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Shikhar Raj Gupta
M.Sc. Scholar, Department of
Agronomy, Naini Agricultural
Institute, SHUATS,
Prayagraj, Uttar Pradesh,
India

Joy Dawson
Professor and Head,
Department of Agronomy,
Naini Agricultural Institute,
SHUATS, Prayagraj,
Uttar Pradesh, India

Vikas Pal
M.Sc. Scholar, Department of
Agronomy, Naini Agricultural
Institute, SHUATS,
Prayagraj, Uttar Pradesh,
India

Corresponding Author:
Shikhar Raj Gupta
M.Sc. Scholar, Department of
Agronomy, Naini Agricultural
Institute, SHUATS,
Prayagraj, Uttar Pradesh,
India

Effect of different organic and inorganic sources of nitrogen and plant growth regulators on growth and yield of finger millet

Shikhar Raj Gupta, Joy Dawson and Vikas Pal

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Abstract

A field experiment was conducted during *Kharif* season of 2025 at CRF (Crop Research Farm), Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, (U.P.). The experiment was laid out in Randomized Block Design with ten treatment combination replicated thrice. The treatment consisted of three different sources of nitrogen which were 100% Nitrogen through Urea, 50% Nitrogen through Urea and 50% through Poultry Manure, 100% Nitrogen through Poultry Manure along with three different Plant Growth Regulators consisting of Salicylic acid (SA) 40 ppm, Gibberellic acid (GA3) 40 ppm and Seaweed Extract (Sagarika) 5%. Application of 50% Nitrogen through Urea and 50% through Poultry Manure + Seaweed extract 5% (Treatment 8) recorded highest plant height (77.12 cm), more number of tillers/running row meter (m^2) (162.67), highest dry weight (1440 g/m^2), number of grains/finger (245.86), number of fingers/earhead (7.47), number of earhead/ m^2 (69.33), test weight (2.53g), seed yield (32.21 q/ha) and stover yield (40.43 q/ha). The same treatment recorded highest gross return (INR 1,68,971.10/ha) while highest net return (INR 1,15,177.60/ha) and higher B:C ratio (2.73) was observed by application of 50% Nitrogen through Urea and 50% Nitrogen through Poultry Manure + Seaweed Extract 5% (Treatment 5).

Keywords: Poultry manure, salicylic acid, Gibberellic acid, seaweed extract, nitrogen

Introduction

Finger millet (*Eleusine coracana* L.) is one of the most important small millets cultivated in the semi-arid and sub-humid tropics of Asia and Africa. It belongs to the family Poaceae and is a self-pollinated allotetraploid species ($2n = 4x = 36$) characterized by its unique digitate inflorescence, from which the name “finger” millet is derived. The crop is recognized for its remarkable adaptability to marginal soils, erratic rainfall, and low input conditions, making it an important component of climate-resilient agriculture. Finger millet is widely regarded as a “nutri-cereal” owing to its superior calcium, iron, dietary fibre, and antioxidant content compared to major cereals like rice and wheat (Saleh *et al.*, 2013) ^[23]. Its C4 photosynthetic pathway enables efficient utilization of light, water, and nitrogen, thereby conferring tolerance to drought and heat stress (Bennetzen *et al.* 2017) ^[2]. These characteristics have renewed global interest in finger millet as a strategic crop for nutritional security and sustainable farming systems.

Nitrogen is one of the most limiting nutrients for finger millet production, playing a central role in chlorophyll formation, protein synthesis, enzymatic activity, and vegetative growth. Adequate nitrogen supply enhances tillering, leaf area development, spike formation, and grain filling, thereby increasing yield. However, nitrogen deficiency results in stunted growth, chlorosis, and reduced biomass accumulation. Nitrogen application significantly improves grain yield and nutrient uptake in finger millet, although response varies with genotype and soil conditions (Ashoka *et al.*, 2009) ^[1]. Efficient nitrogen management is therefore essential to optimize productivity while minimizing environmental losses. Excessive reliance on synthetic nitrogen fertilizers may lead to leaching, volatilization, and soil degradation (Ladha *et al.*, 2005) ^[15]. Hence, balanced and integrated nutrient management strategies are increasingly recommended for sustainable millet cultivation.

