

A. Improving the Quality and Profitability of Durum Wheat through Phosphorous and Nitrogen Management

B. Summary

All three seasons has been completed. In 2002, increasing the rate of applied nitrogen increased the protein content and yield of durum. In 2003, nitrogen increased protein but did not affect seed yield. In 2004 applied nitrogen increased yield (protein is not completed). In 2002, the application of phosphate did not affect yield or protein, however, in 2003 and 2004, the application of phosphate increased seed yield. The response of yield and protein to KCL was erratic and no clear conclusion can be drawn at this time.

C. Background and Objectives of Study

Durum wheat markets demand assurance of minimum quality standards. Grain protein is one of the most important determining durum wheat quality, and durum markets consistently demands a protein content of 13% or higher, for which industry pays a premium. Since the early 1990s, the average protein content of CWAD has been 12.5% or less, leaving a sizeable proportion of the durum crop unsuitable for the premium market. As a result other durum producing countries, mainly the United States and Australia, have increased their share of the international market at our expense.

The reduction in protein content of the durum crop has been attributed to higher levels of precipitation in the Brown and Dark Brown soils zones concomitant with a decline in soil available nitrogen. In the Thin Black soil zone inadequate nitrogen supplies have also affected kernel quality, becoming a major degrading factor, with the concomitant decline in returns to the farmer. Under the moister conditions experienced in the past decade, leaf spotting diseases, kernel diseases - particularly red smudge and black point- and fusarium head blight have become more prevalent. These diseases have played an important role in contributing to lower grain yields and substantial downgrading of CWAD.

Crop management techniques that allow producers to maximize the probability of obtaining a significant protein premium and minimize the probability of their durum crops being downgraded will have a significant effect on their net return.

The overall objective is to develop knowledge that will permit durum producers to implement crop and soil fertility management strategies geared to, improving grain quality, grain protein, yield and achieving a higher grade for the grain they produce.

The objectives of this specific experiment are :

- 1) To determine the response of durum to varying rates of both N and P when residual levels of both are low.
- 2) To determine if the placement, seed placed or side banded of phosphate and potassium chloride will the affect the yield or quality of durum.

D. Study Description

Plot Size: 35 feet x 15ft

Reps: 4

Treatments:

- I) Nitrogen (Side banded)
- 1) 30 kg/ha (Fertilizer+Residual N)
 - 2) 85 kg/ha (Fertilizer+Residual N)
 - 3) 140 kg/ha (Fertilizer+Residual N)

II) Phosphate (Side banded)

- 1) 0 kg/ha
- 2) 20 kg/ha
- 3) 40 kg/ha

III) Additional treatments

- 1) 20 kg/ha of seed placed P + 85 kg/ha (Fertilizer+Residual N)
- 2) 40 kg/ha of seed placed P + 85 kg/ha (Fertilizer+Residual N)
- 3) 40 kg/ha of seed placed P + 20 kg/ha of seed placed K₂O + 140 kg/ha (Fertilizer+Residual N)
- 4) 40 kg/ha of side banded P + 20 kg/ha of side banded K₂O + 140 kg/ha (Fertilizer+Residual N)
- 5) 40 kg/ha of side banded P + 60 kg/ha of side banded K₂O + 140 kg/ha (Fertilizer+Residual N)

(Fertilizer+Residual N)

Location: Indian Head

Cultivar: AC Avonlea

Data Collection:

- E. Soil test: 0-6 inches, 6-24 inches, N bulked across reps, P, K, and S bulked across the test
- F. plant density, (minimum of 2-one metre of row per plot)
- G. Tiller density (# of heads per unit area at maturity, 2- one metre of row per plot)
- H. Plant height, (2 per plot)
- I. days to maturity,
- J. Lodging, (1-9, 1= upright and 9=flat)
- K. Disease ratings Leaf spots
- L. Grain yield,
- M. Test weight,
- N. Retain subsample
- O. 1000 Kernel weight,
- P. Protein content

E. Results

All three seasons have been completed. In 2002, increasing the rate of applied nitrogen increased the protein content and yield of durum. In 2003, a drier year than 2002 at this location the application of nitrogen increased protein but did not affect seed yield. In 2002, the application of phosphate did not affect yield or protein, however, in 2003, the application of phosphate increased seed yield. The placement of phosphate in the seed row verse side banded did not affect yield in 2002, 2003, and 2004 or protein in 2002 and 2003 (2004 protein analysis has not been completed). There was an interesting interaction between nitrogen and phosphate on hard vitreous kernels in 2002. The addition of phosphate at the low nitrogen rate reduced the percentage of hard vitreous kernels in the harvested sample (Table 4). This did not occur in 2003.

