Nitrogen-deficiency symptoms

*Stunted, yellowish plants. Older leaves or whole plants are yellowish green.*

Old leaves and sometimes all leaves become light green and chlorotic at the tip. Leaves die under severe N stress. Except for young leaves, which are greener, leaves are narrow, short, erect, and lemon-yellowish green. The entire field may appear yellowish. N deficiency often occurs at critical growth stages such as tillering and panicle initiation when the demand for N is large. N deficiency results in reduced tillering, small leaves, and short plants. Grain number is reduced. The visual symptoms of N deficiency can be confused with those of S deficiency (Section 2.5), but S deficiency is less common and tends to first affect younger leaves or all leaves on the plant.

**Photo captions**

(a) Leaves are yellowish green in the 0 N omission plot, since fertilizer is not applied.

(b) Leaves of N-deficient plants are light green, narrow, and smaller.

(c) Tillering is reduced where N is deficient.

(d) Tillering is greater where N fertilizer has been applied.
Nutrient Deficiency

(a) [Image of a field]

(b) [Image of rice plants]

(c) [Image of a sign indicating "NO FERTILIZER N"]

(d) [Image of a sign indicating nutrient levels]

Nitrogen
**Phosphorus-deficiency symptoms**

*Stunted dark green plants with erect leaves and reduced tillering.*

P-deficient plants are stunted with greatly reduced tillering. Leaves are narrow, short, very erect, and “dirty” dark green. Stems are thin and spindly and plant development is retarded. The number of leaves, panicles, and grains per panicle is also reduced. Young leaves appear to be healthy but older leaves turn brown and die. Maturity is delayed (often by 1 week or more). When P deficiency is severe, plants may not flower at all. Red and purple colors may develop in leaves if the variety has a tendency to produce anthocyanin. Leaves appear pale green when P and N deficiency (Section 2.1) occur simultaneously. Moderate P deficiency is difficult to recognize in the field. P deficiency is often associated with other nutrient disorders such as Fe toxicity at low pH (Section 2.13), Zn deficiency (Section 2.4), Fe deficiency (Section 2.9), and salinity (Section 2.18) in alkaline soils.

**Photo captions**

(a) Tillering is reduced where P is deficient.

(b) Even under less pronounced P deficiency, stems are thin and spindly and plant development is retarded.

(c), (d) Plants are stunted, small, and erect compared with normal plants.
Nutrient Deficiency

(a) Phosphorus deficiency in crops.

(b) (c) (d) Close-up images of plants with different nutrient levels.
Potassium-deficiency symptoms

*Dark green plants have yellowish brown leaf margins or dark brown necrotic spots first appear on the tips of older leaves.*

Under severe K deficiency, leaf tips are yellowish brown. Symptoms appear first on older leaves, then along the leaf edge, and finally on the leaf base. Upper leaves are short, droopy, and “dirty” dark green. Older leaves change from yellow to brown and, if the deficiency is not corrected, discoloration gradually appears on younger leaves. Leaf tips and margins may dry up. Yellow stripes may appear along leaf interveins and lower leaves become droopy. Leaf symptoms of K deficiency (particularly the appearance of yellowish brown leaf margins) are similar to those of tungro virus disease. Unlike K deficiency, however, tungro occurs as patches within a field, affecting single hills rather than the whole field. When K deficiency is severe, rusty brown spots appear on the tips of older leaves and later spread over the whole leaf, which then turns brown and becomes desiccated. Irregular necrotic spots may also occur on panicles.

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**Photo captions**

(a), (b), (c) Leaf tips and margins become yellowish brown and dry up under K deficiency.

(d) Plants are more susceptible to pests and diseases, and secondary infections are common.

(e) Leaf rolling may occur.

(f) Hybrid rice produces more biomass and therefore has a greater K requirement than inbred rice so that K-deficiency symptoms may occur earlier in hybrid (left) than inbred rice (right).

