D-5822
[1-9]

RESEARCH ARTICLE Agricultural Science Digest

Influence of Precision Nutrient Management on Dry Matter Accumulation and Partitioning of Rice in Southern Odisha

Lalichetti Sagar[1], Sagar Maitra[1], Sultan Singh[2], Masina Sairam[1]

10.18805/ag.D-5822

ABSTRACT

Background: The nutrient management practices are largely known to influence dry matter accumulation and translocation in rice. However, the role of precision nutrient management in dry matter partitioning to the reproductive parts of rice is still unexplored.

Methods: The present trial was conducted during *boro* season of 2021-22 at PG Experimental Farm, MSSSoA, CUTM, Odisha. The experiment was laid out in randomized block design with 11treatments that were replicated thrice. The treatments examined under the investigation were namely, absolute control, 75% recommended dose of fertilizer (RDF), 100% RDF, 125% RDF, 75% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation, 100% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation, leaf colour chart (LCC) 3 based nitrogen management, LCC 4 based nitrogen management, sufficiency Index (SI)-based N management at a threshold value less than 90%, Nutrient expert (NE) based nutrient recommendation, Rice crop manager (RCM) based nutrient recommendation.

Result: The results of the study indicated that SI-based N management at a threshold value less than 90% results in highest allocation, shoot dry matter to the panicle (53.46%); while, absolute control of nutrients resulted in highest percentage allocation of shoot dry matter to culm (23.72%) and leaves (33.88%) during maturity.

Key words: Leaf colour chart, Nano urea, Nutrient expert, Rice crop manager, Sufficiency index.

INTRODUCTION

The availability of nutrients, particularly nitrogen (N), phosphorus (P) and potassium (K), plays a crucial role in determining the productivity of rice (Shankar *et al*., 2022). Over the past fifty years, there has been a significant increase in the application of N, P and K fertilizers but the rice crop's response to these added fertilizers has been diminishing (Shenoy, 2020). Inefficient utilization of N, P and K fertilizers not only reduces rice yield but also contributes to significant environmental pollution (Singh and Sapkota, 2022). As rice serves as the primary staple food crop for over half of the global population, the declining productivity of rice poses a critical challenge to food security (Mohanta *et al*., 2021). Given the current situation, precision nutrient management has emerged as a promising alternative. This approach utilizes optical sensors or decision support tools to tailor fertilizer recommendations according to specific rice varieties and the agro-climatic conditions of a particular region.

Enhancing the longevity of leaf greenness during the grain filling stage is expected to improve the allocation of biomass towards the reproductive structures of rice plants (Kamal *et al*., 2019). This is crucial because photosynthesis during the grain-filling period contributes significantly, around 60 to 80%, to the final carbon content of the grains. The remaining carbon content comes from stored carbohydrates in the leaf sheaths and culms that were deposited before flowering (Yoshida, 1981). The availability of nutrients, particularly nitrogen, plays a significant role in determining the greenness of rice leaves, especially under favorable weather conditions. However, when nutrient availability is limited, plants tend to allocate a larger proportion of biomass to their roots rather than their shoots (Saghaiesh and Souri, 2018; Hermans *et al*., 2006). Additionally, the allocation of accumulated shoot biomass to vegetative and reproductive structures is not constant and can vary depending on nutrient availability.

The high yielding variety "Naveen" is highly recommended for cultivation during the boro season in southern Odisha. To enhance the productivity of the variety in the specific agro-climatic region, with minimum environmental degradation, it is essential to develop a comprehensive understanding of how the precise management of nutrients affects the accumulation and distribution of dry matter into the reproductive organs. Additionally, this understanding enables the customization of fertilizer recommendations using smart tools and decision support systems, ultimately leading to the development of an effective fertilizer application schedule. Based on the above facts, a field trial conducted to study the influence of nutrients in dry matter partitioning in *boro* rice.

[1]Department of Agronomy, Centurion University of Technology and Management, Bhubaneswar-761 211, Odisha, India.
[2]Department of Agronomy, Sri Karan Narendra Agricultural University, Jobner-303 328, Rajasthan, India.

Corresponding Author: Lalichetti Sagar, Department of Agronomy, Centurion University of Technology and Management, Bhubaneswar-761 211, Odisha, India. Email: lalichetti sagar@cutm.ac.in

How to cite this article: Sagar, L., Maitra, S., Singh, S. and Sairam, M. (2023). Influence of Precision Nutrient Management on Dry Matter Accumulation and Partitioning of Rice in Southern Odisha. Agricultural Science Digest. DOI: 10.18805/ag.D-5822.