The response of yield and protein to KCL was erratic and no clear conclusion can be drawn at this time. Once all the seed quality data has been completed then a complete and through examination of the data will be completed.

Table 1. The effect of phosphate and nitrogen rate, and phosphate and potassium chloride placement on durum at Indian Head in 2002 (02-881)

	Yield	Protein	Disease	Height	Lodging	Test weight	Grade
Kg ha ⁻¹	Kg ha ⁻¹	%	Aug 12	cm	1-9	kg hL ⁻¹	
Nitrogen Rate(fertilizer + residual)							
30	2824.6 <i>b</i>	11.7 <i>c</i>	10.6 <i>a</i>	85 <i>a</i>	1.8 <i>a</i>	78.3 <i>a</i>	3.6 <i>a</i>
85	3325.5 <i>a</i>	14.0 <i>b</i>	10.0 <i>b</i>	87 <i>a</i>	2.3 <i>a</i>	78.2 <i>a</i>	3.7 <i>a</i>
140	3332.1 <i>a</i>	14.8 <i>a</i>	10.1 <i>b</i>	88 <i>a</i>	2.1 <i>a</i>	78.1 <i>a</i>	4.0 <i>a</i>
Contrasts							
Linear	**	**	*	0.06	NS	NS	0.08
Quadratic	**	**	0.08	NS	0.07	NS	NS
Phosphate Rate							
0	3145 <i>a</i>	13.5 <i>ab</i>	10.1 <i>a</i>	85 <i>a</i>	1.8 <i>b</i>	78.1 <i>a</i>	3.8 <i>a</i>
20	3201 <i>a</i>	13.7 <i>a</i>	10.4 <i>a</i>	88 <i>a</i>	2.3 <i>a</i>	78.3 <i>a</i>	3.6 <i>a</i>
40	3137 <i>a</i>	13.4 <i>b</i>	10.2 <i>a</i>	87 <i>a</i>	2.2 <i>ab</i>	78.3 <i>a</i>	3.9 <i>a</i>
Contrasts							
Linear	NS	NS	NS	NS	0.09	NS	NS
Quadratic	NS	*	NS	0.08	0.07	NS	NS
85N + 20P SP	3406	14.2	10.3	89	2.8	78.3	3.5
85N + 40P SP	3391	13.5	10.3	90	2.8	78.5	3.5
140N + 40P SP + 20k ₂ O SP	3416	14.5	9.8	86	2.8	78.0	3.5
140N + 40P SB + 20k ₂ O SB	3939 ^Z	14.4	9.8	87	2.8	78.1	4.3
140N + 40P SB + 60k ₂ O SB	3364	15.2	9.8	88	2.5	77.9	4.0
20 P SP vs 20 P SB	NS	NS	NS	NS	NS	NS	NS
0 vs 60 K ₂ O SB	NS	0.06	NS	NS	NS	NS	NS
CV	8.7	2.3	5.2	4.1	25	0.54	15

SP = seed placed, SB = side banded ^ZThis treatment was re-seeded on the side of the trial

Table 2. The effect of phosphate and nitrogen rate, and phosphate and potassium chloride placement on durum at Indian Head in 2002 (02-881)

