CROP INSIGHTS

Post Flood and Fallow Syndrome Examined

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Summary

- Flooding destroys many acres of cropland each year, leaving fields dead or unplanted for up to a year.
- Crops often exhibit purpling, light green color and poor vigor when planted in fields that have been fallowed for a year or more.
- Mutually beneficial fungi called vesicular-arbuscular mycorrhizae (VAM) enhance nutrient uptake in plants, especially phosphorus.
- Fallowed fields have reduced levels of VAM and may delay nutrient uptake and plant growth.
- This *Crop Insights* reviews post-flood and fallow syndrome, its causes, and possible agronomic management options to prevent it.

Post Flood or Fallow Syndrome Defined

Flooding in North America is common and can affect large regions of cropland in any given year. Large areas of the Midwest and Great Plains were inundated with water in 1993, as was Georgia in 1994 and the Midwest again in 1996.

In many areas, floods destroyed the crop or prevented planting, which led to a fallow period before the next cropping year. In fields left fallow due to flooding or ponding, plant growth the following year has sometimes displayed symptoms of phosphorus (P) deficiency. These deficiencies occur even though soil testing often indicates more available P after flooding than in nonflooded fields.

Post flood syndrome, or ***fallow syndrome***, refer to the same phenomenon – crops grown in fields flooded or fallow the previous year that show symptoms of P and zinc (Zn) deficiency, severe stunting, purple or light green color and poorly developed roots. In addition to early season growth symptoms, yields losses can be dramatic in some instances, especially in corn.

Fallow syndrome has been reported in other countries, as well as the United States. In the Darling Downs area of Australia, both P and Zn deficiency symptoms were observed in fields left fallow for long periods (Thompson, 1987). In South Dakota, researchers found that P levels were low in corn plants grown on land that was not cropped the preceding year. In the 1960s, University of Minnesota researchers conducted a study to evaluate summer fallow vs. cover crops as options for land enrolled in federal crop diversion programs. Results of this study mirrored experiences of farmers in that era who observed that corn growth after summer fallow was sometimes depressed until midsummer. The key findings of this study are listed below:

- Corn after fallow showed retarded growth and lighter green foliage than after cover crops.
- Although visual symptoms disappeared in July, ear moisture percentage at harvest was about five percent higher than after cover crops. This indicates that the early-season delay persisted for the entire season.

- Although symptoms of light green leaves suggested N deficiency, tissue nutrient analysis indicated that only P concentrations were lower in corn grown after fallow. These low P concentrations occurred despite high to very high available soil-P levels.
- Grain yields were reduced about 15 percent for corn following fallow compared to corn after cover crops.
- For corn after weeds (mostly foxtail), the early season growth problems did not occur.
- In addition to corn, sunflowers were also studied and did not suffer from growth or nutrition problems.

Corn plants showing classical phosphorus deficiency symptoms due to post flood syndrome.

Causes of Flood or Fallow Syndrome

Work by Thompson in 1987 found an association between the fallow period and decreased mycorrhizal (a particular type of beneficial fungi) colonization potential for the succeeding crop. Mycorrhizal fungi have been found to affect plant uptake of various essential plant nutrients including P and Zn. These fungi are dependent on host plants to complete their life cycle. If plants are not grown in a field, mycorrhizal hyphae and spores are substantially reduced. Subsequently, newly planted crops are slow to be infected because of the relatively low number of spores present.

What are Mycorrhizae Fungi?

Fungi infect the roots of most plants. Fortunately, most of the fungi form a symbiotic relationship – a relationship that is mutually beneficial. One of these beneficial fungi is called **mycorrhizae**. The symbiotic relationship between mycorrhizae and plants is characterized by a bi-directional flow of nutrients where carbon flows to the fungus and inorganic nutrients move to the plant, providing a critical link between the plant root and soil.

Mycorrhizal spores germinate and the hyphae then invade rootlets and grow both inside and outside the rootlet. Fungal hyphae on the exterior of roots serve as an extension of roots for water and nutrient absorption. There are literally thousands of species that belong in the group of fungi forming endomycorrhizae, the type of mycorrhizal fungi that benefit field and vegetable crop plants. Hyphae invade roots and move within and between cells. Coils of hyphae or branched hyphal structures formed within root cells are called **arbuscules**. Swellings that form on the hyphae and contain oil are **vesicles**. These structures form the basis for referring to endomycorrhizae as **vesicular-arbuscular mycorrhizae** or **VAM** for short.

Mycorrhizal fungi benefit by the carbon provided to them by the plant. The benefits to the host plant include:

- Increasing the effective root surface for increased absorption of nutrients (particularly phosphorus)
- Rootlets functioning longer
- Increasing heat and drought tolerance
- Making soil nutrients more available

The most important role of VAM is the disintegration of soil organic matter and the absorption and transport of the released soil nutrients to the plant. Fungal hyphae can be 100 times longer than plant roots and significantly extend the absorption zone of the root system.

Post Flood Syndrome Research

Research conducted in the Midwest by Ellis (1998) investigated the affect of flooded soil conditions on decreases in VAM hyphae or spores. Soil and plant samples were collected from sites that had been flooded and fallowed the previous year in Missouri and Iowa. Plant root colonization by VAM fungi was significantly reduced in flooded fields, compared with nonflooded fields. Plants sampled in late May had a purple color and were low in P even though soils were considered high in P. By July, plants were not P deficient, however, root colonization was still significantly less in flooded and fallowed soils. Whole plant and grain yields from flooded fields were less than from nonflooded areas (Table 1).

