W 976

Visual Symptoms: A Handy Tool in Identifying Nutrient Deficiency in Corn, Cotton and Soybean

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Generally, a nutrient deficiency occurs as a result of low soil nutrient levels. However, prevailing environmental conditions, soil properties, growth conditions and root diseases may restrict nutrient uptake and induce deficiencies in crops even if soil nutrient levels are estimated sufficient for optimum yield. For example, low or high soil pH, soil compaction and excessively wet or dry soil may prevent nutrient uptake. A handy diagnostic tool to identify nutrient deficiency in crops is via visual observation of symptoms. However, this tool may not always provide a definite diagnosis of the nutrient status of the plant. Keep in mind other conditions are capable of inducing symptoms that closely resemble those of nutrient deficiencies. To address this, visual symptoms should be corroborated with plant tissue and soil testing, and examination of the history of nutrient applications to the field. Adequate knowledge of visual symptoms and tissue testing may help guide corrective actions in-season or preventive action in the following season to avoid yield loss.

The *form* and *location* of symptoms on the affected crop will help guide the diagnosis. Symptoms associated with deficiency may take several forms including chlorosis, necrosis and abnormal growth. Chlorosis occurs when the production of chlorophyll is reduced which results in a yellow to pale green leaf color. Nitrogen (N), magnesium (Mg), sulfur (S), and iron (Fe) are nutrients that play important roles in chlorophyll production and function; hence, their deficiencies tend to cause chlorosis. Next is necrosis, which occurs when the plant tissue dies. Necrosis is commonly associated with N, phosphorus (P), and potassium (K) deficiencies. Abnormal growth occurs when inadequate amounts of a nutrient in the plant restrict cell elongation and replication resulting in stunted growth, deformation or crinkled leaves.

Where the symptomology occurs on the plant depends on the mobility of the nutrient within the plant (Figure 1). Plant nutrients can be classified as mobile or immobile within the plant. Mobile nutrients such as N, P, K and Mg can be translocated from the older leaves to the developing plant parts. Hence, deficiency symptoms tend to show on older, lower leaves. On the other hand, immobile nutrients like Calcium (Ca), Sulfur (S), and most micronutrients have limited mobility within plants and deficiency symptoms occur in younger, upper leaves.

Because plant nutrients may be mobile or immobile, it is important to understand how to sample tissue correctly for accurate results. Sampling an older leaf or trifoliate may result in the mobile nutrient concentration being falsely low. Sampling a younger leaf or trifoliate may cause mobile nutrient results to be too high. This publication provides information on identifying N, P, K, Mg, S, zinc (Zn), and boron (B) nutrient deficiencies in corn, cotton and soybean using visual symptoms. In addition, information on common causes of these deficiencies, deficiency levels in leaf tissue and in-season corrective actions are provided in this publication.

Figure 1. *Schematic chart showing the location of visual nutrient deficiency symptoms.*