Organic sources of nitrogen, particularly nutrient-rich animal manures, play an essential role in sustaining soil health and improving crop productivity. Such organic amendments release nutrients slowly through mineralization, ensuring prolonged availability during crop growth. Application of poultry-based organic manures has been reported to improve soil organic carbon, microbial biomass, and nitrogen availability in millet systems. In addition to nitrogen, these organic inputs supply micronutrients and enhance soil structure, porosity, and water-holding capacity. Improved microbial activity resulting from organic amendments contributes to better nutrient cycling and root proliferation. Although nutrient release from organic sources may initially be slower compared to synthetic fertilizers, their long-term benefits on soil fertility and sustainability are substantial (ICAR, 2015) ^[11].

Gibberellic acid (GA₃) is another important growth regulator that influences cell elongation, enzyme activation, and reproductive development. Exogenous application of gibberellic acid promotes stem elongation, panicle exertion, and enhanced grain filling in cereals. GA₃ stimulates α -amylase activity during seed germination, thereby improving seedling vigour and early establishment. In finger millet, appropriate concentrations of GA₃ have been reported to increase plant height, leaf area, and spike length, ultimately contributing to higher yield attributes (Patel *et al.*, 2016) ^[20]. However, excessive application may result in lodging due to excessive elongation, emphasizing the need for dose optimization. The integration of gibberellic acid with balanced nitrogen supply may synergistically enhance growth and reproductive efficiency.

Salicylic acid functions as a signaling molecule involved in plant defence, stress tolerance, and physiological regulation. Salicylic acid application enhances photosynthetic rate, antioxidant enzyme activity, and tolerance to abiotic stresses such as drought and salinity (Khan *et al.*, 2015) ^[14]. It regulates stomatal conductance and modulates endogenous hormone levels, thereby improving growth under stress conditions. In cereals, foliar application of salicylic acid has been associated with improved biomass production and grain yield under suboptimal environments (Nazar *et al.*, 2011) ^[18]. Its role in inducing systemic acquired resistance further contributes to enhanced plant health. The combined use of salicylic acid with nutrient management strategies may therefore stabilize yield in finger millet under changing climatic scenarios.

Seaweed extract is a cheap organic source of fertilizers. Application of seaweeds as fertilizers and their importance in crop productivity have been reported by many authors. The seaweed extracts have been shown to contain many bioactive substances that favorably affect yield and quality of several crops. They contain, besides plant essential macro- and micro-nutrients, several plant growth regulators such as IAA, gibberellins, cytokinin's, choline chloride and glycine betaine that are responsible for bringing out many physiological responses in plants Singh *et al.* (2015) ^[25].

Materials and Methods

A field experiment was carried out in alluvial soil at the Crop Research Farm of the Department of Agronomy, SHUATS, Prayagraj, U.P., during the *Kharif* season of 2025. It is located at 25° 24' 42" N latitude, 81° 50' 56" E longitude and 98 m altitude above the mean sea level. This

area is situated on the right side of the river Yamuna by the side of Prayagraj Rewa Road about 5 km away from Prayagraj city. A composite soil sample was collected at a depth of 0-30 cm. It was air dried, crushed, and tested for physical and chemical properties. The soil was sandy clay loam in texture with soil reaction of (pH 7.6), 0.69 organic matter (0.72%), available nitrogen (152.7 kg/ha), phosphorus (10.4 kg/ha), potassium (174.0 kg/ha) On 25th July 2024, Finger millet seeds were planted with a 45 cm x 15 cm spacing. Experiments were carried out in a Randomized block design. To apply nutrients as a spreading method, 4-5 cm deep furrows were dug along the seed rows using a hand hoeing. Ten days after sowing, the gaps were filled by transplanting once germination took place. Where necessary, seedlings were trimmed out to maintain 30 cm x 10 cm spacing. In order to reduce crop density, weed competition, intercultural operations were carried out between 25 and 45 days intervals. On 19th Nov 2025, harvesting of the crop was done. At regular intervals from germination to harvest, plant growth parameters such as plant height (cm), dry weight (g/plant), CGR and RGR were assessed. At harvest, yield metrics such as tiller/plant, seeds/tiller, test weight (g), seed yield (kg/ha), straw yield (kg/ha), and harvest index (%) were measured at 20, 40, 60, 80 and 100 DAS. Analysis of variance (ANOVA), as it relates to randomized block design, was used to statistically examine the observed data of ten treatments (Gomez and Gomez, 1984 and Mohan *et al.* 2024) ^[9, 17].

