Cropping System Impact on Phosphorus Management of Flax

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The phosphorus (P) nutrition of flax was found to be influenced most by preceding crop in rotation, while tillage system and P fertilizer management had only minor impact.

Reduced tillage systems are becoming increasingly popular on the Canadian prairies. They have been shown to conserve soil moisture, increase crop yield potential, and improve soil quality, while reducing time, labor, and equipment costs in farming operations. Reducing tillage also has important implications for nutrient management. It impacts soil moisture relations, the distribution of nutrients in the profile, surface accumulation of crop residues, and changes the type and activity of soil micro-organisms compared to conventional tillage. Ultimately, this directly influences nutrient availability and fertilizer management decisions.

Phosphorus fertilization of flax can be problematic because flax is very sensitive to seed-placed applications of monoammonium phosphate (MAP). Broadcast application has not been effective in correcting P deficiencies. Pre-plant or side band applications of P fertilizer to flax have low efficiency unless they are positioned within 1 to 2 in. of the seed-row. Therefore, unless a producer has access to seeding equipment capable of side-banding, P fertilization of flax is frequently ineffective. This has caused some producers to skip P application in flax and increase the P supply in the preceding crops, in an attempt to increase residual P for use by the subsequent flax crop in rotation.

Flax is a highly mycorrhizal crop. It is possible mycorrhizal associations could be responsible for part of the positive response that flax shows in no-till systems, and for the limited fertilizer P response observed in field studies. If so, P fertility requirements in flax could be greatly affected by tillage system (no-till preserves mycorrhizae) and whether the preceding crop was mycorrhizal or not (wheat vs. canola, respectively).

We asked the question: Could P fertilization be reduced or eliminated for flax by using no-till, adding extra P to the previous crop in rotation, and using a mycorrhizal crop before flax?

This field study was established at two locations approximately 4 miles apart, on the same clay loam soil type (Udic Boroll) in southern Manitoba. The Research Centre location was in conventional tillage…average pH, 7.8; average organic matter, 5.0%; initial soil test P (Olsen), 10 to 15 parts per million (ppm). The Zero-till Farm was an established (6 years) no-till field…average pH, 7.7; average organic

A strategy to maintain soil P levels through the rotation by targeting applications to more responsive crops may be more cost effective than application of P to flax, unless P supply is extremely depleted.

matter, 5.0%; initial soil test P (Olsen) 10-12 ppm. In year one of the study, canola and spring wheat were seeded using conventional tillage (CT) and no-till (NT), and fertilized with either 0, 22, or 44 lb P_2O_5/A side-banded at seeding. After harvest of the canola and wheat, the stubble in the CT plots was tilled. In year two, the flax was seeded into both stubble and tilled plots, with fertilizer P side banded at either 0 or 44 lb P_2O_5/A (**Table 1**). This 2-year sequence was repeated three times at each location (1999-2000, 2000-2001 and 2001-2002). Plant roots were evaluated for mycorrhizal association at five weeks of growth and seed yield was collected at crop maturity.

Mycorrhizal incidence in 2001 was greater for flax following wheat than flax following canola at both locations, although the difference was larger at the Research Centre than the Zero-till Farm (**Table 1**). This supports previous research which identified canola as a non-mycorrhizal crop, reducing association with crops seeded after canola in rotation. Association was greater with NT than CT at the Zero-till Farm after both of the preceding crops and at the Research Centre after canola. There was no effect of tillage system at the Research Centre after wheat. The level of mycorrhizal association was very high after wheat at the Research Centre, so it is possible that the tillage system had no effect due to the high degree of association present in wheat stubble. Association was reduced at both locations by side-banded P fertilization in the flax, with an interesting tendency (p=0.06) for mycorrhizal association to increase with residual P at the Research Centre and decrease with residual P at the Zero-till Farm. These mycorrhizal incidence results, from a single year of sampling, indicate a high degree of variability associated with preceding crop, fertilizer rate, and tillage practice. Similar patterns in mycorrhizal responses occurred in 2002, although

Table 1. Effect of P fertilizer application to current year flax, previous crop type and P fertilizer management, and tillage system on mycorrhiza incidence and flax seed yield.

