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Growth dynamics and productivity of rice (*Oryza sativa* L.) under gradient levels of Konkan Annapurna Briquette (KAB) fertilizers in a rice-mint cropping system

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Abstract

A field experiment was conducted during the *kharif* seasons of 2020 and 2021 to evaluate the effect of gradient levels of Konkan Annapurna Briquette (KAB) fertilizers on growth dynamics and productivity of rice (*Oryza sativa* L.) under a rice-mint cropping system. The experiment was laid out in a randomized block design with three treatments comprising 80% (B₁), 100% (B₂) and 120% (B₃) of the recommended dose of fertilizers (RDF) applied through KAB. The results revealed that growth indices such as crop growth rate (CGR), relative growth rate (RGR), leaf area index (LAI) and net assimilation rate (NAR) were significantly influenced by KAB levels, with higher values recorded under B₃, which remained statistically at par with B₂ in most cases. CGR and LAI attained peak values during 61-90 days after transplanting, indicating maximum vegetative growth during this period. Leaf area ratio (LAR), however, was not significantly affected by treatments. Yield attributes and yields were significantly improved with increasing levels of KAB fertilizers. The highest grain yield (52.31 q ha⁻¹) and straw yield (60.08 q ha⁻¹) were recorded under B₃, which was statistically at par with B₂ (49.96 and 57.97 q ha⁻¹, respectively) but significantly superior over B₁. Biological yield and harvest index also followed a similar trend. The improvement in yield under higher KAB levels was mainly attributed to enhanced growth parameters and better assimilate partitioning. Overall, the study indicated that application of 100% RDF through KAB is sufficient to achieve optimum growth and productivity of rice, while further increase to 120% RDF resulted in marginal gains without significant advantage.

Keywords: Rice, briquette fertilizers, KAB, growth dynamics, yield, growth indices, rice-mint system

Introduction

Rice (*Oryza sativa* L.) is a principal staple crop feeding more than half of the world's population and plays a vital role in ensuring food security, particularly in Asian countries. In India, rice is a dominant crop in the agricultural economy; however, its productivity is often constrained by inefficient nutrient management, especially under intensive cropping systems like rice-mint, where continuous cultivation leads to nutrient depletion and imbalance. Nitrogen (N), phosphorus (P) and potassium (K) are the primary nutrients governing rice growth and productivity, but their use efficiency under conventional fertilization practices remains low. It is estimated that only 30-50% of applied nitrogen is utilized by rice plants, while the rest is lost through volatilization, leaching and runoff, resulting in reduced productivity and environmental concerns (Rahman and Samanta, 2024) [5]. Improving Nutrient Use Efficiency (NUE) is therefore essential for sustainable rice production.

In this context, fertilizer briquette technology, particularly deep placement of briquettes, has emerged as a promising approach to enhance NUE and crop productivity. Briquette fertilizers release nutrients slowly and maintain their availability in the root zone, thereby minimizing losses and improving uptake efficiency. Studies have shown that deep placement of urea and NPK briquettes significantly enhances nitrogen recovery, growth parameters and grain yield of rice compared to conventional fertilizer application methods (Eldridge *et al.*, 2022; Naveen *et*

et al., 2024) [1, 4]. Similarly, slow-release fertilizer deep placement has been reported to increase rice yield by 8-23% and improve sustainability of production systems (Lan *et al.*, 2024) [3]. Konkani Annapurna Briquette (KAB), a composite fertilizer containing essential nutrients, has gained attention as an efficient nutrient management strategy in rice-based systems. Application of KAB briquettes has been reported to improve crop growth, yield attributes and overall productivity by ensuring balanced and sustained nutrient supply (Jadhav *et al.*, 2024) [2]. Furthermore, briquette-based fertilization has been recognized as an environmentally friendly approach that reduces nutrient losses and enhances fertilizer use efficiency (Sarker *et al.*, 2021) [6].

Crop growth analysis using parameters such as Crop Growth Rate (CGR), Relative Growth Rate (RGR), leaf area index (LAI) and Net Assimilation Rate (NAR) provides valuable insights into the physiological processes governing biomass accumulation and yield formation. These growth indices are highly sensitive to nutrient availability and serve as reliable indicators for evaluating the effectiveness of fertilizer management practices. Although the benefits of briquette fertilizers have been widely documented, information on the response of rice to gradient levels of Konkani Annapurna Briquette (KAB) under rice-mint cropping systems is limited. In particular, systematic evaluation of growth dynamics and productivity of rice under varying KAB levels has not been adequately explored under field conditions. Therefore, the present investigation was undertaken to evaluate the effect of gradient levels of Konkani Annapurna Briquette (KAB) fertilizers on growth dynamics and productivity of rice in a rice-mint cropping system.

