Flooded Soil Syndrome

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Fallow Syndrome is a condition where crops planted the year after an extended period with no plant growth exhibit reduced early growth and yield. On corn plants the syndrome exhibits classic phosphorus (P) deficiency symptoms, including slow-stunted early growth, purple coloration, and poorly developed roots. This effect is called Fallow Syndrome because it is observed in soils where, for moisture conservation, the land has been idled for a year and kept fallow with no crop or weed growth. This allows accumulation of moisture in the soil for the next cycle of crop production.

A similar syndrome can be observed after extensive flooding due to the lack of plant growth in submerged areas. This is sometimes called "Flooded Soil Syndrome." This may be an issue in 2012 in the Missouri River floodplain as the flooding spanned a long period during the 2011 growing season. Crops were planted and there was some growth before the flooding, but none the rest of the season. The syndrome tends to affect corn more than soybean, but it can be an issue with soybean as well.

Possible Causes

There are several possible reasons for the syndrome.

One reason often suggested is the decreased survival of active arbuscular mycorrhizae (AM, previously called VAM) fungi populations due to lack of host plants. Water saturation itself does not reduce the AM population. These beneficial fungi form important relationships with plant roots, particularly related to uptake of P and other nutrients with limited mobility in the soil. The AM fungi require a host plant, that is, active roots in the soil. They cannot be propagated in soil alone. In the year following flooding, AM colonization potential and activity are reduced. However, as the season and plant growth progress, AM root colonization can increase to levels similar to that in non-flooded soil. In addition to the AM issue, soil fluctuating anaerobic (flooded) to aerobic (non-flooded) conditions can reduce plant available P. In combination, reduced AM fungal populations and low plant available P reduce early season crop P uptake.

Another possible reason relates to increased strength of P retention by soil constituents. Reduced crop-availability of P after flood waters recede occurs through two mechanisms. One is the alternating conditions associated with water-saturated soil and then with normal aerated or dry soil. This influences the oxidation state of iron (Fe) and crystalline Fe-oxide. This cycle often increases the soil P retention capacity when soils initially return to normal/dry conditions. Therefore, soils may be deficient in P during short periods after flooding, although the effect tends to disappear over weeks or months with normal aerated soil.

Another mechanism reducing P availability relates to the extent of sedimentation. Although there is scarce information about this effect, research has shown that high sedimentation rates provide a renewal of reactive minerals with P retention sites. This may occur because of inorganic

sediment constituents (mainly clay-sized fractions and Fe compounds), but also may occur with organic materials. Several processes can take place, such as influencing chelation of cations and inhibition of Fe oxide crystallization. Sedimentation can result in increased P retention when soil dries after a flood, but the effect is highly variable and unpredictable because it is highly dependent on particle size and sediment chemical and mineralogy properties.

It is not certain that a Flood-Induced Soil Syndrome condition will occur in 2012 crops following the flood of 2011, or if it does, the extent or severity. Research is fairly limited as to the effect on crop production and the duration of 2011 flooding is likely longer than the situations studied in past research.

Avoiding Flooded Soil Syndrome

Consider several things when trying to alleviate development of the "Flooded Soil Syndrome."

Plant a cover crop, which will provide host plant roots for the re-colonization of AM fungi. The more time a cover crop has to grow, the greater the chance of AM recovery and rebuilding the mycorrhizal population. Any plant growth would be helpful, even weeds, but preferably a cover crop like winter rye, wheat, or oat. If the cover crop can be seeded in the early fall, then a crop like oat that will winter kill could be planted. If the cover crop has to be seeded late fall due to prolonged wet soils, a cover crop that will survive the winter and provide growth in the spring should be planted, like winter rye or winter wheat. In the spring, allow as much time for growth as possible and still have timely crop planting. A separate fact sheet discusses cover crop options and management.

Soil test. For better results, especially for soil test P, allow time after the flood waters recede for soils to dry and return to a normal aerated state. This may mean that sampling should be delayed until late fall or better spring. Reactions of P with soil Fe can affect P test levels and interpretation, especially if fields are sampled immediately after flood waters recede or shortly after soils dry. Fields with sand deposition and erosion will require intense sampling after land leveling and sand mixing or removal to differentiate affected areas and new fertilization needs. Also, surface soil test levels could increase or decrease in fields where sediments and associated nutrients are deposited.

Apply more P than called for by soil-test interpretations for normal soil conditions. The research studying P application after a flooded period is limited and results somewhat mixed. And in addition, perhaps none conducted in a situation where the flooding extended for the length of time as 2011 in much of the Missouri river floodplain. In general, the research in corn following flooding and fallow has indicated that a high rate of P banded near the seed row (60 or more lb P_2O_5/acre, two inches beside and two inches below the seed row, approximately twice the normal recommended starter P rate) helps to alleviate poor early plant growth and often, but not always, increases corn yield. A higher than normal broadcast P rate applied shortly before planting also can help. This improvement especially occurs when soil P tests are low.

Effectiveness of seed-placed P is uncertain. Fertilizer rate suggestions are based on quite limited research. We are not aware of research with seed placed P fertilizer (for corn) related to the Flood Syndrome. Due to limitation of rate (seed safety), it is questionable that placement with the seed would fully overcome P availability issues. It is suggested to not place fertilizer with soybean seed (due to injury potential).

Apply phosphorus in spring. In research following fallow, broadcast P has not always been as effective as banded P in increasing yield. When broadcasting P following the flooded conditions, spring application is suggested to avoid the period of increased soil retention that can occur shortly after soils dry.

Research in 1994 following the Mississippi River flood of 1993 showed no corn plant growth or yield response to foliar N and P fertilizer application. In that research, yield was increased with 25 lb N/acre applied in a starter band.

Soybean is not as affected by the syndrome as corn, however, if planting soybean, banded or broadcast high P rates are still advised. For any crop, it is important to use soil testing to determine fertilization needs. However, for P, to help reduce potential issues with the syndrome, application is advised for corn and soybean no matter the soil test level.

In 2012 plant a crop, such as soybean or sorghum, that is not as susceptible.

If planting soybean, add a ***Bradyrhizobium japonicum*** **inoculum to the soybean seed as insurance for adequate nodulation.** This would be especially important in fields with considerable deposition or soil disturbance.

Attempting to colonize fields with AM fungi is not feasible. There are several reasons for this, including the availability of AM inoculum (it can only be propagated with live plant roots, thus limiting economical mass production). It will take time, but once soils return to aerobic conditions and plants are growing, the soil microflora will recover naturally. Therefore, other than adding *Bradyrhizobium* japonicum to soybean seed, adding microbes to flooded soils is not needed.

Extended flooding of soil causes many detrimental issues for soil microflora. However, the microflora is resilient and will naturally recover once flood waters recede. This cycle of soil flooding and recovery has happened many times in river floodplains, and will again. Implementing the practices outlined above can help with short-term, flood-related crop production issues that may occur in 2012.

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