Results and Discussions

Growth parameter

Plant Height

The data of growth parameter are presented in Table 1. At 100 DAS, significant and higher plant height (77.12 cm) was recorded in treatment 8 [50% Nitrogen through urea and 50% nitrogen through poultry manure + Sea weed extract (Sagarika) 5%]. The superiority of T8 at this stage suggests the sustained nutrient release pattern by urea and poultry manure. Urea have provided instant N to the crop during the initial stages while poultry manure might have supplied remaining N and other essential micro nutrients during the later part of crop growth, while seaweed extract enhances enzymatic activity and photosynthetic efficiency. This increase in plant height by seaweed extract might be attributed to its synergistic interaction with available endogenous auxin and it could be observed in terms of cell wall plasticity and cell elongation as reported in chena millet Datta and Nanda, 1985 ^[6]. Similar result was also observed by Manasa *et al.*, (2022) ^[16].

Plant Dry Weight

At harvest significant and higher plant dry weight (1211.07g/m²) was recorded in treatment 8 [50% Nitrogen through urea and 50% nitrogen through poultry manure + Sea weed extract (Sagarika) 5%] and was significantly superior to all other treatments. The data indicated that combined application of urea and poultry manure have given a higher biomass accumulation either it's in treatment 8 or in treatment 5 which is at par with treatment 8. The increased biomass in treatment 8 may be attributed to synergistic effects of readily available nitrogen and bioactive compounds present in seaweed extract (cytokinins, auxins, betaines, micronutrients).

Number of tillers/running row meter (m²)

At 100 DAS, significantly higher number of tillers (162.67/running row meter (m²)) was recorded in treatment 8 [50%N through Urea and 50%N through Poultry Manure + Sea Weed Extract (Sagarika) 5%]. The data indicates combined application of urea and poultry manure along with seaweed extract resulted in higher number of tillers. Dutta *et al.*, (2003) reported that the use of organic fertilizers together with chemical fertilizers, compared to the addition of organic fertilizers alone, had a higher positive effect on microbial biomass and hence soil health. Similar results were also reported by Ghimri *et al.*, (2019) [8].

Yield Attributes**Number of fingers/earhead**

Significant and higher number of fingers/earhead (7.46) were recorded in treatment 8 [50% Nitrogen through urea and 50% Nitrogen through poultry manure + Sea weed extract (Sagarika) 5%]. The higher number of fingers per earhead under the combined treatment can be attributed to improved nutrient availability and enhanced hormonal stimulation, which support better reproductive development. Similar increases in yield components with seaweed extract application have been reported by Sarita *et al.* (2021) [22], where foliar seaweed extract enhanced key yield attributes in wheat, indicating its positive influence on reproductive structures.

Number of seeds/finger

Significant and higher number of seeds/finger (245.53) were recorded in treatment 8 [50% Nitrogen through urea and 50% Nitrogen through poultry manure + Sea weed extract (Sagarika) 5%]. The balanced provision of nitrogen from both organic and inorganic sources can optimize plant nutrition and reproductive development, while the seaweed extract supplies bioactive compounds (e.g., cytokinins and other hormones) that stimulate flower and seed formation. Similar benefits of seaweed extract on reproductive yield components, including grains per spike, have been reported by Hasany *et al.* (2019) [10], where foliar seaweed application increased the number of grains per spike in wheat compared with untreated controls, indicating enhanced grain set under bio-stimulant use.

Number of earheads/m²

Significant and higher number of earheads (m²) (69.33) were recorded in treatment 8 [50% Nitrogen through urea and 50% nitrogen through poultry manure + Sea weed extract (Sagarika) 5%]. The increased number of earheads (m²) under the combined nutrient and seaweed extract treatment is likely due to improper tiller survival and enhanced reproductive initiation. A combined supply of nitrogen from both organic and inorganic sources supports vigorous vegetative growth and productive tillering, while seaweed extract's natural hormones and micronutrients enhance nutrient uptake and physiological processes, leading to more productive earheads per unit area. Similar increases in spike or ear density with integrated nutrient and bio-stimulant applications have been reported by (Niccolai *et al.* 2021).

Test weight (g)

Highest test weight (2.53 g) was recorded in treatment 8 [50% Nitrogen through urea and 50% nitrogen through poultry manure + Sea weed extract (Sagarika) 5%].

However there was no significant difference among the treatments.

Seed Yield (t/ha)

Highest seed yield (3.21 t/ha) was found in treatment 8 [50% Nitrogen through urea and 50% nitrogen through poultry manure + Sea weed extract (Sagarika) 5%]. The higher seed yield under 50% urea + 50% poultry manure can be attributed to synergistic effects between readily available inorganic nitrogen and the gradual nutrient release from organic manure. Integrated nutrient management has been shown to significantly increase grain yield compared with sole fertilizer application.