Submitted: 14-06-2023 **Accepted:** 27-07-2023 **Online:** 09-08-2023

MATERIALS AND METHODS

The study took place in the *boro* season of 2021-22 at the PG Experimental Farm of M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management in Odisha, India. The farm is located at coordinates 18°48′18″N and 84°10′45″E, with an elevation of 88 meters above mean sea level. The study took place in an irrigated environment and the crop received a total of 6.6 mm of rainfall during its growth period. The average minimum temperature varied from 15.7 to 26.7°C, while the maximum temperature ranged from 27.4 to 38.1°C. In the duration of the crop season, the relative humidity at 7 a.m. and 2 p.m. averaged at 92.8% and 55.1%, respectively. The crop season also had an average of 8.8 hours of sunshine per day. The soil of the experimental field was sandy loam in texture, slightly acidic in reaction (6.23 pH), low in organic carbon (0.34%), available nitrogen (176 kg/ha), available zinc (0.58 ppm) and medium in phosphorus (16 kg/ha), potassium (127 kg/ha), respectively.

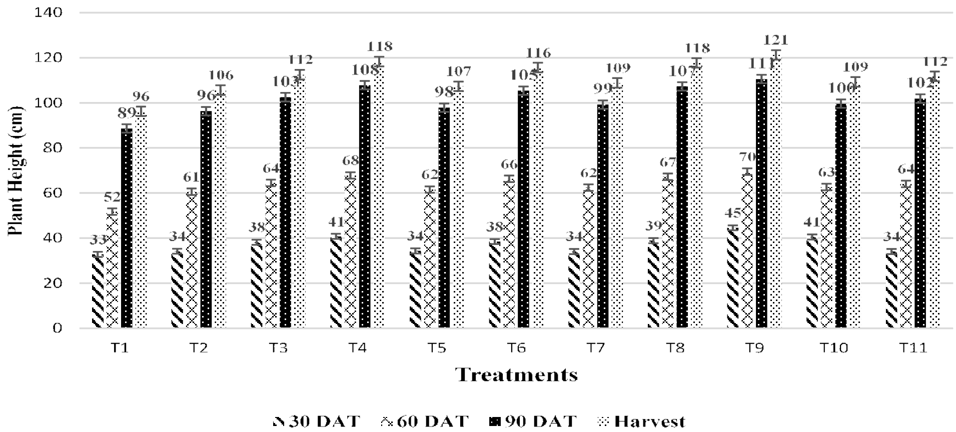
The rice variety Naveen (IET 14461, CR 749-20-2) was sown on 08th December, 2021 with a seed rate of 40 kg/ha in nursery and later transplanted in the main field on 07th January, 2022. The fertilizers were applied as per the treatments. The experiment was conducted in randomized block design with eleven treatments that were replicated thrice. The treatments probed under this investigation were namely, absolute control, 75% recommended dose of fertilizer (RDF), 100% RDF (120-60-60 N-P_2O_5-K_2O), 125% RDF, 75% RDF fb nano urea spray @ 2 ml/L at panicle initiation, 100% RDF fb nano urea spray @ 2 ml/L at panicle initiation, leaf colour chart (LCC) 3 based nitrogen management, LCC 4 based nitrogen management, Sufficiency Index (SI)-based N management at a threshold value less than 90%, Nutrient Expert (NE)-based nutrient recommendation (109-35-58 N-P_2O_5-K_2O), Rice Crop Manager (RCM)-based nutrient recommendation (112-32-25 N-P_2O_5-K_2O).

The data related to dry matter (DM) accumulation and distribution at different growth stages, namely, tillering, heading and maturity. For each treatment, five individual rice plants were selected and harvested at each growth stage. The harvested plants were then separated into leaves, culms and panicles, which were subsequently dried in paper bags at 65°C and weighed using an electronic balance. The average dry weights of the leaves, culms and panicles were calculated. The shoot dry matter was determined by summing up the dry weights of all above ground plant components. All the observations were statistically analyzed by F-test at 5 percent level of significance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growth parameters

The height of rice plants progressively increased with advancement in age and the tallest plants were observed at the time of harvest (Fig 1). The height of the plant was primarily influenced by the culm height until it reached the heading stage. Afterward, the length of the panicle played a crucial role in determining the overall height of the plant. The precision nutrient management treatments had a significant impact on plant height at all the stages of growth. Among the treatments, the SI-based N management treatment recorded significantly taller rice plants over absolute control (no fertilizer application) at 30, 60, 90 DAT and at harvest. Nitrogen is a crucial element found in chlorophyll and contributes to cell division and elongation. Phosphorus is involved in energy transfer, photosynthesis,



Notation- T1: Absolute control; T2: 75% recommended dose of fertilizer (RDF); T3: 100% RDF; T4: 125% RDF; T5: 75% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation; T6: 100% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation; T7: Leaf colour chart (LCC) 3 based N management; T8: LCC 4 based N management; T9: SI-based N management at a threshold value less than 90%; T10: NE-based nutrient recommendation; T11: RCM-based nutrient recommendation.

