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The Effects of Top-Dressed Nitrogen on Soft Red Winter Wheat Varieties

HOWARD N. LAFEVER

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER
Wooster, Ohio

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INTRODUCTION

The application of top-dressed nitrogen to wheat is widely practiced in Ohio and other Midwestern states. According to surveys conducted in Ohio by the Statistical Reporting Service, U. S. Department of Agriculture, approximately 42%, 41%, and 47% of the Ohio wheat acreage were fertilized after seeding in the crop harvest years 1968, 1969, and 1970, respectively.[1] These top-dressed fertilizer applications presumably consisted of ammonium nitrate or other nitrogen-containing fertilizers.

Soil tests do not routinely include analysis for nitrogen since this element is the most transient in the soil. Recommended rates of application of nitrogen to wheat in most cases are empirically determined, with previous cropping and nitrogen fertilizer practices as a guide. The purpose of this study was to determine if the newer varieties of wheat included in these tests would respond to higher levels of nitrogen through higher yields with less lodging than varieties which have been grown in the state for several years.

PROCEDURE

These studies were conducted in 1968, 1969, and 1970 at the Ohio Agricultural Research and Development Center, Wooster, and in 1970 at the OARDC Northwestern Branch, Wood Co., Ohio. In 1968, four levels of top-dressed nitrogen (0, 50, 100, and 150 lb. per acre) in the form of 33½% ammonium nitrate were applied to five varieties of soft red winter wheat (Benhur, Logan, Monon, Redcoat, and Seneca). In 1969, five levels of top-dressed nitrogen (0, 50, 100, 150, and 200 lb. per acre) were applied to six varieties (Benhur, Logan, Monon, Redcoat, Reed, and Arthur). In 1970, these five levels of nitrogen were applied to five varieties (Benhur, Logan, Redcoat, Arthur, and Blueboy) grown at Wooster while four levels of nitrogen (0, 50, 100, and 150 lb. per acre) were applied to four varieties (Benhur, Logan, Redcoat, and Arthur) grown at the Northwestern Branch. Three of the varieties were common to all studies.

A split plot design with four replications was used each year, with varieties as the main plots and rates of nitrogen as subplots. Seeding

[1]Calculated from data in Crops, January 1 Crop Report of 1969, 1970, and 1971, respectively.

TABLE 1.—Seeding Date, Seeding Rate, Previous Crop, Soil Test Data, and Fertilization for Rate of Nitrogen Studies on Soft Red Winter Wheats.

Harvest Year	Preceding Crop	Soil Type	Seeding Date	Seeding Rate	Soil Test Data pH	P lb./A	K lb./A	Fertilizer Application
1968 (Wooster)	Oats	Canfield silt loam	10/3/67	90 lb./A	6.4	109	315	250 lb./A of 5-20-20 at seeding. N applied 3/25/68.
1969 (Wooster)	Oats	Canfield silt loam	9/28/68	90 lb./A	5.9	58	285	300 lb./A of 5-20-20 at seeding. 1 ½ tons per acre of lime prior to seeding. N applied 3/4/69.
1970 (Wooster)	Oats	Canfield silt loam	10/1/69	90 lb./A	6.1	38	212	300 lb./A of 5-20-20 at seeding. N applied 3/13/70.
1970 (N.W. Branch)	Corn	Hoytville silty clay loam	10/10/69	90 lb./A	6.4	43	346	250 lb./A of 0-26-26 at seeding. N applied 3/16/70.

date, seeding rate, previous crop, soil test data, and fertilization information are shown in Table 1.

Tests for statistically significant differences were made at the 5% level.

RESULTS AND DISCUSSION

Tables 2, 3, 4, and 5 show the results obtained in these studies in 1968, 1969, 1970 (Wooster), and 1970 (Northwestern Branch), respectively. The pooled data for all varieties grown at Wooster in all 3 years show that increasing rates of nitrogen usually resulted in delayed heading date, increased lodging, and decreased test weight, all of which are undesirable. However, in the 1970 study at Northwestern Branch, no significant changes occurred in these three traits.

