A Survey of Soil Organic Matter Levels and Their Relationship to Nitrogen Needs

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A report of the general survey o£ the levels of available phosphate in the soils in Utah, Idaho, Washington, Montana and South Dakota was made in the 1950 Proceedings of the American Society of Sugar Beet Technologists. A report is now made of a similar survey of the levels of organic matter.

It is recognized that the organic matter levels in the native soils of these areas will vary according to soil type and temperature and vary further on cultivated soils depending upon cultivation, crop history, amount of organic matter which has been returned to the soil and general soil management. It was the aim of this survey to help find the average content of organic matter in the soils of each area and to establish a correlation between organic matter levels and nitrogen needs.

Table 1.—Amount of Organic Matter in the Soil from the Back-Titration Figures of Ferrous Ammonium Sulfate.

Back Titration of Ferrous Ammonium Sulfate	Percentage Organic Matter	Tons Organic Matter per Acre	Approximate Lbs. N per Acre
18.1	0.5	5	500
16.3	1.0	10	1,000
14.5	1.5	15	1,500
12.6	2.0	20	2,000
10.7	2.5	25	2,500
8.9	3.0	30	3,000
7.0	3.5	35	3,500
5.2	4.0	40	4,000
3.3	4.5	45	4,500
1.5	5.0	50	5,000

During the last six years more than 450 field trials with commercial fertilizer have been conducted by the Utah Idaho Sugar Company in cooperation with farmers throughout the area in which it operates. These trials were designed to determine the deficiency of both nitrogen and phosphorus.

The correlation of organic matter levels with nitrogen needs was made by determining the organic matter level on the unfertilized check plots of each field trial and correlating the organic matter level found with yield increases obtained on plots receiving nitrogen applications.

After extensive comparisons it was decided that there was a correlation between organic matter level and nitrogen needs, that soil tests could be used to supplement data obtained from field tests and that organic content levels could be helpful in estimating nitrogen needs when allowances were made for cropping and fertilizer history; and with this information an extensive soil sampling and soil analysis program was undertaken.

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Soil Testing Procedures

Obtaining the Soil Sample

All soil samples were taken by members of the Sugar Company field staff. The sample from each field test was obtained by using a small soil sampling tube which could be pushed into the top six or eight inches of soil. At least 12 small samples were obtained over the field area, and the soil was mixed thoroughly in a bucket. A composite sample of 1.5 pounds of soil from each field sampled was sent to the local factory chemist to be air-dried, sieved and reduced to 100 grams by use of the Jones sampler. At regular intervals as sufficient samples were accumulated they were sent to the general laboratory for analysis.

Table 2.—Results of Soil Analyses for Organic Matter, Showing the Percentage of the Samples Falling into Each of the Organic Matter Groups. 1950.

District	0.5 Percent	1.0 Percent	1.5 Percent	2.0 Percent	2.5 Percent	3.0 to 4.0 Percent	4.0 and over Percent	No. of Samples
Gunnison	5	24	30	31	9	1	0	63
West Jordan	10	19	28	26	7	9	1	167
Garland	1	10	27	30	21	8	3	219
Idaho	3	31	29	21	4	1	1	403
Washington	39	26	22	4	9	0	0	23
Montana	8	14	35	22	12	8	6	82
South Dakota	1	9	29	35	16	10	0	214
Nebraska	0	0	5	18	11	55	11	38
Weighted Average	4	19	31	26	11	7	2	1,209

Methods of Analysis

The method used for determining organic matter percentage in soils is essentially that of Walkley and Black. Some modifications have been made and the detailed procedure is outlined below:

Reagents:—Primary standard $K_2Cr_20_7$, 4N—Grind and dry at 120° C. to 140° C. reagent grade $K_2Cr_20_7$. On the analytical balance weigh out 196.1430 g. of $K_2Cr_20_7$. Dissolve in water and dilute to one liter at 20° C.

H_2S0_4 36 N—to each liter concentrated H_2S0_4 add 1.25 g. Ag_2S0_4 H_3P0_4~ 85 percent.

Diphenylamine—dissolve three gm. in 100 ml. 36NH_2S0_4.

Ferrous Ammonium sulfate, 0.2 N—70 gm. of salt plus 20 m. 36 N H_2S0_4 made up to one liter. Adjust to 0.2 N by titrating against the four N $K_2Cr_2O_7$ using disphenylamine as indicator as described under "procedure." This solution should be checked once each week as it is only fairly stable.

Procedure:—Weigh out into a 150-ml. beaker, 0.500 ± 0.005 gm. of the dry powdered soil. Add (with a pipette) exactly one ml. 4N $K_2Cr_2O_7$ and 10 ml. 36 N H_2S0_4 containing the Ag_2S0_4. Heat on a hot plate until white fumes just appear (175° C.) Cool, add approximately 100 ml. distilled water (caution), five ml. 85 percent H_3P0_4 and two drops of disphenylamine solution. Titrate with 0.2 N ferrous ammonium sulfate until the blue color disappears and the green color appears. When using this amount of soil and one m. of $K_2Cr_2O_7$, the amount of organic matter in the soil from the back-titration figures of ferrous ammonium sulfate is shown in Table 1.

The factor for organic matter per ml. of $K_2Cr_2O_7$ is 0.027 for the 0.500 gm. sample taken. If soil analyzed is more than five percent organic, two ml. of the $K_2Cr_2O_7$ must be used. For very high organic content use 0.100 gm. soil.

The color is not always purple or blue on adding the indicator at the beginning of the titration, but this color always appears, just before the end point when the color flashes to green. This occurs with little or no warning.

