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EVALUATION OF NITROGEN MANAGEMENT PRACTICES IN LATE SOWN RICE VARIETIES UNDER SEMI-ARID CONDITIONS

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ABSTRACT

The trial was carried out during *kharif* 2021 at the ICAR-Indian Institute of Rice Research farm, Rajendranagar, Hyderabad. Late sowing of rice often leads to reduced nitrogen use efficiency, primarily because nitrogen fertilizer is applied in excess and at growth stages when crop demand is low, which increases nutrient losses and ultimately lowers productivity. Therefore, improving nitrogen use efficiency through appropriate nitrogen management practices is essential for sustaining rice productivity and minimizing environmental losses. To address this issue, the study was laid out in a split-plot design with three replications. Three short-duration rice varieties DRR Dhan-44, MTU 1010 and MTU 1156 were assigned to the main plots, while four nitrogen management practices were allotted to the sub-plots: recommended dose of nitrogen (RDN) at 120 kg N ha^{-1}, silicon-coated urea at 90 kg N ha^{-1}, Leaf Colour Chart (LCC)-based nitrogen application at 105 kg N ha^{-1}, and Soil Test Crop Response (STCR)-based nitrogen application at 114.5 kg N ha^{-1}. Among the varieties, MTU 1156 recorded the highest available soil nutrients, with nitrogen (245 kg ha^{-1}), phosphorus (36.9 kg ha^{-1}) and potassium (279 kg ha^{-1}), followed by DRR Dhan-44 and MTU 1010. Among nitrogen management practices, LCC-based nitrogen application at 105 kg N ha^{-1} resulted in the highest available soil nitrogen, phosphorus, and potassium, followed by STCR-based application and RDN, while the lowest values were observed with silicon-coated urea at 90 kg N ha^{-1}.

***Key words*:** STCR, LCC, nutrient use efficiency, late sown short duration rice, silicon-coated slow release urea

Introduction

Rice (*Oryza sativa* L.) stands as a fundamental sustenance for over half the global population. India is the global second-highest producer of rice and contributes about 20 per cent of global rice production (FAO 2019). In Andhra Pradesh, rice is the major staple food crop and is mainly grown under irrigated conditions during both seasons (*Kharif* and *Rabi*). The impacts of global warming and erratic weather patterns result in unpredictable monsoon rainfall, leading to delayed rice sowing, particularly in *Kharif* season across Andhra Pradesh. Farmers who plant long-duration rice varieties late often find themselves at the mercy of cyclones and intense depressions. Most rice cultivars die within a week of complete submergence a major constraint to rice production in the South and Southeast that causes annual losses of over US$1 billion, mainly affecting the poorest farmers (Sarangi *et al.*, 2020) Thus, there is a pressing necessity to introduce short-duration rice varieties in these regions, allowing them to evade such extreme climatic upheavals. Late sowing may result in diminished spikelet counts and reduced nitrogen use efficiency due to misaligned growth periods with available light and temperature. Nevertheless, elevating nitrogen rates and increasing seedling density can alleviate these repercussions (Yuan *et al.*, 2022). A significant factor contributing to low nitrogen use efficiency in rice is the excessive application of nitrogen fertilizers, frequently

disregarding the crop's growth stage, which leads to nutrient waste and ecological harm. Constraining nitrogen during pivotal growth periods can result in considerable yield decreases, as rice necessitates sufficient nitrogen for optimal growth and development (Legesse *et al.*, 2023). Current nitrogen fertilizer recommendations for rice use fixed application rates and timings over large cultivation areas, without considering differences in soil nitrogen availability across fields. In addition to variation between fields, changes in crop growth over time also influence the nitrogen requirement of the crop. Recently, by optimize nitrogen application has led to enhanced crop yields and diminished environmental repercussions through more efficient nutrient utilization (Subedi and Panta, 2018). Recently, by knowing the initial soil nitrogen status with (STCR) and with the help of Leaf Color Chart (LCC) real-time N management strategies have been developed for rice. The objective of this research work is to determine the Nitrogen Use Efficiency (NUE) and economic feasibility (cost-benefit ratio) of different nitrogen application methods. "In late-sown rice under semi-arid conditions, the adoption of short-duration and stress-tolerant varieties like MTU 1156 and DRR Dhan-44 with precision nitrogen management practices such as Leaf Colour Chart (LCC) or Soil Test Crop Response (STCR) is an alternative sustainable approach to the conventional blanket application of nitrogen (RDN). This integration is expected to mitigate the adverse effects of terminal heat and moisture stress, leading to improved growth parameters, higher grain yield and enhanced nitrogen use efficiency. Furthermore, the use of silicon-based slow-release urea may alleviate drought stress and sustain soil health, ultimately resulting in better productivity of late-sown rice compared to traditional varieties and nitrogen management practices.

