International Journal of Plant & Soil Science

Volume 37, Issue 11, Page 65-71, 2025; Article no.IJPSS.147172
ISSN: 2320-7035

Improving Beneficial Microbial Population in Soils of Baby Corn (*Zea mays* L.) through Nutrient Management in the New Alluvial Zone of West Bengal, India

Subham Chakraborty [a++*], Ashim Kumar Dolai [a#], Atanu Mahanty [a++], Gurupada Saren [a++] and Souvan Kumar Patra [a++]

[a] Department of Agronomy, Institute of Agricultural Science, University of Calcutta, Kol-700019, West Bengal, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2025/v37i115824

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://pr.sdiarticle5.com/review-history/147172

Short Research Article

Received: 29/08/2025
Published: 08/11/2025

ABSTRACT

A field study was carried out during the *rabi* season of 2019 at the Agricultural Experimental Farm of Calcutta University located at Baruipur, West Bengal after the harvest of *Kharif* rice to evaluate the influence of integrated nutrient management in baby corn (*Zea mays* L.) on soil microbial population

---

[++]Ph.D. Scholar;
[#]Asst. Professor;
**Corresponding author: E-mail: subhame2994@gmail.com;*

Cite as: *Subham Chakraborty, Ashim Kumar Dolai, Atanu Mahanty, Gurupada Saren, and Souvan Kumar Patra. 2025. "Improving Beneficial Microbial Population in Soils of Baby Corn (Zea Mays L.) through Nutrient Management in the New Alluvial Zone of West Bengal, India". International Journal of Plant & Soil Science 37 (11):65–71. https://doi.org/10.9734/ijpss/2025/v37i115824.*

in lower Gangetic alluvial land. The experimental plot was set up in a Randomized Complete Block Design replicated thrice having eight integrated nutrient management treatments viz., 100% recommended dose of NPK (RDF: N 120 kg ha^{-1}, P_2O_5 60 kg ha^{-1} and K_2O 60 kg ha^{-1}); 75% of NPK + 2.5 t of vermicompost ha^{-1} + 2.4 litre ha^{-1} of seaweed extract spray; 75% NPK + 5 t ha^{-1} of FYM + 2 t ha^{-1} of vermicompost; 50% NPK + 2.5 t ha^{-1} of FYM + 1.5 litre ha^{-1} of humic acid spray; 75% NPK + 4.5 litre ha^{-1} of seaweed extracts spray; 75% NPK + 2.5 t ha^{-1} of vermicompost + 2.4 litre ha^{-1} of humic acid; 0.2 t ha^{-1} of Neem pellets + 7.5 t ha^{-1} of FYM + 2.5 t ha^{-1} of vermicompost + 2 litre ha^{-1} of seaweed extract spray; Control in soil pH of 6.2 and the land was medium low land with clay loam texture. Microbial populations were determined in this study, and results showed that baby corn recorded a greater number of microfloral populations after harvest viz., fungi-(102.00) × 10^4 and (105.00) × 10^4, actinomycetes-(23.00) × 10^5 and (26.00) × 10^5 total bacteria-(102.00) × 10^6 and (113.00) × 10^6 under the treatment comprised of 75% NPK with 2.5 t vermicompost ha^{-1} and seaweed extract 2.5 litre ha^{-1} whereas lower microbial count was recorded in the control plot.

Keywords: Baby corn; integrated nutrient management; microflora; seaweed.

1. INTRODUCTION

Like rice and wheat, maize is also the staple diet for most of the people**.** It is known as the queen of cereals having its place of origin in Central America and domesticated 7000 years ago**.** Both the corn and the fodder are economically important and provide nutrition to humans as well as animals (Jinjala et al*.,* 2016). A few decades ago, the cultivation of baby corn (*Zea mays* L.) spread all over the world due to its high nutritive value and short duration maturity period which fetches high market price has very high demand in food processing industries and consumed by people as vegetable. Baby corn is actually an immature ear harvested at the emergence of silk (Bairagi et al*.,* 2015). Baby corn is suitable for the gangetic alluvial belt of West Bengal and the farmers can earn huge profits through its cultivation. Necessary agronomic management practices like integrated nutrient management must be adopted by farmers as it would ensure the quality and quantity of production. Soil is a dynamic body which supports and sustains various forms of life. It acts as a shelter for numerous forms of microorganisms which maintains the nutrient exchange cycle between soil and plants. Microorganisms play a vital role in increasing plant yield and productivity by supplying essential nutrients required for the growth and development of plants. Their potentiality to fix nutrients like nitrogen from the atmosphere and various enzymatic processes transform phosphorus from insoluble form to available form benefits plants to get access to such nutrients (Zhang et al*.,* 2025). Soil microbial population with the use of organic source of nutrients (like animal manure, mulches and other organic residues) which may play a role in improving the yield of crop through supply of nutrients and microbial activity is increased to a great extent (Kamara et al*.,* 2015). More the population of beneficial microbes, the better will be the soil health and ultimately yield of the crop.

