Late summer or early fall are critical times to survey your fields for any fertility related issues, especially if those fields are soybean, peanut or cotton fields. For corn fields, this time period would be earlier, such as July, if it was spring-planted corn just as the corn was in the kernel fill stage or at early dent stage. However, especially, for cotton and peanuts, this is the time of the year when most crops have basically completed the vegetative growth stage and are well into the reproductive stage and crop maturation period of the plant’s life cycle. It is during this reproductive stage when the plant has the highest demand for nutrients. Macronutrients, classified as primary nutrients such as Nitrogen, Phosphorus and Potassium and secondary nutrients are also a concern such as Magnesium, Sulfur and Calcium, as well as, micronutrients such as Boron, Manganese, Iron, Copper, Molybdenum, Zinc and Chlorine.

**Common Nutrient Deficiencies or Toxicities**

Typically we will observe deficiencies of primary nutrients such as Nitrogen, Phosphorus and Potassium most commonly because these nutrients are used in the largest quantity by the plant, hence the name Macronutrients. However, there are three other macronutrients supplied by the atmosphere in the form of air and water that I have not listed - Carbon, Hydrogen and Oxygen. This gives us a total of sixteen essential nutrients for the growth and development of plants.
Primary Nutrients:

Nitrogen (N) is the nutrient that is most frequent in limiting crop production and is needed in greatest quantities for most non legume crops. Soil testing is not reliable for determining amounts available to the current crop; therefore testing is not routinely performed for this nutrient. Nitrogen is stored in the soil’s organic matter and the release is determined by the soil temperature, moisture and growing season. Alabama soils are low in organic matter; therefore a standard recommendation is given for that particular crop as opposed to any soil analysis.

What to look for: Nitrogen is very mobile in the plant, therefore the oldest foliage with nitrogen deficiency will be a much lighter color green as the Nitrogen is mobile in the plant. Severe Nitrogen deficiency will lead to necrosis of the plant tissue as the nitrogen translocates through the plant to younger tissue.
**Phosphorus (P)** All of our Alabama soils are typically very low in phosphorus, especially in the subsoil. However, through many years of fertilization and many years with the application of manures such as poultry litter, observations have been made of soils with very high levels of Phosphate. Phosphorus is a nutrient that is mobile in the plant, therefore deficiencies will often be found in the older tissue of the plant. Granted, deficiencies are a concern but excessive levels of Phosphate are a concern from a water quality and pollutant perspective as well. From a crop demand perspective for Phosphate, the requirement level is rather low for cotton, peanuts, corn or soybeans. Peanuts only require 20 pounds per acre plant available while other crops require a minimal level of 50 pounds Phosphate. It is uncommon to find deficiencies of Phosphate in most Alabama crops but I have observed it in corn at least once.

**What to look for:** Phosphorus deficiency is not obvious in some plants because cotton and peanuts require very low amounts of Phosphorus. However, corn will exhibit a purpling effect from a Phosphorus deficiency. Usually this is during the early growth stages of corn. Sometimes the purpling effect can be considered stress and not an actual Phosphorus deficiency. In most plants the leaf tissue will exhibit a leaf margin purpling.

![Phosphorus Deficiency in Corn](image)

**Potassium (K)** Most sandy Coastal Plain soils are at relatively low levels in Potassium and this nutrient is certainly a very important nutrient for crop production. Clay soils or heavier soils are most likely higher in this nutrient. Recently, improved productivity of varieties has increased the demand of Potassium for optimal production. However, fertility studies have shown that potassium can accumulate in soils when the recommended rate is applied. Excessive levels of Potassium may lead to Magnesium deficiencies, especially on sandy soils. Certain crops require more Potassium than others and the demand of that nutrient is certainly evident, especially for cotton; for optimal cotton production, on soil group 1 (CEC 0-4.6) the Potassium level should be at least 120 pounds/ac of available K and on soil
group 2 (CEC 4.6 – 9.0) the available K should be 180 pounds/ac of K. During boll or pod fill a deficiency will be evident with foliar symptoms.

