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Influence of nutrient levels and weed management practices on growth performance of finger millet (*Eleusine coracana* L.) cultivars under Bastar plateau region of Chhattisgarh

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Abstract
A field experiment was conducted to evaluate the influence of different varieties, nutrient levels, and weed management practices on the growth parameters of finger millet (*Eleusine coracana*) under the agro-climatic conditions of the Bastar Plateau region of Chhattisgarh. The study was laid out in a split-split plot design with three varieties (Indira Ragi-1, CG Ragi-2, and CG Ragi-3), three nutrient levels (75%, 100%, and 125% of recommended dose of nitrogen), and four weed management practices (pre-emergence herbicide + mechanical weeding, post-emergence herbicide, hand weeding twice, and weedy check). Results revealed non-significant differences in plant population across treatments at all stages. However, other growth parameters were significantly influenced from 60 DAT onwards. Among varieties, CG Ragi-2 consistently outperformed others in plant height, dry weight, leaf area, LAI, tiller number, CGR, and RGR, followed by Indira Ragi-1. The application of 125% RDN significantly enhanced all growth traits, while the lowest values were recorded under 75% RDN. Hand weeding twice was the most effective weed management practice, showing maximum values for all growth parameters, while the weedy check recorded the lowest. Significant interactions between variety and nutrient level, as well as three-way interactions including weed management, further highlighted the synergistic effect of optimal genotype, fertility, and weed control. Overall, the combination of CG Ragi-2 with 125% RDN and hand weeding twice proved most effective in enhancing the growth and biomass accumulation of finger millet. These findings underline the importance of integrated agronomic management in improving crop performance under rainfed conditions.

Keywords: Finger millet, varieties, nutrient levels, weed management, growth parameters

Introduction
Finger millet (*Eleusine coracana* L.), commonly known as ragi, is a vital nutri-cereal grown primarily in arid and semi-arid regions of India, prized for its high calcium, dietary fiber, and antioxidant content (Devi *et al.*, 2014) [4]. Its resilience to abiotic stress and adaptability to marginal lands make it a staple for rural and tribal populations, particularly in the Bastar Plateau region of Chhattisgarh (Upadhyaya *et al.*, 2007; Agricultural Research, 2018) [28]
Chhattisgarh has emerged as a millet hub in recent years. The state's Millet Mission (launched in September 2021) has doubled the area under millets from 96,000 ha to a targeted 160,000 ha in the 2023 kharif season and increased average ragi productivity from 4.5 q/ac to about 9 q/ac. However, statewide small millet cultivation area declined from 119,000 ha in 2014-15 to 44,000 ha in 2022-23; yet, productivity nearly doubled from ~232 kg/ha to ~492 kg/ha during the same period Despite these positive trends, recent data show Chhattisgarh's millet production dropped from 33.7×10^3 tonnes in 2018-19 to 23.4×10^3 tonnes in 2022-23. According to Ministry of Agriculture estimates, the state produced merely around 1,010 tonnes of ragi in 2021-22, reflecting limited adoption relative to national benchmarks.
In the Bastar Plateau, where average yields remain as low as 4-9 q/ha under traditional broadcast and no-input practices, the sustenance of tribal farming systems is challenged by outdated agronomy and soil fertility constraints.

Growth parameters such as plant height, tiller count, leaf area index (LAI), and biomass are key indicators of agronomic efficiency and directly influence ultimate productivity (Patel *et al.*, 2010; Kumar *et al.*, 2015) [11, 8]. Crop growth and development are profoundly influenced by nutrient availability. Balanced application of nitrogen, phosphorus, and potassium enhances chlorophyll synthesis, leaf area expansion, root proliferation, and biomass accumulation thereby improving vegetative vigor (Singh & Prasad, 2008; Kumar *et al.*, 2015) [24, 8]. Conversely, weed competition during the initial 30-40 days of crop growth can significantly limit light, nutrients, water, and space, suppressing tillering and canopy development (Rathore *et al.*, 2012; Yadav *et al.*, 2017) [19, 29].

Cultivar-specific response further complicates agronomic optimization different genotypes show varied growth dynamics under input management, necessitating genotype × management studies to tailor locally adapted recommendations (Ravindran *et al.*, 2018) [20].

Moreover, integrated weed and nutrient management can yield synergistic benefits: weed control often improves nutrient uptake, while balanced fertilization enhances crop competition against weeds (Channappagoudar & Biradar, 2007) [1]. Given Chhattisgarh especially Bastar is lagging in both area and production despite policy support, there is a compelling need for targeted research. The present study was therefore designed to evaluate the influence of varying nutrient levels and weed management practices on growth parameters plant height, tiller count, leaf area index, and biomass of selected finger millet cultivars under Bastar Plateau conditions. Such insights aim to strengthen sustainable, input-efficient, and productivity-enhancing strategies for tribal agroecosystems.

Material and Methods

The present field experiment entitled "Influence of nutrient levels and weed management practices on growth performance of finger millet (*Eleusine coracana* L.) cultivars under Bastar plateau region of Chhattisgarh" was conducted during the Summer seasons of 2021 and 2022 at the Instructional Cum Research Farm, S.G. College of Agriculture and Research Station, Jagdalpur, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur (C.G.). The experimental site is geographically located at 19°5′ to 20°15′ N latitude and 80°30′ to 82°15′ E longitude, with an average altitude of 552 meters above mean sea level. The climate of the region is sub-humid with monsoonal rainfall, receiving an annual average precipitation of 1200-1400 mm, mostly during June to September.

The experiment was laid out in a split-split plot design with three replications. The treatments consisted of: Main plot (Varieties) V_1: Indira Ragi-1, V_2: CG Ragi-2, V_3: CG Ragi-3. Sub plot (Nutrient levels)-N_1: 75% Recommended Dose of Nutrients (RDN), N_2: 100% RDN, N_3: 125% RDN. Sub-sub plot (Weed management practices)-W_1: Hand weeding twice (20 and 40 DAS), W_2: Oxadiargyl 80 g a.i. ha-1, PE + One mechanical weeding at 40 DAT W_3: Bispyribac Na 20 g a.i .ha-1, PoE, W4: Weedy check. The recommended dose of nutrients was 60:30:30 kg $N:P_2O_5:K_2O$ ha^{-1}, applied through urea, single super phosphate, and muriate of potash, respectively. Nitrogen was applied in two equal splits—half as basal and half at 30 DAS. The crop was sown at a spacing of 30 cm × 10 cm, using a seed rate of 5 kg ha^{-1}. Uniform agronomic practices were followed for all treatments. The field was prepared with a tractor-drawn cultivator, and plots were leveled using plankers. Seeds were sown manually in rows, and gap filling was done at 10 DAS. Irrigation was not required due to adequate rainfall during the crop growth period. Growth observations were recorded at 30, 60, and 90 days after sowing (DAS) and at harvest. The parameters studied included: Plant height (cm), Number of tillers ($plant^{-1}$), Leaf area (cm), Leaf area index (LAI), Dry matter accumulation (g $plant^{-1}$), Crop Growth Rate (CGR), Relative Growth Rate (RGR), Leaf area was calculated using the formula by Montgomery (1911), and LAI was derived using standard procedures. CGR and RGR were calculated as per the methodology described by Watson (1952).

Results and Discussion

Plant population (hills m-2)

The data pertaining to plant population of finger millet as influenced by different varieties, nutrient levels, and weed management practices, recorded at 30 days after transplanting (DAT) and at harvest, are presented in Table 1. The statistical analysis revealed that differences in plant population across all treatments were non-significant at both observational stages.

Plant height (cm)

As presented in Table 1, plant height of finger millet was not significantly influenced by any treatment at 30 days after transplanting (DAT). However, significant differences were observed at 60 DAT, 90 DAT, and at harvest. The lack of variation at the early stage may be attributed to similar initial growth rates across treatments.

With respect to varietal performance, CG Ragi-2 (V_2) consistently recorded the tallest plants at 60 and 90 DAT and at harvest, which was statistically at par with Indira Ragi-1 (V_1), while CG Ragi-3 (V_3) exhibited the lowest plant height throughout the study. These differences can be ascribed to genetic variation in vegetative vigour and responsiveness to applied inputs (Kumari *et al.*, 2017; Patel *et al.*, 2019) [9, 12]. As the crop matured, the cumulative effect of varietal growth potential became more evident.