2. MATERIALS AND METHODS

The experiment was undertaken in the rabi season of 2019 (January-April) at the Experimental Farm of Calcutta University, Baruipur, West Bengal. The experimental field was situated at (22º22´ N, 88º26´ E) and 9 m latitude. The soil texture was clay loam in nature with pH 6.2, organic carbon 0.62%, 214 kg ha^{-1} of total N, 34 kg ha^{-1} of available P and 260 kg ha^{-1} of available K after harvest of rice. The experiment was set up in a Randomized Block Design (RBD) consisting three replications with eight integrated nutrient management treatments viz. 100% recommended dose of NPK (RDF: N 120 kg ha^{-1}, P_2O_5 60 kg ha^{-1} and K_2O 60 kg ha^{-1}); 75% of NPK + 2.5 t of vermicompost ha^{-1} + 2.4 litre ha^{-1} of seaweed extract spray; 75% NPK + 5 t ha^{-1} of FYM + 2 t ha^{-1} of vermicompost; 50% NPK + 2.5 t ha^{-1} of FYM + 1.5 litre ha^{-1} of humic acid spray; 75% NPK + 4.5 litre ha^{-1} of seaweed extracts spray; 75% NPK + 2.5 t ha^{-1} of vermicompost + 2.4 litre ha^{-1} of humic acid; 0.2 t ha^{-1} of Neem pellets + 7.5 t ha^{-1} of FYM + 2.5 t ha^{-1} of vermicompost + 2 litre ha^{-1} of seaweed extract spray; Control.

The baby corn variety KSP-1224 was sown during the 2nd week of January in 2019 maintaining a spacing of 45 cm × 25 cm. The fertilizer sources for N, P_2O_5 and K_2O was urea, SSP and MOP, respectively. The required quantity of fertilizers was evenly broadcasted along with the required amount of FYM and vermicompost as per the treatments during final land preparation. Seaweed extract pre-mix and humic acid pre-mix are applied as foliar spray at 3 intervals viz., 15, 30 and 45 days after sowing in 500 litres of water hectare^{-1}. Irrigation to crop fields was provided whenever necessary. Collection of soil samples from the rhizosphere was done at various intervals viz., before sowing and at harvest. The count of the microbial population was performed by using their respective agar medium following serial dilation technique and pour plate method. The plates were incubated at 30°C in an incubator. The data on colony counts were done at 5 days and 10 days of incubation.

The fungi count was made using Martin's rose bengal streptomycin agar medium (Table 1). Sterile streptomycin was added just prior to plating to the medium. Jensen's agar medium (Table 2) was used for actinomycetes to take the colony of total actinomycetes. A pH of 6.5-6.6 was maintained for the medium and sterilization was done at 15 lbs pressure for 20 minutes. The total bacteria count was done using Thornton's agar medium (Table 3) with the pH of the medium at 7.4 and sterilized for 20 minutes at 15 lbs pressure.

Statistical analysis of the collected data was evaluated utilizing the methods as referred by Gomez & Gomez (1984).

Table 1. Martin's rose bengal streptomycin agar medium (Martin, 1950)

Composition	Chemical formula	Amount
Potassium dihydrogen phosphate	KH_2PO_4	1.0 g
Magnesium sulphate	$MgSO_4$, $7H_2O$	0.5 g
Dextrose	$C_6H_{12}O_6$	10.0 g
Peptone		5.0 g
Agar		10.0 g
Rose Bengal (1:300 aq)		10.0 ml
Distilled water		1000 ml
Streptomycin		30 µg ml^{-2}

Table 2. Jensen's agar medium (for actinomycetes) (Jensen, 1930)

Composition	Chemical formula	Amount
Dextrose	$C_6H_{12}O_6$	2.0 g
Casein [dissolved in 10 ml of 0.1 (N) NaOH]		5.0 g
Dipotassium hydrogen phosphate	K_2HPO_4	0.2 g
Magnesium sulphate	$MgSO_4$, $7H_2O$	0.2 g
Yeast extract		0.5g
Potassium chloride	KCl	0.2g
Ferrous sulphate	$FeSO_4$ $2H_2O$	Trace
Agar		15.0 g
Distilled water		1000 ml

