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Influence of nutrient levels on growth and yield performance of foxtail millet (*Setaria italica* L.) varieties in Jammu region

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Abstract

The experiment was conducted during the kharif seasons of 2023 and 2024 at the Agronomy Research Farm, Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST)-Jammu, Jammu and Kashmir, India, to evaluate the potential of different foxtail millet (*Setaria italica* L.) varieties under varying nutrient levels in order to identify the most suitable variety-nutrient combination for achieving higher growth, yield and economic returns. The study consisted of 3 varieties (SiA 3085, SiA 3156 and local variety) and five different nutrient levels. The results revealed that higher dry matter accumulation (293.34 g/m²), number of effective tillers (55.57/m²), grain yield (1625.67 kg/ha), net returns (54017 ₹/ha) and benefit–cost ratio (2.71) were recorded in variety SiA 3085, which showed similar results to variety SiA 3156. However, among the different nutrient levels, higher dry matter accumulation (289.74 g/m²), number of effective tillers (59.50/m²), grain yield (1717.27 kg/ha), net returns (57492 ₹/ha) and benefit–cost ratio (B : C) (2.78) were observed with the application of 40-20-10 kg nitrogen, phosphorus and potassium (NPK)/ha, which also showed similar results to 40-20-00 kg NPK/ha. The same trend was also observed in physiological studies. Therefore, based on the findings of the two-year study, it was concluded that variety SiA 3085 is the most suitable under Jammu conditions. Furthermore, the nutrient level 40-20-10 kg NPK/ha was found to be economically suitable for foxtail millet cultivation in the Jammu region.

Keywords: foxtail millet; nutrient levels; SiA 3085; SiA 3156; varieties

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Introduction

Millets are ancient cereal crops cultivated for thousands of years and are recognised for their adaptability to harsh climatic conditions and low-input agriculture. These crops are mainly grown in dry and semi-dry regions under rainfed ecosystems and play an important role in ensuring food and nutritional security. India is one of the leading millet-producing countries in the world and contributes substantially to global millet production (1). However, after the Green Revolution, the cultivation of millets declined due to the greater emphasis on rice and wheat-based production systems, resulting in reduced dietary diversity and nutritional imbalance. Among the different millet crops, foxtail millet (*Setaria italica* L.) is one of the ancient, domesticated cereals and is widely cultivated in the countries associated with the Asian and African continents. It is considered an important millet crop because of its short duration, drought tolerance and suitability to diverse agro-climatic conditions. In India, it is grown over an area of 0.87 lakh hectares with a production of 0.66 lakh tonnes and a productivity of 762 kg/ha (2). In India, foxtail millet is cultivated on limited acreage, mainly in southern states, while its cultivation in northern regions, including Jammu, remains comparatively low. The crop possesses high nutritional value, containing appreciable amounts of protein, carbohydrates, minerals and dietary fibre (3). Due to its gluten-free nature and low glycemic index, it is considered beneficial for diabetic and health-conscious consumers. Additionally, it is rich in fibre and antioxidants, which help reduce the risk of chronic diseases (4). In recent years, increasing awareness regarding nutritional security and climate-resilient agriculture has renewed interest in millet cultivation (5). Efficient nutrient management is essential for achieving higher productivity and maintaining soil fertility. Among the major nutrients, nitrogen, phosphorus and potassium (NPK) significantly influence crop growth, development

and yield. Nitrogen promotes vegetative growth, P supports root development and energy transfer, while K enhances stress tolerance and improves crop quality. Imbalanced nutrient applications may adversely affect crop performance and soil health, whereas balanced fertilisation helps sustain productivity and environmental stability (6, 7). The agro-climatic conditions of Jammu and Kashmir provide suitable opportunities for millet cultivation due to the crop's adaptability and resilience under variable environmental conditions. Although several studies have evaluated the influence of nutrient management or varietal performance in foxtail millet, very limited information is available regarding their combined evaluation under the subtropical agro-climatic conditions of Jammu. Furthermore, the interactive response of improved foxtail millet varieties to graded NPK levels in this region has not been adequately investigated. Therefore, the present study was undertaken to identify the most suitable variety and optimum nutrient level for improving growth, productivity and profitability of foxtail millet under Jammu conditions.

Materials and Methods

The field experiment was conducted during the kharif seasons of 2023 and 2024 at the Research Farm, Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST)-Jammu, Chatha, Jammu and Kashmir, India. The experimental site is situated at 32.40° N latitude and 74.58° E longitude with an altitude of 293 m above mean sea level. The soil of the experimental field was sandy clay loam in texture, slightly alkaline in reaction, low in organic carbon (4.27 g/kg) and available N (241.20 kg/ha) and medium in available P (15.57 kg/ha) and K (157.48 kg/ha). The experiment was laid out in a factorial randomised block design (FRBD) with 3 replications. The study comprised two factors, namely, foxtail millet varieties and different nutrient levels. In total, 15 treatment combinations were evaluated (Table 1). The nutrient treatments were formulated to evaluate the individual and combined effects of N, P and K on the growth and productivity of foxtail millet under Jammu conditions. The gross plot size was 12 m² (4 × 3 m), whereas the net plot size was 6 m² (3 × 2 m).

