NITROGEN fertili

by Armand Bauer and J. C. Zubriski

Nitrogen fertilizers have produced profitable yield increases of small grains on many soils, particularly when applied on nonfallow land. These increases in yield from supplemental applications of nitrogen undoubtedly occur because many soils release available nitrogen from soil organic matter too slowly for maximum production of rapidly growing crops.

The release of available nitrogen from organic matter, which for all practical purposes is the only source of nitrogen in soils, is brought about by soil micro-organisms. The activity of these micro-organisms is governed by several factors, among them being temperature, moisture, aeration and abundance of an energy source. This energy source is, in the main, organic matter. The rate of release of available nitrogen increases as all factors regulating microbial activity approach their optimum.

Micro-organisms involved in release of available nitrogen are active at soil temperatures as low as 34 degrees F. However, activity increases with increasing temperatures under ideal conditions to an optimum of 86 to 95 degrees F. At temperatures higher than these, activity again decreases.

Soil moisture and soil aeration required for maximum microbial activity, with respect to quantity and distribution, are similar in range to those required by most crops for optimum growth. Hence, just as crop production is affected by climatic conditions, so also is the release of available nitrogen.

With a few exceptions, primarily soils of coarse texture, North Dakota soils are

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Its effect on small grain on non-fallow land . . .

well supplied with organic matter as evidenced by their dark color. This organic matter is composed of plant and animal residues in varying stages of decomposition. These stages range, generally, from small amounts of recently deposited plant and animal residues, through intermediate stages of decomposition of these residues, to humus. Humus makes up the major portion of the organic matter.

The presence of large amounts of organic matter, in any form, however, is no assurance that adequate amounts of nitrogen will become available to crops for maximum performance. Indeed, incorporation of crop residues which contain a high proportion of carbon to nitrogen may reduce temporarily the total available nitrogen supply in soils, particularly when rapid decomposition of these materials is taking place. This reduction of the supply of available nitrogen in the soil continues until the proportion of carbon to nitrogen in the residues is sufficiently narrowed to supply the carbon and nitrogen in the proportion required by the micro-organisms.

Humus contains a proportion of carbon to nitrogen narrow enough to render some of this nitrogen in available form upon decomposition. However, humus is quite stable and fairly resistant to microbial attack. Hence, it is only under favorable conditions of temperature, moisture and aeration, in soils adequately supplied with organic matter, that available nitrogen may be released rapidly enough to meet crop needs.

APPLICATION OF NITROGEN ON NON-FALLOW LAND HAS GENERALLY GIVEN YIELD INCREASES.

Usually, conditions favoring maximum microbial activity in North Dakota soils do not begin until late spring because of low soil temperatures. Then, as temperatures become more favorable as the growing season advances, soil moisture may be in short supply for rapid release of the nitrogen because of relatively low amounts of precipitation and the competitive demands from crops.

Moisture may not become as limiting for microbial activity in soils being fallowed, as in cropped soils since there is little, if any, plant growth on fallow soils to utilize the water retained by the soil. Moisture, however, may still become limiting on fallow land for micro-organisms because of evaporation losses, even though total precipitation may have been normal.

The nitrogen released from organic matter during the fallow period accumulates in the soil. The crop then grown on fallow land can use the accumulated nitrogen plus the nitrogen released during its growing season. These amounts released during the two seasons are generally adequate to meet crop needs.

Crops grown on nonfallow land, not supplied with commercial nitrogen must, generally, depend entirely on the nitrogen released during its growing season. Since the amount of nitrogen released in cropped soils during one season is relatively small, supplemental applications of nitrogen have, in the majority of cases tested, given yield increases.

Prior to 1955, few trials were conducted on nonfallow land in which more than two rates of nitrogen fertilizer were tested (No nitrogen is considered a rate of application). In the trials in which more than two rates of nitrogen were tested, the rates of application were applied in 20 pound increments or more. The results of all wheat and barley trials in which nitrogen was applied as a variable have been summarized by Dr. R. A. Young, Associate Soil Scientist, in Bimonthly Bulletin, Volume 20, No. 3, 1958—"Fall Application of Nitrogen Fertilizer."

During the past three seasons (1955-1957) 5 rates of nitrogen fertilizer were tested on nonfallow sites. Fourteen of these trials were seeded to wheat and 5 to barley.

The purposes of these trials were to determine levels of nitrogen fertilizer needed for maximum yields of wheat and barley and to determine the effect of these rates of nitrogen fertilizer applied by drill attachment on germination and early seedling development of the test crops.

The trials were conducted on soils having varying chemical and physical characteristics (Table 1) and on fields of varying cropping history (Table 2).