Plant height was also significantly influenced by nutrient levels from 60 DAT onwards. The application of 125% RDN (N_3) resulted in significantly taller plants compared to other treatments. This response is likely due to improved nitrogen availability enhancing cell division and elongation, thereby promoting greater vegetative growth (Sharma *et al.*, 2016; Devi *et al.*, 2020) [23, 3].

Among weed management practices, hand weeding twice (W_3) produced the tallest plants across all stages, while the weedy check (W_4) recorded the shortest. Effective weed control likely reduced competition for light, nutrients, and water, facilitating better plant growth (Tiwari *et al.*, 2018; Jat *et al.*, 2019) [27, 7].

The interaction between varieties and nutrient levels was found significant at 90 DAT and harvest during both years and on a mean basis (Table 1.1). The combination of CG Ragi-2 (V_2) with 125% RDN (N_3) resulted in the maximum plant height, although it was statistically at par with $V_1 \times N_1$, $V_1 \times N_3$, $V_2 \times N_1$, $V_2 \times N_2$, and $V_3 \times N_3$. This indicates that varietal responsiveness to nutrient availability becomes more pronounced during the later stages of growth when nutrient uptake and biomass accumulation are at their peak (Sharma *et al.*, 2016; Kumari *et al.*, 2017) [23, 9]. Other

interaction effects were non-significant, suggesting that the individual influence of each factor predominated (Jat *et al.*, 2019) [7].

Dry weight (g hill^{-1})

The data presented in Table 2 indicate that plant dry weight was not significantly affected by any treatment at 30 days after transplanting (DAT). However, significant differences were observed at 60 DAT, 90 DAT, and at harvest during both years and on a pooled mean basis. The absence of early-stage differences may be attributed to uniform growth conditions and minimal biomass accumulation during the initial vegetative phase.

Among the varieties, CG Ragi-2 (V_2) recorded significantly higher plant dry weight at all observed stages—60 DAT, 90 DAT, and at harvest—during both years and on the mean basis, followed by Indira Ragi-1 (V_1), while CG Ragi-3 (V_3) produced the least. The superior performance of CG Ragi-2 can be attributed to its vigorous vegetative growth, well-developed canopy, and efficient source-sink relationship, which collectively enhance biomass production (Somasundaram *et al.*, 2009) [25].

With respect to nutrient levels, 125% RDN (N_3) resulted in significantly greater plant dry weight at all stages compared to lower nutrient levels. Enhanced nitrogen availability likely promoted higher nitrogen uptake, stimulating tillering, leaf development, and overall metabolic activity, thereby supporting increased dry matter accumulation (Ramesh *et al.*, 2002; Rajendran & Kumar, 2012) [16, 15].

Weed management also significantly influenced plant dry weight from 60 DAT onwards. The treatment with hand weeding twice (W_3) recorded the highest dry weight, while the lowest was observed under the weedy check (W_4). These findings underscore the importance of weed control in reducing competition for water, nutrients, and light, thereby fostering improved biomass accumulation (Rao, 2000; Chauhan & Johnson, 2010) [17, 2].

The interaction between varieties and nutrient levels was significant at 60 DAT, 90 DAT, and harvest in both years and on the mean basis (Table 2.1-2.2). At 60 DAT, the combination of CG Ragi-2 (V_2) with 125% RDN (N_3) resulted in significantly higher dry weight hill^{-1}, which was at par with CG Ragi-2 × 75% RDN (N_1), CG Ragi-2 × 100% RDN (N_2), and Indira Ragi-1 × 125% RDN (V_1N_3).

At 90 DAT, during the first year, Indira Ragi-1 (V_1) with 100% and 125% RDN (N_2, N_3) showed significantly higher dry weight hill^{-1}. During the second year, CG Ragi-2 (V_2) combined with 125% RDN (N_3) recorded the highest values, statistically similar to its interactions with 75% and 100% RDN and V_1 × 125% RDN. On the two-year mean basis, the highest dry weight hill^{-1} was observed under V_1 × 125% RDN, which was at par with all three nutrient levels under CG Ragi-2.

At harvest, CG Ragi-2 × 125% RDN consistently produced the highest dry weight hill^{-1} across both years, statistically similar to V_1 × 125% RDN and V_2 × 100% RDN in 2021. These results align with the findings of Sharma *et al.* (2016) and Kumari *et al.* (2017) [23, 9], who reported that varietal responses to nutrient availability become more pronounced during later growth stages.

The three-way interaction of variety × nutrient level × weed management was significant at 90 DAT (Table 4.3.2). The combination CG Ragi-3 × 125% RDN × transplanting at 20 and 40 DAT recorded the highest dry weight hill^{-1}, though it was at par with several other effective combinations. These included: V_1 × 100% RDN × hand weeding twice ($V_1N_2W_3$), V_1 × 125% RDN × pre-emergence herbicide + mechanical weeding ($V_1N_3W_1$), V_1 × 125% RDN × post-emergence herbicide ($V_1N_3W_2$), V_1 × 125% RDN × hand weeding twice ($V_1N_3W_3$), V_2 × 75% RDN × post-emergence herbicide ($V_2N_1W_2$), V_2 × 75% RDN × hand weeding twice ($V_2N_1W_3$), V_2 × 100% RDN × pre-emergence herbicide + mechanical weeding ($V_2N_2W_1$), V_2 × 100% RDN × hand weeding twice ($V_2N_2W_3$), V_2 × 125% RDN × pre-emergence herbicide + mechanical weeding ($V_2N_3W_1$), V_3 × 125% RDN × hand weeding twice ($V_3N_3W_3$). Similar trends were observed in the second year, where several interactions, including $V_1N_3W_1$, $V_2N_1W_2$, $V_2N_1W_3$, $V_2N_2W_3$, and $V_2N_3W_1$, produced comparable results. On a mean basis, these combinations continued to show parity, highlighting the synergistic effect of improved genotype, optimal nutrient application, and effective weed management in enhancing dry matter accumulation (Patil *et al.*, 2007; Rao *et al.*, 2009) [14, 18].

Leaf area (cm hill^{-1})

The data presented in Table 3 indicate that leaf area (cm hill^{-1}) was not significantly influenced by any treatment at 30 days after transplanting (DAT). However, significant differences emerged at 60 DAT, 90 DAT, and at harvest, reflecting the enhanced canopy development typical of later crop growth stages (Ramesh *et al.*, 2002) [16].

Among the varieties, CG Ragi-2 (V_2) consistently exhibited the highest leaf area across all growth stages, followed by Indira Ragi-1 (V_1), while CG Ragi-3 (V_3) recorded the lowest. These variations are likely attributed to genotypic differences in vegetative vigour, leaf size, and canopy architecture, as supported by earlier findings (Somasundaram *et al.*, 2009; Kumari *et al.*, 2017) [25, 9].

Nutrient levels significantly influenced leaf area from 60 DAT onwards. The application of 125% RDN (N_3) resulted in the highest leaf area, followed by 100% RDN (N_2), while the lowest was observed under 75% RDN (N_1). This trend suggests that higher nitrogen availability enhances leaf expansion and chlorophyll synthesis, leading to improved foliage development (Rao *et al.*, 2009; Rajendran & Kumar, 2012) [18, 15].

Weed management practices also exhibited significant effects from 60 DAT onwards. Hand weeding twice (W_3) resulted in the maximum leaf area, followed by pre-emergence herbicide + mechanical weeding (W_1) and post-emergence herbicide (W_2). The lowest leaf area was recorded under the weedy check (W_4). Effective weed control likely reduced competition for essential resources such as light, nutrients, and water, thereby supporting better foliar development (Chauhan & Johnson, 2010; Tiwari *et al.*, 2018) [2, 27].

Leaf area index (LAI)

The data presented in Table 4 reveal that leaf area index (LAI) was not significantly influenced by any treatment at 30 days after transplanting (DAT). However, significant differences became evident at 60 DAT, 90 DAT, and harvest stages, indicating that variations in canopy development among treatments emerged progressively as the crop matured (Ramesh *et al.*, 2002) [16].

