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Shivani Kumari
M.Sc. Scholar, Department of
Agronomy, Naini Agricultural
Institute, Sam Higginbottom
University of Agriculture,
Technology and Sciences,
Prayagraj, Uttar Pradesh, India

Victor Debbarma
Assistant Professor, Department of
Agronomy, Naini Agricultural
Institute, Sam Higginbottom
University of Agriculture,
Technology and Sciences,
Prayagraj, Uttar Pradesh, India

Kuheli Bakshi
M.Sc. Scholar, Department of
Agronomy, Naini Agricultural
Institute, Sam Higginbottom
University of Agriculture,
Technology and Sciences,
Prayagraj, Uttar Pradesh, India

Corresponding Author:
Shivani Kumari
M.Sc. Scholar, Department of
Agronomy, Naini Agricultural
Institute, Sam Higginbottom
University of Agriculture,
Technology and Sciences,
Prayagraj, Uttar Pradesh, India

Effect of organic manure and plant geometry on growth and yield of finger millet (*Eleusine coracana* L.)

Shivani Kumari, Victor Debbarma and Kuheli Bakshi

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Abstract

The field experiment titled “Effect of organic manure and plant geometry on growth and yield of Finger millet (*Eleusine coracana* L.)” was conducted at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh during *Kharif* season of 2024. The experiment was laid out in Randomized Block Design with nine treatments which were replicated thrice. The results revealed that treatment 8 [Poultry manure (2 t/ha) + 25 cm x 25 cm] was found to be more desirable with higher growth parameters viz, significantly taller plant height (78.93 cm), maximum number of tillers/running row meter (27.67), higher plant dry weight (21.04 g), yield attributes and yield namely maximum number of fingers/hill (27.33), higher grain yield (2.66 t/ha) and higher stover yield (5.36 t/ha). Maximum gross return (127740.00 INR/ha), net return (90090.00 INR/ha) and benefit cost ratio (2.39) recorded in treatment 8 [Poultry manure (2 t/ha) + 25 cm x 25 cm] was found to be productive as well as economically feasible.

Keywords: Finger millet, organic manure, plant geometry, growth parameters, yield attributes, economics

1. Introduction

Finger millet (*Eleusine coracana* L.) is a highly valued millet crop which is cultivated extensively in India and several African countries. Its name derived from the distinctive finger-like branches of its panicle. Globally it is third most important millet after sorghum and pearl millet. While it is primarily a *Kharif* season crop, it is also cultivated in limited areas during the *Rabi*/summer seasons in Karnataka and Odisha. This crop exhibits a wider adaptability to various soil types, ranging from poor to highly fertile soils, and can withstand certain levels of alkalinity. Finger millet is often referred to as a miracle crop due to its impressive nutritional value. It provides 328 kcal of energy, 7.3 g of protein, 72 g of carbohydrates, 2.6 g of crude fiber, 344 mg of calcium, and 8.9 mg of iron for every 100 g, which is why it is considered as a nutri-cereal. In addition to vitamins A, B, and phosphorus in lesser amounts, finger millet is recognized for having the highest iodine content among food grains. This grain is uniquely characterized by its slow digestion and the gradual release of sugar into the bloodstream, making it a recommended choice for those with diabetes. Additionally, ragi is low in phytic acid and rich in dietary fiber. Its gluten-free status makes it a fantastic alternative for people who are sensitive to gluten.

In the global scenario, the total area under finger millet production is 4-4.5 million hectares and total production of 5 million tons of grain (ICRISAT, 2024) [6]. In India, it is cultivated in an area of 1.1 million hectares with the production of 1.6 million tonnes giving an average productivity of 1.5 tonnes per hectare (GOI, 2023) [12]. In Uttar Pradesh, the specific data for finger millet alone is limited, total area under millet production is 2.24 million hectares with the production of 4.91 million tonnes giving an average yield of 2194 kg/hectare (GOI, 2023) [4].

Even with its recognized nutritional and agronomic value, finger millet often underperforms under field conditions due to various limiting factors. These include inadequate soil fertility, uneven nutrient distribution, and inappropriate plant geometry, all of which hinder crop growth, tillering, and the development of fingers. Additionally, farmers often depend excessively on chemical fertilizers and conventional spacing techniques that do not promote optimal crop growth. These challenges are intensified by low organic matter content in the soil, poor root

development, and ineffective use of available nutrients. As a result, organic manure is the ideal choice for effective soil enrichment, and ensuring adequate plant geometry supports healthier growth and maximizes yield potential.

