The Use of Chemical Additives to Control Soil Crusting and Increase Emergence of Sugar Beet Seedlings¹

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During the past three years there has been considerable widespread interest concerning the possibilities of using chemical additives to improve the physical conditions of soils. The chemicals have the one direct effect of increasing the stability of soil aggregates, which in turn affects pore space, permeability, surface crusting, etc. This report is concerned primarily with the value of a few of the numerous chemical additives for controlling soil crusting arid increasing the emergence of sugar beet seedlings.

There has been a very limited amount of literature in technical publications to date reporting the value of additives for increasing emergence of plant seedlings. In a report summarizing the status of early research work with soil additives Martin $(3)^3$ noted that one-fifth pound of active conditioner per hundred square feet prevented serious crusting and greatly facilitated the emergence of bean seedlings and other vegetable crops. Others have made a similar observation (1) (4), but usually without reporting actual experimental results.

A problem of crusting exists, particularly on clay soil. There are approximately 55,000 acres of irrigated land on the Belle Fourche irrigation project in western South Dakota, two-thirds of which is a clay or clay loam soil. Sugar beets are grown commercially in the area and in some seasons the poor emergence of sugar beets is attributed to crusting.

The information in this report was obtained from stand counts of sugar beets in five trials conducted in 1952 and 1953. In three of these trials the emergence data were obtained as a part of field experiments designed to study early growth and production as affected by moisture x additive or fertility x additive. The last two trials were conducted to study emergence only. No discussion is made of the value of commercial fertilizer to increase emergence, early growth or production of the sugar beets even though such was a part of the trials conducted. A discussion of the response of sugar beets to fertilization in this area can be found in studies previously reported (2). (5), (6).

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* Figures in parentheses refer to literature cited.

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Experimental Procedure

The following trials were conducted on the Pierre clay at Newell, South Dakota, and on the Orman clay at Arpan, South Dekota:

Trial 1. VAMA was incorporated with Pierre clay soil at the rates and depths indicated in Table 1 *in* May of 1952. All rates of the additive occurred with and without starter phosphate consisting of 40 pounds of P_2O_5 per acre applied as triple superphosphate in bands 4 inches wide and 3 inches deep at the location of the sugar beet row. Application was accomplished by broadcasting the phosphate and/or VAMA on the soil surface and incorporated by the use of a Merry tiller. Each plot was 30 feet long and 4 beet rows wide. The treatments were completely randomized in each of the three replications.

Eleven decorticated sugar beet seeds were planted per foot of row by the use of an experimental belt type fertilizer applicator and appropriate furrow openers on May 13. The number of seedlings which had emerged were counted on May 21, 24 and 28 for two 100-inch sections of row in each plot.

Composited disturbed soil samples were collected for water stable aggregate analysis in July, 1952- These were collected from the unfertilized check plots and from the unfertilized plots treated with .20 percent VAMA to a depth of 6 inches.⁴

Trial 2. The four additive treatments given in Table 1 were placed on plots 70 feet long and 12 beet rows wide on the Orman clay in May, 1952. The four replications of these large plots were subdivided into 6 fertilizer plots each 35 feet long and 4 rows wide. The additive and fertilizer were broadcast on the soil surface and incorporated to a depth of 4 inches by the use of a garden size rototiller and a Merry tiller. The whole area was then harrowed once to firm the seedbed. Decorticated sugar beet seed was planted at the rate of approximately 6 pounds per acre with a commercial International drill on May 15. The number of plants emerged on *one* 100-inch section of each of the two middle rows of each 4-row plot was counted after emergence was complete.

Trial 3. In the spring of 1952, the Pierre clay on one-half of a series of 18 small plots, 9×30 feet, was aggregated with HPAN to a depth of 14 inches. The additive was applied by removing the soil with a small crawler-type tractor equipped with a front-mounted blade. As the soil was replaced, a little at a time, the additive was incorporated by the use of a small roto-tiller. Moisture treatments were superimposed and corn produced on the plots in 1952. The late fall irrigations and precipitation made the soil moisture content uniformly high for all plots as winter began.

