

SOIL FERTILITY MANAGEMENT ISSUES FOLLOWING DROUGHT DAMAGED CROPS - PHOSPHORUS, POTASSIUM, AND pH

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Exceptionally dry conditions this summer will result in low crop yield in much of Iowa, and weather forecasts call for normal or below normal rainfall through the fall. These dry conditions and low yields will significantly reduce phosphorus (P) and potassium (K) removal with crop harvest, and may also affect soil-test P, K, and pH results complicating test interpretations.

P and K Removal With Crop Harvest

Removal of P and K with harvest influences the amount of available P and K in soils. Estimates of removal are used to decide fertilizer application to maintain soil-test P and K levels within the Optimum interpretation category. The amount of P and K removed is calculated from the yield of harvested grain or biomass and its P and K concentration. It is easy to measure crop yield for an entire field, and also for different field areas with grain yield monitors. Yield monitors are very useful to estimate yield (and P and K removal) for field areas with different yield levels due to drought or other reasons. Taking grain samples for analysis is an option for estimating P and K concentrations, but the easiest and less costly approach is to use average concentrations per unit of yield for different crops and harvested plant parts, as listed in the ISU Extension and Outreach publication PM 1688 (A general guide for crop nutrient and limestone recommendations in Iowa). Those values are long-term estimates, and grain analysis during the last few years indicate they represent the upper range of concentrations observed today. For example, values from PM 1688 for corn grain are 0.375 lb P₂O₅/bu and 0.30 lb K₂O/bu; and for soybean grain values are 0.80 lb P₂O₅/bu and 1.5 lb K₂O/bu.

No matter the option used to estimate grain or biomass P and K concentrations, there is a great deal of uncertainty and variability concerning drought effects. Depending on moisture availability during different portions of the growing season, there could be relatively more or less grain dry matter production than nutrient uptake and translocation from vegetative plant parts to the grain, which would result in lower or higher concentrations, respectively. When sampling grain or biomass for analysis, you should remember that there is large variability within fields, so take several samples to adequately represent the field or different field areas. Using averages from PM 1688 also is a reasonable approach because even with large variability in P and K concentrations, research has shown that yield level is the most important factor determining the amount of P and K removed. This is shown for corn and soybean in Figure 1. There are good increasing linear relationships between yield level of corn and soybean with both P and K removal, even though the grain P and K concentration varied greatly. The grain P concentration ranges were 0.17 to 0.43 lb P₂O₅/bu for corn and 0.43 to 1.1 lb P₂O₅/bu for soybean. The K concentration ranges were 0.14 to 0.30 lb K₂O/bu for corn and 0.43 to 1.8 lb K₂O/bu for soybean. Therefore, concern about differences in grain P and K concentration due to dry conditions should be much less than getting good estimates of harvested yield.

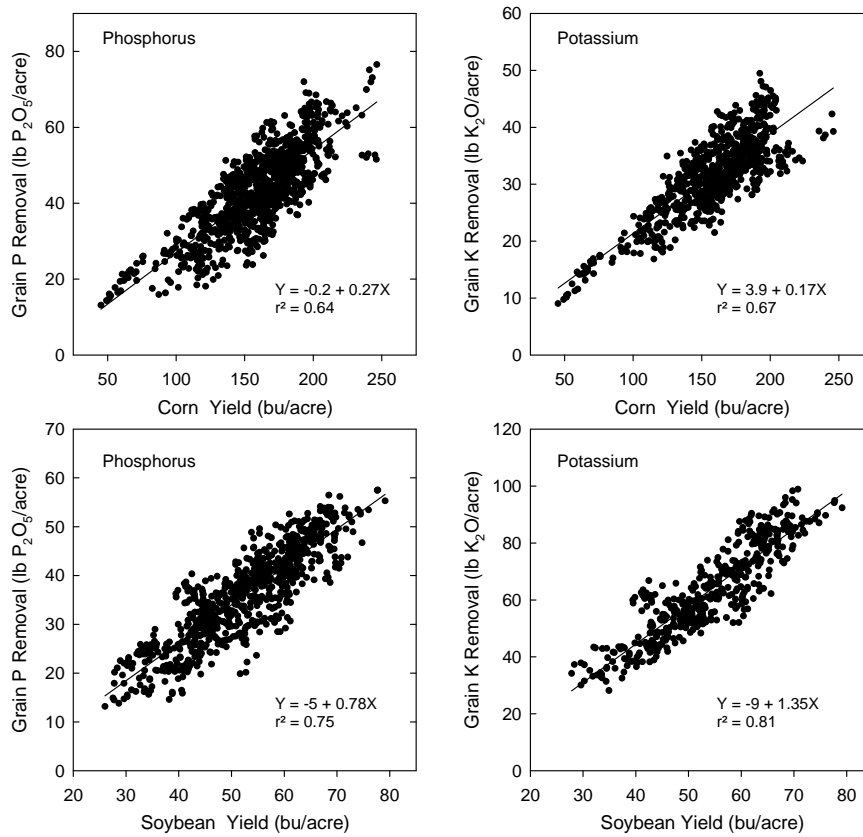


Fig. 1. Relationship between corn and soybean grain yield and P or K removal with harvest across many sites, years, and treatments (data points are averages by site).

