Nitrogen Fertilizer Requirement of Feed and Malting Barley Compared to Wheat, 2011

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Summary

Barley is generally thought to require less nitrogen fertilizer than wheat, but how much less has not been clearly documented. The purpose of this study is to compare the nitrogen fertilizer requirements of barley and wheat. A study was conducted at the Maricopa Agricultural Center testing the response of 2 durum wheats (Kronos and Havasu), 2 bread wheats (Yecora Rojo and Joaquin), 2 feed barleys (Baretta and Nebula), and 2 malting barleys (Conrad and Moravian 69) to 7 rates of nitrogen fertilizer (0, 30, 60, 90, 120, 150, and 180 lbs N/acre). The surface soil was relatively high in nitrate at planting (19 ppm NO_3-N) contributing an estimated 76 lbs N/acre. Maximum yield was obtained at 156 (durum), 147 (wheat), 137 (feed barley), and 127 (malting barley) lbs N/acre. However, since the yield of durum and bread wheat was higher than feed and malting barley, the nitrogen fertilizer per 100 pounds of grain yield was similar for these crop types (~2.37 lbs N per 100 lbs of grain). If the 76 lbs N/a of nitrogen estimated to be available from the surface soil were included, then about 3.62 lbs of N would have been required per 100 lbs of grain for both wheat and barley. The N requirement reported in this study does not include the extra N potentially needed for wheat to obtain acceptable protein levels. In conclusion, wheat required more nitrogen fertilizer than barley to obtain maximum yield in our study, but the amount of nitrogen fertilizer required per 100 pounds of grain was similar.

Introduction

Barley has a reduced requirement for nitrogen fertilizer compared to wheat since it does not require late season applications to boost grain protein. Furthermore, some evidence also exists that barley requires less nitrogen fertilizer than wheat for equivalent yields independent of the grain protein issue. If we assume that wheat and barley have equivalent grain yields but that barley has 12% protein in the grain compared to 14% for wheat, then barley would require at least 15% less nitrogen fertilizer than wheat. However, this does not account for differences between wheat and barley in their nitrogen fertilizer requirement during the season and their relative efficiency in extracting nitrogen from the soil.

Most of the barley grown in Arizona is used for feed. However, some malting barley has been grown in the past. Malting companies require that barley have grain protein content below 10-12%. Producing malting barley with low grain protein as been difficult in Arizona in the past, and may require that the grower apply low nitrogen fertilizer rates and risk that yields will be low as a result. So, if Arizona is ever to become a major supplier of malting barley, the nitrogen fertilizer requirement of this crop needs to be studied in order to determine the nitrogen fertilizer rate that provides acceptably low grain protein and optimum grain yield.

Nitrogen fertilizer is a major cost in barley production, and growers may benefit from knowing how barley responds to nitrogen fertilizer especially compared to wheat, which they may be more familiar with. The objective of this study is to evaluate nitrogen fertilizer requirement of feed and malting barley compared to wheat.

Procedure

A study was conducted at the University of Arizona Maricopa Agricultural Center to evaluate nitrogen fertilizer requirement of feed and malting barley compared to wheat. The soil type was a Casa Grande sandy loam with a preplant soil nitrate level of 19 ppm NO_3-N and phosphate level of 2.0 ppm P. N fertilizer treatments were split equally between applications at planting and the 5-leaf stage for total N rates of 0, 30, 60, 90, 120, 150, and 180 lbs N/acre using urea (46-0-0) as a N fertilizer source. The N fertilizer was applied by hand to plots 52 inches x 20 ft in size. The seed was planted with a cone planter in seven rows spaced 6 inches apart and 20 ft long. The seeding rate was approximately 100 lbs/acre for durum varieties and 85 lbs/acre for barley varieties. The experimental design of was a split plot with N rates (0, 30, 60, 90, 120, 150, and 180 lbs N/acre) as main plots and varieties (Kronos and Havasu durums, Yecora rojo and Jaoquin wheat, Baretta and Nebula feed barley, and Conrad and Moravian 69 malting barley) as subplots, and replicated 4 times. Cultural practices are listed in Table 1. The following data was collected: grain yield, straw yield, total yield, harvest index, test weight, plant height, lodging, heading, physiological maturity, yellow berry, grain protein, straw N concentration and light interception on Feb 10 at the 5 leaf stage. Grain was harvested with a small plot combine and yields are expressed on an "as is" moisture basis. HVAC was determined from 10 g of seed. Physiological maturity is defined as when the glumes turn brown. Light interception was determined by dividing the average of six readings from a sunfleck ceptometer at ground level by incident light level. Grain protein was expressed on a 12% moisture basis and straw N was expressed on a 0% moisture basis. Abbreviations for the sources of varieties are: APB = Arizona Plant Breeders, WPB = Western Plant Breeders, WWW = World Wide Wheat, UC = University of California.