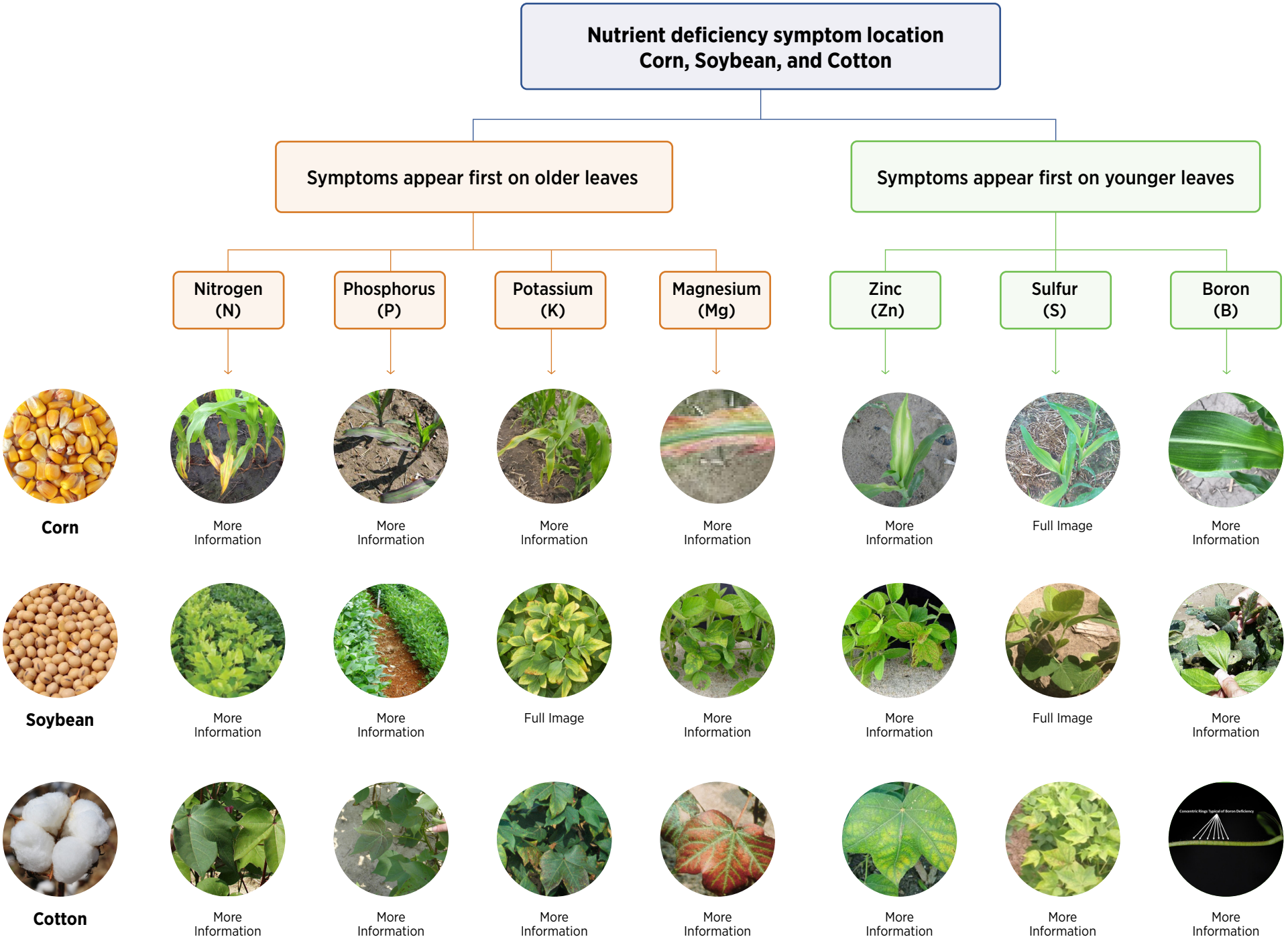


Table 1. *Visual nutrient deficiency symptoms and plant-tissue deficiency levels for corn, cotton and soybean.*