(g) Plant growth is restricted in the absence of K.
Nutrient Deficiency

(a) Potassium
Zinc-deficiency symptoms

*Lower leaves of stunted plants become droopy and dry with dusty brown spots and streaks 2–4 weeks after transplanting.*

Symptoms appear 2–4 weeks after transplanting, with uneven plant growth and patches of poorly established hills in the field, but the crop may recover without intervention. Under severe Zn deficiency, tillering decreases and may stop completely, and the time to crop maturity may increase. Zn deficiency can also increase spikelet sterility in rice. Midribs, particularly near the leaf base of younger leaves, become chlorotic. Leaves lose turgor and turn brown as brown blotches and streaks appear on lower leaves, enlarge, and coalesce. A white line sometimes appears along the leaf midrib. Plant growth is stunted and leaf blade size is reduced. In Japan, Zn deficiency is the cause of the “Akagare Type II” disorder in rice.

**Photo captions**

(a) Uneven field with stunted plant growth (foreground).

(b) Tillering is reduced, leaves are droopy and dry up.

(c), (d) Appearance of dusty brown spots and streaks.
Nutrient Deficiency

(a) Zinc deficiency in plants.
Sulfur-deficiency symptoms

_Pale green plants, light green-colored young leaves._

In contrast to N deficiency (Section 2.1), where older leaves are affected first, S deficiency results in yellowing of the whole plant and chlorosis is more pronounced in young leaves, the tips of which may become necrotic. There is, however, no necrosis of lower leaves of the type that occurs in N-deficient plants. Also, compared with N deficiency, leaves are a paler yellow in S-deficient plants. Because the effect of S deficiency on yield is more pronounced during vegetative growth, symptoms should be detected and corrected early. S deficiency is often not properly diagnosed, as foliar symptoms are sometimes mistaken for N deficiency. Other symptoms and effects on growth are

- Reduced plant height and stunted growth.
- Reduced number of tillers.
- Plant development and maturity delayed by 1–2 weeks.

Photo captions

(a), (b) The leaf canopy appears pale yellow because of yellowing of the youngest leaves, and plant height and tillering are reduced.

(c), (d) Chlorosis is more pronounced in young leaves, where the leaf tips may become necrotic.
Nutrient Deficiency

(a) Sulfur

(b) Comparison of Sulfur-deficient and normal plants.

(c) Close-up of plant leaves showing sulfur deficiency.

(d) Field view of sulfur-deficient plants.
Silicon-deficiency symptoms

Soft, droopy leaves and culms.

Leaves become soft and droopy; this increases mutual shading, which reduces photosynthetic activity and results in smaller grain yields. Occurrence increases of diseases such as blast (caused by *Pyricularia oryzae*) or brown spot (caused by *Helminthosporium oryzae*). Severe Si deficiency reduces the number of panicles per m² and the number of filled spikelets per panicle. Si-deficient plants are particularly susceptible to lodging.

**Photo captions**

(a) Decreased resistance to diseases such as *Bipolaris oryzae*.

(b) Droopy leaves (left) compared with those of normal rice plant (right).

(c) Brown spots on leaves.

(d) On organic soils in Florida, rice plants treated with Si amendments were more resistant to *Bipolaris oryzae* and *Pyricularia grisea* (lighter-colored fields), compared with untreated fields (darker-colored fields) © Elsevier Science (1997).
Magnesium-deficiency symptoms

*Orange-yellow interveinal chlorosis on older leaves.*

Mg-deficient plants are pale-colored, with interveinal chlorosis first appearing on older leaves and later on younger leaves as deficiency becomes more severe. Green coloring appears as a “string of beads” compared with K deficiency, in which green and yellow stripes run parallel to the leaf (Section 2.3). In severe cases, chlorosis progresses to yellowing and finally necrosis in older leaves. Other symptoms and effects of Mg deficiency are

- Reduced number of spikelets and reduced 1,000-grain weight.
- Reduced grain quality (% milled rice, protein, and starch content).
- Fe toxicity may be more pronounced where Mg is part of multiple nutrient-deficiency stress involving K, P, Ca, and Mg.