Table 1. VAM colonization and grain yield of corn in 1994 following flooding during 1993. Data are an average of four sites in Iowa and Missouri. Adapted from Ellis (1998).

	VAM Colonization (%)		**Grain Yield** (Bu/ac)
	May	July	
Flooded	17	31	179
Nonflooded	49	60	191

Further greenhouse work by Ellis showed that post-flood syndrome and fallow disorder appear to have the same cause. Both have a loss of VAM fungi and subsequent P or Zn deficiencies in the following crop year. Recolonization of VAM fungi after flooding was associated with not having a host plant available rather than having an extended period of saturated soil conditions.

In a University of Minnesota crop rotation study conducted in three environments, there were no consistent negative effects for corn grown after fallow (Table 2). Previous seasons of soybean or fallow increased yields compared to continuous corn. This study substantiates the experiences of many that fallow does not always depress subsequent crop yields. Cropping systems like those in the arid Great Plains states routinely benefit from the additional soil moisture available after the previous year's summer fallow. Some experienced crop observers believe that fallow syndrome is more likely when fallow occurs during wet, cool conditions. But this observation has not been substantiated by research. Improving the knowledge base of the role and function of mycorrhizae in cropping systems will lead to a better understanding of when fallow syndrome may be a problem.

Table 2. Grain yields of corn grown in three rotation systems during 1983-1984 at three Minnesota locations.

Location and Year	Crop Sequence		
	Continuous Corn	Soybean/ Corn	Fallow/ Corn
	Grain Yield (bu/ac)		
Lamberton, 1983	109	142	131
Waseca, 1983	100	126	133
Waseca, 1984	131	169	154

Managing Mycorrhizae

The dramatic plant growth response achieved in potted plant studies in the 1980s following inoculation with VAM in low fertility soils led to a flurry of activity aimed at using these organisms as biofertilizers. Field responses were often disappointing, especially in high-input agricultural systems, and many concluded that mycorrhizae had little practical importance in agriculture. Further studies, however, have confirmed that most agricultural plants are colonized by mycorrhizal fungi and that they can have a substantial impact on crop productivity. Certainly, it is important to be aware of the presence of mycorrhizae in cropping systems and understand the impact of management decisions on mycorrhizal functioning.

Several factors that should be considered when assessing the role of mycorrhizae in cropping systems include:

- **Mycorrhizal dependency of the host crop**. Although most agricultural crops have mycorrhizae, not all benefit equally from the symbiosis. Generally, coarse-rooted plants benefit more than fine-rooted plants. Crops that are particularly dependent upon mycorrhizae include onion, corn, strawberry and trees.

- **Nutrient status of the soil**. Given that one of the major benefits of VAM is improved P uptake, the management of mycorrhizal fungi will be most critical when soil phosphorus is limiting. Soils may require additional P to compensate for reduced VAM colonization in the year following a flooded and fallow condition.

- **Inoculum potential of the mycorrhizal fungi**. The rate at which mycorrhizal fungi reproduce and colonize the host plants can be affected by management practices such as fertilizer, crop rotation, fallowing and tillage. Soil disturbance such as tillage can reduce the effectiveness of the mycorrhizal symbiosis and thus absorption of P by the host plant. Crop rotation can affect the diversity and function of mycorrhizal fungi. Thompson (1987) describes the long-fallow disorder in Australia where researchers found that a fallow period resulted in a decline in VAM fungi in the soil and reduced colonization of the crop plants in the field. Similarly, planting of a nonhost plant such as canola can lead to reduction in VAM fungi in the field.

Agronomic Recommendations

Growers facing the potential of post-flood or fallow syndrome should consider the following management optons:

- Attempt to **establish a cover crop** in portions of fields that were not planted or were drowned-out due to excessive water. In many instances this will be difficult because persistent rains may not allow enough soil drying to permit planting. Also, ponded portions of some fields are not easily accessible.
- The **choice of cover crop species** will depend on several variables. Herbicides applied earlier in the growing season will result in rotational crop restrictions. Consult herbicide labels for crop rotation information. The length of the remaining growing season may dictate cover crop choice. With July planting, sorghum-sudangrass would provide potential to produce a forage crop. However, nitrogen requirements for sorghum-sudangrass growth are high and nitrogen availability may be limited for soils that have been saturated for long periods. By late August, small grains – which thrive in cool weather – would likely be a better choice than sorghum-sudangrass that is adapted to warm temperatures.
- **Weed growth** will support mycorrhizae populations, but may provide less consistent ground cover, more erosion risk, and increased future weed pressure than cover crops.
- Utilize a high analysis **P fertilizer** with corn in a starter band in fields with potential for fallow syndrome problems. Broadcast applications of P fertilizer have not been effective in preventing fallow syndrome, particularly in soils with high soil test P. High soil test P will lessen the fallow syndrome problem, but not eliminate it. Ellis (1998) recommends the use of 60 to 80 lbs P/acre of starter fertilizer applied the year after flood and fallow to help offset mycorrhizal loss.
- Using **VAM fungal inoculant** as a way of restoring a mycorrhizal population is not readily available and would be too expensive to apply for field crops.
- Soybeans may also be affected by fallow syndrome, but researchers and growers have generally experienced less growth retardation than for corn.

References

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