Results and Discussion

This growing season was characterized by below average temperature overall and below average rainfall (Table 2). Even though the overall temperature was average, February and May were colder than average and December was warmer than average. Unusually cold weather during February in particular slowed the crop growth and could have caused unseen damage, although the only damage evident was some leaf tip burn.

Grain yield increased with nitrogen fertilizer application for all the varieties tested (Table 3). The yield increase could be described by a linear and/or quadratic function. Plant height of Kronos, Yecora Rojo, and Conrad was increased by N rate. Light interception of Kronos was increased by N rate. Heading of Conrad, maturity of Baretta, and maturity averaged over varieties was delayed by N rate. Harvest index, test weight, lodging, yellow berry, grain protein, and straw N were not affected by N rate. Differences among varieties were detected for all variables measured. The only variety x N rate interaction detected was for lodging.

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Acknowledgments

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Table 1. Cultural practices for the small grain nitrogen trial at Maricopa.

Cultural information	Maricopa
Previous crop	Fallow
Soil texture	Sandy Loam
Nominal planting date	12/14/10
Effective planting date	12/15/10
Irrigation dates (amount)	12/15 (3.21 in.) 1/27 (3.89 in.) 2/25 (3.59 in.) 3/17 (3.89 in.) 3/31 (2.39 in.) 4/13 (5.38 in.) 4/25 (4.08 in.) Total (26.43 in.)
Nitrogen dates (amount)	12/15 (0 to 90 lbs N/a) as 46-0-0 1/27 (0 to 90 lbs N/a) as 46-0-0 Total = 0 to 180 lbs N/a
Phosphorus (date, amount, fertilizer)	12/15 (50 lbs P_2O_5/a) 0-45-0
Pesticides (date)	None
Harvest date	5/26

Table 2. Climatic data from AZMET for Maricopa during the 2011 growing season compared to the long-term average.

Climate variable	Unit	Year(s)	Dec	Jan	Feb	Mar	Apr	May	Dec-May
Max	ºF	2011	70	67	66	79	85	90	76
Temp.	ºF	Avg	65	66	70	77	85	95	76
Min	ºF	2011	38	32	34	44	54	57	43
Temp.	ºF	Avg	35	36	39	44	51	60	44
Ppt.	inches	2011	0.39	0	0.4	0.05	0.32	0	1.16
	inches	Avg	0.62	0.72	0.85	0.79	0.26	0.2	3.43

Table 3. Response of small grain varieties to nitrogen rate at Maricopa in 2011. Crop types planted were durum (Kronos and Havasu), wheat (Yecora Rojo and Joaquin), feed barley (Baretta and Nebula), and malting barley (Conrad and Moravian 69). The surface soil was relatively high in nitrate at planting time (19 ppm NO_3-N).

