THE INTERACTION OF SEED PLACED AND SIDE BANDED PHOSPHOROUS WITH NITROGEN AND POTASSIUM CHLORIDE FERTILIZER ON THE AGRONOMIC PERFORMANCE OF DURUM WHEAT

W.E. May and G.P. Lafond
Indian Head Research Farm, Agriculture and Agri-Food Canada,
Indian Head, Saskatchewan, Canada mayb@agr.gc.ca, 306-695-5225

ABSTRACT

Developing knowledge on the effects of nitrogen, phosphorous, and fertilizer placement on durum yield and quality 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. A study was conducted examining the effect of nitrogen and phosphorous, in a two way factorial on durum yield and quality. Several extra treatments were added to compare the effects of side banded and seed placed phosphorous and potassium on durum yield and quality. There were no significant interactions between the level of nitrogen and the rate of applied phosphate for any of the variables measured in this experiment. The placement of the phosphorous or potassium in the seed row or side banded did affect the yield components except for head density. Plant density decreased as the nitrogen rate increased. Phosphorous and potassium did not affect yield and there was no difference due to placement, side banded verses seed row. There was a curvilinear increased in protein as the rate of nitrogen increase. There was a small decrease in protein as the rate of phosphorous increased. Hard vitreous kernels and midge damage increased as nitrogen increased and smudge decreased as the rate of phosphorous increased. The placement of phosphorous and potassium did not affect the quality of durum wheat. On an Indian Head heavy clay soil with low levels of residual phosphorous, the yield and most quality parameters of durum wheat were not improved by the addition of phosphorous fertilizer.

INTRODUCTION

Durum wheat markets demand assurance of minimum quality standards. Grain protein, hard vitreous kernels, black point, smudge, fusarium and midge are major determinants of quality in durum. Crop management techniques that allow producers to maximize the probability of producing durum of high quality will have a significant effect on their net return. The effect on nitrogen on yield, protein and hard vitreous kernels of durum wheat have been investigated (Dexter et al. 1982; Anderson 1985; Puri et al. 1989). However, the effect of phosphorous and its interaction on durum yield and quality has not been studied extensively.

Phosphorous is critical to early season growth and development (Grant et al. 2001). In a soil low in phosphorous there may be an advantage to placing the phosphorous in the seed row verses in a side band, that places the fertilizer approximately 2.5 cm to the side and 2.5 cm below the seed. The two objectives of this study were to determine the response of durum to varying rates of both nitrogen and phosphorous when residual levels of phosphorous were low and to determine if phosphate placement, seed row or side banded would affect the yield or quality of durum wheat.

MATERIALS AND METHODS

This experiment consisted of a two way factorial with four replications with several extra treatments added to compare side banded and seed placed phosphorous and potassium. The factors used were nitrogen and phosphorous. Three rates of nitrogen were used that combined added nitrogen fertilizer and residual nitrogen in the soil from a depth of 0 to 60 cm. The three nitrogen rates were 30, 85 and 140 kg ha^{-1}. Three rates of phosphorous fertilizer were applied 0, 20 and 40 kg ha of P_2O_5. The experiment was conducted at Indian Head, SK, (50E 33' N, 103E 39' W; 579 m elevation) in 2002, 2003 and 2004. The residual nitrogen in the soil from 0-60 cm was 28 kg ha^{-1} in 2002, 36 kg ha^{-1} in 2003 and 35 kg ha^{-1} in 2004 using a $NaHCO_3$ extraction procedure described by Hamm et al. (1970). The residual phosphorous in the soil from 0-15 cm was 8.6 kg ha^{-1} in 2002, 8.9 kg ha^{-1} in 2003 and 4.9 kg ha^{-1} in 2004.

The management practices are reported below. The cultivar used in this experiment was AC Avonlea. The targeted plant density was 250 plants m^{-2}. The soil type was an Indian Head heavy clay (Thin Black soil zone). The experiment was seeded into canola *(Brassica napus*) stubble in all three years. Glyphosate was applied as a preseeding burnoff just prior to seeding. Plots were seeded directly into standing stubble using a low disturbance no-till plot seeder with a row spacing 30.5 cm. The Plot size was 4 x 10.7. When fertilizer was side banded it was placed approximately 2.5 cm to the side and 5 cm below the seed. All the nitrogen fertilizer was side banded. The seeding dates were May 7 in 2002, May 14 in 2003 and May 10 in 2004. All in-crop herbicides were applied using the label-recommended application parameters at the appropriate a crop/weed stage. The herbicides used varied depending on the weed spectrum.

