Reference 14 Plant nutrients

Summary

This reference is about the importance of nutrients for rice production and the symptoms of nitrogen, phosphorus, potassium and zinc deficiencies. Together with Reference 3, this reference serves as a basis for Reference 15 (integrated soil-fertility management).

Essential nutrients

In order to grow, plants need solar radiation (light), water and nutrients. These nutrients are present in the soil, air, or in water (soil solution). In general, 18 different nutrients are necessary for normal growth and full development.

There are major nutrients (present in at least 0.1% of plant dry matter) and micro-elements (present in less than 0.1% of plant dry matter). The major nutrient coming from the air is carbon (C). Hydrogen (H) comes from water, and oxygen (O) from water and the air. These elements—C, H and O—are transformed by photosynthesis (the engine of plant growth) into carbohydrates for the plant. The major nutrients present in the soil are:

- Nitrogen (N);
- Phosphorus (P);
- Potassium (K);
- Calcium (Ca);
- Magnesium (Mg);
- Sulfur (S).

The essential micronutrients from the soil are: iron (Fe), manganese (Mn), boron (B), zinc (Zn), copper (Cu), chlorine (Cl), cobalt (Co), molybdenum (Mo) and nickel (Ni).

All these elements play an important role in plant growth. We will consider three major nutrients—nitrogen, phosphorus and potassium— and some micronutrients—iron and zinc. In general, the most limiting factor for rice growth in inland valleys is nitrogen, followed by phosphorus and potassium.

Nitrogen

Nitrogen is undoubtedly the most vital nutrient for rice growth. Rice absorbs large quantities of nitrogen to enhance growth, development, yield and grain quality. Nitrogen is present in the soil, but often in insufficient quantities. Rice needs nitrogen almost throughout the vegetative cycle, but in particular at tillering and panicle-initiation stages. Nitrogen accumulates first in the leaves (vegetative phase), then migrates to the panicles and grains (maturity). At maturity, 75% of the nitrogen assimilated is present in the grains. Nitrogen is essential for the normal development of the plant. Nitrogen deficiency induces stunting and a uniform yellowing of the plants (*see* Photo pages: Photo 14.1).

Nitrogen is a very mobile nutrient. Two to three days after an application of N fertilizer, the leaves turn back to green. Excess nitrogen induces high sensitivity to diseases and can lead to lodging.

Because of its high mobility, nitrogen is easily lost to the plant. Leaching due to rain or stagnant water in the plots can transport nitrogen deeper into the soil, out of reach of the roots. Nitrogen can also be transformed into gaseous forms (especially in alkaline soils with high pH) or fixed in the soil (micro-organisms capture N for the decomposition of organic matter).

After a dry period, rains can rapidly start the decomposition of organic matter in the soil. This can cause significant movement of nitrogen from the uplands towards the inland-valley lowlands. This nitrogen flow has been estimated at 80 kg/ha per year, an important loss to the uplands. Crops growing in the hydromorphic zone (e.g. arboriculture, bananas or plantains) or lowland zone (rice) benefit from this flow.

The nitrogen content of the soil can be estimated by observing its surface color, texture and structure. A dark, clayey and well-structured soil with plenty of active soil fauna (especially worms) indicates, in general, good levels of nitrogen.

Phosphorus

Phosphorus is normally applied as basal fertilizer during land preparation (Reference 12). The effect of phosphorus application is not as visible as it is for nitrogen. However, it has been proven that phosphorus plays an important role in the physiological development of the plant. Phosphorus stimulates root development, tillering and pollination, and reduces the period to maturity. Phosphorus stimulates recovery after stress (rodent attack, cold, etc.). Lack of phosphorus can reduce yields. The symptoms of phosphorus deficiency are dark green leaves and reduced tillering (*see* Photo pages: Photo 14.2); plant development is delayed and is very heterogeneous. Most inland-valley soils contain a large quantity of phosphorus.

Phosphorus is not a mobile nutrient and will not be lost easily (as N is) and applying P fertilizer can be a good investment in soil fertility that will bring returns over many years. When organic matter is added to the soil, phosphorus may become more mobile.

Potassium

As for phosphorus, potassium application has no immediate visible effect. However, it coordinates the biochemical activity of nitrogen and phosphorus. Potassium plays an important role in the synthesis, transformation and transport of carbohydrates to the grains. This explains why a lack of potassium induces low grain weight.

Potassium also plays an important role in the resistance to some stresses such as drought, insects and diseases. Indicators for potassium deficiency are dark green leaves with yellowing leaf tips and margins, and small brown spots (*see* Photo pages: Photo 14.3). Symptoms first appear on older leaves and develop from the margins of the leaves towards the center. The color of the old leaves changes

from yellow to brown, and the leaf margins and tips dry out. If no potassium is applied, the young leaves will also be affected. Potassium is a mobile element in the soil.

Micro-nutrients

Mineral fertilizers are applied to satisfy the plant's nutrient needs: nitrogen, phosphorus and potassium. In general, soils do not contain these major elements in sufficient quantities that can be easily absorbed by the plant. Micro-nutrients are generally present in higher quantities than the plants need; the most common micro-nutrients are calcium, magnesium, iron and manganese. Lack or excess of micro-nutrients induces physiological disorders, but these are rarely observed except for iron toxicity.

Zinc

Zinc plays an important role in the biochemical processes of the plant; for instance, to produce chlorophyll. Inland-valley or irrigated rice is often confronted with a lack of zinc, in particular on rich, calcareous or limestone soils. The indicators of zinc deficiency are the appearance of brown spots on young leaves two to four weeks after transplanting, resulting in spots of low productivity in the field (*see* Photo pages: Photo 14.4). In severe zinc deficiency, tillering and rice development are hampered. Calcareous or limestone soils with a relative high content of organic matter (>1.5%) are at risk of zinc-deficiency problems. Symptoms are rather similar to those of iron toxicity.

Zinc application

A basal application of 5 to 10 kg Zn/ha, as zinc sulfate or zinc oxide, is often sufficient. Zinc can also be sprayed onto the leaves after transplanting. The roots can also be bathed in a zinc solution before transplanting. If zinc is applied as top-dressing, it should be mixed with sand to get a more homogeneous application.

Bibliography

Dobermann, A. and T. Fairhurst, 2000. *Rice. Nutrient Disorders and Nutrient Management*. Potash & Phosphate Institute (PPI), Potash & Phosphate Institute of Canada (PPIC), and International Rice Research Institute (IRRI), Manila, The Philippines, 191 pp.

Fairhurst, T. and C. Witt (Ed.), 2002. *Rice. A Practical Guide to Nutrient Management*. Potash & Phosphate Institute (PPI), Potash & Phosphate Institute of Canada (PPIC), and International Rice Research Institute (IRRI), Manila, The Philippines, 89 pp. + appendices.

Matsuo, T., K. Kumazawa, R. Ishii, K. Ishihara and H. Hirata, 1995. *Science of the Rice Plant. Vol. II Physiology*. Food and Agriculture Policy Research Center, Tokyo.

Yoshida, S., 1981. *Fundamentals of Rice Crop Science*. International Rice Research Institute, Manila, The Philippines, 269 pp.