Late Nitrogen Application to Improve Grain Protein of Irrigated Sceptre Durum Wheat

T.J. Hogg and S. Brown[1]

Introduction

Rotational requirements for irrigated cropping systems requires the inclusion of cereal crops. Durum wheat has been the cereal of choice in the irrigated area around Lake Diefenbaker. Durum wheat is affected less by diseases than softwheat or CPS wheat and produces higher yields than HRS wheat (h-vine, 1992). Sceptre durum wheat, a shorter strawed **variety,** is the variety of choice due to its high yield potential and lower susceptibility to lodging (Clarke, 1992). However, poor seed quality and low protein content are problems with this variety under irrigated conditions.

Extensive research with irrigated bread wheat has indicated that it is possible to increase grain protein content by the late application of supplemental nitrogen fertilizer (Cassman *et al,* 1992; Cooper and Blakeney, 1990; Fischer *et al.* 1993; Pushman and Bingham, 1976; Randall et al. 1990; Smith et al, 1989; Smith et al, 1991; Strong, 1982; Strong 1986; Stark and Tindall, 1992; Wuest and Cassman 1992a; Wuest and Cassman, 1992b). Generally, supplemental nitrogen applied at or near flowering increases protein content of the grain with little effect on grain yield. Early season nitrogen management should be targeted to optimize grain yield and late supplemental applications of nitrogen provided to optimize grain protein content (Cassman *et al,1992;* Stark and Tindall, 1992; Wuest and Cassman 1992a).

Research with late application of nitrogen to irrigated durum wheat has also indicated increased crude protein content in the gram with increased quantity of nitrogen (Robinson *et al,* 1979). Applying supplemental nitrogen fertilizer after the boot stage, when demand for nonprotein nitrogen for glutenin production occurs, resulted in the greatest increase in protein and consequent reduction in yellow berry percentage of durum wheat.

By increasing seed quality and protein content of durum wheat irrigators could take advantage of the higher selling prices offered by the Canadian Wheat Board and thus, improve economic returns Therefore, a project was initiated to determine the effect of late nitrogen application on the protein content of irrigated durum wheat in the Lake Diefenbaker area of Saskatchewan.

Materials and Methods

Two sites were selected in the spring of 1995 and one site in the spring of 1996 to determine the effect of both preplant and late (anthesis) nitrogen applications on the yield and protein content of irrigated Sceptre durum. One site was also established in the spring of 19% to determine the effect of late (anthesis) nitrogen source on the protein content of irrigated Sceptre durum. These sites were located in the SSRID No. 1 on coarse textured sandy soils developed on sandy glacial-fluvial and lacustrine deposits (Ellis et *al, 1968).*

For the preplant + late nitrogen trials treatments included combinations of preplant and late (anthesis) nitrogen applications. Ammonium nitrate (34-O-O) was used as the nitrogen source. A factorial arrangement of treatments in a randomized complete block design with four replicates was used at all sites. For the late nitrogen source trial the nitrogen sources used were granular ammonium nitrate (34-O-O), granular urea (46-0-O). liquid urea ammonium nitrate (28-O-O) and liquid urea (46-O-O). Individual treatments for all trials measured 3 m x 6 m.

Sceptre durum wheat was seeded at all sites using a specially designed drill equipped with a Conserva Pak seed and fertilizer furrow opener system (30 cm row spacing) and air delivery system. Phosphate fertilizer was sidebanded at a rate of 30 kg P_2O_5/ha.

Soil samples were collected from the plot areas prior to plot establishment to determine soil fertility levels.

At harvest, yield samples were collected by straight cutting an area 4 rows x 6 m from the middle of each treatment using

[1] **Agronomist and technician, Saskatchewan Irrigation Development Centre, Outlook, Saskatchewan**

a small plot combine. The grain samples were cleaned and weighed. A subsample of each individual treatment was used to determine moisture content, protein content, seed weight and test weight. Test weight was determined following Canadian Graincommissionstandards(CanadianGrain Commission,1991). Yield was calculated at constant moisture content. Grain protein content was determined on whole grain samples using near infrared transmittance (NIT).

Results

Soil analysis of samples collected in the spring prior to plot establishment for each site indicated available nitrogen ranged from 50-65 kg NO,-N/ha. Current soil test recommendations indicate 120- 130 kg N/ha were required to obtain a targeted durum wheat yield of 5000 kg/ha at 13.5% protein under optimum irrigation conditions (total water application = 450 mm).

