Indian Farming 75 (05): 25-27; May 2025

Nutrient deficiencies in rice-wheat systems:

Symptoms, causes and amelioration

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The rice-wheat system (RWS), prevalent across diverse agro-ecological regions, faces significant nutrient management challenges due to the intensive and sequential cultivation of rice followed by wheat. This dual-cropping regimen accelerates soil nutrient depletion, leading to widespread deficiencies that compromise soil fertility and crop productivity. The deficiency symptoms of nitrogen (N), phosphorus (P), potassium (K), sulfur (S), zinc (Zn), iron (Fe), and manganese (Mn) manifest through distinct symptoms, such as chlorosis, stunted growth, and poor yield, affecting both rice and wheat differently. Intensive farming practices, monoculture, and imbalanced fertilizer application exacerbate these deficiencies. Effective management requires balanced fertilization, regular soil testing, and targeted interventions, including specific nutrient applications and foliar sprays. Addressing these deficiencies with precision is crucial for maintaining soil health, optimizing crop yields, and ensuring the sustainability of the RWS.

Keywords: Intensive cultivation, Micro-nutrients deficiency, Rice-wheat cropping system

THE rice-wheat system (RWS), a fundamental agricultural production system in different agro-ecological regions globally encounters critical challenges associated with nutrient deficiencies. This intensive cropping regime is characterized by the sequential cultivation of rice followed by wheat in the same fields, poses a substantial risk of rapid soil nutrient depletion if not managed with precision and care. The dual-cropping nature of RWS which demands continuous cultivation and harvesting, accelerates the rate at which essential soil nutrients are exhausted. Nutrient deficiencies in the RWS are a growing concern due to the increased nutrient uptake by high-yielding varieties of these staple crops. Without adequate replenishment and soil management strategies, these deficiencies can lead to diminished soil fertility, adversely affecting crop productivity and ecosystems' sustainability. The complex interplay of soil health, nutrient availability, and crop demands necessitates a thorough understanding of the symptoms, underlying causes and effective solutions for nutrient imbalances. Therefore, identifying the symptoms of nutrient deficiencies such as chlorosis, stunted growth, and poor yield enables timely intervention and management. These symptoms manifest differently across various nutrients, impacting plant health and crop yield in distinct ways. For instance, nitrogen (N) deficiency often results in yellowing of lower older leaves and stunted growth, while phosphorus (P) deficiency is marked by dark green or purplish discoloration and reduced root development.

Causes of nutrient deficiencies in rice-wheat system

The causes of these deficiencies are multifaceted, encompassing intensive farming practices, monoculture, soil erosion, leaching, and imbalanced fertilization. Intensive farming, characterized by the continuous rotation of rice and wheat, rapidly depletes soil nutrients without adequate replenishment. Monoculture further exacerbates nutrient imbalances as specific crops extract particular nutrients from the soil, leaving others deficient. Soil erosion and leaching contribute to nutrient loss through the removal of topsoil and the leaching away of soluble nutrients, respectively. Additionally, imbalanced fertilizer use, often relying heavily on nitrogen (N), can lead to deficiencies in other essential nutrients like P and potassium (K). Therefore, addressing these nutrient deficiencies require a comprehensive approach to soil management and fertilization. Implementing balanced fertilization practices, which include the application of both macronutrients (N, P and K), secondary nutrients (sulphur, S) and micronutrients, e.g. zinc (Zn), iron (Fe) and manganese (Mn) is crucial for maintaining soil fertility

and optimizing crop yields in RWS. Regular soil testing is indispensable for diagnosing nutrient deficiencies accurately and tailoring fertilization strategies to meet the specific needs of the soil and crops.

