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FURTHER STUDIES ON THE NITRATE ASSIMILATING POWER OF SOILS

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In a paper read at the meeting last year (3) it was pointed out that when a soluble form of organic matter was added to soils which were incubated in tumblers, a considerable quantity of nitrate nitrogen could be used by the micro-organisms of the soil. The amount of nitrate nitrogen assimilated was in a measure determined by the amount of nitrate present at the beginning, the form and amount of organic matter used, and the length of incubation period. Two percent of straw furnished sufficient carbon for the assimilation of 10 mgm. per 100 gms. of soil in one week, and for about 15 mgm. in 3 weeks. Two percent of soluble starch or dextrose permitted the assimilation of about 15 mgm. in 1 week.

Murray (2) added finely chopped straw to soils and noted the disappearance of nitrate nitrogen. He used 50 mgm. per 100 gms. of soil with chopped straw in varying amounts from 0.5 percent to 5.0 percent. When he used 2 percent of straw he noted a loss of 14.99 mgm. of nitrate nitrogen in 6 weeks and only 6.5 mgm. in 12 weeks. It is quite probable that if he had made his determinations at an earlier date he would have found a still larger loss.

Meggett (1) in attempting to prevent large losses of nitrate nitrogen from the soil by leaching, applied sugar to the soil at periodic intervals during the summer and found that it prevented the loss of nitrates. In his laboratory tests he found that when he added 1 percent of sugar to his soil in tumblers plus 10.5 mgm. of nitrate nitrogen per 100 gms. of soil (soil originally contained 13.2 mgm.), all of the nitrates disappeared in 7 days. In another test he found the same disappearance in 3 days. He found no loss loss of total nitrogen. Another point of interest in his work was the acceleration of nitrification after the organic matter had been all used. In work of this nature it is important to keep this fact in mind, since it is desirable to make the determinations at the time when the nitrifiers are least active and the nitrate assimilators are most active.

[1] The authors wish to express their appreciation of the assistance given by Dr. P. E. Brown by his helpful suggestions and reading of the manuscript.

In the fall of 1929 a quantity of soil was collected from 6 different soil types. This was potted into four-gallon stone pots in the greenhouse, using 3 pots of each type of soil. These pots were then numbered A, B, and C for each type and were given the following treatments: A — check; B — sodium nitrate at the rate of 200 lbs. per acre; and C — sodium nitrate at the rate of 200 lbs. and finely chopped dry straw at the rate of 2 tons per acre. The soils were kept watered and fallow. From time to time samples were collected from each pot with a sampling tube so as to get a representative sample, and determinations made of the nitrate content and the nitrate assimilating power.

Some previous work on studying the methods of measuring the nitrate assimilating power by using 5, 10, 15, 20 mgm. of nitrate nitrogen per 100 gms. of soil had indicated that a greater amount might be used to advantage since the smaller quantities were assimilated rather quickly. Accordingly 25 mgm. was selected as the most desirable amount and this amount was used in the work reported here. It was also previously found that where a soluble form of organic matter was used, there seemed to be no advantage of extending the incubation period more than 2 weeks, at least unless a much larger amount of nitrate nitrogen was used. Consequently it was planned to use 4 different incubation periods: 3 days, 1 week, 2 weeks, and 4 weeks. For the three-day and one-week periods dextrose was used at the rate of 1 percent as a source of carbon; for the two-week period starch was used at the rate of 1 percent; and for the four-week period, cellulose acetate at the rate of 1 percent.

Parallel with this test another test was made in which the same amount of nitrate was added but no organic matter. In order to check the results and also to correlate them if possible with the original nitrate content of the soil, two sets of determinations were made using like methods. The first set was made shortly after the soils were potted when the nitrate content was moderately low and the second set later when the nitrate content had materially increased.

The results of this work which were secured from two of the representative soil types are given in tables I and II. These data portray very effectively the results secured from the whole series.

The Calhoun silt loam is a poorer soil than the Carrington loam, i.e., a less productive soil naturally, and the difference appears to be more or less mirrored in the biological activities. The nitrate production was less and also the nitrate assimilating power showed less potential possibilities. It appears, however, that when a soluble form of organic matter was added to the soil the nitrate assimilating organisms were stimulated to such an extent that only small differences could be noted among the different soils.

The accumulation of nitrates in the soil, without a corresponding increase in available carbon, seemed to cause a depression in the vigor of the nitrate assimilating organisms. This same tendency was noted in all of the soils tested. This can be best illustrated from the data of the one-week incubation period. At the first sampling, Dec. 15, the average nitrate content of the three pots of Carrington loam was 3.86 mgm. per 100 gms. of soil and the average amount assimilated when tested without the addition of organic matter was 5.88 mgm. Later, on Feb. 15, when the nitrate content had increased to 5.35 mgm., the amount assimilated under the same conditions dropped to -1.38 mgm., or an increase over the original content plus the 25 mgm. that had been added.

