The Effect of Synthetic Soil Conditioners on Soil-Aggregate Stability and the Production of Potatoes and Stringless Beans

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INTRODUCTION

During the past 5 years considerable attention has been given to the use of synthetic soil conditioners to improve the stability of soil aggregates and hence the allied physical properties of problem soils.

The soil conditioners are either calcium or sodium salts of organic polymers molecularly related to synthetic rubber and fibers. Either a hydrolyzed polyacrylonitril polymer (HPAN) or a modified vinyl acetate maleic acid (VAMA) compound has been the basis of most of the formulations now on the market.

The information now available indicates that the more commonly known conditioners will stabilize soil aggregates but will not form them (*5*)[2]. Some method of fragmenting a dense soil must be used in order to obtain beneficial effects from the stabilizing chemical. The physical conditions usually attained with sound seedbed-preparation techniques can be stabilized longer when the conditioners are effectively used. Widespread use of these chemicals in general farming is at present limited by their cost.

Until price reductions are feasible and more information can be obtained as to response of soils and crops and persistence in the soil, their use will have to be highly specialized, *i.e.*, in flowerbeds, home gardens, nurseries, and as a research tool. As it is possible that the establishment of production facilities and rising competition may effect price reductions, field and laboratory studies were initiated in Puerto Rico to evaluate the use of synthetic soil conditioners as a means of increasing crop production through improvement of soil structure.

MATERIALS AND METHODS

The experimental field was located near the town of Aibonito in the highlands of Puerto Rico. The soil has been classified as a Juncos clay, a Gray-Brown Podzolic medium-deep soil of the uplands, associated with the extensive, rather steep Múcara soils, but owing to its smoother relief it has a thicker surface soil and greater depth to parent rock. It is derived from massive tuffs, tuffaceous shales, and other volcanic rocks.

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[2] Italic numbers in parentheses refer to Literature Cited, p. 133.

Juncos clay has a 7-inch dark grayish-brown plastic, sticky, heavy-clay surface soil. It is underlain by a 14- to 20-inch layer of yellowish-brown, compact, plastic, sticky clay. Below this is a 10-inch layer consisting of disintegrated rock and fine-grained yellowish-brown silty clay loam. Below a depth of 30 to 40 inches are the tuffaceous rocks (*6*). Mineralogical studies of the soil reveal a very high content of feldspars, mostly albite and andesine, with traces of orthoclase (*3*). Montmorillonite predominates in the upper 8-inch layer with some kaolin, but in the 8- to 15-inch layer there is some illite in addition to the other two clay minerals. The exchange capacity reaches 58 m.e. per 100 gm. of dry soil with a clay content of 26 percent.

The experiment was laid out following a balanced incomplete-block design with 10 treatments, including control untreated plots, replicated 6 times in a 15-block arrangement. The plots were 6 by 4 feet in size. The soil conditioners used were formulations 6 and 9 of Krilium[3], dry powder, 100-percent active ingredient, and Aerotil[4], wettable flakes, 83-percent active ingredient. Each chemical was used at three rates: 900, 1,800, and 3,600 pounds to the acre.

The conditioners were applied on January 18, 1954, and carefully mixed with the uppermost 6 inches of soil. The check plots received the same mechanical treatment as the treated plots to minimize any possible differences other than those imposed by the treatments. Before the application of the conditioners the soil was given a preventive treatment with Aldrin at a rate of 1 quart in 50 gallons to the acre for the control of worms and mole crickets.

Potatoes of the Kennebeck variety were planted on January 20, 1954, in rows 2 feet apart, with seven plants to the row. A 10–6–14 fertilizer was applied at a rate of 1,000 pounds to the acre. The potatoes were harvested on April 14, 1954.

Stringless beans of the Bountiful variety were planted in the same plots on April 19, 1954. A 9–10–5 fertilizer was applied at a rate of 800 pounds to the acre. The beans were harvested between June 10 and 24, 1954. Three pickings were necessary to harvest the whole crop. Both the potato and the bean crops were irrigated by sprinkling whenever required.