Among the varieties, LAI differences were non-significant at 30 DAT. From 60 DAT onwards, however, CG Ragi-2

(V_2) consistently recorded the highest LAI, which was statistically at par with Indira Ragi-1 (V_1), while CG Ragi-3 (V_3) exhibited the lowest values. This variation is likely attributable to genotypic differences in leaf expansion capacity, canopy structure, and overall vigour (Somasundaram *et al.*, 2009; Kumari *et al.*, 2017) [25, 9].

Nutrient level treatments did not significantly affect LAI at 30 DAT but showed significant influence at later growth stages. The application of 125% RDN (N_3) consistently resulted in the highest LAI, statistically at par with 100% RDN (N_2), while the lowest LAI was recorded under 75% RDN (N_1). Enhanced nitrogen availability likely promoted increased leaf expansion and photosynthetic surface area, contributing to greater LAI values (Rao *et al.*, 2009; Rajendran & Kumar, 2012) [18, 15].

Weed management practices had non-significant effects on LAI at 30 DAT but significantly influenced it from 60 DAT onwards. Hand weeding twice (W_3) recorded the highest LAI, statistically similar to pre-emergence herbicide + mechanical weeding (W_1) and post-emergence herbicide (W_2). The lowest LAI was observed under the weedy check (W_4). These results highlight the importance of effective weed control in minimizing competition for light, nutrients, and moisture, thereby facilitating improved canopy development (Chauhan & Johnson, 2010; Tiwari *et al.*, 2018) [2, 27].

Number of total tillers (hill^{-1})

The data presented in Table 5 indicate that the total number of tillers per hill was statistically non-significant across treatments at 30 days after transplanting (DAT). However, significant differences were observed at 60 DAT, 90 DAT, and at harvest, suggesting that tiller differentiation is more responsive to treatment effects during the later stages of crop growth (Ramesh *et al.*, 2002) [16].

Among the varieties, CG Ragi-2 (V_2) consistently produced the highest number of total tillers hill^{-1} at all growth stages, followed by Indira Ragi-1 (V_1), whereas CG Ragi-3 (V_3) recorded the lowest tiller count. The superior tillering performance of V_2 could be attributed to its greater genetic potential and better adaptability under the prevailing agro-climatic conditions (Somasundaram *et al.*, 2009; Patil *et al.*, 2007) [25, 14].

Table 1: Effect of varieties, nutrient levels and weed management practices on plant population at 30 DAT and at harvest and plant height of finger millet at various time intervals

Treatment	Plant population (hills m-2)						Plant height (cm)											
	30 DAT			At harvest			30 DAT			60 DAT			90 DAT			At harvest		
	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean
Varieties																		
V1: Indira Ragi-1	29.06	29.89	29.48	28.72	29.56	29.14	43.58	46.08	44.83	73.47	74.92	74.20	92.47	94.29	93.38	112.06	113.44	112.75
V2: CG Ragi-2	29.14	30.00	29.57	28.81	29.67	29.24	44.56	46.97	45.76	74.92	76.37	75.64	93.92	95.74	94.83	113.58	114.96	114.27
V3: CG Ragi-3	29.00	29.72	29.36	28.67	29.36	29.02	43.53	45.91	44.72	69.97	71.41	70.69	87.64	89.46	88.55	107.44	108.82	108.13
SEm±	0.06	0.08	0.08	0.06	0.10	0.07	0.43	0.70	0.50	0.50	0.85	0.60	0.77	0.80	0.78	0.75	0.70	0.90
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.50	2.60	1.80	2.33	2.40	2.38	2.35	2.10	2.70
Nutrient levels																		
N1: 75% RDN	29.03	29.81	29.42	28.69	29.47	29.08	43.28	45.71	44.49	71.50	72.94	72.22	89.83	91.65	90.74	108.97	110.35	108.97
N2: 100% RDN	29.06	29.83	29.45	28.72	29.50	29.14	43.56	45.99	44.77	72.58	74.03	73.31	90.92	92.74	91.83	110.83	112.21	110.83
N3: 125% RDN	29.11	29.97	29.54	28.78	29.61	29.20	44.83	47.25	46.04	74.28	75.73	75.00	93.28	95.09	94.18	113.28	114.66	113.28
SEm±	0.09	0.07	0.04	0.09	0.08	0.04	0.45	0.61	0.46	0.40	0.30	0.42	0.50	0.70	0.60	0.58	0.41	0.53
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.20	0.90	1.30	1.50	2.10	1.80	1.74	1.23	1.61
Weed management practices																		
W1	29.07	29.89	29.48	28.74	29.52	29.13	43.96	46.41	45.19	73.70	75.12	74.41	92.26	94.05	93.16	111.81	113.19	112.50
W2	29.04	29.85	29.45	28.70	29.52	29.11	43.67	46.07	44.87	72.15	73.60	72.87	90.70	92.50	91.60	110.37	111.75	111.06
W3	29.15	29.93	29.54	28.81	29.59	29.20	44.48	47.04	45.76	75.19	76.66	75.92	93.74	95.59	94.67	113.48	114.86	114.17
W4	29.00	29.81	29.41	28.67	29.48	29.08	43.44	45.75	44.60	70.11	71.56	70.84	88.67	90.50	89.58	108.44	109.82	109.13
SEm±	0.07	0.07	0.05	0.07	0.08	0.05	0.88	0.80	0.68	0.31	0.35	0.40	0.43	0.50	0.48	0.44	0.52	0.51
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.93	1.15	1.20	1.30	1.50	1.44	1.35	1.56	1.54

Note;-W1: Oxadiargyl 80 g a.i. ha-1, PE + One mechanical weeding at 40 DAT, W2: Bispyribac Na 20 g a.i .ha-1, PoE, W3: Hand weeding twice at 20 and 40 DAT and W4: Weedy check

Table 1.1: Interaction effect of varieties and nutrient levels on plant height at 90 DAT and at harvest of finger millet

Treatment	Plant height (cm)							
Nutrient levels	**N1: 75% RDN**	**N2: 100% RDN**	**N3: 125% RDN**	**Mean**	**N1: 75% RDN**	**N2: 100% RDN**	**N3: 125% RDN**	**Mean**
Varieties	90 DAT (2021)				At harvest (2021)			
V1: Indira Ragi-1	91.67	93.25	92.17	92.36	110.67	113.25	113.08	112.33
V2: CG Ragi-2	93.92	93.58	94.58	94.03	112.92	113.33	114.58	113.61
V3: CG Ragi-3	83.92	85.92	93.08	87.64	103.33	105.92	112.17	107.14
Mean	89.84	90.92	93.28		108.97	110.83	113.28	
	2022				2022			
V1: Indira Ragi-1	93.43	95.09	94.92	94.48	104.71	114.63	114.46	111.27
V2: CG Ragi-2	95.80	95.42	96.34	95.85	114.30	114.71	115.96	114.99
V3: CG Ragi-3	85.73	87.72	94.01	89.15	112.05	107.30	113.55	110.97
Mean	91.65	92.74	95.09		110.35	112.21	114.66	
	Two years mean				Two years mean			
V1: Indira Ragi-1	92.55	94.17	94.00	93.57	111.36	113.94	113.77	113.02
V2: CG Ragi-2	94.86	94.50	95.46	94.94	113.61	114.02	115.27	114.30
V3: CG Ragi-3	84.82	86.82	93.09	88.24	104.02	106.61	112.86	107.83
Mean	90.74	91.83	94.18		109.66	111.52	113.97	

	2021		2022		Two years mean		2021		2022		Two years mean	
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
V at same N	1.21	3.73	1.11	3.41	1.15	3.55	1.20	3.70	1.21	3.71	1.19	3.68
N at same V	1.58	5.37	1.45	5.00	1.49	5.12	1.57	5.33	1.58	5.36	1.56	5.30

Table 2: Effect of varieties, nutrient levels and weed management practices on dry weight of finger millets at various time intervals

