GENERAL AGRONOMY

Comparison of the Effects of Manures and Commercial Fertilizers on the Yield of Sugar Beets[1]

ROBERT GARDNER and D. W. ROBERTSON[2]

Manures and commercial fertilizers are recognized as good sources of plant nutrients. Manures, however, contribute many things to the soil which are not contained in commercial fertilizers. The two classes of materials are therefore not wholly comparable, but some comparisons are useful as an indication of the extent to which commercial fertilizers can be substituted for manures. The results of such comparisons are now being obtained in an experimental program on the Agronomy Farm of the Colorado Agricultural Experiment Station.

The following report covers the effects of manures and commercial fertilizers on two crops of sugar beets in an experiment designed to continue through an 8-year rotation. The rotation has not yet been completed but the effects of the treatments on the yields of the two crops of sugar beets are believed to be of sufficient interest to justify reporting them before completion of the experiment.

The sequence of the crops in the rotation is as follows: Sugar beets, small grain, sugar beets, alfalfa (4 years), and corn. The experiment began with sugar beets which were preceded by corn. The corn followed alfalfa. The soil is Fort Collins loam and is naturally very fertile, but it had not received any manure in more than 10 years when the experiment was started. However, the land had been in a previous fertilizer experiment beginning in 1935. The previous fertilizer treatments consisted primarily of varying rates of nitrogen application but several phosphate treatments were also applied. The effects of some very heavy phosphate applications were still evident in 1941 but no evident effects of the nitrogen treatments remained. The previous experiment was reported in an earlier paper (1)[3].

Because of the previous experiment on the land it was necessary to retain the original plot arrangement which consisted of 4 blocks of 21 plots each. It was also necessary to arrange systematically the treatments superimposed on the previous phosphate-treatment plots.

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[2]Agronomists, Colorado Agricultural Experiment Station, Fort Collins, Colo.

[3]Italic numbers in parentheses refer to literature cited.

Table 1.—Soil treatments.

No.	Manure (5 tons/acre) Kind	Date	Treble superphosphate Rate/acre	Date	Ammonium sulphate Rate/ acre	Date	Potassium sulphate Rate/acre	Date	Sodium sulphate Rate/acre	Date
1	(check)								99 pounds	April
2										1942
3			5,000 pounds	June 1935						
4			5,000 pounds	June 1935	(649 pounds	April 1942				
					(165 pounds	April 1944				
5			5.000 pounds	June 1935	(649 pounds	April 1942	(314 pounds	April 1942		
					(166 pounds	April 1944	(223 pounds	April 1944		
6			(150 pounds	April 1942	(649 pounds	April 1942				
			(110 pounds	April 1944	(728 pounds	April 1944				
7			(150 pounds	April 1942	(649 pounds	April 1942	(314 pounds	April 1942		
			(116 pounds	April 1944	(728 pounds	April 1944	(349 pounds	April 1944		
8					(649 pounds	April 1942				
					(728 pounds	April 1944				
9	Old	Oct, 27, 1941								
10	Old	Oct. 15, 1941								
11	Old	Oct. 15, 1941	60		pounds	April 1942				
12	Artificial	Oct. 27, 1941								
13	Old	April 10, 1942								
14	Old	March 27, 1942								
15	Fresh	April 10, 1942								
16	Fresh	April 11, 1942*								
17	Fresh	March 27, 1942								
18	Fresh	March 27, 1042			113 pounds	April 1942				
19	Artificial	April 10, 1942								
20	Straw	April 10, 1942	636 pounds	April 1942	601 pounds	April 1942				
21	Alfalfa	April 10, 1942								

*Spread on surface after plowing

These included 5 plots in each block. The new treatments were randomized in the other 16 plots of each block. A total of 21 treatments are included. These are outlined in Table 1. All the manure and other organic materials were applied at the rate of 5 tons of dry material per acre. The individual treatments are discussed in connection with the comparisons made in presenting the experimental results shown in table 2.

Table 2.—Effect of fertilizers on beet crop.