Nutrient	Deficiency symptoms and plant/leaf tissue deficiency levels		
	Corn	**Soybean**	**Cotton**
Macronutrients			
Nitrogen (N)	**Plant:** Stunted yellowish-green plants with spindle stems. **Leaf:** Appear first on older (lower) leaves. V-shaped yellowing starting from the tip and progressing down the midrib towards the base of the leaf. Deficiency is diagnosed when recently mature leaf N at early growth and earleaf N at tasseling is less than 3.0 percent and less than 2.8 percent, respectively (Table 2).	**Plant:** Pale green plants. **Leaf:** Appear first on older (lower) leaves. Pale yellow leaves leading to brown older leaves; veins are prominent. Deficiency is diagnosed when tissue N at flowering is less than 3.25 percent (Table 3).	**Plant:** Stunted plant, reduced boll size, reduced boll retention and increased aborted bolls. **Leaf:** Appear first on older (lower) leaves. Yellowish-green leaf color with reduced leaf size; reddening of the leaf blade in severe cases. Deficiency is diagnosed when recently mature leaf blade N at early bloom and late bloom is less than 3 percent (Table 4).
Phosphorus (P)	**Plant:** Stunted, dark green to bluish-green plants. **Leaf:** Appear first on older (lower) leaves. Reddish-purplish leaf tips and margins. Deficiency is diagnosed when recently mature leaf P at early growth and earleaf N at tasseling is less than 0.30 percent and less than 0.25 percent, respectively (Table 2).	**Leaf:** Appear first on older (lower) leaves. Yellowing along leaf margin progressing to browning; veins remain green. Deficiency is diagnosed when tissue K at flowering is less than 1.5 percent (Table 3).	**Plant:** Stunted growth and poor boll retention. **Leaf:** Appear first on older (lower) leaves. Dark green with reddish-purplish leaf. **Flower:** Delayed flower. Deficiency is diagnosed when recently mature leaf blade P at early bloom and late bloom is less than 0.2 percent and less than 0.15 percent, respectively (Table 4).
Potassium (K)	**Plant:** In severe cases, plants may lodge late in the growing season. **Leaf:** Appear first on older (lower) leaves. Yellowing and then necrosis (tissue dies) of corn leaf margin in severe cases. Yellowing starts from the tip of the leaf and progresses along the edges towards the base of the leaf. Deficiency is diagnosed when recently mature leaf K at early growth and earleaf N at tasseling is less than 2.0 percent and less than 1.8 percent, respectively (Table 2).	**Leaf:** Dark green to bluish leaves with interveinal, small lesions. Appear first on older (lower) leaves. Deficiency is diagnosed when tissue P at flowering is less than 0.3 percent (Table 3).	**Plant:** Stunted plant **Leaf:** Early season (pre-bloom) deficiency symptoms appear first on older (lower) leaves whiles late season (post bloom) deficiency often appears in upper leaves. Light green to gold mottling between leaf veins, progressing to yellowing and then browning of leaf margin and between the veins. There may be development of red and yellow colors on leaf. Deficiency is diagnosed when recently mature leaf blade K at early bloom and late bloom is less than 1.5 percent and less than 0.75 percent, respectively (Table 4).
Magnesium (Mg)	**Plant:** Stunted plants (severe cases). **Leaf:** Appear first on older (lower) leaves. Olive green/mustard yellowing interveinal stripping which progress towards the base and midrib. Necrosis of leaf tip and margins. Older leaves become reddish-purple. Deficiency is diagnosed when recently mature leaf Mg at early growth and earleaf N at tasseling is less than 0.15 percent (Table 2).	**Plant:** Stunted plants (severe cases). **Leaf:** Appear first on older (lower) leaves. Olive green/mustard yellowing interveinal stripping which progress towards the base and midrib. Necrosis of leaf tip and margins. Older leaves become reddish-purple. Deficiency is diagnosed when recently mature leaf Mg at early growth and earleaf N at tasseling is less than 0.15 percent (Table 2).	**Leaf:** Appear first on older (lower) leaves. Interveinal stripping; older leaves become reddish-purple. Deficiency is diagnosed when recently mature leaf blade Mg at early bloom and late bloom is less than 0.3 percent (Table 4).

Table 1 Continued.