Variety	N rate	Grain yield	Harvest Index	Test weight	Plant height	Lodging	Light intercep-tion	Head-ing	Matur-ity	Yellow berry	Grain protein	Straw N
	lbs N/a	lbs/a	%	lbs/bu	inches	%	%			%	%	%
Kronos	0	5869	46.1	61.5	33.3	0	52	3/24	5/3	6	13.6	0.39
	30	6091	48.9	60.8	33.8	6	48	3/24	5/2	4	13.3	0.34
	60	6365	47.8	61.1	34.3	6	40	3/24	5/3	3	14.2	0.32
	90	6404	50.5	61.9	33.8	0	59	3/25	5/3	3	13.9	0.40
	120	6656	48.8	61.8	34.0	0	69	3/25	5/2	1	14.3	0.40
	150	6698	49.3	61.5	34.5	25	60	3/25	5/4	1	13.8	0.46
	180	6812	47.5	62.3	35.5	0	71	3/25	5/4	5	13.4	0.41
	linear	*	ns	ns	*	ns	*	ns	ns	ns	ns	ns
	quadratic	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	ns
Havasu	0	4603	42.5	63.0	33.5	0	76	3/26	5/4	1	14.6	0.37
	30	5809	46.7	63.2	34.8	0	74	3/26	5/3	7	13.2	0.32
	60	5997	45.9	62.7	33.8	0	50	3/25	5/2	3	14.4	0.47
	90	6414	42.5	62.6	35.8	6	73	3/25	5/3	3	13.5	0.38
	120	6638	42.8	62.9	34.0	0	67	3/25	5/4	1	14.7	0.45
	150	7099	46.6	63.0	35.3	0	41	3/27	5/4	0	14.2	0.39
	180	6691	44.0	62.5	35.3	0	61	3/26	5/4	0	14.3	0.43
	linear	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	quadratic	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Yecora rojo	0	4094	48.6	62.3	28.5	0	74	3/27	5/1	2	14.5	0.39
	30	4259	46.7	62.6	29.3	0	53	3/28	5/3	11	13.5	0.32
	60	4778	47.2	62.7	30.5	0	58	3/28	5/3	1	14.3	0.44
	90	5338	46.5	62.0	31.3	0	61	3/30	5/4	4	13.8	0.41
	120	5870	47.8	62.3	30.3	0	67	3/30	5/4	0	15.1	0.44
	150	5791	47.6	62.4	30.5	0	48	3/29	5/4	0	14.8	0.49
	180	6260	47.5	63.1	29.0	0	63	3/27	5/3	1	14.7	0.38
	linear	**	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	quadratic	ns	ns	ns	*	ns	ns	ns	ns	ns	ns	ns
Joaquin	0	4675	45.1	62.4	35.3	0	70	3/26	5/4	0	15.9	0.51
	30	4830	45.5	62.7	35.5	0	45	3/27	5/3	11	13.9	0.33
	60	5252	43.9	62.5	35.5	0	49	3/26	5/3	4	14.3	0.38

	90	6039	45.8	61.9	37.0	0	72	3/27	5/4	1	14.3	0.32
	120	5370	44.4	61.9	35.3	0	65	3/27	5/3	0	16.0	0.57
	150	5410	44.7	62.8	33.3	0	55	3/25	5/4	0	15.3	0.43
	180	5022	45.4	62.6	36.3	0	57	3/27	5/3	2	15.3	0.41
	linear	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	quadratic	**	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Baretta	0	5083	50.5	50.8	28.8	0	55	3/28	5/1	----	12.6	0.67
	30	5256	52.0	51.0	29.0	0	52	3/30	5/2	----	12.2	0.65
	60	5515	50.7	51.2	29.0	0	60	3/26	5/1	----	12.5	0.58
	90	6373	50.5	51.3	28.3	0	39	3/28	5/2	----	12.5	0.66
	120	5953	51.2	51.2	28.5	0	27	3/29	5/3	----	12.8	0.68
	150	6361	50.9	50.6	30.5	0	36	3/28	5/4	----	12.5	0.73
	180	5830	51.7	50.7	29.8	0	33	3/28	5/3	----	11.8	0.56
	linear	**	ns	ns	ns	ns	ns	ns	*	----	ns	ns
	quadratic	ns	ns	ns	ns	ns	ns	ns	ns	----	ns	ns
Nebula	0	3575	37.7	52.0	30.3	0	32	3/25	4/28	----	13.0	0.68
	30	3857	35.4	51.2	31.2	0	50	3/25	4/29	----	12.1	0.75
	60	4225	41.8	51.3	32.3	0	52	3/25	5/1	----	12.9	0.69
	90	4388	39.3	51.7	32.3	0	42	3/25	5/1	----	12.2	0.89
	120	4956	39.3	49.6	30.3	0	36	3/25	5/1	----	12.8	0.79
	150	4970	37.7	48.5	32.0	0	55	3/25	5/1	----	13.2	0.89
	180	4503	35.1	51.4	32.0	0	59	3/24	5/1	----	13.0	0.77
	linear	*	ns	ns	ns	ns	ns	ns	ns	----	ns	ns
	quadratic	ns	ns	ns	ns	ns	ns	ns	ns	----	ns	ns
Conrad	0	3676	34.7	52.7	37.3	0	67	3/19	4/22	----	13.8	0.51
	30	4259	39.6	54.5	35.3	0	70	3/20	4/23	----	13.0	0.46
	60	4074	41.4	53.8	37.5	0	59	3/19	4/24	----	12.8	0.49
	90	4954	35.4	54.3	38.8	0	81	3/19	4/22	----	12.8	0.43
	120	5325	39.7	54.1	38.3	0	78	3/20	4/25	----	14.7	0.52
	150	4582	35.6	53.5	40.0	6	67	3/22	4/23	----	14.0	0.66
	180	4426	38.3	54.2	39.3	0	76	3/22	4/23	----	14.1	0.59
	linear	*	ns	ns	*	ns	ns	*	ns	----	ns	ns
	quadratic	*	ns	ns	ns	ns	ns	ns	ns	----	ns	ns
Moravian 69	0	3985	44.2	52.6	31.6	0	50	4/1	5/1	----	11.8	0.54
	30	5124	42.7	52.1	32.8	0	60	4/3	5/1	----	11.5	0.51
	60	5482	45.7	51.9	32.3	0	49	4/3	5/1	----	11.9	0.66
	90	5820	45.0	52.7	31.8	0	49	4/3	5/1	----	11.3	0.63

