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The names and affiliations of all authors are provided below, following the references.

Response of Kodo millet (*Paspalum Scrobiculatum* L.) varieties to different levels of fertilizer under rainfed condition at Bastar Plateau Region of Chhattisgarh

Suhail Khan¹, Narendra Kumar², Pravindra Kumar Salam³, Tejpal Chandrakar⁴,
 Devendra Pratap Singh⁵, Bhumiika Tandav⁶, Divya Sahu⁷

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ABSTRACT

Abstract: The present investigation entitled “Response of Kodo millet (*Paspalum scrobiculatum* L.) varieties to different levels of fertilizer under rainfed condition at Bastar Plateau Region of Chhattisgarh” was conducted during the Kharif season of 2025 at the New Upland Research cum Instructional (NURI) Farm, Lamker, under S.G. College of Agriculture and Research Station, Jagdalpur, Chhattisgarh. The experiment was laid out in a split-plot design with three replications, comprising four fertility levels, viz., F_0 : absolute control, F_1 : 75% RDF, F_2 : 100% RDF and F_3 : 125% RDF as main-plot treatments, and three varieties, viz., V_1 : KMV 588, V_2 : TNAU 86 and V_3 : JK 137 as sub-plot treatments. Among the fertility levels, F_3 (125% RDF) recorded the highest plant height, number of tillers plant⁻¹, dry matter accumulation, leaf area index, crop growth rate and relative growth rate. Among varieties, V_2 (TNAU 86) recorded the highest plant height, whereas V_3 (JK 137) recorded the highest number of tillers plant⁻¹, dry matter accumulation, leaf area index, crop growth rate and relative growth rate. The interaction $F_3 \times V_3$ recorded the highest values of number of tillers plant⁻¹, dry matter accumulation and leaf area index for the traits showing significant interaction. Among yield attributes, F_3 recorded the highest panicle length and number of grains panicle⁻¹, while V_3 recorded the highest values for these traits. Grain and straw yields were significantly influenced by fertility levels and varieties. F_3 recorded the highest grain yield (19.46 q ha⁻¹) and straw yield (36.17 q ha⁻¹), while V_3 recorded 14.77 and 27.14 q ha⁻¹, respectively. The interaction $F_3 \times V_3$ recorded the highest grain yield (21.74 q ha⁻¹) and straw yield (40.56 q ha⁻¹). Economic analysis showed that F_3 recorded the highest gross return (₹67,712 ha⁻¹), net return (₹43,881 ha⁻¹) and B:C ratio (2.84), whereas V_3 recorded ₹51,332 ha⁻¹ gross return, ₹29,641 ha⁻¹ net return and a B:C ratio of 2.29. The highest B:C ratio (3.17) was obtained with $F_3 \times V_3$. Overall, higher fertility levels improved growth, yield and economic returns, while JK 137 showed superior performance under the rainfed conditions of the Bastar Plateau region of Chhattisgarh.

Keywords: Kodo millet, Fertility levels, Varieties, Growth, Yield, Economics, Rainfed condition

Introduction

Millets are important climate-resilient cereal crops because of their adaptability to diverse agro-climatic conditions and suitability for relatively low-input production systems. The global importance of millets was further recognized with the declaration of 2023 as the *International Year of Millets* by the United Nations (Anonymous, 2021) [1]. Among small millets, kodo millet (*Paspalum scrobiculatum* L.) is an ancient crop believed to have been domesticated in India nearly 3000 years ago (De-Wet *et al.*, 1983) [2]. It is well adapted to tropical and subtropical environments and is traditionally cultivated under rainfed and moisture-limited conditions (Saxena *et al.*, 2018). In India, kodo millet has considerable importance in tribal farming systems, particularly in central India, where it forms part of traditional food systems (Pali *et al.*, 2019) [3]. Despite its adaptability to marginal and rainfed environments, productivity of kodo millet remains constrained by inadequate nutrient management, use of low-yielding cultivars and limited adoption of improved agronomic practices. Fertility management is an important factor influencing crop growth, yield attributes and productivity. Dubey (1991) [4] reported the importance of fertilizer application in improving the growth and production of kodo millet, while Thakur *et al.* (1994) [5] reported an increase in kodo millet yield with nitrogen application. Similarly, Jalajakshi *et al.* (2022) [6] observed improvement in yield attributes with higher fertilizer levels, which was associated with better growth and dry matter development. Recent research has also emphasized the importance of appropriate nutrient management for improving millet productivity (Sahu *et al.*, 2026) [7]. The response to fertility levels, however, may vary among varieties because genotypes differ in growth characteristics and yield potential. Therefore, selection of a suitable variety along with an appropriate fertility level is important for improving kodo millet productivity under specific agro-climatic conditions. Vishwanatha *et al.* (2024) [8] emphasized the importance of suitable agronomic manage