Table 1. Treatment details of the experimental study

Sl. No.	Treatment
Factor A	**Varieties**
V_1	SiA 3085
V_2	SiA 3156
V_3	Local
Factor B	**Nutrient doses**
N_0	Absolute control
N_1	30-30-00 kg NPK/ha
N_2	40-20-00 kg NPK/ha
N_3	30-30-10 kg NPK/ha
N_4	40-20-10 kg NPK/ha

N: nitrogen; P: phosphorus; K: potassium.

During the crop growing period, the meteorological conditions in both years were generally favourable for foxtail millet cultivation in the Jammu region. The maximum temperature ranged from approximately 31.0–39.5 °C, while the minimum temperature varied from about 14.0–27.0 °C. The weekly rainfall ranged from 0–220 mm, with the highest rainfall received during the 30–36th standard meteorological weeks (SMW), whereas comparatively dry conditions prevailed during the later stages of crop growth (Fig. 1). Although slight year-to-year variations in temperature and rainfall distribution were observed, these remained within the optimum range for foxtail millet growth and did not cause any significant heat or moisture stress. The differences in crop growth and grain yield between the two years were primarily attributed to experimental treatments rather than variations in prevailing weather conditions.

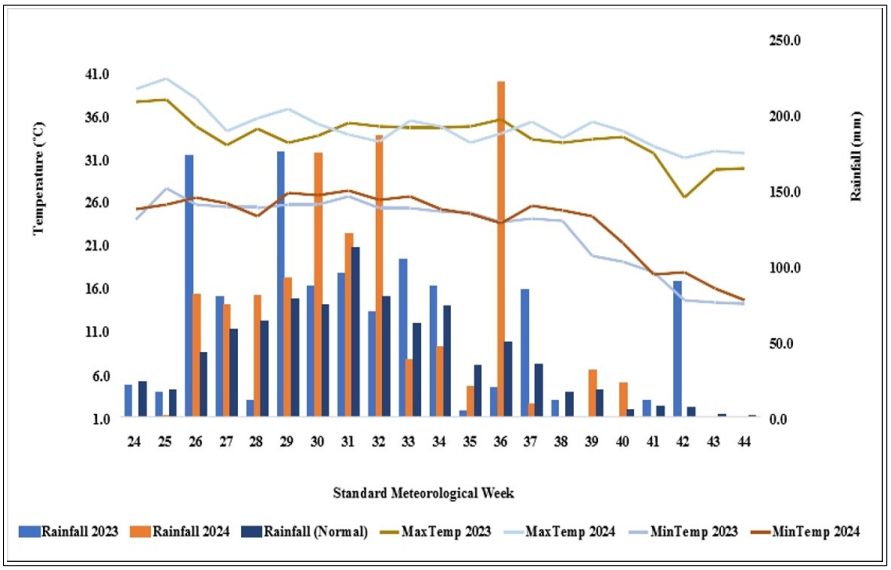


Fig. 1. Graphical representation of meteorological data of foxtail millet grown during kharif season 2023 and 2024.

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The observations on growth parameters such as plant height, number of tillers, dry matter accumulation, leaf area index (LAI) and crop growth rate were recorded at different growth stages. Phenological observations including days to 50 % flowering and days to maturity were also noted. Yield attributes, namely, effective tillers, number of grains per panicle and test weight were recorded at harvest. Grain yield, straw yield and harvest index were determined after crop harvest. The economic analysis was carried out by computing the cost of cultivation, gross returns, net returns and benefit-cost ratio (B : C) for each treatment. Crop growth rate and LAI were calculated using the following formulas:

$$\text{Leaf area index} = \frac{\text{Leaf area}}{\text{Ground area}}$$

$$\text{Crop growth rate} = \frac{W_2 - W_1}{T_2 - T_1}$$

where, W_1 = dry matter of crop at time T_1, W_2 = dry matter of crop at time T_2.

Statistical analysis

In statistical analysis, the field data were gathered and examined using online package for statistical analysis (OPSTAT) software (8). Before analysis, the assumptions of normality and homogeneity of variance were examined using Shapiro-Wilk and Levene's tests respectively. The data were subjected to factorial analysis of variance (ANOVA) following a FRBD. The significance of year, treatment and their interaction was examined. Since the interaction between the factors was non-significant for most observations, pooled analysis over the two years was performed. To compare treatment means, the least significant difference (LSD) at a 5 % level was computed for each parameter.

Results

Growth studies

Plant height

The results showed that plant height at 50 days after sowing (DAS) and at harvest was significantly influenced by cultivars and fertiliser levels. However, their interaction was non-significant. The variety SiA 3156 (V2), which was statistically equivalent to SiA 3085 (V1), showed considerably higher plant height (106.76, 121.56 cm) at 50 DAS and at harvest. However, the maximum plant height (111.23, 127.78 cm) among nutrient levels was recorded under treatment N4 (40-20-10 kg NPK/ha), which was statistically comparable to N2 (40-20-00 kg NPK/ha) at 50 DAS and at harvest (Table 2).

Number of tillers

The results indicated that the number of tillers was significantly affected by varieties and nutrient level, but the interaction effect was found to be non-significant. A higher tiller count (83.28, 80.23/m²) was recorded in variety SiA 3085 (V1), which was statistically at par with SiA 3156 (V2). However, among the nutrient levels, a higher number of tillers (87.34, 85.76/m²) was recorded in N4 (40-20-10 kg NPK/ha), which was statistically comparable to N2 (40-20-00 kg NPK/ha) at 50 DAS and at harvest (Table 2).