Fig 1: Influence of precision nutrient management on plant height of *boro* rice.

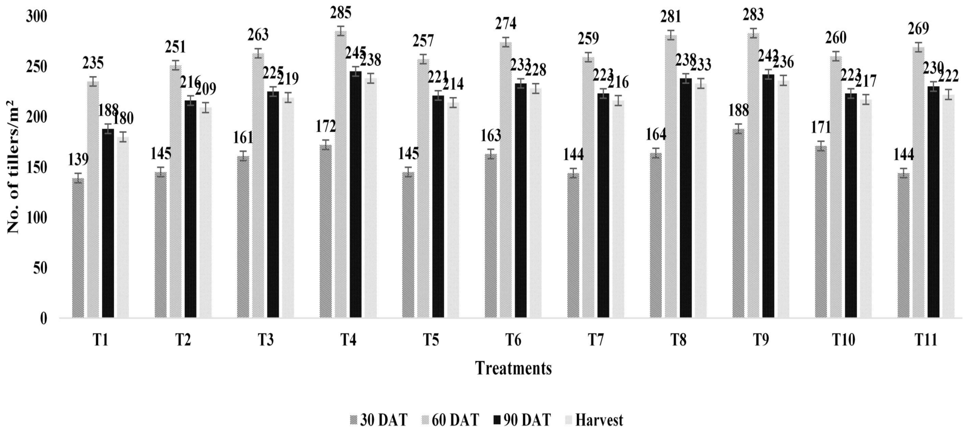
and the movement of nutrients to various plant parts. Potassium also plays a vital role in the transportation of water, nutrients and carbohydrates within the plant, as well as in the activation of enzymes. These factors could explain the observed outcomes.

A perusal of data indicated a progressive increase in number of tillers per square meter up to 60 DAT and then declined thereafter towards maturity irrespective of precision nutrient management (Fig 2). Nevertheless, among the treatments, the SI-based N management noted significantly maximum number of tillers per hill compared to control. The growth of tiller primordium relies on the appropriate and sufficient supply of macro-nutrients, especially nitrogen. Nitrogen plays a crucial role in increasing the cytokinin levels within the tiller nodes and promoting the sprouting of tiller primordium. However, as the number of tillers increases over time, a competition arises for nutrients, light and moisture. The competition among tillers leads to a higher degree of variation in the distribution of photosynthates. To effectively address this issue, the natural occurrence of tiller mortality proves to be highly advantageous.

The earlier research conducted by Subedi *et al.* (2019); Ali *et al.* (2015) and Bhat *et al.* (2022) in rice supports the aforementioned discussion regarding plant height and the number of tillers per square meter observed at various dates.

Culm dry matter accumulation

The perusal of data presented in Table 1 revealed a significant influence of precision nutrient management on culm dry matter accumulation at all the three growth stages,



Notation- T1: Absolute control; T2: 75% recommended dose of fertilizer (RDF); T3: 100% RDF; T4: 125% RDF; T5: 75% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation; T6: 100% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation; T7: Leaf colour chart (LCC) 3 based N management; T8: LCC 4 based N management; T9: SI-based N management at a threshold value less than 90%; T10: NE-based nutrient recommendation; T11: RCM-based nutrient recommendation.

Fig 2: Influence of precision nutrient management on number of tillers/m^2 of *boro* rice.

Table 1: Culm dry matter (g/hill) at different growth stages of rice as influenced by precision nutrient management.

Treatments	Culm dry matter (g/hill)		
	Tillering	Heading	At maturity
Absolute control	2.37	3.75	3.67
75% RDF	3.17	4.51	4.50
100% RDF	3.28	4.95	5.00
125% RDF	3.44	5.31	5.37
75% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation	3.25	4.82	4.79
100% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation	3.28	5.05	5.15
LCC 3 based nitrogen management	3.42	4.80	4.72
LCC 4 based nitrogen management	3.56	5.21	5.21
SI-based N management	4.08	5.75	5.35
NE-based nutrient recommendation	3.73	4.97	4.98
RCM-based nutrient recommendation	3.82	4.98	5.04
SEm (±)	0.18	0.26	0.31
CD (P=0.05)	0.54	0.76	0.91