Corresponding Author:

Suhail Khan

Postgraduate Scholar,
 Agronomy Section, S. G.
 College of Agriculture and
 Research Station,
 Jagdalpur, ICKV, Raipur,
 Chhattisgarh, India

ment for realizing the production potential of kodo millet. The Bastar Plateau region of Chhattisgarh is predominantly characterized by rainfed agriculture, where kodo millet is an important crop in tribal farming systems. However, information on the comparative performance of kodo millet varieties under different fertility levels in the rainfed conditions of this region is limited. Therefore, the present investigation was undertaken to evaluate the effect of different fertility levels on growth, yield and yield attributes of kodo millet varieties and to assess their economic performance under rainfed conditions of the Bastar Plateau region of Chhattisgarh.

Material and Methods

2.1 Experimental site and season

The field experiment was conducted during the *Kharif* season of 2025 at the New Upland Research cum Instructional (NURI) Farm, Lamker, under S.G. College of Agriculture and Research Station, Jagdalpur, Chhattisgarh. The experimental site falls under the Bastar Plateau Agro-climatic Zone. During the crop-growing period from July to November 2025, a total rainfall of 1,443.5 mm was received over 67 rainy days, with mean maximum and minimum temperatures of 30.0 and 20.9 °C, respectively.

2.2 Experimental design and treatments

The experiment was laid out in a split-plot design with three replications. Four fertility levels were assigned to the main plots and three kodo millet varieties to the sub-plots, resulting in 12 treatment combinations. The fertility treatments were F_0 : absolute control, F_1 : 75% RDF, F_2 : 100% RDF and F_3 : 125% RDF. The varieties were V_1 : KMV 588, V_2 : TNAU 86 and V_3 : JK 137. The gross plot size was 4.5 m × 4.0 m and the net plot size was 3.5 m × 3.6 m. The crop was sown at 20 cm × 10 cm spacing on 8 July 2025. The recommended fertilizer dose was 60:40:20 kg N:P₂O₅:K₂O ha⁻¹.

2.3 Crop management

The experimental field was prepared by tractor-drawn cultivation, followed by harrowing and planking. Kodo millet seed was used at 15 kg ha⁻¹ and treated with carbendazim @ 2.5 g kg⁻¹ seed. Fertilizers were applied according to the respective treatment. The entire phosphorus and potassium and 50% of nitrogen were applied basally, while the remaining nitrogen was applied in two equal splits at active tillering and panicle initiation. Thinning was carried out at 20 days after sowing to maintain a uniform plant population.

2.4 Observations

Growth observations were recorded at 30-day intervals and included plant height, number of tillers plant⁻¹, dry matter accumulation, leaf area index (LAI), crop growth rate (CGR) and relative growth rate (RGR). Days to 50% flowering and maturity were also recorded. Yield attributes included panicle length, number of grains panicle⁻¹ and 1000-grain weight. Grain yield, straw yield and harvest index were recorded after harvest.

Dry matter was determined from five randomly selected plants per net plot after oven-drying the samples at 60 °C for 48 h to constant weight. LAI was calculated as the ratio of leaf area to ground area following Watson (1947) [9]. CGR and RGR were calculated using the respective standard growth-analysis equations described in the thesis.

2.5 Harvest and yield estimation

The crop was harvested manually at physiological maturity. KMV 588 and JK 137 were harvested earlier, while TNAU 86 was harvested later because of its comparatively longer duration. The harvested produce was dried, threshed and cleaned. Grain yield from each net plot was recorded and converted to q ha⁻¹.

2.6 Economic analysis

Cost of cultivation was calculated based on expenditure incurred on field operations, seed, fertilizer, labour and other inputs at prevailing prices. Gross return was calculated from grain yield and the prevail-

ing market price. Net return was obtained by subtracting the cost of cultivation from gross return, while the benefit-cost ratio was calculated as gross return divided by cost of cultivation.