Table 2. Influence of cultivars and nutrient levels on growth performance of foxtail millet under field conditions (two-year pooled data)

Treatment	Plant height (cm)		Tillers count/m²		Dry matter accumulation (g/m²)	
	50 DAS	At harvest	50 DAS	At harvest	50 DAS	At harvest
Cultivars						
V_1 - SiA 3085	101.45	115.64	83.28	80.23	293.34	446.56
V_2 - SiA 3156	106.76	121.56	79.44	75.56	282.47	432.36
V_3 - Local	91.33	105.57	72.34	68.67	195.57	320.47
SEm (±)	1.63	1.87	1.28	1.37	2.81	3.47
LSD (p = 0.05)	4.76	5.47	3.75	3.94	8.17	9.87
Nutrient levels						
N_0 - Absolute control	87.65	97.76	67.65	63.33	204.47	316.47
N_1 - 30-30-00 kg NPK/ha	97.45	112.43	78.87	74.47	254.67	390.08
N_2 - 40-20-00 kg NPK/ha	107.48	124.34	84.54	82.21	281.36	440.23
N_3 - 30-30-10 kg NPK/ha	99.34	112.45	79.86	75.56	255.39	395.49
N_4 - 40-20-10 kg NPK/ha	111.23	127.78	87.34	85.76	289.74	456.70
SEm (±)	2.12	2.44	1.67	1.71	3.62	4.39
LSD (p = 0.05)	6.12	7.08	4.94	5.08	10.46	12.74
Interaction	NS	NS	NS	NS	18.68	21.87

DAS: days after sowing.

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Dry matter accumulation

Dry matter accumulation was significantly affected by varieties and nutrient levels at 50 DAS and at harvest. Furthermore, the interaction effect between varieties and nutrient level was significant. Among the varieties, the higher dry matter accumulation (293.34, 446.56 g/m²) was recorded in variety SiA 3085 (V1), which was statistically equivalent to SiA 3156 (V2). However, among the nutrient levels, the higher dry matter accumulation (289.87, 456.47 g/m²) was recorded in N4 (40-20-10 kg NPK/ha), which showed similar results to N2 (40-20-00 kg NPK/ha) at 50 DAS and at harvest (Table 2).

A significant interaction was observed between varieties and nutrient levels regarding dry matter accumulation at 50 DAS and at harvest. In this case, the highest dry matter accumulation (334.51, 508.83 g/m²) was found in variety SiA 3085 (V1) under N4 (40-20-10 kg NPK/ha), whereas the lowest (132.66, 208.45 g/m²) was found in the local variety (V3) under N0 (absolute control) at 50 DAS and at harvest (Table 3, 4).

Table 3. Cultivars and nutrient level interaction effects on dry matter accumulation at 50 days after sowing (DAS) of foxtail millet

Treatment	N_0	N_1	N_2	N_3	N_4
Cultivars					
V_1 - SiA 3085	246.12	286.45	309.88	289.74	334.51
V_2 - SiA 3156	234.63	274.92	301.17	281.06	320.57
V_3 - Local	132.66	202.64	233.03	195.37	214.15
SEm (±)			1.49		
LSD (p = 0.05)			18.68		

Table 4. Cultivars and nutrient level interaction effects on dry matter accumulation at harvest of foxtail millet

Treatment	N_0	N_1	N_2	N_3	N_4
Cultivars					
V_1 - SiA 3085	381.22	429.85	471.63	441.27	508.83
V_2 - SiA 3156	359.74	421.16	454.72	424.58	501.60
V_3 - Local	208.45	319.25	394.34	320.63	359.68
SEm (±)			7.69		
LSD (p = 0.05)			21.67		

Crop growth rate

It determines the rate at which dry matter accumulates at various phases of crop development and measures a plant growth rate trend throughout the growing season. A higher crop growth rate (CGR) (9.16, 2.63) was observed in variety SiA 3085 (V1), whereas among the nutrient levels, the higher crop growth rate (9.05, 2.87) was shown by N4 (40-20-10 kg NPK/ha) at 25-50 DAS and 75 DAS to harvest (Fig. 2).

Leaf area index

Leaf area index (LAI) is an essential growth metric for evaluating the plant's ability to absorb light required for photosynthesis. The observed results revealed that higher LAI (1.50, 1.30) was shown by variety SiA 3085 (V1), whereas among the nutrient levels, the higher LAI (1.57, 1.32) was shown by N4 (40-20-10 kg NPK/ha) at 50 DAS and at harvest (Fig. 3).