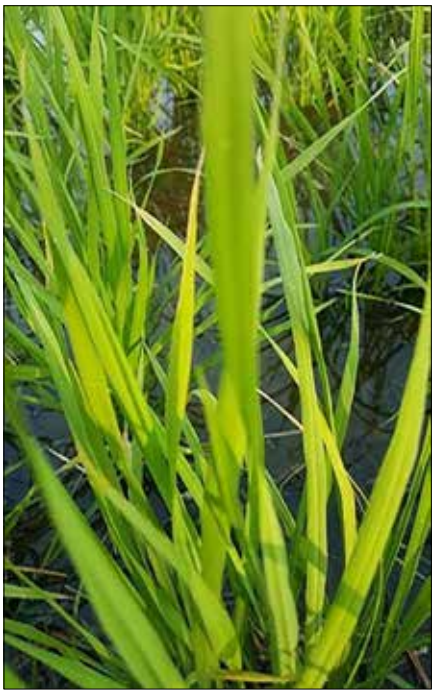
Typical symptoms of nutrient deficiencies

***Nitrogen deficiency*:** N deficiency is characterized by stunted growth, yellowing of older leaves (chlorosis), and poor grain development. In rice, this manifests as pale green or yellowish leaves, while in wheat, it results in reduced tillering and smaller and lighter grains.

***Phosphorus deficiency*:** P deficiency leads to dark green or purplish discoloration of leaves, particularly older ones. In rice, plants may exhibit stunted growth and poor root development. In wheat, the deficiency causes reduced plant height, delayed maturity and lower grain yield.

***Potassium deficiency*:** K deficiency is marked by leaf edges turning yellow and browning, with possible necrosis. Rice plants may show poor root growth and lodging, while wheat plants often exhibit weak straw, making them prone to lodging and reduced yield.

***Sulfur deficiency*:** S deficiency results in uniform yellowing of the younger leaves. It affects protein synthesis, leading to reduced crop yield and quality in wheat. Wheat crops are prone to S deficiency when grown in sandy soils, particularly when prolonged winter rains occur during the early growth period. Sulfur deficiency initially affects the younger leaves, causing them to lose their normal green coloration. The topmost leaves turn a light yellow, except for the tips, while the lower leaves maintain their green color for a longer duration. This pattern of yellowing is distinct from N deficiency, which typically starts with the yellowing of the lower leaves and progresses upward.

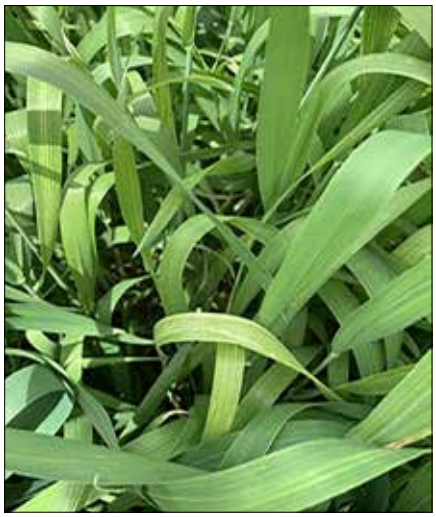


Typical symptoms of nitrogen (N) deficiency in rice

Typical symptoms of iron (Fe) deficiency in rice

***Zinc deficiency*:** In rice, Zn deficiency symptoms typically manifest 2–3 weeks after transplanting. Initially, the lower leaves of affected rice plants develop a rusty brown discoloration near the base, eventually leading to their desiccation. Seedlings suffering from zinc deficiency exhibit stunted growth and lack tillering. In severely degraded soils, Zn deficiency symptoms may still appear in localized patches despite the application of the prescribed Zn sulfate amount. Zinc deficiency in wheat is characterized by stunted and bushy growth, with leaves exhibiting chlorosis in the middle, eventually leading to leaf breakage and hanging.

Iron deficiency: Under conditions of water scarcity, chlorosis typically manifests in the youngest leaves of seedlings approximately two-three weeks after transplanting. This symptom of Fe deficiency in rice often leads to plant death and, in severe cases, can result in the complete failure of the crop.