Increased rates of nitrogen had no significant effects on plant height and percent protein in 1968. However, a significant increase in both traits occurred in 1969 and 1970 at both locations. These changes are considered undesirable, since increased height increases the probability of lodging and increased protein in soft red winter wheat is a cause of considerable concern to millers and bakers. Increased protein content contributes to poor baking quality in the products in which soft wheats are used. Unless varieties can be developed which inherently have lower protein content, high rates of nitrogen application may lead to the marketing of undesirable wheat.

No significant differences in mean yields of all varieties occurred in 1968 or 1970 at Northwestern Branch due to different rates of nitrogen. However, in 1969 and 1970 at Wooster, the effects of nitrogen on yield were significant.

The effects of nitrogen on yield varied with variety as shown by the presence of significant interactions in 1968 and 1970 at Wooster. The application of nitrogen to Benhur and Redcoat in 1968 and to Redcoat and Arthur in 1970 at Wooster produced significant yield increases. Large but non-significant increases occurred in yields of Redcoat and Arthur in 1969, in yields of Benhur and Redcoat at Northwestern Branch in 1970, and in yields of Benhur at Wooster in 1970. In contrast, all rates of nitrogen on Logan, Monon, Seneca, and Blueboy in all tests resulted in either yield reductions or small, non-significant yield increases. Thus, it is apparent from these studies that response to nitrogen application is largely dependent on the variety under consideration. Season and location effects also appear important.

A major factor in the differential responses of varieties to high levels of nitrogen is straw strength, although other factors may also be involved. Many older varieties lodged severely with moderate top-dressing of nitrogen, thus leading to reduced yields through seed shriveling, higher disease incidence, and other causes. Thus, yield reductions resulting from the application of nitrogen can be explained on the basis of increased lodging in several cases by examination of the data. However, some varieties in some years even in the absence of lodging showed no response to the application of nitrogen. No good explanation for this lack of response was obvious from examination of the field plots. It can be speculated that some other growth factor such as water was limiting and caused a lack of response to nitrogen application. It is also possible that residual soil nitrogen from previous crops or fertilizer applications was near the optimum level for wheat.

Percent lodging for each variety averaged over all levels of nitrogen, although varying considerably with years, provides a good measure of relative straw strength. Of the four varieties grown in at least 2 years, Benhur and Redcoat would thus be rated as stiff-strawed varieties and Logan and Monon as somewhat weaker strawed, with Logan the better of the latter two. These observations are consistent with observations made on state-wide variety yield traits conducted during these same years.

It is apparent that stiffer strawed varieties are needed if the addition of large amounts of nitrogen is to be used as a means of increasing wheat yields. For the varieties in these studies, the addition of more than 50 lb. of nitrogen per acre to any variety except Redcoat was not usually economical, primarily because of increased lodging. The application of even 50 lb. of nitrogen resulted in severe lodging of Logan, Monon, and Seneca in 1968 and of Monon in 1969. Even though the varieties in this study are considered to be stiff-strawed relative to varieties grown 15 to 20 years ago, the data indicate that there is still much need for improvement of this trait.

Season and location effects on the yield responses of certain varieties to increasing nitrogen rates are evident from a comparison of data in Tables 2, 3, 4, and 5. Benhur and Redcoat, the only two varieties which exhibited positive and significant yield responses to nitrogen application in 1968, showed no significant responses in 1969. In 1970, only Redcoat and Arthur in the Wooster study exhibited positive and significant yield responses to nitrogen. Although there was considerably more lodging in 1969 than in 1968, the lack of significant responses to nitrogen in 1969 did not appear to be directly associated with increased lodging. This fact was especially evident in 1970 at both locations where lodging was non-existent or minimal and yet no significant yield responses occurred in most cases with the application of nitrogen. In order to apply nitrogen at optimum levels each year, one would need to be aware of the post-application growing conditions. This is not possible and thus the average effects of nitrogen application must be relied upon to estimate optimum application rates.