A nursery seeder was used to plant the seed and apply the fertilizer. Ammonium nitrate (33.5-0-0), concentrated superphosphate (0-46-0), and muriate of potash (0-0-60) were used as a source of nitrogen (N), available phosphoric acid (P_2O_5), and water soluble potash (K_2O), respectively.

The average yields of grain for these trials are given in Table 2.

Discussion of Results

The levels of application of nitrogen which produced the best yields ranged from no nitrogen to the 40 or possibly 50 pound rate.

In 8 of the 14 wheat trials, yield of grain was significantly increased by nitrogen fertilizer. In 5 of these 8 trials, (Hettinger 1957, Hettinger 1956, Dickinson, Hettinger 1955 and Weiser) 20 pounds of nitrogen per acre, together

Table 1. SOIL TYPES AND SOME CHEMICAL CHARACTERISTICS OF SOILS AT 19 EXPERIMENTAL SITES

Name	County	Year	Soil Type[1]	Carbonates[2]	pH	Soil Phosphorus Rating
Hettinger Sub.	Adams	1955	Cheyenne loam	0	6.3	Very low
Hettinger Sub.	Adams	1956	Cheyenne loam	0	6.5	Very low
Unknown	Stutsman	1956	Ops loam	0	7.1	Very low
McMartin	Pembina	1956	Glyndon silt loam	3	7.8	Low
Engbrecht	Mercer	1956	Arnegard loam	0	7.1	High
Keidel	Morton	1956	Williams loam	0	6.3	Very low
Hettinger Sub.	Adams	1957	Cheyenne loam	0	5.9	Very low
Dickinson Sub.	Stark	1957	Vebar sandy loam	0	7.3	Low
Schulz	Cass	1957	Fargo clay	0	7.0	Very low
Horne	Traill	1957	Glyndon silt loam	2	7.5	Medium—high
Sebens	Sargent	1957	Aastad clay loam	0	5.9	Medium—high
Hanson	Ramsey	1957	Barnes loam	0	6.7	Very low
Wesier	Emmons	1957	Agar silt loam	0	6.1	Very low
Bauer	McIntosh	1957	Roseglen silt loam	0	6.8	Low
Odegaard	Traill	1956	Overly silty clay loam	0	7.0	Very low
Ronan	Grand Forks	1956	Glyndon silt loam	2	7.6	Very low
Askew	Cass	1957	Overly silty clay loam	0	6.4	Very low
Heuer	Ransom	1957	Emma fine sandy loam	0	6.3	Very low
Busch	Grand Forks	1957	Bearden silty clay loam	1	7.5	Low

1/ Not correlated.
2/ "O" indicates not limy.

Table 2. EFFECT OF FERTILIZER TREATMENT ON YIELD OF WHEAT AND BARLEY GROWN ON NONFALLOW LAND (1955-1957)

			YIELD (BUSHELS/ACRE) [1/]								
Name	Crop	Previous Crop	Check	0+35 +0	10+35 +0	20+35 +0	30+35 +0	40+35 +0	50+35 +0	30+35 +15	LSD[6/] 5%
Hettinger[3/] '55	Wheat	Corn	24.3	28.0		31.2	31.7	33.7	35.7	[5/]	3.2
Hettinger '56	"	Corn	19.9	18.7		22.8	25.1	24.9	24.9	24.0	4.0
Unknown	"	Flax	10.0	9.7		15.4	18.6	20.2	16.4	14.7	5.9
McMartin	"	Barley	22.3	21.1		26.8	30.6	33.8	34.9	29.2	3.2
Engbrecht	"	Corn	20.3	23.6		21.0	20.7	18.9	19.5	19.3	N.S.
Keidel	"	Flax	20.1	24.3		20.7	23.1	21.1	20.1	22.2	N.S.
Hettinger '57	"	Corn	24.6	26.4		29.3	25.9	22.8	22.0	24.6	3.3
Dickinson	"	Corn	14.6	15.8		20.7	20.1	19.9	20.1	20.1	2.8
Schulz[2/]	"	Soybeans	30.8	34.4	38.3	40.4	46.2	50.8	50.5	47.4	3.6
Horne	"	Potatoes	44.1	47.3		48.6	50.2	48.1	47.9	49.5	3.1
Sebens	"	Corn	45.7	47.1		47.9	47.6	47.8	48.0	47.9	N.S.
Hanson[3/]	"	Brome-Alfalfa[4/]	15.9	18.4	17.2	17.4	16.1	17.2	17.2	17.2	N.S.
Weiser	"	Corn	32.1	38.8		46.6	44.1	47.6	47.9	46.6	2.9
Bauer[3/]	"	Corn	25.5	25.6		25.8	26.8	26.9	26.8	26.9	N.S.
Odegaard	Barley	Wheat	32.3	32.6		45.6	52.7	56.0	56.4	60.6	10.0
Ronan	"	Wheat	39.3	41.3		42.9	46.3	46.3	47.3	44.3	5.1
Askew[2/]	"	Soybeans	41.2	47.9	56.3	57.6	58.3	64.8	69.9	60.2	8.0
Heuer	"	Wheat	18.8	19.1		33.4	40.9	40.8	39.9	38.6	4.6
Busch	"	Wheat	34.0	40.2		41.5	41.4	38.7	39.6	43.4	4.7

1/ Numbers refer to amount applied of total nitrogen, available phosphoric acid and water soluble potash, respectively.