viz., tillering, heading and maturity stages analyzed in this study. Among all the treatments, SI-based N management with an index value less than 90 per cent was noted to record the significantly highest accumulation of dry matter into the culm during tillering and heading stages. The treatments namely nitrogen management based on LCC with a threshold of 4, nutrient management guided by NE and RCM at tillering stage performed equally well. At heading stage, the treatments like 125% RDF, LCC 4 based nitrogen management and the application of 100% RDF followed by nano urea spray at a rate of 2 ml/L during panicle initiation remained on par with the superior treatment. At maturity, 125% RDF recorded to be superior in terms of culm dry matter accumulation and remained on par with all the treatments under comparison except with absolute control which exhibited the lowest culm dry matter accumulation. Plant nutrients perform various important functions throughout different stages of crop growth. During the vegetative stage, nitrogen enhances plant vigor by stimulating the growth of tillers, increasing leaf size and number. Phosphorus, on the other hand, contributes to root development, while potassium strengthens the culm and provides resistance against both biotic and abiotic stresses. The quantity and timing of nutrient application are crucial factors that influence the accumulation of dry matter in the culm. As the crop progresses towards the heading stage, the culm dry matter gradually increases. However, after this stage, there are no significant differences in culm dry matter accumulation. Interestingly, treatments with a higher proportion of potassium compared to increased nitrogen application demonstrate an increase in culm dry matter production at maturity. In contrast, other treatments exhibit a declining trend, which can be attributed to specific physiological role of nutrients in rice. Previous findings of (Amanullah and Inamullah, 2016; Wu *et al.,* 2023) in rice and Santana *et al.* (2023) in sugarcane regarding culm dry matter were in corroboration with this discussion.

Leaf dry matter accumulation

The data revealed that the leaf dry matter accumulation was significantly influenced by precision nutrient management during tillering, heading and maturity stages (Table 2). At tillering stage, SI-based N management with an index value less than 90% was found to record the significantly highest leaf dry matter accumulation which remained on par with nutrient management guided by NE and RCM. Similarly, at heading stage, SI-based N management with an index value less than 90 per cent was found to record the significantly highest leaf dry matter accumulation and these results were comparable with leaf dry accumulated by 125% RDF, nitrogen management based on LCC with a threshold of 4, 100% RDF with and without additional application of nano urea spray at 2 ml/L during panicle initiation, nutrient recommendation using RCM and nutrient recommendation using NE. At maturity, the highest dry matter accumulation was observed with application of fertilizers at 125% RDF which was closely followed and remained on par by all the treatments under comparison except with application of fertilizers at 75% of the recommended dose and absolute control which recorded the lowest leaf dry matter accumulation. Leaves play a vital role in conducting photosynthesis, making them an important site for active metabolic activities. When evaluating the photosynthetic contribution of various plant parts during maturity, it is essential to consider the longevity of the green tissue. While the panicle tends to turn yellow relatively early during ripening, the leaves should retain their green colour for a longer duration. This longevity is primarily influenced by the availability of nutrients in accordance with the crop's requirements. Of all the primary nutrients, nitrogen plays a particularly crucial role in determining the functionality of leaves from the heading stage until maturity. This is because nitrogen levels are closely associated with the chlorophyll content in rice crop. These findings corroborate with the findings of Song *et al.* (2020) and Yao *et al.* (2014).

Table 2: Leaf dry matter (g/hill) at different growth stages of rice as influenced by precision nutrient management.

Treatments	Leaf dry matter (g/hill)		
	Tillering	Heading	At maturity
Absolute control	3.54	4.98	5.24
75% RDF	4.75	5.95	6.43
10% RDF	4.94	6.54	7.15
12% RDF	5.19	7.01	7.68
75% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation	4.87	6.39	6.84
100% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation	4.94	6.67	7.36
LCC 3 based nitrogen management	5.16	6.34	6.74
LCC 4 based nitrogen management	5.38	6.88	7.45
SI-based N management	6.26	7.58	7.64
NE-based nutrient recommendation	5.68	6.46	7.12
RCM-based nutrient recommendation	5.82	6.57	7.20
SEm (±)	0.28	0.36	0.42
CD (P=0.05)	0.83	1.07	1.24

Panicle dry matter accumulation

The data on panicle dry matter accumulation was recorded heading and at maturity (Table 3). During heading and maturity stages, the highest panicle dry matter accumulation was noted by SI-based nitrogen management with a threshold value less than 90% which remained on par with 125% RDF and LCC-based nitrogen management at a threshold 4 while the lowest panicle dry matter accumulation was noted by absolute control. After heading, nitrogen uptake becomes increasingly significant, especially when aiming for high yields by increasing the harvest index. The SI-based N management approach ensures the optimal supply of nitrogen during critical crop growth stages, leading to improved translocation of the absorbed dry matter from the straw to the primary sink. The higher allocation of dry matter to panicles at maturity indicates an enhanced movement of dry matter from leaves and culms towards the grain-bearing structures or sink during the grain filling period. These findings are supported by the earlier findings of Meena *et al.* (2019) and Paul *et al.* (2021).