2.7 Statistical analysis

The experimental data were statistically analyzed using analysis of variance appropriate for split-plot design following Gomez *et al.* (1984) [10]. The significance of treatment effects was tested using the appropriate error terms, and critical difference (CD) at the 5% probability level was used for comparison of treatment means where applicable.

3. Results and Discussion

3.1 Growth characteristics

Plant height

The data revealed that treatment F_3 (125% RDF) recorded significantly taller plants at all the growth stages. However, plant height under F_3 was statistically at par with F_2 (100% RDF) at 30, 60, 90 DAS and at harvest. The shortest plants were recorded under F_0 (absolute control). Among the varieties, V_2 (TNAU 86) recorded significantly higher plant height throughout the crop growth period, although it remained statistically at par with V_1 (KMV 588) at 30 DAS, while V_3 (JK 137) recorded the lowest plant height. The interaction between fertility levels and varieties was found to be non-significant at all the growth stages. The superior plant height under F_3 may be attributed to the adequate availability of nutrients, particularly nitrogen, which promoted chlorophyll formation, photosynthetic activity, cell division and cell elongation, resulting in enhanced vegetative growth. Similar findings were reported by Sahu *et al.* (2026) [7]. The greater plant height observed in V_2 (TNAU 86) may be associated with its genetic potential and better utilization of available nutrients, which favoured vigorous vegetative growth. Similar observations were reported by Singh *et al.* (2026) [11].

Number of tillers

The data indicated that F_3 (125% RDF) produced significantly higher number of tillers per plant at 30, 60 and 90 DAS and at harvest, whereas the lowest number of tillers was recorded under F_0 (absolute control). Among the varieties, V_3 (JK 137) recorded significantly higher number of tillers per plant at all the growth stages, while V_1 (KMV 588) recorded the lowest number of tillers. The interaction between fertility levels and varieties was significant at 90 DAS and at harvest. The treatment combination $F_3 \times V_3$ (125% RDF × JK 137) recorded the highest number of tillers per plant, whereas the lowest was recorded under $F_0 \times V_1$ (absolute control × KMV 588). The higher tillering under F_3 may be attributed to the favourable availability of nutrients, which promoted tiller initiation, vegetative growth and survival of productive tillers. The superior performance of V_3 may be related to its better genetic potential and efficient utilization of available resources. Similar findings were reported by Korir *et al.* (2018) [12] and Srikanya *et al.* (2020) [13].

Dry matter accumulation

The results showed that F_3 (125% RDF) recorded significantly higher dry matter accumulation at all the growth stages, while the lowest dry matter accumulation was observed under F_0 (absolute control). Among the varieties, V_3 (JK 137) recorded significantly higher dry matter accumulation at all the growth stages, whereas V_1 (KMV 588) recorded the lowest values. The interaction between fertility levels and varieties was non-significant at 30, 60 and 90 DAS but became significant at harvest. The interaction $F_3 \times V_3$ (125% RDF × JK 137) recorded the highest dry matter accumulation at harvest. The higher dry matter production under F_3 may be attributed to adequate and balanced nutrient availability, which enhanced vegetative growth, leaf development and photosynthetic activity, thereby promoting greater accumulation of assimilates. The superior dry matter accumulation in V_3 may be associated with its vigorous growth and better utilization

of available nutrients. Similar findings were reported by Sahu *et al.* (2026) [7] and Srikanya *et al.* (2020) [13].

Leaf area index, crop growth rate and relative growth rate

The data revealed that F₃ (125% RDF) recorded the highest leaf area index, crop growth rate and relative growth rate, whereas the lowest values were generally observed under F₀ (absolute control). Among the varieties, V₃ (JK 137) recorded the highest values for these growth parameters, while V₁ (KMV 588) recorded comparatively

lower values. The interaction between fertility levels and varieties was significant for leaf area index at harvest, whereas the interaction effect for crop growth rate and relative growth rate remained non-significant. The higher growth rates under F₃ may be attributed to improved vegetative growth, greater leaf area development and enhanced assimilate production resulting from adequate nutrient supply. The better performance of V₃ may be associated with its superior growth potential and efficient utilization of available resources.