At the time of harvesting the bean crop, soil samples were taken from each plot. Aggregate stability was determined in the 2- to 1-mm. size according to the method proposed by Brant, Bendixen, and Slater (*1*). This procedure requires that the aggregates be soaked for 2 minutes followed by

[3] Trade name for a number of organic polymers developed by the Monsanto Chemical Co., St. Louis 4, Mo.

[4] Trade name for the chemical supplied by the American Cyanimid Co., 30 Rockefeller Plaza, New York 20, N. Y.

wet screening for 15 minutes. The aggregates remaining in the 1-mm. sieve were oven-dried at 105° C. and percentage stability was determined by dividing the oven-dried weight by the weight of aggregates used originally.

EXPERIMENTAL RESULTS

SOIL-AGGREGATE STABILITY

Table 1 presents the data obtained on aggregate stability of the soils under various stabilizing treatments. The untreated soils had nearly 67 percent of water-stable aggregates. In general, the percentage of stable aggregates increased to over 73 to 78 at the lower level of conditioner treatment, 75 to nearly 87 at the intermediate level, and from almost 84 to 91 at the high level. At all levels formulation 6 of Krilium was the most effective soil-aggregate stabilizing compound. There were significant and even highly significant differences between the stability of soil aggregates in the check plots and in all the conditioner-treated plots, except in those where Krilium 9 was applied at the minimum level. The over-all differences were significant at the 1-percent level.

TABLE 1.—*Water-stable aggregates in Juncos clay as affected by treatment with 3 soil conditioners used at 3 levels*

Treatment identification No.	Treatment		Water-stable aggregates
	Conditioner	Rate per acre	
		Lb.	*Percent*
1	Check	—	66.9
2	Krilium 9	3,600	87.9
3	do.	1,800	78.0
4	do.	900	73.4
5	Krilium 6	3,600	91.1
6	do.	1,800	85.7
7	do.	900	78.1
8	Aerotil	3,600	83.5
9	do.	1,800	75.7
10	do.	900	75.4
L.S.D. at the 5-percent level			7.1
L.S.D. at the 1-percent level			9.5

The influence of synthetic soil-conditioning chemicals on the structural conditions of Juncos clay is shown graphically in figure 1.

POTATO YIELDS

Data on the yields of potatoes from untreated and soil-conditioner-treated plots are given in table 2. The over-all differences are significant,