Materials and Methods

The experiment was conducted during *Kharif* 2021 at the Indian Institute of Rice Research (IIRR) farm, Rajendranagar, Hyderabad, which lies in the Southern Telangana agro-climatic zone under semi-arid conditions. The experimental soil was clay loam in texture, non-saline in nature, and low in available nitrogen (250 kg ha^{-1}). The trial was laid out in a split-plot design with three replications. Three short-duration rice varieties-DRR Dhan-44, MTU 1010, and MTU 1156-were assigned to the main plots, while four nitrogen management levels were allotted to the sub-plots, including Soil Test Crop Response (STCR) based nitrogen application at 114.5 kg N ha^{-1} with a target yield of 6 t ha^{-1}. All rice varieties had a duration of about 120 days, were sown in the first week of August 2021, and harvested on 18 December 2021. Nitrogen was applied at tillering, panicle initiation and flowering stage. LCC observations were taken at weekly interval beginning at 14 days post-transplanting to 50% flowering stage (Bhat *et al.*, 2022). Spraying of Chlorpyriphos 1.6 ml L^{-1} and carbofuran granules 7.5 kg ha^{-1} cartap hydrochloride 50% SP @ 2g L^{-1} for the control of leaf folder and yellow stem borer respectively.

Results and Discussion

In Fig 1. among the diverse varieties evaluated, nitrogen uptake (23.6 kg N ha^{-1}), 36.3 kg N ha^{-1}, 54.5 kg N ha^{-1}, and 70.6 (grain), 45.5 (straw) kg N ha^{-1}, at active tillering, panicle initiation and flowering stage of rice crop respectively, was achieved by MTU 1156, it was followed by by DRR Dhan-44. The effect of adding nitrogen to rice crop is not always the same, it differs between different rice varieties and also between different growing seasons was given by Jahan *et al.*, (2020). In the realm of nitrogen management practices, at the active tillering phase, a rate of RDN @ 120 kg N ha^{-1} yielded the most significant nitrogen uptake (24.5 kg ha^{-1}). However, the application of nitrogen fertilizer (Fig 2.) guided by LCC @ 105 kg N ha^{-1} resulted in higher nitrogen uptake (36.9 kg ha^{-1}), (56.0 kg ha^{-1}), (72.0 kg ha^{-1}) grain and (46.6 kg ha^{-1}) straw at the respective stages of panicle initiation, flowering and harvest. Similar findings were documented by Bhavana *et al.*, (2020), where higher nitrogen uptake in grain was attributed to enhanced nitrogen availability, and superior translocation of accessible nitrogen, ultimately increases grain yield and increased biomass production. Various rice varieties display distinct nitrogen use efficiencies, with select varieties thriving under low nitrogen conditions due to their superior nitrogen uptake and utilization capabilities (more extensive and deeper root systems, enabling greater soil volume exploration and presence of high-affinity nitrogen transporters or low-nitrogen-availability-specific regulators of primary and lateral root growth) as reported by Tantray *et al.*, 2022; Liu *et al.*, 2023).

Among the diverse varieties (Table 1), MTU 1156 emerged as the best, boasting an impressive post-harvest

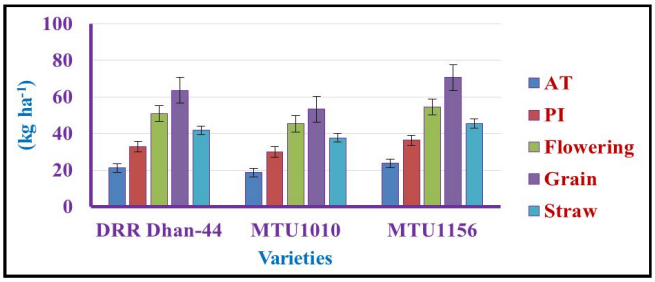


Fig.1: Nitrogen uptake (kg ha^{-1}) of short duration rice varieties at different growth stages of rice (AT- Active tillering, PI- Panicle initiation).

Table 1: Post-harvest soil's nitrogen, phosphorus, and potassium availability status as influenced by short duration rice varieties and nitrogen management practices.