Treatment	Dry weight (g hill^{-1})											
	30 DAT			60 DAT			90 DAT			At harvest		
	2021	**2022**	**Mean**	**2021**	**2022**	**Mean**	**2021**	**2022**	**Mean**	**2021**	**2022**	**Mean**
Varieties												
V1: Indira Ragi-1	2.03	2.10	2.06	17.23	18.98	18.10	31.98	33.86	32.92	39.61	41.51	40.56
V2: CG Ragi-2	2.06	2.15	2.11	17.57	19.46	18.51	32.51	34.47	33.49	40.33	42.26	41.30
V3: CG Ragi-3	2.03	2.09	2.06	16.70	18.42	17.56	30.86	32.62	31.74	37.39	39.35	38.37
SEm±	0.05	0.05	0.03	0.10	0.12	0.11	0.13	0.12	0.14	0.14	0.11	0.12
CD (P=0.05)	NS	NS	NS	0.30	0.37	0.34	0.40	0.36	0.43	0.44	0.34	0.38
Nutrient levels												
N1: 75% RDN	2.01	2.11	2.06	16.69	18.40	17.55	30.83	32.54	31.69	37.94	39.73	38.84
N2: 100% RDN	2.03	2.11	2.07	17.23	19.01	18.12	32.01	33.94	32.97	39.29	41.19	40.24
N3: 125% RDN	2.08	2.13	2.10	17.57	19.46	18.51	32.51	34.47	33.49	40.10	42.20	41.15
SEm±	0.07	0.06	0.06	0.10	0.08	0.09	0.07	0.08	0.07	0.12	0.14	0.12
CD (P=0.05)	NS	NS	NS	0.32	0.26	0.27	0.22	0.24	0.22	0.37	0.42	0.38
Weed management practices												
W1	2.04	2.12	2.09	17.31	19.14	18.22	31.93	33.82	32.87	39.23	41.28	40.26
W2	2.04	2.10	2.07	17.08	18.92	18.00	31.60	33.46	32.53	38.93	40.79	39.86
W3	2.06	2.15	2.10	17.54	19.47	18.50	32.65	34.62	33.64	40.31	42.25	41.28
W4	2.01	2.09	2.05	16.73	18.29	17.51	30.96	32.70	31.83	37.96	39.84	38.90
SEm±	0.08	0.08	0.08	0.06	0.10	0.08	0.20	0.25	0.22	0.30	0.26	0.31
CD (P=0.05)	NS	NS	NS	0.18	0.30	0.24	0.60	0.75	0.66	0.90	0.78	0.94

Note;-W1: Oxadiargyl 80 g a.i. ha-1, PE + One mechanical weeding at 40 DAT, W2: Bispyribac Na 20 g a.i .ha-1, PoE, W3: Hand weeding twice at 20 and 40 DAT and W4: Weedy check

Table 2.1: Interaction effect of varieties and nutrient levels on dry weight of finger millet at various time intervals

Treatment	Dry weight (g hill^{-1})											
Nutrient levels	N1	N2	N3	Mean	N1	N2	N3	Mean	N1	N2	N3	Mean
Varieties	60 DAT (2021)				90 DAT (2021)				At harvest (2021)			
V1: Indira Ragi-1	16.68	17.15	17.51	17.11	31.43	32.73	32.73	31.98	38.94	39.22	40.66	39.61
V2: CG Ragi-2	17.53	17.67	17.84	17.68	32.42	32.66	32.66	32.51	40.09	40.15	40.75	40.33
V3: CG Ragi-3	15.88	16.88	17.35	16.70	28.66	32.16	32.16	30.86	34.80	38.49	38.89	37.39
Mean	16.69	17.23	17.57		30.83	32.51	32.51		37.94	39.29	40.10	
	2022				2022				2022			
V1: Indira Ragi-1	18.42	18.79	19.49	18.90	33.19	33.72	34.66	33.86	40.95	40.81	42.76	41.51
V2: CG Ragi-2	19.42	19.47	19.73	19.54	34.35	34.40	34.67	34.47	41.86	42.08	42.85	42.26
V3: CG Ragi-3	17.35	18.76	19.16	18.42	30.08	33.69	34.09	32.62	36.38	40.68	40.99	39.35
Mean	18.40	19.01	19.46		32.54	33.94	34.47		39.73	41.19	42.20	
	Two years mean				Two years mean				Two years mean			
V1: Indira Ragi-1	17.55	17.97	18.50	18.00	32.31	32.76	33.70	32.92	39.94	40.02	41.71	40.56
V2: CG Ragi-2	18.47	18.57	18.79	18.61	33.38	33.44	33.66	33.49	40.98	41.12	41.80	41.30
V3: CG Ragi-3	16.61	17.82	18.25	17.56	29.37	32.73	33.12	31.74	35.59	39.59	39.94	38.37
Mean	17.55	18.12	18.51		31.69	32.97	33.49		38.84	40.24	41.15	
	2021		2022	Two years mean		2021		2022	Two years mean		2021	
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
V at same N	0.14	0.45	0.18	0.55	0.15	0.47	0.12	0.38	0.13	0.42	0.12	0.38
N at same V	0.03	0.11	0.03	0.10	0.03	0.09	0.03	0.10	0.03	0.10	0.03	0.09
Note-N1: 75% RDN, N2: 100% RDN, N3: 125% RDN												

	2022		Two years mean									
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
V at same N	0.21	0.64	0.24	0.74	0.21	0.66						
N at same V	0.05	0.17	0.05	0.17	0.04	0.15						

Table 2.2: Interaction effect of varieties (V), nutrient levels (N) and weed management practices (W) on dry weight at 90 DAT of finger millet

Treatment	Dry weight at 90 DAT (g hill^{-1})														
W	W1	W2	W3	W4	Mean	W1	W2	W3	W4	Mean	W1	W2	W3	W4	Mean
V X N	2021					2022					Two years mean				
V1N1	31.49	30.89	32.02	31.29	31.43	33.42	32.82	33.95	32.55	33.19	32.46	31.86	32.99	31.92	32.31
V1N2	32.19	32.09	32.52	30.36	31.79	34.12	34.02	34.45	32.29	33.72	33.16	33.06	33.49	31.33	32.76
V1N3	33.02	32.69	33.19	32.02	32.73	34.95	34.62	35.12	33.95	34.66	33.99	33.66	34.16	32.99	33.70
V2N1	31.89	32.86	33.02	31.89	32.42	33.82	34.79	34.95	33.82	34.35	32.86	33.82	33.99	32.86	33.38
V2N2	32.79	31.79	33.69	31.62	32.47	34.72	33.72	35.62	33.55	34.40	33.76	32.76	34.66	32.59	33.44
V2N3	32.86	31.96	34.05	31.76	32.66	34.79	33.89	36.31	33.69	34.67	33.82	32.92	35.18	32.72	33.66
V3N1	29.13	28.77	30.81	25.93	28.66	30.72	30.02	32.74	26.85	30.08	29.92	29.40	31.78	26.39	29.37
V3N2	31.52	31.86	32.06	31.62	31.76	33.45	33.79	33.99	33.55	33.69	32.49	32.82	33.02	32.59	32.73
V3N3	32.46	31.52	32.52	32.12	32.16	34.39	33.45	34.45	34.05	34.09	33.42	32.49	33.49	33.09	33.12
Mean	31.93	31.60	32.65	30.96		33.82	33.46	34.62	32.70		32.87	32.53	33.64	31.83	
	SEm±		CD (P=0.05)			SEm±		CD (P=0.05)			SEm±			CD (P=0.05)	
V at same N & W	0.47		1.43			0.48		1.46			0.46			1.43	
V X N X W	0.50		1.53			0.51		1.55			0.50			1.52	

Table 2.3: Interaction effect of varieties (V), nutrient levels (N) and weed management practices (W) on dry weight at harvest of finger millet

