Nutrient Management of Soybeans with the Potential for Asian Rust Infection

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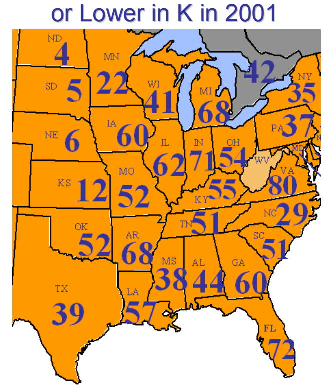
The focus of research and management for controlling Asian rust in soybeans has been on fungicides and genetic development. This approach is clearly justified considering the aggressive nature of the pathogen involved and what is known about managing fungal diseases. However, much is also known about the influence of plant nutrition on susceptibility and tolerance of crops to diseases. It seems reasonable to study the influence of nutrients in managing Asian soybean rust as part of overall management to control the disease. Some examples follow of situations where mineral nutrition plays a significant role in the severity of disease development.

Potassium (K)

Potassium deficiency symptoms such as thin cell walls, weakened stalks and stems, smaller and shorter roots, sugar accumulation in the leaves, and accumulation of unused nitrogen (N) encourage disease infection (PPI, 1998). Each of these reduces the ability of the plant to resist entry and infection by fungal, bacterial, and viral disease organisms. For example, the incidence of leaf spot disease caused by *Cercospora, Stemphylium*, and *Alternaria* in cotton has been related to K fertility. Soybean stem canker infection has been associated with low soil K levels and K fertilization has reduced occurrence of leaf spot disease resulting from *Helminthosporium* in Coastal bermudagrass. These observations are of particular importance when the current soil K status of major soybean growing areas is considered (Fixen, 2002; see figure). Where K nutrition is inadequate, there is potential for crops to be more susceptible to disease.

Percent of Soils Testing Medium or Lower in K in 2001



Chloride (Cl)

Application of Cl, usually in the form of KCl (muriate of potash), has been shown to reduce the severity of numerous fungal diseases (Fixen, 1993). These include take-all, common root rot, tan spot, Septoria, leaf rust, and stripe rust in wheat; common root rot, spot blotch, Fusarium, and root rot in barley; stalk rot in corn; stem rot and sheath blight in rice; hollow heart and brown center

Leaf rust suppression on flag leaves of winter wheat in Bosque county Texas

Pioneer 2158 at anthesis. NH_4Cl applied at 40 lbs Cl/A

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in potatoes; Fusarium yellows in celery; downy mildew in pearl millet; gray leaf spot in coconut palm and sudden death syndrome in soybean (Sanogo and Yang, 2001). Several studies have demonstrated that cereal varieties may differ in response to Cl and the associated disease effect.

Manganese (Mn)
Although studies have shown that several micronutrients can be involved in development of resistance in plants to both root and foliar diseases, Mn is thought to be the most important (Graham and Webb, 1991). Manganese is usually lower in tissues susceptible to fungal, viral, and bacterial pathogens than in resistant tissues (Huber and Wilhelm, 1988). Effects of Mn on plant disease severity have been reported for numerous crops and diseases including root rot, take-all, powdery mildew, leaf rust, and stem rust in cereals; damping off and wilt in cotton; late blight, stem canker and scab in potato and blight in soybean. As with Cl, studies have shown differences among varieties in response and some have observed that many newer glyphosate resistant soybean varieties have a reduced capacity to either take up or translocate Mn (Huber et al., 2004).

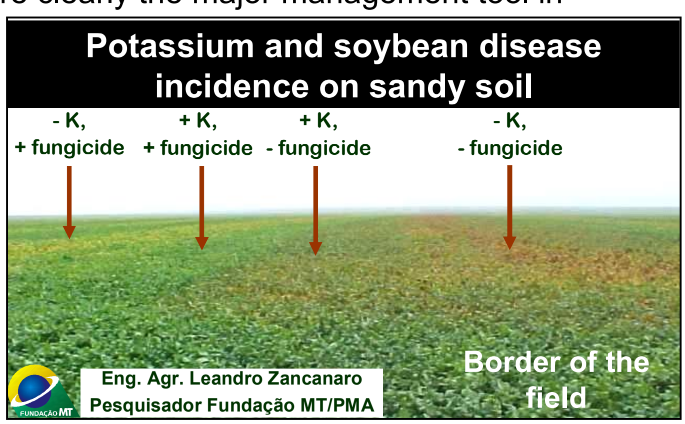
Phosphorus (P)
The likelihood of stem and leaf disease problems increases with crop stress and nutrient shortages and imbalances. Leaf rust in winter wheat has been reduced and yields increased by providing adequate P and K nutrition to the crop (PPI, 1999). A study on the effect of NPK fertilization on rust infected soybeans in the Philippines showed some rust suppression when either P (superphosphate) or K (KCl) was applied, but showed the greatest suppression when both nutrients were used.

