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Integrated Nutrient Management in Paddy

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ABSTRACT: Rice (*Oryza sativa* L.) is a staple food for nearly half of the world's population. Being an agricultural commodity it is the third-highest worldwide produced commodity after sugarcane and maize. At present the current world population is 7.3 billion which is expected to reach 8.5 billion by 2030. As a result the global demand towards grain is projected to double but the challenge to achieve even higher rice production level still remains. In order to meet the global demand of the growing population, rice production must be substantially increased with the adoption of the concept of Integrated Nutrient Management (INM) which must be given topmost priority. Integrated nutrient management is the maintenance or adjustment of soil fertility, plant nutrient supply to an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources of plant nutrients in an integrated manner. This concept is of very much importance since it involves the use of inorganic fertilizers along with organic sources that are applied to soil for increasing the quality and yield of plants in a sustainable manner without harming the natural ecosystem. With the use of integrated nutrient management in rice it has increasingly improved the overall respondents on the grain crop which leads to maximum growth characteristics and yield attributes.

KEYWORDS: rice, integrated, nutrient, management, sustainable, organic

I. INTRODUCTION

Intensive rice cropping with short-duration high-yielding varieties along with increased use of mineral fertilisers and improved irrigation facilities have resulted in spectacular increases in crop productivity. This has, however, led to gradual replacement of organic manures as sources of plant nutrients. There has been a sharp increase in the prices of P and K fertilisers following withdrawal of subsidy, which has led to their decreased consumption by the farmers. The low purchasing power of the farming community and the issue of soil health have again renewed interest in organic recycling. Organic sources available for use in rice production include the bulky organic manures like FYM, quick growing leguminous shrubs grown in the cropping sequence, leguminous trees grown in alley formations and using their loppings as mulch materials, forage or food legumes properly inoculated with Rhizobia and grown in the sequence, blue green algae and *Azolla*. [1,2] Yield potential of both the crops in rice-based cropping systems can be realized by organic manuring of Kharif rice with the available sources along with mineral fertilization of both the crops in the acid lateritic soil conditions of eastern India. Highest yields of Kharif and Rabi rice were obtained with application of green manure and N application.

Long-term experiments have shown that neither organic sources nor mineral fertilisers alone can achieve sustainability in crop production. Continuous use of FYM is effective in stabilizing rice productivity under low to medium cropping intensity where the nutrient demand is relatively small. Nonetheless, integrated use of organic and mineral fertilisers has been found to be more effective in maintaining higher productivity and stability through correction of deficiencies of secondary and micronutrients in the course of mineralisation on one hand and favourable physical and soil ecological conditions on the other. Organic manuring also improves the physical and microbial conditions of soil and enhance fertiliser use efficiency when applied in conjunction with mineral fertilisers. Thus, all the major sources of plant nutrients such as soil, mineral, organic and biological should be utilised in an efficient and judicious manner for sustainable crop production in rice-rice cropping system.[3,4]

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Several studies have been conducted on the complementary use of organic and mineral fertilisers in cropping systems involving rice. Extensive field investigations in the acid lateritic soils at Kharagpur revealed that locally available organic materials such as chopped straw, FYM, water hyacinth compost, *Azolla* and green manure in situ with sunnhemp and dhaincha can substitute N fertilizer up to 50 per cent of the total crop requirement. In a study on fertilizer economy through organic manures in rice-rice cropping system, it was found that total produce with application of 90 kg N + 12 t FYM/ha to Kharif rice and 60 kg N/ha to Rabi rice was close to 120 kg N/ha +60 kg P₂O₅/ha to Kharif rice and 60 kg N/ha to Rabi rice. Annual dressing of 10-15t FYM/ha along with optimal NPK fertilisers enhanced rice yield over the optimal NPK dose by 25 and 20 percent in Kharif and Rabi season respectively under the lateritic soils of Bhubaneswar. [5,6] It was however more beneficial to apply the organic manure in the Kharif season because of its better decomposition and mineralisation of nutrients in soil. Further, the effect of FYM application was found to be comparable or even superior to lime amendment on the acidic soils which seemed mainly due to the formation of Al-organo-chellates, resulting in the reduction of Al concentration in soil solution to levels beneficial to plant growth. Similarly, in the red soils of Hyderabad, the average increase in rice yield due to NPK + FYM was 17-21 percent in both Kharif and Rabi seasons. These and other results suggest that substitution of 25-50 percent of the N through FYM in Kharif and application of 75-100 percent optimum level of NPK in the Rabi produced the highest yields of rice. The beneficial effect of organic manures in increasing nitrogen-use-efficiency was also evident, particularly in the Rabi season. Further application of NPK fertilisers [7,8] alone did not influence the yield of succeeding rice crop but the residual effect was observed with the incorporation of organic manure. The grain yield of Kharif rice was increased by 21-22 percent and 10-13 percent with the application of *Azolla* or wheat straw and FYM or water hyacinth compost, respectively. The residual effect of these sources on the succeeding Rabi rice showed a yield increase of 14-18 percent and 8-10 percent compared with the control. Further, the residual effect was more pronounced with integrated used of NPK fertilisers and organic manures. Therefore, integrated nutrient supply is important as a soil ameliorant in alleviating the adverse soil ecological conditions as in the case of acid lateritic soils and in improving soil fertility and productivity.[9,10]

