SUFFICIENT SOIL AND TISSUE NUTRIENT LEVELS FOR SOYBEANS

Producers use soil testing to inform them of how much of the 16 essential nutrients are in their soils. Most soil test results provide information about the amount of the major [Phosphorus (P) and Potassium (K)] and secondary [Sulfur (S), Calcium (Ca), and Magnesium (Mg)] macronutrients that a soil sample contains, but likely do not provide information about the amount of micronutrients in the sample unless the submitting producer requests that and pays an additional testing fee.

Knowing just how much of a particular nutrient is in the soil is of value, but knowing the amount of each nutrient in the soil or tissue in relation to its sufficiency for optimum soybean yield is the most valuable information.

If nutrient deficiency symptoms appear in growing soybean plants, tissue testing is a verified way of determining the level of a particular nutrient in the plant in order to discern if in fact a particular nutrient is deficient in the plant exhibiting symptoms. This will allow the affected producer to take remedial measures either in the present crop (least effective) or plan for remedial measures that will prevent recurrence of a deficiency in subsequent crops (most effective).

The information in the **below table** is a compilation of soil and tissue sufficiency levels of each nutrient that are deemed necessary to produce a soybean crop. These data are gleaned from myriad sources which each have some if not all of the information shown in the table. Thus, the table values may not exactly match those in specific sources, but rather are a reasonable "assimilation" of information from those myriad sources. Consult the addendum (Nov. 2021 update) at the end of this article for critical tissue K concentrations that are specific for soybean reproductive stages.

As stated above, having a soil sample tested for some micronutrient levels may be more expensive than the standard soil test offered by most labs. This additional cost will vary among labs, and should be determined from each lab's website before submitting samples for more than their standard analysis.

Remember that soil pH level is critical for the availability of several micronutrients. A graph (Fig. 1) depicting the relative availability of micronutrients by soil pH can be found here.

For a complete treatment of soil sampling for nutrient analysis, click here. A link to the MSU Soil Testing Lab is included. For a complete treatment of soybean tissue sampling and analyses for determining nutrient deficiencies, click here.

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Soil and tissue sufficiency levels for soybean essential nutrients (soil levels in lb/acre are approximate amounts in top 6 in. of soil). Tests for soil micronutrients are not as precise as those for soil pH, P, and K.

		Tissue levels	
Nutrient/Element	**Soil level[a]**	**Critical level**	**Sufficiency range**
Phosphorus (P)	40-60 ppm; 80-120 lb/acre	0.25%	0.26-0.60%
Potassium (K)	130-175 ppm; 260-350 lb/acre	**1.70%***	**1.71-2.50%**
Sulfur (S)	>10 ppm; >20 lb/acre	0.20%	0.21-0.60%
Calcium (Ca)	>400 ppm; >800 lb/acre	0.79%	0.80-1.40%
Magnesium (Mg)	>30 ppm; >60 lb/acre	0.25%	0.26-0.70%
Manganese (Mn)	>40 ppm; >80 lb/acre	20 ppm	21-100 ppm
Boron (B)	NA	20 ppm	21-60 ppm
Copper (Cu)	>1 ppm; >2 lb/acre	9 ppm	10-30 ppm
Molybdenum (Mo)[b]	---	0.9 ppm	1.0-5.0 ppm
Zinc (Zn)	4-8 ppm; 8-16 lb/acre	20 ppm	21-60 ppm
Iron (Fe)[b]	---	50 ppm	51-300 ppm
Chlorine	Not established		

[a]1 ppm = ~2 lb/acre in top 6 in. of soil.
*See attached addendum for specific critical levels based on soybean reproductive stage.
[b]Soil tests for iron and molybdenum are considered to be of little value in predicting supply of these nutrients in soil.
NA = data not available.

ADDENDUM

Nov. 2021 Update

High input prices may cause some producers to cut back on certain fertilizers–e.g. potassium (K)–that they normally might apply ahead of future soybean plantings. This reaction is certainly understandable, and may in fact be an acceptable option if producers have been diligent with their past fertility additions so that the soil reservoir of K is deemed sufficient for an optimum or near-optimum yield.

