Bacterial Activities in an Orchard Soil

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BACTERIAL ACTIVITIES IN AN ORCHARD SOIL

Rudger H. Walker

One of the chief problems with which soils investigators have been concerned for a number of years is that of securing a laboratory test that will serve as an index to the fertility of the soil. In as much as nitrogen is so important an element in crop production it is believed that the power of the micro-organisms to oxidize the nitrogen of the soil would be an indication of the crop producing power of that soil. A very good review of the literature on this subject has been given by Waksman. (1) (2) After a detailed investigation of this problem he came to the conclusion that the ammonification test could not be used as a criterion in determining the fertility of the soil. On the other hand he found a very close correlation between the crop producing power of the soil and its nitrifying power.

The investigations conducted at the State Experimental Orchard at Council Bluffs during the past 15 years indicate that nitrogen is the limiting element in the growth and yield of the orchard trees. Also that the bacterial flora play an important role in the nitrogen changes which take place in the soils of this orchard. This orchard has been under four distinct cultural treatments during that time. Plots 100 and 600 have been under a clover sod culture. Plots 200 and 500 have been cultivated in the earlier part of the season and sown to some cover crop for the late summer. Plot 300 has been under clean cultivation without any crop. Plot 400 has been left as a check plot and has received no treatment other than the natural growth of a blue grass sod. The effects of these various cultural treatments upon the yield of fruit has been very marked as is shown in Table I.

<table>
<thead>
<tr>
<th>TABLE I</th>
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<tr>
<td>AVERAGE YIELD PER ACRE PER YEAR IN POUNDS OF APPLES FOR THE PAST TEN YEARS</td>
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<td>CLOVER SOD</td>
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In view of these facts it was deemed advisable to make a bacteriological study of the nitrogen changes of the soils under these
various cultural treatments, with special reference to their ammonifying and nitrifying powers.

For the purpose of this study samples of the surface and sub-surface soils from each of these plots were taken in September 1924 and shipped to the State College greenhouse. The soils were then screened and placed in one gallon glazed earthenware pots. Twelve pots were filled with surface soil and twelve with sub-surface soil from each of the six orchard cultural treatments. Four of each twelve were treated with dried blood, four with ammonium sulfate, and four were left untreated. The dried blood and ammonium sulfate applications were made on the basis of an equivalent amount of nitrogen to that contained in a one hundred pound per acre application of nitrate of soda. The soils were incubated in the greenhouse for a period of 20 weeks. The moisture content was kept optimum by frequent additions of distilled water. Samples were taken at intervals of four weeks and analyzed for nitrate and ammonia nitrogen. The ammonia was determined by the aeration method, and the nitrates by the phenoldisulfonic acid method. The ammonia determinations were discontinued after the first 12 weeks, because there was no ammonia nitrogen found in any of the samples. This was probably due to such a long incubation period, namely 4 weeks, before the first samples were taken. It is believed that the nitrogen of the materials added had been oxidized beyond the ammonia stage by that time. The results of the nitrate determinations are presented in Table II.

**TABLE II**

<table>
<thead>
<tr>
<th>NITRATES IN PARTS PER MILLION AS AN AVERAGE OF 720 DETERMINATIONS</th>
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<tr>
<td>CLOVER SOD</td>
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<tr>
<td>Untreated soils</td>
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<tr>
<td>Treated with dried blood</td>
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<tr>
<td>Treated with ammonium sulfate</td>
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</table>

Figures representing the nitrate content of a soil which are based upon the average of several determinations and extending throughout a long period of time, as these should give a true estimate of the nitrogen oxidizing power. Assuming this to be true and that the average yield of fruit for the past ten years is an indication of the crop producing power of the various plots it is at once noticed from the results that there is a very close relationship between the two. Because the biological condition of a soil is

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dependent upon the chemical and physical conditions, and that the fertility of a soil is dependent upon elements other than nitrogen, the kind of crop grown and various other factors, it could not be expected that the nitrogen oxidizing power of a soil would be an exact mathematical interpretation of the crop producing power. On the other hand if these two factors showed a reasonably close correlation from time to time and under various conditions there is no reason why this test could not be used by the scientist who was acquainted with the physical and chemical nature of soils in interpreting the producing capacity of a soil.

In Figure I is shown a graphic representation of the figures in Table I and II. These graphs show rather definitely that there is a correlation between the crop productivity of a soil on the one hand and the nitrogen oxidizing power on the other.

![Graph showing correlation between crop producing power and nitrogen oxidizing power of variously treated orchard soils.](image)

**Fig. 1.** Graphs showing correlation between crop producing power and nitrogen oxidizing power of variously treated orchard soils.

If the materials used be compared as to their efficiency as a source of nitrogen for this test it will be noticed that the correlation is greater with the ammonium sulfate treated soils and the untreated soils; while the correlation was the least when dried blood was used. This would probably indicate that dried blood was not as efficient as a source of nitrogen as ammonium sulfate or the soils own nitrogen.

**SUMMARY**

The results of several investigators as is reported by Waksman,
(1) (2) point to the fact that there is a close correlation between the crop producing power of a soil and its nitrogen oxidizing power.

The work reported here was a study of the nitrogen oxidizing power of the soils in an orchard which have been under four distinct cultural treatments for the past 15 years.

The nitrogen oxidizing power of these soils was compared with their crop producing power. The average yield of fruit during the past ten years was used as a measure of the crop producing power.

There is a definite correlation between the crop producing power of these soils and their nitrogen oxidizing power.

Dried blood as a source of nitrogen did not give as close a correlation as did ammonium sulfate or the soil's own nitrogen.

CONCLUSIONS

The nitrogen oxidizing power of a soil as determined by its average nitrate content throughout a long period of incubation, accompanied by a knowledge of its physical and chemical nature will serve as a criterion of its crop producing power.

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