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Efficient nutrient management

technologies for increased rice productivity

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Efficient nutrient management is crucial for optimizing rice productivity, ensuring environmental sustainability and resource conservation. Over the years, several efficient nutrient management technologies have been designed to enhance rice productivity. The general recommended dose (GRD) of fertilizers serves as a foundational guideline for nutrient application, but its effectiveness is significantly improved when combined with site-specific practices. Soil test-based fertilizer application is a key technology that provides tailored nutrient solutions by analyzing soil conditions and deficiencies, thereby promoting precise and efficient fertilizer use. Integrated nutrient management (INM) further enhances productivity by integrating organic and inorganic fertilizers, improving soil health and structure, and fostering sustainable agricultural practices. The leaf colour chart (LCC) offers a practical tool for managing nitrogen (N) application by correlating leaf colour intensity with N levels, thereby optimizing fertilizer N use and reducing environmental impact. For salt-affected soils, which present unique challenges, strategies such as applying gypsum to alkaline soils and managing irrigation practices are vital to mitigate salinity impacts and improved soil fertility. These integrated approaches not only enhance nutrient uptake and rice yield, but also contribute to sustainable farming by reducing input costs and minimizing negative environmental effects.

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THE general recommended dose (GRD) of fertilizers provides a baseline for nutrient application in rice cultivation. Typically, the GRD includes a balanced application of essential nutrients, viz. nitrogen (N), phosphorus (P), and potassium (K) to support optimal plant growth. But the soils differ widely with respect to their physical and chemical properties depending upon the fertilizer management by the individual farmer and the parent material from which it is originated. Often, the fertilizer application practices of farmers are very faulty not only in the sense that they are applying either over or under fertilizer dose to their crops, but also their time and method of fertilizer application is very erratic. Even the uniform adoption of GRD, does not always ensures the economy and efficiency of applied fertilizer, because the variation in the soil fertility status is not taken into account. Therefore, the blanket application of fertilizer regardless of the soil fertility status and its properties might end up with overuse of chemical fertilizers in high fertility soils and vice versa. Further, it may also leads to additional financial burden due to the over application of a nutrient which in reality is required in low quantity and vice versa. This is the actual constraint in the efficient nutrient management, optimum plant growth and hence the crop production.

Table 1. Recommended fertilizer schedule for rice cultivation in medium fertile soils

Nutrient (kg/ha)			Fertilizers (kg/ha)			
N	P_2O_5#	K_2O#	Urea*	DAP**	SSP	MOP
105	30	30	225	67.5	187.5	50.0

* Make appropriate reductions for farm yard manure, green manures and pressmud

** When DAP is used, reduce urea dose by 25 kg

Apply only when soil test shows deficiency of these nutrients

Soil test recommended dose

Fertilizer application according to soil test results has been identified as one of the most credible option to ensure balanced nutrition to the crops. Soil test-based fertilizer application also promotes environmental sustainability by minimizing nutrient losses and reducing the impact on ecosystems. By analyzing soil samples for nutrient content and deficiencies, farmers can apply fertilizers in precise quantities that match the specific needs of their soil and crops. This targeted application reduces the risk of over-fertilization, improves nutrient uptake by plants, and enhances overall crop yield. Soil is categorized into low, medium and high category based on the soil test to recommend the dose for fertilizer application. In general, quantity of fertilizer is increased or decreased by 25% over GRD if the soil test falls into low or high category, respectively. Recommendation of N fertilizer is given on the basis of the soil organic carbon (SOC) content, because SOC is known to govern N availability in the soil system. In this contest, soils with SOC <0.40%, 0.40-0.75% and >0.75% are rated as low, medium and high N availability, respectively. Therefore, for soils with low or high category SOC needs 25% more or less N fertilizers, respectively over GRD.

In case of phosphorus, only 10–40% of the applied P through fertilizers is being utilized by the crops during the first crop growing season and rest remained un-utilized in the soil. Therefore, P fertilizers applied to crops are known to leave considerable residual effect on the succeeding crop. *Rabi* crops are known to respond more to P fertilizer application as compared to *kharif* crops. Therefore, it is recommended that fertilizer P should be applied to wheat and its application to the succeeding rice crop in a cropping sequence may be skipped. However, in soils testing low in available P (<12.5 kg/ha), it is recommended to apply 67.5 kg diammonium phosphate (DAP) per ha or 187.5 kg single super phosphate (SSP) per ha. Moreover, P fertilizer recommendations to the crops are made on the basis of available P content and SOC content. The P application is same as that of nitrogen.

Soil testing with available potassium (K) <138 kg/ha and >138 kg/ha are rated as low and sufficient K soils, respectively. In K deficient soils, rice requires 50 kg muriate of potash per hectare to meet its nutritional requirement.

Intensive cropping coupled with the use of high analysis macro-nutrient fertilizers over years has made soils deficient in micro-nutrients. Among micro-nutrients, zinc (Zn) and iron (Fe) are important nutrients affecting rice production. Soils testing DTPA extractable Zn and Fe less than 0.6 and 4.5 mg/kg are rated as Zn and Fe deficient, respectively. Since *kharif* crops are known to be more prone to Zn deficiency, it is recommended to apply zinc sulphate ($ZnSO_4$) to the *kharif* crops in a rice-wheat system. Zinc deficiency can be corrected by applying zinc sulphate ($ZnSO_4$) (with 21.5% Zn) @62.5 kg/ha or $ZnSO_4$ (with 33% Zn) @37.5 kg/ha. In contrast, Fe deficiency in rice can be combated efficiently with 3–4 foliar applications of 1.0 % solution of ferrous sulphate ($FeSO_4$) (with 20% Fe) at weekly intervals.