Materials and Methods

The field experiment was conducted during the *kharif* seasons of 2020 and 2021 at the Experimental Farm, Department of Agronomy, College of Agriculture, Dr. Balasaheb Sawant Konkani Krishi Vidyapeeth, Dapoli, Maharashtra, India. The soil of the experimental field was lateritic, well-drained and sandy clay loam in texture. Composite soil samples (0-30 cm depth) were collected before the initiation of the experiment and analyzed using standard procedures. The soil was slightly acidic in reaction (pH 5.74), medium in available nitrogen (286 kg ha⁻¹) and phosphorus (12.9 kg ha⁻¹), high in available potassium (257 kg ha⁻¹), and rich in organic carbon (1.26%). The experiment was laid out in a Randomized Block Design (RBD) with nine replications. The treatments consisted of three gradient levels of Konkani Annapurna Briquettes (KAB). B₁; 80% recommended dose of fertilizers (RDF) through KAB, B₂; 100% RDF through KAB and B₃; 120% RDF through KAB. Rice variety 'Ratnagiri-8' was used for the study. Twenty-four day old seedlings were transplanted at a spacing of 25 cm × 15 cm, maintaining 2-3 seedlings hill⁻¹. Well-decomposed farmyard manure (5 t ha⁻¹) and Glyricidia green biomass (7.5 t ha⁻¹) were incorporated during land preparation. Konkani Annapurna Briquettes (KAB) were applied as per treatment levels (80%, 100% and 120% RDF equivalent to 175 kg ha⁻¹) through deep placement at 5 Days after Transplanting (DAT). Necessary plant protection measures were undertaken to control insect pests and diseases. All other agronomic practices were followed as per recommended package of practices. Observations on various growth parameters were recorded at different stages (30, 60, 90 DAT and at harvest). Based on these observations, various

growth indices were computed using standard procedures and formulae. At harvest, the observations were recorded on 1000-grain weight (g), Grain yield (q ha⁻¹), Straw yield (q ha⁻¹), Biological yield (q ha⁻¹) and Harvest index (%). Grain and straw yields were recorded from net plot area and converted to hectare basis. The experimental data were analyzed using analysis of variance (ANOVA) appropriate for Randomized Block Design as described by Gomez and Gomez (1984). The significance of treatment differences was tested using the critical difference (CD) at 5% level of probability (P = 0.05).

Results and Discussion

Growth dynamics

Crop Growth Rate (CGR) of rice was significantly influenced by gradient levels of Konkani Annapurna Briquette (KAB) fertilizers at all growth stages during both years (2020 and 2021). CGR increased progressively from 0-30 DAT to 61-90 DAT and declined thereafter.

Up to harvest. Among the treatments, application of 120% RDF through KAB (B₃) recorded the highest CGR across all stages, which remained statistically at par with 100% RDF (B₂) but significantly superior over 80% RDF (B₁). During the peak growth period (61-90 DAT), CGR under B₃ reached 21.97 and 20.44 g m⁻² day⁻¹ during 2020 and 2021, respectively. The higher CGR under increased KAB levels may be attributed to enhanced nutrient availability in the root zone due to deep placement, leading to improved leaf area development and photosynthetic efficiency. Similar increases in CGR under briquette fertilization have been reported by Eldridge *et al.* (2022) [1] and Naveen *et al.* (2024) [4], who observed improved nitrogen availability and biomass accumulation under deep placement techniques. The decline in CGR at later stages (91 DAT to harvest) could be due to leaf senescence and reduced assimilatory surface, which is a normal physiological phenomenon in rice crops.

Relative Growth Rate (RGR) decreased continuously with crop age across all treatments during both years. The highest RGR values were observed during early growth stages (0-30 DAT), followed by a gradual decline towards maturity. Treatment B₃ recorded marginally higher RGR values (0.1686 and 0.1662 g g⁻¹ day⁻¹ during 2020 and 2021, respectively), though it remained statistically at par with B₂. The improved RGR at higher KAB levels may be due to efficient nutrient uptake and enhanced metabolic activity during early growth stages. The decreasing trend of RGR with crop advancement is attributed to increased accumulation of structural biomass and reduced contribution of new tissues, as also reported by Sarker *et al.* (2021) [6] and Lan *et al.* (2024) [3] in rice under improved nutrient management.

Leaf area index (LAI) was significantly influenced by KAB levels at all growth stages. LAI increased up to 61-90 DAT and declined thereafter. The highest LAI was recorded under B₃, reaching 5.15 and 4.78 during 2020 and 2021, respectively, which was significantly superior to B₁ and statistically comparable with B₂. Increased LAI under higher KAB levels may be attributed to improved nitrogen availability, resulting in enhanced leaf expansion and canopy development. These findings are in agreement with Jadhav *et al.* (2024) [2], who reported increased LAI in rice with briquette fertilizer application due to sustained nutrient release, and Rahman and Samanta (2024) [5], who highlighted improved canopy growth under deep placement fertilization.

