Influence on Soil Fertility on Wheat Yield in North Dakota

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Wheat is grown on more acres in North Dakota than any other crop and is very important to the state's economy. From 1920, to the present time, approximately 9 million acres (Table 1) have been devoted to growing wheat each year (1). Data collection on the harvested acres and average yield started in 1879.

Managing the plant nutrient supply for the North Dakota wheat crop is also vital to the state's economy. Of the factors that influence growth of crops, the influence of nutrients is direct and well documented. For example, lack of nitrogen shows up as a light green to yellow color on older leaves that spreads to the entire plant if the deficiency is severe. This is accompanied by decreased yield. Similar deficiencies are known for other nutrients. It is significant that we have had chemical soil tests available for the past 40 years in North Dakota that can identify the probability of a nutrient deficiency before the crop has been planted. Field trials have shown that it takes about 2.5 pounds of nitrogen to produce an extra bushel of wheat in North Dakota (2).

Nature alone has not provided an adequate nitrogen supply for North Dakota's wheat crop. Data presented by Jenny (3) show that the supply of available nitrogen decreased rapidly when virgin prairie soils were cultivated. Figure 1 indicates how the supply of available N in prairie soils decreased with cropping in the North Central United States. Since the nitrogen supply in the soil has such a large influence on crop yield, it is easy to understand what happened to the wheat yields in North Dakota during the first 50 years of cropping, a period when nitrogen fertilizer was not available to replace that removed by cropping. As shown in Figure 2, the average yield of wheat in North Dakota steadily decreased from approximately 20 bushels per acre in 1880 to 8 bushels per acre in the 1930s. The rate of yield decrease during this period approximately follows the rate of decrease in soil nitrogen levels shown in Figure 1. These historical data indicate that the production practices used from 1880 to approximately 1940 were not sustainable.

Table 1. Average wheat acreage, yield per acre and use of NPK on wheat in North Dakota.

5 Year Period	Harvested Acreage	Yield	N, P_2O_5 and K_2O
	(000 acre)	bu/acre	lb/acre
1897	85	20.5	—
1880-1884	480	19.4	—
1885-1889	1,972	14.7	—
1890-1894	3,200	13.2	—
1895-1899	3,926	14.5	—
1900-1904	4,216	11.9	—
1905-1909	6,822	13.9	—
1910-1914	8,912	10.5	—
1915-1919	7,206	9.7	—
1920-1924	9,405	10.9	—
1925-1929	9,979	9.6	—
1930-1934	8,072	8.2	—
1935-1939	6,713	8.0	—
1940-1944	8,337	16.5	—
1945-1949	10,127	13.7	1
1950-1954	9,365	11.4	3
1955-1959	6,665	17.9	12
1960-1964	5,924	23.3	16
1965-1969	7,211	25.8	30
1970-1974	8,452	26.4	32
1975-1979	10,061	26.3	35
1980-1984	9,533	27.7	42
1985-1989	8,723	27.0	52

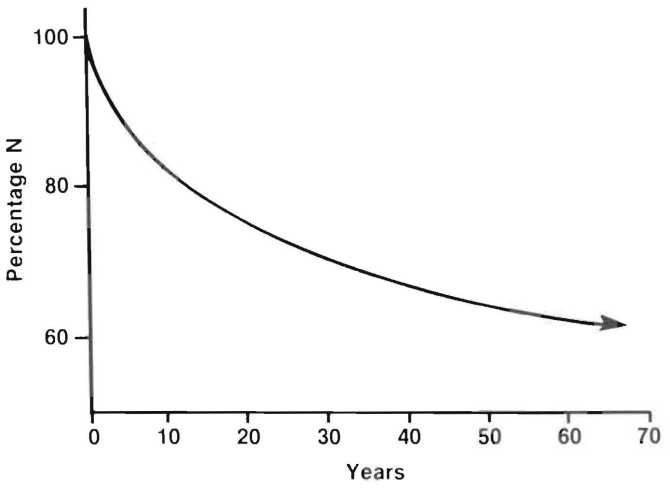

Figure 1. Decline of soil nitrogen with years of cultivation under average farming conditions in the prairie states of the USA (after Jenny).

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Starting in the late 1930s through the 1940s new production practices were introduced that greatly influenced subsequent wheat yields in North Dakota. Two of these were the introduction of commercial fertilizer and the use of weed control chemicals. Commercial fertilizer use by growers in North Dakota since the early 1940s is well documented (4). Herbicide use is not as well documented, but we do know that herbicide use was accepted and expanded rapidly after introduction of 2,4-D in the late 1940s. Other factors that had an influence on wheat yield were better machines for planting and harvesting, better insect and disease control, and release of higher yielding varieties resistant to new strains of rust. The steady increase in average wheat yields in North Dakota since the 1940s reflects these changes in technology.

Figure 2 shows the average yield of wheat started to increase in the 1940s and that this increase was closely related to the use of commercial fertilizer in North Dakota. By 1960, the average yield increased to the level it had been in 1880 when the once-fertile prairie soil was first tilled. Since 1960, average yields have continued to increase as more fertilizer and better weed control practices have been adopted. Thus, there is strong evidence that replacement of nutrients removed by wheat from 1880 to approximately 1940 has been a major factor in increasing average wheat yields in North Dakota. As a result, agriculture in North Dakota has become sustainable at a much higher yield level than would have been the case if commercial fertilizers were not used.