In the Calhoun silt loam the average nitrate content on Dec. 15 was 1.57 mgm. and the average amount assimilated was 6.40 mgm. On Feb. 15 the average nitrate content was 2.36 mgm. and the average amount assimilated was 1.62 mgm. In each soil there was a rapid drop in the nitrate assimilating efficiency as the nitrate content of the soil increased, when tested without the use of organic matter. Also, at both dates of sampling the Calhoun silt loam showed a lower nitrate content and a higher nitrate assimilating power, when measured by this method, than did the Carrington loam. These same general tendencies were exhibited by the other soils.

When organic matter was added to the soils for incubation these differences were largely ironed out and the Carrington loam by this method showed slightly higher nitrate assimilating power.

It appeared also that it required some time for the nitrate to have any appreciable effect on the nitrate assimilating organisms. When the soils were first potted the soils of B pots had a higher nitrate content due to the addition of fertilizer; yet this apparently had no effect on the nitrate assimilating organisms at the early sampling dates but did depress the nitrate assimilating power, when measured without organic matter, at the later dates of sampling.

In the C pots, where chopped straw was added in addition to sodium nitrate, the nitrate content of the soils did not drop suffi-

Table I — Nitrate Assimilation Studies on Carrington Loam in the Greenhouse

Pot Treatment	Mgm. NO_3 — N. per 100 Gms. of Dry Soil											
	3 Days Incubation			1 Week Incubation			2 Weeks Incubation			4 Weeks Incubation		
	NO_3 Content	NO_3 — N. Assimilated: NO_3 + Dextrose	NO_3 — N. Assimilated: NO_3 Alone	NO_3 Content	NO_3 — N. Assimilated: NO_3 + Dextrose	NO_3 — N. Assimilated: NO_3 Alone	NO_3 Content	NO_3 — N. Assimilated: NO_3 + Starch	NO_3 — N. Assimilated: NO_3 Alone	NO_3 Content	NO_3 — N. Assimilated: NO_3 + Cellulose Acetate	NO_3 — N. Assimilated: NO_3 Alone
	Soil Sampled Nov. 28			Soil Sampled Dec. 15			Soil Sampled Jan. 6			Soil Sampled Jan. 10		
Check	2.75	8.65	1.70	3.45	12.91	6.15	4.72	13.67	—1.23	4.72	2.22	0.52
Soil + $NaNO_3$	3.21	10.57	2.41	4.76	13.74	7.06	5.00	11.35	—2.80	5.88	3.38	1.68
Soil + $NaNO_3$ + straw	3.70	10.15	3.05	3.45	13.40	4.45	4.35	12.10	—1.25	4.67	2.47	0.47
	Soil Sampled Jan. 25			Soil Sampled Feb. 15			Soil Sampled Feb. 4			Soil Sampled Jan. 31		
Check	6.45	9.90	0.20	4.95	12.15	—0.75	5.88	11.68	—2.47	6.42	2.52	0.92
Soil + $NaNO_3$	7.14	12.29	0.29	5.95	12.30	—1.65	7.36	14.76	—3.89	6.94	2.84	1.24
Soil + $NaNO_3$ + straw	6.76	10.56	2.81	5.15	9.60	—1.75	6.34	11.04	—2.96	5.42	1.82	1.02

Table II — Nitrate Assimilation Studies on Calhoun Silt Loam in the Greenhouse

Pot Treatment	Mgm. NO_3 — N. per 100 Gms. of Dry Soil											
	3 Days Incubation			1 Week Incubation			2 Weeks Incubation			4 Weeks Incubation		
	NO_3 Content	NO_3 — N. Assimilated: NO_3 + Dextrose	NO_3 — N. Assimilated: NO_3 Alone	NO_3 Content	NO_3 — N. Assimilated: NO_3 + Dextrose	NO_3 — N. Assimilated: NO_3 Alone	NO_3 Content	NO_3 — N. Assimilated: NO_3 + Starch	NO_3 — N. Assimilated: NO_3 Alone	NO_3 Content	NO_3 — N. Assimilated: NO_3 + Cellulose Acetate	NO_3 — N. Assimilated: NO_3 Alone
	Soil Sampled Nov. 28			Soil Sampled Dec. 15			Soil Sampled Jan. 6			Soil Sampled Jan. 10		
Check	0.50	10.49	5.50	0.50	11.05	6.10	1.33	9.63	—1.47	1.84	0.24	0.89
Soil + $NaNO_3$	2.74	9.79	4.74	2.55	11.10	7.55	2.63	11.53	0.28	3.12	0.62	0.27
Soil + $NaNO_3$ + straw	3.30	11.85	4.95	1.66	11.01	5.56	1.56	8.71	—0.44	2.30	2.90	1.00
	Soil Sampled Jan. 25			Soil Sampled Feb. 15			Soil Sampled Feb. 4			Soil Sampled Jan. 31		
Check	1.89	7.94	2.39	2.06	11.21	2.01	2.33	4.43	—0.52	1.97	3.27	2.72
Soil + $NaNO_3$	3.25	8.90	3.75	3.09	12.94	1.59	3.78	6.78	—0.42	3.45	3.45	2.15
Soil + $NaNO_3$ + straw	2.22	8.72	3.17	1.96	11.21	1.26	2.23	8.43	1.03	2.08	2.83	3.28

ciently to have much effect. Consequently the results from these soils was not materially different from that of the untreated soils.

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