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RESPONSE OF CHICKPEA TO NITROGEN AND PHOSPHORUS FERTILIZATION

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ABSTRACT

A field study conducted in 1996 at four locations on soils with relatively low levels of available N and/or to investigate the N and P fertility requirements of desi- and kabuli-type chickpea. The treatments included four levels of "starter N" (46-O-O at 0, 15, 30, and 45 kg N ha-l) and 3 levels of seed-placed P_2O_5 (11-54-o at 0,20, and 40 kg P_2O_5 ha-l). Regular monitoring of the plots indicated that although growth stages during active plant growth (i.e., days to flowering, pod formation, etc.) were largely unaffected by fertilizer application, seed maturity was, in some instances, extended as a consequence of fertilizer application. Estimates of symbiotic N_2 fixation suggest that increasing increments of fertilizer N resulted in concomitant reductions in symbiotic N_2 fixation by kabuli-type chickpea whereas symbiotic N_2 fixation by desi-type chickpea was less sensitive to inorganic N. Application of "starter N" and seed-placed P_2O_5 did not confer a predictable seed yield advantage to either desi- or kabuli-type chickpea. Because results of the 1996 field season indicated few, if any, yield responses to seed-placed N and P, the field design was modified in 1997 to accommodate sideband applications of P_2O_5 fertilizer. As was observed in 1996, application of starter N reduced N_2 fixation and did not result in a significant seed yield advantage. Moreover, in 1997, application of P_2O_5 did not confer a consistent seed yield advantage at all sites. Similarly, the influence of P_2O_5 placement on seed yield was not consistent.

INTRODUCTION

Chickpea acreage continues to expand in Saskatchewan. As acreage increases, there is a need to investigate and develop appropriate agronomic practices for this crop. The objective of this study is to investigate the N and P fertility requirements of chickpea with the goal of optimizing crop yield potential while minimizing fertilizer inputs. Current guidelines for safe rates of fertilizer applied with the seed do not include P_2O_5 recommendations for chickpea. Moreover, there are no existing guidelines regarding the use of "starter N" for chickpea production. The effect of N fertilizer is of interest because the application of "starter N" in low N soils is recommended for pulse crop production although high rates of inorganic N can adversely affect N_2 fixation. Finally, chickpea requires a relatively long growing season (1 10- 120 days) and excessive fertilizer application could have detrimental consequences on crop maturity. Chickpea, like lentil, has an indeterminate growth habit and may need to experience a N or moisture stress to induce seed set.

MATERIALS AND METHODS

In 1997, two study sites were established at Kenaston (Dark Brown soil zone) and Watrous (Moist Dark Brown soil zone). Soils at the Watrous site contained 9.2 kg N ha^{-1} and 16.0 kg P ha^{-1} whereas soils at the Kenaston site contained 8.4 kg N ha^{-1} and 6.6 kg P ha^{-1}. The experiments were established for desi- and kabuli-type chickpea using a randomized complete block design consisting of 24 treatments laid out as a 4 x 3 x 2 factorial experiment, replicated 4 times. At each location, 12 fertility treatments were imposed as follows: "starter N" as 46-O-O at 0, 15, 30 and 45 kg N ha" and P applied as 11-54-o at 0, 20 and 40 kg P_2O_5 ha-'. The P_2O_5 treatments were applied both in the seed-row and as a side-band application whereas N was sidebanded in all treatments.

Symbiotic nitrogen fixation was estimated using the N-difference method. Flax (var. McGregor) was seeded as the reference crop. The plots were monitored regularly and growth stages were evaluated. At midseason (early pod-fill), plant tissue samples were harvested from representative 1-m^2 areas within each plot. These samples were analyzed for P and N concentration. Seed yield, total dry matter yield, harvest index and percent seed protein were determined at maturity.

Results were analyzed using the GLM procedure in SAS (SAS Institute, Inc). The effect of treatments was assessed by contrast analysis. The significance of the differences between means was assessed using the LSD test (P=0.05).

RESULTS AND DISCUSSION

Stand counts revealed that fertilizer treatments did not have a negative impact on early germination and emergence of chickpea (data not shown). These observations were somewhat surprising given the relatively high rate of P placed with the seed (40 kg P_2O_5 ha^{-1}) and the sensitivity of many pulse crops to seed-placed P_2O_5. It is important to note that these results represent a single year of data and thus it would be unadvisable at this early date to assume that chickpea is tolerant to seed-placed P_2O_5, irrespective of these encouraging observations.

