The Effect of Phosphorus and Potassium Fertilization on Irrigated Pea Production

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Introduction

Pea is an important crop in the rotation under irrigated conditions. In recent years, pea has had higher potential economic returns than the traditional cereal crops. Consequently, pea acreage in the irrigated area of Saskatchewan around Lake Diefenbaker has been increasing.

Proper management is needed for optimum production. Early seeding is recommended to promote flowering during the cooler days of early summer. However, cooler soil temperatures early in the growing season can reduce the availability of phosphorus (Sutton 1969) and potassium (Schaff and Skogley 1982) due to restricted movement of these two nutrients. Previous work with irrigated pea has shown a response to phosphorus applications (Slinkard and Henry, 1979). As well, potassium additions have been suggested to improve seed quality of some crops (Bauer and Vasey 1964; Christensen *et al* 1981; Zubriski *et al* 1970). Thus, supplemental application of phosphorus and potassium may be required for maximum production. Therefore, a study was initiated to determine the effect of phosphorus and potassium fertilization on irrigated pea production.

Materials and Methods

Field trials were conducted in 1992 and 1993 in the Outlook irrigation district on a site (SE03-31-07-W3) where the soil is classified as a Bradwell very fine sandy loam (Ellis *et al* 1968). Green pea cv. Radley was seeded at a 20 cm row spacing with a seeding rate to provide approximately 60 plants/m^2. Potassium (potassium chloride, 0-0-60), 0, 17 and 34 kg K_2O/ha and phosphorus (monoammonium phosphate, 11-51-0), 0, 22, 44, 66 and 88 kg P_2O_5/ha, were applied in two ways, seedplaced and sidebanded. Field plots were arranged in a split-split plot design with placement as the main plot, potassium rate as the subplot and phosphorus rate as the sub-subplot with six replications. The plot sizes were 2.4 m x 6 m in 1992 and 1.2 m x 6 m in 1993. Irrigation and other cultural operations were performed according to standard recommendations. The test plots received total precipitation plus irrigation of 278 mm in 1992 and 400 mm in 1993 during the growing season.

Soil samples were collected from the plot area prior to plot establishment each year for routine soil fertility analysis.

Stand counts were taken from the three centre rows of 0.5 m in length in each treatment.

The crop was harvested at maturity by direct cutting. Yield estimates and average seed weight were recorded after the samples were cleaned. Yields were adjusted to 16% moisture content.

Results

Soil analysis for the plot area each year are presented in Table 1. The soil available phosphorus level was considered marginal for irrigated pea according to current soil test guidelines with recommendations in the range of 30-40 kg P_2O_5/ha in 1992 and 25-35 kg P_2O_5/ha in 1993. Available potassium levels were high and considered sufficient in both years.

Plant Stand

In 1992, there was no significant effect of any of the treatment combinations on plant stand (Table 2). However, there was a trend of decreasing plant stand with increasing rates of both seedplaced phosphorus and potassium compared to the sideband application.

In 1993, there was a significant effect of fertilizer placement and its interaction with phosphorus rate on plant stand (Table 3). Seedplaced fertilizer produced lower plant stand than sidebanded fertilizer. There was a significant reduction in plant stand with an increase in the rate of seedplaced phosphorus. In contrast, an increase in the rate of sidebanded phosphorus did not affect plant stand. Previous research with irrigated pea has indicated a reduction in plant stand with an increase in the rate of seedplaced monoammonium phosphate (Slinkard and Henry 1979). Generally, high rates of seedplaced fertilizer that have a high salt index, such as nitrogen and potassium, can reduce seedling emergence resulting in lower stands (Randall and Hoeft 1988).

Yield

The method of fertilizer placement and rate of phosphorus application significantly affected seed yield in 1992 (Table 4). A significant placement by potassium rate interaction was also observed. The application of phosphorus fertilizer produced a 7-11% higher seed yield compared to the control treatment that received no phosphorus fertilizer. The yield responses among the various phosphorus rates (22-88 kg P_2O_5/ha) were not significantly different. The various treatment combinations did not produce significant yield responses in 1993 (Table 5).

Increase in the rate of seedplaced potassium produced lower seed yields (Table 4 and 5). However, the differences were only significant in 1992. In contrast, increase in the rate of sidebanded potassium did not affect seed yield in either year.

In 1993, the initial soil phosphorus level was higher than in 1992. However, there was no response to the phosphorus applications even though the current soil test guidelines recommended additional phosphorus.

In 1993, despite a reduction in the plant stand due to the high rates of fertilizer placed with the seed, the final seed yield was not reduced. This could be due to yield compensation through increased yield per plant at lower plant density.

Yields in 1993 were lower than in 1992, likely due to the cool and excessively wet growing conditions in 1993. Higher incidence of foliar diseases in 1993 may have caused a reduction in seed yield compared to 1992.