Shoot dry matter accumulation

The data on shoot dry matter was recorded at tillering, heading and maturity stages and present in Table 4. The data reveals an increasing trend in shoot dry matter accumulation with the advancement in age of the rice crop and percentage accumulation of shoot dry matter was comparatively higher between tillering and heading than between heading and at maturity. At tillering stage, the significantly highest dry matter accumulation was recorded by SI-based N management at a threshold value less than 90% which remained on par with nutrient management guided by NE and RCM. At heading stage, SI-based N management at a threshold value less than 90% was found to be significantly superior to control in terms of shoot dry matter accumulation and remained on par with 125% RDF

Table 3: Panicle dry matter (g/hill) at different growth stages of rice as influenced by precision nutrient management.

Treatments	Panicle dry matter (g/hill)	
	Heading	At maturity
Absolute control	2.87	6.56
75% RDF	3.92	9.31
100% RDF	4.99	12.14
125% RDF	5.97	14.77
75% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation	4.36	10.35
100% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation	5.31	13.10
LCC 3 based nitrogen management	4.58	10.78
LCC 4 based nitrogen management	5.77	14.08
SI-based N management	6.55	14.93
NE-based nutrient recommendation	4.32	9.33
RCM-based nutrient recommendation	4.84	11.76
SEm (±)	0.29	0.59
CD (P=0.05)	0.86	1.74

Table 4: Shoot dry matter (g/hill) at different growth stages of rice as influenced by precision nutrient management.

Treatments	Shoot dry matter (g/hill)		
	Tillering	Heading	At Maturity
Absolute control	5.91	11.60	15.47
75% RDF	7.92	14.38	20.25
100% RDF	8.21	16.48	24.29
125% RDF	8.63	18.28	27.82
75% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation	8.12	15.56	21.97
100% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation	8.23	17.03	25.62
LCC 3 based nitrogen management	8.58	15.73	22.23
LCC 4 based nitrogen management	8.94	17.87	26.74
SI-based N management	10.34	19.88	27.92
NE-based nutrient recommendation	9.41	15.76	22.43
RCM-based nutrient recommendation	9.64	16.38	24.00
SEm (±)	0.46	0.88	1.47
CD (P=0.05)	1.36	2.63	4.38

and LCC-based N management at a threshold 4. At maturity stage, the highest dry matter accumulation was observed with application of 125%RDF which remained on par with SI-based N management at a threshold value less than 90%, LCC based nitrogen management at a threshold 4, 100% RDF with additional application of nano urea at 2 ml/L during panicle initiation, 100% RDF without nano urea application and nutrient management guided by RCM. The absolute control treatment consistently displayed the lowest dry matter accumulation across all three phenophases under consideration.The reason behind this occurrence could be attributed to the fact that precise nutrient management enhances the availability of nutrients, leading to an increased conversion of carbohydrates into proteins. This heightened protein synthesis stimulates cellular activities in the growing regions of the plant, such as cell division and elongation. These physiological processes manifest in visible traits like taller plant height and a greater number of tillers per plant. Consequently, this contributes to a greater accumulation of dry matter in the above-ground parts of the plant. The findings in this trial were similar to the earlier findings of Nayaka *et al.* (2021) and Puteh *et al.* (2014).

Dry matter partitioning

During the early growth stage of rice, specifically the tillering phase, there were no notable differences in the percentage of dry matter partitioning between the leaves and culms when precision nutrient management was employed (Table 5). However, the partitioning of dry matter into the leaves was higher than that into the culms at the tillering stage. As the growth stages advanced towards heading and physiological maturity, there was an increase in shoot dry matter accumulation when nutrients were adequately supplemented through real-time demand monitoring. During the heading stage, a larger proportion of dry matter was allocated to the leaves compared to the culms and panicles. However, this trend changed at maturity, where the highest proportion of dry matter was allocated to the panicles. The shift in dry matter allocation towards the panicles at maturity can be attributed to the reproductive phase of the rice plant. The panicles, being the reproductive structures responsible for grain production, require a greater share of assimilates for seed development. This allocation strategy optimizes the plant's resources to maximize grain yield during the crucial reproductive phase. Similar findings were observed by Mahajan *et al.* (2012) and Paul *et al.* (2021).

Among the treatments at maturity, The SI-based N management at a threshold less than 90% was observed to be the most efficient precision nutrient management strategy which allocated around 53.46% of the total shoot dry matter to the panicle. Conversely, the poor accumulation as well as translocation of assimilates occurred in absolute control. This indicates the role of primary nutrients in accumulation and translocation of accumulated biomass. The SI-based N management facilitated a greater translocation of assimilates towards the reproductive structures of the plant, promoting panicle development and ultimately leading to increased grain production might be due to availability of nitrogen at peak period of crop demand. Similar observations were found earlier by Moe *et al.* (2019) and Stuerz and Asch (2019).