Net assimilation rate (NAR) showed a declining trend with crop

age but was significantly influenced by KAB levels. Treatment B₃ recorded higher NAR values across growth stages, for

example 5.26 and 5.39 g m⁻² day⁻¹ during 31-60 DAT in 2020 and 2021,

Table 1: Effect of gradient levels of KAB on CGR (g m⁻² day⁻¹), RGR (g g⁻¹ day⁻¹), LAI, NAR (g m⁻² day⁻¹) and LAR (cm²g⁻¹) of rice during *Kharif* 2020 & 2021

Treatments	Crop Growth Rate (g m ⁻² day ⁻¹)							
	0-30 DAT		31-60 DAT		61-90 DAT		91 to harvest	
	2020	2021	2020	2021	2020	2021	2020	2021
B ₁	4.80	4.58	14.36	13.31	18.23	16.56	6.34	4.99
B ₂	5.18	4.80	16.05	14.99	21.01	19.77	7.13	5.45
B ₃	5.27	4.90	16.40	15.54	21.97	20.44	7.68	6.35
SE	0.17	0.14	0.51	0.51	0.86	0.66	1.04	0.76
CD @ 5%	0.52	0.43	1.53	1.54	2.59	1.98	3.13	2.28
G. M.	5.08	4.76	15.60	14.61	20.40	18.93	7.05	5.60
Relative Growth Rate (g g ⁻¹ day ⁻¹)								
B ₁	0.1655	0.1639	0.0462	0.0454	0.0223	0.0220	0.0052	0.0044
B ₂	0.1682	0.1656	0.0470	0.0472	0.0229	0.0231	0.0053	0.0043
B ₃	0.1686	0.1662	0.0471	0.0476	0.0233	0.0231	0.0055	0.0047
SE	0.0011	0.0010	0.0004	0.0006	0.0008	0.0007	0.0008	0.0006
CD @ 5%	0.0034	0.0030	0.0011	0.0019	0.0024	0.0021	0.0023	0.0018
G. M.	0.1674	0.1653	0.0468	0.0467	0.0229	0.0227	0.0053	0.0045
LAI								
B ₁	2.16	1.99	3.82	3.52	4.39	4.01	1.86	1.73
B ₂	2.25	2.07	4.10	3.83	5.00	4.45	1.94	1.80
B ₃	2.30	2.12	4.16	3.88	5.15	4.78	1.98	1.83
SE	0.04	0.04	0.08	0.09	0.15	0.15	0.04	0.04
CD @ 5%	0.12	0.13	0.24	0.26	0.44	0.45	0.11	0.11
G. M.	2.24	2.06	4.03	3.74	4.84	4.41	1.92	1.78
NAR (g m ⁻² day ⁻¹)								
B ₁	15.05	15.37	4.95	4.98	4.47	4.45	2.25	1.82
B ₂	15.65	15.62	5.21	5.26	4.64	4.79	2.21	1.86
B ₃	15.75	15.76	5.26	5.39	4.75	4.75	2.32	2.09
SE	0.61	0.54	0.21	0.22	0.20	0.18	0.41	0.27
CD @ 5%	1.83	1.60	0.62	0.66	0.61	0.54	1.22	0.80
G. M.	15.48	15.59	5.14	5.21	4.62	4.67	2.26	1.92
LAR (cm ² g ⁻¹)								
B ₁	38.83	36.90	94.02	92.01	50.10	49.56	24.56	24.72
B ₂	38.96	37.41	90.47	89.99	49.50	48.23	23.86	23.35
B ₃	39.51	37.94	91.75	90.40	49.88	49.29	23.98	23.90
SE	0.91	0.85	3.65	3.50	1.87	1.81	0.99	0.88
CD @ 5%	2.73	2.54	10.93	10.49	5.59	5.42	2.96	2.65
G. M.	39.10	37.42	92.08	90.80	49.83	49.03	24.13	23.99

Respectively. Enhanced NAR under higher KAB levels may be due to improved photosynthetic efficiency and better utilization of intercepted radiation. Similar improvements in NAR under balanced fertilization and slow-release nutrient sources have been reported by Eldridge *et al.* (2022) ^[1] and Lan *et al.* (2024) ^[3].

Leaf Area Ratio (LAR) was not significantly influenced by different levels of KAB fertilizers at most growth stages, although slight variations were observed. LAR values were higher during early growth stages and declined with crop maturity. The non-significant effect indicates that biomass partitioning between leaf and total plant weight remained relatively stable across treatments. This observation is consistent with findings of Sarker *et al.* (2021) ^[6], who also reported limited influence of fertilizer levels on LAR compared to other growth parameters.

