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Nutrient management in little millet (*Panicum sumatrense* L.) for different row spacing

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Abstract

A field experiment was conducted during *kharif* 2025 at the All India Coordinated Research Project on Weed Management, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, to study the effect of row spacing and nutrient management on growth and yield of little millet (*Panicum sumatrense* L.). The experiment was laid out in Factorial Randomized Block Design with three replications and twelve treatment combinations. Factor A comprised three row spacing viz., S₁: paired row, S₂: 45 cm and S₃: 30 cm, while Factor B consisted of four nutrient levels viz., N₀: control, N₁: 100% GRDF (40:20:20 NPK kg ha⁻¹), N₂: 125% GRDF (50:25:25 NPK kg ha⁻¹) and N₃: 150% GRDF (60:30:30 NPK kg ha⁻¹). At harvest, 30 cm spacing recorded significantly higher plant height (116.52 cm), number of tillers (169.67 m⁻²) and leaf area index (3.37), whereas 45 cm spacing recorded significantly higher leaf area (526.76 cm² plant⁻¹), leaf dry matter (9.01 g plant⁻¹), stem dry matter (9.11 g plant⁻¹), root dry matter (3.73 g plant⁻¹) and total dry matter (21.71 g plant⁻¹). Among nutrient levels, 150% GRDF recorded the highest values of major growth parameters and remained statistically at par with 125% GRDF for most characters. The 45 cm spacing recorded higher grain weight plant⁻¹ (4.15 g) and number of panicles plant⁻¹ (3.87), while 30 cm spacing recorded significantly higher grain yield (1430 kg ha⁻¹) and straw yield (4387 kg ha⁻¹). Application of 150% GRDF recorded the highest grain yield (1493 kg ha⁻¹) and straw yield (4300 kg ha⁻¹), which were statistically at par with 125% GRDF. The interaction of 30 cm spacing with 150% GRDF recorded the highest grain yield (1682 kg ha⁻¹), which was at par with 30 cm spacing with 125% GRDF (1602 kg ha⁻¹). Similarly, the highest straw yield was recorded with 30 cm spacing combined with 150% GRDF (4882 kg ha⁻¹), which was at par with 30 cm spacing combined with 125% GRDF (4867 kg ha⁻¹).

Keywords: Little millet, row spacing, nutrient management, plant population, growth, grain yield, straw yield

Introduction

Little millet (*Panicum sumatrense* L.) is an important small millet crop cultivated predominantly under rainfed conditions. The crop possesses considerable adaptability to moisture stress and relatively poor soil conditions and therefore has an important role in sustainable dryland agriculture. In recent years, millets have received increased attention because of their nutritional value, climate resilience and potential contribution towards diversification of cereal-based production systems. Productivity of little millet is influenced by several agronomic factors, among which crop geometry and nutrient management are particularly important. Row spacing regulates plant population, canopy development, light interception and the availability of soil moisture and nutrients to individual plants. An excessively wide spacing may result in underutilization of available resources, whereas closer spacing increases plant population per unit area and may enhance yield per hectare despite reduced productivity on an individual plant basis.

Nutrient management is another important determinant of crop growth and yield. Little millet is commonly cultivated in low-input conditions, and inadequate nutrient supply may restrict tillering, leaf development, dry matter accumulation and grain formation. Adequate nitrogen, phosphorus and potassium supply can promote vegetative growth, root development, tillering and assimilate production, thereby improving yield formation.

Despite the inherent advantages of little millet, it faces several agronomic, environmental and practical challenges.

Variability in the soil properties, rainfall pattern and temperature affect plant responses and make it difficult to establish universal applicable recommendations. Therefore, multi-location and multi-season research including diverse soil types, climatic conditions, and integrated nutrient management approaches are required for developing more comprehensive and widely applicable recommendations for sustainable little millet production.

Materials and Methods

The field experiment was conducted during the *kharif* season of 2025 at the All India Coordinated Research Project on Weed Management, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra to study the effect of row spacing and nutrient management on growth and yield of little millet (*Panicum sumatrense* L.).

