PHOSPHORUS AND POTASSIUM REMOVAL AND LEACHING FROM RESIDUE IN CORN AND SOYBEAN

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Introduction

Research is continually being conducted to adjust and update recommendations for phosphorus (P) and potassium (K), and to better understand relationships between nutrient application, grain yield, nutrient removal with harvest, and soil-test values. Studies in Iowa and other states of the north central region have been used to develop guidelines about P and K removal rates in corn and soybean for use together with soil testing information to manage P and K.

There is very large temporal variability in soil-test K (STK) in the region, and significantly less for soil-test P (STP). Potassium does not form part of organic compounds and is in the soluble ion form in plant tissue and crop residue. Potassium is located mainly in the cytoplasm and cell vacuoles where it activates enzymes, regulates stomata functions, and assists in transfer of compounds across membranes. Therefore, the relative amounts of K removal and both amounts and patterns of its recycling with residue may have an effect on STK and its temporal variability. In contrast, most P is incorporated into the plant organic matter and there is a small amount in solution or soluble forms. Plant phosphorus is contained in cell membranes, nucleic acids, and is a major component of the energy compounds that drive photosynthesis and plant metabolism in general.

Little research has been conducted to describe K or P loss from standing plants from physiological maturity (PM) until harvest and in crop residue after grain harvest. The different functions of P and K within the plant and their different distribution among plant tissues affects accumulation in different plant parts, and may also influence losses from plant tissue and from residue after grain harvest.

Therefore, the objectives of this ongoing study were to determine P and K accumulation in aboveground corn and soybean tissues at PM, to quantify P and K removal with grain harvest, and assess trends for P and K loss from plant tissue and residue.

Summary of Procedures

Field trials were established in 11 Iowa fields located at Iowa State University Research Farms during 2009 and 2010. The trials locations were in the central, northeast, north, southeast, south, and southwest regions of the state. The trials included several fertilization treatments, but for this study we sampled treatments with non-limiting K and P fertilization rates. Plant samples were taken from all four replications of the treatments. Physiological maturity samples for corn included aboveground vegetative plant parts, cobs, and grain from six plants per plot. For soybean, samples included aboveground vegetative plant parts (including pod shells) and grain from a 15-ft^2 area of each plot. Plant tissue samples were dried, weighed, and analyzed for total

K and P concentrations. At grain harvest, five residue samples were collected from each plot. The corn samples included residue of 10 plants and the soybean samples included residue collected from a 50-ft^2 area. The samples were placed in mesh plastic bags on top of non-tilled ground, and were removed at roughly 45 day intervals from harvest until spring. The plant tissue and residue samples were dried, weighed, ground, and analyzed for total K and P concentrations.

Highlight of Results

Potassium concentrations within corn plants at PM were much higher than for P except for grain (Table 1). The total accumulation within aboveground plant parts at this growth stage was nearly double for K than for P (170 lb K_2O/acre and 83.1 lb P_2O_5/acre, respectively). The difference would be much greater if the amounts were expressed in an elemental basis. With regards to relative accumulation between vegetative and cob tissue compared with grain, 76% of total P was accumulated in the grain, with only 29% of total K accounted for in grain. At grain harvest, the amount of P accumulated in grain was 56% greater than for K.

In soybean, both K concentrations and accumulation for vegetative plant tissue and grain at PM were much higher for soybean than that of P (Table 2). Total K accumulation at this stage was more than triple that of P (182 lb K_2O/acre and 47.2 lb P_2O_5/acre, respectively). With regards to the relative accumulation between vegetative tissue and grain, 65% of the total P was in the grain compared with only 32% of the total K. At the PM stage, roughly 66% of total nutrient accumulation had occurred in grain, with the remaining amount translocated between PM and grain harvest. This difference between PM and grain harvest times was not observed for corn. Perhaps the timing of our sampling time at some sites was too early, because we wanted to avoid loss of too many senescing soybean leaves.