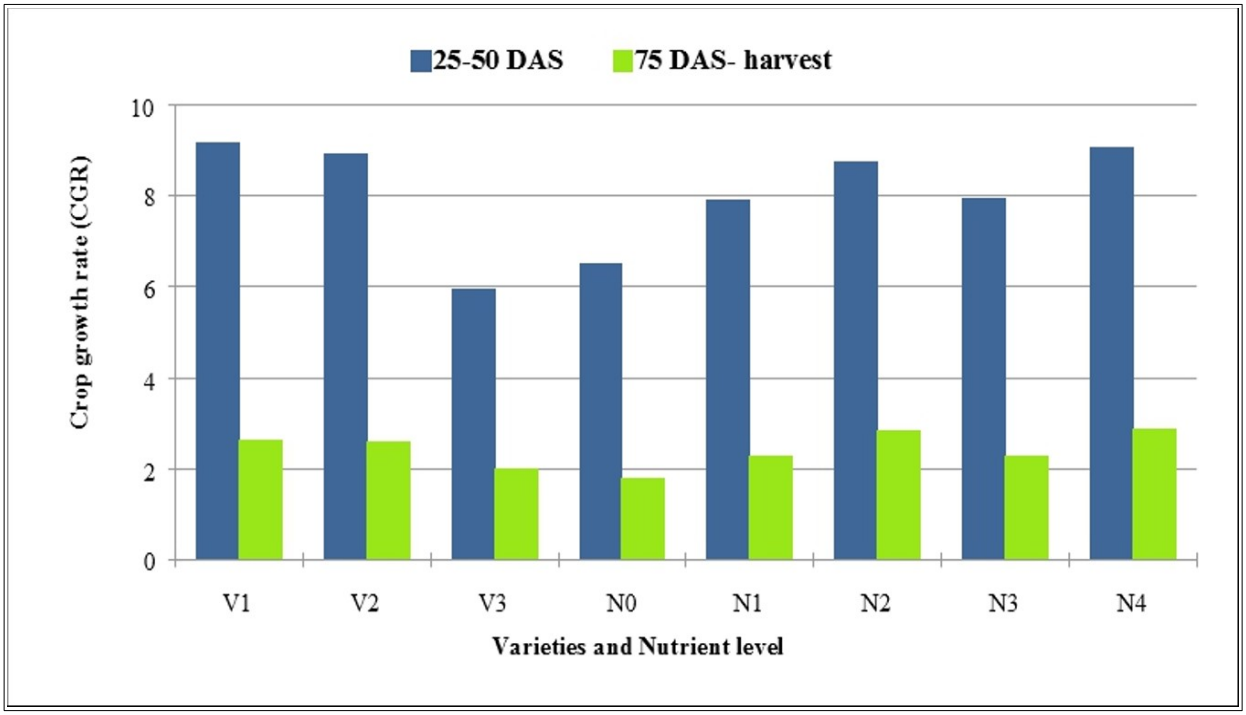


Fig. 2. Response of cultivars and nutrient levels on crop growth rate (CGR) of foxtail millet.

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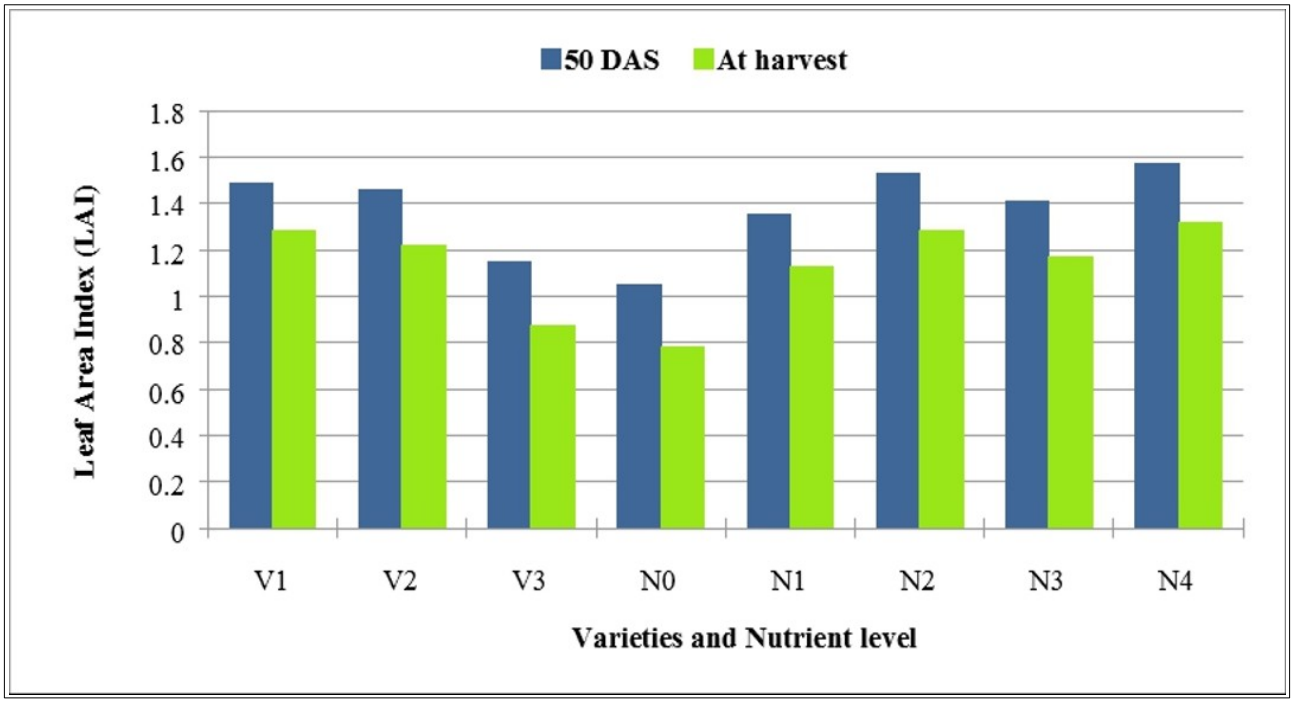


Fig. 3. Response of cultivars and nutrient levels on leaf area index (LAI) of foxtail millet.