One of the most significant biodegradable manure is Farmyard manure (FYM). It has a direct impact on crop yield by facilitating the respiratory process, enhancing cell permeability, and influencing growth hormones. To mitigate nutrient stress in organic farming, it is crucial to thoroughly understand the nutrient release patterns from organic materials, as a close alignment between nutrient availability and crop needs is essential. Thus, establishing and applying effective nutrient management practices is essential for the success of organic farming, as well as for increasing yield, improving product quality, and fostering soil health. FYM contains 0.5% nitrogen, 0.2% phosphorus, and 0.5% potassium and plays a vital role in maintaining soil health and crop productivity by boosting biological activity, improving physical-chemical characteristics, and enhancing soil fertility. Vermicompost is produced through the decomposition of organic waste, facilitated by earthworms, resulting in a high-quality compost that mainly consists of worm castings and decomposed organic matter. This process of vermicomposting effectively transforms domestic refuse, animal waste, and agricultural residues into fertilizers that are rich in nutrients for plants and soil. The nutrient composition of vermicompost includes 3% nitrogen, 1% phosphorus, and 1.5% potassium. It contributes to maintaining soil health, mitigating environmental pollution, and improving soil structure and its capacity to retain water. Additionally, it enhances nutrient solubility, alters soil salinity, density, and pH levels, and fosters the activity of microorganisms that facilitate the absorption of macro- and micronutrients by plants through organic means (Kavya *et al.*, 2023) [7]. Poultry manure has the highest concentrations of organic carbon, nitrogen, phosphorus, potassium, and calcium, as well as the lowest carbon-to-nitrogen ratio. Additionally, poultry manure is richer in nitrogen than other livestock wastes. The slow-release nature of this manure contributes to a reduction in nitrogen loss (Nissi and Debbarma, 2022) [13].

Crop geometry is an important factor in boosting production by improving the efficiency of moisture and nutrient absorption from the soil (root spread) and the plant canopy. This efficiency facilitates the maximum absorption of solar radiation, which is essential for the effective synthesis of photosynthates. Furthermore, research has shown that using the square method of sowing can lead to higher yields of finger millet compared to traditional farming methods (Kumar *et al.*, 2021) [9].

2. Materials and Methods

The field experiment was conducted during *Kharif* season 2024 at Crop Research Farm (CRF), Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.) to study the “Effect of organic manure and plant geometry on growth and yield of Finger millet (*Eleusine coracana* L.)”. The soil of the experimental field was sandy loam in texture, with soil pH 7.1, low level of organic carbon (0.452%), available N (178.48 Kg/ha), available P (23.6 Kg/ha) and available K (231.4 Kg/ha). The experiment was laid out in Randomized Block Design with nine treatments and three replications. The treatment combinations are T1 [FYM (12 t/ha) + 20 cm x 15 cm], T2 [FYM (12 t/ha) + 25 cm x 25 cm], T3 [FYM (12 t/ha) + 30 cm x 10 cm], T4 [Vermicompost (3 t/ha) + 20 cm x 15 cm], T5 [Vermicompost (3 t/ha) + 25 cm x 25 cm], T6 [Vermicompost (3 t/ha) + 30 cm x 10 cm], T7 [Poultry manure (2 t/ha) + 20 cm x

15 cm], T8 [Poultry manure (2 t/ha) + 25 cm x 25 cm] and T9 [Poultry manure (2 t/ha) + 30 cm x 10 cm]. Data collected on growth parameters viz., Plant height (cm), Number of tillers/running row meter, Plant dry weight (g), Crop growth rate (g/m²/day), Relative growth rate (g/g/day)] and yield attributes viz., Number of fingers/hill, Test weight (g), Grain yield (t/ha), Stover yield (t/ha), Harvest index (%) were subjected to statistically analysed by analysis of variance method as described by Gomez and Gomez (1976) [5]. Economics were also calculated [Cost of cultivation (INR/ha), Gross returns (INR/ha), Net returns (INR/ha) and benefit-cost ratio].

3. Results and Discussion

3.1 Growth attributes

3.1.1 Plant height (cm)

The data revealed that significant and taller plant height (78.93 cm) was recorded in treatment 8 [Poultry manure (2 t/ha) + 25 cm x 25 cm]. However, treatment 5 [Vermicompost (3 t/ha) + 25 cm x 25 cm] was found to be statistically on par with treatment 8 [Poultry manure (2 t/ha) + 25 cm x 25 cm] (Table 1.) Significantly taller plant height was observed with the application of poultry manure (2 t/ha) may be due to enhanced nitrogen availability with poultry manure incorporation in the soil which helped continuous slow release of nutrients promoting a better crop growth. Similar finding was reported by Aravind *et al.* (2020) [1]. Further, plant geometry of 25 cm x 25 cm observed taller plant height might be due to wider spacing resulted in reduced competition among plants for solar radiation, space, water leading to more efficient utilization of available resources for better plant growth, particularly in terms of plant height. Similar finding was reported by Debbarma *et al.* (2024) [2].

