Response of Wheat to Nitrogen on Indiana Soils[1]

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In 1946 Horrall (2) found that nitrogen needed for maximum yield of wheat varied with each experimental location. This difference, he thought, was due primarily to the degree of rust and scab infestation rather than to soil differences. At that time, 20 pounds of nitrogen at planting plus 40 pounds of nitrogen top-dressed in spring was the highest yielding treatment on three of his four test locations.

Peterson (3) found that anhydrous ammonia and ammonium nitrate applied in the fall were more effective on poorly-drained, strongly acid soils than on well-drained, slightly acid soils. Fall and spring applied anhydrous ammonia and ammonium nitrate were compared at several rates and on six locations. In general, he found that the tallest wheat and the largest yields were obtained with the application of ammonium nitrate broadcast in spring. However, he noticed that at one location in the second year of the experiment that fall applications of nitrogen reduced the winter killing of the wheat. Soil properties and yield results of Peterson's research with wheat are summarized in a Purdue publication about wheat fertilization (1). In addition to Peterson's work, this publication reports a fall versus spring nitrogen application experiment with wheat on Plainfield sand. It definitely shows that spring application was much better than fall on this sandy soil.

Results of eight years of demonstrations are reported in another Purdue publication concerning small grains (4). It shows that 1½ to 2 more bushels of wheat were obtained per acre from 25 pounds of nitrogen top-dressed in the spring than from the same amount of nitrogen top-dressed in the fall.

The purposes of this study were (1) to compare application of all of the nitrogen at planting in two different 1-1-1 ratio fertilizers with application of a small amount of nitrogen in the fall at planting plus most of the nitrogen top-dressed in early spring, and (2) to study rates of nitrogen top-dressed in spring in relation to soil type and cropping and fertilization history.

METHODS AND PROCEDURES

Experiment 1

This experiment was conducted on four locations with winter wheat in 1957-1958. The descriptions of the soils used are given in Table 1. Certified Dual wheat was seeded at 6 to 7 pecks per acre on three locations. Certified Vermillion was seeded at the same rate on the Purdue Agronomy Farm, the fourth location.

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A randomized block design with four replications and four treatments was used at each of the four locations. Time of nitrogen fertilizer application was the variable studied. Treatments are given in Table 2. The hypothesis tested was that spring application of most of the nitrogen on winter wheat was better than fall application at planting. Two grades of fertilizer, a 12-12-12 and a 15-15-15, were used to apply all of the nitrogen in fall at planting. A 5-20-20 was used for the remaining two treatments.

Fall application of the nitrogen was in late September or in early October at seeding. Spring application was in March or early April before rapid spring growth started. Row fertilizer was applied with a farm wheat drill. Rates of phosphate and potash applied were essentially the same on all treatments. Spring top-dressing was done by hand using ammonium nitrate as the fertilizer material.

Lodging percentages were estimated visually. Two people working independently made the Purdue Agronomy Farm estimates. One person made each of the other estimates.

Yields were determined by harvesting all of each plot except a small strip across each end with a combine. Plot size was approximately 100 feet long by 5 feet wide.

Table 1. Description of soils used in experiments.

Farm	Crop & Yield in 1957	Soil Type	Soil pH	Purdue Soil Tests: Available Phosphate Lbs. A.	Purdue Soil Tests: Available Potash Lbs. A.
Purdue Agronomy Lafayette, Indiana	Soybeans 35-40 bu. per A.	Russell silt loam	6.8	108 (medium)	198 (medium)
Wm. Windle Lafayette, Indiana	Soybeans 27 bu. per A.	Elston loam	6.1	45 (low)	133 (low)
Roy Becht Milroy, Indiana	Sweet corn 5 tons per A.	Fincastle-Crosby silt loams	6.1	48 (low)	198 (medium)
Frank McRoberts Hazelton, Indiana	Corn 70-80 bu. per A.	Alford silt loam	5.9	14 (very low)	79 (very low)
Wolfe & Summers Carlisle, Indiana	Soybeans yield not known	Princeton sandy loam	6.7	124 (medium)	160 (low)
Oatley Thrasher Rockport, Indiana	Tobacco about 2000 lbs. per A.	Weinbach clay loam	5.6	146 (medium)	110 (low)

Experiment 2

This experiment was conducted on Alford silt loam at Hazelton, Indiana, in conjunction with Experiment 1.