Treatment	Dry weight at harvest (g hill^{-1})														
W	W1	W2	W3	W4	Mean	W1	W2	W3	W4	Mean	W1	W2	W3	W4	Mean
V X N	2021					2022					Two years mean				
V1N1	39.09	38.49	39.95	38.22	38.94	40.85	40.59	42.05	40.32	40.95	39.97	39.54	41.00	39.27	39.94
V1N2	39.79	39.01	40.45	37.63	39.22	41.89	39.76	42.55	39.05	40.81	40.84	39.39	41.50	38.34	40.02
V1N3	40.95	40.62	41.12	39.95	40.66	43.05	42.72	43.22	42.05	42.76	42.00	41.67	42.17	41.00	41.71
V2N1	38.82	40.95	41.45	39.14	40.09	40.92	42.39	42.89	41.24	41.86	39.87	41.67	42.17	40.19	40.98
V2N2	40.72	39.72	41.62	38.54	40.15	42.15	42.72	42.82	40.64	42.08	41.44	41.22	42.22	39.59	41.12
V2N3	40.79	39.89	42.64	39.69	40.75	42.89	41.99	44.74	41.79	42.85	41.84	40.94	43.69	40.74	41.80
V3N1	35.52	34.82	37.54	31.31	34.80	37.62	36.23	39.64	32.03	36.38	36.57	35.53	38.59	31.67	35.59
V3N2	38.25	38.59	38.79	38.35	38.49	40.89	40.35	41.02	40.45	40.68	39.57	39.47	39.90	39.40	39.59
V3N3	39.19	38.25	39.25	38.85	38.89	41.29	40.35	41.35	40.95	40.99	40.24	39.30	40.30	39.90	39.94
Mean	39.23	38.93	40.31	37.96		41.28	40.79	42.25	39.84		40.26	39.86	41.28	38.90	
	SEm±		CD (P=0.05)			SEm±		CD (P=0.05)			SEm±			CD (P=0.05)	
V at same N & W	0.54		1.64			0.53		1.59			0.51			1.55	
V X N X W	0.55		1.67			0.54		1.63			0.53			1.60	

Table 3: Effect of varieties, nutrient levels and weed management practices on leaf area of finger millets at different time intervals

Treatment	Leaf area (cm)											
	30 DAT			60 DAT			90 DAT			At harvest		
	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean
Varieties												
V1: Indira Ragi-1	73.47	73.85	73.66	240.36	245.36	242.86	280.36	285.36	282.86	170.36	175.36	172.86
V2: CG Ragi-2	74.00	74.69	74.35	242.76	247.76	245.26	282.76	287.76	285.26	172.76	177.76	175.26
V3: CG Ragi-3	73.08	73.75	73.42	229.44	234.44	231.94	269.44	274.44	271.94	159.44	164.44	161.94
SEm±	0.32	0.35	0.24	0.50	0.61	0.58	0.65	0.70	0.53	0.41	0.51	0.48
CD (P=0.05)	NS	NS	NS	1.50	1.83	1.72	1.95	2.10	1.60	1.24	1.54	1.45
Nutrient levels												
N1: 75% RDN	72.86	73.64	73.25	226.10	231.10	228.60	266.10	271.10	268.60	156.10	161.10	158.60
N2: 100% RDN	73.72	74.47	74.10	233.74	238.74	236.24	273.74	278.74	276.24	163.74	168.74	166.24
N3: 125% RDN	73.97	74.88	74.43	252.72	257.72	255.22	292.72	297.72	295.22	182.72	187.72	185.22
SEm±	0.40	0.43	0.42	0.66	0.76	0.86	0.74	0.92	1.02	1.25	1.30	1.27
CD (P=0.05)	NS	NS	NS	2.02	2.32	2.72	2.25	3.02	3.25	3.78	4.10	3.92
Weed management practices												
W1	73.07	73.56	73.31	236.64	241.64	239.14	276.64	281.64	279.14	166.64	171.64	169.14
W2	73.67	74.70	74.19	237.93	242.93	240.43	277.93	282.93	280.43	167.93	172.93	170.43
W3	74.89	75.85	75.37	242.08	247.08	244.58	282.08	287.08	284.58	172.08	177.08	174.58
W4	72.44	72.61	72.53	233.44	238.44	235.94	273.44	278.44	275.94	163.44	168.44	165.94
SEm±	0.90	1.21	0.98	0.67	0.70	0.78	0.81	0.82	0.76	0.91	1.02	1.12
CD (P=0.05)	NS	NS	NS	1.89	2.12	2.40	2.45	2.50	2.35	2.96	3.09	3.41

Note;-W1: Oxadiargyl 80 g a.i. ha-1, PE + One mechanical weeding at 40 DAT, W2: Bispyribac Na 20 g a.i .ha-1, PoE, W3: Hand weeding twice at 20 and 40 DAT and W4: Weedy check

Table 4: Effect of varieties, nutrient levels and weed management practices on leaf area index of finger millet at different time intervals

Treatment	Leaf area index											
	30 DAT			60 DAT			90 DAT			At harvest		
	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean
Varieties												
V1: Indira Ragi-1	0.37	0.37	0.37	1.20	1.23	1.21	1.40	1.43	1.41	0.85	0.88	0.86
V2: CG Ragi-2	0.37	0.37	0.37	1.21	1.24	1.23	1.41	1.44	1.43	0.86	0.89	0.88
SEm±	0.37	0.37	0.37	1.15	1.17	1.16	1.35	1.37	1.36	0.80	0.82	0.81
SEm±	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01
CD (P=0.05)	NS	NS	NS	0.03	0.03	0.06	0.03	0.03	0.03	0.03	0.03	0.03
Nutrient levels												
N1: 75% RDN	0.36	0.37	0.37	1.13	1.16	1.14	1.33	1.36	1.34	0.78	0.81	0.79
N2: 100% RDN	0.37	0.37	0.37	1.17	1.19	1.18	1.37	1.39	1.38	0.82	0.84	0.83
N3: 125% RDN	0.37	0.37	0.37	1.26	1.29	1.28	1.46	1.49	1.48	0.91	0.94	0.93
SEm±	0.01	0.01	0.01	0.02	0.03	0.02	0.02	0.03	0.03	0.02	0.03	0.03
CD (P=0.05)	NS	NS	NS	0.06	0.09	0.06	0.06	0.09	0.09	0.06	0.09	0.09
Weed management practices												
W1	0.37	0.37	0.37	1.18	1.21	1.20	1.38	1.41	1.40	0.83	0.86	0.85
W2	0.37	0.37	0.37	1.19	1.21	1.20	1.39	1.41	1.40	0.84	0.86	0.85
W3	0.37	0.38	0.38	1.21	1.24	1.22	1.41	1.44	1.42	0.86	0.89	0.87
W4	0.36	0.37	0.36	1.17	1.19	1.18	1.37	1.39	1.38	0.82	0.84	0.83
SEm±	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CD (P=0.05)	NS	NS	NS	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03

Note;-W1: Oxadiargyl 80 g a.i. ha-1, PE + One mechanical weeding at 40 DAT, W2: Bispyribac Na 20 g a.i .ha-1, PoE, W3: Hand weeding twice at 20 and 40 DAT and W4: Weedy check

Table 5: Effect of varieties, nutrient levels and weed management practices on number of total tillers of finger millet at different time intervals

Treatment	Number of total tillers (hill^{-1})											
	30 DAT			60 DAT			90 DAT			At harvest		
	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean
Varieties												
V1: Indira Ragi-1	1.74	1.68	1.71	2.97	2.99	2.98	4.03	4.08	4.06	3.88	3.99	3.94
V2: CG Ragi-2	1.83	1.98	1.91	3.31	3.30	3.31	4.08	4.38	4.23	3.93	4.29	4.11
V3: CG Ragi-3	1.53	1.65	1.59	2.63	2.68	2.66	4.00	4.05	4.03	3.83	3.96	3.90
SEm±	0.12	0.13	0.11	0.11	0.07	0.08	0.01	0.02	0.03	0.01	0.03	0.02
CD (P=0.05)	NS	NS	NS	0.33	0.21	0.24	0.03	0.06	0.09	0.03	0.09	0.06
Nutrient levels												
N1: 75% RDN	1.42	1.57	1.49	2.55	2.66	2.60	3.97	4.00	3.98	3.88	3.84	3.86
N2: 100% RDN	1.67	1.82	1.74	2.80	2.82	2.81	4.22	4.06	4.14	4.13	3.90	4.01
N3: 125% RDN	2.01	1.93	1.97	2.91	2.91	2.91	4.33	4.17	4.25	4.24	4.06	4.15
SEm±	0.07	0.01	0.05	0.02	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.04
CD (P=0.05)	0.22	0.03	0.15	0.06	0.06	0.09	0.09	0.09	0.10	0.06	0.10	0.13
Weed management practices												
W1	1.70	1.84	1.77	3.09	3.17	3.14	4.77	4.59	4.68	4.54	4.39	4.46
W2	1.70	1.85	1.78	3.10	3.21	3.16	4.78	4.60	4.69	4.56	4.41	4.48
W3	2.07	2.22	2.15	3.47	3.47	3.47	5.14	4.96	5.05	4.91	4.76	4.84
W4	1.31	1.15	1.23	1.33	1.33	1.33	2.00	2.00	2.00	2.33	1.98	2.16
SEm±	0.08	0.08	0.08	0.08	0.07	0.07	0.10	0.11	0.10	0.10	0.11	0.12
CD (P=0.05)	0.24	0.22	0.22	0.22	0.19	0.19	0.30	0.33	0.32	0.30	0.33	0.36