3.1.2 Number of tillers/running row meter

Results revealed that significant and maximum number of tillers/running row meter (27.67) was recorded in treatment 8 [Poultry manure (2 t/ha) + 25 cm x 25 cm]. However, treatment 5 [Vermicompost (3 t/ha) + 25 cm x 25 cm] and treatment 9 [Poultry manure (2 t/ha) + 30 cm x 10 cm] were found to be statistically on par with treatment 8 [Poultry manure (2 t/ha) + 25 cm x 25 cm] (Table 1). Significant and maximum number of tillers/running row meter was observed with the application of poultry manure (2 t/ha) might be due to higher macro and micro nutrient content of the poultry manure which enables continuous slow and steady release of nutrients which might have helped in better tillering. Similar finding was reported by Aravind *et al.* (2020) [1]. Further, plant geometry of 25 cm x 25 cm observed maximum number of tillers/running row meter which may be attributed to the fact that each individual plant in square planting got the advantages of more liberal nutrients, space and other growth resources due to less competition of lower plant population and also planting in square method with wider spacing might have resulted in profuse tillering, which might have facilitated plants for better utilization of the resources. Similar finding was also reported by Kumar and Paramasivan (2020) [10].

3.1.3 Plant dry weight (g)

Results revealed that significant and higher plant dry weight (21.04 g) was recorded in treatment 8 [Poultry manure (2 t/ha) + 25 cm x 25 cm]. However, treatment 5 [Vermicompost (3 t/ha) + 25 cm x 25 cm], treatment 7 [Poultry manure (2 t/ha) + 20 cm x 15 cm] and treatment 9 [Poultry manure (2 t/ha) + 30 cm x 10 cm] were found to be statistically on par with treatment 8

[Poultry manure (2 t/ha) + 25 cm x 25 cm] (Table 1). Significant and higher plant dry weight was observed with the application of poultry manure (2 t/ha) could be due to the availability and adequate supply of organic matter by the poultry manure. Similar finding was reported by Nissi and Debbarma (2022) ^[13] in foxtail millet. Further, significantly higher plant dry weight was observed with plant geometry of 25 cm x 25 cm might be due to wider spacing improves nutrient uptake, light interception, and aeration, leading to increased photosynthetic efficiency and dry matter accumulation. Similar finding was reported by Padmaja *et al.* (2024) ^[14].

3.1.4 Crop growth rate (g/m²/day)

The results showed that during 75-100 DAS (Days After Sowing), significant and higher crop growth rate (9.63 g/m²/day) was recorded in treatment 1 [FYM (12 t/ha) + 20 cm x 15 cm]. However, treatment 3 [FYM (12 t/ha) + 30 cm x 10 cm], treatment 6 [Vermicompost (3 t/ha) + 30 cm x 10 cm], treatment 7 [Poultry manure (2 t/ha) + 20 cm x 15 cm] and treatment 9 [Poultry manure (2 t/ha) + 30 cm x 10 cm] were found to be statistically on par with treatment 1 [FYM (12 t/ha) + 20 cm x 15 cm] (Table 1). Significant and higher crop growth rate was observed with the application of FYM (12 t/ha) might be due to organic sources release slow and continuous availability of nutrients enhance cell division, elongation as well as various metabolic processes which increases plant growth attributes which ultimately attained the highest source capacity and dry matter accumulation. Similar finding was reported by Shreya and Debbarma (2024) ^[17] in rice. Further, significant and higher crop growth rate was observed with plant geometry of 20 cm x 15 cm, possibly due to the closer spacing, which may be attributed to the small ground area subtended by each individual plant; this might have ensured early canopy ground cover, thus capturing more solar energy and utilization of soil moisture and available nutrients. Similar finding was reported by Debbarma *et al.* (2024) ^[2].

3.1.5 Relative growth rate (g/g/day)

The highest relative growth rate (0.0196 g/g/day) was recorded in treatment 1 [FYM (12 t/ha) + 20 cm x 15 cm] and though there was no significant difference among the treatments (Table 1).