When all factors are examined concerning optimum top-dressing rates of nitrogen, the dangers and costs of over-application appear much greater than those of under-application. In addition to the undesirable effects of over-application indicated by the data in this study, it is also well established that excessive nitrogen can produce excessive early growth which may later exhaust the soil water supply in dry seasons, thereby reducing yields. Excessive nitrogen can also increase the susceptibility of wheat to such diseases as rusts and powdery mildew.

The variable responses to nitrogen top-dressing observed in these studies point out the extreme difficulty in making accurate recommendations for rates of top-dressing. Numerous environmental factors affect wheat's response to differential levels of nitrogen application. Perhaps the most important fact revealed by these studies is that only Benhur and Redcoat in 1968 and Redcoat and Arthur in 1970 at Wooster showed significant yield increases with applications of top-dressed nitrogen. If these results are representative of results which would be obtained over a period of several years at different locations, serious consideration should be given to the value of top-dressed nitrogen. Additional studies are presently being conducted in other soil types and locations and should provide a basis for further improvement of recommendations for the use of nitrogen on wheat.

TABLE 2.—Responses of Five Wheat Varieties to Four Levels of Top-dressed Nitrogen, Wooster, Ohio, 1968.

Top-dressed Nitrogen	Variety	Heading Date	Plant Height (in.)	Percent Lodged	Percent Protein*	Test Weight (lb./bu.)	Yield (bu./A)
0	All	6-2	39	9	12.9	58.8	43.1
50	All	6-3	40	35	12.7	57.6	44.9
100	All	6-4	39	46	13.0	56.3	43.0
150	All	6-4	39	47	13.2	56.2	40.8
5 % LSD—nitrogen rates		0.3 day	N.S.†	9 %	N.S.	1.0 lb.	N.S.
Avg.	Benhur	5-28	32	2	13.1	57.2	37.0
Avg.	Logan	6-5	40	45	13.3	56.2	48.6
Avg.	Monon	5-28	38	51	12.8	56.0	40.1
Avg.	Redcoat	6-8	39	1	12.6	58.9	45.4
Avg.	Seneca	6-7	48	74	13.0	57.8	38.8
5 % LSD—varieties		2.1 day	2 in.	12 %	N.S.	0.5 lb.	3.1 bu.
0	Benhur	5-28	31	0	13.1	56.1	32.1
50	Benhur	5-28	32	3	12.8	57.7	38.4
100	Benhur	5-28	32	3	13.0	57.6	40.0
150	Benhur	5-30	32	3	13.3	57.5	37.5

*Whole grain protein at 14 % moisture.
†Not significantly different.

TABLE 2. (Continued).—Responses of Five Wheat Varieties to Four Levels of Top-dressed Nitrogen, Wooster, Ohio, 1968.

Top-dressed Nitrogen	Variety	Heading Date	Plant Height (in.)	Percent Lodged	Percent Protein*	Test Weight (lb./bu.)	Yield (bu./A)
0	Logan	6-4	39	2	12.3	59.4	55.1
50	Logan	6-5	40	35	13.4	57.2	54.5
100	Logan	6-6	40	54	13.7	55.1	46.1
150	Logan	6-7	39	78	14.0	53.1	38.9
0	Monon	5-28	37	5	12.9	57.5	50.7
50	Monon	5-28	38	56	12.8	55.8	45.7
100	Monon	5-29	38	74	13.2	54.6	41.5
150	Monon	5-29	37	70	12.3	56.0	41.6
0	Redcoat	6-6	37	0	13.1	60.7	33.3
50	Redcoat	6-7	39	0	12.3	59.3	44.6
100	Redcoat	6-9	40	1	11.9	57.7	50.2
150	Redcoat	6-9	40	1	12.9	58.0	53.5
0	Seneca	6-5	49	37	13.2	60.1	44.2
50	Seneca	6-7	48	84	12.3	57.9	41.0
100	Seneca	6-7	47	89	13.3	56.7	37.1
150	Seneca	6-8	47	86	13.2	56.6	32.8
5% LSD—N rates within varieties		0.7 day	N.S.	21%	N.S.	2.2 lb.	5.1 bu.