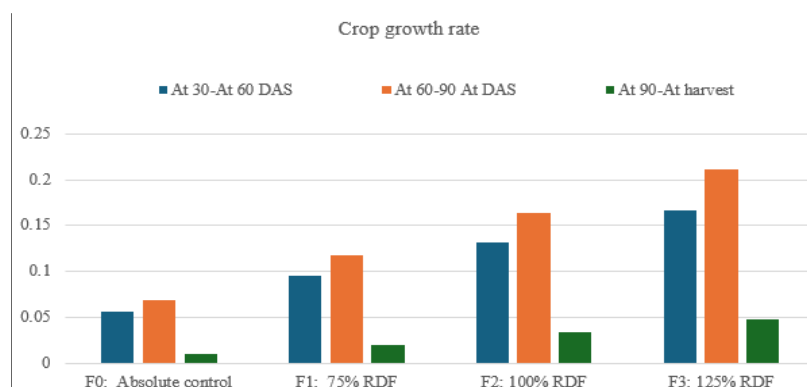


Figure 1. Effect of different fertility levels on crop growth rate of kodo millet

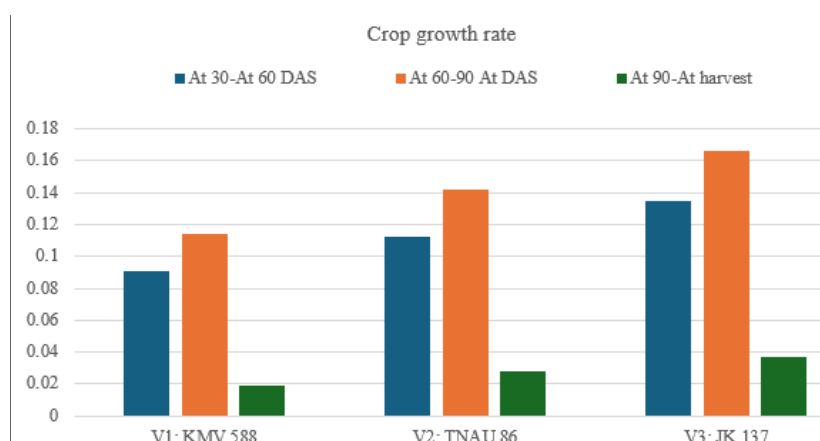


Figure 2. Effect of different on varieties crop growth rate of kodo millet

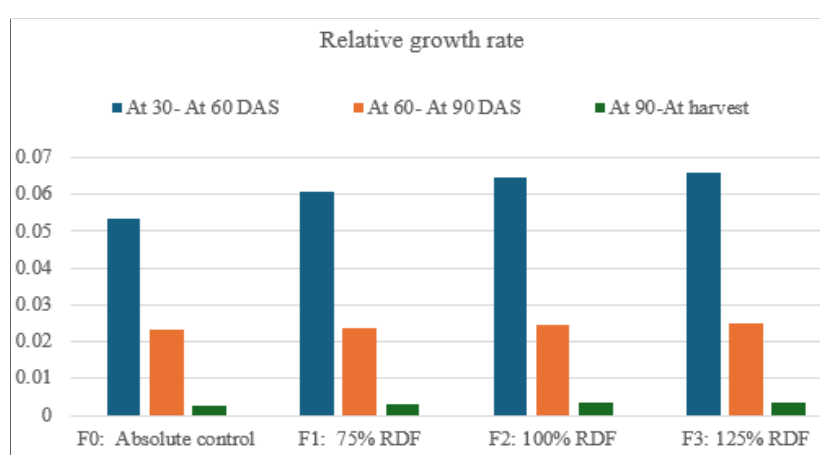


Figure 1. Effect of different fertility levels on crop growth rate of kodo millet

3.2 Yield attributes and yield

Panicle length

The results revealed that F₃ (125% RDF) recorded significantly longer panicles among the fertility levels, although it remained statistically at par with F₂ (100% RDF), while the shortest panicles were observed under F₀ (absolute control). Among the varieties, V₃ (JK

137) recorded significantly longer panicles and was statistically at par with V₂ (TNAU 86), whereas V₁ (KMV 588) recorded the shortest panicles. The interaction effect between fertility levels and varieties was non-significant. The increase in panicle length under higher fertility may be attributed to improved nutrient availability, which promoted better reproductive growth and translocation of assimilates towards the developing panicles. Similar findings were reported by Deshmukh *et al.* (2025) [14].

