



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
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NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(7): 06-10
Received: 04-04-2026
Accepted: 08-05-2026

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Effect of establishment methods and nutrient management on growth and yield performance of future food foxtail millet (*Setaria italica* L.)

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i7a.5880>

Abstract

The field experiment was conducted in Split Plot Design comprising three crop establishment methods (E₁: Broadcasting, E₂: Line sowing, E₃: Transplanting) in main plots and three nutrient management practices N₁-5ton FYM ha⁻¹, N₂-5 ton Vermicompost ha⁻¹, N₃-40:20:20kg N: P₂O₅:K₂O ha⁻¹ through chemical fertilizer in sub plot.

The results revealed that, among different crop establishment methods transplanting method resulted in highest plant height at 60 DAS (80.10 cm) and 90 DAS (137 cm), highest dry matter accumulation (122 g m⁻², 404 g m⁻², 787 g m⁻² at 30 DAS, 60 DAS and 90 DAS respectively), highest number of grains per panicle (2036), highest test weight (3.28 g), number of effective tillers per square meter (133), highest panicle length (23 cm), highest grain yield (2425 kg ha⁻¹), highest stover yield (4872 kg ha⁻¹) and highest harvest index (33). On the other hand, among different nutrient management practices, N₂ registered highest plant height up to 90 DAS (35 cm, 80 cm, 137 cm at 30 DAS, 60 DAS, 90 DAS respectively), highest dry matter accumulation (120 g m⁻², 329 g m⁻², 801 g m⁻² at 30 DAS, 60 DAS, 90 DAS respectively), highest number of grains per panicle (2076), highest number of effective tillers per square meter (124), highest panicle length (22.06 cm), highest grain yield (2196 kg ha⁻¹) and highest stover yield (4931 kg ha⁻¹).

Keywords: Foxtail millet, establishment methods, nutrient, yield

Introduction

Millets are among the earliest farm cereal crops in the Indian subcontinent, with archaeological evidence indicating their cultivation for more than 10,000 years. They have historically been grown predominantly in dry and semiarid agroecological regions due to their strong tolerance to drought, high temperatures, and poor soil fertility. Their short growing duration and low input requirements made them particularly suitable for subsistence based farming systems.

In eastern India, foxtail millet (*Setaria italica*) has also been cultivated, particularly in parts of West Bengal. Although not as extensively grown as rice, foxtail millet is cultivated in rainfed upland areas of districts such as Purulia, Bankura, and parts of Birbhum. The crop is well adapted to the lateritic and low-fertility soils prevalent in these regions. It requires relatively low water and can be grown during the *kharif* season under minimal management conditions. In recent years, there has been renewed interest in foxtail millet cultivation in West Bengal due to its climate resilience, short growing cycle, and recognized nutritional benefits. This revival aligns with broader national efforts to promote millets as sustainable and nutritious crops for future food systems.

The main ways to grow foxtail millet are transplanting and broadcasting. Although transplanted crops generally produce higher yields than directly seeded crops, the transplantation method requires substantially greater labour input. This is primarily due to the additional operations involved, including nursery raising, seedling uprooting, transportation, and manual transplanting into the main field. The only alternative left for West Bengal's rural districts due to labor shortages and heavy rainfall is to directly sow foxtail millet in places with good drainage. This method is speedier and has the potential to be commercially successful. Therefore, a scientific investigation

Of foxtail millet crop establishment techniques is required. Nitrogen (N) is the nutrient that typically restricts crop output, its availability is a critical component in crop productivity. Nitrogen aids in the early development of photosynthesis capable leaf area. There will be a net reduction in the amount of nitrogen available for the grain in the absence of further nitrogen accumulation, which may lower grain production (Sinclair *et al.*, 2004) [7]. The productivity of agriculture and environmental preservation depend on the effectiveness of nitrogen fertilizers. As a result, the rate at which nitrogen is added has a significant impact on production. The best way to use nitrogen is to balance crop demand and nitrogen availability. Foxtail millet may be regarded as a crop with a high nitrogen efficiency because it benefits from little nitrogen inputs. In light of the aforementioned, the following objective have been set for current investigation is taken up to study “Effect of establishment methods and nutrient management on growth and yield performance of future food Foxtail Millet (*Setaria italica* L.)”.