*Whole grain protein at 14% moisture.

TABLE 3.—Responses of Six Wheat Varieties to Five Levels of Top-dressed Nitrogen, Wooster, Ohio, 1969.

Top-dressed Nitrogen	Variety	Heading Date	Plant Height (in.)	Percent Lodged	Percent Protein*	Test Weight (lb./bu.)	Yield (bu./A)
0	All	5-29	46	40	12.1	58.2	53.7
50	All	5-29	47	44	12.4	58.1	56.7
100	All	5-30	47	56	13.0	57.8	55.7
150	All	5-31	47	52	13.1	57.3	51.5
200	All	5-31	47	59	13.2	57.0	50.3
5% LSD—nitrogen rates		0.3 day	0.6 in.	9%	0.3%	0.5 lb.	3.3 bu.
Avg.	Benhur	5-26	45	38	13.2	59.0	52.2
Avg.	Logan	6-2	46	39	12.4	56.9	53.3
Avg.	Monon	5-27	45	88	12.3	56.7	47.3
Avg.	Redcoat	6-1	49	36	11.7	58.2	53.3
Avg.	Reed	6-5	49	44	13.9	58.1	48.1
Avg.	Arthur	5-27	45	55	13.2	57.7	67.2
5% LSD—varieties		1 day	2 in.	40%	0.7%	0.9 lb.	6.0 bu
0	Benhur	5-25	44	31	12.7	59.0	53.7
50	Benhur	5-25	45	36	13.0	59.0	54.7
100	Benhur	5-26	45	34	13.5	59.4	52.7
150	Benhur	5-26	45	31	13.2	58.8	50.9
200	Benhur	5-27	46	56	13.4	58.7	49.2
0	Logan	5-31	46	26	11.7	57.7	57.6
50	Logan	6-1	46	29	11.8	57.2	55.7
100	Logan	6-1	47	41	12.8	57.8	55.0
150	Logan	6-2	46	47	12.7	56.5	52 5
200	Logan	6-3	47	54	12.9	55.4	45.8

*Whole grain protein at 14% moisture.

TABLE 3. (Continued).—Responses of Six Wheat Varieties to Five Levels of Top-dressed Nitrogen, Wooster, Ohio, 1969.

Top-dressed Nitrogen	Variety	Heading Date	Plant Height (in.)	Percent Lodged	Percent Protein*	Test Weight (lb./bu.)	Yield (bu./A)
0	Monon	5-25	45	69	12.2	57.8	49.0
50	Monon	5-26	46	91	12.2	57.4	49.8
100	Monon	5-27	45	95	12.0	56.7	47.5
150	Monon	5-28	44	94	12.6	56.3	46.9
200	Monon	5-28	44	94	12.6	55.6	43.0
0	Redcoat	5-31	46	20	10.8	58.3	46.0
50	Redcoat	5-31	49	17	11.3	59.2	54.9
100	Redcoat	6-2	50	52	11.8	57.9	57.5
150	Redcoat	6-2	50	52	12.3	57.6	53.5
200	Redcoat	6-3	49	40	12.1	57.9	54.9
0	Reed	6-3	48	45	13.2	58.1	51.1
50	Reed	6-4	49	37	13.5	57.4	50.6
100	Reed	6-5	49	42	14.2	57.0	47.4
150	Reed	6-6	49	40	14.2	57.0	45.7
200	Reed	6-6	49	55	14.2	56.7	45.8
0	Arthur	5-26	45	50	12.2	58.5	64.7
50	Arthur	5-27	45	50	12.4	58.7	74.7
100	Arthur	5-28	45	69	13.5	57.9	73.7
150	Arthur	5-27	44	47	13.8	57.7	59.7
200	Arthur	5-28	44	57	14.0	57.9	63.1
5% LSD—N rates within varieties		0.7 day	1.5 in.	N.S.†	0.8%	N.S.	N.S.

