Nitrogen Management for Irrigated Malting Barley

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Objective

The objective of this study was to measure the impact of varying nitrogen (N) rates and timings of N application on the grain yield and protein composition of irrigated barley.

Materials and Methods

A study was established at the NDSU Carrington Research Extension Center to evaluate the effect of polymer coated urea and split applications of N on irrigated barley. A split split plot design with three factors (N rates, application strategy, and variety) was used. The N rates were: 0, 30, 60, 90, and 120 lbs. N/ac. The application methods were: 100% applied pre-emergence (PRE), 100% applied polymer coated pre-emergence (PC PRE), and a split-application (split) with 50% applied pre-emergence followed by 50% post-emergence. The N fertilizer source material was urea. The polymer coated urea was Nutrisphere-N (Simplot). The barley varieties evaluated were: Stellar-ND, Tradition, Pinnacle, and 2ND21867. The trial was direct-seeded into soybean stubble April 15 at a seeding rate of 1.2 million pure live seeds per acre in 7-inch rows. The pre-emergence fertilizer applications were applied shortly after planting and were incorporated with 0.35 inches of irrigation water on April 16. The post-emergence fertilizer treatments were applied at the 4- to 4.5-leaf stage on May 27. The trial was harvested August 12. Soil samples were taken from the 0 lb./ac plots associated with the 100% PRE treatment and from all three 90 lbs./ac treatments. Soil samples were taken: April 15, May 23 (3.5-leaf stage), and post-harvest on September 16. Plant tissue samples were also taken from the corresponding treatments on May 23.

Results

Nitrogen Fertilizer Rates:

When averaged over application strategy and variety; days to head and the percentage of plump kernels decreased slightly as the N rates increased, while the number of heads per acre, plant lodge, and the percentage of thin kernels increased as the N rates increased (Table 1). There were slight differences in test weights but no trends were evident.

Table 1. Barley response to nitrogen rates.

Nitrogen Rate	Days to Head	# of Heads	Plant Lodge	Plump >6/64	Thin <5/64	Test Weight
lb/ac		million/ac	0-9	%		lb/bu
0	72.1	1.34	0.3	98.1	0.7	47.0
30	71.6	1.39	0.9	97.0	0.7	47.6
60	71.4	1.47	1.6	96.7	0.7	48.0
90	71.2	1.47	1.7	96.6	0.8	47.8
120	71.1	1.52	2.5	95.7	0.9	47.3
LSD 0.05	0.6	0.11	0.4	1.3	0.1	0.6

Application Strategy: When averaged over N rates and variety; the application strategy did not affect the days to head, number of heads per acre, plant lodge, plump, or test weight (Table 2).

Table 2. Barley response to N application strategy.

Application Strategy	Days to Head	# of Heads	Plant Lodge	Plump >6/64	Test Weight
		million/ac	0-9	%	lb/bu
PRE	71.6	1.41	1.4	97.4	47.7
PC PRE	71.6	1.44	1.2	96.5	47.4
Split	71.3	1.47	1.5	96.6	47.6
LSD (0.05)	NS	NS	NS	NS	NS

Nitrogen Fertilizer Rate by Application Strategy: There was a nitrogen fertilizer rate by application strategy interaction for plant height, grain protein, and grain yield. Taking soil samples from the 0 lb. N pre-emergence treatment only was an error. Soil samples taken on April 19 indicated that there were significant differences in the amount of available nitrogen in the soil (Table 3). One would expect similar response from the three application strategies when no fertilizer was applied but significant differences in plant height and grain yield occurred (Table 4). Since we did not sample the 0 lb. N treatments for the PCPRE and split application strategies; we can only hypothesize that these differences occurred due to differences in available soil nitrogen.

Table 3. Soil and plant tissue test results.

Nitrogen Rate	Application Strategy	Soil Sampling Date			Plant Tissue Test
		4/19	5/23	9/16	
lb/ac			lb N/ac		N ppm
0	PRE	46.5	86.3	19.3	2618.3
90	PRE	64.3	116.3	20.8	2787.1
90	PC PRE	48.8	90.3	19.0	2990.5
90	Split	41.8	88.0	27.5	2668.3
LSD (0.05)		6.6	11.3	2.5	95.7

Table 4. Barley response to nitrogen rates and application strategy.

Nitrogen	Application Strategy								
Rate	PRE	PC PRE	Split	PRE	PC PRE	Split	PRE	PC PRE	Split
lb/ac	Plant Height (inch)			Grain Protein (%)			Grain Yield (bu/ac)		
0	29.5	26.9	28.6	10.6	10.3	10.3	80.5	68.2	71.5
30	33.0	32.5	32.1	10.3	10.4	10.1	83.2	85.4	86.3
60	35.8	37.2	37.6	10.5	10.5	10.7	110.2	110.8	116.4
90	36.5	37.8	38.1	10.4	11.2	11.2	111.9	120.6	134.6
120	38.5	38.0	38.5	11.2	10.8	11.5	124.1	132.1	136.6
LSD 0.05		1.3			0.4			8.3	

When fertilizer was applied; plant heights were similar at the 120 lb. N rate, but were shorter in the PRE treatments at the 30, 60, and 90 lb. rates when compared the PC PRE and split application treatments (Table 4).