Nutrient	Deficiency symptoms and plant/leaf tissue deficiency levels		
	Corn	**Soybean**	**Cotton**
Sulfur (S)	**Plant**: Stunted light green plants with spindly stems. **Leaf:** Appear first on younger (upper) leaves. Yellowing of leaves. Deficiency is diagnosed when recently mature leaf S at early growth and earleaf N at tasseling is less than 0.15 percent (Table 2).	**Plant:** Pale green to yellow plants. **Leaf:** Pale green to yellowing of leaves without prominent vein or necrosis. Appear first on younger (upper) leaves. Deficiency is diagnosed when tissue S at flowering is less than 0.25 percent (Table 3).	**Plant:** Stunted plant. **Leaf:** Appear first on younger (upper) leaves. Yellowing of leaves and leaf vein. Deficiency is diagnosed when recently mature leaf blade S at early bloom and late bloom is less than 0.25 percent and less than 0.30 percent, respectively (Table 4).
Micronutrients			
Zinc (Zn)	**Plant:** Stunted plant. **Leaf:** Appear first on younger (upper) leaves. Interveinal stripping from the base of the leaf and progress to the tip or whitish band at the base of the leaf. Margins, midrib area and tips of leaf usually remain green. Deficiency is diagnosed when recently mature leaf Zn at early growth and earleaf N at tasseling is less than 20 ppm (Table 2).	**Plant:** Pale green plants **Leaf:** Pale yellow leaves leading to brown older leaves; veins are prominent. Appear first on younger (upper) leaves. Deficiency is diagnosed when tissue Zn at flowering is less than 21 ppm (Table 3).	**Leaves:** Appear first on younger (upper) leaves. Interveinal chlorosis and leathery upturned leaves. Deficiency is diagnosed when recently mature leaf blade Zn at early bloom and late bloom is less than 20 ppm and less than 50 ppm, respectively (Table 4).
Boron (B)	**Plant:** Stunted plant. **Leaf:** "Zippering" at leaf edges. Appear first on younger (upper) leaves. Deficiency is diagnosed when recently mature leaf B at early growth and earleaf B at tasseling is less than 5 ppm (Table 2).	**Leaf:** Distorted, stunted terminal abnormal uppermost leaves. Waxy leaf surface. Appear first on younger (upper) leaves. **Flower:** Abortion of flower. Deficiency is diagnosed when tissue B at flowering is less than 20 ppm (Table 3).	**Leaves:** Appear first on younger (upper) leaves. Distorted leaves and appearance of dark bands on the petioles. **Flower:** Deformed or aborted flowers and boll shedding Deficiency is diagnosed when recently mature leaf blade B at early bloom and late bloom is less than 20 ppm and less than 15 ppm (Table 4).

Early corn growth refers to corn plants greater than four inches in height.
Deficiency concentrations referenced in this publication are from R. Campbell 2013

Visual N, P, K, S, Zn and B deficiency symptoms for corn

Nitrogen (N) deficiency

Figure 2. Corn plants with N deficient leaves. Nitrogen deficient leaves exhibiting V-shaped yellowing starting from the tip and progressing down the midrib towards the base of the leaf will appear first on older (lower) leaves. Photo from University of Minnesota Extension.

Phosphorus (P) deficiency

Figure 3. Corn plants with P deficient leaves. Phosphorus deficient leaves with a reddish-purplish leaf tips with margins. Visual deficiency symptoms appear first on older (lower) leaves. Photo from Moe's Diagnostic Centre.

Potassium (K) deficiency

Figure 4. Corn plants with K deficient leaves. Potassium deficient leaves are yellowish green in color. Yellowing starts from the tip of the leaves and progresses along the edges towards the base of the lower leaves. Margins of leaf turn brown, as tissue dies (necrosis). Photo courtesy of Jasper Teboh.

Sulfur (S) deficiency

Figure 5. Corn plant with S deficient leaves. Sulfur deficient leaves are pale or yellowish-green in color and appears first on younger (upper) leaves. Location of deficiency is useful in differentiating between S and N deficiency. Photo courtesy of the NC State Extension.

Zinc (Zn) deficiency

Figure 6. Corn plants with Zn deficient leaves. Zinc deficient leaves show a broad band of white or yellowish color and appears on upper leaves. Yellowing starts from the base of the leaves and progresses to the tip. Margins, midrib area and tips of leaf usually remain green. There is interveinal stripping of leaves (not very visible in the photo). Photo courtesy of Jim Camberato and Stephen Maloney.

Boron (B) deficiency

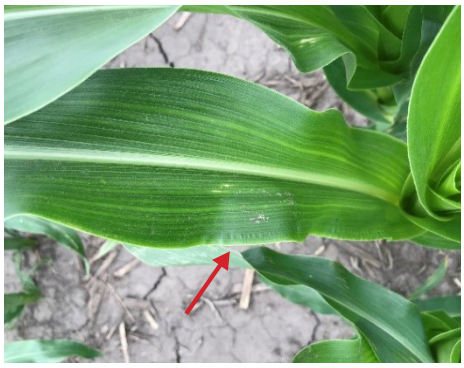


Figure 7. Corn plants with B deficient leaves. Boron deficient leaves show "zippering" at leaf edges and appear first on younger (upper) leaves. Photo courtesy of ILSOYADVISOR.