Note;-W1: Oxadiargyl 80 g a.i. ha-1, PE + One mechanical weeding at 40 DAT, W2: Bispyribac Na 20 g a.i .ha-1, PoE, W3: Hand weeding twice at 20 and 40 DAT and W4: Weedy check

Nutrient management significantly influenced tiller production at all observed stages. The application of 125% RDN (N_3) resulted in the highest number of tillers hill^{-1}, followed by 100% RDN (N_2), with the lowest recorded under 75% RDN (N_1). Higher nitrogen availability likely enhanced vegetative growth, tiller initiation, and the development of axillary buds (Rajendran & Kumar, 2012; Rao *et al.*, 2009) [15, 18].

Weed management practices also had a notable impact from 30 DAT onwards. Hand weeding twice (W_3) led to the maximum tiller production, followed by pre-emergence herbicide + mechanical weeding (W_1) and post-emergence herbicide (W_2). The weedy check (W_4) consistently recorded the lowest number of tillers. The observed improvement in tillering under effective weed control regimes may be due to reduced competition for essential growth resources such as light, moisture, and nutrients (Chauhan & Johnson, 2010; Tiwari *et al.*, 2018) [2, 27].

Crop growth rate (CGR)

The crop growth rate (CGR) of finger millet, expressed in g hill^{-1} day^{-1}, as depicted in Figure 1, showed a progressive increase during the early growth stages, peaking at 60 and 90 days after transplanting (DAT), followed by a decline towards harvest across both years and on a pooled mean basis. This trend is consistent with the typical sigmoidal growth pattern of cereals, wherein initial slow development transitions into a phase of rapid biomass accumulation during the vegetative and early reproductive stages, tapering off as the crop reaches physiological maturity (Thakur *et al.*, 2011; Reddy & Reddy, 2008) [26, 21].

Among the tested varieties, CG Ragi-2 (V_2) consistently registered the highest CGR throughout the crop's life cycle, followed by Indira Ragi-1 (V_1), while CG Ragi-3 (V_3) recorded the lowest values. The superior growth rate in V_2 may be attributed to its larger leaf area, better canopy architecture, and higher physiological efficiency under field conditions (Somasundaram *et al.*, 2009; Patil *et al.*, 2007) [25, 14].

Nutrient management significantly influenced CGR. The application of 125% RDN (N_3) resulted in the highest CGR at 60 and 90 DAT, followed by 100% RDN (N_2), while the lowest was observed under 75% RDN (N_1). Enhanced nitrogen levels likely promoted leaf area expansion, photosynthetic efficiency, and metabolic activity, leading to increased dry matter accumulation (Sharma *et al.*, 2013; Patil *et al.*, 2017) [22, 14].

Similarly, weed management had a notable effect on CGR. The highest CGR was recorded under hand weeding twice (W_3), followed by pre-emergence herbicide + mechanical weeding (W_1) and post-emergence herbicide (W_2), while the weedy check (W_4) recorded the lowest values. These results highlight the importance of timely and effective weed control in minimizing resource competition, thereby facilitating enhanced crop growth (Gharde *et al.*, 2018; Rao, 2000) [5, 17].

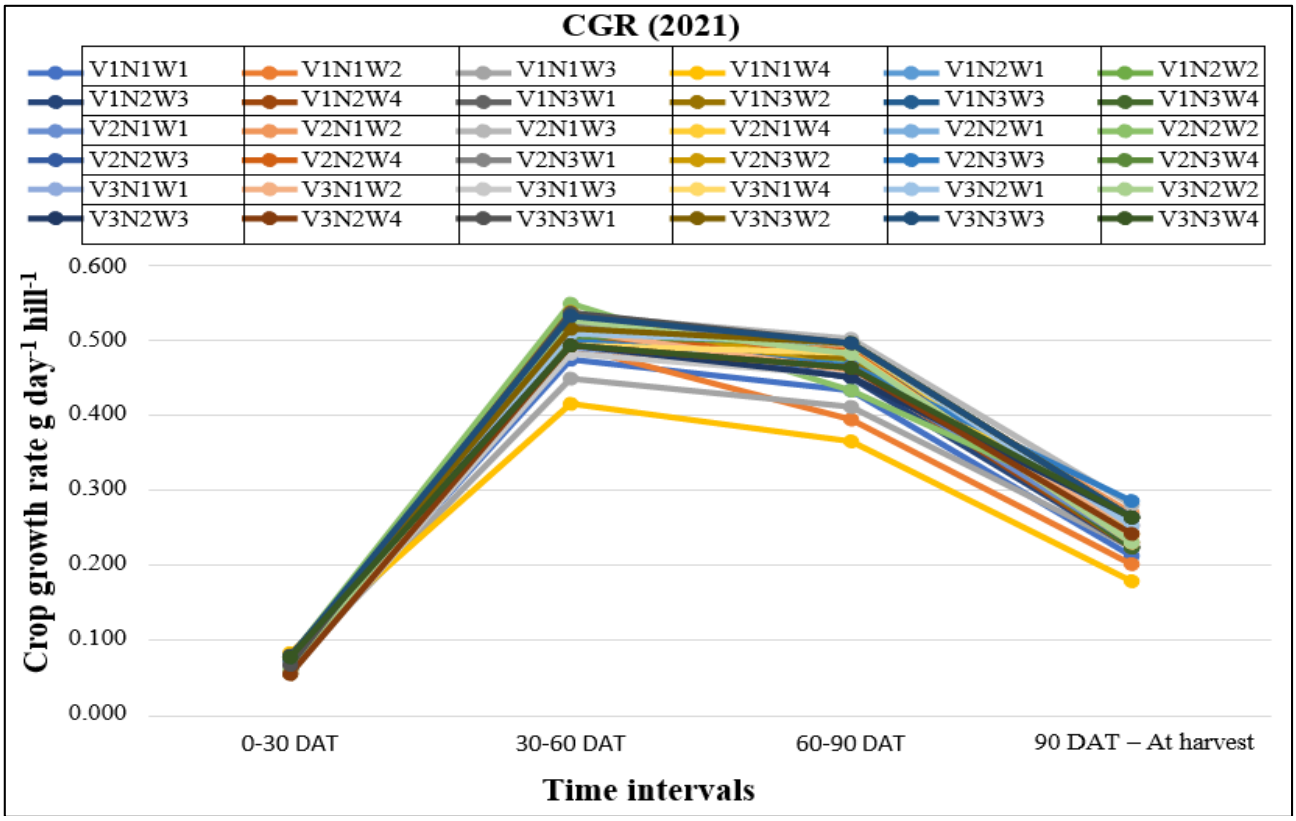
Relative growth rate (RGR)

