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Management of Nutrient Deficiencies in Direct Seeded Rice

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Direct seeding of rice refers to the process of establishing a rice crop from seeds sown in the field rather than by transplanting seedlings from the nursery. Direct seeding method of paddy cultivation usually results in certain nutrients deficiencies which are corrected by timely application of fertilizers.

Introduction

In Asia, rice is commonly grown by transplanting one month-old seedlings into puddled and continuously flooded soil (land preparation with wet tillage). Repeated puddling adversely affects soil physical properties by dismantling soil aggregates, reducing permeability in subsurface layers, and forming hard-pans at shallow depth all of which can negatively affect the following non-rice upland crop in rotation. Excessive pumping of water for puddling in peak summers in North West Indo-gangetic plain (IGP) causes decline in water table and poor quality water for irrigation. Whereas, in eastern IGP rice transplanting depends mainly on monsoonal rains; and dependency on ponded water for customary practice of puddling delays rice transplanting by one to three weeks. Therefore, farmers are changing either their rice establishment methods (from transplanting to direct seeding in puddle soil [Wet-DSR]) or tillage practices or both (puddle transplanting to dry direct seeding in unpuddled soil [Dry-DSR]).

Direct seeding avoids three basic operations, namely, puddling (a process where soil is compacted to reduce water seepage), transplanting and standing water. At present, 23%, 26% and 28% of rice is direct-seeded in world, in South Asia and in India, respectively (Rao et al., 2007). There are three principal methods of direct seeding of rice (DSR): dry seeding (sowing dry seeds into dry soil), wet seeding (sowing pre-germinated seeds on wet puddle soils) and water seeding (seeds sown into standing water). Wet-DSR is primarily done to manage the labour shortage but, with the elevating shortages of water, the incentive to develop and adopt dry-DSR has increased. Dry-DSR production is negligible in irrigated areas but is practiced traditionally in most Asian countries in rainfed upland ecosystems. In Asia, dry seeding is extensively practiced in rainfed lowlands, uplands, and flood-prone areas, while wet seeding remains a common practice in irrigated areas. Water seeding is widely practiced to manage weeds such as weedy rice, which are normally difficult to control.

Nutrient Deficiency Management

Land preparation and water management are the principal factors governing the nutrient dynamics in DSR. Since direct seeding follows aerobic cultivation of paddy, it usually results in different nutrient dynamics because in DSR prepared land remains dry and aerobic throughout the season. In direct seeding, availability of several nutrients including N, P, S and micronutrients such as Zn and Fe, is likely to be a constraint. In addition, loss of N due to nitrification, denitrification, volatilization, and leaching is likely to be higher in Dry-DSR than in conventional tilled-transplanted rice (CT-TPR). Micronutrient deficiencies are of concern in DSR – imbalances of such nutrients (e.g. Zn, Fe, Mn, S and N) result from improper and imbalanced N fertiliser application. General recommendations for NPK fertilizers are similar to those in puddled transplanted rice, except that a slightly higher dose of N (22.5-30 kg ha^{-1}) is suggested in DSR to compensate for the higher losses and lower availability of N from soil mineralization at the early stage as well as the longer duration of the crop in the main field in Dry-DSR. The general recommendation is to apply a full dose of P and K and one-third N as basal at the time of sowing. Split applications of N are necessary to maximize grain yield and to reduce N losses and increase N uptake. The remaining two-third dose of N should be applied in splits and topdressed in equal parts at active tillering and panicle initiation stage. To meet nutrient demand and to avoid nutritional deficiencies, fertilization schedule as mentioned below has been followed (Pepsico International 2011):

Days After Sowing	Fertilizer (in kg $acre^{-1}$)				
	Urea	DAP	MOP	Librel Zn	Librel Fe
At sowing	15	25	20	0.5	0.5
20	15-20	0	0	0	0
35	10-15	0	0	0	0