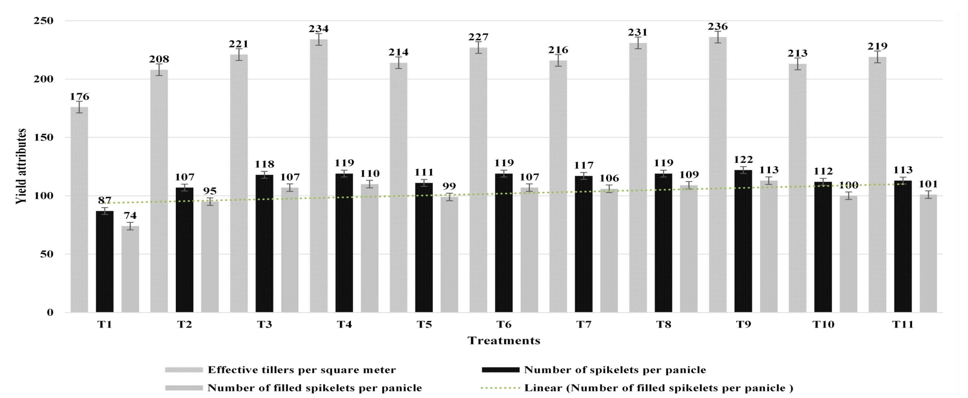
Yield and yield attributes

The yield attributes such as effective tillers per square meter, number of spikelets per panicle and number of filled spikelets panicle were significantly influenced by precision nutrient management (Fig 3) and SI-based N management expressed a significant superiority in production of all these yield attributes which might be due to adequate availability of nitrogen at peak period of demand.

The precision nutrient management had a notable effect on the production of rice grain and straw (Fig 4). The SI-based N management resulted in significantly higher grain yield compared to the absolute control. The adoption of SI-based nitrogen management yielded a substantial 16.68%

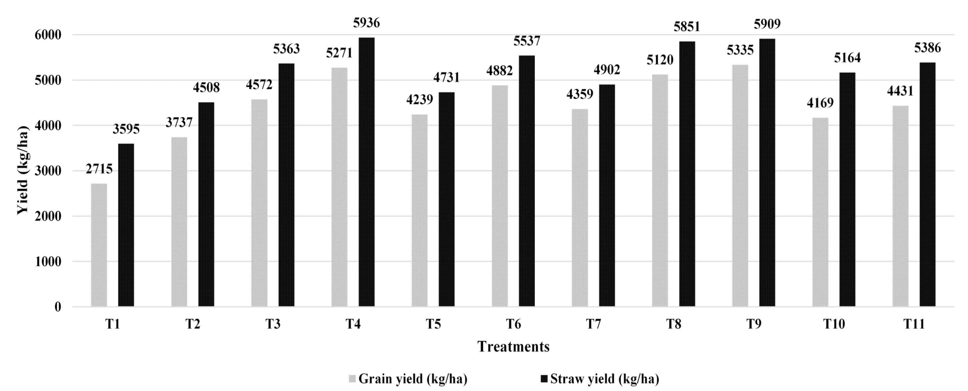
Table 5: Percentage of dry matterpartitioning into culm, leaf and panicle at tillering, heading and physiological maturity in rice.

Treatments (2021-22)	Dry matter partitioning (%)								
	Tillering			Heading			Maturity		
	Culm	Leaf	Panicle	Culm	Leaf	Panicle	Culm	Leaf	Panicle
Absolute control	40.02	59.98	-	32.38	42.93	24.69	23.72	33.88	42.40
75% RDF	40.03	59.97	-	31.34	41.36	27.29	22.22	31.75	46.03
100% RDF	39.92	60.08	-	30.07	39.68	30.25	20.62	29.45	49.93
125% RDF	39.83	60.17	-	29.04	38.33	32.63	19.33	27.61	53.07
75% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation	40.02	59.98	-	31.05	41.00	27.94	20.13	28.76	51.10
100% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation	39.92	60.08	-	29.67	39.16	31.17	20.12	28.74	51.14
LCC 3 based nitrogen management	39.86	60.14	-	30.54	40.30	29.16	21.21	30.30	48.49
LCC 4 based nitrogen management	39.77	60.23	-	29.18	38.51	32.30	19.50	27.86	52.64
SI-based N management	39.49	60.51	-	28.92	38.16	32.92	19.16	27.38	53.46
NE-based nutrient recommendation	39.67	60.33	-	31.58	40.99	27.42	21.77	31.10	42.80
RCM-based nutrient recommendation	39.62	60.38	-	30.36	40.06	29.58	20.98	29.98	49.04



Notation- T1: Absolute control; T2: 75% recommended dose of fertilizer (RDF); T3: 100% RDF; T4: 125% RDF; T5: 75% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation; T6: 100% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation; T7: Leaf colour chart (LCC) 3 based N management; T8: LCC 4 based N management; T9: SI-based N management at a threshold value less than 90%; T10: NE-based nutrient recommendation; T11: RCM-based nutrient recommendation.