In May of 1953 a seedbed was prepared by rototilling and harrowing. Decorticated sugar beet seed at the rate of approximately 6 pounds per acre was planted with a commercial type drill on May 5. The number of seedlings emerged was determined by counting six 100-inch sections of row in

 4 Aggregate analysis in all trials was determined at the Soil and Water Conservation Research Branch Laboratory at Mandan, North Dakota.

each plot on each of three dates. The soil temperature was determined on various dates by inserting a thermometer into the soil to the desired depth and taking the reading after a lapse of about one minute. Three such readings were made for each plot on each date.

Composite disturbed samples of soil were collected in July of 1952 for water stable aggregate analysis from the top six inches of soil on both the additive-treated and untreated plots.

Natural weather conditions were depended upon to produce a crust in the first three trials and a crust was produced artificially in the two trials which follow

Trials 4 and 5. These two trials were conducted on the Pierre clav in the fall of 1953. Decorticated sugar beet seed was planted with a handoperated garden drill on September 7 and 27 for Trials 4, and 5, respectively, VAMA, IBMA and CMC at 0 to 66 pounds per acre, treated area, were applied as a .3 percent water solution spraved in a band 4 inches wide on the soil surface above each planted row. The rates were obtained by maintaining a constant pressure in the portable hand sprayer and varying the length of time of application. There were four replications of the treatments on the 15-foot single row plots.

One day or more after the application of the additive, water from a garden hose was sprinkled on each row to insure the formation of a crust.

	Rate fo	or treated	Depth o	ť					
Additive	area incorp Pounds % of soil tion per acre weight (inche		tion (inches)	a. F	lants per	Percent aggregation >2.0 mm >2 mm			
Trial L. Pi	erre clax—I	1591		5/21	5/24	5799	674		
None	n			11	64	60	•/ •	79	61.3
VAMA	2502	.025	9	9	59	65		0.0	5115
VAMA	500*	.05	3	21	55	61			
VAMA	2502	.05	11/2	11	63	66			
VAMA	1000°	.10	3	12	65	64			
VAMA	2000 ²	.20	3	15	61	65			
VAMA	4000	.20	6	10	60	58		20.0	78.5
15, D. at .0	5 for any da	de la		NS	NS	NS			
Trial 2. Or	man clay—l	952							
None	0						32		
VAMA	330	.05	4				31		
HPAN	\$30	.05	4				31		
HPAN	1520	.20	4				58		
L.S.D. at .0	5						- 4		
Trial S. Pi	erre clay-li	953							
None	0			9	22	30		20.6	70.0
HPAN	4666	.10	14	22	37	46		38.6	93.7
L.S.D. at .05 for any date			7	7	7				

Table L .-- The Number of Plants Emerged Per 100 Inches of Row and the Percent of Water Stable Aggregates in the Trials in Which the Additives Were Incorporated With the Soll.

"The emergence reported is the average for the additive treatment receiving the various

fertilizer annents. 13 Applied in Dands 4 Inches wide in the sugar beet rows 22 inches apart; thus, actual rate is 4/22 of the announc given.

The end of the garden hose was placed in a one-gallon tan having nail holes punched in the bottom and held a few inches above the ground The amount applied to each plot was held constant by making the length of time of application to each plot about 45 seconds. The subsoil was dry and to facilitate germination it was necessary to apply supplemental water by gently sprinkling with water. This was applied after the other treatments and was gentle enough that a crust was not produced on the untreated soil between the rows.

The number of plants emerged per 100 inches of row was determined on three dates for both Trial 4 and 5.

Results and Discussion

The results of stand counts are given in Table 1. The data have been analyzed statistically and in no instance was an interaction between date x treatment found.

Trial 1 The number of plants emerged in Trial 1 was more than 60 percent of the total number of seeds planted. Such a proportion is a very good emergence. Neither the additive treatment nor the starter phosphate had any effect on emergence. There was no crusting problem and the soil moisture conditions were good. The results of the laboratory analysis given in I able 1, indicate that the percentage of water-stable aggregates was increased by treatment with additive. This effect was visibly apparent in the field.

Trial2Intrial2thenumber of plants emerged on the soil treated

with 1,320 pounds per acre of HPAN was 10 to 20 percent greater than that of the other treatments. Although not statistically significant, there was a tendency for the emergence on the plots treated with 330 pounds per acre of VAMA to be slightly greater then the emergence for either the same

rate of HPAN or for the untreated check.