Fertilizer effects on rust severity and soybean yield in the Philippines (Piccio and Franje, 1980).

$N+P_2O_5+K_2O$, lb/A	Rust reaction	IWGSR score	Grams/ 100 seeds	Yield, bu/A
0+0+0	S	343	9.12	15.5
27+0+0	S	343	9.58	18.9
0+60+0	MS	333	9.46	18.6
0+0+32	MS	333	9.58	19.3
27+60+32	MR	232	10.46	22.1

S=susceptible, MS=moderately susceptible, MR= moderately resistant; IWGSR=International Working Group system for soybean rust (late pod filling)

Questions
The obvious challenge is that little is known about the specific effects of these nutrients on Asian rust in soybeans. Fungicides are clearly the major management tool in managing the disease, but it is possible that within the context of fungicide application timing or frequency and soybean production economics, there is a role for more intensive management of nutrients needed by the soybean crop. This photo from a rust infected soybean field in Brazil where application misses resulted in “checks” for KCl and fungicide application appears to show



effects of both on the disease. Anecdotal evidence such as this, along with a history of verified disease-nutrition interactions, lead to numerous questions. Some follow.

- Does potash (KCl) application influence rust development in soybeans similar to its effects on cereal crops?
    - If it does, is the effect due to K or Cl?
    - Do soybean varieties differ in reaction as do wheat varieties?
    - What is the effect of fungicide application on K or Cl response?
    - Is there a combination of KCl and fungicide use that offers a more profitable management strategy under certain conditions?
    - Is there reason to apply at least a portion of the crop rotation's K need as KCl prior to soybean establishment to capitalize on positive disease effects (if Cl is involved in rust suppression and considering that it is highly leachable, earlier application may not be effective)?
- Does the Mn status of soybean plants influence disease development or response to fungicide application?
    - Do glyphosate resistant (RR) varieties differ from conventional varieties?
    - Does glyphosate application influence Mn levels and disease development?
    - Does foliar Mn application to low Mn plants influence disease development or yield?
- How important is P nutrition in reducing the impact of rust on soybeans?
    - Are optimum soil test P levels and plant tissue levels the same for soybeans under pressure from rust?
    - Is there any benefit from applying P fertilizer directly to soybeans that will likely be under rust pressure?

Research and On-farm Trials

An immediate need exists to develop answers to these questions. Both on-farm strip trials conducted with field-scale equipment and more complex small plot experiments designed to assess interactions could be conducted. Examples follow.

Small Plot Study

- Factors (3x3x3 factorial = 27 treatments; minimum of 4 reps)
    - Main plot – Fungicide/Mn (3): Check, fungicide, foliar Mn
    - First split - Variety (3): Two RR, one non RR
    - Second split - K vs Cl (3): Check, KCl, $CaCl_2$ (rate of 50 lb Cl/A)
- Measurements
    - Soil – standard soil tests and Mn (0-6 inch); K, nitrate and Cl incrementally to 2 feet
    - Plant – progressive rust severity, tissue K, Cl and Mn, grain yield, seed size

Field Scale Strip Trials

- Many different options; suggest multiple sets per field
- Four treatment option: Check, fungicide, KCl, fungicide + KCl
- Monitor daily during rust season
- Select a set of similar fields planted to different soybean varieties
- Take photos and grain yield

Sentinel plots

- Create plots that will have high probability of being the first to develop rust if innoculum is present.

Management in 2005

So, we have theories and lots of researchable questions concerning holistic management of soybeans under pressure from Asian rust. What should soybean growers do in 2005? The science of nutrient management of soybeans and soybean rotations has not changed. In many respects, there's just one more reason to correctly manage nutrients for the soybean crop. Suggestions follow.

- Be sure soil tests are up to date on fields going into soybeans and that samples have been taken using a sound sampling protocol that captures the manageable variability of the field.
- Follow the recommendations resulting from the soil tests.
- If potash (KCl) and P have not been applied prior to soybeans in the rotation, now might be a good time to make a shift to applying a portion of the rotation needs at that time. On soils with poor internal drainage where salts accumulate in the root zone, such as the flatwood soils of the southeastern U.S., soil Cl levels will likely be very high and high rates of KCl may contribute to Cl toxicity for Cl sensitive soybean varieties (Parker et al.,1986). Generally, Cl toxicity on soybeans appears to be limited to soils naturally high in salts and those being irrigated with high Cl (>100 ppm) water (Snyder et al., 1995). Local agronomists or advisers should be consulted on appropriate KCl rates for local conditions.
- As fields are being scouted for rust, take the opportunity to collect plant tissue samples for nutrient analysis. This is an excellent time to verify that the nutrient management program in place is indeed providing balanced nutrition to the crop and giving it the greatest opportunity to do battle with whatever stress it encounters … be it disease, drought, compaction, or some other challenge of Mother Nature or of man. Be sure to include Mn in the elements tested.
- Learn as much as you can. Read. Leave check strips. Observe. Record.

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