Green manure of legume shrubs or tree loppings has been known to be beneficial for sustaining rice productivity. Sunnhemp and dhaincha are popular legumes for green manuring in rice and can accumulate up to 100 kg N/ha in 50-55 days. Incorporation of these green manures in situ before transplanting rice supplies about 45-60 kg N/ha, besides providing a significant residual effect to the succeeding crops. Fertilizer use efficiency is improved when a legume crop such as *Sesbania cannabina* or *Lathyrus sativus* is introduced in rice-rice cropping system. Adding loppings of leguminous trees like *Leucaena leucocephalla* and *Glyricidia naps* grown in alleys can also meet the crop N requirement substantially. The productivity of rice-rice cropping system can be increased by about 1 t/ha besides a net saving of 30 kg fertilizer N/ha by including a short-duration legume such as cowpea or greengram and incorporating its residues into the soil after harvesting the grains. Similarly, blue green algae culture in the rice field can contribute about 25 kg N/ha to the rice crop. [11,12] Algae multiply and cover the field like a carpet which when incorporated into the soil, decomposes and releases N for rice crop. *Azolla* can be grown in tanks or in rice fields and incorporated into the soil after 4-6 weeks. Nitrogen contribution through *Azolla* dual cropping with rice has been worked out to be about 25-30 kg N/ha. *Azolla* growth is generally poor without P fertilisation but a substantial improvement in growth and yield of rice is achieved when dual cropped *Azolla* is fertilized with P and incorporated into the soil at a later stage. An application of about 30 kg P₂O₅/ha is adequate for optimum growth of *Azolla*. The use of *Azolla* appears to be promising in the Rabi season when there is good water management and availability of other organic sources like FYM and green manures is limited.[13]

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II. DISCUSSION

Transplanted Puddled Lowland Rice

Seed treatment

- Treat the seeds in Carbendazim or Pyroquilon or Tricyclozole solution at 2 g/l of water for 1 kg of seeds. Soak the seeds in water for 10 hrs and drain excess water.
- This wet seed treatment gives protection to the seedlings up to 40 days from seedling disease such as blast and this method is better than dry seed treatment.
- If the seeds are required for sowing immediately, keep the soaked seed in gunny in dark and cover with extra gunnies and leave for 24hrs for sprouting.
- **Seed treatment with *Pseudomonas fluorescens***: Treat the seeds with talc based formulation of *Pseudomonas fluorescens* 10g/kg of seed and soak in 1lit of water overnight. Decant the excess water and allow the seeds to sprout for 24hrs and then sow.
- **Seed treatment with biofertilizers** : Five packets (1kg/ha) each of *Azospirillum* and Phosphobacteria or five packets (1kg/ha) of Azophos bioinoculants are mixed with sufficient water wherein the seeds are soaked overnight before sowing in the nursery bed (The bacterial suspension after decanting may be poured over the nursery area itself). Biocontrol agents are compatible with biofertilizers. Biofertilizers and biocontrol agents can be mixed together for seed soaking. Fungicides and biocontrol agents are incompatible.[14,15]