Application of both starter N and P_2O_5 enhanced midseason biomass yields of desi- and kabuli-type chickpea (Table 1). In particular, application of starter N resulted in incremental increases in midseason biomass yields (i.e., a statistically significant linear response (P=0.001)) Application of starter N similarly enhanced the concentration of N in the plant tissue at midseason (early pod-fill) (data not shown). Generally, the highest rate of fertilizer N resulted in the highest concentration of N in the plant tissue at midseason.

Although fertilizer P application influenced the concentration of P in the plant tissue at midseason, the effect of the fertilizer was not consistent between sites or chickpea varieties (Tables 2 and 3). Desi-type chickpea apparently was more responsive to the fertilizer P application that kabuli-type chickpea and the highest tissue P concentrations were achieved when the P_2O_5 was applied as a sideband treatment. However, it is important to note that the effects of fertilizer placement (i.e., seed-placement versus sideband) were not statistically significant. Starter N also influenced P concentration in the plant tissue, presumably as a result of a dilution effect.

Table 1. The impact of starter N and P_2O_5 fertilizer on desi- and kabuli-type chickpea biomass yield, determined at midseason (i.e., early pod-fill) in 1997.

Treatment (kg ha-‘)		Midseason Biomass Yield (kg ha^{-1})			
		Desi-type, chickpea		Kabuli-type chickpea	
		Watrous	Kenaston	Watrous	Kenaston
N	0	1776	1524	2297	1794
	15	2066	1554	2346	1886
	30	2315	1499	2464	1976
	45	2278	1957	2610	2033
	LSD	184	253	232	184
P_2O_5	o	2014	1379	2328	1781
	20 (seed)	2030	1676	2334	1757
	20 (side)	2201	1486	2307	1931
	40 (seed)	2168	1797	2563	2042
	40 (side)	2130	1816	2614	2100
	LSD	n.s.	283	260	206

Table 2. General linear model analysis for the effect of N and P fertilizer application on the concentration of P in the plant tissue of desi- and kabuli-type chickpea at midseason in 1997 (N treatment contrasts not shown).

Source	Desi-chickpea		Kabuli-chickpea	
	Watrous	Kenaston	Watrous	Kenaston
N	0.003	n.s.	0.097	n.s.
P	n.s.	0.024	n.s.	n.s.
N*P	n.s.	0.078	n.s.	n.s.
Contrast				
P_2O_5 treatments				
0 vs 20	n.s	0.011	0.096	n.s.
0 vs 40	0.076	0.004	n.s.	n.s.
20 vs 40	n.s.	n.s.	n.s.	n.s.
Seed vs Side	n.s.	n.s.	n.s.	n.s.
Rate * Placement	n.s.	n.s.	ns.	n.s.

Table 3. The impact of starter N and P_2O_5 fertilizer on the concentration of P in the plant tissue of desi- and kabuli-type chickpea at midseason (i.e., early pod-fill) in 1997 (N treatment data not shown).

	P concentration (%)			
	Desi-type chickpea		**Kabuli-type chickpea**	
Treatment (kg ha-')	**Watrous**	**Kenaston**	**Watrous**	**Kenaston**
P_2O_5 0	**0.26**	**0.21**	**0.26**	**0.22**
20 (seed)	**0.28**	**0.23**	**0.27**	**0.22**
20 (side)	**0.27**	**0.26**	**0.28**	**0.23**
40 (seed)	**0.28**	**0.25**	**0.27**	**0.24**
40 (side)	**0.29**	**0.25**	**0.26**	**0.23**
LSD	**0.02**	**0.03**	n.s.	n.s.

Although starter N application enhanced both midseason biomass yield and tissue N concentration, final seed yield was unaffected by starter N, irrespective of the rate of N application (Tables 4 and 5). The fact that early biomass yield enhancement was not reflected in final seed yield suggests that N fixation may not have contributed much N to early plant growth, whereas biologically fixed N may have contributed significantly to the N nutrition of the crop during later growth stages. Thus, the early impact of exogenous N sources to chickpea growth and development were mitigated by the subsequent impact of N derived from symbiotic N_2 fixation.