Number of grains per panicle

The number of grains per panicle was significantly higher under F_3 (125% RDF), followed by F_2 and F_1 , while the lowest number was recorded under F_0 (absolute control). Among the varieties, V_3 (JK 137) recorded the highest number of grains per panicle, followed by V_2 (TNAU 86), whereas V_1 (KMV 588) recorded the lowest value. The interaction effect between fertility levels and varieties was non-significant. The higher number of grains per panicle under F_3 may be attributed to better crop growth, greater assimilate production and improved translocation towards reproductive structures. The superior performance of V_3 may be associated with its better genetic potential and efficient utilization of available nutrients.

Test weight

In case of test weight, F_3 (125% RDF) recorded the highest numerical value, followed by F_2 and F_1 , while the lowest value was observed under F_0 (absolute control). Among the varieties, V_3 (JK 137) recorded the highest numerical test weight, whereas V_1 (KMV 588) recorded the lowest value. However, the differences in test weight due to fertility levels and varieties were statistically non-significant. The interaction effect was also non-significant. The numerical improvement in

test weight under higher fertility may be associated with improved assimilate production and translocation towards grain development.

Grain yield and straw yield

The results revealed that F_3 (125% RDF) recorded significantly higher grain yield and straw yield, whereas F_0 (absolute control) recorded the lowest values. Among the varieties, V_3 (JK 137) produced significantly higher grain yield and straw yield, while V_1 (KMV 588) recorded the lowest values. The interaction between fertility levels and varieties was significant for both grain yield and straw yield. The highest grain yield (21.74 q ha^{-1}) and straw yield (40.56 q ha^{-1}) were recorded under the treatment combination $F_3 \times V_3$ (125% RDF $\times$ JK 137). The increase in grain yield under F_3 may be attributed to better vegetative growth, greater dry matter accumulation, improved leaf area development and enhanced translocation of photosynthates towards developing grains. Similarly, the higher straw yield may be associated with greater biomass production under adequate nutrient availability. The superior performance of V_3 may be attributed to its better genetic potential and efficient utilization of available nutrients, resulting in improved yield attributes and grain production. Similar findings were reported by [Sneha et al. \(2025\)](#) [15], [Divya et al. \(2017\)](#) [16] and [Bhavani et al. \(2021\)](#) [17].

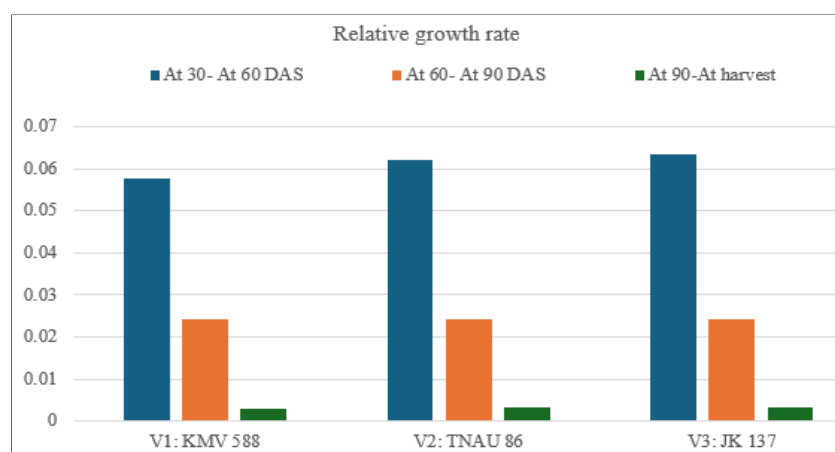


Figure 2. Effect of different on varieties crop growth rate of kodo millet

Harvest index

The data indicated that harvest index was not significantly influenced by fertility levels, varieties or their interaction. Although numerical differences were observed among the treatments, the variation was insufficient to reach statistical significance. This suggests that the increase in biological productivity under higher fertility levels was accompanied by a broadly proportional increase in grain and straw production.

3.3 Economics

Among the fertility levels, F_3 (125% RDF) recorded the highest cost of cultivation of ₹23,831 ha^{-1} . However, the higher productivity obtained under F_3 resulted in the highest gross return of ₹67,712 ha^{-1} ,

net return of ₹43,881 ha^{-1} and B:C ratio of 2.84. Among the varieties, V_3 (JK 137) recorded the highest gross return of ₹51,332 ha^{-1} , net return of ₹29,641 ha^{-1} and B:C ratio of 2.29. The interaction effect on B:C ratio was significant, and the treatment combination $F_3 \times V_3$ (125% RDF $\times$ JK 137) recorded the highest B:C ratio of 3.17. The higher economic returns under F_3 may be mainly attributed to the increased grain and straw productivity obtained through improved crop growth and yield attributes. Similarly, the higher returns recorded under V_3 were associated with its superior grain and straw yield under the experimental conditions.