**What to look for:** In most crops, especially corn, cotton and peanuts what you should look for is leaf margin burn. This will be pronounced by a yellowing, browning effect which will lead to necrosis of the leaf tissue. Potassium is mobile in the plant, therefore often the older tissue will exhibit the deficiency first but the demand for Potassium in cotton is so great that the whole cotton plant will exhibit deficiency symptoms.

*Potassium Deficiency in Cotton*

**Secondary Nutrients:**

**Calcium (Ca)** Calcium is supplied primarily to Alabama crops through either Calcitic or Dolomite limestone. If a proper soil testing program is in place most of the time this nutrient will not be deficient. However, there are certain crops such as peanuts, tomatoes, peppers and watermelons that
require more calcium than other crops. Historically the rating that is considered “high” levels for Calcium in these sensitive crops is 300 pounds per acre of plant available calcium. However, in recent years the recommendation by agronomists has been to have around 500 to 600 pounds of plant available calcium for these crops. The reason being is that Virginia type peanuts require more calcium and many of the runner varieties used in the breeding programs have had some Virginia lines in backcrosses in developing some runner varieties of peanuts. For growers of some of these sensitive crops the addition of Gypsum is recommended to supply additional calcium without adversely increasing the soil pH.

**What to look for:** Calcium deficiency is more evident in crops such as peanuts, tomatoes, peppers, and watermelons. Usually, this leads to bloom-end tissue death when there is not enough Calcium; therefore, the term “blossom end rot” is used in tomatoes where the bloom-end rots or decays. In peanuts, the peg will form and the peanut will begin developing but there will not be enough Calcium to fully develop the kernel and this leads to “pops” in peanuts. In severe cases of Calcium deficiency the pod will abort and will not even develop a hull in peanuts. Calcium is not mobile in the plant.

![Calcium Deficiency in Peanuts](image)

**Magnesium (Mg)** Magnesium is also supplied by dolomite or calcitic limestone. Some sandy soils are deficient in this nutrient, especially associated with lower pH levels. If this is the case then dolomite would need to be the liming source since dolomite has a higher level of Mg as opposed to calcitic limestone. If the Magnesium level is adequate then either calcitic or dolomite is acceptable as a liming material. In soils with a CEC (cation exchange capacity) of 0 to 4.6 it is recommended to have at least 26 lbs/ac of plant available Magnesium. In soils with a CEC over 4.6 it is recommended to have at least 51 lbs/ac of plant available Magnesium.
What to look for: In cotton this will lead to stunted growth and reddening of the leaf tissue in between the veins. Magnesium is mobile in the plant therefore lower leaves should exhibit the deficiency first.

Magnesium Deficiency in Cotton

Sulfur (S) Sulfur deficiency has increased in recent years because the source of Phosphate used to manufacture fertilizer blends does not have the sulfur that it once did when triple super Phosphate was used as a phosphate source. Sulfur deficiencies are more prevalent in sandy soils because the sulfur is highly leachable and sulfur accumulates in the clay subsoil. Therefore deep sands have a much higher probability of being deficient. All crops should receive 10 to 20 pounds of Sulfur each year. Sulfur is a mobile nutrient therefore it moves in the plant and the older tissue will exhibit chlorosis.

What to look for: Sulfur deficiency is commonly observed in cotton on sandy soils. It is also observed in small grain crops, grown on sandy soil, early in the plants life cycle. This could be due to root restriction of the plant or lack of Sulfur. An application of Sulfur early in the plants life will correct the problem. Look for the older tissue to become chlorotic as the nutrient moves in the plant to more juvenile tissue.

