Late Season Water and Nitrogen Effects on Durum Quality, 1995 (Preliminary)

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Abstract

Durum grain quality is affected by many factors, but water and nitrogen are factors that the grower can control. The purpose of this research was to determine 1) the nitrogen application rate required at pollen shed to maintain adequate grain protein levels if irrigation is excessive or deficient during grain fill and 2) if nitrogen applications during grain fill can elevate grain protein. Field research was conducted at the Maricopa Agricultural Center using the durum varieties Duraking, Minos, and Turbo. The field was treated uniformly until pollen shed when nitrogen was applied at rates of 0, 30, and 60 lbs/acre. During grain fill, the plots were irrigated based on 30, 50, or 70% moisture depletion. In a separate experiment, nitrogen fertilizer was applied at a rate of 30 lbs N/acre at pollen shed only, pollen shed and the first irrigation after pollen shed, and pollen shed and the first and second irrigation after pollen shed. Irrigation had no effect on grain protein level, although increasing nitrogen rates at pollen shed from 0 to 30 and 30 to 60 lbs N/acre increased protein by 1 percentage point. Nitrogen fertilizer application at the first irrigation after pollen shed increased grain protein content from 10.4 to 11.4% and application at the first and second irrigation after pollen shed increased grain protein content further to 11.9% averaged over varieties. Irrigation management during grain fill may not play as large a role in controlling grain protein content as was originally thought except perhaps on heavy soils, and nitrogen fertilizer application during grain fill may not be too late to increase grain protein content.

Introduction

The biggest problem facing the durum industry in Arizona is producing an acceptable quality of grain for pasta-making. Many factors influence durum grain quality such as the cultivar and growing season weather, but only nitrogen and water management can be controlled after planting by the grower. Nitrogen fertilizer management plays a major role in the production of high quality grain. Applications of nitrogen fertilizer during early stages affects yield while applications near pollen shed increase grain protein levels. An application of 30 pounds of nitrogen per acre is recommended near pollen shed to ensure acceptable grain protein levels according to current University of Arizona guidelines. This recommendation assumes that irrigations during the grain fill period will be applied according to crop requirements and that yields will be "normal". Excessive irrigations can reduce nitrogen availability due to leaching and lack of oxygen in the soil, and lead to reduced grain protein concentration. High yields tend to dilute the protein accumulated in the grain and reduce protein concentration.

This research was undertaken to answer the following questions: 1) Will an application of 30 pounds of nitrogen fertilizer per acre at pollen shed ensure acceptable grain quality if irrigations during grain fill are inadequate or excessive? and 2) Can nitrogen fertilizer applications during the grain fill period elevate grain protein concentration in anticipation of high yields?

Procedure

Field studies were conducted at the Maricopa Agricultural Center on Field 105, a Casa Grande Sandy Loam. The previous crop in the field was sudangrass. Preplant fertilizer was applied at the rate of 60 lbs N/acre and 75 lbs P_2O_5/acre as 16-20-0. Duraking, Minos, and WestBred Turbo were planted into dry soil and irrigated up on November 30, 1994. The seed was planted with a grain drill in 12 ft. wide strips. The seeding rate was 120 pounds of seed per acre. The plots were 12 ft. x 50 ft.

Irrigation water and nitrogen fertilizer were applied at similar rates until pollen shed (see Tables 1 and 2). Starting at pollen shed, two experiments were conducted to determine: 1) the influence of irrigation during grain fill on the effectiveness of nitrogen applications at pollen shed and 2) the influence of nitrogen applications during grain fill on grain protein. Experiment 1 was designed as a split-split plot with four replications and irrigation levels during grain fill as main plots, varieties as subplots, and nitrogen rate at pollen shed as sub-subplots. Irrigation levels maintained during grain fill were 30, 50, and 70% soil moisture depletion as determined by neutron probe readings. The amount of water applied for each irrigation level during grain fill was based on the soil moisture depletion and assuming an irrigation efficiency of 0.7. A larger volume of water than necessary to replace depleted moisture was applied to the 30% treatment in order to get water down to the end of the field. Duraking, Minos, and Turbo were the varieties and nitrogen was applied at pollen shed at rates of 0, 30, and 60 lbs N/acre. Experiment 2 was designed as a split plot with varieties as main plots and nitrogen application during grain fill as subplots. Nitrogen was applied at a rate of 30 lbs N/A at pollen shed only, pollen shed plus the first irrigation after pollen shed, and pollen shed plus the first and second irrigation after pollen shed.

