BRITISH COLUMBIA

Phosphorus Deficiency in Seedling Corn – Crop Rotation Considerations

By Shabtai Bittman, Grant Kowalenko, and Derek Hunt

Silage corn (*Zea mays* L.) is grown on approximately 20,000 acres in the coastal region of British Columbia as a forage for the local dairy industry. While soil test P levels on dairy farms are generally medium to high in the region due to the addition of manure, it is not uncommon for farmers to report P deficiency symptoms at the 3- to 6-leaf growth stage of the corn crop. Cool soil temperature is the main reason given for the purpling of corn seedlings, with the high yielding corn hybrids considered most likely to display the color change because of high levels of the pigment, anthocyanin.

Early season colonization of silage corn by vesicular arbuscular mycorrhizae (VAM) is influenced by previous crop in the rotation. Growing silage corn on either fallow or stubble of a non-VAM colonizing crop like canola can result in early season phosphorus (P) deficiencies that limit harvested silage yield and reduce dry matter at maturity.

In an attempt to evaluate the impact of early season P deficiency on silage corn production, research staff at the Pacific Agri-Food Research Centre in Agassiz, have been monitoring the fertilizer and crop management practices used in research trials. They have regularly observed that the purple coloration and stunting of well-fertilized corn corresponds to cropping practices in the previous year. Corn planted in the previous year's alleyways showed severe purpling and stunting, whereas the corn planted in areas previously growing corn flourished. Typically, these alleyways were fallowed using a rotovator. The most severe stunting was observed on soil areas that were fallowed for several years. Having P-starved corn plants growing next to P-sufficient plants on soils with abundant levels of soil test P was a major problem for the corn hybrid testing program being managed at the Centre.

The phenomenon of P deficiency in young plants growing on previously fallowed soils has been well documented for corn, wheat and other crops. There is considerable information that points to inadequate populations of VAM in fallow soils as the cause of this P deficiency. In fact, the current opinion of many researchers is that young seedlings require an established network of VAM hyphae to enhance early season P uptake. The spores of VAM, which have long-term persistence and found almost everywhere in agricultural soils, require substantial time to develop a sufficient network. Cool soils influence the activity of VAM, slowing their early season development. As a result, farmers routinely use low rates of starter P with the seed at planting of corn to try and overcome this early season deficiency.

At present, P recommendations in Canada do not take the VAM status of a soil into consideration. Two reasons may be suggested:

1) There is no convenient test for VAM in the soil, especially one that can be used prior to planting.
2) Relatively few studies on VAM have evaluated crop yield.

No attempt has ever been made to systematically develop soil test correlations for P in concert with assessment of VAM in Canada.

This is despite clear indication that common farming practices...such as summerfallow, crops planted following 'cruciferous' and other non-VAM crops, intensive tillage, and flooding...may affect P nutrition in young crops. Today farmers need to know not just when starter P is required, but also when it is not required to achieve optimum yield. In particular, the strategic use of P in heavily manured soils is critical.

To evaluate the effect of rotation on early season silage corn, P nutrition research trials were established in the coastal region of British Columbia. Data were collected on corn growth in 1995, 1997 and 1998, with the plot area in the pre-seeding year managed with corn, summerfallow or canola. Locally adapted silage corn hybrids were planted between early May and early June at a rate of 30,000 to 32,000 seeds per acre using 30-inch row spacing. Fertilizer, except P, was broadcast at recommended rates. Nitrogen (N) was applied as ammonium nitrate at 180 to 225 lb N/A broadcast prior to seeding. On some treatments, fertilizer P was side banded at a rate of 60 lb P_2O_5/A at seeding, while on other treatments no P was applied. Plants were sampled at several growth stages for tissue P concentration and VAM colonization at the 3-leaf stage. Silage yield and percent dry matter were measured at the dent stage.

In all three years of the study, colonization of corn roots by VAM was significantly lower after fallow than after corn (**Table 1**). The effect of planting corn after canola on VAM was equivalent to planting corn after fallow. These results are consistent with previous research on corn. However, in this study the application of P fertilizer had little effect on VAM colonization, in contrast to many published reports. There was no evidence of an interaction between the previous

TABLE 1. Influence of P application and previous crop on VAM colonization, seedling tissue P, silage dry matter yield, and silage dry matter percentage at Agassiz, BC in 1995, 1997 and 1998.