Nutrient management

- Apply 1 tonne of fully decomposed FYM or compost to 20 cents nursery and spread the manure uniformly on dry soil.
- Basal application of DAP is recommended when the seedlings are to be pulled out in 20-25 days after sowing in less fertile nursery soils.
- For that situation, before the last puddling, apply 40 kg of DAP and if not readily available, apply straight fertilizers 16 kg of urea and 120 kg of super phosphate.
- If seedlings are to be pulled out after 25 days, application of DAP is to be done 10 days prior to pulling out.
- For clayey soils where root snapping is a problem, 4 kg of gypsum and 1 kg of DAP/cent can be applied at 10 days after sowing.[16]

Main field

Nutrient management

Application of organic manures

- Apply 12.5 t of FYM or compost or green leaf manure @ 6.25 t/ha.
- If green manure is raised @ 50 kg seeds/ha *in situ*, incorporate it to a depth of 15 cm using a green manure trampler or tractor.
- In the place of green manure, press-mud / composted coir-pith can also be used.

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Stubble incorporation

- Apply 10 kg N/ha (22 kg urea) at the time of first puddling while incorporating the stubbles of previous crop to compensate immobilization of N by the stubbles.
- This may be done at least 10 days prior to planting of subsequent crop. This recommendation is more suitable for double crop wetlands, wherein, the second crop is transplanted in succession with short turn around period.

Biofertilizer application

- Broadcast 10 kg of soil based powdered BGA flakes at 10 DAT for the dry season crop. Maintain a thin film of water for multiplication.
- Raise Azolla as a dual crop by inoculating 250 kg/ha 3 to 5 DAT and then incorporate during weeding for the wet season crop.
- Mix 10 packets (2 kg/ha) each of *Azospirillum* and Phosphobacteria or 10 packets (2 kg/ha) of Azophos inoculants with 25 kg FYM and 25 kg of soil and broadcast the mixture uniformly in the main field before transplanting and
- *Pseudomonas fluorescens* (Pf 1) at 2.5 kg/ha mixed with 50 kg FYM and 25 kg of soil and broadcast the mixture uniformly before transplanting.[17,18]

Application of inorganic fertilizers

- Apply fertilizer nutrients as per STCR-IPNS recommendations for desired yield target (Appendix I) (or)
- N dose may be through Leaf Color Chart (LCC)*
- P & K may be through Site Specific Nutrition Management by Omission plot technique**

If the above recommendation are not able to be followed, adopt blanket recommendation as follows:

Nutrients	N	P2O5 (kg/ha)	K2O
Short duration varieties (dry season)			
a) Cauvery delta & Coimbatore tract	150	50	50
b) For other tracts	120	40	40
Medium and long duration varieties (wet season)			
Hybrid rice	175	60	60
Low N responsive cultivars (like Improved White Ponni)	75*	50	50

* For Ponni, N should be applied in three splits at AT, PI and H stages** in addition to GLM or FYM application.

**Phenological stages of rice (days after sowing)

Stages	Short (105)	Medium (135)	Long (150)
Active Tillering (AT)	35-40	50-55	55-60
Panicle Initiation (PI)	45-50	70-75	85-90
Heading (H)	70-75	100-105	115-120

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* N management through LCC

- Time of application is decided by LCC score
- Take observations from 14 DAT in transplanted rice or 21 DAS in direct seeded rice. Repeat the observations at weekly intervals up to heading
- Observe the leaf colour in the fully opened third leaf from the top as index leaf. Match the leaf color with the colours in the chart during morning hours (8-10 am). Take observation in 10 places.
- LCC critical value is 3.0 in low N response cultures like White Ponni and 4.0 in other cultivars and hybrids
- When 6/10 observations show less than the critical colour value, N can be applied as per the following recommendation : Application of 25 kg N ha⁻¹ (1 bag urea) at 7 DAT followed by N @ 40 kg ha⁻¹ each time for kuruvai/ short duration rice / 30 kg ha⁻¹ each time for medium & long duration rice as and when the leaf colour value falls below the critical value of 4 for varieties and hybrids and critical value of 3 for white ponni, monitored from 14 DAT.
- For aged seedlings : Basal application of 35 kg N per ha is recommended to avoid yield loss when seedlings aged 35 - 45 days are used for transplanting and the LCC based N management can be followed from 14 DAT.[19,20]

**Recommendation of P&K fertilizer rates based on SSNM approach for rice growing tracts of Tamil Nadu (other than Cauvery Delta)