Data Collection

Durum plants were counted 3 to 5 wk after seeding and durum heads were counted after heading in two 1-m sections of crop row within each plot. Leaf disease was rated using the McFadden Scale (McFadden 1991) after heading. Lodging was rated in each plot at physiological maturity using a 1 to 9 scale (1 = standing, 9 = completely lodged). A 1.42 m wide strip in the middle of the plot was harvested. Grain yield was recorded on a clean grain basis at 13% seed moisture content. Kernel weight was calculated by weighing 700 to 1000 kernels. Seeds head^{-1} were calculated from heads m^{-2}, grain yield and kernel weight. Seeds m^{-2} were calculated using grain yield and kernel weight. Test weight was measured using methodology specified by the Canadian Grain Commission (1998). Protein content of whole durum samples were determined using a portable Zeltec ZX50 NIR analyzer (Williams 1979). Samples were evaluated by the Canadian Grain Commission for the percentage of hard vitreous kernels, and the percentage of kernels damaged by black point, smudge, fusarium and midge (Canadian Grain Commission 1998). The proc mixed procedure of SAS was used to combine the three years of data and calculate the analysis of variance, means and contrasts (Littel et al. 1996).

RESULTS AND DISCUSSION

There were no significant interactions between the level of nitrogen and the rate of applied phosphate for any of the variables measured in this experiment. The yield components of the durum wheat did not respond to the addition of phosphorous or potassium (Table 1). The placement of the phosphorous or potassium in the seed row or side banded did affect the yield components except for head density. The head density was higher when 40 kg ha^{-1} of P_2O_5 and

20 kg ha^{-1} of K_2O were seed placed instead of side banded. Plant density decreased as the nitrogen rate increased. This has been observed in oat under a similar production system (May et al. 2004). The head density compensated by increasing as the nitrogen rate increased. Seeds m^{-2}, the summation of all the yield components except kernel weight under went a curvilinear increase as the nitrogen rate increased. Kernel weight was not affected by the nitrogen rate. As the nitrogen rate was increased there was a curvilinear increase in seed yield. Phosphorous and potassium did not affect yield and there was no difference when the nutrients were placed in a side banded or in a seed row in this experiment.(Table 2).

Protein was affected by the rate of nitrogen and phosphorous but not by fertilizer placement. There was a curvilinear increased in protein as the rate of nitrogen increase (Table 2). Similar trends have been reported by several studies (Dexter et al. 1982; Puri et al. 1989). There was a small decrease in protein as the rate of phosphorous increased. Maturity was delayed as the nitrogen rate increased (Table 2). There was a curvilinear decrease in leaf diseases as the nitrogen rate increased. Test weight was not affected by the addition or placement of nutrients. Hard vitreous kernels and midge damage were affected by the nitrogen rate and smudge was affected by the rate of phosphorous. The percentage of hard vitreous kernel increase as the nitrogen rate increased (Table 3). A similar response has been observed in several studies (Anderson 1985; Puri et al. 1989). The percentage of midge damage increased as the nitrogen rate increased. There was a curvilinear decrease in the percentage of smudge infected kernels as the rate of applied phosphate increased. The placement of phosphorous and potassium did not affect the quality of durum wheat.

In conclusion, for the fertilizer rates used in this experiment there was no detectable difference between side banding and seed row placement of phosphorous and potassium on a heavy clay soil. The application of phosphorous only had a positive benefit by reducing the percentage of kernels infected with smudge. On an Indian Head heavy clay soil with low levels of residual phosphorous, the yield and most quality parameters of durum wheat were not improved by the addition of phosphorous at seeding.

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Table 1. The effect of phosphate and nitrogen rate, and phosphate and potassium chloride placement on durum at Indian Head					
Nitrogen Rate (fertilizer + residual) (kg ha^{-1})	Plant density (plants m^{-2})	Head density (heads plant^{-1})	Seed density (seeds head^{-1})	Seed density (seeds m^{-2})	Kernel weight (g 1000 seeds^{-1})
30	191	1.4	27.6	6851	39.2
85	182	1.5	29.6	7823	39.4
140	172	1.7	27.8	7861	39.4
Contrasts					
Linear	**	**	NS	**	NS
Quadratic	NS	NS	0.07	*	NS
Phosphate Rate (kg ha^{-1})					
0	180	1.5	27.6	7286	39.2
20	178	1.6	28.7	7627	39.7
40	186	1.5	28.7	7620	39.1
Contrasts					
Linear	NS	NS	NS	NS	NS
Quadratic	NS	NS	NS	NS	NS
85N + 20P SP	185	1.5	29.3	8022	40.5
85N + 40 P SP	171	1.7	28.9	7931	39.4
140N + 40P SP + 20K_2O SP	161	2	26.2	8080	40.3
140N + 40P SB + 20 K_2O SB	180	1.7	28.9	8395	40.3
140N + 40P SB + 60 K_2O SB	172	1.6	28.8	7783	40.3
20 P SP vs 20 P SB	NS	NS	NS	NS	NS
0 vs 20 K_2O SB	NS	NS	NS	NS	NS
0 vs 60 K_2O SB	NS	NS	NS	NS	NS
20 vs 60 K_2O SB	NS	NS	NS	NS	NS
SB vs SP for P and K_2O	NS	*	NS	NS	NS
SEM	21.9	0.12	1.99	1043	1.95