The experiment was laid out in Factorial Randomized Block Design with two factors, three replications and twelve treatment combinations. The crop variety used was PDKV-Tejashree. The gross plot size was 4.00 m × 3.60 m and the net plot size was 3.40 m × 2.70 m. The experimental site was located in the Central Vidarbha agro-climatic zone at 20°42' N latitude, 77°02' E longitude and an altitude of 307.42 m above mean sea level. The soil of the experimental site was medium black in texture. The initial soil analysis indicated low available nitrogen (160.80 kg ha⁻¹), medium available phosphorus (20.00 kg ha⁻¹) and high available potassium (306.93 kg ha⁻¹). The soil had pH 7.81, electrical conductivity 0.21 dS m⁻¹ and organic carbon 0.430%. The available nitrogen, phosphorus and potassium were, and respectively. During the crop season, a total rainfall of 615.9 mm was received from the 27th to 40th meteorological week, against a normal rainfall of 532 mm. The crop experienced 33 rainy days during the growing period.

Table 1: Treatment details

Factor A-Spacing	
S1	Paired row
S2	45cm
S3	30 cm
Factor B-Nutrient levels	
N0	Control
N1	40:20:20 NPK (100% GRDF)
N2	50:25:25 NPK (125% GRDF)
N3	60:30:30 NPK (150% GRDF)

Results and Discussion

Effect of spacing and nutrient levels on growth parameters

Plant height

Row spacing significantly affected plant height at harvest. The 30 cm spacing recorded the highest plant height of 116.52 cm, followed by paired row spacing (114.92 cm), while the lowest plant height was recorded with 45 cm spacing (113.39 cm). The greater plant height under closer spacing may be associated with increased competition for incident radiation, resulting in greater vertical growth of plants. Similar responses to closer plant geometry have been reported in little millet by of Asewar *et al.* (2023) ^[1].

Nutrient management significantly influenced plant height. Application of 150% GRDF recorded the highest plant height (122.86 cm), followed by 125% GRDF (122.20 cm). These two treatments were statistically at par. The control recorded the lowest plant height (96.83 cm). Improved plant

height under higher nutrient levels may be attributed to better availability of nitrogen, phosphorus and potassium, which supported cell division, cell elongation and vigorous vegetative growth. The result is in agreement with Niharika *et al.* (2021) ^[9] and Janani *et al.* (2022) ^[15].

Number of tillers

The number of tillers m⁻² was significantly influenced by row spacing. At harvest, 30 cm spacing produced the highest number of tillers (169.67 m⁻²), followed by 45 cm spacing (128.80 m⁻²), while paired row spacing recorded the lowest value (120.97 m⁻²). The higher tiller population per unit area under 30 cm spacing was primarily due to the greater plant population accommodated within a given land area. The findings are in conformity with Syed *et al.* (2022) ^[15] in little millet

Application of 150% GRDF produced 151.72 tillers m⁻², which was statistically at par with 125% GRDF (148.57 m⁻²). The control recorded only 124.03 tillers m⁻². The increase in tiller production with higher nutrient supply may be attributed particularly to greater nitrogen availability during the tillering phase. Similar observations were reported by Raundal *et al.* (2017) ^[11] and Niharika *et al.* (2021) ^[9].

Leaf area and leaf area index

Among spacing, 45 cm spacing recorded significantly higher leaf area of 526.76 cm² plant⁻¹ compared with paired row spacing (516.39 cm² plant⁻¹) and 30 cm spacing (505.72 cm² plant⁻¹). Greater leaf area under wider spacing can be attributed to greater availability of physical space, light, moisture and nutrients to individual plants, resulting in enhanced leaf expansion. . These results collaborated with the findings of Syed *et al.* (2022) ^[15] and Hiwale *et al.* (2025) ^[4] in little millet.