Table 1. Effect of different fertility levels and varieties on growth parameter of kodo millet

Treatments	Plant height (cm)	Number of tillers (plant ⁻¹)	Dry matter accumulation (g plant ⁻¹)	Leaf area index (LAI)
Fertilizer levels (main plot)				
F_0 : Absolute control	72.80	3.97	4.47	0.80
F_1 : 75% RDF	78.43	5.40	7.48	0.91
F_2 : 100% RDF	82.96	7.13	10.55	1.02
F_3 : 125% RDF	89.22	8.56	13.60	1.09
SEm $\pm$	2.12	0.23	0.31	0.03
CD at 5%	7.34	0.81	1.09	0.12

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Treatments	Plant height (cm)	Number of tillers (plant ⁻¹)	Dry matter accumulation (g plant ⁻¹)	Leaf area index (LAI)
Varieties (sub-plot)				
V ₁ : KMV 588	77.73	5.13	7.23	0.79
V ₂ : TNAU 86	89.33	6.33	9.03	0.95
V ₃ : JK 137	75.49	7.33	10.82	1.13
SEm ±	1.55	0.21	0.17	0.02
CD at 5%	4.65	0.63	0.52	0.06
Interaction (<i>F</i> × <i>V</i>)	NS	S	S	S

Table 2. Interaction effect between different fertility levels and varieties on growth parameter of kodo millet

Fertilizer levels	V ₁ : KMV 588	V ₂ : TNAU 86	V ₃ : JK 137
Number of tillers (plant⁻¹)			
F ₀ : Absolute control	2.70	4.23	4.97
F ₁ : 75% RDF	2.87	5.60	7.73
F ₂ : 100% RDF	6.50	7.07	7.83
F ₃ : 125% RDF	8.47	8.40	8.80
SEm ± = 0.41		CD at 5% = 1.30	
Dry matter accumulation (g plant⁻¹)			
F ₀ : Absolute control	3.32	3.99	6.11
F ₁ : 75% RDF	6.00	8.00	8.45
F ₂ : 100% RDF	8.91	10.08	12.67
F ₃ : 125% RDF	10.70	14.06	16.05
SEm ± = 0.42		CD at 5% = 1.37	
Leaf area index (LAI)			
F ₀ : Absolute control	0.65	0.76	1.00
F ₁ : 75% RDF	0.75	1.02	0.95
F ₂ : 100% RDF	0.85	0.98	1.22
F ₃ : 125% RDF	0.91	1.02	1.34
SEm ± = 0.05		CD at 5% = 0.16	

Table 3. Effect of different fertility levels and varieties on yield attribute and yield of kodo millet

Treatments	Panicle length (cm)	Grains panicle ⁻¹	Test weight (g)	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Harvest index (%)
Fertilizer levels (main plot)						
F ₀ : Absolute control	6.04	103.69	3.47	5.83	10.85	34.61
F ₁ : 75% RDF	7.13	114.62	3.80	11.58	21.07	35.52
F ₂ : 100% RDF	7.85	131.72	3.83	16.40	31.03	34.66
F ₃ : 125% RDF	8.27	152.47	4.15	19.46	36.17	35.05
SEm ±	0.25	5.61	0.13	0.39	0.60	1.06
CD at 5%	0.87	19.42	NS	1.34	2.09	NS
Varieties (sub-plot)						
V ₁ : KMV 588	6.33	122.03	3.77	12.29	22.81	35.01
V ₂ : TNAU 86	7.55	123.89	3.69	12.90	24.38	34.66
V ₃ : JK 137	8.08	130.95	3.98	14.77	27.14	35.21
SEm ±	0.25	2.07	0.16	0.35	0.67	0.63
CD at 5%	0.74	6.21	NS	1.06	2.00	NS
Interaction (<i>F</i> × <i>V</i>)	NS	NS	NS	S	S	NS

(continued on next page)

Table 4. Interaction effect between different fertility levels and varieties on yield attribute and yield of kodo millet