Table 3. Thornton's agar medium (Thornton, 1922)

Composition	Chemical formula	Amount
Dipotassium hydrogen phosphate	K_2HPO_4	1.0 g
Calcium chloride	$CaCl_2$	0.1 g
magnesium sulphate	$MgSO_4$, $7H_2O$	0.2 g
Sodium chloride	NaCl	0.1 g
Ferric Chloride	$FeCl_3$, $6H_2O$	0.002g
Potassium nitrate	KNO_3	0.5g
Asparagine	$C_4H_8N_2O_4$	0.5g
Mannitol	C_6H_8 $(OH)_6$	1.0g
Agar		15.0 g
Distilled water		1000 ml

3. RESULTS AND DISCUSSION

3.1 Effect of Different Integrated Nutrient Management Practices on Fungi Population

The fungi population in Table 4 revealed that pre-sowing stages showed non-significant output during both counts taken at 5 days after plating and 10 days after plating. At harvest, 5 days after plating revealed T_2-(75% of NPK+2.5 t ha^{-1} of vermicompost+2.4 litre ha^{-1} of seaweed extract spray) with (102.00) CFU × 10^4 g^{-1} had no significant difference with T_1-(100% recommended dose of NPK)-(98.00) CFU × 10^4 g^{-1} but differs significantly with by T_7-(0.2 t ha^{-1} of Neem pellets+7.5 t ha^{-1} of FYM+2.5 t ha^{-1} of vermicompost+2 litre ha^{-1} of seaweed extract spray)-(83.00) CFU × 10^4 g^{-1} and T_8-(Control plot)-(0.00) CFU × 10^4 g^{-1} resulted in the lowest colony. After 10 days of plating T_2-(75% of NPK+2.5 t ha^{-1} of vermicompost+2.4 litre ha^{-1} of seaweed extract spray) with (105.00) CFU×10^4 g^{-1} had no significant difference with T_1-(100% recommended dose of NPK) with (104.00) CFU x 10^4 g^{-1} followed by T_7-(0.2 t ha^{-1} Neem pellets+7.5 t ha^{-1} of FYM+2.5 t ha^{-1} of vermicompost+2 litre ha^{-1} of sea weed extract spray)-(90.00) CFU x 10^4 g^{-1} and other treatments respectively whereas showed significant difference with T_8-(Control plot) that indicated the lowest with (7.00) CFU × 10^4 g^{-1}. The soil fungi have a positive correlation with an organic source of nutrients as the organic nutrients provide carbon which acts as a food source for existing soil fungal population and through feeding of carbon they multiply and enables nutrient cycling. So, the application of both seaweed and vermicompost, both of which are organic in nature seems to increase the fungal population in the soil. Kuttimani et al*.,* (2017) and Krishnan, (2014) also observed similar findings.

3.2 Effect of Different Integrated Nutrient Management Practices on Actinomycetes Population

From the Table 4, the showed that during the pre-sowing stages, non-significant results were recorded. The data at harvest, 5 days after plating revealed that T_2-(75% of NPK+2.5 t ha^{-1} of vermicompost+2.4 litre ha^{-1} of seaweed extract spray) with (23.00) CFU × 10^5 g^{-1} with highest count was statistically at par with T_1-(100% Recommended dose of NPK)-(22.00) CFU × 10^5 g^{-1} with CFU x 10^5 g^{-1} followed by T_7-(0.2 t ha^{-1} of Neem pellets+7.5 t ha^{-1} of FYM+2.5 t ha^{-1} of vermicompost+2 litre ha^{-1} of seaweed extract spray)-(16.00) CFU × 10^5 g^{-1} and other treatments but showed significant difference with T_6-(75% NPK+2.5 t ha^{-1} of vermicompost+2.4 litre ha^{-1} of humic acid)-(8.00) CFU × 10^5 g^{-1} followed by T_4-(50% NPK+2.5 t FYM ha^{-1}+humic acid spray @ 1.5 litre ha^{-1})-(6.00) CFU × 10^5 g^{-1} and T_8-(Control plot)-(0.00) CFU × 10^5 g^{-1} as the lowest colony. At harvest 10 days after plating revealed the highest colony in T_2-(75% of NPK+2.5 t ha^{-1} of vermicompost+2.4 litre ha^{-1} of seaweed extract spray) with (26.00) CFU × 10^5 g^{-1} does not differ significantly with T_1 (100% Recommended dose of NPK)-(20.00) CFU × 10^5 g^{-1} , T_5-(75% NPK+4.5 litre ha^{-1} of seaweed extract spray)-(20.00) CFU × 10^5 g^{-1} and other treatments respectively and T_8-(Control plot) being the lowest with (4.00) CFU × 10^5 g^{-1}. It may be because of the favourable pH of the soil and required soil environment which enhanced their multiplication rate in the rhizospheric region of soil due to the application of an organic source of nutrients and the seaweed provided to plants which contain several growth-promoting substances and other nutrients along with organic acids, proteins etc. through their contact with plant roots into the soil. The addition of organics in the soil can be considered one of the primary factors for increasing the actinomycetes population in the soil Somasundaram et al*.,* (2003); Nagaraju et al*.,* (2022).