The plots were harvested with a small plot combine on May 19, 1995 (Duraking and Minos) and on June 1, 1995 (Turbo). The harvested area was 5 ft. x 45 ft. The grain was weighed, moisture determined, and grain yield was calculated on a 10% moisture basis. Grain protein was estimated by multiplying 5.7 by total grain nitrogen determined by the Kjeldahl method and adjusting to 12% moisture. Hard vitreous amber count and black tip were determined from a 10 g sample and expressed as % by weight. Plant height and lodging were measured before harvest. Pollen shed was defined as the first day of pollen shed and physiological maturity date was defined as the point when the glumes turn color. Durum quality is being analyzed by the California Wheat Commission Lab in Woodland, CA and will be presented in the final report.

Discussion

Nitrogen rate at pollen shed and variety influenced grain protein and other measured variables, but irrigation during grain fill had no effect (Table 3). Duraking yielded the highest, but Minos had the highest grain protein, hard vitreous amber count, and amount of black point (a fungal disease on the grain that decreases grain quality). Nitrogen rates of 30 and 60 pounds nitrogen per acre at pollen shed increased grain yield of Duraking and Turbo, but not of Minos. Increasing nitrogen rates from 0 to 30 and 30 to 60 lbs N/acre increased grain protein by about 1 percentage point. Hard vitreous amber counts and black point was also increased by an increase in nitrogen rate at pollen shed. Currently, 30 lbs N/acre is recommended at pollen shed to ensure adequate protein content in durum. Higher rates may be needed for certain varieties or if the nitrogen status of the plant is low at pollen shed. The fact that irrigation during grain fill had no main or interactive effect on grain protein is surprising. The irrigation interval of the wettest treatment averaged every 7 days during grain fill, and protein levels in this treatment were similar to the driest treatment, which received water every 14 days on average during grain fill. Presumably, protein levels would decrease with excessive irrigation and a higher rate of nitrogen at pollen shed would be required to maintain adequate protein. This was not the case in our experiment on a sandy loam soil, but excessive irrigation during grain fill may decrease grain protein content on heavier soil types.

Nitrogen application during grain fill increased grain protein content and hard vitreous amber count, but did not affect grain yield or occurrence of black point. The highest yielding variety was Duraking in this experiment, and varietal differences in plant height and maturity were noted. Nitrogen applications during grain fill were too late to affect yield as anticipated, but increases in grain protein content from these applications were also not expected. Nitrogen applications during grain fill have not been recommended in the past, but our research suggests that this practice may be effective in increasing grain protein levels.

Acknowledgments

Financial support for this project was received from the Arizona Grain Research and Promotion Council.

Table 1. Schedule of nitrogen fertilizer application.

			Irrigation x Nitrogen Experiment			Late Season Nitrogen Experiment		
			lbs N/acre at pollen shed			30 lbs N/acre at		
Date	Stage	Form of nitrogen	0	30	60	Pollen shed only	Pollen shed and 1st irrigation after pollen shed	Pollen shed and 1st and 2nd irrigation after pollen shed
			lbs N/acre					
Nov 29	Preplant	16-20-0	60	60	60	60	60	60
Feb 09	6 leaf	UN32	50	50	50	50	50	50
Mar 06	Late boot	UN32	75	75	75	75	75	75
Mar 23	Pollen shed	Urea	0	30	60	30	30	30
Apr 04	+ 12 d	Urea	0	0	0	0	30	30
Apr 17	+ 25 d	Urea	0	0	0	0	0	30
SUM	Season		185	215	245	215	245	275

Table 2. Irrigation schedule.