In addition, N can be managed using a leaf colour chart (LCC). Two options are recommended for applying fertilizer N using a LCC. In the fixed-time option, N is applied at a preset timing of active tillering and panicle initiation and the dose can be adjusted upward or downward based on leaf colour. In the real-time option, farmers monitor the colour of rice leaves at regular intervals of 7–10 days from early tillering (20 DAS) and N is applied whenever the colour is below a critical threshold value. For high-yielding inbreds and hybrids, N application should be based on a critical LCC value of 4, whereas, for basmati types, N should be applied at a critical value of 3. Slow-release (SRF) or controlled-release N fertilizers (CRFs) offer the advantage of a "one-shot dose" of N and because of their delayed release pattern may better match crop N demand to reduce its losses and labour cost. CRF improves N use efficiency and yield compared with untreated urea and due to these benefits CRF with polymer-coated urea is successfully used by Japanese farmers in ZT-dry-DSR. But due to four to eight times higher cost than that of conventional fertilizers, farmers' use of CRF is limited (Shaviv and Mikkelsen 1993). Apart from Nitrogen for P and K, it is better to use granular complex NPK mixtures for

LCC for assessing nitrogen dose (Pepsico International 2011) basal application. Most of the planters have problem with placements of powdery materials like MOP, moreover when urea is mixed with DAP in fertilizer box it absorbs moisture and creates problems in dropping resulting uneven distribution of fertilizers. Therefore urea should be broadcasted separately. Band or localized placement of water-soluble P fertilizers is more efficient than broadcast application of the same in powdered form, and sparingly soluble P fertilizers should be finely divided and not concentrated in localized placements. At the time of sowing application of 25 kg ha^{-1} DAP is very effective for better growth of crop. Split application of K has also been suggested for direct seeding in medium-textured soil. In these soils, K can be split, with 50% as basal and 50% at early panicle initiation stage. To overcome Sulphur deficiency, ground application of 2 kg/acre of Librel Sulphur needs to be done.

Zinc and Iron are another major deficiencies in DSR. At the time of sowing 0.5 kg of Librel Zinc and 0.5 kg of Librel Fe are drilled and the remaining fertilizers are broadcast for better nutrient management in DSR. After 30-35 days of sowing, Libmix @ 2 g per liter of water is sprayed. This helps to overcome the deficiencies of Zinc and Iron. Reasons for Zn deficiency in rice fields include low redox potential, high carbonate content and high pH. In aerobic soils, Fe oxidation by root released oxygen reduces rhizosphere soil pH and limits release of Zn from highly insoluble fractions for availability to the rice plant. Basal application of zinc to the soil is found to be the best and application of 25–50 kg ha^{-1} zinc sulphate is recommended to avoid its deficiency. However, if a basal application is missed, the deficiency can be corrected by topdressing up to 45 days. For foliar application, spray of 0.5% zinc sulphate two to three times at intervals of 7-15 days just after the appearance of deficiency symptoms is recommended. A pH below neutral in the rhizosphere increases solubility of P and Zn and hence their availability. The timing and source of Zn application may influence Zn uptake in DSR.

Under aerobic condition deficiency of Fe is more profounded due to oxidation of available ferrous form to unavailable ferric form in soil. For correction of iron deficiency, at the time of sowing 0.5 kg of Librel Fe are drilled into the soil and it has been observed that foliar application is superior to soil application (Anonymous 2010). Foliar-applied Fe is easily translocated acropetally and even retranslocated basipetally. A total of 9 kg Fe ha^{-1} in three splits (40, 60, and 75 DAS) as foliar application (3% of $FeSO_4.7H_2O$ solution) has been found to be effective (Pal et al., 2008). Iron sulphate applied under aerobic condition quickly oxidized into ferric forms (Fe^{3+}) that is not taken up by the crop.

Conclusion

DSR with suitable conservation practices has potential to produce slightly lower or comparable yields as that of TPR and appears to be a viable alternative to overcome the problem of labour and water shortage. Despite controversies, if properly managed, comparable yield may be obtained from DSR compared with TPR. This transition changes the mineral nutrients dynamics of soil; the availability of most microelements is reduced in DSR. On the research front much needs to be done on the nutrient dynamics in soils under DSR. Also, research is needed on soil ecology in rice soils. Under different rice production zones across the continents need to develop a site-specific package of production technologies for different rice production system.

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