I. Effect of Preplant and Late N aoolication on Durum Yield and Seed Quality

Yield

Grain yield showed a response to the preplant nitrogen applications but no response to the late nitrogen applications (Table 1). This response occurred at all sites with some variability among the sites. However, the overall trends were similar.

Seed Weight and Test Weight

Seed weight and test weight decreased as the preplant nitrogen application rate increased (Tables 2 and 3). Late nitrogen application had no effect on either seed weight or test weight. Test weight for all pre-plant nitrogen application rates met the minimum test weight of 77.0 kg/hL for No. 2 CWAD (Canadian Grain Commission, 1991). These results would indicatedthatthe' increase in yield was associated with an increase in the number of seeds produced rather than an increase in seed size since seed weight decreased with an increase in preplant nitrogen application rate.

Late nitrogen application to irrigated bread wheat has been shown to increase grain test weight (Randal *et al*, 1990; Stark and Tindall, 1992; Strong, 1982) possibly due to vacuoles in the grain filling with protein (Randal *et al*, 1990). Irrigated durum wheat has also shown greater grain density where supplemental nitrogen was applied at the boot stage in comparison to all nitrogen applied preplant (Robinson et *al*, 1979). These trends were not shown in the present work.

% Protein

Protein content of the durum grain increased as both the preplant and late nitrogen application rates increased (Table 4). Protein content of the durum grain wa *increased* by *25% (12.1%* to *15.0%) with the* application of both preplant and late nitrogen The late (anthesis) nitrogen application had a greater effect on increasing grain protein content than the preplant nitrogen application especially at the lower preplant nitrogen application rates. However, the large preplant nitrogen applications, as recommended by current soil test guidelines for irrigated durum, also produced large protein increases (12.1% to 13.8%).

II. Effect of Late Nitrogen Source on Durum Seed Quality

Late nitrogen source and rate of application had no effect on either seed weight or test weight of the irrigated durum at 1 site in 1996 (Tables 5 and 6). These results are similar to those found for the preplant + late nitrogen application trials.

Protein content was affected by both late nitrogen source and rate even though protein level was high where no late nitrogen was applied (Table 7). All nitrogen sources increased protein content above that of the control treatment where no nitrogen was applied. Protein content increased with late nitrogen application for all sources except the liquid urea ammonium nitrate (28-O-O). The granular ammonium nitrate and granular ure anitrogen sources produced a higher protein content than the two liquid nitrogen sources (urea ammonium nitrate and liquid urea). Increases in grain nitrogen content have been found by other workers to be increased more by foliar applications than by soil applied nitrogen (Gooding and Davies, 1992). Application of the liquid urea ammonium nitrate could have resulted in volatile losses of nitrogen under the conditions of application for the present work As well, the liquid urea ammonium nitrate could have damaged the durum foliage resulting in less absorption of the applied nitrogen.

III. Economics

Economic considerations of supplemental late nitrogen application to increase protein content of irrigated durum wheat must also be taken into account Copper and Blakeney (1990) indicated that large price premiums for high protein are necessary to make the practice of supplemental late nitrogen application economic. A grading system that is specific enough to take into account price premiums for small protein increments would be necessary to obtain the full value of supplemental late nitrogen applications. The protein premium paid must yield a greater return than the additional cost of nitrogen fertilizer required to obtain that protein content.

The retum to fertilizer nitrogen is influenced by grade, yield and protein content. For the present work, the return to fertilizer nitrogen assuming the durum graded No. 2 CWAD, nitrogen cost $0.77/kg and transportation and handling charges cost $43 (Glenside, Saskatchewan deductions 1995/96) are presented in Table 8. Net retum to fertilizer nitrogen reached a maximum at maximum yield. The preplant nitrogen applications contributed more to the net return than did the late nitrogen applications especially at the higher rates. This was due to both an increase in yield as well as an increase in protein content as the preplant nitrogen applications were increased. The effect of the late nitrogen applications was only due to an increase in protein content_ Late nitrogen contribution to the total net return was small where net return reached a maximum. Marginal retum was positive for the preplant nitrogen applications up to the point where the net return reached a maximum value. These results indicate that even though there was a positive economic return to the late nitrogen applications, the majority of the economic return was contributed by the preplant nitrogen applications where protein premiums were high.