3.3 Effect of Different Integrated Nutrient Management Practices on Total Bacterial Population

The total bacterial population in Table 4 indicates that before the application of treatments revealed no significant variation in both counts i.e., 5 days after plating and 10 days after plating. At harvest, 5 days after plating T_2-(75% NPK along+2.5 t ha^{-1} of vermicompost +2.4 litre ha^{-1} of seaweed) revealed the highest total bacteria population of (102.00) CFU × 10^6 g$^{-1,}$ and T_8-(Control plot) recorded the lowest population among all other treatments of (36.00) CFU × 10^6 g^{-1}. T_2 (75% NPK along with 2.5 t ha^{-1} of vermicompost+2.4 litre ha^{-1} of seaweed extract spray) does not differ significantly from T_1-(100% recommended dose of NPK) (98.00) CFU × 106 g 1 and T_7-(0.2 t ha^{-1} of Neem pellets+7.5 t ha^{-1} of FYM+2.5 t ha^{-1} of vermicompost+2 litre ha^{-1} of seaweed extract spray) (83.00) CFU × 106 g^{-1} whereas T_2-(75% NPK +2.5 t ha^{-1} of vermicompost+2.4 litre ha^{-1} of sea weed extract spray) had significant difference with T_5-(75% NPK+4.5 litre ha^{-1} of seaweed extract spray)-(76.00) CFU

Table 4. Effect of Integrated nutrient management on the population of fungi (x 10^4), actinomycetes (x 10^5) and total bacteria (x10^6)

Treatments	Fungi (x 10^4)				Actinomycetes (x 10^5)				Total bacteria (x 10^6)			
	Pre-Sowing (after 5 days after plating)	Pre-Sowing (after 10 days after plating)	At Harvest (after 5 days after plating)	At Harvest (after 10 days after plating)	Pre-Sowing (after 5 days after plating)	Pre-Sowing (after 10 days after plating)	At Harvest (after 5 days after plating)	At Harvest (after 10 days after plating)	Pre-Sowing (after 5 days after plating)	Pre-Sowing (after 10 days after plating)	At Harvest (after 5 days after plating)	At Harvest (after 10 days after plating)
T_1	0(0.71)	32(5.70)	98(9.92)	104(10.22)	16(4.06)	22(4.74)	22(4.74)	20(4.53)	5(2.35)	23(4.85)	98(9.92)	103(10.17)
T_2	3(1.87)	31(5.61)	102(10.12)	105(10.27)	17(4.18)	20(4.53)	23(4.85)	26(5.15)	7(2.74)	21(4.64)	102(10.12)	113(10.65)
T_3	2(1.58)	32(5.70)	36(6.04)	40(6.36)	17(4.18)	21(4.64)	3(1.87)	5(2.35)	6(2.55)	20(4.53)	46(6.82)	71(8.46)
T_4	0(0.71)	33(5.79)	46(6.82)	53(7.31)	18(4.30)	22(4.74)	6(2.55)	9(3.08)	6(2.55)	22(4.74)	67(8.22)	77(8.80)
T_5	0(0.71)	33(5.79)	76(8.75)	80(8.97)	16(4.06)	21(4.64)	16(4.06)	20(4.53)	7(2.74)	23(4.85)	76(8.75)	91(9.57)
T_6	3(1.87)	32(5.70)	67(8.22)	69(8.34)	15(3.94)	20(4.53)	8(2.92)	12(3.54)	5(2.35)	20(4.53)	72(8.15)	87(9.35)
T_7	3(1.87)	31(5.61)	83(9.14)	90(9.51)	16(4.06)	21(4.64)	16(4.06)	20(4.53)	8(2.92)	22(4.74)	83(9.14)	97(9.87)
T_8	2(1.58)	32(5.70)	0(0.71)	7(2.74)	16(4.06)	20(4.53)	0(0.71)	4(2.12)	5(2.35)	21(4.64)	36(6.04)	55(7.45)
SE m (±)	NS	NS	0.3	1.4	NS	NS	0.38	1.12	NS	NS	0.4	0.3
CD at 5%	NS	NS	0.9	4.4	NS	NS	1.17	3.39	NS	NS	1.2	1.0