In contrast, leaf area index was significantly higher under 30 cm spacing (3.37), followed by 45 cm spacing (2.34) and paired row spacing (2.29). The higher LAI under closer spacing was associated with the greater number of plants per unit area, which compensated for the smaller individual leaf area. Similar observations have been reported by Hebbal *et al.* (2018) ^[3] and Janani *et al.* (2022) ^[15].

Among nutrient levels, 150% GRDF recorded the highest leaf area (552.41 cm² plant⁻¹) and LAI (2.86), which were statistically at par with 125% GRDF recording 548.97 cm² plant⁻¹ and 2.84, respectively. The control recorded the lowest values. Improved nutrient availability favoured leaf initiation and expansion and consequently increased canopy development. These findings corroborate the report of Charate *et al.* (2018).

Dry matter accumulation

The 45 cm spacing recorded significantly higher total dry matter (21.71 g plant⁻¹) at harvest. Wider spacing allowed individual plants greater access to light, moisture, nutrients and growing space and consequently promoted greater biomass accumulation on an individual plant basis. Similar results were reported by Prakasha *et al.* (2018) in finger millet.

Among nutrient levels, 150% GRDF produced the significantly higher total dry matter (22.48 g plant⁻¹), which remained statistically at par with 125% GRDF, which recorded 21.72 g plant⁻¹. The greater dry matter accumulation under higher nutrient levels may be attributed

to improved nutrient availability, greater leaf development and enhanced photosynthetic activity. Similar responses have been reported by Melavanki *et al.* (2024) ^[8] and Padmaja *et al.* (2024) ^[10].

Table 1: Growth parameters of little millet at harvest as influenced by row spacing and nutrient management

Treatment	Plant height (cm)	No of Tillers m ⁻²	Leaf area (cm ² plant ⁻¹)	LAI	Total dry matter(g plant ⁻¹)
Factor A-Row spacing					
S1-Paired row	114.92	120.97	516.39	2.29	20.92
S2-45 cm	113.39	128.80	526.76	2.34	21.71
S3-30 cm	116.52	169.67	505.72	3.37	19.46
SE(m)±	0.49	2.29	3.23	0.05	0.32
CD at 5%	1.44	6.73	9.48	0.16	0.95
Factor B-Nutrient management					
N0-Control	96.83	124.03	438.44	2.26	18.27
N1-100% GRDF	117.88	134.93	525.34	2.71	20.31
N2-125% GRDF	122.20	148.57	548.97	2.84	21.72
N3-150% GRDF	122.86	151.72	552.41	2.86	22.48
SE(m)±	0.57	2.65	3.73	0.06	0.37
CD at 5%	1.66	7.77	10.95	0.18	1.09
Interaction	NS	NS	NS	NS	NS
GM	114.94	139.81	516.29	2.67	20.69

Effect of spacing and nutrient levels on yield attributes
Grain weight and number of panicles

Row spacing significantly affected grain weight plant⁻¹ and number of panicles plant⁻¹. The 45 cm spacing recorded the significantly higher grain weight (4.15 g plant⁻¹) and number of panicles (3.87 plant⁻¹), followed by paired row spacing with 3.92 g plant⁻¹ and 3.77 panicles plant⁻¹. The lowest values were observed under 30 cm spacing, with 3.42 g grain weight plant⁻¹ and 3.61 panicles plant⁻¹. The superior performance of individual plants under wider spacing may be associated with greater availability of light, moisture, nutrients and growing space, thereby facilitating greater reproductive growth. In contrast, closer spacing increased competition among plants and restricted reproductive development on an individual plant basis. These results were supported by Sarala *et al.* (2020) ^[12] in little millet. Nutrient management significantly increased grain weight and number of panicles plant⁻¹. Application of 150% GRDF

recorded the highest grain weight (4.30 g plant⁻¹) and number of panicles (4.23 plant⁻¹), which were statistically at par with 125% GRDF recording 4.27 g plant⁻¹ and 4.17 panicles plant⁻¹, respectively. The improvement in yield attributes under higher nutrient levels may be attributed to improved tillering and greater assimilate availability for reproductive structures. These results are in close agreement with those of Padmaja *et al.* (2024) ^[10] in finger millet.