**Photo captions**

(a) Orange-yellow interveinal chlorosis usually appears first on older leaves.

(b) Chlorosis may also appear on the flag leaf.

(c) Mg deficiency may also be induced by large applications of K fertilizer on soils with low Mg status.
Nutrient Deficiency

(a) Magnesium

(b)

(c)
Calcium-deficiency symptoms

*Chlorotic-necrotic split or rolled tips of younger leaves.*

Symptoms are usually visible only under severe Ca deficiency (e.g., in pot experiments and soil exhaustion experiments). The tips of the youngest leaves become white (bleached), rolled, and curled. Necrotic tissue may develop along the lateral margins of leaves, and old leaves eventually turn brown and die. Ca deficiency may resemble B deficiency (Section 2.12), and therefore plant tissue analysis may be required to distinguish the cause of symptoms. There is little change in the general appearance of the plant except in cases of acute Ca deficiency. Extreme deficiency results in stunting and death of the growing point.

Photo captions

(a), (b) Symptoms occur only under severe Ca deficiency, when the tips of the youngest leaves may become chlorotic-white.
Nutrient Deficiency

(a) (b)
Iron-deficiency symptoms

*Interveinal yellowing and chlorosis of emerging leaves.*

Whole leaves become chlorotic and very pale. The entire plant becomes chlorotic and dies if Fe deficiency is very severe. Fe deficiency is very important on dryland soils but often disappears one month after planting. Fe deficiency results in decreased dry matter production, reduced chlorophyll concentration in leaves, and reduced activity of enzymes involved in sugar metabolism.

**Photo captions**

(a) Fe deficiency is mainly a problem on upland soils.

(b) Interveinal yellowing of emerging leaves.

(c) Plants are stunted and have narrow leaves (left) if Fe deficiency is severe.
Nutrient Deficiency

Iron
Manganese-deficiency symptoms

*Interveinal chlorosis starting at the tip of younger leaves.*

Pale grayish green interveinal chlorosis spreads from the tip of the leaf to the leaf base. Necrotic brown spots develop later, and the leaf becomes dark brown. Newly emerging leaves are short, narrow, and light green. At tillering, deficient plants are shorter, have fewer leaves, weigh less, and have a smaller root system than plants supplied with sufficient Mn. Plants are stunted but tillering is not affected. Affected plants are more susceptible to brown spot (caused by *Helminthosporium oryzae*). Mn-deficient rice plants are often deficient in P. In soils where both Mn deficiency and Fe toxicity occur, Mn-deficient rice plants contain a large concentration of Fe, and may also show symptoms of bronzing (Section 2.13).

**Photo captions**

(a) Deficiency is mainly a problem in rice grown in upland and organic soils with low Mn status.

(b), (c) Leaves are affected by interveinal chlorosis that appears at the tip of younger leaves.
Manganese
Copper-deficiency symptoms

Chlorotic streaks, bluish green leaves, which become chlorotic near the tips.

Cu-deficient leaves develop chlorotic streaks on either side of the midrib, followed by the appearance of dark brown necrotic lesions on leaf tips. New leaves do not unroll and the leaf tip maintains a needle-like appearance, while the leaf base appears normal. Tillering decreases. Pollen viability is reduced under Cu deficiency, resulting in increased spikelet sterility and many unfilled grains (revealed by analysis of yield components). Absorption of Cu from the soil solution is inhibited by Zn and vice versa.

Photo captions

(a) Deficiency mainly occurs in organic soils.
(b) Chlorotic streaks and dark brown necrotic lesions may develop on the tips of younger leaves.
(c) New leaves may have a needle-like appearance.
Nutrient Deficiency

(a)

(b)

(c)

Copper