Silver sulphate is used to prevent chlorine interference in saline soils. Sufficient silver ion is present to precipitate the chlorides as AgCl, and so prevent the oxidation by the chromic acid.

Large amounts of $CaSO_4$ from our calcareous soils along with AgCl tend to alter the shades of the color produced. The color change at the end point, however, is still quite sharp and easily recognized.

Table 3.—Relationship of Organic Matter Levels to Yield Response in Field Tests.

	Organic Matter Levels					
	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%
Percent of tests responding to nitrogen applied alone	90	94	75	75	85	80
Percent of tests responding to phosphate applied alone	40	88	75	69	43	60
Percent of tests which gave greatest response to a mixture of nitrogen and phosphate	70	88	88	94	86	80
Percent of tests which gave greatest response to nitrogen applied alone	30	6	8	6	0	0
Percent of tests which gave greatest response to phosphate applied alone	0	6	4	0	14	20

Analytical Results

A summary of the organic matter content levels in soils from various areas are shown in Table 2. It is evident from the data that the organic matter levels varied greatly both within and between districts.

It is recognized that organic matter levels should vary between areas and soil types. However, each area furnished examples of what proper organic levels should be in soils where good management practices were being followed, and when due allowance for the effect of the previous crop and previous fertilizer history was made, the organic matter level proved helpful in estimating nitrogen needs.

Relationship of Soil Analysis to Field Tests

In all the field trials nitrogen and phosphate fertilizers were tested both alone and in combination. Thus in any one test it was possible to compare yields from plots receiving either phosphate or nitrogen alone with yields from unfertilized plots, and also to compare the yield from plots receiving nitrogen and phosphorus with the yield from plots receiving either phosphate or nitrogen alone. Soil samples were obtained on all plots not receiving phosphate, and this made it possible to correlate chemical soil tests with actual yield responses in the field. The relationship found between the chemical tests and nitrogen responses from field tests is shown in Tables 3 and 4.

Table 4 shows that in Washington, Utah and Idaho there was a tendency for a smaller yield increase and percent yield increase from the application of 400 pounds of ammonium nitrate as the organic matter level increased. Montana and South Dakota did not follow this tendency. These two areas, probably because of their complicated soil problems, seldom conform to any general fertilizer practice.

Table 3 shows that most of the tests gave a response to phosphate and nearly all of the tests gave a response to nitrogen, irregardless of the organic matter level. However, as shown *in* Table 4, the magnitude of the increase decreased as the organic matter content increased. Table 3 also shows that a larger percentage of the tests gave the greatest response to nitrogen alone when the organic matter level was low and that a larger percentage of the

Table 4.—Relationship of Organic Matter Levels to Yield Increases from Nitrogen Application in Different Growing Areas.

	Organic Matter Levels					
Areas and Treatment	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%
Washington						
Yield of Checks	26.25	29.23	29.99	....	34.76	......
Increase from 400 pounds						
Ammonium Nitrate	6.19	3.67	4.95	....	1.24	....
Percent Increase	24	13	16	.	4	.....
Idaho and Utah						
Yield of Checks	12.83	15.99	15.99	17.11	19.60	17.92
Increase from 400 pounds						
Ammonium Nitrate	2.98	1.85	1.72	1.24	1.86	1.72
Percent Increase	23	12	11	7	9	9
Montana and South Dakota						
Yields of Checks	....	....	15.15	11.04	13.22	14.15
Increase from 400 pounds						
Ammonium Nitrate	....	....	.69	1.50	1.53	0.45
Percent Increase	.. .	.. ..	5	14	12	3

tests gave the greatest response to phosphate alone when the organic matter level was high, but that in a great majority of the tests the greatest response was obtained from a mixture of phosphate and nitrogen regardless of the organic matter level.

Table 5 shows the percent of tests in each organic matter level which gave the most profitable yield from the three amounts of nitrogen. In Utah, Idaho, South Dakota and Montana, the checks gave the most profitable yield only on fields with a high organic matter content while the highest rate of nitrogen (400 pounds of ammonium nitrate) gave the most profitable response on a large percentage of all the tests and on practically all of the tests where the organic matter level was low. In Washington, where more nitrogen is needed because of a longer growing season and higher yields, the highest rate of nitrogen gave the most profitable yield in all of the tests regardless of the organic matter content of the soil. However, the fields with a low organic matter content gave larger increases than did the fields with a high organic matter level.

Table 5.—Relationship of Organic Matter Levels to Rate of Most Profitable Nitrogen Application.

Area and Treatments	Organic Matter Levels in Percent					
	0.5	1.0	1.5	2.0	2.5	3.0
Idaho, Utah, Montana, South Dakota and Nebraska						
Percent of tests which gave the most profitable yield from no nitrogen	0	0	0	0	0	40
Percent of tests which gave the most profitable yield from an application of 200 pounds A.N.	0	22	24	44	50	20
Percent of tests which gave the most profitable yield from an application of 400 pounds A.N.	100	78	76	56	50	40
Washington						
Percent of tests which gave the most profitable yield from no nitrogen	0	0	0	0	0	0
Percent of tests which gave the most profitable yield from an application of 200 pounds A.N.	0	0	0	0	0	0
Percent of tests which gave the most profitable yield from application of 400 pounds A.N.	100	100	100	100	100	100

It is evident from these data that there are many cases where chemical tests did not tell the complete story. Some factors responsible for this situation are previous crop, kind of crop residues from the previous crop and previous fertilizer history. It is felt, however, that the results of the soil tests are very helpful when used by someone who has a knowledge of past cropping history, past fertilizer history, and who has available considerable information from field trials in the general area.