Materials and Methods

A field experiment was conducted during *Rabi*, 2023-2024 at the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, and West Bengal. The experiment was laid out in split-plot design with 9 treatments replicated thrice. The treatment consists of three methods of establishments as main plot treatment (Broadcasting, Line Sowing, Transplanting) and three nutrient management practices as sub plot treatment (5 ton FYM ha⁻¹, 5 ton Vermicompost ha⁻¹, 40 kg N+ 20 kg P₂O₅+ 20 kg K₂O kg ha⁻¹ through urea, SSP and MOP). A local variety was selected for study. Sowing was done at 28th December of 2023. All the nutrients were applied as basal. The soil of the experimental site was sandy loam in texture with a pH 4.86 and had a low nitrogen (172 kg ha⁻¹), medium phosphorus (16.23 kg ha⁻¹) and medium potassium (136.62 kg ha⁻¹). In Transplanting and line sowing foxtail millet seeds were placed 20 (R x R) x 10 (P x P) cm and 20 cm (R x R) respectively. Broadcasting, Line sowing and Transplanting were done with a seed rate @30 kg ha⁻¹, 20 kg ha⁻¹, 10 kg ha⁻¹ respectively. The maximum temperature and minimum temperature varied from 18.57°C to 34.97°C and 9.29°C to 24.04°C, the maximum relative humidity varied from 50.00% to 92.43% and the minimum relative humidity varied from 34.57% to 83.00%. The optimum requirement of rainfall for foxtail millet is 500-750 mm. whereas, the total amount of rainfall received during the crop growth period of foxtail millet was 226.80 mm which was less than the actual rainfall requirement of crop. Thereafter, the deficit amount was supplemented with irrigation.

Plant height was recorded at selective dates by measuring the distance from the base of the stem to tip of the panicle for five randomly selected plants from each treatment. The number of tillers per square meter was observed from each treatment plot by counting the effective tillers using 1 square meter quadrat. Total dry matter production was also recorded at selective dates where five plants were randomly selected from each treatment, uprooted, cleaned, sun dries and then oven dried at 80°C until reaching a constant weight, which is expressed as grams per square meter by multiplying the individual plant dry weight with no of plants per square meter. CGR was calculated at 30-60 DAS and 60-90 DAS as the formula given by Watson (1958). From five randomly selected plants panicles which were collected from each treatment and grains were separated and average no. of

grains per panicle was recorded. Thousand- grain weight was determined by weighing 1000 number of grains samples from from panicles. At full maturity mature spikes and panicles were harvested from the 1 m × 1m net plot area and sundried. After dried the grains were manually shelled, dried again, weighed and converted into kg ha⁻¹ basis. The Harvest index was computed as a percentage by dividing economic yield by biomass yield as described by Donald and Hamblin (1976)

Result and discussion

Growth parameters

Plant height

Among the treatment combination, Transplanting method of establishment and 5 ton FYM ha⁻¹ were recorded the highest plant height at 30 DAS, 60 DAS and 90 DAS. Plant height showed 3.1 % and 5.9 % increase in treatment receiving 5 ton FYM ha⁻¹ than the treatment receiving 5 ton vermicompost ha⁻¹ and 40 kg N + 20 kg P₂O₅ + 20 kg K₂O kg ha⁻¹ respectively. This might be due to the prolonged release of nutrients from FYM boosted their effectiveness and generated favorable conditions for plant growth, applying organic sources of nitrogen through FYM had a good effect on plant height and dry matter of finger millet. This results were in close conformity with Ojha *et al.* (2018) [5] in foxtail millet.