A randomized block design with four replications was used. Variety, rate, and time of seeding were the same as that used in Experiment 1. Fertilizer grade and rate was the variable. Treatments are given in Table 3. The hypothesis tested was that rates of spring applied nitrogen as high as 65 pounds per acre would increase yields of winter wheat. In

addition, spring top-dressing of phosphate and potash fertilizer was tested.

Fall application of row fertilizer was by a wheat drill at planting. Spring top-dressing was by hand using ammonium nitrate.

Yields were determined by harvesting with a combine. Plot size was approximately 120 feet long by 5 feet wide.

Experiment 3

This experiment was conducted at two locations with winter wheat in 1959-1960. The description of the soils used is given in Table 1. Certified Vermillion wheat was seeded in October at the rate of 6 to 7 pecks per acre.

A randomized block design with four replication and four treatments was used at each of the two locations. As in the two previous experiments fertilizer nitrogen applied to winter wheat was the variable tested. Treatments are given in Table 4. The hypothesis tested was that rates of spring applied nitrogen as high as 90 pounds per acre would increase yields of winter wheat. Plot size was approximately 60 feet long by 3.5 feet wide. Harvesting was done with a small plot combine.

All plots had 300 pounds per acre of 0-20-20 drilled into the soil before seeding plus 300 pounds per acre of 5-20-20 drilled at seeding.

RESULTS AND DISCUSSION

Experiment 1

There was some lodging on two of four locations. Only on the Russell silt loam was there an apparent relation of lodging to treatment. The treatment with 29 pounds per acre of nitrogen applied in the spring had 50% lodging on this soil. Other treatments had less. The treatment which received the least nitrogen, 9.5 pounds per acre, had the least lodging, 33 per cent. There was a tendency toward lower yields on the treatment which had the most lodging. Yields are given in Table 2. However, yields of wheat were not significantly different on either the Russell silt loam or on the Fincastle-Crosby silt loams.

Spring application of 29 pounds per acre of nitrogen along with 5-20-20 drilled in the fall on Elston loam resulted in a meaningful increase in yield of 9.6 bushels per acre more than fall application of 5-20-20 alone. Also, spring application of most of the nitrogen resulted in significantly higher yields than applying all of the nitrogen at planting in 15-15-15 or 12-12-12 on the same farm. This Elston loam because of its high porosity apparently allowed nitrates to leach out of the rooting zone over the winter. Hence, spring application of most of the nitrogen was highest yielding and appeared to be related to soil type.

On the Alford silt loam the general relationship of yield to treatments was the same that was found on the Elston loam. Yields were not as high, and the differences in yields among treatments were not as great as those found on the Elston loam.

The Alford silt loam near Hazelton, Indiana, is approximately 140 miles south of the Elston loam near Lafayette, Indiana. In this southern location winters are somewhat less severe with less frozen soil and more winter leaching. This should have resulted in greater yield differences among treatments on the Alford silt loam than on the Elston loam. How-

ever, the reason for the smaller differences may be related to higher soil tests for available phosphate and available potash and lighter soil texture on the Elston loam than that found on the Alford silt loam.

Table 2. Influence of fertilization upon yields of winter wheat at four locations in Indiana, 1958

Time and rate of nitrogen application		Fertilizer grade applied in fall[2]	Yields			
Fall lbs./A.	Spring lbs./A.		Russell silt loam bu./A.	Elston loam bu./A.	Fincastle Crosby silt loams bu./A.	Alford silt loam bu./A.
9.5	29	5-20-20	43.1	49.4	30.7	29.8
38.7	0	15-15-15	47.6	44.5	31.1	27.2
38.9	0	12-12-12	47.4	46.2	31.0	28.1
9.5	0	5-20-20	46.9	39.8	31.2	25.4
Average			46.3	45.0	31.0	27.7
Least significant difference at the 5% level			not significant	2.4	not significant	1.9
Least significant difference at the 1% level			not significant	3.5	not significant	2.7

Experiment 2

Wheat yields given in Table 3 largely reflected the influence of phosphate and potash fertilizer or phosphate, potash, and nitrogen fertilizer. Of course, the 0-62.4-62.4 fertilizer had a much higher yield than the treatment with no fertilizer applied. There was an indication of a higher yield although not a significant one, with 12.9-51.4-51.4 than with the 0-62.4-62.4 fertilizer. There was a definite trend toward higher yields with nitrogen top-dressed in spring in addition to 12.9-51.4-51.4 drilled at

Table 3. Influence of fertilizer upon yields of wheat on Alford silt loam in Indiana, 1958.