Physiological studies

Parameters such as days to 50 % flowering and days to maturity are very crucial for determining the growth, development and assessing the duration of the crop under different treatments. Among different varieties, the shorter-duration variety SiA 3085 (V1) took fewer days to reach 50 % flowering and maturity (45.10, 74.58 days), while the local variety (V3) took longer (48.76, 77.67 days). However, among the different nutrient levels, the shorter duration to reach 50 % flowering and maturity (43.79, 72.78 days) was observed in N0 (absolute control), while the longer duration (48.25, 78.13 days) was taken by N4 (40-20-10 kg NPK/ha) (Fig. 4).

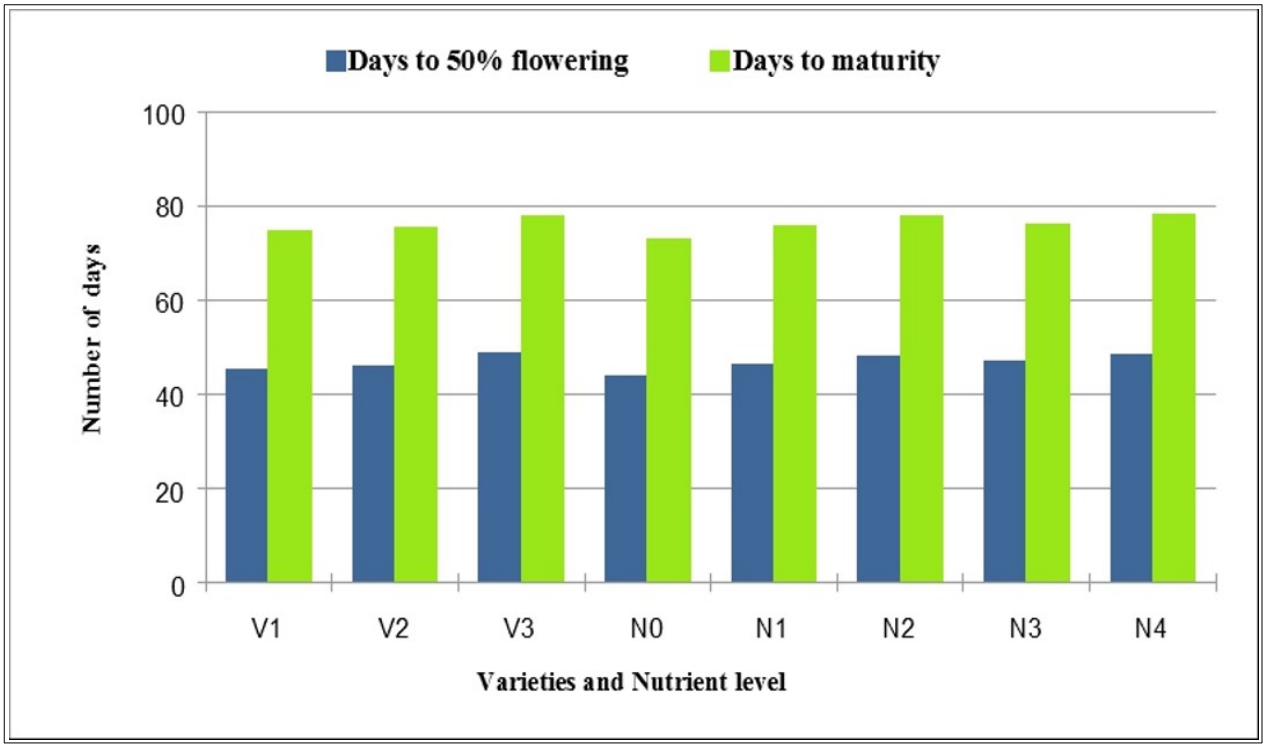


Fig. 4. Response of cultivars and nutrient levels on phenological studies of foxtail millet.

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Yield parameters

Effective tillers

Varieties and nutrient levels significantly influenced the number of effective tillers and their interaction effect was also significant. The variety SiA 3085 (V1) showed a higher number of effective tillers (55.57/m²), which was statistically equivalent to SiA 3156 (V2). Among the various nutrient levels, N4 (40-20-10 kg NPK/ha) had more effective tillers (58.87/m²), which was statistically equivalent to N2 (40-20-00 kg NPK/ha) (Table 5).

Regarding the interaction, the maximum number of effective tillers (61.12/m²) was found in variety SiA 3085 (V1) under N4 (40-20-10 kg NPK/ha), whereas the lowest (30.94/m²) was recorded in the local variety (V3) under treatment N0 (absolute control) (Table 6).

Grains/panicle

Varieties and nutrition levels had a significant impact on the number of grains per panicle, while their interaction was non-significant. Variety SiA 3085 (V1) recorded the maximum number of grains per panicle (1189.42)**,** which was statistically at par with SiA 3156 (V2). Among the various nutrient levels, N4 (40-20-10 kg NPK/ha) had more grains per panicle (1231.11), which was statistically similar to N2 (40-20-00 kg NPK/ha) (Table 5).