Micronutrients

The seven Micronutrients are just as important as the primary and secondary nutrients but are used in much smaller quantities. Most Alabama soils are adequate but following the recommendations are also
very important to successful crop production. In most cases the over application can lead to toxicities more often than crop deficiencies, therefore adhering to the recommended rate is very important. Metals such as Zn and Cu can build up in the soil and lead to toxicities in certain crops. In Alabama, most response in a micronutrient application has been limited to Zinc in corn and Boron in cotton, peanuts and some vegetable crops. However, in some cases soil pH can be too high resulting in Manganese being deficient in peanuts therefore requiring a foliar application of Manganese.

**Boron (B)** Boron is recommended for cotton, peanuts, and clovers grown for seed, alfalfa, cauliflower, broccoli, root crops, apples, pears, plums, strawberries and some vegetable crops. A routine recommendation of .2 to .4 pounds of actual Boron per acre is recommended during early reproductive stages. Foliar sprays are recommended because Boron is highly leachable in the soil if applied in with a fertilizer and the amount needed by the plant is in micro amounts therefore foliar sprays are the most efficient way to supply this nutrient to the plant. The applications may be split between different foliar sprays to reduce any foliar burn that may occur with these foliar Boron sprays. Boron deficiencies in peanuts are evident as “hollow heart” kernels which would result in damage resulting in being classified as seg 2 peanuts which reduces the value significantly. “Hawk” billed bolls are symptoms of boron deficient cotton. Hawk billed bolls develop when the seeds do not develop in one of the locks of the cotton boll.

**What to look for:** In peanuts, with severe Boron deficiency we have observed the lack of flowering and any pegging of peanuts. In addition to this, we have observed stem splitting when associated with Boron deficiency. In deficiencies less severe, look inside the peanut kernel itself to see if “hollow heart” is evident.

In cotton, it is very rare to see Boron deficiencies. However in severe cases the seeds of some locks of cotton may not develop resulting in “hawk billed” bolls.

**Zinc (Zn)** Zinc is recommended for corn on sandy soils where the pH is above 6.0 or the first year after applying lime. It is also recommended for peaches, pecans, apples and pears. From research, these are the only crops that have responded to applications of Zinc. In cases of Zinc toxicity that have been observed in peanuts, the recommendation is to keep a higher pH over 6.0 to keep the Zinc out of soil solution so that Zinc toxicity will not adversely affect the peanuts.

**What to look for:** In corn the leaves are more striped with a white looking stripe. Zinc has limited mobility; therefore the deficiency could be more evident in the more juvenile foliage. Corn would be a crop that we should think about possible deficiencies with Zinc, therefore it is recommended to apply Zinc to corn.
Zinc toxicity has been documented in peanuts and what one should see are severely stunted plants to the point of no vegetative growth. Typically this has occurred where there was once a pecan orchard or a byproduct high in Zinc was applied to a field without consideration to the contamination that it has on the soil.

**Iron (Fe)** is a common deficiency for only a few crops such as soybeans on higher pH soils and some specialty crops such as centipede, azaleas and blueberries. A foliar application of Iron will correct this deficiency.

**What to look for:** Soybeans and sod are noted for Iron deficiency. An entire yellowing of the plant is a visible symptom of Iron deficiency. Iron is not mobile in the plant, therefore the entire plant will exhibit the deficiency symptoms.

**Molybdenum (Mo)** application is recommended to soybeans as a foliar or seed treatment for all soils in northern Alabama or Black belt soils. Deficiency of Mo on acid soils can be prevented by liming. Molybdenum deficiency is not common at all on Alabama’s southern sandy soils.

**Manganese (Mn)** is high in almost all of Alabama soils and is not recommended for any crop. However, on several cases when the pH has been elevated above 6.5 this has induced a Manganese deficiency in peanuts. This is usually caused by over liming. If this occurs a timely application of foliar Manganese is recommended and it will correct the deficiency.

**What to look for:** We most often find Manganese deficiency in peanuts where the pH is too high. Manganese is not mobile in the plant and the entire leaves of the plant will become chlorotic with the
veins of the leaves usually remaining green. Often this occurs where lime was piled or poultry litter was piled in a field or in heavy soils when the field has been limed and the pH in these areas are over 6.5.