Table 2. *Nutrient sufficiency ranges for recently matured leaf at early growth (greater than 4 inches) or recently matured ear leaf at tasseling for corn (Source: Campbell, R. 2013).*

Growth Stage	N	P	K	Ca	Mg	S	B	Fe	Mn	Cu	Zn	Mo
	Percent						ppm					
Early growth	3.0 - 4.0	0.3 - 0.5	2.0 - 3.0	0.25 - 0.8	0.15 - 0.6	0.15 - 0.4	5 - 25	30 - 250	20 - 150	5 - 25	20 - 70	0.1 - 2.0
Tasseling	2.8 - 4.0	0.25 - 0.5	1.8 - 3.0	0.25 - 0.8	0.15 - 0.6	0.15 - 0.6	5 - 25	30 - 250	15 - 150	5 - 25	20 - 70	0.1 - 2.0

Visual N, P, K, Mg, S and B deficiency symptoms for soybean

Nitrogen (N) deficiency

Figure 8. Healthy soybean plants (dark green plant on left and right) and N deficient plant (middle). The leaves of N deficient plants are yellowish-green in color. Symptoms appear first on older (lower) leaves. Photo courtesy of Arkansas Soybean Production Handbook.

Phosphorus (P) deficiency

Figure 9. Healthy soybean plants (left) and P deficient plant (right). Phosphorus deficient plant with stunted growth, lack of canopy and upright leaves. Phosphorus deficient leaves may be dark green to bluish leaves with small lesions. Symptoms appear first on older or lower leaves. Photo courtesy of Nebraska Institute of Agriultural and Natural Resources.

Potassium (K) deficiency

Figure 10. Soybean plant with K deficient leaves. Potassium deficiency is associated with interveinal chlorosis that begins from the leaf tip and margins. Chlorosis then progresses to necrosis (browning). Symptoms appear first on older (lower) leaves. Photo from Mississippi State University Extension.

Magnesium (Mg) deficiency

Figure 11. Soybean plants with Mg deficient leaves. Magnesium deficient plant with interveinal mottling of leaves and interveinal necrosis. Symptoms appear first on older (lower) leaves. Photo courtesy of the Nebraska Institute of Agricultural and Natural Resources.

Sulfur (S) deficiency

Figure 12. Soybean plants with S deficient leaves. The leaves of S deficient plant are yellowish-green in color with reduced leaf size. Symptoms appear first on younger (upper) leaves. Location of deficiency is useful in differentiating between N and S deficiency Photo courtesy of the Mississippi State University Extension.

Boron (B) deficiency

Figure 13. Soybean plants with B deficient leaves. The leaves of S deficient plant are darker green in color and distorted/deformed. Plants may show waxy leaf surface. Symptoms appear first on younger (upper) leaves. Photo courtesy of the University of Arkansas Soil Fertility Program.

Table 3. *Nutrient sufficiency ranges for recently matured trifoliate soybean leaf at early growth and flowering (Source: Campbell, R. 2013)*

Growth Stage	N	P	K	Ca	Mg	S	B	Fe	Mn	Cu	Zn
	Percent						ppm				
Early growth	3.5 - 5.5	0.30 - 0.60	1.7 - 2.5	1.1 - 2.2	0.30 - 0.60	-	-	-	-	-	-
Flowering	3.25 - 5.0	0.30 - 0.60	1.5 - 2.25	0.8 - 1.4	0.25 - 0.70	0.25 - 0.60	20 - 60	25 - 300	17 - 100	4 - 30	21 - 80

Visual N, P, K, Mg, S and B deficiency symptoms for cotton

Nitrogen (N) deficiency

Figure 14. Healthy leaf (left) and an N deficient leaf (right). Nitrogen deficient leaves are pale or yellowish-green in color with reduced leaf size. Symptoms appear first on older (lower) leaves. Photo from CDFA.