Seed weight

Seed weight showed no significant response to any of the fertilizer treatments in either 1992 (Table 6) or 1993 (Table 7) except in 1993 where phosphorus main effects showed significant responses. Applications of potassium have been suggested to improve seed quality through increased seed weight (Bauer and Vasey 1964). However, no significant effects were observed in relation to increasing seed weight by application of phosphorus or potassium fertilizer in the present study.

Economics of phosphorus applications

Economics of phosphorus applications were calculated based on the 1992 data only as the yield responses to phosphorus applications were not significant in 1993. Net return was greatest for the 44 kg P_2O_5/ha application rate (Table 8).

Summary

Irrigated pea responded differently to phosphorus and potassium fertilization for the two years that this study was conducted. In 1992, a positive yield response was obtained with phosphorus fertilization, and 44 kg/ha additional phosphorus gave the best economic return. Sidebanding of fertilizer produced higher yield response than seedplacement. Increased rates of seedplaced potassium lowered seed yield while higher rates of seedplaced fertilizer tended to lower plant stand. In 1993, although increased rates of fertilizer caused a reduction in plant stand there was no corresponding reduction in seed yield. The cool moist growing conditions in 1993 and the high disease levels may have masked the effects of the fertilizer treatments. Seed weight was not influenced by phosphorus or potassium or the method of fertilizer application.

Phosphorus fertilization appears to be more important than potassium fertilization for irrigated pea production on soils testing medium in available phosphorus and high in available potassium.

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Table 1. Soil analysis for the irrigated pea phosphorus and potassium fertilization rate x placement experiment.

Year	Depth (cm)	pH	1:1 E.C. (dS/m)	NO_3-N	P	K	SO_4-S
				(kg/ha)			
1992	0-15	7.9	0.2	16	24	672	32
	15-30	8.3	0.2	12			15
	30-60	8.6	0.3	13			23
1993	0-15	7.2	0.1	11	32	672	30
	15-30	7.6	0.1	6			19
	30-60	8.3	0.1	8			37

Table 2. Rate and placement effects of phosphorus and potassium on plant stand of Radley pea: 1992.

Fertlizer placement	P_2O_5 kg/ha	Plant stand (plants/m^2) K_2O (kg/ha) 0	17	34	Mean	Mean
Seed placed						
	0	52	47	49	49	
	22	50	56	49	52	
	44	53	45	47	48	
	66	48	45	40	44	
	88	50	45	41	46	
	Mean	51	48	45		48
Side banded						
	0	55	53	49	52	
	22	55	53	53	54	
	44	51	54	52	52	
	66	53	52	56	54	
	88	55	56	49	53	
	Mean	53	53	52		53
K_2O mean		52	51	48		

P_2O_5 mean	Plants/m^2
0	51
22	53
44	50
66	49
88	50

Analysis of Variance

Source of variation	Significance	LSD (5.0%)
Fert. placement (S)	NS	-
Phosphorus (P)	NS	-
Potassium (K)	NS	-
S x P	NS	-
S x K	NS	-
P x K	NS	-
S x P x K	NS	-

NS indictates non-significant treatment effects.

Table 3. Rate and placement effects of phosphorus and potassium on plant stand of Radley pea: 1993.

Fertlizer placement	P_2O_5 kg/ha	Plant stand ($plants/m^2$)				
		K_2O (kg/ha)				
		0	17	34	Mean	Mean
Seed placed						
	0	58	63	57	59	
	22	59	57	57	58	
	44	53	60	48	53	
	66	50	49	50	49	
	88	47	50	50	49	
	Mean	53	56	52		54
Side banded						
	0	67	60	58	62	
	22	59	62	62	61	
	44	69	67	60	61	
	66	57	65	61	61	
	88	59	70	66	65	
	Mean	57	65	61		58
K_2O mean		57	60	57		

P_2O_5 mean	$Plant/m^2$
0	60
22	59
44	57
66	55
88	57

Analysis of Variance

Source of variation	Significance	LSD (5.0%)
Fert. placement (S)	*	4
Phosphorus (P)	NS	-
Potassium (K)	NS	-
S x P	*	6
S x K	NS	-
P x K	NS	-
S x P x K	NS	-

NS indictates non-significant treatment effects.

Table 4. Rate and placement effects of phosphorus and potassium on seed yield of Radley pea: 1992.