Table 1: Effect of methods of establishment and nutrient management practices on plant height of foxtail millet at 30, 60, 90 DAS

Plant height (cm)			
	30 DAS	60 DAS	90 DAS
Main Plot			
E1	31	68	125
E2	31	78	137
E3	35	80	137
SEm (±)	1.65	1.89	1.08
CD (p=0.05)	NS	7.43	4.24
Sub Plot			
N1 : 5ton FYM ha ⁻¹	33	80	143
N2: 5ton Vermicompost ha ⁻¹	32	73	130
N3 :40 kg N + 20 kg P ₂ O ₅ +20 kg K ₂ O kg ha ⁻¹	31.14	73	126
SEm (±)	1.43	1.73	2.55
CD (p=0.05)	NS	5.35	7.87
Interaction			
SEm (±)	2.48	3.00	4.42
CD (p=0.05)	NS	NS	NS

Dry matter accumulation

Among different crop establishment methods, Transplanting method was recorded highest dry matter accumulation up to 90 DAS. In transplanting method, maximum plant height and noticeably greater number of tillers were achieved where the above ground and below ground resource utilization was better than other methods of establishment. This results were merely similar with Hebbal *et al.* (2018) [2].

Among the nutrient management treatments, N2 (5ton Vermicompost ha⁻¹) recorded the highest dry matter accumulation at all stages. This superiority is due to the prolonged nutrient release from FYM, which enhanced nutrient effectiveness and created favorable growth conditions which further positively influence the dry matter accumulation in foxtail millet. This findings are merely similar with Ojha *et al.* (2018) [5].

Table 2: Effect of methods of establishment and nutrient management practices on Dry matter accumulation (g m^{-2}) of foxtail millet at 30,60, 90 DAS

Dry matter accumulation (g m^{-2})			
Treatments	30 DAS	60 DAS	90 DAS
Main Plot			
E1 :Broadcasting	115.44	334.50	567.11
E2 :Line sowing	120.00	381.94	764.78
E3 :Transplanting	122.33	404.27	787.67
SEm($\pm$)	1.19	4.85	24.73
CD ($p=0.05$)	4.67	19.07	97.12
Sub Plot			
N1 : 5ton FYM ha^{-1}	120.27	376.33	699.33
N2 : 5ton Vermicompost ha^{-1}	120.77	379.77	801.33
N3 : 40 kg N+20 kg P_2O_5 +20 kg K_2O kg ha^{-1}	116.72	364.61	618.89
SEm($\pm$)	1.11	6.80	27.48
CD ($p=0.05$)	3.44	NS	84.68
Interaction			
SEm($\pm$)	1.93	11.78	47.60
CD ($p=0.05$)	7.59	NS	NS

Crop growth rate

Higher crop growth rate was found in transplanting method of establishment and the treatment receiving 5ton Vermicompost ha^{-1} at 30 DAS, 60 DAS, 90 DAS. Higher number of tiller production, uniform growth, higher plant height, robust plant and root system rather than the broadcasting and line sowing. This may be due to

the fact that in broadcasting and line sowing non uniform plant population gave rise to higher intra specific and inter specific plant competition for the above and below ground resources. Similar findings were recorded by Hebhal *et al.* (2018) ^[2].

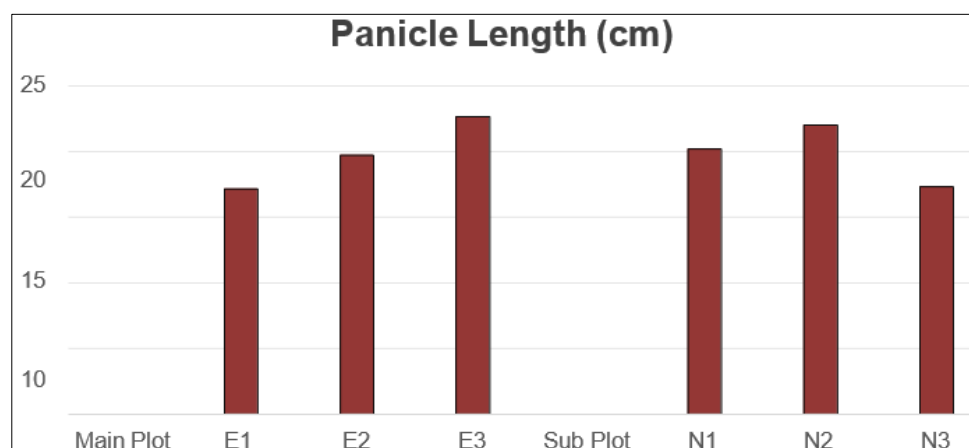
Table 3: Effect of methods of establishment and nutrient management practices on crop growth rate of foxtail millet at 30-60 DAS and 60-90 DAS

