	35.8
0.75% Keltex, x5 N. S. -Ca $(NO_3)_2$ 1% sucrose & 0.05% asparagin	40	39	37	39	40	195	39.0
Control	32	32	30	31	35	160	32.0

Analysis of variance

Source	D. F.	S. S.	Variance
Total	14	155.6	
Replications	4	27.6	6.90**
Treatments	2	122.8	66.40**
Error	8	5.2	0.65

Treatments: R. E. (5% = 1.22; (1% = 1.80 P = 3

Table 15 shows that the addition of organic nutrients promoted seedling growth.

C. Appropriate amount of asparagin for seed treatment.

Various amounts of asparagin were added to the mixture of 0.75% Keltex, 1% sucrose and x5 N. S. -Ca $(NO_3)_2$. Monogerm sugar beet seeds were treated with these solutions. Emergence of the seedlings from treated seed was tested.

In Fig. 3 are shown typical seedlings resulting from addition of the inorganic and organic nutrients to algin "Keltex" for the seed treatment.

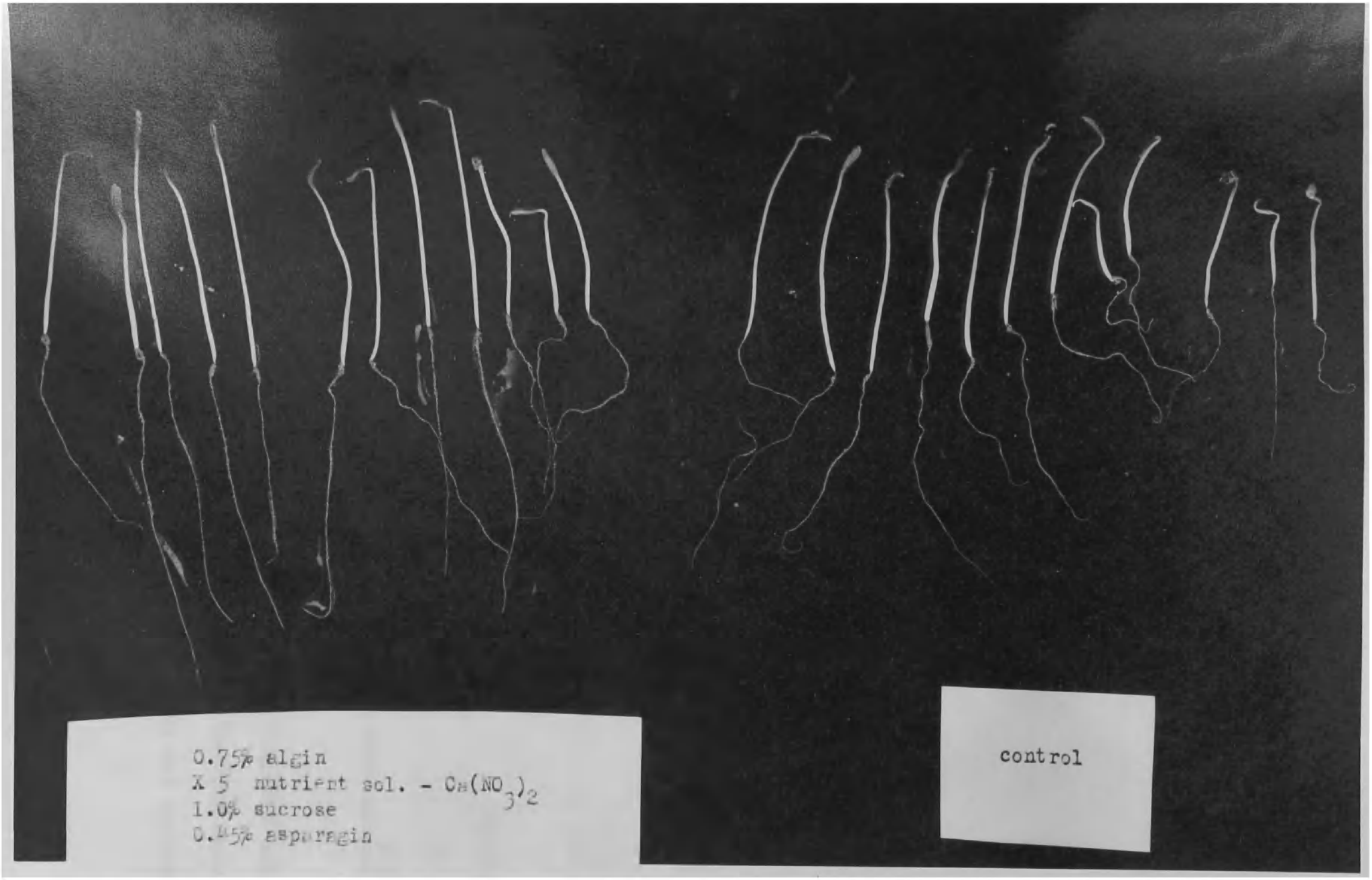


Fig. 3. Sugarbeet seedlings from monogerm seeds treated with 0.75% Keltex, x5 nutrient solution - $Ca(NO_3)_2$, 1% sucrose and 0.45% asparagin.

TABLE 16

Emergence of seedlings from monogerm sugar beet seeds treated with Keltex, x5 nutrient solution, sucrose and various amount of asparagin. The soil contained 11.5% water. Average weight in mg of 10 best seedlings from 20 seeds 5 days after planting.