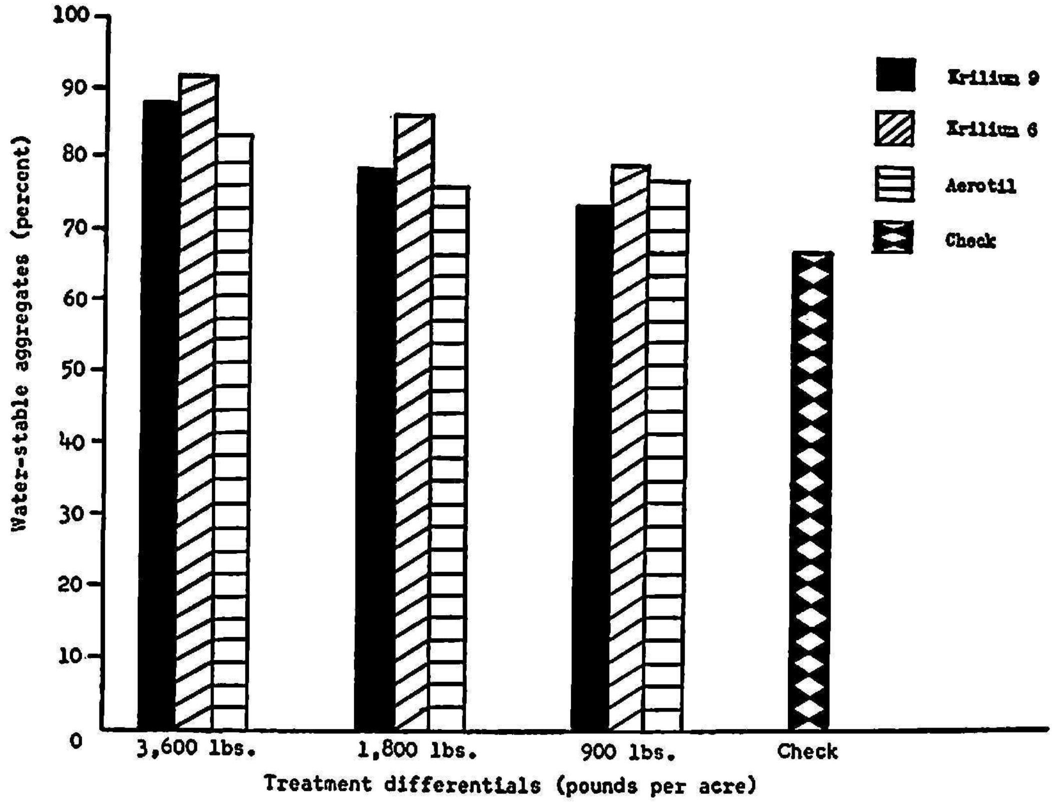

FIG. 1.—Effect of various soil conditioners at three rates of application on the stability of soil aggregates.

TABLE 2.—*Yield of potatoes on Juncos clay as affected by treatment with 3 soil conditioners used at 3 levels*

Treatment identification No.	Treatment		Yeld of indicated size per acre			Total
	Conditioner	Rate per acre	Large (over 2" diam.)	Medium (2"-1½" diam.)	Small (under 1½" diam.)	
		Lb.	*Cwt.*	*Cwt.*	*Cwt.*	*Cwt.*
1	Check	—	2.7	7.5	0.9	11.1
2	Krilium 9	3,600	4.4	9.7	1.5	15.6
3	do.	1,800	4.6	9.1	1.1	14.8
4	do.	900	5.4	6.7	1.1	13.2
5	Krilium 6	3,600	5.5	8.4	1.1	15.0
6	do.	1,800	5.7	6.1	1.2	13.0
7	do.	900	2.9	8.8	1.3	13.0
8	Aerotil	3,600	4.1	8.3	1.2	13.6
9	do.	1,800	4.4	9.4	.7	14.5
10	do.	900	2.7	9.7	1.3	13.7
L.S.D. at the 5-percent level			2.1	2.1	0.5	2.0
L.S.D. at the 1-percent level			2.8	2.9	.6	2.7

with yields in most treated plots significantly higher than in the check plots, except at the low levels of both Krilium formulations and in the intermediate level of Krilium 6. The mean significant differences in tuber yields range from approximately 2.5 to 4.5 hundredweights to the acre. Table 2 further shows that there was a significant tendency in some of the conditioner-treated plots to produce larger tubers. These larger tubers were as a rule well-shaped with a mean diameter of over 2 inches on the longer axis.

TABLE 3.—*Yield of stringless beans on Juncos clay as affected by treatment with 3 soil conditioners used at 3 levels*

Treatment identification No.	Treatment		Yield per acre at indicated picking			Total
	Conditioner	Rate per acre	1st.	2nd.	3d.	
		Lb.	*Cwt.*	*Cwt.*	*Cwt.*	*Cwt.*
1	Check	—	46.4	104.0	25.9	176.3
2	Krilium 9	3,600	52.1	102.5	18.0	172.6
3	do.	1,800	46.0	99.9	24.9	170.8
4	do.	900	39.2	93.2	25.4	157.8
5	Krilium 6	3,600	44.6	102.0	27.0	173.6
6	do.	1,800	64.0	107.0	18.6	189.6
7	do.	900	43.7	98.6	26.0	168.3
8	Aerotil	3,600	48.2	103.3	22.0	173.5
9	do.	1,800	46.5	92.2	26.2	164.9
10	do.	900	62.5	102.8	17.5	182.8
L.S.D. at the 5-percent level			15.5	16.1	9.3	22.2
L.S.D. at the 1-percent level			20.8	21.5	12.4	29.7