These results indicate that fertilizing to current soil test recommendations provides sufficient nitrogen to produce high yields and protein with the least risk to take advantage of the current protein pricing for durum. Late nitrogen application can be used to increase protein content, however, the economic return is not high enough to balance the risk of grade loss due to factors such as poor harvest conditions, disease and/or insect damage.

Data from several site years are required before specific recommendations on the economics of late nitrogen application to irrigated durum can be made.

Conclusion

Protein content of irrigated sceptre durum increased as the rate of both preplant and late nitrogen applied was increased. The liquid source urea ammonium nitrate **(28-O-O)** produced lower protein increases than granular ammonium nitrate, granular urea or liquid urea possibly due to volatile nitrogen losses and/or foliage damage.

Late nitrogen application had little effect on other seed quality parameters such as seed size and weight.

Economics of preplant and late nitrogen applications to irrigated durum indicated that fertilizing to current soil test recommendations provides sufficient nitrogen to produce high yields and protein with the least risk to take advantage of the current protein pricing for durum. Late nitrogen application can be used to increase protein content, however, the economic return is not high enough to balance the risk of grade loss due to factors such as poor harvest conditions, disease and/or insect damage.

Data from several site years are required before specific recommendations on the economics of late nitrogen application to irrigated durum can be made.

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Table 1. Grain yield for the irrigated durum preplant + late nitrogen application experiment (3 rite years).

Preplant N Application (kg/ha)	Grain Yield @ 14.5% moisture (kg/ha) Late N Application (kg/ha)				Preplant N Mean
0	3717	40%	3950	4591	4089
30	4305	4465	4324	4692	4447
60	4699	4759	4846	4867	4793
90	4925	5064	5103	5424	5129
120	5092	4976	4941	5125	5034
Late N Mean	4548	4672	4633	4940	

Factorial ANOVA LSD(0.05)	
Preplant N (P)	308
Late N (L)	NS[1]
P x L	NS

[1] not significant

Table 2. Seed weight for the irrigated durum preplant + late nitrogen application experiment (3 site years).

Preplant N Application (kg/ha)	Seed Weight (g/1000 seeds) Late N Application (kg/ha)				Preplant N Mean
0	40.n	40.79	41.70	42.31	41.39
30	40.18	41.54	40.83	41.31	40.97
60	39.48	39.34	40.98	41.59	40.35
90	39.94	38.60	39.12	38.88	39.14
120	39.54	40.68	40.18	39.64	40.01
Late N Mean	39.98	40.19	40.56	40.75	

Factorial ANOVALSD (0.05)	
Preplant N (P)	NS[1]
Late N (L)	NS
P x L	NS

[1] not significant

Table 3. Tat weight for the irrigated durm **preplant** + **late** nitrogen application **experiment** (3 **site** years).

Preplant N **Application (kg/ha)**	Test Weight (kg/hL)				**Preplant** N **Mean**
	Late N Application **(kg/ha)**				
0	**78.2**	78.1	78.3	77.9	78.4
30	78.1	78.3	77.9	77.2	n.9
60	n.7	78.0	77.2	n.5	n.6
90	n.3	76.7	**77.1**	**77.0.**	**77.0**
120	**77.0**	**77.0**	**77.0**	76.7	76.9
Late N Mean	**77.7**	77.6	n.5	n.3	

Factorial ANOVA LSD(0.05)	
Preplant N **(P)**	0.5
Late N **(L)**	NS[1]
P x L	NS

[1] not **significant**

Table 4. **Protein content** for **the irrigated durum preplant** + **late nitrogen** application **experiment (3 site years).**

Preplant N **Application (kg/ha)**	**Protein (%)**				**Preplant** N **Mean**
	Late N **Application (kg/ha)**				
0	12.1	128	14.4	14.8	13.5
30	126	13.1	14.2	14.9	13.7
60	129	13.9	14.4	15.0	14.1
90	13.2	13.9	14.3	14.5	14.0
120	13.8	14.3	14.9	14.9	14.5
Late N Mean	12.9	13.6	14.4	14.8	

Factorial **ANOVA LSD(0.05)**	
Preplant N **(P)**	0.5
Late N **(L)**	0.4
P x L	NS’

[1] **not significant**

Table **5.** **Seed** weight for the irrigated **durum late** nitrogen **application rate x source** experiment (1 site year).