		Seed Yield (kg/ha)				
		K_2O (kg/ha)				
Fertlizer placement	P_2O_5 kg/ha	0	17	34	Mean	Mean
Seed placed						
	0	5198	4791	4263	4751	
	22	4973	4826	4904	4901	
	44	5265	5103	5078	5149	
	66	5213	4676	4930	4940	
	88	5172	4947	4890	5003	
	Mean	5764	4869	4813		4952
Side banded						
	0	4561	4589	4670	4607	
	22	5052	5305	4991	5116	
	44	5498	5196	5239	5311	
	66	5274	5463	5541	5426	
	88	4568	5331	5377	5092	
	Mean	4990	5177	5164		5114
K_2O mean		5077	5023	4988		

P_2O_5 mean	Seed Yield (kg/ha)
0	4679
22	5008
44	5230
66	5183
88	5048

Analysis of Variance

Source of variation	Significance	LSD (5.0%)
Fert. placement (S)	*	98
Phosphorus (P)	*	303
Potassium (K)	NS	-
S x P	NS	-
S x K	*	307
P x K	NS	-
S x P x K	NS	-

NS indictates non-significant treatment effects.

Table 5. Rate and placement effects of phosphorus and potassium on seed yield of Radley pea: 1993.

		Seed Yield (kg/ha)				
		K_2O (kg/ha)				
Fertlizer placement	P_2O_5 kg/ha	0	17	34	Mean	Mean
Seed placed						
	0	4390	4586	4583	4514	
	22	4421	4760	4281	4536	
	44	4910	4716	4576	4748	
	66	4625	4506	4409	4512	
	88	4475	4535	4476	4495	
	Mean	4564	4620	4499		4561
Side banded						
	0	4788	4692	4745	4783	
	22	4416	4749	4627	4580	
	44	4383	4543	4670	4523	
	66	4717	4581	4739	4731	
	88	4642	4531	4582	4585	
	Mean	4589	4562	4680		4610
K_2O mean		4577	4636	4589		

P_2O_5 mean	Seed Yield (kg/ha)
0	4649
22	4558
44	4635
66	4622
88	4540

Analysis of Variance

Source of variation	Significance	LSD (5.0%)
Fert. placement (S)	NS	-
Phosphorus (P)	NS	-
Potassium (K)	NS	-
S x P	NS	-
S x K	NS	-
P x K	NS	-
S x P x K	NS	-

NS indictates non-significant treatment effects.

Table 6. Rate and placement effects of phosphorus and potassium on seed weight of Radley pea: 1992.

Fertlizer placement	P_2O_5 kg/ha	Seed weight (mg) K_2O (kg/ha) 0	17	34	Mean	Mean
Seed placed						
	0	183	179	182	182	
	22	179	176	174	177	
	44	179	176	177	177	
	66	182	175	180	179	
	88	182	173	180	178	
	Mean	181	176	179		179
Side banded						
	0	177	179	178	178	
	22	182	173	182	179	
	44	178	183	180	180	
	66	181	178	178	179	
	88	178	172	174	175	
	Mean	179	177	178		178
K_2O mean		180	176	179		

P_2O_5 mean	Seed weight (mg)
0	180
22	178
44	179
66	179
88	177

Analysis of Variance

Source of variation	Significance	LSD (5.0%)
Fert. placement (S)	NS	-
Phosphorus (P)	NS	-
Potassium (K)	NS	-
S x P	NS	-
S x K	NS	-
P x K	NS	-
S x P x K	NS	-

NS indictates non-significant treatment effects.

Table 7. Rate and placement effects of phosphorus and potassium on seed weight of Radley pea: 1993.

Fertlizer placement	P_2O_5 kg/ha	Seed weight (mg) K_2O (kg/ha) 0	17	34	Mean	Mean
Seed placed						
	0	153	163	161	159	
	22	150	159	154	154	
	44	157	165	161	161	
	66	161	157	154	157	
	88	157	160	159	159	
	Mean	156	161	158		158
Side banded						
	0	162	155	163	160	
	22	153	149	153	153	
	44	149	147	159	159	
	66	154	149	158	158	
	88	157	148	157	157	
	Mean	155	150	158		154
K_2O mean		155	155	158		

P_2O_5 mean	Seed weight (mg)
0	159
22	153
44	156
66	155
88	156

Analysis of Variance

Source of variation	Significance	LSD (5.0%)
Fert. placement (S)	NS	-
Phosphorus (P)	*	4
Potassium (K)	NS	-
S x P	NS	-
S x K	NS	-
P x K	NS	-
S x P x K	NS	-

NS indictates non-significant treatment effects.

Table 8. Marginal return for phosphorus fertilizer applications on irrigated Radley pea: 1992.

P_2O_5 Rate (kg/ha)	Yield (kg/ha)	Marginal Yield Increase (kg/ha)	Marginal Cost[1] ($/ha)	Marginal Return[2] ($/ha)	Net Return ($/ha)
0	4679	0	0	0	0
22	5008	329	15.10	42.48	42.48
44	5230	222	15.10	23.75	66.23
66	5183	-47	15.10	-23.33	42.90
88	5048	-135	15.10	-38.73	4.17

[1] 11-51-0 @ $350/tonne.

[2] Feed pea @ $175/tonne.