STRINGLESS-BEAN YIELDS

The tests with stringless beans were made to determine the influence of soil-conditioner treatment on a plant of a different kind. In other areas it has been shown that not all crops respond to conditioner treatment (*4*). The beans were planted shortly after harvesting the potatoes. The mean crop yields are shown in table 3. There were no significant differences in total yields. The treatments had no effect on bean-crop maturity either.

DISCUSSION

Previous work by Jefferies, *et al.* (*3*), has indicated that Juncos clay contains slightly over 20 percent of free oxides and organic matter. This perhaps may explain the rather high percentage of water-stable aggregates in the untreated soil, as reported in table 1. Increases as high as 97 percent were obtained with the treatments in individual plots. Potato tuber production was definitely affected in a beneficial way by the increased stability of aggregates obtained from treatment. The increases in yields ranged from almost 20 to 40 percent in extreme cases. These yield increases are not exciting in view of the extremely high expenses that farm-scale application of the conditioning chemicals would entail at current prices. Furthermore, even if some of these conditioners have been observed to have persistent effects on the soil (*2*) for more than 2 or maybe 3 years in cooler regions, it is very possible that their action would decrease with time in warmer areas.

The lack of response of the bean, in contrast to the potato crop, to improved soil-aggregate stability stresses the importance of plant differences in assessing soil characteristics in experimental work. All crops do not respond in similar fashion to changed physical conditions in the soil. What might prove useful for a given crop might be worthless for another.

Under present conditions it seems worthwhile to study the possibilities of using cheaper materials such as filter-press cake, bagasse, sawdust, and crop residues for the improvement of soil structural conditions rather than using the costly synthetic polymers.

SUMMARY

Data are presented here on the effect of the synthetic soil conditioners Krilium (formulations 6 and 9) and Aerotil on the aggregate stability of Juncos clay and on the yield of potatoes and string beans.

The conditioners used were formulations 6 and 9 of Krilium, dry form, and Aerotil, wettable flakes, each at rates of 900, 1,800, and 3,600 pounds to the acre.

At all levels Krilium 6 showed the highest aggregate-stabilizing capacity. Significant and highly significant differences were obtained between the stability of soil aggregates in the check plots and in all conditioner-treated plots, except where Krilium 9 was used at the minimum level. The production of potatoes of the Kennebeck variety was significantly increased by conditioner treatment, except at the low levels of both Krilium formulations and the intermediate level of formulation 6. Stringless beans did not respond to the increased stability of soil aggregates, which stresses the importance of recognizing crop differences in assessing soil characteristics.

RESUMEN

Se presentan aquí datos sobre el efecto de tres acondicionadores sintéticos de suelos en la estabilidad de los agregados, o unidades estructurales, del suelo Juncos arcilloso y en los rendimientos de papas y habichuelas sin fibra.

Los acondicionadores probados fueron Krilium 6 y 9 y Aerotil, cada uno

a razón de 900, 1,800 y 3,600 libras por acre. El Krilium 6 fué el mejor agente estabilizador de agregados. Se obtuvo diferencias significativas entre la estabilidad de los agregados en los suelos de las parcelas testigos y en los de las parcelas que recibieron tratamiento químico, excepto donde se usó la cantidad mínima de Krilium 9. La producción de papas de la variedad Kennebeck aumentó significativamente con los tratamientos, excepto con los niveles bajos de Krilium 6 y 9 y con el intermedio de Krilium 6. Los rendimientos de habichuelas sin fibra no se afectaron significativamente como resultado de los efectos de los tratamientos en la estabilidad de los agregados del suelo. Esto señala la necesidad de reconocer las diferencias entre las plantas al evaluar las propiedades del suelo.

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