3.2 Yield attributes

3.2.1 Number of fingers/hill

The results revealed that significant and maximum number of fingers/hill (27.33) was recorded in treatment 8 [Poultry manure (2 t/ha) + 25 cm x 25 cm]. However, treatment 5 [Vermicompost (3 t/ha) + 25 cm x 25 cm] was found to be statistically on par with treatment 8 [Poultry manure (2 t/ha) + 25 cm x 25 cm] (Table 2). Significantly maximum number of fingers/hill was observed with the application of poultry manure (2t /ha), which might be due to the presence of uric acids in poultry manure that can accelerate nutrient release and promote more extensive root growth, enabling crops to take up more nutrients from the soil, leading to a quicker transformation of synthesized photosynthates into proteins; as a result, this process increases the formation of protoplasm, thereby improving yield attributes like number of fingers and overall yield. Similar finding was reported by Ramesh *et al.* (2024) [16]. Further, plant geometry of 25 cm x 25 cm observed maximum number of fingers/hill may be due to it provide optimal spacing and a favorable microclimate for crops, facilitating the efficient use of available

moisture and nutrients; this arrangement can also promote early adoption, leading to improved allocation of photosynthates to reproductive structures, ultimately resulting in enhanced yield characteristics like number of fingers. Similar finding was reported by Kumar *et al.* (2019) [8].

3.2.2 Test weight (g)

The highest test weight (3.01 g) was recorded in treatment 8 [Poultry manure (2 t/ha) + 25 cm x 25 cm] and though there was no significant difference among the treatments (Table 2).

3.2.3 Grain yield (t/ha)

The data revealed that significant and higher grain yield (2.66 t/ha) was recorded in treatment 8 [Poultry manure (2 t/ha) + 25 cm x 25 cm]. However, treatment 5 [Vermicompost (3 t/ha) + 25 cm x 25 cm] was found to be statistically on par with treatment 8 [Poultry manure (2 t/ha) + 25 cm x 25 cm] (Table 2). Significant and higher grain yield was observed with the application of poultry manure (2t /ha), which could be due to the efficient utilization of nutrients present in poultry manure and these nutrients enhance the plant's overall physiological functions, particularly photosynthetic efficiency, leading to better growth and ultimately resulting in increased grain yield of finger millet. Similar finding was reported by Gani and Shinggu (2016) ^[3]. Further, significant and higher grain yield was observed with plant geometry of 25 cm x 25 cm, possibly due to the observed increase in growth indices resulting from the availability of wider spacing and adequate nutrients and this favorable environment enhanced plant vigor and promoted better physiological performance, as reflected by improved growth parameters including taller plant height, increased number of tillers per running row meter, and more robust plant structure, thereby facilitating efficient photosynthesis and effective translocation of assimilates from source to sink, ultimately contributing to higher grain yield. Similar finding was reported by Prakasha *et al.* (2018) ^[15].

3.2.4 Stover yield (t/ha)

The data revealed that significant and higher stover yield (5.36 t/ha) was recorded in treatment 8 [Poultry manure (2 t/ha) + 25 cm x 25 cm]. However, treatment 7 [Poultry manure (2 t/ha) + 20 cm x 15 cm] and treatment 9 [Poultry manure (2 t/ha) + 30 cm x 10 cm] were found to be statistically on par with treatment 8 [Poultry manure (2 t/ha) + 25 cm x 25 cm] (Table 2). Significant and higher stover yield was observed with the application of poultry manure (2 t/ha) might be due to poultry manure serves as an effective source of nitrogen, phosphorus, and potassium (NPK), along with essential micronutrients that promote plant growth which leads to improved plant establishment, higher dry weight, and enhanced grain filling, ultimately resulting in higher stover yield. Similar finding was reported by Sreenivasulu *et al.* (2023) ^[18]. Further, significant and higher stover yield was observed with plant geometry of 25 cm x 25 cm may be due to the development of a denser plant population, larger root volume, the presence of numerous and robust tillers, and more substantial plant biomass. Similar finding was reported by Malsawmzuala and Debbarma (2024) ^[11] in little millet.

3.2.5 Harvest index (%)

The highest harvest index (35.36%) was recorded in treatment 5 [Vermicompost (3 t/ha) + 25 cm x 25 cm] and though there was no significant difference among the treatments (Table 2).

3.3 Economic analysis

The maximum benefit cost ratio (2.39) was recorded in treatment 8 [Poultry manure (2 t/ha) + 25 cm x 25 cm] (Table 3). Maximum benefit cost ratio was observed with the application of Poultry manure (2 t/ha) might be due to organic source of nutrient such as poultry manure, may be attributed to improved soil health, which leads to enhanced plant growth, better yield components, increased overall yield, and higher market prices

for organic products. Similar finding was reported by Debbarma *et al.* (2024) [2]. Further, plant geometry of 25 cm x 25 cm observed maximum benefit cost ratio, this could be due to it allows adequate plant stand with sufficient aeration and sunlight interception, promoting higher tillering and finger development which improve the yield without proportionally increasing the cost of cultivation, thereby resulting in a higher economic return.