Manganese Deficiency in Peanuts

Copper (Cu) and Chlorine (Cl) have not been found to be deficient on any Alabama soils and there is no recommendation to apply these micronutrients. Caution should be given to monitoring Copper levels that may be accumulated in animal waste such as poultry litter and certain copper based pesticides.

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<th>Nutrient Mobility within Plants</th>
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What to do if a Problem is suspected:

1. **Research history of the Field**
   If areas in the crop fields are not uniform in nature this would give us an indication that the problem is not a spray issue and could be fertility related. The reason being is the level of fertility in the soil will typically vary by soil type, nutrient levels or pH levels within the field. This creates zones that we may refer to as “hot spots.” Also, question the historical
management of the field. What was the previous crop for the past two to three years? Was the field managed uniformly over the past few years? The answers to these questions will be an early indicator to possible clues to what the issue might be. For example: if a cotton field is experiencing severe premature leaf shed in the month of August or September, ask what was planted there the previous two to three seasons ago. Often it is discovered that the field was once a hay field which would lead us to suspect Potassium deficiency.

2. **Pull comparison samples**
   Usually there are good areas and bad areas in the field. It is recommended that we pull a soil and tissue sample from each of the different areas so that a comparison can be made to what might be causing the production issue. Remember to be specific in pulling the soil and tissue samples. This is not a routine sampling for the field. We are trying to determine specifically what is affecting the plants’ growth. Also remember to include the growth stage of the plant when sending in the tissue sample. As the plant matures the expected sufficiency ranges will adjust to the crop’s growth stage, therefore to get an accurate sufficiency range we must identify the crop’s growth stage. Also, pull the soil or nematode samples from the base of the affected plants so that we can be sure to get the soil that the plant is growing in and is a concern due to possible fertility or nematode issues.

3. **Look at the plant’s Root System**
   Often what is visual from an above ground perspective and appears to be a simple nutritive deficiency is really a root issue which has induced a deficiency issue. One such example of this is cotton that appears to have Potassium deficiency in certain areas of the field which in turn is really a Root Knot Nematode issue. The Root Knot nematodes are destroying the Phloem and Xylem tissue which transport nutrients through the plant. If there is concern in this area, a Nematode Soil Sample would be warranted. Again a comparison sample is always good to collect to discover the problem or eliminate the cause of concern.

4. **Keep the integrity of the Sample intact**
   If the sample is a nematode sample, we must keep it cool and moist. I would recommend a plastic bag to keep the nematode sample in which would prevent the sample from drying out. Also keep the sample in a cooler to preserve the viability of the sample. For leaf tissue samples, it is recommended to place them in a paper bag which would allow the leaf tissue to dry out and breathe without molding. The tissue will be dried at the lab before analysis anyhow. Soil samples are not hard to maintain the integrity as long as you don’t spill and mix the soil. Also, it goes without saying, but do not mix the samples before the identification and submission of samples.
5. **Interpret the results**

Sometimes the results are not black and white and the issue is not as forthcoming. In these cases forward the results to other agronomists for their opinion. Sometimes there are no good answers from these results and you might have to explore other options.

6. **Document areas**

Once a fertility issue is documented through any sampling and analysis efforts, these areas either by field or within an area of a field should be documented so that future adjustments can be made to the field to improve production. Documentation by either by GPS or other means should be done so that future applications can be applied to address any fertility issue to be corrected.

7. **Application**

After the crop is harvested applications can be redefined or even reanalyzed through grid soil sampling and fall applications of nutrients such as Potassium, Phosphate and Limestone. Typically we should wait until near planting to apply Potassium but in very low levels a fall application would be recommended in an effort to get the Potassium into the soil and improve the fertility before the next crop season. Especially in Potassium sensitive crops, such as cotton, it has taken two to three years to get the Potassium levels increased to the level that no deficiencies were evident during the growing season.