Figure 1 shows the concentrations and amounts of K in soybean and corn tissues (except grain) from the PM growth stage until the following spring. Although the tissue K concentration was very different for corn and soybean, the trends over time were very similar. The amount of K in corn and soybean tissues at PM was similar, but both the K content and loss trends over time differed significantly. By the late fall, the K concentration in corn residue decreased by 31% of the concentration at PM whereas the K concentration in soybean residue decreased by 65%. Total corn K loss from PM until harvest was 41% but for soybean was significantly greater at 62%. The K loss from residue during winter was small (when soil was frozen or covered by snow), and there was increased loss in early spring. By April, 13% of the plant K at PM remained in the soybean residue and 38% in the corn residue.

Figure 2 shows the P concentrations and amounts of P in soybean and corn tissues (except grain) from PM until the following spring. Phosphorus concentration was greater in soybean than for corn, although there was a greater amount of total P in the corn plant tissues. By the late fall, P concentration in corn decreased by 27% of the concentration at PM, whereas the P concentration in soybean decreased by 65% of the concentration at PM. Total P loss from PM to harvest for soybean was 67% of the PM content whereas for corn total P loss was only 31%. The additional P loss from residue during winter and spring was small. By April, 25% of the plant P at PM remained in the soybean residue and 53% in the corn residue.

For both corn and soybean, a greater percentage of P remained in the residue by late fall and spring. The remaining nutrient content was significantly different for P and K, however (53 and 38% for corn and 25 and 13% for soybean). This difference could be due to a larger proportion of organic P than K within the plant.

The amount and distribution of rainfall, mainly from PM until late fall affected the amounts and distribution of tissue P and K loss over time. However, study of these relationships has not been completed at this time. Also, at this time we are working on nine additional trials.

Preliminary Conclusions

Nutrient accumulation of total plant tissue for K was much greater than for P. Although K showed greater accumulation, the proportion of nutrient removed with grain was greater for P than for K. The plant nutrient lost from physiological maturity to grain harvest was large and of approximately similar relative magnitude for both nutrients, but was greater for soybean than for corn. Nutrient loss from crop residue from harvest to late fall also were significant for K but were very small for P. Additional nutrient losses from residue during winter and spring were much smaller, but were greater for K than for P. The loss trends for both nutrients were more pronounced for soybean than for corn.

The results observed for K and both crops, but especially for soybean, should be considered when interpreting large temporal soil-test K variability and making decisions concerning soil sampling date.

Acknowledgements

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Table 1. Phosphorus and potassium concentration, uptake, and removal across the corn site-years.

		Phosphorus	Potassium
Plant Tissue	Units	Physiological Maturity	
Concentration Veg. Tissue	% P or K	0.12	1.23
Concentration Cob		0.04	0.73
Concentration Grain		0.30	0.35
Veg. Parts Accumulation	lb/acre K_2O or P_2O_5	19.0	109.2
Cob Accumulation		1.2	12.2
Grain Accumulation		62.9	49.0
Total Accumulation		83.1	170.0
		Harvest	
Concentration Harvest Grain	% P or K	0.29	0.36
Harvest Grain Yield	bu/acre	170	170
Removal with Grain	lb/ac K_2O or P_2O_5	63.3	40.7

Table 2. Phosphorus and potassium concentration, uptake, and removal across the soybean site-years.

		Phosphorus	Potassium
Plant Tissue	Units	Physiological Maturity	
Concentration Veg. Tissue	% P or K	0.13	1.80
Concentration Grain		0.57	1.84
Veg. Parts Accumulation	lb/acre K_2O or P_2O_5	16.7	124
Grain Accumulation		30.5	57.7
Total Accumulation		47.2	182
		Harvest	
Concentration Harvest Grain	% P or K	0.58	1.97
Harvest Grain Yield	bu/acre	57.1	57.1
Removal with Grain	lb/ac K_2O or P_2O_5	45.0	81.3