Fig 3: Influence of precision nutrient management on yield attributes of *boro* rice.



Notation- T1: Absolute control; T2: 75% recommended dose of fertilizer (RDF); T3: 100% RDF; T4: 125% RDF; T5: 75% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation; T6: 100% RDF *fb* nano urea spray @ 2 ml/L at panicle initiation; T7: Leaf colour chart (LCC) 3 based N management; T8: LCC 4 based N management; T9: SI-based N management at a threshold value less than 90%; T10: NE-based nutrient recommendation; T11: RCM-based nutrient recommendation.

Fig 4: Influence of precision nutrient management on grain and straw yield of *boro* rice.

improvement in rice grain and a 13.17% increase in the overall yield of rice compared to the conventional approach of applying 100% RDF at fixed time intervals. The main reason for these outcomes could be attributed to the sustained greenness of leaf during the ripening stage which increased production and allocation of photosynthates from the source to the grain. Similar findings were reported by Santos *et al.* (2019) and Singh and Khind (2015).

In terms of straw yield, application of 125% RDF showcased better results compared to other treatments, but it was on par with SI-based nitrogen management. Applying 125% RDF resulted in a significant 10.68% rise in straw yield compared to 100% RDF and an impressive 65.11% increase when compared to the absolute control. However, the straw yield achieved from 125% RDF was similar to that obtained from 100% RDF. The enhanced response observed with the application of 125% RDF can be attributed to the additional supply of potassium compared to the recommended dose. This conversation aligns with the previous research conducted by Islam *et al.* (2016) and Akter *et al.* (2023). However, the positive impact of the excess potassium was counterbalanced by the timely and appropriate application of nitrogen through SI-based nitrogen management, along with the recommended doses of phosphorus and potassium.

CONCLUSION

Based on the present study, it can be concluded that real-time application of nitrogen referring to greenness index, along with sufficient levels of phosphorus and potassium, promotes higher accumulation and efficient distribution of dry matter towards the reproductive part of the plant. As a result, this allocation is expected to attribute an increased grain yield and minimize the yield gap for the Naveen variety cultivated during the *boro* season in southern Odisha.

Conflict of interest: None.

REFERENCES

Akter, S., Kamruzzaman, M., Khan, M.Z., Amin, M.S. (2023). Enhanced potassium fertilization improved rice (*Oryza sativa*) yield and nutrient uptake in coastal saline soil of Bangladesh. Journal of Soil Science and Plant Nutrition. 23: 1884-1895.

Ali, A.M., Thind, H.S., Sharma, S., Singh, Y. (2015). Site-specific nitrogen management in dry direct-seeded rice using chlorophyll meter and leaf colour chart. Pedosphere. 25: 72-81.

Amanullah and Inamullah. (2016). Dry matter partitioning and harvest index differ in rice genotypes with variable rates of phosphorus and zinc nutrition. Rice Science. 23(2): 78-87.

Bhat, T.A., Kanth, R.H., Jan, B., Nazir, A., Ahanger, S.A., Mir, M.S., Naikoo, N.B., Fayaz, S., Dar, K.A., Gul, A., Mansoor, T. (2022). Real-Time nitrogen application of rice varieties based on leaf colour chart under system of rice intensification in temperate climate. Agronomy. 12: 2229. https://doi.org/10.3390/agronomy12092229.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedure for Agricultural Research. 2nd Edn. International Rice Research Institute. Los Banos, Philippines. John Willy and Sons. New York. pp. 324.

Hermans, C., Hammond, J.P., White, P.J., Verbruggen, N. (2006). How do plants respond to nutrient shortage by biomass allocation. Trends in Plant Science. 11: 610-617.

Islam, A. and Muttaleb, A. (2016). Effect of potassium fertilization on yield and potassium nutrition of Boro rice in a wetland ecosystem of Bangladesh. Archives of Agronomy and Soil Science. 62: 1530-1540.

Kamal, N.M., Gorafi, Y.S.A., Abdelrahman, M., Abdellatef, E. Tsujimoto, H. (2019). Stay-green trait: A prospective approach for yield potential and drought and heat stress adaptation in globally important cereals. International Journal of Molecular Sciences. 20: 5837. doi: 10.3390/ijms20235837.

Mahajan, G., Timsina, J., Jhanji, S., Sekhon, N.K. Singh, K. (2012). Cultivar response, dry-matter partitioning and nitrogen-use efficiency in dry direct-seeded rice in Northwest India. Journal of Crop Improvement. 26: 767-790.

Meena, A.K., Singh, D.K., Pandey, P.C. Nanda, G. (2019). Dynamics of dry matter and nitrogen distribution in transplanted rice on mollisols. Journal of Plant Nutrition. 42: 749-758.