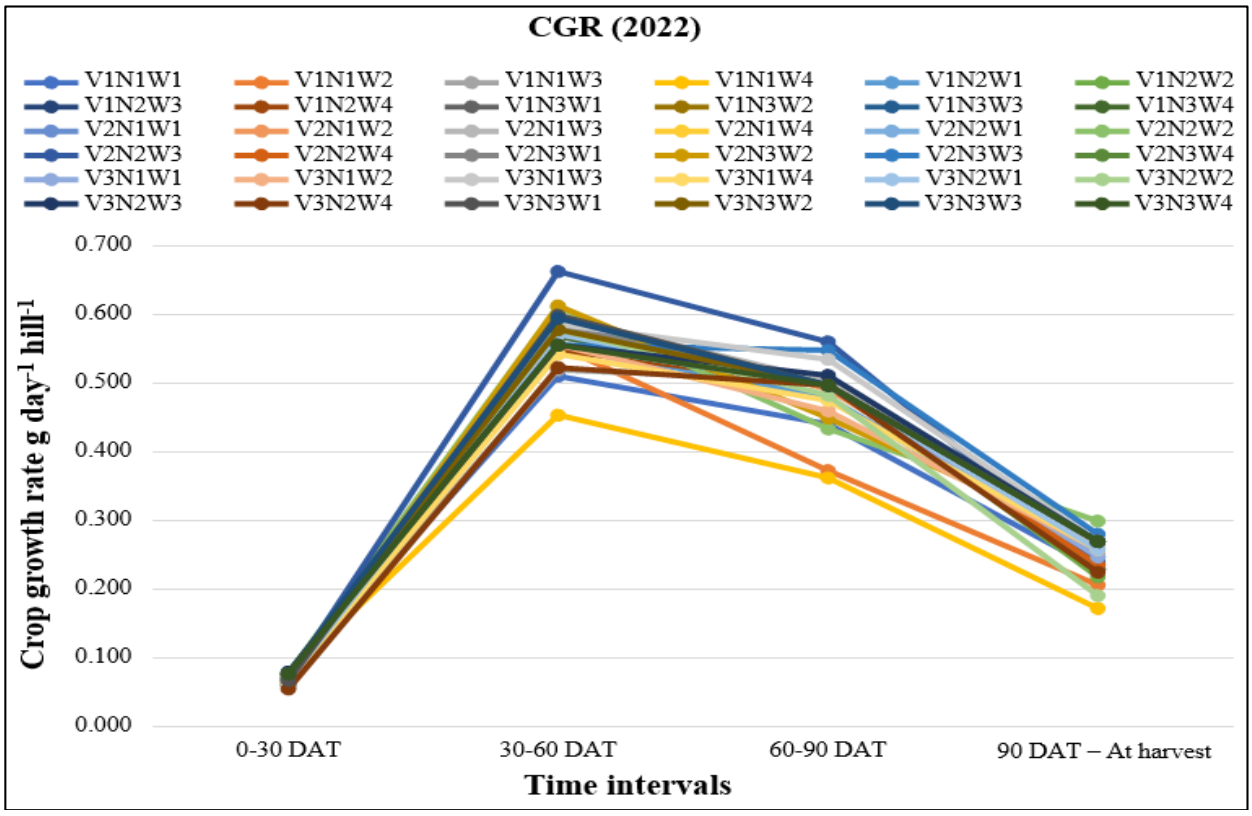
The relative growth rate (RGR) of finger millet, expressed in g g^{-1} day^{-1}, as illustrated in Figure 2, exhibited a progressive decline from transplanting to harvest. The highest RGR values were observed during the early vegetative stages, followed by a marked decrease at 60 and 90 days after transplanting (DAT), and a further reduction towards harvest. This declining trend is typical of cereal crops, where young plants with lower biomass demonstrate faster relative dry matter accumulation, which gradually diminishes as plant size and structural complexity increase (Thakur *et al.*, 2011; Reddy & Reddi, 2008) [26, 21].

Among the tested varieties, CG Ragi-2 (V_2) consistently exhibited the highest RGR across all growth stages, followed by Indira Ragi-1 (V_1), while CG Ragi-3 (V_3) recorded the lowest. The superior RGR performance of V_2 can be attributed to its enhanced physiological efficiency, greater leaf area, and better adaptation to environmental conditions (Somasundaram *et al.*, 2009; Patil *et al.*, 2007) [25, 14].

With respect to nutrient management, 125% RDN (N_3) treatment produced the highest RGR, followed by 100% RDN (N_2), while the lowest values were observed under 75% RDN (N_1). This indicates that increased nitrogen availability supports greater photosynthetic activity and leaf expansion, particularly in early growth stages, leading to improved relative growth (Sharma *et al.*, 2013; Patil *et al.*, 2017) [22, 14].

Weed management practices also exerted a significant influence on RGR. The highest RGR was achieved under hand weeding twice (W_3), followed by pre-emergence herbicide + mechanical weeding (W_1) and post-emergence herbicide (W_2), whereas the weedy check (W_4) recorded the lowest. Effective weed suppression minimizes competition for essential growth resources, particularly during critical early stages, thus promoting enhanced biomass accumulation and higher RGR (Gharde *et al.*, 2018; Rao, 2000) [5, 17].





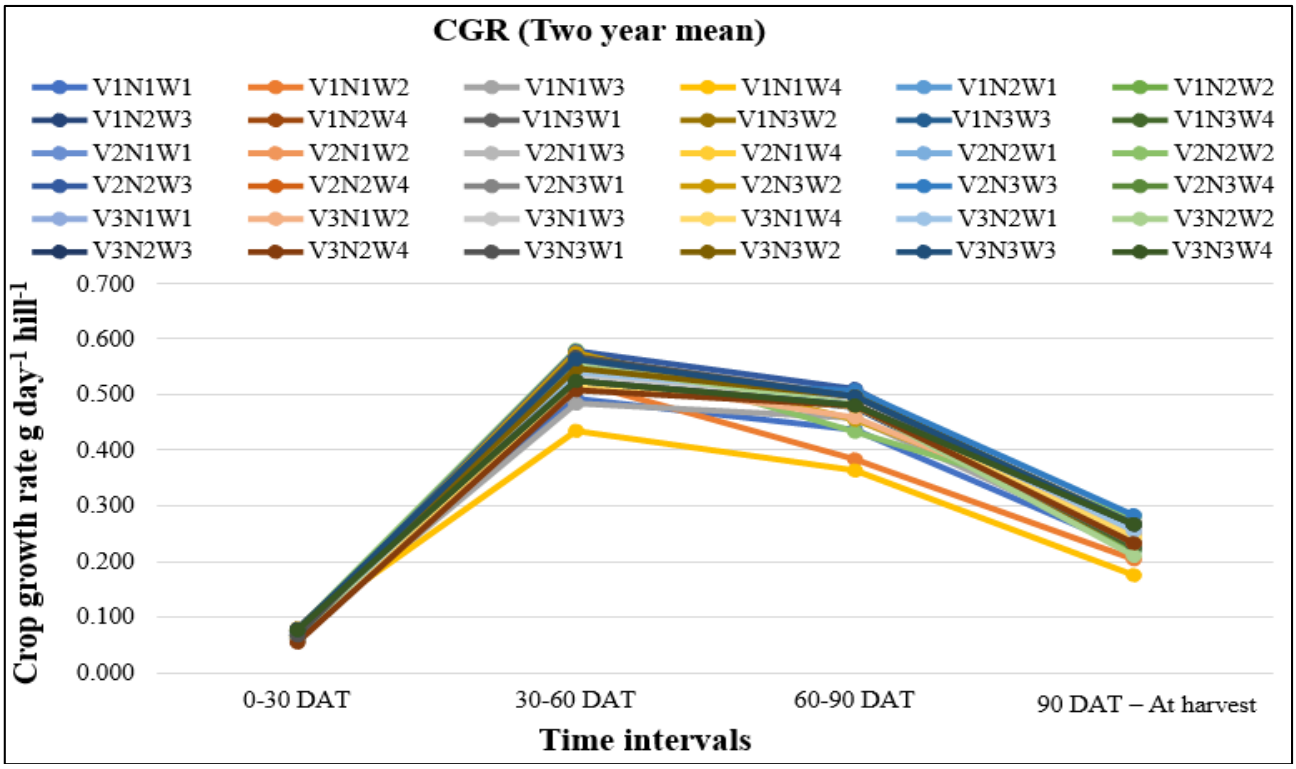
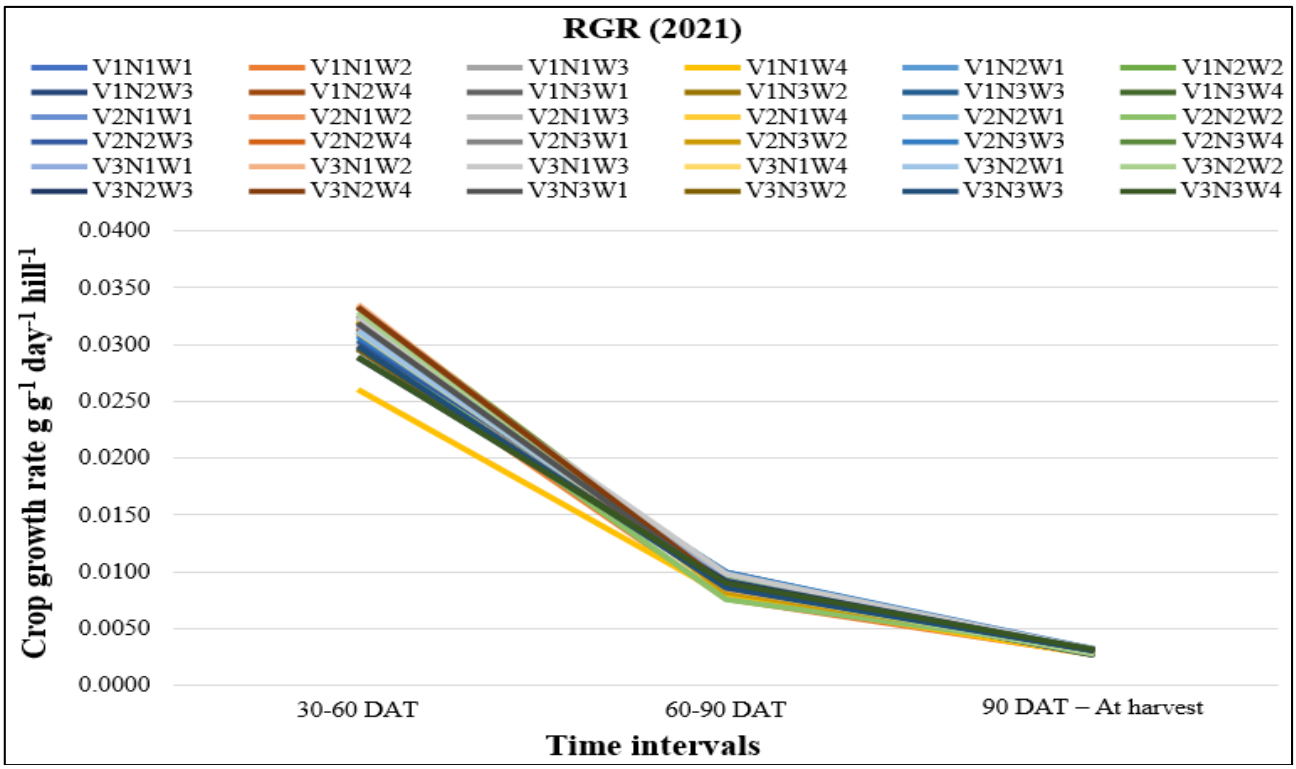