Yield and productivity

Test weight was not significantly influenced by KAB levels, although a slight increase was observed with increasing fertilizer levels. The highest pooled value (19.13 g) was recorded under B₃. This suggests that grain size is largely governed by genetic

factors rather than nutrient levels, which is in agreement with findings of Naveen *et al.* (2024) ^[4]. Grain yield was significantly influenced by different KAB levels. Treatment B₃ recorded the highest pooled grain yield (52.31 q ha⁻¹), which was statistically at par with B₂ (49.96 q ha⁻¹) but significantly superior over B₁ (43.18 q ha⁻¹). The increase in grain yield under higher KAB levels can be attributed to higher CGR and LAI improved photosynthetic efficiency leads to better assimilate partitioning. These results are in line with Eldridge *et al.* (2022) ^[1] and Lan *et al.* (2024) ^[3], who reported significant yield improvement under briquette deep placement due to enhanced nutrient use efficiency.

Straw yield followed a trend similar to grain yield. The highest pooled straw yield (60.08 q ha⁻¹) was recorded under B₃, followed by B₂ and B₁. The increase in straw yield reflects enhanced vegetative growth due to improved nutrient availability, as also reported by Jadhav *et al.* (2024) ^[2]. Biological yield differed significantly among treatments. Treatment B₃ recorded the highest pooled biological yield (112.39 q ha⁻¹), which was at par with B₂ but

Table 2: 1000 grain weight (g), grain yield (q ha⁻¹), straw yield (q ha⁻¹), biological yield (q ha⁻¹) and harvest index (%) of rice as influenced by different treatments during *Kharif* 2020, 2021 and pooled data

Treatments	1000 grain weight (g)			Grain yield (q ha ⁻¹)			Straw yield (q ha ⁻¹)			Biological yield (q ha ⁻¹) ⁻¹			Harvest index (%)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
B ₁	18.50	18.22	18.36	45.42	40.93	43.18	54.84	48.91	51.87	100.26	89.84	95.05	45.32	45.56	45.43
B ₂	18.91	18.75	18.83	52.49	47.44	49.96	60.93	55.02	57.97	113.42	102.46	107.94	46.28	46.30	46.29
B ₃	19.27	18.99	19.13	54.70	49.92	52.31	63.18	56.98	60.08	117.88	106.90	112.39	46.40	46.70	46.54
SE	0.37	0.43	0.34	1.71	1.47	1.50	2.02	1.70	1.75	3.72	3.17	3.26	0.07	0.03	0.05
CD @ 5%	1.10	1.29	1.01	5.13	4.41	4.51	6.04	5.10	5.25	11.17	9.50	9.76	0.20	0.10	0.15
G. M.	18.89	18.65	18.77	50.87	46.10	48.48	59.65	53.64	56.64	110.52	99.73	105.13	46.00	46.19	46.09

Significantly superior over B₁. Higher biological yield under increased KAB levels is a cumulative effect of improved growth parameters and efficient nutrient utilization. Harvest index showed a slight but significant increase with increasing KAB levels. The highest pooled harvest index (46.54%) was recorded under B₃. Improved harvest index indicates better partitioning of assimilates towards grain yield, which is consistent with findings of Rahman and Samanta (2024) ^[5].

Conclusion

The present investigation clearly demonstrated that gradient levels of Konkan Annapurna Briquette (KAB) fertilizers significantly influenced the growth dynamics and productivity of rice (*Oryza sativa* L.) under the prevailing agro-climatic conditions. Application of KAB fertilizers improved key growth parameters such as crop growth rate (CGR), leaf area index (LAI) and net assimilation rate (NAR), which in turn enhanced biomass production and yield. The highest values for growth and yield attributes were consistently recorded under 120% RDF through KAB (B₃); however, these were statistically at par with 100% RDF (B₂) in most cases. Grain yield was significantly increased with higher KAB levels, with B₃ recording the maximum yield, followed closely by B₂. The improvement in yield was primarily attributed to better nutrient availability, enhanced photosynthetic efficiency, and improved assimilate partitioning. Yield attributes such as test weight showed non-significant variation, indicating their genetic control. Although 120% RDF resulted in marginally higher growth and yield, the lack of significant advantage over 100% RDF suggests that application of 100% RDF through KAB (B₂) is optimal and efficient for achieving higher productivity of rice. This level ensures better nutrient use efficiency while avoiding unnecessary fertilizer input. Therefore, it can be concluded that deep placement of Konkan Annapurna Briquettes at 100% recommended dose is a viable and sustainable nutrient management strategy for improving growth and yield of rice in rice-based cropping systems.

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