	Plant density	Head density	Panicle density	Seed density	Seed density	Kernel weight
Kg ha ⁻¹	plants m ⁻²	heads m ⁻²	heads plant ⁻¹	seeds head ⁻¹	seeds m ⁻²	g 1000 seeds ⁻¹
Nitrogen Rate(fertilizer + residual)						
30	175a	236b	1.4b	29a	6631b	42.6a
85	170a	263ab	1.6b	30a	7823a	42.5a
140	163a	295a	1.9a	27a	7837a	42.5a
Contrasts						
Linear	NS	**	**	NS	**	NS
Quadratic	NS	NS	NS	NS	*	NS
Phosphate Rate						
0	167a	252a	1.5a	30a	7353a	42.9a
20	166a	268a	1.7a	29a	7470a	42.8a
40	175a	275a	1.6a	28a	7468a	42.0a
Contrasts						
Linear	NS	NS	NS	NS	NS	*
Quadratic	NS	NS	NS	NS	NS	NS
85N + 20P SP	173	276	1.6	28	7834	43.5
85N + 40P SP	150	310	2.2	26	7890	43.0
140N + 40P SP + 20k ₂ O SP	159	297	1.9	27	7953	42.9
140N + 40P SB + 20k ₂ O SB	165	283	1.7	33	9227	42.8
140N + 40P SB + 60k ₂ O SB	165	299	1.8	27	7935	42.4
20 P SP vs 20 P SB	NS	NS	0.06	0.07	NS	0.08
0 vs 60 K ₂ O SB	NS	NS	NS	0.07	NS	NS
CV	16	13	19	16	8.8	2.5

Table 3. The effect of phosphate and nitrogen rate, and phosphate and potassium chloride placement on durum at Indian Head in 2002 (02-881)

Nitrogen Rate (fertilizer + residual)Kg ha ⁻¹	Hard vitreous Kernels	Black point	Smudge	Fusarium	Midge	Ergot
	%	%	%	%	%	%
30	47.7 <i>b</i>	0.18 <i>a</i>	0.8 <i>b</i>	1.5 <i>a</i>	2.3 <i>b</i>	0.0011 <i>a</i>
85	69.8 <i>a</i>	0.21 <i>a</i>	0.9 <i>ab</i>	1.3 <i>a</i>	3.3 <i>a</i>	0.0015 <i>a</i>
140	73.8 <i>a</i>	0.26 <i>a</i>	1.1 <i>a</i>	1.4 <i>a</i>	3.6 <i>a</i>	0.0001 <i>a</i>
Contrasts						
Linear	**	NS	0.06	NS	**	NS
Quadratic	*	NS	NS	NS	NS	NS
Phosphate Rate						
0	69.7 <i>a</i>	0.26 <i>a</i>	1.1 <i>a</i>	1.6 <i>a</i>	3.0 <i>a</i>	0.0003 <i>a</i>
20	63.0 <i>ab</i>	0.20 <i>a</i>	0.8 <i>b</i>	1.4 <i>a</i>	3.0 <i>a</i>	0.0013 <i>a</i>
40	58.6 <i>b</i>	0.19 <i>a</i>	1.0 <i>ab</i>	1.4 <i>a</i>	3.1 <i>a</i>	0.0011 <i>a</i>
Contrasts						
Linear	*	NS	NS	NS	NS	NS
Quadratic	NS	NS	NS	NS	NS	NS
85N + 20P SP	71.8	0.13	0.7	1.0	3.4	0.0000
85N + 40P SP	65.4	0.20	1.2	1.2	3.4	0.0000
140N + 40P SP + 20k ₂ O SP	69.0	0.30	1.0	1.8	3.1	0.0030
140N + 40P SB + 20k ₂ O SB	62.5	0.20	1.1	2.2	2.8	0.0015
140N + 40P SB + 60k ₂ O SB	67.3	0.18	1.1	1.5	3.5	0.0023
20 P SP vs 20 P SB	NS	NS	NS	*	NS	NS
0 vs 60 K ₂ O SB	NS	NS	NS	NS	NS	0.09
CV	17	52	33	45	33	247

Table 4. The effect of phosphate and nitrogen rate, and phosphate and potassium chloride placement on the Hard Vitreous Kernels in durum at Indian Head in 2002 (02-881)

	Phosphate Rate			Contrasts	
	0	20	40	Linear	Quadratic
Nitrogen Rate (fertilizer + residual)Kg ha ⁻¹	Hard Vitreous Kernels (%)				
30	65.4	45.2	32.5	**	NS
85	73.5	67.0	69.0	NS	NS
140	70.3	76.8	74.3	NS	NS
Contrasts					
Linear	NS	**	**		
Quadratic	NS	NS	*		
CV	17				