Figures in parentheses are square root transformed values $\sqrt{0.5}$; NS: Not significant.

Notations used: T_1-100% recommended dose of NPK (RDF: N 120 kg ha^{-1}, P_2O_5 60 kg ha^{-1} and K_2O 60 kg ha^{-1}); T_2-75% of NPK+2.5 t of vermicompost ha^{-1}+2.4 litre ha^{-1} of seaweed extract spray; T_3-75% NPK+5 t ha^{-1} of FYM+2 t ha^{-1} of vermicompost; T_4-50% NPK+2.5 t ha^{-1} of FYM+1.5 litre ha^{-1} of humic acid spray; T_5-75% NPK+4.5 litre ha^{-1} of seaweed extracts spray; T_6-75% NPK+2.5 t ha^{-1} of vermicompost+2.4 litre ha^{-1} of humic acid; T_7-0.2 t ha^{-1} of Neem pellets+7.5 t ha^{-1} of FYM+2.5 t ha^{-1} of vermicompost+2 litre ha^{-1} of seaweed extract spray; T_8-Control plot.

× 10^6 g^{-1} followed by other treatments respectively. The results for 10 days after plating also showed significant variations among the treatments where T_2-(75% NPK along+2.5 t ha^{-1} of vermicompost +2.4 litre ha^{-1} of seaweed)-(113.00) CFU × 10^6 g^{-1} recorded highest colony and (Control plot) T_8-(55.00) CFU × 10^6 g^{-1} resulted in lowest count for total bacteria. The increase in the population of total bacteria may be due to the application of nitrogen containing substances in T_2 (75% NPK+2.5 t ha^{-1} vermicompost+2.4 litre ha^{-1} of seaweed extract spray) mainly organic nutrients as compared to control plot which might have enhanced the bacterial population to increase in quantity due creation of favourable conditions due to decomposition and mineralization of organic substances applied in soil. Similar trends were observed by Kumari et al*.,* (2017); Gunjal and Chitodkar, (2017).

It was finally observed that the microfloral population before application of treatments was less, but after applying nutrients through foliar application of seaweed, humic acid and soil application of vermicompost, neem pellets, FYM along with the application of a recommended dose of NPK the population of microflora increased. The addition of organic matter through different sources to soil provided the required amount of energy for soil microbes to multiply and form new cells. Similar findings could be corroborated with that of Wolf and Wagner, (2005); Moharana et al*.,* (2012). The presence of various compounds of biological activities in fermented preparation i.e. growth hormones, vitamins and organic acids secretions and other bioactive metabolites etc. enhances the fertility of the soil by enabling the microbial population to colonize in the rhizosphere zone of the soil. The seaweed or humic acid applied on the crop secretes root exudates which act as a food for soil microbes. Another reason might be that the soil microbial population are mostly chemo-autotrophs and carbon from organic sources are their food after oxidation of those organic sources helping in enhancing soil microbial colony. This finding are similar with that of Ingle et al., (2014); Mcspadden & Gardener, (2007). The total bacteria and fungi population was observed to be dominant throughout the experiment. A good percentage increase in soil microflora would result in improving and increasing the nutrient status of soil which would lead to enhanced productivity of crops. Similar findings were observed by Dolai et al*.* (2015).

4. CONCLUSION

It can be concluded that use of combined sources of organic and synthetic fertilizers is must to protect the soil health and sustain the crop production and productivity through improving beneficial soil microbes for which maximum application of organic sources (Vermicompost, Farmyard manure, Oilcakes, seaweed extracts etc.) of nutrients for crops are must in agricultural field that will enable nutrient recycling as well as other physio-chemical and biological activities thus improving yield of crops.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Bairagi, S., Pandit, M. K., Sidhya, P., Adhikary, S., & Koundinya, A. V. V. (2015). Impact of date of planting and crop geometry on growth and yield of baby corn (*Zea mays var. rugosa*). *Journal of Crop and Weed, 11*(2), 127–131.