*Whole grain protein at 14% moisture.
†Not significantly different.

TABLE 4.—Responses of Five Wheat Varieties to Five Levels of Top-dressed Nitrogen, Wooster, Ohio, 1970.

Top-dressed Nitrogen (lb./A)	Variety	Heading Date	Plant Height (in.)	Percent Lodged	Percent Protein*	Test Weight (lb./bu.)	Yield (bu./A)
0	All	5-26	39.4	0.1	11.5	57.0	41.3
50	All	5-26	40.6	0.2	12.2	57.1	45.5
100	All	5-27	40.4	0.7	12.6	57.1	46.6
150	All	5-27	40.3	2.9	13.1	56.7	45.7
200	All	5-27	40.1	5.4	13.5	56.0	44.4
5% LSD—nitrogen rates		0.2 day	0.8 in.	2.5%	0.4%	0.4 lb.	3.2 bu.
Avg.	Benhur	5-23	37.1	0.4	12.9	57.7	37.6
Avg.	Logan	5-31	41.6	1.4	12.5	56.3	44.3
Avg.	Redcoat	5-31	45.6	0.0	12.6	56.3	45.2
Avg.	Arthur	5-24	38.0	1.7	12.6	58.5	60.8
Avg.	Blueboy	5-24	38.5	5.8	12.3	55.2	35.5
5% LSD—varieties		0.5 day	1.5 in.	2.7%	N.S.	0.5 lb.	3.8 bu.
0	Benhur	5-22	35.2	0.0	11.4	57.4	34.6
50	Benhur	5-23	37.5	0.0	12.8	58.1	40.1
100	Benhur	5-23	37.5	0.0	13.2	57.7	38.0
150	Benhur	5-24	37.5	1.0	13.4	57.9	38.8
200	Benhur	5-24	37.8	1.0	13.6	57.2	36.7
0	Logan	5-30	41.8	0.0	11.4	57.0	45.4
50	Logan	5-30	42.2	0.0	11.7	56.5	46.0
100	Logan	5-31	42.2	0.5	12.5	56.5	46.0
150	Logan	6-1	41.0	0.5	12.9	56.5	43.8
200	Logan	6-1	40.8	6.2	13.7	54.8	40.2

*Whole grain protein at 14% moisture.

TABLE 4 (Continued).—Responses of Five Wheat Varieties to Five Levels of Top-dressed Nitrogen, Wooster, Ohio, 1970.

Top-dressed Nitrogen (lb./A)	Variety	Heading Date	Plant Height (in.)	Percent Lodged	Percent Protein*	Test Weight (lb./bu.)	Yield (bu./A)
0	Redcoat	5-30	45.0	0.0	11.9	56.1	39.7
50	Redcoat	5-30	46.5	0.0	12.0	56.3	44.6
100	Redcoat	5-31	45.5	0.0	12.1	56.8	49.6
150	Redcoat	6-1	46.2	0.0	13.1	55.8	45.3
200	Redcoat	6-1	45.0	0.0	13.8	56.5	46.6
0	Arthur	5-23	37.0	0.0	11.4	58.5	51.5
50	Arthur	5-24	37.8	0.0	12.2	58.8	60.5
100	Arthur	5-24	38.0	1.8	12.9	58.7	62.7
150	Arthur	5-24	38.8	1.8	13.3	58.5	65.7
200	Arthur	5-25	38.2	5.0	13.3	57.8	63.9
0	Blueboy	5-22	37.8	0.5	11.5	56.0	35.1
50	Blueboy	5-23	39.0	0.8	12.1	55.6	36.4
100	Blueboy	5-24	39.0	1.2	12.3	55.6	36.8
150	Blueboy	5-24	38.0	11.2	12.6	54.8	34.7
200	Blueboy	5-24	38.8	15.0	13.2	53.9	34.5
5% LSD—N rates within varieties		0.6 day	N.S.†	5.7%	0.8%	1.0 lb.	7.2 bu.