P in flax	P in previous crop	Research Centre				Zero-till Farm			
		Canola		Wheat		Canola		Wheat	
		CT	NT	CT	NT	CT	NT	CT	NT
lb P_2O_5/A		Mycorrhiza incidence[1], % of root area covered							
0	0	4.65	5.80	9.40	8.00	3.01	6.13	3.86	8.23
0	22	4.00	6.85	9.31	9.68	3.19	5.47	3.42	4.01
0	44	5.65	11.43	11.38	10.63	3.25	3.50	2.33	7.79
22	0	3.83	4.52	11.04	6.33	5.14	4.30	2.12	5.64
22	22	5.41	5.85	7.19	12.68	3.17	2.70	1.52	4.33
22	44	6.40	4.84	8.10	8.46	1.90	4.42	2.18	3.69
Tillage mean		4.99	6.55	9.40	9.30	3.28	4.42	2.57	5.62
Preceding crop mean						5.77	9.35	3.85	4.09
lb P_2O_5/A		Seed yield[2], bu/A							
0	0	24.9	25.1	25.1	28.4	25.5	22.1	30.1	27.8
0	22	23.9	27.1	26.6	26.7	24.0	22.2	29.0	29.5
0	44	24.4	24.6	26.8	27.9	26.4	22.2	27.4	28.3
22	0	24.1	25.4	27.0	27.2	27.2	21.3	29.6	28.8
22	22	25.3	25.8	29.1	28.7	23.8	23.9	30.8	25.7
22	44	25.7	25.0	28.9	28.4	23.9	21.5	31.2	29.1
Tillage mean		24.7	25.5	27.3	27.9	25.1	22.2	29.7	28.2
Preceding crop mean						25.1	27.6	23.7	28.9

[1]Mycorrhiza incidence for 2001 flax crop only.
[2]Grain yield response an average of 3 years, 2000-2002.

mycorrhizal association was more consistently depressed with residual P than in 2001.

There were few significant influences of the management variables evaluated in this study on the seed yield of flax. Preceding crop was found to have the greatest influence on flax seed yield at both sites (p=0.0001), with mean seed yield averaging 10% and 22% higher after wheat than canola at the Research Centre and Zero-till Farm sites, respectively (Table 1). The effect may be due to a number of factors, including some degree of allelopathy from canola residue, early season competition from volunteer canola plants, and restriction in mycorrhizal colonization after canola.

There was a tendency (p=0.07) for seed yields at the Research Centre site to be higher when P fertilizer was applied to flax, although the difference was small. At the Zero-till Farm site P application had no effect on flax seed yield. Flax yield did not seem to be effected by tillage system in the study. At the Zero-till Farm site, flax seed yield tended (p=0.08) to be higher after CT than NT. These results support previous research on the Canadian prairies which found that flax is well adapted to no-till seeding systems.

Based on the interim information from this study, it appears that P nutrition of flax can be influenced by tillage system, preceding crop, residual P from fertilization of preceding crops and by side-banded P application in the flax. Therefore, it may be possible to select different P management strategies to optimize flax P nutrition and seed yield, depending on the cropping system and crop rotation used and the equipment available. The overall benefit from either applying P fertilizer to the flax crop or increasing P application in the preceding crop to benefit the following flax crop was minimal.

The P status of the soils in this study was low to moderate and P fertilizer responses occurred in other crops. Phosphorus fertilization of flax may be more beneficial on soils where P supply is extremely depleted. However, with moderate deficiencies, the benefit is likely to be low. A P management strategy to maintain P through the rotation by targeting applications to more responsive crops would possibly be more cost-effective than application of P to flax. If soil P levels are not depleted, increased applications of P to preceding crops will likely not improve the yield of the following flax crop. BC

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