NS – not significant; SB – side banded; SP – seed placed

Table 2. The effect of phosphate and nitrogen rate, and phosphate and potassium chloride placement on durum at Indian Head					
Nitrogen Rate (fertilizer + residual)	Yield	Protein	Maturity	Leaf Disease	Test weight
(kg ha^{-1})	(kg ha^{-1})	(%)	(days)	(0-11)	(kg hl^{-1})
30	2672.0	12.3	104	8.8	78.3
85	3058.0	14.4	107	8.0	78.1
140	3066.0	15.0	110	8.0	77.7
Contrasts					
Linear	**	**	**	**	NS
Quadratic	*	**	NS	*	NS
Phosphate rate (kg ha^{-1})					
0	2834	14.0	107	8.2	77.5
20	3004	14.0	107	8.4	78.4
40	2958	13.6	107	8.3	78.3
Contrasts					
Linear	NS	**	NS	NS	NS
Quadratic	NS	NS	NS	NS	NS
85N + 20P SP	3241	14.2	107	8.4	76.4
85N + 40P SP	3096	13.8	107	8.3	78.5
140N + 40P SP + 20k_2O SP	3223	14.7	109	8	78.7
140N + 40P SB + 20k_2O SB	3334	14.8	109	8.2	78.5
140N + 40P SB + 60k_2O SB	3112	15	110	7.7	78.2
20 P SP vs 20 P SB	NS	NS	NS	NS	NS
0 vs 20 K_2O SB	NS	NS	NS	NS	NS
0 vs 60 K_2O SB	NS	NS	NS	NS	NS
20 vs 60 K_2O SB	NS	NS	NS	NS	NS
SB vs SP for P and K_2O	NS	NS	NS	NS	NS
SEM	337	0.23	14.4	1.93	2.1

NS – not significant; SB – side banded; SP – seed placed

Table 3. The effect of phosphate and nitrogen rate, and phosphate and potassium chloride placement on durum at Indian Head

Nitrogen Rate (fertilizer + residual) (kg ha^{-1})	Hard Vitreous Kernels (%)	Black point (%)	Smudge (%)	Fusarium (%)	Midge (%)
30	65	0.2	0.61	2	1.08
85	77.4	0.17	0.62	1.7	1.49
140	77.8	0.2	0.62	1.8	1.61
Contrasts					
Linear	**	NS	NS	NS	**
Quadratic	0.06	NS	NS	NS	NS
Phosphate rate (kg ha^{-1})					
0	73.1	0.21	0.75	1.8	1.41
20	75	0.2	0.51	1.8	1.37
40	72.1	0.15	0.59	2.1	1.41
Contrasts					
Linear	NS	0.055	0.06	NS	NS
Quadratic	NS	NS	*	NS	NS
85N + 20P SP	77.6	0.17	0.58	1.70	1.50
85N + 40P SP	75.7	0.17	0.72	2.10	1.40
140N + 40P SP + 20k$_2$O SP	73.3	0.18	0.52	2.00	1.40
140N + 40P SB + 20k$_2$O SB	78.2	0.15	0.55	1.20	1.40
140N + 40P SB + 60k$_2$O SB	76.1	0.15	0.57	1.80	1.50
20 P SP vs 20 P SB	NS	NS	NS	NS	NS
0 vs 20 K_2O SB	NS	NS	NS	NS	NS
0 vs 60 K_2O SB	NS	NS	NS	NS	NS
20 vs 60 K_2O SB	NS	NS	NS	NS	NS
SB vs SP for P and K_2O	NS	NS	NS	NS	NS
SEM	12.2	0.1	0.3	1.2	0.99

NS – not significant; SB – side banded; SP – seed placed