The Long-time Effect of Rotation Length on the Yield and Chemical Constituents of the Soil

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The data from fertility experiments conducted over long periods of time may be valuable in that the information is gathered over a number of years and the upward and downward trends of yields and soil fertility over long periods may be brought out. The effects of crop rotation on crop yields and chemical characteristics of the soil have been studied and reported by numerous investigators. Bauer et al. (2) showed that after 55 years cropping on the Morrow plots the 3-year rotation of corn, oats, and clover still gave a yield of 48.0 bushels of corn without the use of fertilizer compared to 29.2 bushels for the continuous corn plots. Chen and Arny (7) found that corn in a corn-oats rotation yielded 3.55 bushels more than continuous corn. Prince et al. (13) compared the effects of three cropping systems on soil management after 40 years. The three cropping systems were: green manure with and without lime, and no lime or green manure. Crop yields were 9% better on the first system than on the second, and 32% better on the first than on the third. Smith (15) found that crop rotations without manure were as effective in maintaining yields of corn, wheat, and oats as heavy applications of manure on these crops grown continuously.

Snyder (16) compared the loss of nitrogen from rotations with continuously cropped soils and found that nitrogen content of the rotation soil had gone up 0.007%, but a loss of 0.028% from the continuous wheat plots had occurred. Workers in Ohio (6) found that even where a clover sod had been plowed down every third year, there was an apparent loss of about one-fifth of the original organic matter and nitrogen in 29 years, during which time nothing had been returned to the land but the roots and the stubble of the crops harvested. It was also concluded that 16 tons of manure in a 5-year rotation maintained organic matter, but there was still some loss of nitrogen.

Salter and Green (14) showed that losses of nitrogen and carbon varied with the rotations in descending order of loss as follows: (1) continuous corn, (2) continuous wheat, (3) continuous oats, (4) 5-year rotation, and (5) 3-year rotation. Dodge and Jones (8) found wider C:N ratios after continuous corn than after 16- and 3-year rotations. Commercial fertilizers had no effect on the C:N ratio.

MATERIALS AND METHODS

The rotation plots under investigation are located at the Northeast Experiment Station of the University of Minnesota, near Duluth, Minn. The study was set up to compare 3-, 4-, and 5-year rotations, consisting of 1 year each of cultivated crop and grain, and hay for 1 to 3 years. The plots were on land cropped for 2 years, and are 1/10 acre in size. The plot got the equivalent of 2 tons of manure per acre annually until 1938; since that time each plot received an average of 2 1/2 tons per acre per year. The manure was applied during the rotation, always on grain stubble.

The soils under consideration are members of the Cloquet association (10).

According to climatological data (17) the mean annual rainfall for the Station area is 27.94 inches, and the mean annual temperature is 33.0°F. The average number of frost free days is 135.

METHODS

Soil samples were taken from the plots after each series had been cropped for 30 years.

The soil was analyzed for nitrogen by the Kjeldahl method with the modifications suggested by Prince (12). Carbon was determined by means of a carbon train as described in A. O. A. C. (1). Methods used for adsorbed and acid-soluble phosphorus were essentially those outlined by Bray and Kurtz (3) with a few modifications. The pH was measured with a glass electrode potentiometer. A soil-water ratio as described by Peech et al. (11) was used.

EXPERIMENTAL RESULTS

CROP YIELDS

Average crop yields from the various rotations can be found in Table 1.

From appearances of the over-all average yields, barley had been little affected by the length of the rotation (Table 1). When barley yields averaged over 5-year periods are considered, it is found that the rotations have followed the same general trend throughout the 30-year period (Fig. 1). There was a fairly steady increase in yields from 1919 to 1928, regardless of rotation.