Trial 3. A very definite increase in the emergence of plants and the aggregation of the soil was attributed to the treatment with HPAN in Trial 3. The total number of plants emerged per 100 inches of row was



Figure 1. Because of the difference in the soil temperature the snow method from the plots having normal soil before it melted on those plots with additive-treated soil. 30 on the untreated soil in comparison to 46 on the treated soil. In as much as there was very little crusting of the soil surface it is likely that other factors must be considered to explain this large difference. The additive-treated soil appeared to be more friable and less hard than the untreated soil. The degree of hardness of the soil below the surface is no doubt just as important as the surface condition termed "crusting," except that crusting is a more extreme and easily observed condition. It was also observed that during the period of germination and emergence the temperature of the additive-treated soil was higher than that of the normal soil.

Date		Soil temperature, degrees Centigrade							
	Mean air	14-toch	ո մշրտի	21/2-juch depth					
	temperature (Degrees C.)	Normal 1011	HPAN treated	Normal soil	HPAN				
April 8	0.6	7.3	6.5						
April 13	3.9	12.7	13.4	10.0	10.0				
April 20	12.2	14.2	15.5	13.0	13.8				
May 19	13.9	24.9	25.5	23.2	23.7				
May 27	22.2	23.1	23.9	22.1	22.6				

Table 2.—A	Comparison of	the	Temperature	of	the	Additive-treated	Soi1	and	Normal
Soil in Trial 3.									

Attention was first focused on the difference in soil temperature by the observance of a checkerboard pattern produced by the location of the melting snow on the morning of April 8, 1953, as shown in Figure 1. The rate at which the thin layer of snow melted was slower and the soil temper-. ature lower on the additive-treated plots. In contrast, the soil temperature data in Table 2 for the remainder of the spring season indicates that the additive-treated soil was "warmed up" more readily by the warm spring air. This factor may have been of importance in as much as the higher temperatures were favorable to the germination and growth of seedlings.



Figure 2. Typical appearance of a 4-inch band of soil treated with soil additive (VAMA at 12 pounds per acre). Left. Contrast with untreated check. Right. Note that the string crosses the band about 3 inches to the left of the division between treated and untreated area.

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Trials 4 and 5. There was no difference in the emergence attributed to additive treatment in Trials 4 or 5. It was possible to see the effect of the additive treatment on a thin layer of soil surface where the spray applications were made (Figure 2). Nevertheless, the soil just beneath the surface was hard and cracked.

Conclusions

The results of these studies indicate that the soil additives will aggregate and improve the physical condition of the soil. The emergence of sugar beet seedlings was increased, under the conditions of these trials, however, only when the additive was applied at rates of several hundred pounds per acre and incorporated to a depth of four or more inches in the soil. It is possible that emergence would have been increased with the shallower incorporations of additive, if crusting conditions had prevailed during the time such treatments were being tried.

An increase of emergence was not obtained in the trials where low rate spray applications of dilute solutions of the additive were made. Nevertheless there may be some value for such a procedure as in these trials rather a severe "crust" or "caking" was produced. These trials do indicate that we cannot expect surface applications of soil additives to control thick crusting or caking but they may be of value in controlling a shallow surface crust. The economy and ease of applying the additives as a dilute spray suggests that more trials of this type should be conducted under commercial field conditions. Low rates of application per acre can probably be more satisfactorily obtained by reducing the width of the treated area rather than reducing the rate on the area treated.

Summary

The value of chemical additives to increase the emergence of sugar beet seedlings was studied in five field plot trials on the clay soils of western South Dakota.

Application was made by broadcasting the additives on the soil surface and incorporating them to various depths in three of the trials. Natural weather conditions were depended upon to produce a crust on the soil surface.

Additives were also applied as dilute water solutions, .3 percent, sprayed on the soil surface in two of the trials. A rather severe crust was produced by applying water with a garden hose.

An increase in emergence attributed to the additive treatment was obtained in two of the three trials in which natural weather conditions were depended upon to produce a crust. Although no increase in emergence was obtained by the relatively economical surface spray method of application, this method may be satisfactory with less severe crusting conditions. The effect of the additive on the soil was visibly apparent in all of the trials.

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