Stover Yield (t/ha)

Highest stover yield (4.27 t/ha) was found in treatment 8 [50% Nitrogen through urea and 50% nitrogen through poultry manure + Sea weed extract (Sagarika) 5%]. However treatment 5 [50%N through Urea and 50%N through Poultry Manure + Gibberellic Acid 40 ppm] and treatment 7 [100%N through Urea + Sea Weed Extract (Sagarika) 5%] were found significantly at par with treatment 8 [50% Nitrogen through urea and 50% nitrogen through poultry manure + Sea weed extract (Sagarika) 5%]. The increased stover yield under the integrated treatment may be linked to improved vegetative growth and prolonged nutrient availability throughout the crop growth period. Poultry manure contributes organic matter that enhances soil moisture retention and root proliferation, while urea supplies immediate nitrogen for rapid canopy development, resulting in greater total biomass accumulation. Similar increases in straw yield under combined organic and inorganic nutrient application were reported by Dhaka *et al.* (2014).

Harvest Index (%)

Highest harvest index (44.2) was found in treatment 5 [50%N through Urea and 50%N through Poultry Manure + Gibberellic Acid 40 ppm] and there was no significant difference among the treatments.

Economics

The data on cost of cultivation, gross returns, net returns and B:C ratio as influenced by different treatment is presented in table 3.

Cost of cultivation (INR/ha)

Maximum cost of cultivation (INR 73,466.00/ha) was recorded in Treatment 9 [100% Nitrogen through Poultry Manure + Seaweed Extract (Sagarika) 5%] and minimum cost of cultivation (INR 34,425.00/ha) was recorded in treatment 10 [Control] as compared to other treatments.

Gross Return (INR/ha)

Maximum gross return (INR 1,78,191.00/ha) was recorded in Treatment 8 [50% Nitrogen through urea and 50% nitrogen through poultry manure + Sea weed extract (Sagarika) 5%] and minimum gross return (INR 87,410.20/ha) was recorded in treatment 10 [Control] as compared to other treatments.

Net Return (INR/ha)

Maximum net return (INR 1,16,023.00/ha) was recorded in Treatment 5 [50%N through Urea and 50%N through Poultry Manure + Gibberellic Acid 40 ppm] and minimum net return (INR 37,665.40/ha) was recorded in treatment 9

[100% Nitrogen through Poultry Manure + Seaweed Extract (Sagarika) 5%] as compared to other treatments.

Benefit Cost Ratio (B:C)

Maximum benefit cost ratio (2.75) was recorded in

Treatment 5 [50%N through Urea and 50%N through Poultry Manure + Gibberellic Acid 40 ppm] and minimum benefit cost ratio (0.51) was recorded in treatment 9 [100% Nitrogen through Poultry Manure + Seaweed Extract (Sagarika) 5%] as compared to other treatments.

Table 1: Effect of different organic and inorganic sources of nitrogen and plant growth regulators growth attributes of Finger Millet.

S. No.	Treatments	Plant height (cm)	Dry weight (g)	Number of tillers/running row meter (m ²)
		100 DAS	100 DAS	100 DAS
1	100% Nitrogen through Urea + Salicylic acid 40 ppm	63.17	1141.33	125.33
2	50% Nitrogen through Urea and 50% Nitrogen through Poultry manure + Salicylic acid 40 ppm	62.59	1156.00	130.67
3	100% Nitrogen through Poultry manure + Salicylic acid 40 ppm	41.12	701.33	90.67
4	100% Nitrogen through Urea + Gibberellic acid 40 ppm	64.24	1086.33	133.33
5	50% Nitrogen through Urea and 50% Nitrogen through Poultry manure + Gibberellic acid 40 ppm	72.68	1294.67	152.00
6	100% Nitrogen through Poultry manure + Gibberellic acid 40 ppm	42.60	769.33	90.67
7	100% Nitrogen through Urea + Seaweed extract (Sagarika) 5%	61.62	1142.67	125.33
8	50% Nitrogen through Urea and 50% Nitrogen through Poultry manure + Seaweed extract (Sagarika) 5%	77.12	1440.00	162.67
9	100% Nitrogen through Poultry manure + Seaweed extract (Sagarika) 5%	34.08	898.67	90.67
10.	Control (N:P:K-60:30:30 kg/ha)	58.37	998.67	117.33
	F test	S	S	S
	SEm(+)	4.30	71.60	4.09
	CD (P = 0.05)	12.78	212.74	12.16

Table 2: Effect of different organic and inorganic sources of nitrogen and plant growth regulators on yield attributes of finger millet.