Treatment No.		Tons beets 1942	Tons beets 1944	Pct. sucrose 1942	Pct. sucrose 1944	Tons sucrose 1942	Tons sucrose 1944	Pct. stand 1942	Pct. stand 1944
1	(check)	11.42	11.21	15.3	18.3	1.75	2.05	90.6	09.9
2	(S)	13.02	12.55	15.5	18.8	2.02	2.36	92.6	79.5
3	(P)	14.86	15.32	15.5	19.0	2.30	2.91	98.9	81.4
4	(NP)	18.24	17.48	15.3	18.9	2.79	3.30	97.4	85.5
5	(NPK)	18.19	10.31	15.2	18.8	2.70	3.07	92.4	84.9
6	(NP)	17.44	17.31	15.2	18.2	2.65	3.15	95.4	85.1
7	(NPK)	17.05	10.68	15.5	18.2	2.04	3.04	98.3	80.0
8	(N)	14.90	12.74	15.4	18.1	2.29	2.31	94.8	81.4
9	(Old manure.)	15.08	14.21	15.9	18.7	2.49	2.66	90.1	80.9
10	(Old manure)	15.43	14.37	15.7	18.9	2.42	2.72	94.4	75.4
11	(Old manure)	15.76	15.33	15.S	19.2	2.49	2.94	100.5	89-5
12	(Art. manure)	13.01	J 4.35	15.9	19.1	2.10	2.74	96.8	86.1
13	(Old manure)	15.56	14.59	15.0	19.0	2.43	2.77	96.8	81.1
14	(Old manure)	15.62	15.18	15.7	19.1	2.45	2.90	98.3	84.5
15	(Fresh manure)	17.62	14.34	15.3	18.3	2.70	2.02	93.9	84.1
10	(Fresh manure)	15.03	14.19	15.8	18.6	2.47	2.64	100.5	84.5
17	(Fresh manure)	10.45	15.46	15.2	18.0	2.50	2.88	92.8	74.5
IS	(Fresh manure)	17.58	16.28	15.3	19.0	2.69	3.09	90.8	89.9
19	(Art. manure)	13.93	12.33	15.7	18.8	2.19	2.32	92.5	92.5
20	(Straw 4- NPK)	10.03	18.00	15.1	18.7	2.42	3.38	90.5	88.2
21	(Alfalfa)	18.08	16.04	15.2	19.2	2.75	3.08	97.8	80.4
		332.12	314.33	325.1	393.5	51.36	58.93	1008.1	1741.3
	Mean	15.82	14.97	15.58	18.74	2.446	2.806	95.62	82.91
	(S. E. of diff.) x 2	1.72	2.69	.441	.508	.290	.510		

Experimental Results

Effect of the Nitrogen, Phosphorus, and Potassium Balance on Crop Yields.—The treatments numbered 3, 4, 5, 6, 7, and 8 in Tables 1 and 2 are commercial fertilizer treatments. These may be compared with each other and with the manures numbered 9 to 21. Numbers 3, 4. and 5 had previously received very heavy phosphate applications, 6 and 7 light applications, and 8 no phosphate. The fertilizers put on in 1942 were applied at rates for each constituent equal to the soluble amount of that constituent in the fresh manure applications. Treatment 2 was added to the experiment as an additional check to determine the possible effects of sulphur in the ammonium sulphate used as the nitrogen carrier.

A comparison of treatments 1 and 3 shows an increased yield of 3.44 tons in 1942 and 4.11 tons in 1944 resulting from the heavy phosphate application in 1935. Comparing treatment 4 and 3 shows that adding nitrogen to the phosphated plots increased the yield 3.38 tons more than the phosphate alone in 1942 and 2.17 tons in 1944. There was no significant difference between the results where nitrogen, phosphorus, and potassium were all three applied in treatment 5 and those where only the two elements were applied in treatment 4. It is evident from these results that potassium was not a limiting factor in the soil.

Numbers 4 and 5 were treated again for the 1944 crop at rates of application comparable to the insoluble constituents in the fresh manure, the purpose being to make the nutrients applied by each fertilizer in the two applications equal in amount to the same elements applied in the manure. It was also desired to see what the effect on the second crop would be of applying fertilizer constituents approximately equal to another application of manure. Applications were therefore made to numbers 6, 7, and 8, in 1944 in amounts approximately equal to the total of each constituent in a manure application of 1942. These heavier applications resulted in a significant reduction of sugar percentage., indicating that the nitrogen was slightly in excess of the needs of the crop. A comparison of the sucrose percentages of treatments 6, 7, and 8 with most of the other treatments shows significantly lower percentages in these treatments.