Sl.No.	Location	Calibrated SSNM fertilizer dose (kg/ha)*	
		P ₂ O ₅	K ₂ O
1	Cauvery delta		
	(i) Old delta	35	50
	(ii) New delta	35	80
2	Coimbatore District		
	(i) General	30	40
	(ii) Annamalai block	30	80
3	Killikulam	30	50
4	Trichy	35	50
5	Ambasamudram	40	50
6	Bhavanisagar	20	25
7	Paiyur	25	45
8	Yethapur	30	45
9	Aruppukottai	20	30
10	Cuddalore	30	50

** The above SSNM based fertilizer P and K arrived based on yield response are recommended for specific soil series prevailing in different rice growing areas for adoption by farmers

Split application of N and K

- Apply N and K in four equal splits viz., basal, tillering, panicle initiation and heading stages. Tillering and Panicle initiation periods are crucial and should not be reduced with the recommended quantity.
- N management through LCC may be adopted wherever chart is available

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III. RESULTS

Application of P fertilizer

- P may be applied as basal and incorporated.
- When the green manure is applied, rock phosphate can be used as a cheap source of P fertilizer. If rock phosphate is applied, the succeeding rice crop need not be supplied with P. Application of rock phosphate + single super phosphate or DAP mixed in different proportions (75:25 or 50:50) is equally effective as SSP or DAP alone.[21,22]

Application of zinc sulphate

- Apply 25 kg of zinc sulphate/ha mixed with 50 kg dry sand or apply 25 kg of TNAU Wetland rice MN mixture/ha enriched in FYM at 1:10 ratio incubated for 30 days at friable moisture, just before transplanting.
- It is enough to apply 12.5 kg zinc sulphate /ha, if green manure (6.25 t/ha) or enriched FYM, is applied.
- If deficiency symptom appears in the standing crop, foliar application of 0.5% zinc sulphate + 1.0% urea can be given at 15 days interval until the Zn deficiency symptoms disappear.

Application of gypsum

Apply 500 kg of gypsum/ha (as source of Ca and S nutrients) at last ploughing.

Foliar nutrition

Foliar spray of 1% urea + 2% DAP + 1% KCl at Panicle Initiation (PI) and 10 days later for all varieties.

Neem treated urea and coal-tar treated urea

Blend the urea with crushed neem seed or neem cake 20% by weight. Powder neem cake to pass through 2mm sieve before mixing with urea. Keep it overnight before use (or) urea can be mixed with gypsum in 1:3 ratios, or urea can be mixed with gypsum and neem cake at 5:4:1 ratio to increase the nitrogen use efficiency. For treating 100 kg urea, take one kg coal-tar and 1.5 litres of kerosene. Melt coal-tar over a low flame and dissolve it in kerosene. Mix urea with the solution thoroughly in a plastic container, using a stick. Allow it to dry in shade on a polythene sheet. This can be stored for a month and applied basally.[23]

N management through LCC

For sodic soil

In the case of sodic soils, LCC critical value is 4.0 for varieties and 5.0 for the hybrids.

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Other special cultural practices (Contingent Plan)

Application of Pink Pigmented Facultative Methylophilic (Methylobacterium sp.) as seed treatment (@ 200 g / 10 kg seeds), soil application (@ 2 kg / ha) and foliar spray (@ 500 ml / ha) at panicle initiation and flag leaf stages for alleviation of water stress effects in both SRI and transplanted system of rice cultivation.

Transplanted Hybrid Rice

Fertilizer 175:60:60 kg N, P₂O₅ and K₂O/ha

Other nutrient management practices: same as in transplanted rice variety

System of Rice Intensification

Mat nursery preparation

Preparation of soil mixture: Four (4) m³ of soil mix is needed for each 100 m² of nursery. Mix 70% soil + 20% well-decomposed pressmud / bio-gas slurry / FYM + 10% rice hull. Incorporate 1.5 kg of powdered DAP or 2 kg 17-17-17 NPK fertilizer in the soil mixture.

Seed Treatment with biofertilizers: Five packets (1 kg/ha) of Azospirillum and five packets (1kg/ha) of Phosphobacteria or five packets (1 kg/ha) of Azophos. Biofertilizers are mixed with water used for soaking and kept for 4 hrs. The bacterial suspension after draining may be sprinkled in the nursery before sowing the treated seeds

Pre-germinating the seeds 2 days before sowing: Soak the seeds for 24 hr, drain and incubate the soaked seeds for 24 hr, sow when the seeds sprout and radical (seed root) grows to 2-3 mm long.