Dolai, A. K., Ghosh, R. K., Bhowmick, M. K., & Ghosh, P. K. (2015). Improving beneficial microflora population in soils of predominant crop sequences through *Parthenium* utilization. *Journal of Crop and Weed, 11*(1), 208–212.

Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research*. John wiley & sons.

Gunjal, B. S., & Chitodkar, S. S. (2017). Effect of integrated nutrient management on soil properties and soil fertility under in sweet corn–potato cropping sequence in vertisols of Deccan Plateau of India. *International Journal of Chemical Studies, 5*(6), 1343–1351.

Ingle, S. S., Jadhao, S. D., Kharche, V. K., Sonune, B. A., & Mali, D. V. (2014). Soil biological properties as influenced by long-term manuring and fertilization under sorghum (*Sorghum bicolor*)–wheat (*Triticum aestivum*) sequence in vertisols.

Indian Journal of Agricultural Sciences, 84(4), 452–457.

Jinjala, V., Virdia, H., Saravaiya, N., & Raj, A. (2016). Effect of integrated nutrient management on baby corn (*Zea mays* L.). *Agricultural Science Digest – A Research Journal, 36*(4). https://doi.org/10.18805/asd.v36i4.6470

Jensen, H.L. (1930). Azotobacteriaceae. *Bact. Rev.,* 189: 195-214.

Kamara, A., Sorie, K. H., & Saimah, K. M. (2015). Effect of rice straw biochar on soil quality and the early growth and biomass yield of two rice varieties. *Agricultural Sciences, 6*(8), 798–806.

Krishnan, R. V. (2014). *Nutrient management in organic farming of cucumber* (M.Sc. (Ag) thesis). Kerala Agricultural University, Thrissur.

Kumari, S., Chattopadhyaya, N., Mandal, J., & Singh, M. (2017). Integrated nutrient management boost the soil biological properties in rice rhizosphere. *Journal of Crop and Weed, 13*(1), 116–124.*

Kuttimani, R., Somasundaram, E., & Velayudham, K. (2017). Effect of integrated nutrient management on soil microorganisms under irrigated banana. *International Journal of Current Microbiology and Applied Science, 6*(11), 2342–2350.

Martin, J.P. (1950). Use of acid, rose Bengal and streptomycin in the plate method for estimating soil fungi. *Soil Sci.,* 69: 215-32

McSpadden, B. B., & Gardener, B. B. (2007). Diversity and ecology of biocontrol *Pseudomonas* spp. in agricultural systems. *Phytopathology, 97,* 221–226.

Moharana, P. C., Sharma, B. M., Biswas, D. R., Dwivedi, B. S., & Singh, R. V. (2012). Long-term effect of nutrient management on soil fertility and soil organic carbon pools under a 6-year-old pearlmillet–wheat cropping system in an Inceptisol of subtropical India. *Field Crops Research, 136,* 32–41.

Nagaraju, G. S., Vani, P. M., Rani, P. P., & Venkateswarlu, B. (2022). Influence of integrated use of organic and inorganic sources of nutrients on biological properties of soil in sweet corn. *Biological Forum – An International Journal, 14*(3), 1041–1044.

Somasundaram, E., Sankaranan, N., Meena, S., Thiyagarajan, T. M., Chandaragiri, K., & Pannerselvam, S. (2003). Response of green gram to varied levels of *Panchagavya* (organic nutrition) foliar spray. *Madras Agricultural Journal, 90,* 169–172.

Thorton, H.G. (1992). On the development of standardized agar medium for counting soil bacteria with special regard to the repression of spreading colonies.*Ann. Appl. Biol.,* 9:241.

Wolf, D. C., & Wagner, G. H. (2005). Carbon transformations and soil organic matter formation. In D. M. Sylvia, J. J. Fuhrmann, P. G. Hartel, & D. A. Zuberer (Eds.), *Principles and applications of soil microbiology* (pp. 285–332). Pearson Prentice Hall, USA.

Zhang, J., Li, Y., Yuan, J., Wang, L., Guoying, W., & Liang, Z. (2025). Optimizing maize production and soil microbiome structure through reduced chemical nitrogen supplemented with organic fertilizer. *Plants (Basel), 14*(15), 2275.

Peer-review history:
The peer review history for this paper can be accessed here:
https://pr.sdiarticle5.com/review-history/147172