Phosphorus (P) deficiency

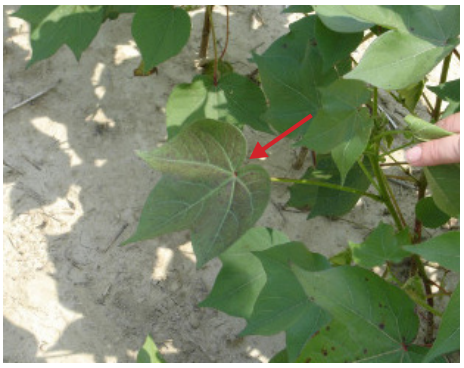


Figure 15. Cotton plant with a P deficient leaf. Phosphorus deficient leaves are dark green in color and may turn reddish-purple as shown in the picture above. Symptoms appear first on older (lower) leaves. Photo from CDFA.

Potassium (K) deficiency

Figure 16. Cotton plant with a K deficient leaf. Potassium deficient leaves show interveinal chlorosis, beginning from the leaf tip and margins. Early season (early bloom) deficiency symptoms appear first on older (lower) leaves while late season (late bloom) deficiency appears on upper leaves. Photo courtesy UTIA.

Magnesium (Mg) deficiency

Figure 17. Cotton plants with an Mg deficient leaves (right). Magnesium deficient leaves show interveinal stripping and older leaves are reddish-purple in color. Symptoms appear first on older (lower) leaves. Photo courtesy of International Plant Nutrition Institute.

Sulfur (S) deficiency

Figure 18. Cotton plants with healthy leaves (left) and S deficient leaves (right). Sulfur deficient leaves are pale or yellowish-green in color. Symptoms appear first on younger (upper) leaves. Location of deficiency is useful in differentiating between S and N deficiency. Photo courtesy UTIA.

Boron (B) deficiency

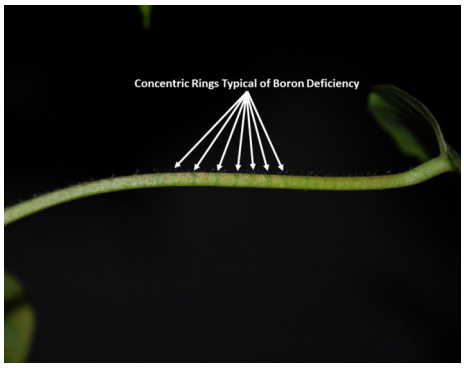


Figure 19. Boron deficient cotton leaf. Boron deficient leaves show appearance of dark bands on the petioles. Symptoms appear first on younger (upper) leaves. Photo courtesy of Mississippi State University Extension.

Table 4. *Nutrient sufficiency ranges for recently matured cotton leaf blade at early and late bloom growth stages (Source: Campbell, R. 2013)*

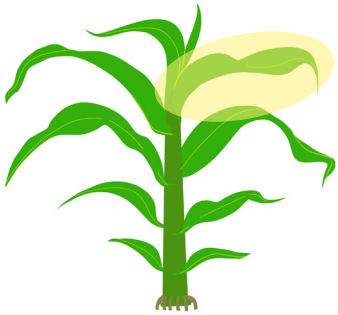
Growth Stage	N	P	K	Ca	Mg	S	B	Fe	Mn	Cu	Zn
	Percent						ppm				
Early bloom	3.0 - 4.5	0.2 - 0.65	1.5 - 3.0	2.0 - 3.5	0.3 - 0.9	0.25 - 0.8	20 - 80	50 - 250	25 - 350	5 - 25	20 - 200
Late bloom	3.0 - 4.5	0.15 - 0.6	0.75 - 2.5	2.0 - 4.0	0.3 - 0.9	0.3 - 0.9	15 - 200	50 - 300	10 - 400	-	50 - 300