*Whole grain protein at 14% moisture.
†Not significantly different.

TABLE 5.—Responses of Four Wheat Varieties to Four Levels of Top-dressed Nitrogen, Northwestern Branch, Wood Co., Ohio, 1970.

Top-dressed Nitrogen (lb./A)	Variety	Heading Date	Plant Height (in.)	Percent Lodged	Percent Protein*	Test Weight (lb./bu.)	Yield (bu./A)
0	All	5-30	34.4	0	12.9	59.9	60.5
50	All	5-30	34.8	0	12.8	60.1	62.9
100	All	5-30	35.7	0	13.8	60.0	62.5
150	All	5-30	36.0	0	13.8	60.2	64.3
5% LSD—nitrogen rates		N.S.†	1.0 in.	N.S.	0.5%	N.S.	N.S.
Avg.	Benhur	5-26	32.6	0	13.6	60.6	52.6
Avg.	Logan	6-2	36.3	0	13.6	59.1	68.1
Avg.	Redcoat	6-2	39.6	0	12.9	59.5	59.0
Avg	Arthur	5-26	32.4	0	13.1	60.9	70.6
5% LSD—varieties		1 day	1.6 in.	N.S.	0.5%	0.7 lb.	8.5 bu.
0	Benhur	5-26	31.0	0	13.2	60.3	48.7
50	Benhur	5-26	31.8	0	13.0	60.3	50.0
100	Benhur	5-26	34.0	0	14.0	60.8	51.9
150	Benhur	5-26	33.8	0	14.1	61.0	59.6
0	Logan	6-2	35.2	0	13.1	58.6	67.5
50	Logan	6-2	36.8	0	12.8	59.6	69.3
100	Logan	6-2	36.5	0	14.6	59.4	67.3
150	Logan	6-2	36.8	0	14.1	58.8	68.2
0	Redcoat	6-2	39.2	0	12.2	59.2	53.2
50	Redcoat	6-2	38.8	0	12.8	59.8	61.7
100	Redcoat	6-2	40.0	0	13.5	59.2	59.0
150	Redcoat	6-2	40.5	0	13.0	60.0	61.8
0	Arthur	5-26	32.2	0	13.1	61.5	72.6
50	Arthur	5-26	32.0	0	12.7	60.7	70.5
100	Arthur	5-26	32.0	0	13.0	60.7	71.9
150	Arthur	5-26	33.0	0	13.8	60.8	67.3
5% LSD—N rates within varieties		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

*Whole grain protein at 14% moisture.

†Not significantly different.

The State Is the Campus for Agricultural Research and Development

Ohio's major soil types and climatic conditions are represented at the Research Center's 11 locations. Thus, Center scientists can make field tests under conditions similar to those encountered by Ohio farmers.

Research is conducted by 13 departments on more than 6200 acres at Center headquarters in Wooster, nine branches, and The Ohio State University.

Center Headquarters, Wooster, Wayne County: 1953 acres
Eastern Ohio Resource Development Center, Caldwell, Noble County: 2053 acres
Jackson Branch, Jackson, Jackson County: 344 acres
Mahoning County Farm, Canfield: 275 acres
Muck Crops Branch, Willard, Huron County: 15 acres
North Central Branch, Vickery, Erie County: 335 acres
Northwestern Branch, Hoytville, Wood County: 247 acres
Southeastern Branch, Carpenter, Meigs County: 330 acres
Southern Branch, Ripley, Brown County: 275 acres
Western Branch, South Charleston, Clark County: 428 acres