Crop growth rate ($\text{g m}^{-2} \text{day}^{-1}$)		
Treatments	30-60 DAS	60-90 DAS
Main Plot		
E1 :Broadcasting	7.30	7.75
E2 :Line sowing	8.73	12.76
E3 :Transplanting	9.40	12.78
SEm ($\pm$)	0.18	0.69
CD ($p=0.05$)	0.73	2.74
Sub Plot		
N1 : 5ton FYM ha^{-1}	8.54	10.77
N2: 5ton Vermicompost ha^{-1}	8.63	14.05
N3 :40 kg N+20 kg P_2O_5 +20 kg K_2O kg ha^{-1}	8.26	8.48
SEm($\pm$)	0.22	1.01
CD ($p=0.05$)	NS	3.13
Interaction		
SEm($\pm$)	0.38	1.75
CD ($p=0.05$)	NS	NS

Yield attributes**Panicle length**

The application of various nutrient sources as a treatment to the soil resulted significant difference in panicle length.

Transplanting method of establishment and nutrient management through vermicompost showed higher panicle length. This improvement subsequently contributed to better yield traits in foxtail millet.

**Fig 1:** Effect of methods of establishment and nutrient management practices on panicle length (cm) of foxtail millet

No. of effective tillers per square meter

Among different crop establishment method, transplanting method was recorded highest number of tillers per square meter (132.31) which was significantly superior to the line sowing (106.44) and broadcasting method (67.88). The transplanting approach produced the greatest number of tillers, which might be caused by enhanced root development and higher nitrogen consumption efficiency, two factors that could help with tillering. Similar finding was recorded by Jyothi *et al.* (2016) [4]. In foxtail millet. On the other hand, N₂ treatment recorded highest number of tillers (123.82) which was significantly superior to the N₃ (105.13) and N₁ (77.68) treatment.

No. of grain per panicle

Among the different crop establishment method, transplanting method was recorded highest numbers of grain per panicle

(2036.41) which was significantly superior to the line sowing method (1968.86) and broadcasting method (1919.24). This may be controlled by the crop's genetic influence, in which case crop management techniques and environmental conditions often have less of an impact. Whereas, N₂ treatment was recorded highest number of grains per panicle (2076.45) among different nutrient management which was significantly superior to the N₁ and N₃ treatment. This might be due to higher amount of accumulation of source to the sink as longer availability of nutrients.

Test weight

Test weight recorded highest in transplanting method (3.28 gm) and lowest in broadcasting method (3.10 gm) but there was no significant difference was seen and Among the different nutrient management, N₃ recorded highest test weight (3.29) and lowest test weight was recorded in N₂ (3.15),

Table 4: Effect of methods of establishment and nutrient management practices on yield attributes of foxtail millet

