Nitrogen Utilization by Wheat as Affected by Rate of Fertilization
C. A. Black, L. B. Nelson, and W. L. Pritchett

The acreage of winter wheat grown in Iowa is rather low compared with the acreages of corn and oats, except in certain counties along the Missouri River in the western part of the state where winter wheat ranks as an important crop. In the six river counties from Woodbury to Fremont, inclusive, the acreage of wheat has been about one-half that of oats and one-tenth that of corn. Observations and experiments in this western area over a period of several years have indicated that nitrogen is ordinarily the first limiting factor in wheat production. This paper reports the results of several field experiments in which nitrogen was applied to wheat. Data are given also on the total and mineralizable soil nitrogen and on the effect of nitrogen fertilization on the nitrogen content of the crop.

EXPERIMENTAL METHODS

The field experiments were laid out in randomized blocks or in Latin squares with from three to six replications and were fertilized by top dressing with ammonium nitrate or ammonium sulfate in April. Yields were measured by threshing the wheat from 3x3-foot quadrats or from a 3-foot swath cut through each plot with a power mower. Where samples of grain and straw were saved for analysis, the samples were cut by hand, from 12 or more locations in each plot, leaving a 1-inch stubble. These samples were bagged, dried, and weighed, and were threshed in a small head thresher. The separated grain was dried and weighed and the weight of straw plus chaff was obtained by difference. The chaff was caught, as far as practicable, and was included with the straw for analysis.

Before the application of fertilizers to the field plots, soil samples were taken to a depth of 6 inches using a soil auger. These soil samples were taken to the laboratory, where they were air-dried. For the determination of mineralizable nitrogen, 100 grams of air-dry soil ground to pass a 2-mm sieve were mixed with 100 grams of quartz sand in a quart mason jar, and the mixture moistened with 25 ml of water. A small sample bottle containing 15 ml of 1 N NaOH was set on the surface of the soil to absorb the carbon dioxide evolved. The jars were sealed and placed in an incubator at 30°C. At the end of the first and second weeks the jars were opened and aspirated with fresh air. At the end of the third week the soils were extracted by shaking with 1 N KCl, the suspensions being adjusted to pH 1 with HCl according to the procedure of Olsen (3). The suspensions were filtered and aliquots were distilled with MgO and Devarda's alloy to determine the total quantity of ammonia, nitrite, and nitrate forms of nitrogen present. Blanks were run with sand alone, and the quantity of ammonia, nitrite, and nitrate nitrogen present in the soil before incubation was subtracted to obtain the quantity of nitrogen mineralized during incubation.

For the determination of the carbon dioxide evolved during incubation, the NaOH was transferred to a 100-ml volumetric flask, an excess of BaCl₂ was added to precipitate the carbonate, and the solution was diluted to volume with CO₂-free distilled water. After mixing and allowing the BaCO₃ to settle, a 25-ml aliquot of the clear supernatant was aspirated with fresh air. The liquid was titrated with 0.1 N HCl using phenolphthalein as indicator. The Voles procedures of Olsen (3) were followed. The suspensions were filtered and the quantity of ammonia, nitrite, and nitrate nitrogen were required per bushel of wheat where the rate of nitrogen application exceeded 40 pounds per acre.

Total nitrogen determinations were made, using a furic acid-salicylic acid-sodium thiosulfate digestion procedure to include nitrates (1), selenium oxychloride being used as catalyst. In the case of soil samples the ammonia content of the digest was determined by the usual distillation method, while with the plant materials the ammonia was determined by the Jacobson, Gerberding (B), and Cutter (B) procedures. In the Jacobson experiment, the yield of wheat was obtained in all but three cases, namely, the 1945 experiment on the Cutter field (area B) where wheat followed clover and the 1946 experiment on the Gilmore field where wheat followed fallow.

The yield data are given in Table 1. A response to nitrogen was obtained in all but three cases, namely, the Jacobson, Gerberding (B), and Cutter experiments. Nitrogen had no significant effect on the yield of wheat in the Jacobson experiment, with the exception of the 1945 experiment on the Cutter field (area B) where wheat followed clover and the 1946 experiment on the Gilmore field where wheat followed fallow.

The efficiency of nitrogen utilization varied considerably within experiments where different quantities of nitrogen were employed. Relatively small quantities of nitrogen were more efficient than large quantities. For example, in the Gerberding and Cutter (A) experiments, 1 bushel of wheat produced by 2.0 pounds of nitrogen where the nitrogen was applied at the rate of 20 pounds per acre, 1 bushel by 2.9 pounds of nitrogen where 40 pounds of nitrogen were applied per acre, and 1 bushel by 5.9 pounds of nitrogen where 80 pounds of nitrogen were applied per acre. These were the two latter experiments a depression in yield was associated with each increment of nitrogen applied.

The efficiency of nitrogen utilization differed considerably within experiments, depending upon the previous management of the fields. This point is illustrated by the data presented in Table 1. Areas were classified into eroded or noneroded. On the eroded area the same quantity of nitrogen was applied and on the noneroded area the same quantity of nitrogen was applied, but the yield was increased 13 bushels per acre and 6.5 pounds where the rate of nitrogen application exceeded 40 pounds per acre.

The efficiency of nitrogen utilization differed considerably between experiments, depending upon the availability of nitrogen in the soil. This point is illustrated by the paired experiments on the Cutter and Jacobson farms. In the Gerberding field, an area was located on an eroded slope where the depth of the A horizon remaining was only 6 to 7 inches whereas on a more gentle slope where the depth of the A horizon was 15 inches the yield of wheat was significantly greater. On the eroded slope area, 80 pounds of nitrogen increased the yield 13 bushels per acre and 6.5 pounds where the rate of nitrogen application exceeded 40 pounds per acre.

RESULTS AND DISCUSSION

The previous management of the fields is not given since all had been cropped to grain without manure or fertilizers for 3 years or more prior to the time of the experiment, with the exception of the 1945 experiment on the Cutter field (area B) where wheat followed clover and the 1946 experiment on the Gilmore field where wheat followed fallow.