One of the negatives of the decision to cut back on K fertilizer addition is the real possibility that the crop will suffer from a K shortage during the growing season. This of course can and likely will result in a yield reduction if K in the amount needed for maximum yield is limiting. Thus, accurate knowledge during the growing season about K sufficiency/insufficiency will be valuable to producers.

In an article titled "Dynamic critical potassium concentrations in soybean leaves and petioles for monitoring potassium nutrition", authors Nathan Slaton et al. describe research results that provide such knowledge. Details about this research and its findings follow.

- Potassium is a macronutrient that is often present at below-optimum levels in the soil, thus requiring K fertilization to ensure its sufficiency for optimum soybean yield.
- Tissue analysis is a commonly-used tool for assessing plant levels of required nutrients, and to develop or change fertility programs.
- Tissue analysis can be a very effective tool as long as the proper plant tissues are sampled at the appropriate developmental stages of soybean.
- The use of a single critical tissue-K concentration such as that in the above table to assess K nutrition across soybean growth stages can lead to inaccurate assessments of plant K sufficiency in the developing crop.
- The objective of the research reported in the above article was to develop dynamic critical-K concentrations for recently matured/fully developed trifoliolate leaves and their petioles from one of the top four nodes of soybean plants during the reproductive period.
- Ten K fertilization trials providing a range of soil-K availability and fertilizer K rates were used to address the objective. All trials were conducted in Arkansas on silt loam soils that were cropped to a flood irrigated rice-soybean rotation.
- Soybean cultivars in the 4.4-5.5 relative maturity group (MG) range were planted in April or May each year. Seed yields were determined in all trials, and relative yield in relation to the treatment with the greatest seed yield was calculated.
- The 10 research trials provided >1400 samples of both leaves and petioles for determining K concentration during the R1-R6 stages. The defined relationships in the article are specific for leaf and petioles as separate tissues.
- Soybean in all 10 trials responded positively to K fertilization, with yield increases ranging from 11.4 to 29.0 bu/acre. Soybean receiving no fertilizer K yielded 59-82% of the maximum yield.
- **Sufficient K concentrations in trifoliolates were greatest at R1 and declined with time. Trifoliolate K concentrations were 1.98% , 1.85%, 1.57%, and 1.13% at 1 (1 DAR1), 20 (20 DAR1), 40 (40 DAR1), and 60 (60 DAR1) days after R1. These times approximate R1, late R2, R3-4, and R5-6, respectively.**
- **Sufficient K concentrations in petioles were also greatest at R1 and declined with time. Petiole K concentrations were 4.97%, 4.0%, 2.84%, and 1.55% at 1 DAR1, 20 DAR1, 40 DAR1, and 60 DAR1. Thus, in the early stages of reproductive development, critical K concentrations in petioles were 2.5 times greater than those in leaves, but at the last sampling time, critical leaf- and petiole-K concentrations were numerically similar.**
- **Tissue samples collected during the R1-R2 period and during late reproductive development were less accurate for predicting critical K concentrations than those collected during mid-reproductive development.**
- The authors caution that the reproductive stages and the time between stages may vary widely based on planting date and soybean MG, as well as environmental conditions affecting the growing crop.

It is interesting to note that the critical leaf-K values at only the 1 DAR1 and 20 DAR1 sampling times are above the general critical level of 1.7% that is shown in the above table. Thus, this general critical value for K sufficiency in soybean is not as accurate as the specific values measured in this research at the different soybean reproductive stages.

The results from this research conclusively show that 1) the time that tissue samples are collected for K analysis will provide differing results based on the reproductive stage of the soybean plant, 2) it is important that the time

of tissue sampling in relation to soybean reproductive stage to determine K sufficiency in leaves and petioles be documented to ensure that the data are interpreted accurately, and 3) if K fertilization is reduced or curtailed based on price and availability of K fertilizers, then tissue sampling during the mid portion of soybean reproductive development can be used to most accurately determine K sufficiency in soybean plants.