Treatments	No. of effective tillers m ⁻²	No. of grains per panicle	Test weight (gm)
Main Plot			
E1 :Broadcasting	67.88	1919.24	3.10
E2 :Line sowing	106.44	1968.86	3.25
E3 :Transplanting	132.31	2036.41	3.28
SEm(±)	5.76	16.16	0.06
CD (p=0.05)	22.64	63.47	NS
Sub Plot			
N1 : 5ton FYM.ha ⁻¹	105.13	1952.93	3.19
N2: 5ton Vermicompost ha ⁻¹	123.82	2076.45	3.15
N3: 40 kg N+20 kg P ₂ O ₅ +20 kg K ₂ O kg ha ⁻¹	77.68	1895.13	3.29
SEm(±)	6.90	33.89	0.07
CD (p=0.05)	21.27	104.44	NS
Interaction			
SEm(±)	6.90	58.70	0.13
CD (p=0.05)	21.27	NS	NS

Grain yield

The grain yield is presented in the table 6. In respect to different establishment methods, line sowing (20 cm apart with continuous seeding) recorded 5.4% higher grain yield and transplanting (20 cm X 10 cm) recorded 20% higher grain yield in comparison to broadcasting method of establishment. Organic sources of nutrient management (5 t vermicompost ha⁻¹) showed 5.64% higher grain yield than inorganic sources of nutrient management. This might be due to This may be because sufficient nutrients were available for a longer length of time during the crop, meeting crop needs and enhancing growth parameters and yield-enhancing traits that ultimately resulted in increased grain yields. Similar research was published in 2012 by Patil (2018) and among different establishment methods Transplanting recorded higher grain yield than line showing and broadcasting. This was explained by the fact that transplanting improved growth metrics and yield- related characteristics including test weight and no of tillers per square meter, which in turn led to an increase in grain

production. Similar findings recorded by Jagtap *et al.* (2013) [3].

Straw yield

According to the table 4.18, among the different crop establishment method, transplanting method was recorded highest stover yield (4872 kg ha⁻¹) which was significantly superior to the line sowing method (4372 kg ha⁻¹) and broadcasting method (3989 kg ha⁻¹). On the other hand, highest stover yield was recorded in N₂ treatment (4931 kg ha⁻¹) which was significantly superior to the N₁ (4287 kg ha⁻¹) and N₃ treatment (4016 kg ha⁻¹).

Harvest index

Transplanting method was recorded highest harvest index (33.29) which was significantly superior to the line sowing (31.89) and broadcasting method (32.68). Whereas, among different nutrient Management, N₃ treatment recorded highest harvest index (34.08) which was significantly superior to the N₂ (30.71) and N₁ treatment (33.06).

Table 6: Effect of methods of establishment and nutrient management practices on grain yield, stover yield, HI (%)

Treatments	Grain yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	HI (%)
Main Plot			
E 1 : Broadcasting	1924	3989	32.68
E 2 : Line sowing	2034	4372	31.89
E 3 : Transplanting	2425	4872	33.29
SEm(±)	31.34	49.18	0.54
CD (p=0.05)	123.06	193.11	NS
Sub Plot			
N1 : 5ton FYM.ha ⁻¹	2114	4287	33.06
N2: 5ton Vermicompost.ha ⁻¹	2196	4931	30.71
N3 :40 kg N+20 kg P ₂ O ₅ +20 kg K ₂ O kg ha ⁻¹	2072	4016	34.08
SEm(±)	30.64	82.43	0.49
CD (p=0.05)	94.42	254.01	1.51
Interaction			
SEm(±)	53.07	142.78	0.85
CD (p=0.05)	NS	NS	NS

Conclusion

Among different crop establishment methods, transplanting method resulted in highest plant height at 60DAS and 90DAS, highest dry matter accumulation, highest number of grains per panicle, highest test weight, no. of effective tillers per square meter, highest panicle length, highest grain yield, highest stover yield. Whereas, Among different nutrient management practices, organic sources of nutrient management (5t vermicompost ha⁻¹) registered highest plant height up to 90 DAS, highest dry matter accumulation, highest number of grains per panicle, highest number of effective tillers per square meter, highest panicle length, highest grain yield and highest stover yield.

Acknowledgement

Authors are thankful to Dean, Faculty of Agriculture specially the Department of Agronomy, Director of farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch- Behar, West Bengal for providing research fields, equipments, inputs and human resources for execution of the experiment.

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