Table 5. *Common causes of nutrient deficiency and nutrient fertilizer sources*

Nutrient	Some common causes	In-season corrective actions
Macronutrients		
Nitrogen (N)	Cold soils Under application of N fertilizers Excess nitrogen loss via leaching, ammonia volatilization, denitrification or runoff.	Sidedress N application. Recommend enhance efficiency N fertilizers when conditions for N loss are predicted during the growing season. **Fertilizer sources:** Urea (46 percent); Urea ammonium nitrate (28-32 percent); Anhydrous ammonia (82 percent); Ammonium sulfate (21 percent); Ammonium nitrate (34 percent); Calcium ammonium nitrate (27 percent).
Potassium (K)	Cold soils Compacted soils Sidewall compaction Potassium stratification	Top dress for early season deficiency and foliar application for late season. **Fertilizer sources:** Potassium Magnesium sulfate (22 percent); Potassium sulfate (50 percent); Potassium nitrate (44 percent); Muriate of potash (60 (R)-62 (W) percent).
Phosphorus (P)	Cold soils Soil compaction Side wall compaction	Top dress for early season deficiency. **Fertilizer sources:** Triple superphosphate (45 percent); Di-ammonium phosphate (46 percent); Mono-ammonium phosphate (52 percent); ammonium polyphosphate (37 percent).
Magnesium (Mg)	Soils with very high soil potassium and ammonia levels Acidic (soil pH less than 5.5) sandy soils	Top dress for early season deficiency. **Fertilizers/ amendments:** Dolomitic lime; Magnesium sulfate (10.5 percent); Sulfate of potash magnesium (11.2 percent); Magnesium oxide (55 percent).
Sulfur (S)	Sandy soils Soils with low organic matter	Sidedress sulfur fertilizer application. **Fertilizers sources:** Ammonium sulfate (24 percent); potassium sulfate (17.6 percent); gypsum (16.8 percent); zinc sulfate (17.8 percent); elemental sulfur.
Micronutrients		
Zinc (Zn)	Alkaline soils (soil pH greater than 7.0) Soils with very high soil phosphorus levels	Foliar fertilization with inorganic or chelated zinc. **Fertilizer sources:** Zinc sulfate (22-36 percent); Zinc chelates (6-14 percent).
Boron (B)	Alkaline soils (soil pH greater than 7.0) Highly leached sandy soils Low organic matter soils Dry soils particularly for soybeans	Foliar fertilization with inorganic or chelated boron. **Fertilizer sources:** Borax (11 percent); Boric acid (17 percent); Sodium pentaborate (18 percent); Sodium tetraborate (14-15 percent); Sodium octaborate (20-21 percent).

Desired parts of plant to sample at respective growth stage

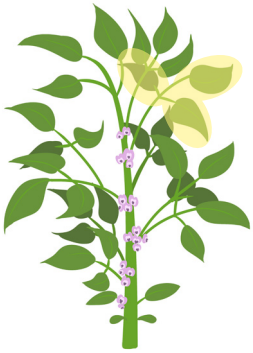
Corn



Corn early growth (greater than four inches in height): Collect the most recent matured leaf (with visible collar) from the tops of 15-20 plants.

Tasseling: Collect earleaf (leaf adjacent to uppermost developing ear) of 15-20 plants.

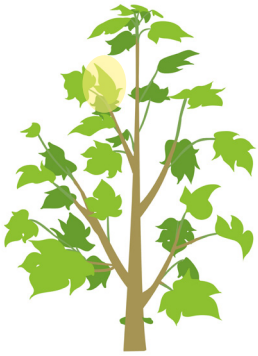
Soybean



Soybean early growth: Collect recently matured trifoliate leaves (trifoliate leaflets unrolled) from the tops of 20-30 plants. Interpretations for N, P, K, Ca and Mg only.

Flowering: Collect recently matured trifoliate leaves (trifoliate leaflets unrolled) from the tops of 20-30 plants either at early or late bloom.

Cotton



Cotton petiole (Week of bloom to eight weeks out): Sample petiole from the most recently matured leaf on a vegetative stem at intervals beginning the week before first bloom and continuing for seven or eight weeks. Immediately remove leaf blade (interpretations only for nitrate, phosphorus and potassium).

Early bloom (one week before to one week after first bloom): Sample the uppermost recently mature cotton leaf blade on the vegetative stem a week before to a week after first bloom. Discard the petiole immediately (usually the fifth leaf from terminal).

Illustrations by Claire Allison Cooke

For plant tissue nutrient submission sheets

please visit: soillab.tennessee.edu.

For more row crop resources

please visit: UTCrops.com.

Further Reading

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