Comparison of the Effects of Manures and Commercial Fertilizers on the Yields of Beets.—Treatment 7 received the same amount of nitrogen, phosphorus, and potassium as there was in the soluble portion of the manure applied to treatments 15 and 18. The yields are nearly the same. Since treatments 6 and 7 also gave nearly the same yields, the results indicate that the increased yields in this experiment resulting from either the manures or commercial fertilizers can be attributed to the nitrogen and phosphorus in these materials. It is apparent that so far as the sugar beet crops in this experiment arc involved commercial fertilizers were able to take the place of manure. Economically, the use of so much fertilizer probably would not be feasible. Additional fertilizers were used on the fertilizer plots in 1944 and the yields were greater than on the manure plots, indicating that the manure added in 1942 was not adequate for the two crops of beets and the grain crop produced in 1943.

Relative Values of Old and Fresh Manures and Fall and Spring Applications.—Well-decomposed manure usually is considered superior to fresh manure. The fresh manure in this experiment, however, produced slightly higher yields than the older material. A comparison of the yields from treatments 13 and 14 with 15, 16, 17, and

18 will show that the yields are slightly better for the latter group which are the fresh manure treatments.

Fresh manure was not available for fall application but comparisons were made of old manure from the same pile applied both in the fall and spring. There is no evident difference in the results.

Application of Manure before plowing and after Plowing.—Treatment 16 was spread on the surface of the soil just after plowing and was tlisked into the soil. The only difference in treatments 15 and 16 is that manure in 15 was spread on the soil just before plowing and manure in 16 just after. The beets in No. 16 grew much faster early in the season but the yield was 2 tons per acre less in 1942 than on the land where the manure was plowed under. The 1944 yields are practically the same for both treatments.

Decomposed and Undecomposed Artificial Manure and Alfalfa as a Manure.—Treatments 12 and 19 were well decomposed artificial manure made by adding water, ammonium sulphate, finely ground limestone, and treble superphosphate to straw and allowing the mixture to decompose in a pile. The material was analyzed and, on the basis of the analysis, enough ammonium sulphate and treble superphosphate and fresh straw were applied to the soil as treatment 20 to equal the constituents of the artificial manure. The potassium in the straw was slightly higher than in the artificial manure.

A comparison of treatment 20 with treatments 12 and 19 shows that the undecomposed straw supplemented with nutrients equal to the artificial manure produced decidedly better results than the artificial manure. (Similar results have previously been observed with artificial manures by Heck *(3, 4)*.

Because of the high plant nutrient content of alfalfa it has sometimes been used as manure and frequently is available in small quantities at stack bottoms. Alfalfa was therefore used in the test. It ranked about equal to the straw and fertilizers over the 2-year period and was slightly superior to the other manures.

Loss of Manure in Storage and from Delayed Plowing after Spreading in the Field.—Manure is known to be a somewhat perishable product and suffers losses both in storage and after spreading in the field. Some observervations on this problem were made in this experiment,. The results of this study have already been reported elsewhere *(2)* by the writers. Under the conditions of storage in an open pile, manure from the same Jot of fresh manure used in the fertilizer experiment lost more than 50 percent of its nutrients and organic matter in a year. When spread on the soil for 2 weeks before plowing, a loss of a little over 20 percent of the nitrogen occurred.

This latter loss did not affect the yield significantly as is shown by a comparison of treatments **10** and 11 and 18 and **19.**

Summary

A field plot experiment now in progress to study the comparative values of manures and commercial fertilizers has given the following results:

1. Phosphorus and nitrogen were both found to be deficient in the soil. Phosphorus added as commercial fertilizer gave approximately 3.5 tons increase in yield of sugar beets. Phosphorus and nitrogen gave approximately 7 tons increase. Addition of potassium to the combination gave no increase over the nitrogen and phosphorus.

2. Nitrogen and phosphorus fertilizers applied at a rate to give the same amount of these elements as there was in the soluble portion of an application of manure gave increase in sugar beet yields equal to that resulting from the manure.

3. Fresh manure was slightly superior to well-decomposed old manure.

4. Application of manure to the land after plowing gave slightly better early growth but lower final yield of beets than manure plowed under.

5. Fresh straw with enough nitrogen and phosphorus added to equal the nitrogen and phosphorus in well-decomposed artificial manure made from straw and commercial fertilizer gave much better results than the artificial manure.

6. Manure stored in a pile for a year lost more than 50 percent of its nutrients and organic matter.

Manure spread on the surface of the soil 2 weeks before plowing lost 20 percent of its nitrogen but did not cause a significantly lower yield of beets than manure plowed under immediately after spreading.

Literature Cited

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