Treatments	Available Nitrogen (kg ha^{-1})	Available Phosphorus (kg ha^{-1})	Available Potassium (kg ha^{-1})	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	B-C ratio
Initial soil status	250	34	265.5			
Varieties						
M_1: DRR Dhan-44	241.1	34.6	273.3	5314	6636	2.4
M_2: MTU 1010	232.0	34.4	266.0	4856	6054	2.1
M_3: MTU 1156	245.7	36.9	277.9	5707	7102	2.63
SEm(±)	3.8	0.6	3.3	96.7	116	0.05
CD (P=0.05)	11.4	1.9	NS	379	456	0.20
CV (%)	5.1	5.2	5.1	6.3	6.1	7.4
Nitrogen management practices						
S_1: RDN @ 120 kg N	242.6	35.4	279.7	5478	6778	2.49
S_2: Silicon coated urea @ 90 kg N	231.3	34.3	265.3	4731	5967	1.99
S_3: Leaf colour chart @ 105 kg N	248.5	36.3	275.3	5758	7112	2.66
S_4: Soil test crop response @ 114.5 kg N	235.8	35.4	269.3	5203	6530	2.30
SEm(±)	3.6	0.6	3.1	127	147.8	0.06
CD (P=0.05)	10.8	1.7	NS	378	439	0.21
CV (%)	5.6	8.3	4.6	7.2	6.7	9.2

soil nitrogen level of 245.7 kg N ha^{-1} as compared to rest of the varieties however it was on par with DRR Dhan-44 have the available soil nitrogen about 241.1 kg N ha^{-1}. The least available soil nitrogen (232.0 kg N ha^{-1}) was claimed with MTU 1010. These findings harmonized with the results of Saha *et al.*, (2018), reported that due to vigorous plant growth and also due to synchronize supply of nutrients throughout the growth stages of rice. In nitrogen management strategies, LCC@105 kg N ha^{-1} achieved peak in post-harvest soil available nitrogen, reaching 248.5 kg ha^{-1}, as compared to other nitrogen management techniques, although it was comparable to the RDN at 120 kg N ha^{-1} plots, which recorded 242.6 kg N ha^{-1}. Real-time nitrogen management, driven by LCC, proved to be a best practice in boosting nitrogen use efficiency for irrigated short-duration rice due to LCC boosts NUE is its ability to synchronize nitrogen supply precisely with crop demand. The synchronization between crop demand and nitrogen supply is the most important aspect of increasing nitrogen use efficiency and reduced nitrogen losses as evidenced by Valinejad *et al.*, (2021).

Among the varieties, the MTU 1156 plots notably recorded higher post-harvest available soil phosphorus level of 36.9 kg ha^{-1} and potassium at 277.9 kg ha^{-1}, and the lowest post-harvest soil available phosphorus (34.4 kg ha^{-1}) and potassium (266.0 kg ha^{-1}) was observed in fields sown with MTU 1010. The co-application significantly bolsters growth, grain yield, and nitrogen use efficiency, underscoring the critical role of balanced fertilization for achieving optimal rice production, as noted by Hou *et al.*, (2019). Among the nitrogen management methods, the plots treated with LCC at 105 kg N ha^{-1} showed the highest post-harvest available soil phosphorus (36.3 kg ha^{-1}) and potassium (275.3 kg ha^{-1}), which experienced a notable increase in contrast to alternative N management practices. (Table 1) LCC-driven nitrogen management remarkably enhances the uptake of nitrogen, phosphorus, and potassium, facilitating elevated yields in crops such as rice and wheat in comparison to conventional methods, as reported by Phulara *et al.*, (2022).

In the realm of short-duration rice cultivars, MTU 1156 has notably achieved the highest grain yield of 5707 kg ha^{-1}. Following closely, DRR Dhan-44 secured the second highest grain yield at 5314 kg ha^{-1}, aligning with the findings of Mohapatra *et al.*, (2021). Varieties that

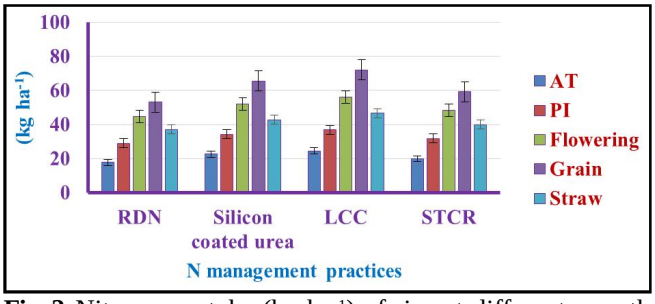


Fig. 2: Nitrogen uptake (kg ha^{-1}) of rice at different growth stages as influenced by nitrogen management practices (AT- Active tillering, PI- Panicle initiation, RDN- Recommended dose of nitrogen, LCC- Leaf colour chart, STCR-Soil test crop response).