Fig 1: Effect on varieties, nutrient levels and weed management practices on crop growth rate of finger millet in various time intervals



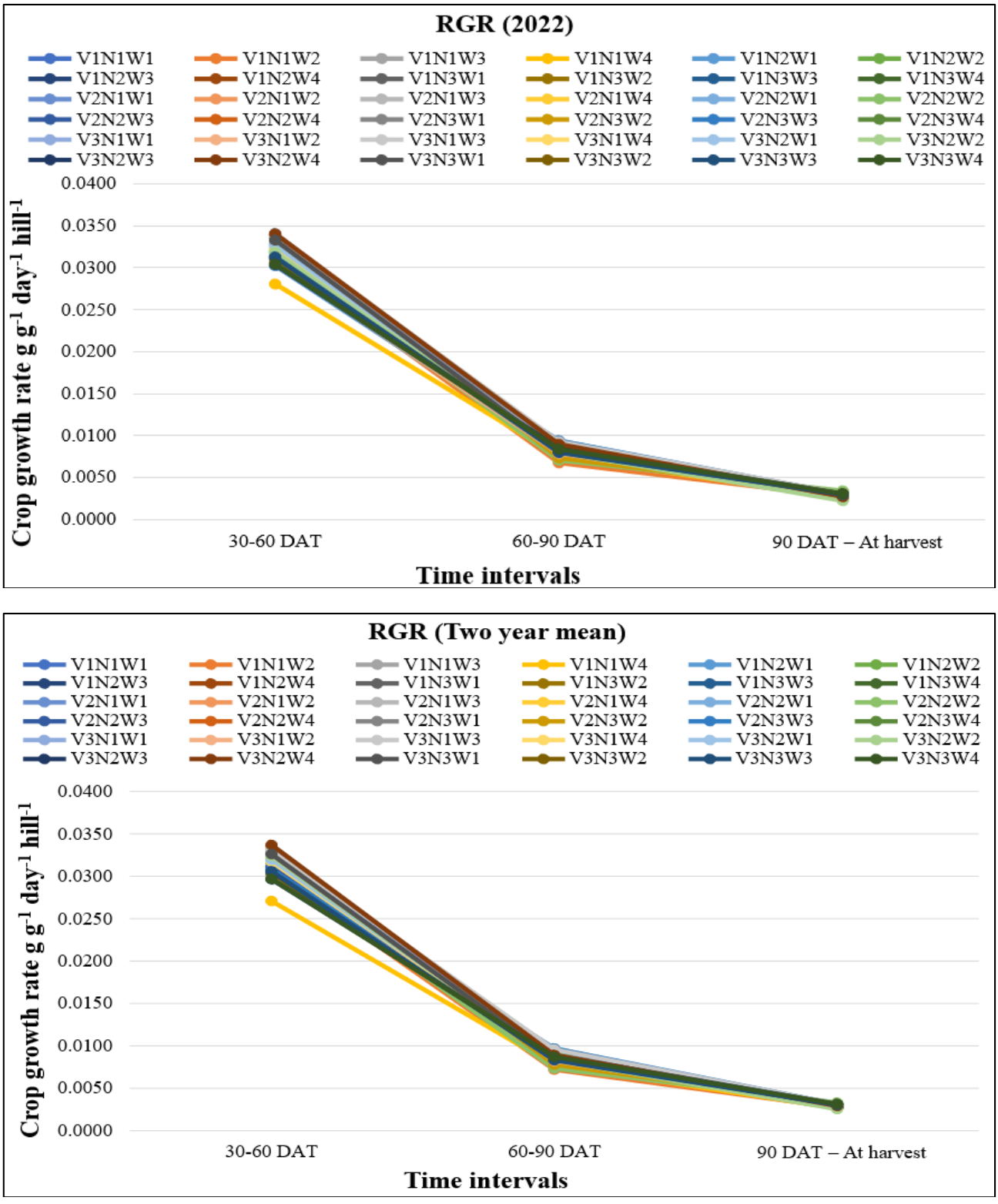


Fig 2: Effect on varieties, nutrient levels and weed management practices on relative growth rate of finger millet varieties in various time intervals

Conclusion

The study revealed that growth performance of finger millet was significantly influenced by varietal selection, nutrient levels, and weed management practices, particularly from 60 days after transplanting (DAT) onward. Among the varieties, CG Ragi-2 (V_2) consistently exhibited superior growth in terms of plant height, dry matter accumulation, leaf area, leaf area index, number of tillers, crop growth rate (CGR), and relative growth rate (RGR), owing to its higher vegetative vigour and resource use efficiency. Application of 125% recommended dose of nutrients (RDN) significantly enhanced all growth parameters, demonstrating the positive impact of increased nutrient availability on physiological development. Similarly, hand weeding twice (W_3) emerged as the most effective weed management practice, ensuring minimal competition and thereby supporting optimal crop growth. Significant interactions between varieties and nutrient levels, as well as a three-way interaction at later stages, further emphasized the importance of integrated management strategies. These

findings suggest that the combined use of high-performing cultivars like CG Ragi-2, elevated nutrient levels, and effective weed control is essential for maximizing the growth potential of finger millet under the Bastar Plateau conditions.

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