Moe, K., Htwe, A.Z., Thu, T.T.P., Kajihara, Y. Yamakawa, T. (2019). Effects on NPK status, growth, dry matter and yield of rice (*Oryza sativa*) by organic fertilizers applied in field condition. Agriculture. 9: 109. https://doi.org/10.3390/agriculture9050109.

Mohanta, S., Banerjee, M., Malik, G.C., Shankar, T., Maitra, S., Ismail, I. A., Hossain, A. (2021). Productivity and profitability of *kharif* rice are influenced by crop establishment methods and nitrogen management in the lateritic belt of the subtropical region. Agronomy. 11: 1280. https://doi.org/10.3390/agronomy11071280.

Nayaka, G.V., Reddy, G.P., Kumar, R.M. (2021). Dry matter production and partitioning in different plant parts of rice cultivars under irrigation regimes and systems of cultivation. Indian Journal of Agricultural Research. 55: 347-352. 10.18805/IJARe.A-5316.

Paul, N.C., Paul, S.K., Salam, M.A., Paul, S.C. (2021). Dry matter partitioning, yield and grain protein content of fine aromatic boro rice (cv. BRRI dhan50) in response to nitrogen and potassium fertilization. Bangladesh Journal of Botany. 50: 103-111.

Puteh, A.B., Mondal, M., Ismail, M. Latif, M.A. (2014). Grain sterility in relation to dry mass production and distribution in rice (*Oryza sativa* L.). Bio-Med Research International. 302179. doi: 10.1155/2014/302179.

Saghaiesh, S.P. and Souri, M.K. (2018). Root growth characteristics of Khatouni melon seedlings as affected by potassium nutrition. Acta Scientiarum Polonorum. Hortorum Cultus. 17: 191-198.

Santana, R.S., Mauad, M., de Medeiros, E.S., Silva, P.V., Mussury Franco Silva, R.M., Goneli, A.L.D. (2023). Dry matter accumulation and macronutrient uptake in sugarcane varieties. Journal of Plant Nutrition. 1-17.

Santos, A.B.D., Silva, M.A.S.D., Silveira, P.M.D., Carvalho, G.D., Stone, L.F. (2019). Nitrogen sufficiency index for estimating nitrogen fertilizer requirement of irrigated rice. Revista Ceres. 66: 422-430.

Shankar, T., Malik, G.C., Banerjee, M., Dutta, S., Praharaj, S., Lalichetti, S., Mohanty, S., Bhattacharyay, D., Maitra, S., Gaber, A., Das, A.K., Sharma, A. and Hossain, A. (2022). Prediction of the effect of nutrients on plant parameters of rice by artificial neural network. Agronomy. 12: 2123. https://doi.org/10.3390/agronomy12092123.

Shenoy, H. (2020). Soil fertility status and productivity of rice as influenced by neem cake-urea mixed application. Journal of Pharmacognosy and Phytochemistry. 9: 102-105.

Singh, B. and Sapkota, T.B. (2022). The effects of adequate and excessive application of mineral fertilizers on the soil. Reference Module in Earth Systems and Environmental Sciences. Amsterdam: Elsevier. https://doi.org/10.1016/B978-0-12-822974-3.00051-3.

Singh, J. and Khind, C.S. (2015). Enhancing fertilizer nitrogen use efficiency in irrigated rice by using a chlorophyll meter and leaf colour chart. The Ecoscan. 9: 663-666.

Song, L., Wang, S., Ye, W. (2020). Establishment and application of critical nitrogen dilution curve for rice based on leaf dry matter. Agronomy. 10: 367. https://doi.org/10.3390/agronomy10030367.

Stuerz, S. and Asch, F. (2019). Responses of rice growth to day and night temperature and relative air humidity-Dry matter, leaf area and partitioning. Plants. 8: 521. https://doi.org/10.3390/plants8110521.

Subedi, P., Sah, S.K., Marahattha, S., Yadav, D.R. (2019). Effects of need-based nitrogen management and varieties on growth and yield of dry direct seeded rice. Pertanika Journal of Tropical Agricultural Science. 42: 453-466.

Wu, M., Jiang, H., Wei, Z., Li, W., Gao, K., Wang, D., Wei, X., Tian, P., Cui, J., Di, Y. Wu, Z., Yang, M. (2023). Influence of nitrogen application rate on stem lodging resistance rice under dry cultivation. Agronomy. 13: 426. https://doi.org/10.3390/agronomy13020426.

Yao, X., Ata-Ul-Karim, S.T., Zhu, Y., Tian, Y., Liu, X., Cao, W. (2014). Development of critical nitrogen dilution curve in rice based on leaf dry matter. European Journal of Agronomy. 55: 20-28.

Yoshida S. (1981). Physiological Analysis of Rice Yield. In: Fundamentals of Rice Crop Science. Makita City (Philippines): International Rice Research Institute. 231-251.