Test weight
Test weight was not significantly influenced by either row spacing or nutrient management. Numerically, 45 cm spacing recorded the highest test weight (1.61 g), while 30 cm spacing recorded 1.57 g. Among nutrient treatments, 150% GRDF recorded 1.62 g compared with 1.58 g under 125% GRDF. The non-significant response indicates that test weight was comparatively stable under the treatments imposed and may have been governed largely by the inherent characteristics of the variety.

Table 2: Yield attributes of little millet as influenced by various row spacing and nutrient levels

Treatment	Grain weight (g plant ⁻¹)	Panicles plant ⁻¹	Test weight (g)
Factor A-Row spacing			
S1-Paired row	3.92	3.77	1.59
S2-45 cm	4.15	3.87	1.61
S3-30 cm	3.42	3.61	1.57
SE(m)±	0.05	0.03	0.02
CD at 5%	0.16	0.09	NS
Factor B-Nutrient management			
N0-Control	2.79	2.76	1.57
N1-100% GRDF	3.96	3.86	1.59
N2-125% GRDF	4.27	4.17	1.58
N3-150% GRDF	4.30	4.23	1.62
SE(m)±	0.06	0.04	0.02
CD at 5%	0.18	0.11	NS
Interaction	NS	NS	NS
GM	3.83	3.75	1.59

Effect of spacing and nutrient levels on grain yield, straw yield and harvest index
Grain yield

Row spacing significantly influenced grain yield. The 30 cm spacing recorded significantly higher grain yield of 1430 kg ha⁻¹, followed by paired row spacing (1245 kg ha⁻¹),

whereas the lowest grain yield was recorded under 45 cm spacing (1216 kg ha⁻¹). The higher grain yield under 30 cm spacing, despite lower grain weight and number of panicles on an individual plant basis, may be attributed to the substantially greater plant population per unit area. Thus, the higher number of plants

compensated for lower individual plant productivity and resulted in greater grain production per hectare. Similar observations have been reported by Bitew and Asargew (2014) ^[2] in finger millet and Jyothi *et al.* (2021) ^[7] in foxtail millet.

Nutrient management significantly influenced grain yield. Application of 150% GRDF recorded the highest grain yield (1493 kg ha⁻¹), which was statistically at par with 125% GRDF (1440 kg ha⁻¹). The control recorded the lowest grain yield (955 kg ha⁻¹). Increased grain yield under higher nutrient supply may be attributed to enhanced plant growth, tiller production, leaf area development, dry matter accumulation and yield attributes. The significant response to higher fertility levels agrees with Asewar *et al.* (2023) ^[1] and Sujathamma and Naik (2022) ^[14], who reported improved growth and yield of little millet with increasing fertilizer levels.

Straw yield

The 30 cm spacing recorded significantly higher straw yield (4387 kg ha⁻¹), followed by paired row spacing (3647 kg ha⁻¹), while the lowest straw yield was recorded under 45 cm spacing (3507 kg ha⁻¹). The higher straw production

under 30 cm spacing may be attributed to the greater plant population, plant height and LAI, resulting in greater cumulative vegetative biomass per unit area. These findings are in close conformity with those reported by Nigus and Melese (2018) in finger millet and Jhansi *et al.* (2025) ^[6] in foxtail millet.

Among nutrient levels, 150% GRDF recorded the highest straw yield (4300 kg ha⁻¹), which was statistically at par with 125% GRDF (4242 kg ha⁻¹). Higher nutrient availability enhanced vegetative growth and dry matter production, thereby increasing straw yield. Similar results were reported by Janani *et al.* (2022) ^[5] in barnyard millet.

Harvest index

Harvest index was not significantly influenced by row spacing or nutrient management. The highest numerical harvest index under row spacing was recorded with 45 cm spacing (25.60%), followed by paired row (25.33%) and 30 cm spacing (24.31%). Among nutrient treatments, 150% GRDF recorded the highest numerical harvest index (25.53%), followed by 125% GRDF (25.41%), whereas control recorded 24.10%.