Soil application of biofertilizers : Application of Azospirillum @ 2 kg and Arbuscular mycorrhizal fungi @ 5 kg for 100 m² nursery area[24]



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Spraying fertilizer solution(optional): If seedling growth is slow, sprinkle 0.5% urea + 0.5% zinc sulphate solution at 8-10 DAS.



Spraying fertilizer solution
(Sprinkle 0.5% urea + 0.5% zinc sulphate solution at 8-10 DAS)

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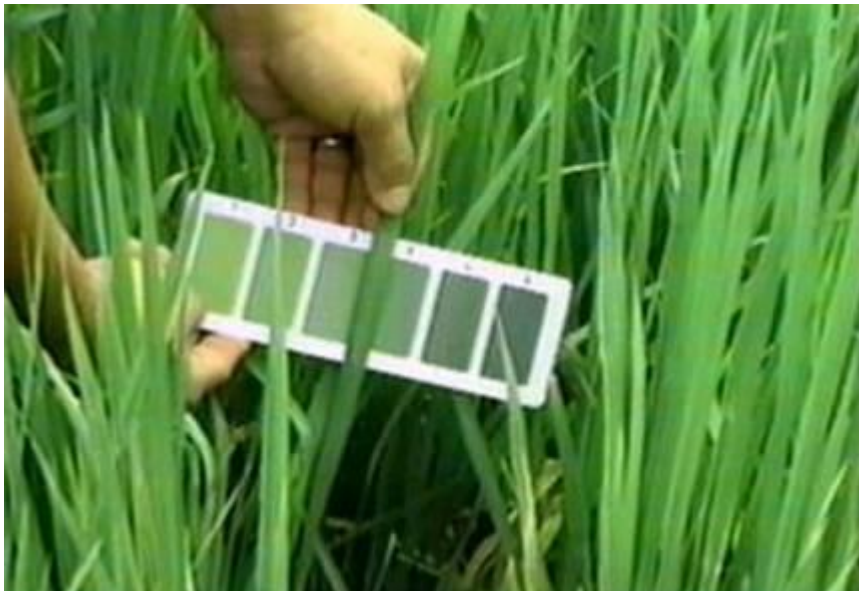
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Main field

Nutrient management

- As per transplanted rice.
- Use of LCC has more advantage in N management.
- Green manure and farm yard manure application will enhance the growth and yield of rice in this system approach.
- Under sodic soils, during rotary weeding, apply Azophosmet @ 2.2 kg/ha and PPFM as foliar spray @ 500 ml/ha[25]



LCC N Management

Wet Seeded Puddled Lowland Rice

Manures and fertilizer application

- For direct wet seeded lowland rice, the recommendation is same at that of transplanted rice. Apply N and K as 25% each at 21 DAS, at active tillering, PI and heading stages.
- If N applied through LCC, use the critical value 4 for line sown drill seeded rice.
- Entire P as basal applied in the last plough or at the time of incorporation of green manure/ compost.
- Biofertilizers as recommended to transplanted rice may be followed wherever feasible and moisture available.
- Micro nutrient, foliar application and biofertilizers as recommended to transplanted rice.[26]

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IV. CONCLUSION



Incorporation of green manure

Dry Seeded Rainfed Un-Puddled Lowland Rice

Manures and fertilizer application

- Blanket recommendation : 50:25:25 kg N:P₂O₅:K₂O /ha
- Apply a basal dose of 750 kg of FYM enriched with fertilizer phosphorus (P at 25 kg/ha) Apply N and K in two equal splits at 20 - 25 and 40 - 45 days after germination.
- If the moisture availability from the tillering phase is substantial, three splits (25 kg N and 12.5 kg K at 20-25, 40-45 and 60-65 DAG) can be adopted.
- N at PI may be enhanced to 40 kg, if the tiller production is high (may be when the estimated LAI is greater than 5.0) and moisture availability ensured by standing water for 10 days.
- Basal application of FeSO₄ at 50 kg/ha is desirable for iron deficient soil (or) apply TNAU
- Rainfed rice MN mixture @ 12.5 kg/ha as EFYM at 1:10 ratio incubated for 30 days at friable moisture.
- Need based foliar application of 0.5% ZnSO₄ and 1% FeSO₄ may be taken up at tillering and PI stages.
- Foliar spray of 1% urea + 2% DAP + 1% KCl at PI and 10 days later may be taken up for enhancing the rice yield if sufficient soil moisture is ensured.[24]