2/ Applied 40 pounds of P_2O_5 per acre instead of 35.

3/ Yields are average of four replications.

4/ Seeded in spring of 1953. Plowed late summer of 1956.

5/ Potash not applied in 1955.

6/ Where differences between means are equal to or greater than number given under LSD, the chances are at least 19 out of 20 that the difference is due to treatment rather than to chance.

with available phosphate presumed to be adequate, was as good a treatment as higher rates of nitrogen with the exception possibly of the 1955 Hettinger trial. In this trial the yield of plots receiving 50 pounds of nitrogen was better than the yield of plots receiving 30 pounds or less.

In one case, Stutsman County, yields were increased by the 30 pound application of nitrogen, but the yield of plots receiving 20 pounds was not significantly better than that of the check plots.

In the two remaining trials (Schulz and McMartin) where response was obtained from the application of nitrogen, the 40 pound rate was significantly better than the 30 pound rate which in turn was significantly better than the 20 pound rate.

Wheat yields were not increased by the application of nitrogen in 6 of the 14 trials (Horne, Sebens, Bauer, Hanson, Keidel and Engbrecht), although yields were increased by available phosphate in the Horne trial. Vegetative responses to nitrogen, as evidenced by greener plants and more rapid growth early in the season, were noted in all trials except Hanson's.

The high yields of the check plots in the Horne and Sebens trials reflect a condition of high fertility and moisture. Since the phosphorus levels of the soils at these two sites were "medium to high", according to soil test, (Table 1) little response to application of available phosphate can be anticipated. Hence nitrogen would most likely be the fertility factor limiting yield. Since moisture appears to have been adequate throughout the growing season (as indicated by the yield of the check plot) it is suggested that under these conditions, release of nitrogen may have been rapid enough to meet the needs of the crop.

Weeds were a problem in the Engbrecht trial and may have affected the outcome.

Soil moisture may have been the limiting factor in the Hanson trial since brome-alfalfa was plowed late in the season.

The yield results of the Keidel and Bauer trials cannot be explained.

In the 5 barley trials, nitrogen fertilizer increased the yields in 4 of the sites, with 30 pounds per acre giving best results in 2 of these (Ronan and Heuer) and 40 pounds per acre in the other 2 (Odegaard and Askew). Yields were not increased by nitrogen in the Busch trial but were increased by available phosphate. High temperatures which prevailed in the area shortly after the grain had headed may have had adverse effects on the crop in the Busch trial.

The application of potash did not increase the yield of any crop in any trial at the rate of nitrogen with which it was applied.

Generally, nitrogen had little effect on test weight of wheat (Table 3). In three trials, (Hettinger '57, Dickinson and Bauer) a reduction occurred, but only from the rates of application larger than those which increased yields.

Of the 5 trials with barley, nitrogen increased test weight in 2 cases (Odegaard and Askew). Phosphorus reduced test weight in the Heuer trial.

In no case did the fertilizer treatment affect germination of the crops, regardless of rate of application used.

SUMMARY AND CONCLUSION

Yield responses of small grains to the application of 20-40 or 50 pounds of nitrogen per acre, when grown on nonfallow land, were obtained in 12 out of 19 trials. The non-responsiveness of 5 of the remaining 7 trials may be attributable (a) to lack of adequate moisture which limited plant growth, (b) to moisture present in adequate quantities for microbial activity, thereby, releasing adequate amounts of nitrogen from soil

Table 3. EFFECT OF FERTILIZER TREATMENT ON THE TEST WEIGHT OF WHEAT AND BARLEY GROWN ON NONFALLOW LAND (1955-1957).