Table 1: Effect of organic manure and plant geometry on the growth attributes of Finger millet

S. no	Treatment combinations	Plant height (cm)	Number of tillers /running row meter	Plant dry weight(g)	CGR (g/m ² /day) 75-100 DAS interval	RGR (g/g/day) 75-100 DAS interval
1.	FYM (12 t/ha) + 20 cm x 15 cm	70.77	23.67	18.71	9.63	0.0196
2.	FYM (12 t/ha) + 25 cm x 25 cm	75.65	24.00	18.93	3.46	0.0135
3.	FYM (12 t/ha) + 30 cm x 10 cm	72.99	24.67	18.96	9.48	0.0188
4.	Vermicompost (3 t/ha) + 20 cm x 15 cm	73.04	23.67	18.87	7.80	0.0148
5.	Vermicompost (3 t/ha) + 22cm x 25 cm	77.56	27.33	20.92	4.36	0.0157
6.	Vermicompost (3 t/ha) + 30 cm x 10 cm	76.16	24.67	19.02	6.78	0.0123
7.	Poultry manure (2 t/ha) + 20 cm x 15 cm	76.34	25.33	20.48	9.03	0.0160
8.	Poultry manure (2 t/ha) + 25 cm x 25 cm	78.93	27.67	21.04	4.30	0.0156
9.	Poultry manure (2 t/ha) + 30 cm x 10 cm	76.35	25.67	19.75	7.54	0.0135
	F-test	S	S	S	S	NS
	S.Em (±)	0.65	0.71	0.56	0.95	0.0020
	CD (p=0.05)	1.96	2.13	1.69	2.85	---

Table 2: Effect of organic manure and plant geometry on yield attributes and yield of Finger millet

S.no	Treatment combinations	Number of fingers/hill	Test weight (g)	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1.	FYM (12 t/ha) + 20 cm x 15 cm	17.33	2.77	2.24	4.70	32.29
2.	FYM (12 t/ha) + 25 cm x 25 cm	23.33	2.68	2.37	4.96	32.29
3.	FYM (12 t/ha) + 30 cm x 10 cm	12.67	2.86	2.27	4.80	32.11
4.	Vermicompost (3 t/ha) + 20 cm x 15 cm	17.67	2.74	2.25	4.85	31.74
5.	Vermicompost (3 t/ha) + 25 cm x 25 cm	26.33	2.80	2.64	4.83	35.36
6.	Vermicompost (3 t/ha) + 30 cm x 10 cm	13.33	2.94	2.46	4.99	33.00
7.	Poultry manure (2 t/ha) + 20 cm x 15 cm	19.00	2.89	2.40	5.16	31.79
8.	Poultry manure (2 t/ha) + 25 cm x 25 cm	27.33	3.01	2.66	5.36	33.15
9.	Poultry manure (2 t/ha) + 30 cm x 10 cm	14.00	2.87	2.48	5.22	32.25
	F-test	S	NS	S	S	NS
	S.Em (±)	1.02	0.06	0.06	0.08	0.78
	CD (p=0.05)	3.05	---	0.17	0.23	---

Table 3: Effect of organic manure and plant geometry on economics of Finger millet

S. no	Treatment combinations	Cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C ratio
1.	FYM (12 t/ha) + 20 cm x 15 cm	49830.00	103470.00	53640.00	1.08
2.	FYM (12 t/ha) + 25 cm x 25 cm	49650.00	113640.00	63990.00	1.29
3.	FYM (12 t/ha) + 30 cm x 10 cm	49950.00	109350.00	59400.00	1.19
4.	Vermicompost (3 t/ha) + 20 cm x 15 cm	52830.00	108525.00	55695.00	1.05
5.	Vermicompost (3 t/ha) + 25 cm x 25 cm	52650.00	126045.00	73395.00	1.39
6.	Vermicompost (3 t/ha) + 30 cm x 10 cm	52950.00	118185.00	65235.00	1.23
7.	Poultry manure (2 t/ha) + 20 cm x 15 cm	37830.00	115740.00	77910.00	2.06
8.	Poultry manure (2 t/ha) + 25 cm x 25 cm	37650.00	127740.00	90090.00	2.39
9.	Poultry manure (2 t/ha) + 30 cm x 10 cm	37950.00	119430.00	81480.00	2.15

4. Conclusion

It is concluded that in finger millet the application of poultry manure (2 t/ha) along with plant geometry 25 cm x 25 cm (Treatment 8) was observed higher yield and benefit - cost ratio.

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