S. No.	Treatments	Number of fingers/earhead	Number of seeds/finger	Number of earheads (m ²)	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest Index (%)
1.	100% Nitrogen through Urea + Salicylic acid 40 ppm	6.80	212.46	58.67	2.39	2.02	2.86	41.9
2.	50% Nitrogen through Urea and 50% Nitrogen through Poultry manure + Salicylic acid 40 ppm	6.93	237.40	58.67	2.47	2.38	3.28	42.0
3.	100% Nitrogen through Poultry manure + Salicylic acid 40 ppm	6.26	215.80	56.00	2.29	1.73	2.57	40.1
4.	100% Nitrogen through Urea + Gibberellic acid 40 ppm	7.00	227.20	56.00	2.46	2.19	2.78	44.1
5.	50% Nitrogen through Urea and 50% Nitrogen through Poultry manure + Gibberellic acid 40 ppm	7.20	243.67	66.37	2.47	2.87	3.59	44.2
6.	100% Nitrogen through Poultry manure + Gibberellic acid 40 ppm	6.60	220.67	53.33	2.46	1.91	2.53	42.9
7.	100% Nitrogen through Urea + Seaweed extract (Sagarika) 5%	6.86	240.67	64.00	2.39	2.55	3.76	40.5
8.	50% Nitrogen through Urea and 50% Nitrogen through Poultry manure + Seaweed extract (Sagarika) 5%	7.46	245.53	69.33	2.53	3.21	4.27	42.5
9.	100% Nitrogen through Poultry manure + Seaweed extract (Sagarika) 5%	6.73	226.20	54.86	2.39	1.99	2.78	41.1
10.	Control (N:P:K-60:30:30 kg/ha)	6.53	222.86	45.33	2.38	1.57	2.14	41.6
	F test	S	S	S	NS	S	S	NS
	S Ed (±)	0.20	5.87	3.27	0.05	1.13	0.23	2.68
	CD (p = 0.05)	0.59	17.46	9.70	-	0.38	0.68	-

Table 3: Effect of different organic and inorganic sources of nitrogen and plant growth regulators on economics of finger millet.

S. No.	Treatments	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C ratio
1.	100% Nitrogen through Urea + Salicylic acid 40 ppm	34,486.56	1,13,047.00	78,560.60	2.28
2.	50% Nitrogen through Urea and 50% Nitrogen through Poultry Manure + Salicylic acid 40 ppm	41,066.56	1,32,737.00	91,670.20	2.23
3.	100% Nitrogen through Poultry Manure + Salicylic acid 40 ppm	47,652.56	97,377.80	49,725.20	1.04
4.	100% Nitrogen through Urea + Gibberellic acid 40 ppm	35,625.00	1,20,853.00	85,228.40	2.39
5.	50% Nitrogen through Urea and 50% Nitrogen through Poultry Manure + Gibberellic acid 40 ppm	42,205.00	1,58,228.00	1,16,023.00	2.75
6.	100% Nitrogen through Poultry Manure + Gibberellic acid 40 ppm	48,791.00	1,05,973.00	57,181.60	1.17
7.	100% Nitrogen through Urea + Seaweed Extract (Sagarika) 5%	60,300.00	1,43,393.00	83,093.00	1.38
8.	50% Nitrogen through Urea and 50% Nitrogen through Poultry Manure + Seaweed Extract (Sagarika) 5%	66,880.00	1,78,191.00	1,11,131.00	1.66
9.	100% Nitrogen through Poultry Manure + Seaweed Extract (Sagarika) 5%	73,466.00	1,11,131.00	37,665.40	0.51
10.	Control (N:P:K 60:30:30)	34,425.00	87,410.20	52,985.20	1.54

Conclusion

Application of treatment 8 [50% Nitrogen through Urea and 50% Nitrogen through Poultry Manure + Seaweed Extract (Sagarika) 5%] has recorded highest yield and maximum B:C ratio was observed in treatment 5 [50%N through Urea and 50% Nitrogen through Poultry Manure + Gibberellic Acid 40 ppm].

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Competing Interests

Authors have declared that no competing interests exists.

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