Irrigation x Nitrogen Experiment									Late Season Nitrogen Experiment		
Post pollen shed soil moisture depletion											
30%			50%			70%			50%		
Date	Stage	Inches	Date	Stage	Inches	Date	Stage	Inches	Date	Stage	Inches
30Nov	Planting	4	30Nov	Planting	4	30Nov	Planting	4	30Nov	Planting	4
09Feb	6 leaf	3	09Feb	6 leaf	3	09Feb	6 leaf	3	09Feb	6 leaf	3
06Mar	Late boot	3	06Mar	Late boot	3	06Mar	Late boot	3	06Mar	Late boot	3
23Mar	Pollen shed	3	23Mar	Pollen shed	3	23Mar	Pollen shed	3	23Mar	Pollen shed	3
31Mar	+ 8 d	2.1	04Apr	+ 12 d	2.8	06Apr	+ 14 d	3.9	04Apr	+ 12 d	2.8
06Apr	+ 14 d	2.1	15Apr	+ 23 d	2.8	21Apr	+ 29 d	3.9	17Apr	+ 25 d	2.8
14Apr	+ 22 d	2.1	28Apr	+ 36 d	2.8				28Apr	+ 36 d	2.8
21Apr	+ 29 d	2.1									
27Apr	+ 35 d	2.1									

Table 3. Irrigation, variety, and nitrogen application at pollen shed effects on grain yield and various grain and plant characteristics.

Irrigation during grain fill	Variety	Nitrogen at Pollen shed	Grain Yield[1]	Grain Protein[2]	Hard Vitreous Amber	Black Point[3]	Plant Height	Lodging	Pollen shed	Physio-logical Maturity
% depletion		lbs/acre	lbs/acre	%	%	%	inches	%		
30	Duraking	0	8000	9.8	43	0.6	37	0	3/18	4/28
30	Duraking	30	8006	10.3	65	0.4	37	13	-	4/29
30	Duraking	60	8623	12.6	91	2.0	37	13	-	4/29
30	Minos	0	6632	11.7	68	0.9	41	8	3/17	4/29
30	Minos	30	6816	13.4	93	1.8	39	28	-	4/28
30	Minos	60	6877	13.8	94	1.4	39	0	-	4/29
30	Turbo	0	6260	10.0	62	0.2	44	0	3/24	5/02
30	Turbo	30	7139	10.9	77	0.2	44	0	-	5/02
30	Turbo	60	6686	11.2	88	0.8	43	0	-	5/02
50	Duraking	0	8414	10.2	67	1.1	37	0	3/19	4/30
50	Duraking	30	8227	11.3	79	0.8	36	0	-	4/29
50	Duraking	60	8457	12.0	93	0.8	36	10	-	4/29
50	Minos	0	6631	10.9	67	1.1	40	8	3/18	4/29
50	Minos	30	6619	12.1	84	1.6	39	5	-	4/28
50	Minos	60	6943	14.1	98	1.8	40	5	-	4/29
50	Turbo	0	6929	9.5	57	0.0	44	0	3/24	5/03
50	Turbo	30	7372	10.7	81	0.6	42	0	-	5/03
50	Turbo	60	7473	11.3	85	1.0	43	0	-	5/03
70	Duraking	0	6938	9.2	36	0.3	36	0	3/18	4/28
70	Duraking	30	7232	10.2	66	1.9	38	0	-	4/28
70	Duraking	60	7838	11.2	89	0.3	35	0	-	4/28
70	Minos	0	6765	9.8	53	0.7	40	0	3/17	4/28
70	Minos	30	6902	11.5	87	2.2	41	15	-	4/28
70	Minos	60	6531	13.3	97	2.1	40	5	-	4/28
70	Turbo	0	6073	9.6	63	0.2	43	0	3/24	5/02
70	Turbo	30	6956	10.5	87	0.4	43	0	-	5/02
70	Turbo	60	6479	11.5	92	0.4	42	0	-	5/03
LSD (5%)[4]			620	1.65	24.4	1.27	2.3	16.5	1.9	1.1
30	All	All	7204	11.5	76	0.9	40	7	3/20	4/30
50	All	All	7451	11.3	79	1.0	40	3	3/20	5/01
70	All	All	6857	10.8	74	0.9	40	2	3/20	4/30
LSD (5%)			NS	NS	NS	NS	NS	NS	NS	NS
All	Duraking	All	7969	10.8	70	0.9	36	4	3/18	4/28
All	Minos	All	6746	12.3	82	1.5	40	8	3/17	4/28
All	Turbo	All	6819	10.6	77	0.4	43	0	3/24	5/03
LSD (5%)			422	0.64	8.1	0.42	0.9	5.2	1.0	1.5
All	All	0	6930	10.1	57	0.6	40	2	-	4/30
All	All	30	7252	11.2	80	1.1	40	7	-	4/30
All	All	60	7323	12.3	92	1.1	39	4	-	4/30
LSD (5%)			207	0.55	7.9	0.39	NS	NS	-	NS

Table 3. (con'd) Irrigation, variety, and nitrogen application at pollen shed effects on grain yield and various grain and plant characteristics.