Previous crop	1995 -P	1995 +P	1997 -P	1997 +P	1998 -P	1998 +P
VAM count						
Corn	107a[1]	115a	290a	302a	140a	136a
Fallow	80b	98b	213b	187b	66b	74b
Canola	N/C[2]		190b	179b	63b	73b
3-leaf stage tissue P, %						
Corn	0.29a		0.28	0.34	0.17b	0.19a
Fallow	0.22a		0.28	0.33	0.15c	0.17b
Canola	N/C		0.28	0.35	0.16bc	0.17b
6-leaf stage tissue P, %						
Corn	0.41a		0.27b	0.31a	0.27ab	0.29a
Fallow	0.37b		0.20c	0.27b	0.17c	0.24ab
Canola	N/C		0.21c	0.27b	0.17c	0.23b
Corn silage dry matter yield, tons/A						
Corn	9.54a		5.76ab	6.26a	8.15ab	8.78a
Fallow	9.23a		5.31b	5.90ab	6.71c	7.20bc
Canola	N/C		5.63ab	6.03ab	6.84c	7.20bc
Dry matter content, %						
Corn	29.1a		26.2	27.6	44.3ab	44.8ab
Fallow	28.3a		26.1	27.8	38.6b	46.4a
Canola	N/C		26.3	26.9	36.4b	42.7ab

[1]Numbers in columns followed by the same letter are not statistically significant at P = 0.05.
[2]N/C – data not collected for canola stubble in 1995.

crop and P application on VAM colonization.

Corn seedling tissue P at the 3-leaf stage showed a positive response to fertilizer P addition. However, it was not influenced to any great extent by previous crop (**Table 1**). At the 6-leaf stage, previous crop did affect tissue P content significantly. As the season progressed, the influence of crop management or P addition had a minor impact on plant tissue P concentration (data not shown).

At harvest of the corn silage, the effect of previous crop was generally greater for the unfertilized than the fertilized treatments, with significant differences in 1998 (**Table 1**). While the differences were small, the trend over all trials was for increased corn yield and earlier maturity...as shown by lower percent dry matter (DM)...after corn than after fallow or canola. The trend was observed even when adequate P was applied.

The results of this research confirm what previous studies have shown. That is, the colonization of corn by VAM is influenced by previous crop in rotation. They also provide new information indicating that the colonization of corn roots by VAM was not negatively influenced by side banded P application, a treatment that in most instances improved the final silage yield and DM percent.

Early season colonization of corn roots by VAM had a positive effect on seedling tissue P concentration. Side banding P fertilizer can correct low P uptake associated with poor colonization of corn roots with VAM. However, this may not fully compensate for low P when there is poor root colonization. BC

Dr. Bittman is Forage Agronomist, Dr. Kowalenko Soil Scientist, and Mr. Hunt Senior Research Technician at the Pacific Agri-Food Research Centre in Agassiz, British Columbia. E-mail: bittmans@em.agr.ca

An Agri-Environmental Model... *(continued from page 17)*

The P Recommendation Model

Optimum P rates were ranked in an ascending order within a given soil fertility group as defined above, and P rates corresponding to conditional expectations of 50th and 80th percentiles were recorded. The 50th percentile is the P rate at which 50 percent of the soils in the class produce an optimal yield. The 80th percentile is the P rate that produces optimal yield 80 percent of the time. Both P recommendation models are presented in **Figure 2**.

For recommendation models, the P rate stabilized at 41 lb P_2O_5/A for $(P/Al)_{M\text{-}III}$ exceeding 15 percent. For the 80 percent conditional expectation model, up to 200 lb P_2O_5/A would be recommended below 15 percent $(P/Al)_{M\text{-}III}$. Above an environmental threshold of 15 percent, the recommendation is 41 lb P_2O_5/A. Correspondingly, a P removal of 41 lb P_2O_5/A would be obtained with tuber yield of 375 cwt/A, assuming P removal of 0.11 lb P_2O_5/cwt of tubers. The largest difference between the present Quebec fertilizer recommendation, based on P alone, and the proposed model based on P saturation occurs above the 15 percent critical value (**Table 1**). Above 15 percent, our model recommends more P than present recommendations.

Thus, the $(P/Al)_{M\text{-}III}$ ratio provides a reliable and unifying criterion for making environmentally acceptable and agronomically efficient fertilizer P recommendations for sustaining potato production. The critical value of 15 percent for the $(P/Al)_{M\text{-}III}$ ratio appears to be an acceptable agri-environmental criterion for the potato crop grown in Quebec light-textured soils. A similar agri-environmental model is currently being developed for corn across a larger range of soil textural classes. BC

Dr. Khiari is research associate and Dr. Parent is professor of soil fertility at the Department of Soil Science and Agri-food Engineering, Laval University, Sainte-Foy, Quebec, Canada. E-mail: lotfi_khiari@yahoo.com and leon-etienne.parent@sga.ulaval.ca