1000-grain weight

Varieties and nutrient levels failed to show any significant effect on 1000-grain weight. The higher grain weight (3.24 g) was shown by variety SiA 3085 (V1), whereas among the nutrient levels, (3.24 g) it was shown by N4 (40-20-10 kg NPK/ha) (Table 5).

Grain yield

The grain yield was significantly affected by varieties and nutrient levels, in which significant interaction was observed between them. A higher grain yield (1625.67 kg/ha) was recorded by variety SiA 3085 (V1), which was statistically equivalent to SiA 3156 (V2). Among the nutrient levels, N4 (40-20-10 kg NPK/ha) showed a higher grain yield (1715.67 kg/ha), which was statistically similar to N2 (40-20-00 kg NPK/ha) (Table 5).

The interaction effect was observed in grain yield between nutrient levels and varieties. In this case, the higher grain yield (1867.76 kg/ha) was observed in variety SiA 3085 (V1) under N4 (40-20-10 kg NPK/ha), whereas the lowest (721.64 kg/ha) was found in the local variety (V3) under N0 (absolute control) (Table 7).

Stover yield

Stover yield was also significantly influenced by varieties and nutrient levels, with a significant interaction between these factors. In this case, the higher stover yield (2839.58 kg/ha) was recorded in variety SiA 3085 (V1), which was statistically at par with SiA 3156 (V2). Among the nutrient levels, N4 (40-20-10 kg NPK/ha) showed a higher stover yield (3023.38 kg/ha), which was statistically similar to N2 (40-20-00 kg NPK/ha) (Table 5).

In this case, the higher stover yield (3209.34 kg/ha) was observed in variety SiA 3085 (V1) under N4 (40-20-10 kg NPK/ha), whereas the lowest (1445.33 kg/ha) was found in the local variety (V3) under N0 (absolute control) (Table 8).

Harvest index

Harvest index was not significantly influenced by varieties or nutrient levels and no interaction was observed. Among the varieties, the harvest index (36.41 %) was found in variety SiA 3085 (V1), whereas among the nutrient levels, the higher harvest index (36.22 %) was found in N4 (40-20-10 kg NPK/ha) (Table 5).

Table 5. Influence of cultivars and nutrient levels on yield parameters of foxtail millet under field conditions (two-year pooled data)

Treatment	Effective tillers/m²	Grains/ panicle	1000-grain weight (g)	Grain yield (kg/ha)	Stover yield (kg/ha)	Harvest index
Cultivars						
V_1 - SiA 3085	55.57	1189.42	3.24	1625.67	2839.58	36.41
V_2 - SiA 3156	53.23	1165.67	3.21	1592.34	2812.33	36.15
V_3 - Local	44.80	1039.45	3.17	1209.45	2451.01	33.04
SEm (±)	0.51	25.76	0.07	14.10	24.89	0.42
LSD (p = 0.05)	1.39	74.10	NS	42.34	72.23	NS
Nutrient levels						
N_0 - Absolute control	43.23	903.34	3.14	987.69	1885.12	34.38
N_1 - 30-30-00 kg NPK/ha	48.87	1132.24	3.18	1492.23	2776.91	34.95
N_2 - 40-20-00 kg NPK/ha	56.64	1218.67	3.22	1655.45	2978.11	35.73
N_3 - 30-30-10 kg NPK/ha	47.76	1168.61	3.21	1526.46	2871.29	34.71
N_4 - 40-20-10 kg NPK/ha	59.50	1231.11	3.24	1717.27	3023.38	36.22
SEm (±)	0.64	33.12	0.09	18.05	32.12	0.51
LSD (p = 0.05)	1.81	95.87	NS	54.25	93.16	NS
Interaction	3.12	NS	NS	89.35	161.27	NS

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Table 6. Cultivars and nutrient level interaction effects on effective tillers of foxtail millet

Treatment	N_0	N_1	N_2	N_3	N_4
Cultivars					
V_1 - SiA 3085	50.12	54.76	57.88	53.97	61.12
V_2 - SiA 3156	48.63	52.98	55.47	51.62	57.45
V_3 - Local	30.94	38.87	56.57	37.69	59.93
SEm (±)			1.09		
LSD (p = 0.05)			3.12		

Table 7. Cultivars and nutrient level interaction effects on grain yield of foxtail millet

Treatment	N_0	N_1	N_2	N_3	N_4
Cultivars					
V_1 - SiA 3085	1137.38	1641.92	1805.14	1676.15	1867.76
V_2 - SiA 3156	1104.05	1608.59	1771.81	1642.82	1834.43
V_3 - Local	721.64	1226.18	1389.40	1260.41	1449.61
SEm (±)			30.87		
LSD (p = 0.05)			89.35		

Table 8. Cultivars and nutrient level interaction effects on straw yield of foxtail millet

Treatment	N_0	N_1	N_2	N_3	N_4
Cultivars					
V_1 - SiA 3085	2105.43	2901.56	3150.72	2920.85	3209.34
V_2 - SiA 3156	2104.62	2820.45	3088.66	2895.73	3152.04
V_3 - Local	1445.33	2608.71	2694.96	2797.29	2708.76
SEm (±)			55.69		
LSD (p = 0.05)			161.27		

Soil studies

Post-harvest soil analysis revealed that higher organic carbon (4.31 g/kg), N (240.22 kg/ha), P (15.82 kg/ha) and K (155.22 kg/ha) were associated with plots of variety SiA 3085 (V1), whereas among the nutrient levels, the higher organic carbon (4.33 g/kg), N (242.34 kg/ha), P (15.87 kg/ha) and K (156.10 kg/ha) were found in N4 (40-20-10 kg NPK/ha) (Fig. 5).