Treatments/Replication	1	2	3	4	5	6	Total	Average
No sucrose, x5 N. S. No asparagin, 0.75% Keltex	39	40	39	36	40	39	233	38.8
1% sucrose, x5 N. S. 0.01% asparagin, 0.75% Keltex	42	42	41	39	43	41	248	40.1
1% sucrose, x5 N. S. 0.05% asparagin, 0.75% Keltex	42	43	42	48	47	43	265	44.3
1% sucrose, x5 N. S. 0.45% asparagin, 0.75% Keltex	43	42	46	47	43	42	263	43.8
Control	34	35	32	33	35	30	199	33.3

Analysis of variance

Source	D. F.	S. S.	Variance
Total	29	585.0	
Treatments	4	489.0	122.25**
Replications	5	18.1	3.62
Error	20	78.8	3.94

R. E. (5% = 2.63 P = 5
(1% = 3.56

Table 16 shows that the additions of 0.05% and 0.45% of asparagin gave the best results. However, difference between the two concentrations was not significant. The addition of 0.05% asparagin was apparently sufficient for the treatment.

D. The approximate amounts of materials added to sugar beet seed balls in the best treatment.

The amounts of inorganic and organic nutrients given to a single seed ball when it was treated with a mixture of 0.75% Keltex, x5 N. S. -Ca $(NO_3)_2$, 1% sucrose and 0.05% asparagin were calculated. The weight of a single seedball was assumed to be 0.02 gm for whole multigerm seed and 0.01 gm for monogerm. The percentage based on the dry weight of seed is given in the last column. The results are given in Table 17.

TABLE 17

Approximate amount of materials added to sugar beet seed balls in the best treatment.

Materials/Amount	For Monogerm per seed	For Multigerm per seed	Percentage of weight of seed
KNO_3	0.67×10^{-5}gm	1.34×10^{-5}gm	0.067
KCl	0.50	1.00	0.050
$(NH_4) NO_3$	0.13	0.26	0.013
$KH_2 PO_4$	0.11	0.22	0.011
$NH_4 H_2 PO_4$	0.38	0.76	0.038
$Mg SO_4 \cdot 7H_2O$	0.60	1.20	0.060
Keltex	2.47	4.95	0.247
Sucrose	3.30	6.60	0.330
Asparagin	0.17	0.33	0.017
Total	8.33	16.66	0.833

Discussion

From the figures given, it is evident that soil water uptake was greatly accelerated by coating sugar beet seedballs with hydrophilic colloid, even though uptake of water vapor from the air was not. Presumably the wetting and swelling of the colloid on the surface of the seed enables a rapid transfer of water to the seed itself. It seems likely, as well, that this wetting of the surface establishes more and better connections between the water films in the soil and the seed. In the case of sand that is definitely too dry for rapid germination, without treatment, the uptake of water by treated seed was enough more to promote germination.

In field trials, even when the treated and untreated seeds were planted in damp soil, some acceleration of germination due to treatment appeared in most cases. When the soil was dry and germination was slow the acceleration of germination by treatment was notable. In one trial Mr. Frakes reported that no other seeds emerged. In the trial for which he gave figures in Table 4, germination of treated seed was very prompt following a light rain on rather dry soil, while untreated seed responded very slowly. From the laboratory figures and field trials, it seems clear that such treatment not only promotes uptake of water from rather dry soil, but also keeps the seeds moist longer during the period when the soil is drying out, thus enabling germination to proceed under minimum moisture conditions.

The possibility is suggested that this principle may be applied widely to other seeds in which soil moisture uptake and retention is a problem, and particularly to small seeds that must be planted shallow.

Although treatment with hydrophilic colloid accelerated water uptake and germination, it was not found to accelerate the growth of seedlings appreciably. This led the author to make an assumption that the deficiency of nutrition in the seed was the limiting factor for the faster growth of seedlings from seed treated with the hydrophilic colloid only. When seeds were treated with a mixture of hydrophilic colloid and mineral nutrient solution the growth of seedlings, and especially the development of roots, was faster than that of seedlings from the seed treated with hydrophilic colloid only. It appears that certain inorganic materials in the nutrient solution were the limiting factors of the growth though it is not yet decided which element is most needed. When seeds were treated with mineral nutrients only, the germination was retarded. Perhaps a higher osmotic pressure caused by the addition of mineral nutrients was the reason for this slow down. However, the addition of hydrophilic colloid to mineral nutrient solution seemed to reduce the effect of osmotic pressure and hasten seed germination.

Further addition of organic materials to the treatment showed more improvement in the growth of seedlings. Perhaps, time is required for the seed enzymes to work and the organic food supply in the sugar beet seed is limited early in the life of the seedling. Therefore the external supply of organic substances might promote the growth of the seedling directly.

The effect of hormones etc. on the further improvement of the growth of seedlings was not completed in this study, although in preliminary trials gibberellin or 6-(substituted-purines (9) alone or in combination were not found to be helpful.

Summary

Surface coatings of seed with hydrophilic colloids were shown to be effective in accelerating water uptake from sand, and in accelerating emergence of seedlings from soil under ordinary planting conditions in the field. Addition of inorganic and organic nutrients to the hydrophilic coating promoted growth of seedlings in the soil.

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