	120	5775	43.4	52.4	31.8	0	70	4/3	5/1	----	12.3	0.56
	150	5985	40.4	52.3	32.3	0	54	4/3	5/1	----	12.1	0.57
	180	4861	41.8	51.7	31.5	0	47	4/3	5/1	----	11.9	0.64
	linear	ns	ns	ns	ns	ns	ns	ns	ns	----	ns	ns
	quadratic	**	ns	ns	ns	ns	ns	ns	ns	----	ns	ns
Avg	0	4445	43.7	57.2	32.3	0	60	3/26	4/30	2	13.7	0.51
	30	4936	44.7	57.3	32.7	1	56	3/26	5/1	8	12.9	0.46
	60	5211	45.6	57.1	33.1	1	52	3/26	5/1	3	13.4	0.50
	90	5716	44.4	57.3	33.6	1	59	3/26	5/1	3	13.0	0.51
	120	5818	44.7	57.0	32.8	0	60	3/27	5/1	1	14.1	0.55
	150	5862	44.1	56.8	33.5	4	52	3/27	5/2	0	13.8	0.58
	180	5551	43.9	57.3	33.6	0	59	3/26	5/1	2	13.5	0.52
	linear	**	ns	ns	ns	ns	ns	ns	*	ns	ns	ns
	quadratic	**	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Kronos	Avg	6414	48.4	61.6	34.1	5	57	3/24	5/3	3	13.8	0.39
Havasu		6179	44.4	62.8	34.6	1	63	3/26	5/3	2	14.1	0.40
Y. Rojo		5199	47.4	62.5	29.9	0	61	3/28	5/3	3	14.4	0.41
Joaquin		5228	45.0	62.4	35.4	0	59	3/26	5/3	3	15.0	0.42
Baretta		5767	51.1	51.0	29.1	0	43	3/28	5/2	----	12.4	0.65
Nebula		4354	38.0	50.8	31.5	0	47	3/25	4/30	----	12.7	0.78
Conrad		4471	37.8	53.9	38.0	1	71	3/20	4/23	----	13.6	0.52
Moravian 69		5290	43.3	52.2	32.0	0	54	4/2	5/1	----	11.8	0.59
LSD$_{.05}$		522	1.8	0.5	0.9	2	11	1	1	ns	0.4	0.07
Variety x N rate		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Table 4. Regression analysis of grain yield vs. N rate for small grain varieties using the equation $y=a+bx^2+cx^3$.

Crop	Type	Variety	Coef. of determination (r^2)	Maximum N rate	Maximum yield	N rate/ 100 lb yield
				lbs N/a	lbs/a	lbs N/ 100 lbs grain
Wheat	Durum	Kronos	0.94	166	6793	2.44
		Havasu	0.85	146	7029	2.08
	Bread wheat	Y. Rojo	0.97	170	6163	2.76
		Joaquin	0.66	123	5696	2.16
Barley	Feed	Baretta	0.83	135	6321	2.14
		Nebula	0.97	139	4950	2.81
	Malting	Conrad	0.76	128	5070	2.52
		Moravian 69	0.80	125	6089	2.05
---	Durum	---	---	156	6911	2.26
---	Bread wheat	---	---	147	5930	2.46
---	Feed barley	---	---	137	5636	2.47
---	Malting barley	---	---	127	5580	2.29
Wheat	---	---	---	151	6420	2.36
Barley	---	---	---	132	5608	2.38