PHOSPHORUS, POTASSIUM, AND pH MANAGEMENT FOLLOWING DROUGHT AFFECTED CROPS

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Dry conditions this summer in some parts of Iowa will result in low and variable crop yield. Low or variable crop growth and yield significantly affect phosphorus (P) and potassium (K) uptake and removal with harvest. If dry conditions continue into the fall soil sampling season soil-test P, K, and pH results also may be affected complicating test interpretations.

P and K removal with crop harvest

Estimates of P and K removal are used to decide fertilizer application to maintain soil-test P and K levels within the Optimum soil-test 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. Grain yield monitors are very useful to measure yield in different field areas with different yield levels due to drought or other reasons. The measured yield and an estimate of the P and K concentrations can be used to calculate P and K removal with harvest. Taking grain or biomass samples for analysis is an option for determining 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). The values in PM 1688 represent the upper range of measured concentrations. For example, values from PM 1688 for corn grain at 15 percent moisture are 0.32 lb P_2O_5/bu and 0.22 lb K_2O/bu; and for soybean grain at 13 percent moisture values are 0.72 lb P_2O_5/bu and 1.2 lb K_2O/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, dry conditions can affect dry matter production and nutrient uptake and translocation from vegetative plant parts to the grain differently, which would result in lower or higher nutrient 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 values from PM 1688 is also a reasonable approach because even with large variability in P and K concentrations, research has shown that the 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 clear increasing linear relationships between yield level of corn and soybean with P and K removal, even though the grain P and K concentration varied greatly. The grain P concentrations ranged from 0.17 to 0.43 lb P_2O_5/bu for corn and 0.43 to 1.1 lb P_2O_5/bu for soybean. The K concentrations ranged from 0.14 to 0.30 lb K_2O/bu for corn and 0.43 to 1.8 lb K_2O/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.

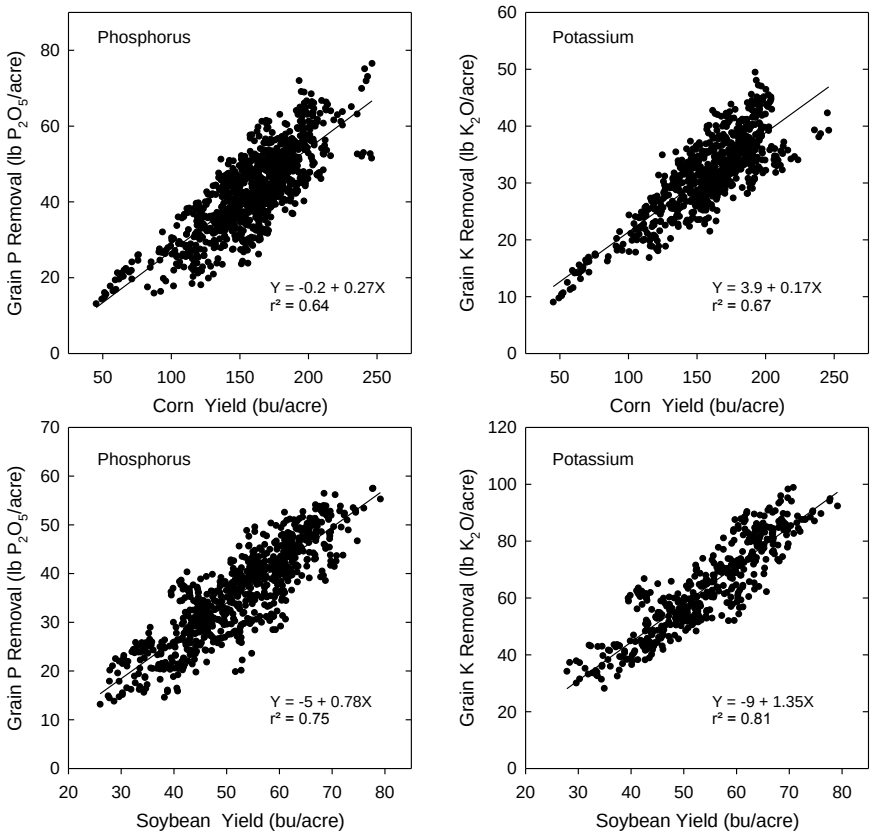

Fig. 1. Relationship between corn and soybean grain yield and P or K removal with harvest across many trial sites, years, and treatments in Iowa (data points are averages by site).

P and K recycling to soil

Short-term P and K recycling to soil from maturing standing plant parts (like leaves), or crop residue after grain harvest, usually is reduced by drought due to reduced nutrient leaching from plant tissue to the soil with the low rainfall. Potassium recycling is much more affected than P because K in plant tissue is soluble in water, because little or no K is incorporated into organic compounds, and plant P is mostly present in organic forms. A 2011 ICM News article "Change in phosphorus and potassium contents of cornstalks over time" addressed this issue. Data in that article and additional recent research showed that on average across fields and years 30% of the P and 40% of the K in the aboveground corn plant parts (except grain) at physiological maturity had been recycled to the soil, whereas 70% of the P and 60% of the K had been recycled. Little P or K was recycled during the winter, and smaller additional amounts were recycled in early spring. The actual amounts recycled were much higher for K (49 and 105 lb K_2O/acre for corn or soybean) than for P (11 and 12 lb P_2O_5/acre for corn or soybean), due to the higher amounts of K in vegetative plant parts.

The amount and rate of P and K recycled from plants between physiological maturity and grain

harvest, and from residue after harvest, increases with increasing rainfall during those periods. The effect of rainfall on recycling was stronger for K than for P, and more rainfall was needed to recycle a certain amount of P or K from corn plants or residue than from soybean plants or residue. The different results for P and K are explained by the K being water-soluble and the P being mostly in organic compounds. Less rainfall is needed for P and K recycling from soybean because most P and K are in the leaves, which drop from the plant and decompose easily even with low rainfall. Therefore, below normal rainfall from the time of physiological plant maturity until the time of soil sampling will result in lower than normal P and K recycling to the soil and consequently lower soil-test K results; however, the reduction will be more pronounced for K than for P.

Soil sampling and testing

Sampling in dry soil conditions often increases sampling error because it is more difficult to control the sampling depth and accomplish proper soil core collection. This may be especially serious in no-till and pastures, due to large nutrient or pH stratification with depth; but stratification is also 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 from the soil core, 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 reactions between different soil nutrient pools, which often results in lower soil-test P and K levels. Potassium is more affected than P because of its different chemistry and reactions in soil. 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 ranging from 0.1 to 0.3 pH units lower 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 pH measurements with dry soil is taking into consideration that the pH value may over-estimate acidity level and the decision if lime should be applied or not, but will not affect the amount of lime to apply.

Suggestions about what to do with drought conditions

1. Consider yield and estimates of P and K removal with harvest to decide maintenance fertilization rates for the Optimum soil-test category. 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.

3. If you have to take soil samples with 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.