Regression studies

A significant positive linear relationship (R^2 = 0.92) was observed between LAI and crop dry matter (Fig. 6a). This indicates that an increase in crop dry matter resulted in an increase in LAI. The higher value of R^2 indicates a higher variation in LAI with changes in crop dry matter. This shows that the increase in leaf area enhances photosynthetic activity, resulting in greater accumulation of dry matter.

Crop dry matter also showed a positive linear relationship with grain yield (Fig. 6b) with a higher coefficient of determination (R^2 = 0.88). The high R^2 value indicates a strong association between these two variables, showing that crop dry matter production was significantly influenced by grain yield. This result clearly showed that a crop with greater dry matter accumulation reflects increased photosynthesis and biomass production, leading to enhanced grain filling and resulting in higher grain yield production.

Relative economics

Economics were determined to identify the most effective and beneficial treatment. Higher gross returns, net returns (54017 ₹/ha) and B : C ratio (2.71) were recorded in variety SiA 3085 (V1), whereas among the nutrient levels, the higher gross returns, net returns (57492 ₹/ha) and B : C ratio (2.78) were observed in N4 (40-20-10 kg NPK/ha) (Table 9).

Table 9. Influence of cultivars and nutrient levels on relative economics of foxtail millet under field conditions (two-year pooled data)

Treatment	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	Benefit-cost ratio
Cultivars				
V_1 - SiA 3085	19940	73957	54017	2.71
V_2 - SiA 3156	19950	72503	52553	2.63
V_3 - Local	19780	55699	35919	1.82
Nutrient levels				
N_0 - Absolute control	17856	45253	27397	1.53
N_1 - 30-30-00 kg NPK/ha	20350	68227	47877	2.35
N_2 - 40-20-00 kg NPK/ha	20080	75485	55405	2.76
N_3 - 30-30-10 kg NPK/ha	21150	69854	48704	2.30
N_4 - 40-20-10 kg NPK/ha	20680	78172	57492	2.78

Discussion

Growth studies

The improved growth parameters were shown by varieties SiA 3085 (V1) and SiA 3156 (V2) due to their enhanced chlorophyll synthesis, greater photosynthetic activity, improved root proliferation and increased nutrient uptake. However, among the different nutrient levels, N4 (40-20-10 kg NPK/ha) and N2 (40-20-00 kg NPK/ha) recorded better growth parameters due to their adequate nutrient supply, in which N promotes cell division and leaf expansion, P enhances root growth and energy transfer, whereas K regulates enzyme activation, stomatal function and assimilate transport. As a result, these physiological processes contributed to greater biomass accumulation and crop growth (9–11).

Physiological studies

Early flowering and maturity were observed in variety SiA 3085 (V1) due to its early vigour and quicker attainment of critical growth stages governed by its genetic makeup, whereas among the nutrient levels, the prolonged duration under N4 (40-20-10 kg NPK/ha) was mainly due to delayed flowering and maturity compared to the control, which may be attributed to prolonged vegetative growth induced by N, allowing greater assimilation and translocation of nutrients (12, 13).

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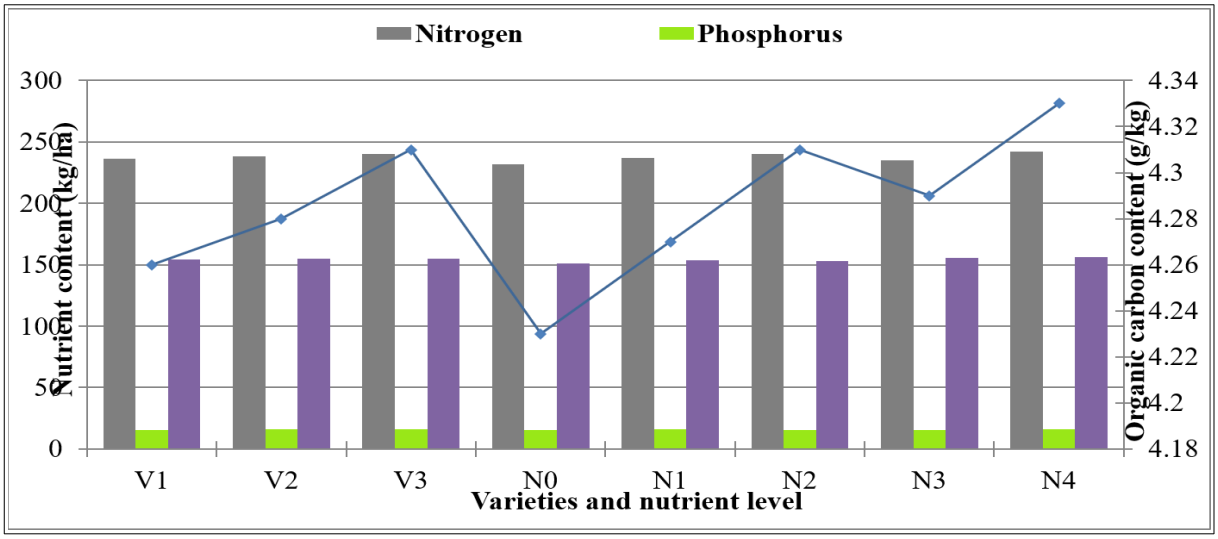


Fig. 5. Response of cultivars and nutrient levels on soil studies of foxtail millet.