Fertilizer levels	V ₁ : KMV 588	V ₂ : TNAU 86	V ₃ : JK 137
Grain yield (kg ha ⁻¹)			
F ₀ : Absolute control	6.35	5.60	5.54
F ₁ : 75% RDF	9.22	11.84	13.68
F ₂ : 100% RDF	15.43	15.66	18.12
F ₃ : 125% RDF	18.15	18.51	21.74
SEm ± = 0.70	CD at 5% = 2.18		
Straw yield (kg ha ⁻¹)			
F ₀ : Absolute control	11.58	10.56	10.42
F ₁ : 75% RDF	16.85	21.77	24.59
F ₂ : 100% RDF	29.05	31.02	33.00
F ₃ : 125% RDF	33.77	34.17	40.56
SEm ± = 1.25	CD at 5% = 3.87		

Table 5. Effect of different fertility levels and varieties on economics of kodo millet

Treatments	Gross return Rs. ha ⁻¹	Net return Rs. ha ⁻¹	B:C ratio
Fertilizer levels (main plot)			
F ₀ : Absolute control	20276	1801	1.10
F ₁ : 75% RDF	40217	18523	1.85
F ₂ : 100% RDF	57141	34379	2.51
F ₃ : 125% RDF	67712	43881	2.84
SEm ±	-	-	0.07
CD at 5%	-	-	0.23
Varieties (sub-plot)			
V ₁ : KMV 588	42740	21050	1.92
V ₂ : TNAU 86	44938	23247	2.01
V ₃ : JK 137	51332	29641	2.29
SEm ±	-	-	0.05
CD at 5%	-	-	0.16
Interaction (F × V)	-	-	S

Table 6. Interaction effect between different fertility levels and varieties on economics of kodo millet

Fertilizer levels	V ₁ : KMV 588	V ₂ : TNAU 86	V ₃ : JK 137
B:C ratio			
F ₀ : Absolute control	1.19	1.06	1.04
F ₁ : 75% RDF	1.48	1.90	2.19
F ₂ : 100% RDF	2.36	2.41	2.77
F ₃ : 125% RDF	2.65	2.70	3.17
SEm ± = 0.11	CD at 5% = 0.35		

Conclusion

The present study conducted during Kharif 2025 under rainfed conditions in the Bastar Plateau region of Chhattisgarh demonstrated that both fertility level and variety influenced the growth, productivity and economic performance of kodo millet. Among the fertility levels, 125% RDF (F₃) recorded superior performance for major growth parameters, yield attributes, grain and straw yield, and economic returns, with a grain yield of 19.46 q ha⁻¹, gross return of ₹67,712 ha⁻¹, net return of ₹43,881 ha⁻¹ and B:C ratio of 2.84.

Among the varieties, JK 137 (V₃) showed better performance for tillering, dry matter accumulation, LAI, growth characteristics, yield attributes, grain and straw yield, and economic returns. The interaction of 125% RDF × JK 137 (F₃ × V₃) recorded the highest grain yield (21.74 q ha⁻¹), straw yield (40.56 q ha⁻¹) and B:C ratio (3.17). Overall, the findings indicate that 125% RDF in combination with JK 137 resulted in higher productivity and economic returns of kodo mil-

let under the rainfed conditions of the Bastar Plateau during the study season. The treatment combination may therefore be considered a promising nutrient-variety combination for enhancing kodo millet productivity under similar agro-ecological conditions.

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Authors

Suhail Khan

Postgraduate Scholar, Agronomy Section, S. G. College of Agriculture and Research Station, Jagdalpur, IGKV, Raipur, Chhattisgarh, India

Narendra Kumar

Assistant Professor, Agronomy Section, Lingo Mudiyal College of Agriculture and Research Station, Narayanpur, IGKV, Raipur, Chhattisgarh, India

Pravindra Kumar Salam

Scientist, Agronomy Section, S. G. College of Agriculture and Research Station, IGKV, Jagdalpur, Chhattisgarh, India

Tejpal Chandrakar

Senior Scientist, Section of Soil Science and Agriculture Chemistry, S. G. College of Agriculture and Research Station, IGKV, Jagdalpur, Chhattisgarh, India

Devendra Pratap Singh

Professor, Department of Agriculture Statistics and Social Science, Collage of Agriculture, IGKV, Raipur, Chhattisgarh, India

Bhumika Tandav

Postgraduate Scholar, Floriculture and Landscaping, Krantikari Debridhur College of Horticulture and Research Station, MGVVV, Durg, Chhattisgarh, India

Divya Sahu

Postgraduate Scholar, Agronomy Section, S. G. College of Agriculture and Research Station, Jagdalpur, IGKV, Raipur, Chhattisgarh, India