Typical symptoms of manganese (Mn) deficiency in wheat

Manganese deficiency: In wheat, Mn deficiency commonly occurs in light soils subjected to intensive cropping, particularly in rice-wheat rotations. Symptoms typically manifest on the middle leaves as interveinal chlorosis, with light greyish-yellow to pinkish-brown or buff-colored specks of varying sizes concentrated mainly in the lower two-thirds of the leaf. Over time, these specks may merge, forming streaks or bands between the veins, which remain green. In cases of severe deficiency, the entire plant may die. The symptoms become most pronounced on the flag leaf during the ear formation stage.

Amelioration of nutrient deficiencies in wheat

For crops sown in *kallar* (salt-affected) soil, apply 25% more N than the recommended amount to compensate for the soil's specific conditions. Conversely, for crops sown after mid-December, reduce N application by 25% from the recommended dose to account for the reduced growth period and lower temperatures. If the full dose of urea has already been applied to the soil and the crop still exhibits signs of N deficiency, spraying 3% urea solution is advised. Ensure the spray is applied in a crosswise manner to thoroughly cover the entire crop.

In soils deficient in Mn, apply a foliar spray of 0.5% manganese sulfate solution (1.0 kg of manganese sulfate in 200 liters of water) 2 to 4 days before the first irrigation. Follow up with three additional sprays at weekly intervals on sunny days. Avoid growing durum wheat varieties in sandy soils, as these varieties are particularly susceptible to Mn deficiency. It is important to note that manganese sulfate is best applied as a foliar spray rather than a soil application, as soil application is not cost-effective.

Apply 25 kg of zinc sulfate (21%) per acre, which typically provides sufficient Zn for 2–3 years. Zinc deficiency can also be addressed through foliar spraying with a 0.5% zinc sulfate solution (21% Zn). To prepare this solution, dissolve 1 kg of zinc sulfate and 0.5 kg of unslaked lime in 200 liters of water. This mixture will cover one acre of wheat with a single application. For effective correction of Zn deficiency, two to three sprays at 15-day intervals are recommended.

In soils deficient in S, where P has been applied using DAP instead of single superphosphate, apply 250 kg of gypsum or 45 kg of bentonite-sulfur (90%) per ha before sowing to meet the sulfur requirements of the wheat crop. If the recommended gypsum dose was already applied to a previous groundnut crop, reduce the application to 125 kg/ha for the wheat crop. Additionally, gypsum can be applied to a standing crop if S deficiency symptoms are observed.

Amelioration of nutrient deficiencies in rice

To manage Zn deficiency, apply 25 kg of zinc sulfate heptahydrate (21%) or 16 kg of zinc sulfate monohydrate (33%) per acre during puddling if the previous crop in the field exhibited symptoms of Zn deficiency. If the deficiency is observed in the current crop, apply this quantity of zinc sulfate as soon as possible. In severely deteriorated soils, symptoms may still appear in patches despite the application of the recommended zinc sulfate dose. In such cases, broadcast 25 kg of zinc sulfate heptahydrate or 16 kg of zinc sulfate monohydrate per ha, mixed with an equal quantity of dry soil, over the affected patches.

To ameliorate Fe deficiency in rice, initiate abundant irrigations as soon as chlorosis is observed. Additionally, apply 2–3 foliar sprays of a 1% ferrous sulfate solution at weekly intervals, using 2.5 kg of ferrous sulfate dissolved in 250 liters of water per ha for each application.

SUMMARY

In conclusion, addressing nutrient deficiencies in the rice-wheat system is essential for sustaining agricultural productivity and environmental health. A complete understanding of the symptoms, causes, and solutions for nutrient imbalances enables effective soil and crop management, ensuring the long-term viability of this critical cropping system. By employing comprehensive nutrient management strategies, farmers can enhance soil fertility, boost crop yields, and advance sustainable agricultural practices.

A balanced approach to nutrient management ensures that the rice-wheat system continues to provide essential food resources while maintaining environmental health.

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