Phosphorus and Potassium Recycling To Soil

Short-term P and K recycling to soil from maturing standing plants parts (like leaves) or crop residue after grain harvest usually is reduced by drought, especially K, due to reduced nutrient leaching with the low rainfall. Potassium in plant tissue is soluble in water, because little or no K combines in organic compounds, and plant P is mostly organic. Last fall an ICM News article "Change in phosphorus and potassium contents of cornstalks over time" provided a summary of very recent research for corn. Similar research conducted for soybean was summarized in the 2011 ICM Conference article "Nutrient uptake by corn and soybean, removal, and recycling with crop residue". On average across fields and years, analysis of corn residue collected in late fall showed that 31% of the P and 41% of the K in the aboveground plant parts (except grain) at physiological maturity had been recycled to the soil, whereas analysis of soybean residue showed that 67% of the P and 62% of the K had been recycled. The actual amounts recycled were much higher for K (49 and 105 lb K₂O/acre for corn or soybean) than for P (11 and 12 lb P₂O₅/acre for corn or soybean), due to the higher amounts of K in vegetative plant parts and residue.

The P and K loss from physiological maturity to harvest was large for both crops. The K concentration of corn residue (after harvest) continued decreasing during the fall and early spring but the P concentration remained approximately constant. The rate of K loss from corn plants

and residue increased with increasing rainfall, but not the P loss. The different results for corn P and K are explained by the K being water-soluble and the P mostly organic forms. For soybean, P and K recycling is rapid no matter the amount of rainfall since most P and K are in the leaves, which drop from the plant and are in contact with the soil and decompose even with low rainfall. Therefore, below normal rainfall from physiological plant maturity until the time of soil sampling will result in lower than normal soil-test K results, but how much lower is difficult to predict.

Soil Sampling and Testing

Sampling in dry soil conditions often increases sampling error because it is more difficult to control the sampling depth and proper soil core collection. This may be especially serious in no-till and pastures, due to large nutrient or pH stratification with depth, but also is present with chisel-plow/disk tillage. When the top inch of soil is very dry and powdery it is very easy to lose this soil portion, which will affect the soil-test result significantly. If soils are dry and hard, getting a full 6-inch depth core can be difficult which means soil with lower soil-test levels will be missed.

With a prolonged drought, low yields and less P and K removal will tend to increase post-harvest soil-test P and K levels, but at the same time less short-term recycling from maturing plants and crop residues will result in lower soil-test levels, mainly for K. Also, dry soil slows down the normal equilibrium between different soil nutrient pools, which often results in lower soil-test P and K levels, but most importantly for K. This is because plants are like pumps taking up P and K from the most available soil pools, and normal rainfall allows for a replenishment of the available nutrient pools from the less available pools. With dry soil, however, this replenishment is limited. So the end result from these three processes makes prediction of what will happen with soil-test values uncertain. Most likely, however, there will be significantly lower than normal soil-test K, and probably also some lower soil-test P results.

Very dry soil conditions may result in lower soil pH values (more acidic in neutral to acidic soils). Differences from 0.1 to 0.3 pH units are common with very dry conditions. This is because small concentrations of soluble salts present in the soil solution are not leached by rainfall, which result in higher hydrogen ion concentration and greater acidity in the soil solution. On the other hand, the dry soil effect on Buffer pH, which is used to estimate lime requirement, is not large or consistent. Therefore, the main issue with dry soil is taking into consideration that the pH result may over-estimate acidity to decide if lime should be applied or not, but will not affect the amount of lime to apply.

Suggestions About What To Do

1. Consider estimates of P and K removal with harvest to decide maintenance fertilization rates for the Optimum soil-test category. Also consider if more than expected P and K applied before this year's low-yielding crop can be accounted for the next crop.
2. Try to delay soil sampling until meaningful rainfall occurs because it will result in a better sample and more reliable soil-test results. It is not possible to say how much rainfall would be

helpful, but we believe it should be enough to thoroughly wet the sample depth for some time before sampling.

2. If you have to take soil samples with the current dry conditions:

- Be careful with sampling depth control and that you get the complete soil core.
- Soil K test results may be lower than they would be with normal conditions due to less recycling to the soil and less replenishment of the soluble or easily exchangeable soil K pools.
- Soil P test results probably will be affected little by the recycling issue.
- Soil pH test result may be a bit more acidic than in normal conditions.