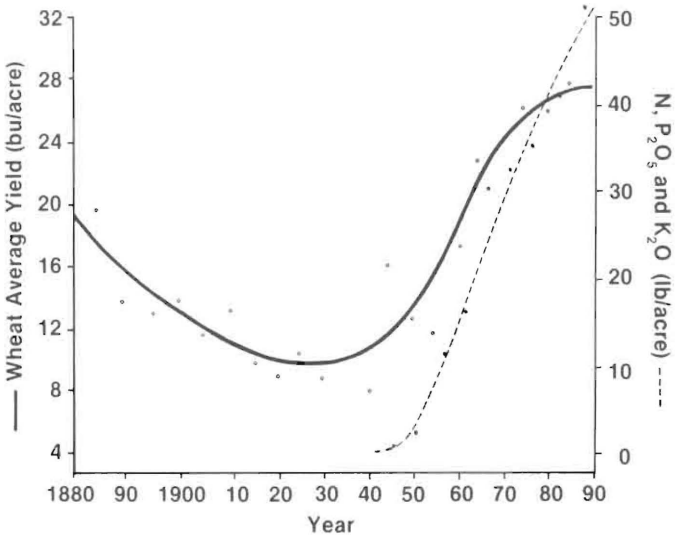

Figure 2. Average wheat yield (solid line) in North Dakota since 1880 in relation to pound per acre of N, P_2O_5 and K_2O used (broken line) on wheat since the 1940s.

Nutrients were and continue to be exported from the state with each grain crop sold through commercial channels. Without introduction of commercial fertilizers to North Dakota's production program the average yield of wheat today would probably be somewhere near the 8 to 10 bushels per acre range, the same as it was in the 1930s. Crops simply cannot grow without nutrients.

Another factor that has had a large influence on wheat yield is the use of herbicides. Figure 3 shows the relationship between average wheat yields and the use of 2,4-D in the U.S. between the years of 1950 and 1970 (5). Here again the data show a good relationship between wheat yield and the use of the herbicide 2,4-D. Weeds compete with crops for nutrients and especially valuable water which is so often in short supply in North Dakota.

Wheat breeding has also had an important role in increasing wheat yields (6), mainly by supplying a constant source of varieties with resistance to current strains of disease and to insects.

Prudent use of commercial fertilizer has many favorable benefits on soil properties and organisms. The main benefit is an increase in the amount of crop residue added to the soil. This has a favorable influence on many soil properties such as tilth and nutrient retention for following crops. The present level of wheat production can be sustained without fear of erosion, loss of soil tilth or ground water pollution when proven technologies such as soil testing, proper fertilization and high residue retention tillage methods are used.

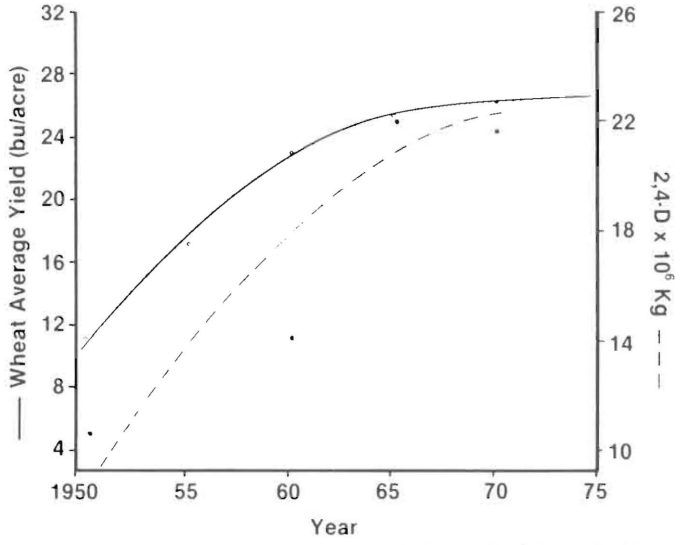

Figure 3. Average wheat yield (solid line) in North Dakota between 1950 and 1975 in relation to the domestic disappearance of 2,4-D (broken line) in the USA between 1950 and 1970.

REFERENCES

1. North Dakota Crop and Livestock Statistics. Issued by USDA Statistical Reporting Service and Department of Agricultural Economics, NDSU.

2. Dahnke, W.C. and C.D. Fanning. 1991. North Dakota fertilizer recommendation tables and equations based on soil test levels and yield goals. Bulletin SF-882, North Dakota State University Extension Service, NDSU, Fargo, ND 58105.

3. Jenny, Hans. 1941. Factors of Soil Formation. p. 252. McGraw-Hill Book Company, Inc. New York and London.

4. Fertilizer Summary Data. Published by the National Fertilizer Development Center, TVA.

5. Bovey, Rodney W. and Alvin L. Young. 1980. The science of 2, 4, 5-T and associated phenoxy herbicide. p. 3. John Wiley and Sons, New York.

6. Frohberg, Richard C. 1991. Economic impact of plant breeding programs. North Dakota Farm Research Vol. 48, No. 4, pp3-8.