	Grain Yield	Grain Protein	Hard Vitreous Amber	Black Point	Plant Height	Lodging	Pollen shed	Physio-logical Maturity
Effect				Significance of Effects[5]				
Irrigation	NS	NS	NS	NS	NS	NS	NS	NS
Variety	**	**	*	**	**	*	**	**
Variety x Irrigation	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen	**	**	**	**	NS	NS	–	NS
Nitrogen x Irrigation	NS	NS	NS	NS	NS	NS	–	NS
Nitrogen x Variety	**	NS	NS	NS	NS	NS	–	NS
Nitrogen x Irrigation x Variety	NS	NS	NS	NS	NS	NS	–	NS

1 Grain yield calculated on a 10% moisture basis.

2 Grain protein calculated on a 12% moisture basis.

3 Black point is a fungal disease of the grain that appears as specks in the pasta.

4 LSD (5%) = least significant difference at the 5% probability level.

5 NS, *, and ** = not significant at the 5% probability level, and significant at the 5% and 1% probability level, respectively.

Table 4. Variety and late season nitrogen application effects on grain yield and various grain and plant characteristics.

Variety	Late season nitrogen[1]	Grain Yield[2]	Grain Protein[3]	Hard Vitreous Amber Count	Black Point[4]	Plant Height	Lodging	Pollen shed	Physio-logical Maturity
	lbs/acre	lbs/acre	%	%	%	inches	%		
Duraking	30	8018	12.0	92	1.8	35	0	3/20	4/29
Duraking	30+30	8551	12.2	95	3.1	35	0	–	4/30
Duraking	30+30+30	8687	13.1	98	2.8	36	0	–	4/30
Minos	30	7166	11.8	89	1.8	39	0	3/16	4/30
Minos	30+30	6750	13.5	96	3.1	39	28	–	4/30
Minos	30+30+30	6611	13.8	99	3.0	41	23	–	4/30
Turbo	30	7296	11.0	83	1.1	43	0	3/24	5/03
Turbo	30+30	7644	12.4	90	2.5	43	0	–	5/04
Turbo	30+30+30	7843	12.9	96	1.5	44	0	–	5/03
LSD (5%)[5]		NS	0.86	4.4	NS	1.6	NS	1.7	0.9
Duraking	All	8419	11.2	95	2.6	35	0	3/20	4/30
Minos	All	6863	11.7	95	2.6	39	18	3/16	4/30
Turbo	All	7611	10.9	90	1.6	43	0	3/24	5/03
LSD (5%)		751	NS	NS	NS	1.6	NS	1.7	1.9
All	30	7493	10.4	88	1.6	39	0	–	5/01
All	30+30	7648	11.4	94	2.9	38	12	–	5/01
All	30+30+30	7817	11.9	97	2.3	40	6	–	5/02
LSD (5%)		NS	0.49	2.6	NS	NS	NS	–	NS
Effects					Significance[6]				
Variety		**	NS	NS	NS	**	NS	**	**
Nitrogen		NS	**	**	NS	NS	NS	–	NS
Nitrogen x Variety		NS	NS	NS	NS	NS	NS	–	NS

[1] Late season nitrogen: 30 = 30 lbs N/acre at pollen shed, 30+30 = 30 lbs N/acre at pollen shed and 30 lbs N/acre at the first irrigation after pollen shed, and 30+30+30 = 30 lbs N/acre at pollen shed, 30 lbs N/acre at the first irrigation after pollen shed, and 30 lbs N/acre at the 2nd irrigation after pollen shed.

[2] Grain yield calculated on a 10% moisture basis.

[3] Grain protein calculated on a 12% moisture basis.

[4] Black point is a fungal disease of the grain that appears as specks in the pasta.

[5] LSD (5%) = least significant difference at the 5% probability level.

[6] NS and ** = not significant at the 5% probability level, and significant at the 1% probability level.