Table 5. The effect of phosphate and nitrogen rate, and phosphate and potassium chloride placement on durum at Indian Head in 2003 (03-881)

Nitrogen Rate (fertilizer + residual)Kg ha ⁻¹	Yield	Protein	Height	Lodging	Maturity	NDVI	Test weight
	Kg ha ⁻¹	%	cm	1-9	days	%	
30	2287	12.5	61.3	1.2	86.4	0.47	81.8
85	2424	14.6	64.3	1.1	88.5	0.51	81.0
140	2408	15.1	63.1	1.1	90.6	0.53	81.1
Contrasts							
Linear	NS	**	NS	NS	**	**	**
Quadratic	NS	**	NS	NS	NS	NS	0.06
Phosphate Rate							
0	2239	14.2	62.6	1.1	88.6	0.49	81.3
20	2471	14.1	63.4	1.2	88.6	0.52	81.6
40	2410	13.9	62.7	1.1	88.3	0.50	81.1
Contrasts							
Linear	*	NS	NS	NS	NS	NS	NS
Quadratic	*	NS	NS	NS	NS	0.06	*
85N + 20P SP	2585	14.6	63	1.3	89	0.5159	81.3
85N + 40P SP	2299	14.3	64	1.3	88	0.5214	81.2
140N + 40P SP + 20k ₂ O SP	2437	15.0	61	1.0	90	0.5190	81.8
140N + 40P SB + 20k ₂ O SB	2580	15.0	61	1.0	90	0.5262	81.0
140N + 40P SB + 60k ₂ O SB	2283	14.7	62	1.0	90	0.5096	81.3
20 P SP vs 20 P SB	NS	NS	NS	NS	NS	NS	NS
0 vs 20 K ₂ O SB	0.08	NS	NS	NS	NS	NS	*
0 vs 60 K ₂ O SB	NS	NS	NS	NS	NS	NS	*
20 vs 60 K ₂ O SB	*	NS	NS	NS	NS	NS	NS
SB vs SP for P and K ₂ O	NS	NS	NS	NS	NS	NS	NS
CV	8.0	4.5	5.6	30	0.8	7.7	2.0

Table 6. The effect of phosphate and nitrogen rate, and phosphate and potassium chloride placement on durum at Indian Head in 2003 (03-881)

Nitrogen Rate(fertilizer + residual)Kg ha ⁻¹	Plant density	Head density	Panicle density	Seed density	Seed density	Kernel weight
	plants m ⁻²	heads m ⁻²	heads plant ⁻¹	seeds head ⁻¹	seeds m ⁻²	g 1000 seeds ⁻¹
30	166	234	1.5	25	5831	39.2
85	154	225	1.5	27	6088	39.8
140	137	244	1.8	26	6020	40.1
Contrasts						
Linear	**	NS	*	NS	NS	**
Quadratic	NS	NS	NS	NS	NS	NS
Phosphate Rate						
0	149	240	1.7	23.9	5604	39.9
20	145	227	1.6	27.6	6220	39.8
40	163	236	1.5	26.2	6115	39.4
Contrasts						
Linear	NS	NS	NS	NS	*	NS
Quadratic	NS	NS	NS	NS	0.059	NS
85N + 20P SP	165	224	1.4	30	6501	39.8
85N + 40P SP	160	235	1.5	25	5785	39.7
140N + 40P SP + 20k ₂ O SP	113	249	2.3	24	5926	41.3
140N + 40P SB + 20k ₂ O SB	146	251	1.8	25	6295	41.0
140N + 40P SB + 60k ₂ O SB	145	213	1.5	27	5593	40.8
20 P SP vs 20 P SB	NS	NS	NS	NS	0.054	NS
0 vs 20 K ₂ O SB	NS	NS	NS	NS	NS	*
0 vs 60 K ₂ O SB	NS	NS	NS	NS	NS	*
20 vs 60 K ₂ O SB	NS	NS	NS	NS	0.06	NS
SB vs SP for P and K ₂ O	0.08	NS	0.054	NS	NS	NS
CV	17	13	22	16	8.7	2.0

Table 7. The effect of phosphate and nitrogen rate, and phosphate and potassium chloride placement on durum at Indian Head in 2003 (03-881)