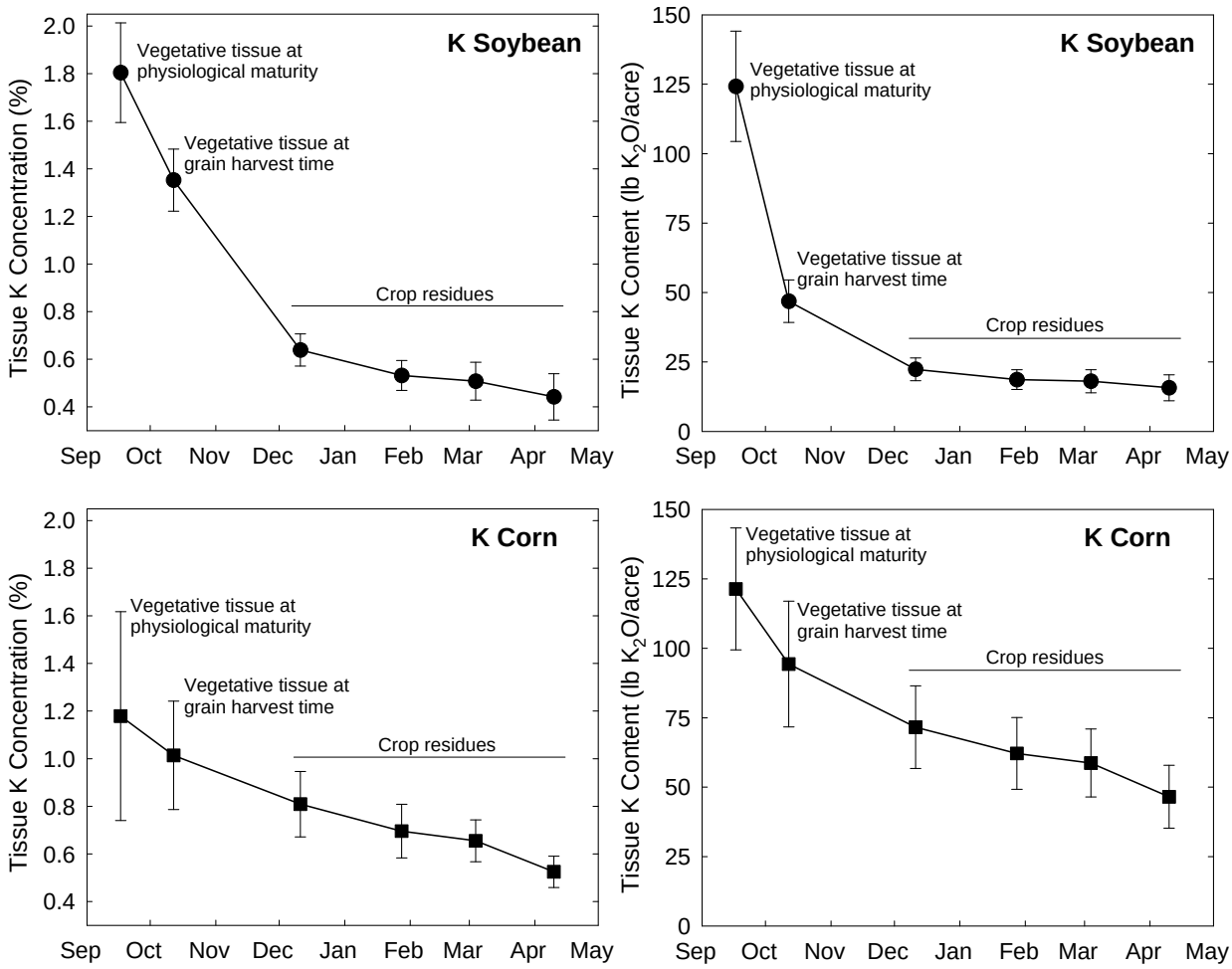

Fig. 1. Potassium concentration and content in corn and soybean plant tissue or residue as a function of time. Vertical lines indicate standard errors of the means.