Treatment		
Lbs./A. drilled at seeding N-P_2O_5-K_2O	Lbs./A. top-dressed in spring N-P_2O_5-K_2O	Yield bu./A.
0-0-0	0-0-0	17.1
0-62.4-62.4	0-0-0	26.4
12.9-51.4-51.4	0-0-0	28.4
12.9-51.4-51.4	25-0-0	31.8
12.9-51.4-51.4	45-0-0	31.8
12.9-51.4-51.4	65-0-0	29.7
16.5-16.5-16.5	45-45-45	33.2
Least significant difference at the 5% level		3.5
Least significant difference at the 1% level		4.6

seeding. The 33.5 bushels per acre with 16.5-16.5-16.5 drilled with the seed plus 45-45-45 top-dressed in spring was highest yielding although not significantly higher than two of the treatments. Inasmuch as it had been

2. Phosphate applications were 38 lbs./A. of P_2O_5 from 5-20-20, 38.7 lbs./A. of P_2O_5 from 15-15-15, and 38.9 lbs./A. of P_2O_5 from 12-12-12. Potash applications expressed in lbs./A. of K_2O were the same as phosphate.

predicted that this treatment would not perform this well, more research should be done on testing this method of fertilizing wheat.

Experiment 3

On one of the two locations reported in Table 4 yields decreased significantly and on the other yields increased significantly with increasing rates of top-dressed nitrogen. Increasing rates of nitrogen resulted in decreased yields on the Weinbach clay loam. It contained a considerable amount of available nitrogen from the previous tobacco crop. Had this not been true, lodging probably would not have increased significantly with increasing rates of top-dressed nitrogen. The correlation coefficient showing the relation between yields and estimated percentages of lodging was –0.77. This r value is significant at the 1% level.

On the Princeton sandy loam soil, results were much different from those on the Weinbach clay loam. This sandy soil with its porous nature was much more likely to allow leaching of previously applied nitrogen than Weinbach clay loam. As shown in Table 4, there was no lodging of wheat at any rate of nitrogen on the Princeton sandy loam, and it appears that there would have been somewhat higher yields with more than 90 pounds per acre of nitrogen top-dressed. Yield increases varied from 17 bushels per acre for the first 30 pounds per acre of top-dressed nitrogen to 4.9 bushels per acre for the last 30 pounds per acre of top-dressed nitrogen. These yield responses were highly significant.

Table 4. Influence of rates of top-dressed nitrogen on yields and lodging percentages of wheat on two locations in Indiana, 1960.

Lbs./A. of nitrogen top-dressed in spring	Yields		Lodging	
	Weinbach clay loam bu./A.	Princeton sandy loam bu./A.	Weinbach silt loam %	Princeton sandy loam %
0	50.2	25.1	30	0
30	39.8	42.1	40	0
60	34.5	50.6	46	0
90	34.5	55.5	55	0
Least significant difference at the 5% level	6.9	2.7	7	none
Least significant difference at the 1% level	10.0	3.9	10	none

Summary

Three different fertilizer experiments were conducted with winter wheat. The first experiment was conducted on four different soil types in the 1957-1958 cropping year. Significant differences in yields were obtained at only two of the four locations. Spring top-dressed nitrogen produced greater yield increases than nitrogen applied at planting in the fall on both the Elston and Alford soils. Difference in response to nitrogen between these two soils appeared to be related to soil type.

In Experiment 2 yields were increased significantly as a result of phosphate and potash fertilization at planting. There was a trend toward

higher yields with 25 pounds per acre of nitrogen top-dressed in spring compared to no top-dressed nitrogen when nitrogen, phosphate and potash were applied in the fall at planting.

In Experiment 3 increasing rates of spring top-dressed nitrogen resulted in significantly decreased yields on Weinbach clay loam. There was a significant negative correlation between lodging and yield of wheat on this soil. On the Princeton sandy loam yields of wheat were increased significantly with increasing rates of spring top-dressed nitrogen. These two soils differed in previous treatment and in texture, both of which apparently influenced nitrogen availability for wheat.

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