Integrated nutrient management (INM)

INM involves the combined use of organic and chemical fertilizers. The application of organic manures and green manures is generally recommended in *kharif* crops, as the high temperature and moisture are very conducive for their rapid decomposition in the soils and quicker release of plant nutrients. Application of 15 tonnes of well decomposed farm yard manure per hectare results in saving of 87 kg urea/ha. Likewise, green manuring 6–8 weeks old Dhaincha/sunhemp/cowpea one week before transplanting rice seedlings, helps in saving 137 kg urea/ha. Pressmud, a by-product of sugar industry applied @15 tonnes/ha helps in saving 137 kg urea/ha. Green manuring with Dhaincha should be suggested in *Kallar* and recently reclaimed soils.

N management in rice based on leaf colour chart (LCC)

LCC is a practical tool for N management in rice cultivation. LCC measures the colour intensity of rice leaves, which correlates with the N content and plant nutritional status. By monitoring leaf colour and adjusting N application based on LCC readings, farmers can achieve optimal N levels, enhance rice growth, and prevent both under- and over-fertilization. This method promotes efficient N use, reduces input costs, and minimizes environmental pollution from excess N. Apply 62.5 kg urea/ha as basal dose. After 14 days of transplanting, start matching the colour of the topmost fully exposed 10 leaves with the LCC at intervals of 7 days under shade of the body. Apply 62.5 kg of urea per hectare if the greenness of six or more leaves out of 10 is less than LCC shade 4. If the colour of the leaves is the same as or darker than LCC shade 4, then no urea should be applied and use

Table 2. P Fertilizer recommendations based on soil test and soil organic carbon (SOC)

Soil organic carbon (SOC; %)	Available P status (kg/ha)			
	Low (<12.5 kg/ha)	Medium (12.5–22.5 kg/ha)	High (22.5–50.0 kg/ha)	Very high (>50.0 kg/ha)
<0.40	25% higher than recommended*	Recommended	25% less than recommended	0
0.40–0.60	25% higher than recommended	25% less than recommended	50% less than recommended	0
>0.60	25% higher than recommended	50% less than recommended	0	0

* Recommended as in Table 1

of LCC should be discontinued after initiation of flowering and no more urea should be applied.

Nutrient management in salt-affected soils

Salt-affected soils present unique challenges for nutrient management in rice cultivation. High salinity can hinder nutrients' uptake, reduce crop yields and impact soil structure. To address these issues, adopting strategies such as integrating organic amendments to enhance soil fertility are essential. Additionally, managing irrigation practices to prevent salt accumulation and using soil conditioners can help mitigate the adverse effects and improve rice productivity in affected areas. Salt-affected soils need 25% more N than in normal soils, because they are low in SOC and the efficiency of N fertilizer in these soils is low. Apply the same amount of P as to the normal soils, but where the Dhaincha is grown for green manuring, and if recommended P has been applied to it, omit the application of P to the succeeding rice crop. In alkali (sodic) soils, Zn deficiency can be corrected by applying the same amount of $ZnSO_4$ as recommended for normal soils, but it is essential to apply the quantity of gypsum recommended on soil test basis before applying $ZnSO_4$. In the absence of gypsum, use efficiency of applied Zn fertilizer will be too low.

Optimum time and method of fertilizer application for efficient management

Timing and method of fertilizer application play a crucial role in enhancing nutrient efficiency and rice productivity. Fertilizers should be applied at critical growth stages to match the plant's nutrient requirements. For example, splitting N applications into multiple doses during key growth phases can significantly improve nutrient uptake and yield. Immobile plant nutrients, viz. P and K should always be applied before last puddling. However, N fertilizer should be applied in three equal splits, viz. at transplanting, three and six weeks after transplanting. If possible, apply the second and third split doses of urea when water is not standing in the field and irrigate the field on the third day of the application of N fertilizer.

Zinc may be applied by broadcast method at transplanting the crop, but where the deficiency is noticed in the growing crop, apply the recommended dose of $ZnSO_4$ as soon as possible. Soil application of $ZnSO_4$ is always better compared to its foliar application, as the soil applied $ZnSO_4$ not only supplies this nutrient to the crop to which it has applied, but also meets the Zn requirement of subsequent 2–3 crops. Since Fe applied to soil gets converted to unavailable forms, foliar application is an economical and efficient way to correct the deficiency. The sprays of $FeSO_4$ should be initiated immediately on appearance of deficiency symptoms.

SUMMARY

Efficient nutrient management is essential for maximizing rice productivity, while ensuring environmental sustainability. Technologies like soil test-based fertilizer application and the use of the LCC enable precise nutrient application, enhancing nutrient use efficiency and minimizing losses. Integrated nutrient management, which combines organic and inorganic inputs, improves soil health and crop yields. In salt-affected soils, practices such as gypsum application and improved irrigation methods help restore fertility. Together, these approaches promote sustainable rice farming by boosting productivity, reducing input costs, and mitigating environmental impact.

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