Dry Seeded Rainfed Un-Puddled Lowland Rice With Supplemental Irrigation

Manures and fertilizer application

- Blanket recommendation : 75:25:37.5 kg N:P₂O₅:K₂O /ha

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- Apply a basal dose of 750 kg of FYM enriched with fertilizer phosphorus (P at 25 kg/ha) Apply N & K in three splits at 20-25, 40-45 and 60-65 days after germination.
- Each split may follow 25kg N and 12.5 kg K₂O.
- If the moisture availability is substantial, split application at panicle initiation may be done with 40 kg N and 12.5 kg K₂O.
- If the moisture availability is substantial, the split at 40-45 DAS (panicle initiation) may be applied up to 40kg N and 12.5kg K₂O to enhance the growth and the grain yield.
- Basal application of ZnSO₄ at 25kg/ha and FeSO₄ at 50/ha is desirable wherever zinc and
- iron deficiency were noted (or) apply TNAU Rainfed rice MN mixture @12.5 kg/ha as EFYM at 1:10 ratio incubated for 30 days at friable moisture.
- Need based foliar application of 0.5% ZnSO₄ and 1% FeSO₄ may be taken up at tillering and PI stages.
- Foliar spray of 1% urea + 2% DAP + 1% KCl at PI and 10 days later may be taken up for enhancing the rice yield if sufficient soil moisture is ensured.

Dry Seeded Irrigated Un-Puddled Lowland Rice

Manures and fertilizer application

- Apply FYM/compost at 12.5 t/ha or 750 kg of FYM enriched with 50 kg P₂O₅ as basal dose in clay soils of Nagapattinam / Tiruvarur district.
- Blanket recommendation : 75:50:37.5 kg N:P₂O₅:K₂O /ha
- N and K in three splits at around 20-25, 40-45 and 60-65 days for short duration varieties or four splits for medium duration varieties at around 20-25, 40-45, 60-65 and 80-85 days after germination is suitable.
- Each split may follow 25kg N and 12.5 kg K₂O.
- If the moisture availability is substantial and canal water received from tillering phases itself, the split at panicle initiation (40-45 DAS in short duration and 60-65 DAS in medium duration) may be applied up to 40kg N and 12.5kg K₂O to enhance the growth and the grain yield.
- To induce tolerance under short and prolonged drought situation in Kuruvai season, apart from seed treatment, foliar spray with 1% KCl + CCC at 500ppm during vegetative stage is effective in mitigating the drought and in increasing the yield.
- Basal application of ZnSO₄ at 25 kg/ha and FeSO₄ at 50 kg/ha is desirable wherever zinc and iron deficiency were noted (or) apply TNAU Rainfed rice MN mixture @12.5 kg/ha as EFYM at 1:10 ratio incubated for 30 days at friable moisture.[25]
- Need based foliar application of 0.5% ZnSO₄ and 1% FeSO₄ may be taken up at tillering and PI stages
- Foliar spray of 1% urea + 2% DAP + 1% KCl at PI and 10 days later may be taken up for enhancing the rice yield if sufficient soil moisture is ensured.

Rice Seed Production

Blanket fertilizer recommendation

Short duration : NPK @ 120:40:40 kg ha⁻¹
Medium duration : NPK @ 150:50:60 kg ha⁻¹
Long duration : NPK @ 150:50:80 kg ha⁻¹

Zinc deficient soils

Apply ZnSO₄ @ 25 kg ha⁻¹

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Foliar application

- DAP 2% or 0.5% NutriGold (organic growth promotor) at boot leaf stage and at 5-10% flowering.
- Spray with 3% cowpea sprout extract at vegetative and flowering stage.

Hybrid seed production Techniques (ADTRH 1 and CORH 2)

Fertilizer application

150 : 60 : 60 kg NPK / ha. N and K applied in 3 split doses *viz.*, basal, active tillering and panicle initiation.

Foliar spray

- Spray DAP 2% at boot leaf stage and at 5-10% flowering (or)
- Spray 0.5% NutriGold (organic growth promotor) at boot leaf stage and at 5-10% flowering (or)
- Spray 3 % cowpea sprout extract at boot leaf stage and at 5-10% flowering.[26]

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