Table 3: Grain yield, straw yield and harvest index of little millet as influenced by various row spacing and nutrient management

Treatment	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Harvest index (%)
Factor A-Row spacing			
S1-Paired row	1245	3647	25.33
S2-45 cm	1216	3507	25.60
S3-30 cm	1430	4387	24.31
SE(m)±	18.92	21.72	0.41
CD at 5%	55.50	63.69	NS
Factor B-Nutrient management			
N0-Control	955	2987	24.10
N1-100% GRDF	1301	3860	25.28
N2-125% GRDF	1440	4242	25.41
N3-150% GRDF	1493	4300	25.53
SE(m)±	21.85	25.08	0.47
CD at 5%	64.08	73.54	NS
Interaction	110.9	127.38	NS
GM	1297	3847	25.08

Interaction effect

The interaction between row spacing and nutrient management was significant for grain and straw yield. The combination of 30 cm spacing with 150% GRDF recorded the highest grain yield of 1682 kg ha⁻¹, which was statistically at par with 30 cm spacing combined with 125% GRDF (1602 kg ha⁻¹). The lowest grain yield reported was 899 kg ha⁻¹ under 45 cm spacing combined with the control treatment. The significant interaction indicates that the response of grain yield to nutrient supply varied with row spacing. The higher plant population established under 30 cm spacing apparently benefited from increased nutrient availability, allowing the crop to sustain greater growth and reproductive production per unit area.

A similar response was recorded for straw yield. The combination of 30 cm spacing with 150% GRDF produced the highest straw yield of 4882 kg ha⁻¹, which was statistically at par with 30 cm spacing combined with 125% GRDF (4867 kg ha⁻¹). The lowest straw yield was recorded under 45 cm spacing with control nutrient management (2657 kg ha⁻¹).

Table 4: Interaction effect between spacing and nutrient levels for grain yield

Treatment	N0	N1	N2	N3	Mean
S1	922	1278	1362	1420	1245
S2	899	1234	1353	1377	1216
S3	1044	1391	1604	1682	1430
Mean	955	1301	1440	1493	1297
SE (m)±	38.02				
CD at 5%	110.9				

Table 5: Interaction effect between spacing and nutrient levels for straw yield

Treatment	N0	N1	N2	N3	Mean
S1	2816	3738	3971	4064	3647
S2	2657	3529	3889	3954	3507
S3	3488	4313	4867	4882	4387
Mean	2987	3859	4242	4300	3847
SE (m)±	43.0				
CD at 5%	127.38				

Conclusion

The present investigation demonstrated that Sowing of Little millet at 30 cm spacing recorded significantly higher values of growth parameters. Whereas, 45 cm spacing produced higher leaf area plant⁻¹, dry matter accumulation plant⁻¹ and yield attributing characters. However both grain and straw yield were significantly higher in spacing 30cm. The highest values of growth contributing characters, yield attributing characters and actual yield was highest in treatment with 150% GRDF (60:30:30) which were at par with 125% GRDF (50:25:25). Among spacing treatments, 30 cm spacing exhibited superior nutrient use efficiency indices. However, 125% GRDF (50:25:25) recorded the highest Agronomic Efficiency and Recovery Efficiency of N, P and K. Whereas, highest values of Partial Factor Productivity and Physiological efficiency were recorded in 100% GRDF (40:20:20). Spacing 30 cm recorded the highest values of gross monetary returns, net monetary returns and benefit-cost ratio. Among nutrient management practices, 150% GRDF (60:30:30) recorded highest values of gross monetary return, net monetary return and B:C ratio, which were statistically at par to those obtained under 125% GRDF (50:25:25). Considering the higher nutrient use efficiency and only marginal economic advantage of 150% GRDF (60:30:30), application of 125% GRDF (50:25:25) can be considered a more balanced and economically sustainable nutrient management practice for little millet at 30 cm spacing.

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