generate a greater quantity of tillers per square meter tend to yield more seeds, as noted by Nayaka *et al.*, (2021). Among the practices for managing nitrogen, LCC at 105 kg N ha^{-1} yielded the maximum grain harvest of 5758 kg ha^{-1}, closely matched by RDN at 120 kg N ha^{-1}, which produced 5478 kg ha^{-1}. STCR at 114.5 kg N ha^{-1} resulted in a grain yield of 5203 kg ha^{-1}, comparable to the outcomes of RDN at 120 kg N ha^{-1}. (Table 1). The efficacy of LCC is amplified by its capacity to deliver precise and timely nitrogen management, thus enhancing nitrogen use efficiency and yield. LCC-focused nitrogen management boosts NUE by administering nitrogen only when the leaf signals deficiency, resulting in diminished nitrogen application while maintaining yield integrity (Bhat *et al.*, 2022).

Among the diverse rice varieties, MTU 1156 has achieved the pinnacle of straw yield with a remarkable 7102 kg ha^{-1} (Table 1). The elevated straw yield of MTU 1156 could be attributed to its superior tillering potential, heightened responsiveness to nitrogen application, and exceptional nitrogen utilization efficiency (Chandra and Kumar, 2020). In terms of nitrogen management strategies, LCC at 105 kg N ha^{-1} recorded highest straw yield of 7112 kg ha^{-1}, though closely rivaled by RDN at 120 kg N ha^{-1}, which yielded 6778 kg ha^{-1}. STCR at 114.5 kg N ha^{-1} yielded a straw production of 6530 kg ha^{-1}, significantly eclipsing the performance of silicon-coated urea at 90 kg N ha^{-1}, which only reached 5967 kg ha^{-1}. Enhanced growth metrics such as leaf area index, tiller density per square meter, and elevated nitrogen uptake during the critical active tillering and panicle initiation phases culminate in superior straw yield (Ma *et al.*, 2023).

With respect to B-C ratio among the varieties, the highest B-C ratio (2.63) was recorded in MTU 1156 which was significantly superior over rest of the varieties. (Table 1) DRR Dhan-44 recorded B-C ratio of 2.4. The lowest B-C ratio was found in MTU 1010 with 2.1. Among the nitrogen management practices, LCC @ 105 kg N ha^{-1} fetched the highest B-C ratio of 2.66. RDN @ 120 kg N ha^{-1} resulted in B-C ratio of 2.49 and was followed by STCR @ 114.5 kg N ha^{-1} (B-C ratio of 2.30). The lowest was found with silicon coated urea @ 90 kg N ha^{-1} with B-C ratio of 1.98.

The higher benefit to cost ratio were realized due to higher grain and dry matter yields (Mohapatra *et al.*, 2021). The variation in benefit cost ratio may be attributed to the variation in the price of agri inputs and support price of produce (Mangaraj *et al.* 2021). Among the nitrogen management practices, LCC @ 105 kg N ha^{-1} recorded the highest B-C ratio. This might be due to higher grain and straw yield as compared to other N management practices. Economics indicated a higher B-C ratio for LCC-3 than with RDN (Amareshappa and Basavanneppa 2019) and with increase in LCC from 3.5 to 5.0 increased the net returns, however further increase to 5.5 did not show any beneficial effect. The benefit cost ratio was higher at LCC 4.5 but, on par with LCC 5.0. (Duttarganvi 2011) and little input cost was incurred due to real time nitrogen management. In LCC based N management nitrogen use efficiency was increased by increasing the number of split doses of nitrogen and it lead to increase in grain and straw yield thereby increasing net returns and benefit coat ratio (Mathukia *et al.*, 2014).

Conclusion

It is concluded that MTU 1156 exhibited the highest uptake of nitrogen, phosphorus and potassium, alongside the most abundant available soil NPK compared to other varieties under late sown conditions. Among all the nitrogen management methods, using the Leaf Colour Chart (LCC) to apply nitrogen at 105 kg N per hectare resulted in the highest uptake of nitrogen, phosphorus and potassium as well as in the soil after harvest. Even though the amount of nitrogen applied through LCC was lower than the recommended dose of 120 kg N per hectare, it worked more effectively. This is because LCC allows for real-time nitrogen application based on the crop's actual need. As a result, the crop was better able to handle climate disturbances, such as cyclones, and utilized the nutrients more efficiently.

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