A statistically significant effect of P_2O_5 on seed yield of chickpea was detected only at one site (i.e., Kenaston, P=0.003) where it was observed that P_2O_5 fertilizer application generally enhanced seed yield of desi-type chickpea (Table 4). Highest yields were achieved when P_2O_5 was sidebanded at a rate of 40 kg ha^{-1}, although this treatment was not significantly different than either the 20 or 40 kg ha^{-1} P_2O_5rate, applied in the seedrow. A similar response was not observed for kabuli-type chickpea.

As was observed in 1996, regular monitoring of the plots indicated that growth stages during active plant growth (i.e., days to flowering, pod formation, etc.) were largely unaffected by fertilizer application. Moreover, in 1997, there were no discernable differences in days to maturity associated with the fertilizer treatments. It is likely that the hot, droughty conditions hastened maturity within all treatments, largely mitigating any potential fertilizer effects.

In general, levels of N fixation were relatively low in 1997 (Table 5). Nitrogen fixation was estimated by the difference method using flax as the reference crop. Flax was chosen as a reference crop because it has a growing season requirement similar to that of chickpea. It is possible that flax may have utilized more soil N thereby resulting in artificially low estimates of N_2 fixation. Alternatively, the hot, droughty conditions experienced during the 1997 growing season may have limited total N_2 fixation. Irrespective of the low estimates of N_2 fixation, it was evident that even relatively low levels of fertilizer N significantly reduced the levels of biological N_2 fixation. The observation that N_2 fixation was limited by increasing increments of fertilizer N application is in keeping with the observation that starter N did not enhance final seed yields. Thus, there was no net gain in N supply for seed development from the fertilizer N because N derived from symbiotic N_2 fixation presumably compensated for lower fertilizer N rates. Placement of P_2O_5 either in the seed-row or as a sideband treatment did not significantly influence N_2 fixation.

Table 4. The impact of starter N and P_2O_5 fertilizer on seed yield of desi- and kabuli-type chickpea in 1997.

Treatment (kg ha-‘)		Seed Yield (kg ha-‘)			
		Desi-type chickpea		Kabuli-type chickpea	
		Watrous	**Kenaston**	**Watrous**	**Kenaston**
N	**0**	1654	1412	1023	1336
	15	1692	1434	1143	1173
	30	1742	1444	1140	1246
	45	1895	1511	1107	1325
	LSD	n.s.	n.s.	ns.	n.s.
P_2O_5	**0**	1769	1256	1117	1282
	20 (seed)	2015	1497	1133	1164
	20 (side)	1636	1390	1169	1218
	40 (seed)	1789	1514	1073	1389
	40 (side)	1519	1593	1031	1296
	LSD	357	174	n.s.	203

Table 5. The impact of starter N and P_2O_5 fertilizer on symbiotic N fixation by desi- and kabuli-type chickpea in 1997.

Treatment ($kg\ ha^{-1}$)		Symbiotic N fixation (%)			
		Desi-type chickpea		Kabuli-type chickpea	
		Watrous	**Kenaston**	**Watrous**	**Kenaston**
N	**0**	**49.6**	**35.2**	**29.2**	**40.7**
	15	**32.2**	**8.2**	**32.4**	**15.9**
	30	18.9	4.0	16.9	1.1
	45	15.1	10.8	5.8	3.8
	LSD	**14.6**	**11.0**	**14.3**	**9.8**
P_2O_5	**0**				
	20 (seed)	**30.8**	**17.7**	**21.4**	**14.2**
	20 (side)	**27.1**	11.3	19.5	16.5
	LSD	**n.s.**	**n.s.**	**ns.**	**n.s.**

SUMMARY

In summary, symbiotic N fixation in chickpea was sensitive to fertilizer N application. Moreover, starter N did not confer a significant seed yield advantage in 1997. Application of P_2O_5 also did not confer a consistent seed yield advantage at all sites; similarly, the influence of P_2O_5 placement on seed yield was inconsistent. Although the influence of P_2O_5 on seed yield of chickpea was'not consistent, it is important to note that at Kenaston, desi-type chickpea seed yields were enhanced by as much as 337 kg ha^{-1} when P_2O_5 was sidebanded at a rate of 40 kg ha^{-1}. Therefore, it is cautioned that significant economic losses may occur if producers do not use P fertilizers according to soil test recommendations.

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