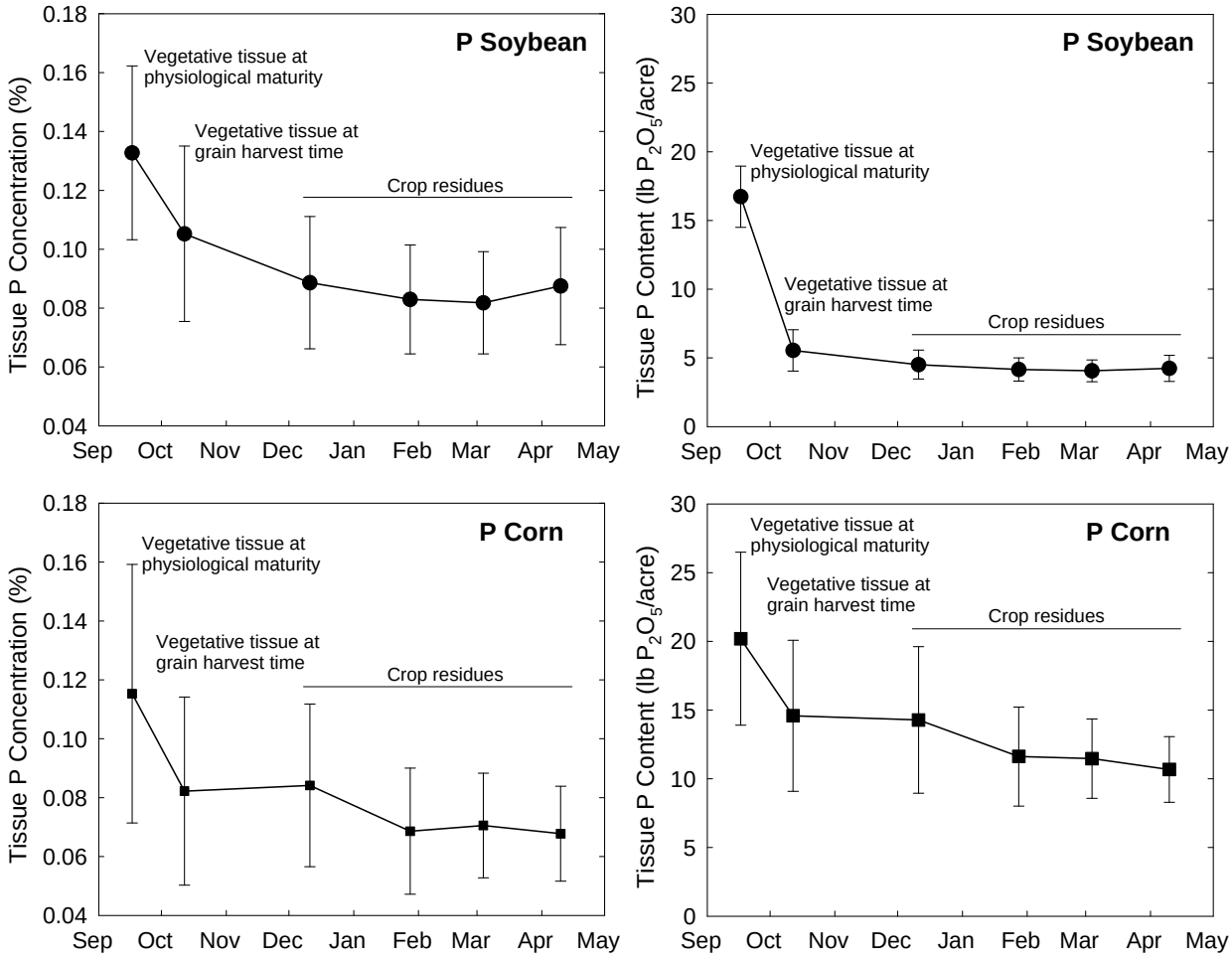

Fig. 2. Phosphorus concentration and content in corn and soybean plant tissue or residue as a function of time. Vertical lines indicate standard errors of the means.

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