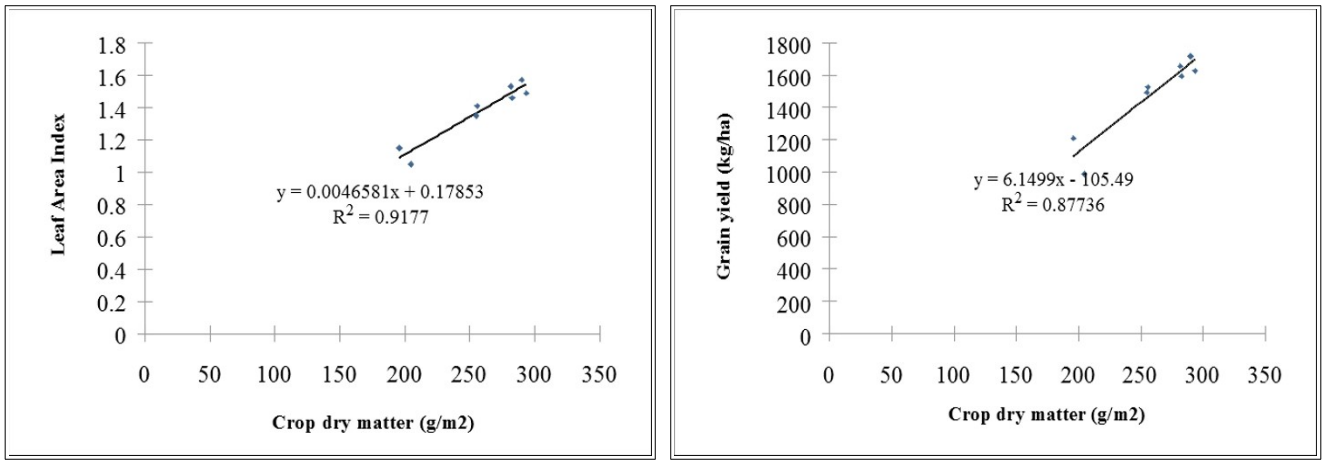


Fig. 6. The relationship between (A) crop dry matter and leaf area index, (B) crop dry matter and grain yield.

Yield attributes and yield

The superior yield attributes and yield were observed in varieties SiA 3085 (V1) and SiA 3156 (V2) due to their superior genetic potential, better source-sink relationship and efficient translocation of photosynthates towards developing grains. However, among the nutrient levels, N4 (40-20-10 kg NPK/ha) and N2 (40-20-00 kg NPK/ha) showed improved results from enhanced source-sink relationship, increased photosynthate production, efficient assimilate translocation and better grain filling. The combined availability of N, P and K ensured sustained crop growth throughout the reproductive phase, ultimately leading to higher productivity (14, 15).

Soil studies

Variety SiA 3085 (V1) resulted in numerically lower soil nutrient values. This is likely due to higher yield production leading to greater nutrient uptake from the soil. However, among various nutrient doses, N4 (40-20-10 kg NPK/ha) showed higher numerical values in soil studies due to balanced nutrient application, which maintained nutrient equilibrium and reduced nutrient depletion after crop uptake (15).

Relative economics

Higher economic returns were achieved with variety SiA 3085 (V1) due to its superior yield potential and better conversion of inputs into output, resulting in higher gross and net returns. Among various nutrient doses, N4 (40-20-10 kg NPK/ha) recorded better economics due to a balanced nutrient supply that resulted in better crop productivity and a higher B : C ratio (16).

Conclusion

The results of the two-year study indicate that among the varieties, SiA 3085 (V1) and SiA 3156 (V2) produced greater dry matter accumulation, grain production, net returns and benefit-cost (B : C) ratio. However, among various nutrient doses, N4 (40-20-10 kg nitrogen, phosphorus and potassium (NPK)/ha) and N2 (40-20-00 kg NPK/ha) produced more tillers, grain yield, organic matter, net returns and B : C ratio.

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Therefore, the present findings provide region-specific recommendations for improving foxtail millet productivity under the subtropical conditions of Jammu. The adoption of variety SiA 3085 with the balanced application of 40-20-10 kg NPK/ha can enhance crop productivity, profitability and nutrient-use efficiency, thereby supporting sustainable and climate-resilient millet cultivation in the region.

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Authors' contributions

RK and LK carried out the research part of the study. AK and NS carried out the corrections in the paper. APS and AM participated in the modification. SKM and SM help in sequence alignment. VT participated in the table's arrangements. HS helped in searching relevant data. All authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest

Authors do not have any conflict of interests to declare.

Ethical issues

None

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