Nitrogen Rate (fertilizer + residual)Kg ha ⁻¹	Hard vitreous Kernels	Black point	Smudge	Fusarium	Midge	Ergot
	%	%	%	%	%	%
30	97.1	0.04	5.0	0.04	0.19	0.001
85	97.5	0.03	5.6	0.03	0.18	0.001
140	97.5	0.03	6.1	0.03	0.15	0.003
Contrasts						
Linear	NS	NS	NS	NS	NS	NS
Quadratic	NS	NS	NS	NS	NS	NS
Phosphate Rate						
0	97.0	0.04	5.8	0.03	0.21	0.001
20	97.7	0.04	5.7	0.04	0.14	0.002
40	97.4	0.03	5.2	0.02	0.17	0.002
Contrasts						
Linear	NS	NS	NS	NS	NS	NS
Quadratic	NS	NS	NS	NS	NS	NS
85N + 20P SP	97.7	0.1	6.8	0.10	0.10	0.002
85N + 40P SP	97.5	0.0	5.3	0.00	0.20	0.001
140N + 40P SP + 20k ₂ O SP	97.8	0.1	4.8	0.00	0.10	0.004
140N + 40P SB + 20k ₂ O SB	97.3	0.0	3.0	0.00	0.10	0.001
140N + 40P SB + 60k ₂ O SB	98.2	0.0	4.3	0.00	0.10	0.000
20 P SP vs 20 P SB	NS	NS	NS	NS	NS	NS
0 vs 20 K ₂ O SB	NS	NS	NS	NS	*	0.07
0 vs 60 K ₂ O SB	0.052	NS	NS	NS	NS	*
20 vs 60 K ₂ O SB	NS	NS	NS	NS	NS	NS
SB vs SP for P and K ₂ O	NS	NS	NS	NS	NS	NS
CV	1.0	98	56	101	56	210

Table 8. The effect of phosphate and nitrogen rate, and phosphate and potassium chloride placement on durum at Indian Head in 2004 (04-881)

Nitrogen Rate (fertilizer + residual)Kg ha ⁻¹	Yield	Protein	Height	Lodging	Maturity	Leaf Diseases	Test weight
	Kg ha ⁻¹	%	cm	1-9	days	(0-11)	
30	2904		101	2.4	121	7.1	367.4
85	3425		107	3.1	124	6.1	366.9
140	3456		108	3.8	125	6.0	362.7
Contrasts							
Linear			**	**	**	**	NS
Quadratic			*	NS	*	*	NS
Phosphate Rate							
0	3118		104	2.8	124	6.2	360.0
20	3341		107	3.3	123	6.4	367.7
40	3326		105	3.3	123	6.5	369.3
Contrasts							
Linear			NS	*	0.06	NS	**
Quadratic			NS	NS	NS	NS	NS
85N + 20P SP	3733		108	3.3	123.8	6.5	373.9
85N + 40P SP	3601		111	3.3	123.5	6.4	369.1
140N + 40P SP + 20k ₂ O SP	3815		109	4.3	125.0	6.3	375.6
140N + 40P SB + 20k ₂ O SB	3863		110	4.0	125.3	6.3	373.4
140N + 40P SB + 60k ₂ O SB	3689		111	3.8	124.8	5.8	369.8
20 P SP vs 20 P SB	0.08		NS	NS	NS	NS	NS
0 vs 20 K ₂ O SB	NS		NS	NS	NS	NS	NS
0 vs 60 K ₂ O SB	NS		NS	NS	NS	NS	NS
20 vs 60 K ₂ O SB	NS		NS	NS	NS	NS	NS
SB vs SP for P and K ₂ O	NS		NS	NS	NS	NS	NS
CV	7.9		3.0	14	0.68	7.5	2.0

Table 9. The effect of phosphate and nitrogen rate, and phosphate and potassium chloride placement on durum at Indian Head in 2004 (04-881)