Grain protein tended to increase as the fertilizer rate increased with the exception of the 90 lb. N rate in the PRE treatment and the 120 lb. N rate in the PC PRE treatment which were slightly lower than expected (Table 4).

Grain yields were similar at the 30 and 60 lb. N increments but were significantly higher for the split application at the 90 lb. N rate (Table 4). The highest grain yields occurred with 90 and 120 lbs. N applied as a split application and 120 lbs. N applied PC PRE.

Variety: Varietal differences are listed in table 5. When averaged over N rates and application strategies, grain yields ranges from 102.0 to 109.7 bu/ac. Pinnacle had the highest grain yield and number of heads per acre and the lowest protein while 2ND21867 had the highest test weight.

Table 5. Variety characteristics averaged over N rates and application strageties.

	Days to Head	# of Heads	Plant Lodge	Plant Height	Plump >6/64	Grain Protein	Test Weight	Grain Yield
		million/ac	0-9	inch		%	lb/bu	bu/ac
Stellar-ND	70.5	1.3	1.9	35.3	95.6	10.8	46.1	102.8
Tradition	71.0	1.3	1.3	35.4	97.1	11.0	47.8	102.0
Pinnacle	72.3	1.6	1.2	34.6	96.7	9.8	47.1	109.7
2ND21867	72.2	1.5	1.2	33.5	97.9	11.0	49.1	104.9
LSD 0.05	0.6	0.1	0.4	0.7	1.1	0.2	0.5	4.3

There was an application strategy by variety interaction for thin kernels (Table 6). Thin kernels were 1% or less. There was no difference in the percentage of thin kernels for the PC PRE treatment. In the PPI and split treatments thins ranged from 0.6 to 1.0% and 0.5 to 0.9%.

Table 6. Thin Kernels (<5/64)

Variety	PRE	PC PRE	Split
		%	
Stellar	0.7	0.9	0.9
Tradition	0.6	0.8	0.5
Pinnacle	1.0	0.8	0.7
2ND21867	0.7	0.8	0.7
LSD 0.05		0.2	

Nitrogen: As previously mentioned, there were differences in the amount of background nitrogen prior to planting (Table 3). Soil and plant tissue samples taken one week prior to the post split application (5/23) indicated about 88 lbs. N/ac for the 0 N, 90 PC PRE, and split treatments while the PRE treatment had 116 lbs. N/ac . Plant tissue samples taken the same day indicated similar N concentrations in the 0 N and split treatment, while the PC PRE treatment had the highest N concentration. Post-harvest soil samples indicated about 19-20 lbs. N in the upper two feet of soil for the 0 lb. N, 90 lb. N Pre, and 90 lb. N PC PRE; and 27.5 lbs. N for the 90 lb. N split application.

The amount of N per bushel when averaged over variety is listed in table 7. Total N is the applied N plus a 40 lb. soybean credit plus a 50 lb. initial soil N level. An average of the initial soil test was used to provide the soil N level. The soil nitrogen by application strategy interaction was not significant (P=0.1027). When averaged over application strategies, the mean amount of N per bushel produced tended to increase as the amount of N increased. When averaged over N rates, there is no difference between the PRE and PC PRE treatments. This is mainly due to the high value in the 0 N, PC PRE treatment. For the 90 and 120 lb. N treatments, the amount of N per bushel produced was about 0.1 lb less for the PC PRE treatment when compared to the PRE treatment. The split application required less N per bushel when compared to both the PRE and PC PRE treatments.

Table 7. Amount of N available per bushel produced.

Nitrogen Rate	Total N[a]	Application Stategy			
		PRE	PC PRE	Split	Mean
------ lb/ac ------		---------- lb N/bu ----------			
0	90	1.22	1.35	1.27	1.28
30	120	1.48	1.51	1.41	1.47
60	150	1.39	1.37	1.30	1.35
90	180	1.62	1.51	1.34	1.49
120	210	1.70	1.60	1.55	1.62
Mean		1.48	1.47	1.37	

[a]Total N = 50 lb. soil + 40 lb. soybean credit + applied N.

LSD 0.05: Nitrogen Rate = 0.08, Application Strategy = 0.06

Summary: The number of heads per acre and plant lodge increased as the fertilizer rate increased. Plant heights were similar at the 120 lb. N rate, but were shorter in the PRE treatments at the 30, 60, and 90 lb. rates when compared the PC PRE and split application treatments. Grain protein tended to increase as the fertilizer rate increased. The highest grain yields occurred with 90 and 120 lbs. N applied as a split application and 120 lbs. N applied PC PRE. The amount of N available per bushel produced tended to increase as the N rate increased. The split application required less N per bushel when compared to both the PRE and PC PRE treatments.

Third and fourth replicates of irrigated malting barley fertility trial.