	TEST WEIGHT								
Name	Check	0+35 +0	10+35 +0	20+35 +0	30+35 +0	40+35 +0	50+35 +0	30+35 +15	LSD 5%
Hettinger '55	58.8	59.8		59.1	59.4	58.6	58.6		N.S.
Hettinger '56	Not Available								
Unknown	51.9	53.5		53.8	53.2	54.2	54.4	52.3	N.S.
McMartin	59.1	59.0		58.8	58.8	59.3	59.2	58.8	N.S.
Engbrecht	Not Available								
Keidel	60.8	60.0		60.0	59.8	59.8	59.7	59.5	N.S.
Hettinger '57	52.3	53.0		50.8	49.1	47.7	46.8	47.1	1.9
Dickinson	54.7	54.7		54.6	52.9	53.1	52.3	52.3	0.9
Schulz	57.6	58.7	57.8	57.7	57.8	57.8	57.3	57.4	N.S.
Horne	58.4	59.4		59.0	58.8	58.4	58.3	59.1	0.7
Sebens	55.1	54.6		54.7	54.4	54.5	54.5	54.8	N.S.
Hanson	52.0	51.5	50.5	52.9	51.9	51.0	51.5	51.3	N.S.
Weiser	59.1	59.6		58.2	57.7	58.8	57.9	58.2	N.S.
Bauer	55.0	54.8		53.9	53.9	52.9	51.9	54.0	1.3
Odegaard	45.6	45.8		46.8	47.3	44.8	46.0	45.5	1.0
Ronan	46.1	46.5		46.7	46.4	45.9	46.8	46.8	N.S.
Askew	43.3	44.3	46.2	46.3	46.2	46.0	46.1	46.1	1.1
Heuer	49.1	47.1		47.4	46.5	46.7	45.8	47.2	1.1
Busch	41.8	41.8		42.6	41.1	41.3	41.6	41.9	N.S.

organic matter, (c) competition of weeds, and (d) unfavorable effects of high temperatures at critical stages of plant development.

Nitrogen fertilizer increased test weight of barley in two trials and decreased test weight of wheat in three cases. The reductions occurred from rates of application that were larger than required for maximum production. Since these reductions were noted only in 1957 trials, it is suggested that seasonal factors, primarily temperature and moisture conditions, play an important role.

Germination and seedling development were not affected by any rate of nitrogen (N) applied. However, these trials may not have been conducted under all situations which may be encountered. Therefore, application of nitrogen (N) in excess of 30 pounds per acre may best be broadcast.

The activity of micro-organisms which transform the nitrogen in the organic matter to forms available to crops is governed, in the main, by climate. Moisture in optimum amounts is, probably, most often limiting because of low total precipitation, unfavorable distribution, and competitive demands by higher plants.

The short growing season is a contributing factor to available nitrogen deficiencies in North Dakota soils in that the rate of release of nitrogen must be more rapid for these short season crops than for crops using similar total amounts utilized over a longer growing period.

Even though the data obtained to date indicate that an application of 20-40 pounds of nitrogen (N) per acre will be adequate for maximum crop production of small grains on most soils, further investigations are required to establish the magnitude and the manner in which conditions, such as inherent soil characteristics, management practices, crop history, and climatic conditions, especially moisture and temperature, affect available nitrogen levels in soils.

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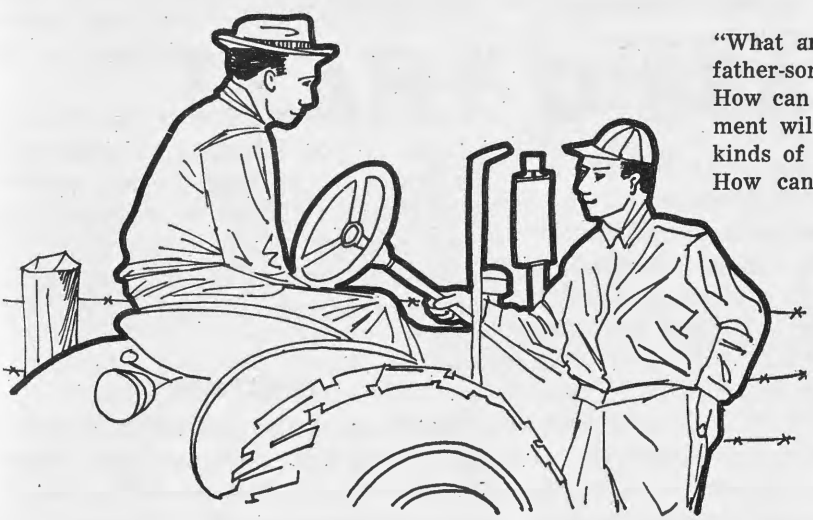

"What are the advantages of a father-son farming agreement? How can we be sure our agreement will be successful? What kinds of agreements are there? How can we go about setting up a sound, fair father-son agreement?" These questions and many others face fathers and sons considering family farming arrangments.*

*Answers to these and other father-son agreement questions are included in the new North Dakota Experiment Station Bulletin 413 "Father and Son Farming Agreements", and also in Extension Circular A-288. Both are available at county extension offices.