Nitrogen Rate(fertilizer + residual)Kg ha ⁻¹	Plant density	Head density	Panicle density	Seed density	Seed density	Kernel weight
	plants m ⁻²	heads m ⁻²	heads plant ⁻¹	seeds head ⁻¹	seeds m ⁻²	g 1000 seeds ⁻¹
30	230	285	1.3	29.1	8090	35.8
85	221	311	1.4	31.4	9558	35.9
140	216	318	1.5	31.2	9725	35.6
Contrasts						
Linear	NS	*	*	NS	**	NS
Quadratic	NS	NS	NS	NS	**	NS
Phosphate Rate						
0	224	312	1.4	29.2	8902	35.0
20	223	310	1.4	30.0	9193	36.4
40	221	291	1.4	32.4	9278	35.8
Contrasts						
Linear	NS	NS	NS	*	NS	NS
Quadratic	NS	NS	NS	NS	NS	NS
85N + 20P SP	217	333	1.6	29.6	9730	38.3
85N + 40P SP	204	289	1.4	36.2	10118	35.5
140N + 40P SP + 20k ₂ O SP	211	373	1.8	27.9	10361	36.8
140N + 40P SB + 20k ₂ O SB	225	331	1.5	32.5	10567	36.5
140N + 40P SB + 60k ₂ O SB	206	305	1.5	32.5	9820	37.6
20 P SP vs 20 P SB	NS	NS	NS	NS	NS	NS
0 vs 20 K ₂ O SB	NS	NS	NS	NS	NS	NS
0 vs 60 K ₂ O SB	NS	NS	NS	NS	NS	NS
20 vs 60 K ₂ O SB	NS	NS	NS	NS	NS	NS
SB vs SP for P and K ₂ O	NS	0.09	0.06	NS	NS	NS
CV	11	11	17	12	6.6	5.1

Table 10. The effect of phosphate and nitrogen rate, and phosphate and potassium chloride placement on durum at Indian Head in 2004 (04-881)

Nitrogen Rate (fertilizer + residual)Kg ha ⁻¹	Hard vitreous Kernels	Black point	Smudge	Fusarium	Midge	Ergot
	%	%	%	%	%	%
30						
85						
140						
Contrasts						
Linear	NS	NS	NS	NS	NS	NS
Quadratic	NS	NS	NS	NS	NS	NS
Phosphate Rate						
0						
20						
40						
Contrasts						
Linear	NS	NS	NS	NS	NS	NS
Quadratic	NS	NS	NS	NS	NS	NS
85N + 20P SP						
85N + 40P SP						
140N + 40P SP + 20k ₂ O SP						
140N + 40P SB + 20k ₂ O SB						
140N + 40P SB + 60k ₂ O SB						
20 P SP vs 20 P SB						
0 vs 20 K ₂ O SB						
0 vs 60 K ₂ O SB						
20 vs 60 K ₂ O SB						
SB vs SP for P and K ₂ O						
CV						

Table 11. The effect of phosphate and nitrogen rate, the yield of durum at Indian Head in 2004 (04-881)

Nitrogen Rate(fertilizer + residual)Kg ha ⁻¹	Phosphate Rate			Linear	Quadratic
	0	20	40		
		kg ha ⁻¹			
30	2749	3215	2746	NS	**
85	3434	3228	3613	NS	0.09
140	3171	3580	3618	*	NS
Contrasts					
Linear	*	0.06	**		
Quadratic	**	NS	*		

F. Indications for Further Research

It is too early in the study to determine the next direction research should go.

G. Extension Activities

Durum, oilseed and Canary Research, Zero Tillage Field Day 2004, Indian Head, July 19, 2004

Durum, Canaryseed, and Swath Grazing Research, IHARF Winter Seminar & Annual Meeting, Indian Head, Jan 21, 2004

Durum, Oat and Canary Research, Zero Tillage Field Day 2003, Indian Head, July 22, 2003

Durum Canaryseed, and Oat Research, IHARF Winter Seminar & Annual Meeting, Indian Head, Jan 22, 2003

Durum Research, Zero Tillage Field Day 2002, July 23, 2002

Durum Research, Proceedings for the Zero Tillage Field Day 2002, July 2002

Durum Research Update, IHARF Newsletter, Summer 2002

Improving My Farms Durum Quality With Crop Rotation & Fertilization CWB Durum Challenge III, The Changing Marketplace Palliser Pavilion, Kinetic Park Swift Current, Saskatchewan Dec 12, 2002