N Source	Seed Weight (g/1000)					N Source Mean
	Late N Application (kg/ha)					
Control	42.94					
28-O-O		44.18	44.29	41.79	4278	43.26
34-O-O		43.44	43.26	44.71	41.88	43.32
46-O-O		43.34	41.99	4239	43.00	42.68
Liquid Urea		43.48	41.08	43.82	42.36	42.69
Late N Mean		43.61	4266	43.18	4251	
RCBD ANOVA LSD(0.05)		NS[1]				
Factorial ANOVA LSD(0.05)						
N Source (S)		NS				
Late N (L)	NS					
S x L		NS				

[1] **not significant**

Table 6. Tat weight for the irrigated **durum late nitrogen application rate** x **source experiment** (1 rite **year).**

N Source	Tat Weight (kg/hL)					N Source Mean
	Late N Application (kg/ha)					
Control	**79.5**					
28-0-0		79.5	79.5	79.3	79.3	79.4
34-O-O		79.4	79.7	79.1	79.5	79.4
46-0-0		79.3	79.5	79.6	79.4	79.5
Liquid Urea		80.3	79.6	79.3	79.3	79.6
Late N Mean		79.6	79.6	79.3	79.4	
RCBD **LSD(0.05)**	**NS[1]**					
Factorial LSD(0.05)						
N S- (S)	NS					
Late N (L)	NS					
S x L	NS					

[1] **not significant**

Table 7. **Protein content** for the irrigated **durum late** nitrogen application **rate x source experiment** (1 **site** year).

N Source	Protein (%)					N Source Mean
	Late N Application (kg/ha)					
Control	14.3					
28-0-0		15.0	14.8	14.8	14.8	14.8
34-0-0		14.8	15.3	15.7	15.6	15.3
46-0-0		14.9	14.8	15.2	15.7	15.2
Liquid Urea		14.6	14.6	14.7	15.2	14.8
Late N Mean		14.8	14.9	15.1	15.3	
RCBD ANOVA LSD (0.05)	0.5					
Factorial ANOVA LSD (0.05)						
N **Source** (S)	0.3					
Late N (L)	0.3					
S x L	NS[1]					

[1] not **significant**

Table 8. **Economics** of **preplant and** late nitrogen applications on irrigated **sceptre durum** (3 rite **years**).

Late N (kg/ha)	Yield **(t/ha)**	**Protein** (%)	**Net** Return' **($/ha)**		**Marginal Return ($/ha)**	
			Preplant	**Late**	**Preplant**	**Late**
			0 **Preplant N**			
0	4.089	121	**0.00**	**0.00**	**0.00**	**0.00**
20		12.8		82.74		82.74
40		14.4		190.01		107.27
60		14.8		174.61		-15.40
			30 **Preplant** N			
0	4.441	126	167.76	**0.00**	167.76	0.00
20		13.1		**69.09**		69.09
40		14.2		102.61		33.52
60		14.9		**87.21**		-15.40
			60 Replant N			
0	**4.793**	12.9	234.27	**0.00**	66.51	0.00
20		13.9		104.43		104.43
40		14.4		11299		8.56
60		15.0		97.59		-15.40
			90 Preplant N			
0	5.129	13.2	395.65	**0.00**	161.38	
20		13.9		15.37		15.37
40		14.3		25.62		10.25
60		14.5		10.22		-15.40
			120 **Preplant** N			
0	5.034	13.8	376.34	0.00	-19.31	
20		14.3		**9.77**		9.77
40		14.9		-5.63		-15.40
60		14.9		-21.03		-15.40

l No. 2 CWAD at specific protein **content less transportation and handling charges (Glenside,** SS) **- 1995/96** crop **year.**

12.0% : **$278-$43** = s235
125% **: $302-$43** = **$259**
13.0% **: $321-$43** = **$278**
13.5% **: $327-$43** = S-284
14.0% **: $332-$43** = **$289**

Fertilizer N = **$0.77/kg**

Net **Return** = Yield **x Price -** Fertilizer N **cost - Return** for **control treatment (ie. 0 preplant N + 0 late N)**