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Effect of Integrated use of Organic and Inorganic Fertilizers on Biochemical and Biological Properties of Maize (*Zea mays* L.)

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Authors' contributions

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

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Abstract

An experiment was conducted on the effect of integrated use of organic and inorganic fertilizers on biochemical and biological properties of maize (*Zea mays L.)* during *kharif* 2024 at wet land farm of S.V. Agricultural College, Tirupati. The experiment was carried out in randomized block design with three replications consisting of ten treatments with Control (T_1), 100% recommended dose of fertilizer (T_2), farm yard manure @ 10 t ha^{-1} (T_3), Poultry manure @ 2 t ha^{-1} (T_4), 100% recommended dose of fertilizer + soil application of liquid biofertilizers *Azospirillum*, phosphorous

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solubilizing bacteria and potassium solubilizing bacteria @ 1.25 litres ha^{-1} each (T_5), 75% recommended dose of fertilizer + soil application of liquid biofertilizers *Azospirillum*, phosphorous solubilizing bacteria and potassium solubilizing bacteria @ 1.25 litres ha^{-1} each (T_6), 75% recommended dose of fertilizer + farm yard manure @ 10 t ha^{-1} (T_7), 75% recommended dose of fertilizer + poultry manure @ 2 t ha^{-1} (T_8), 75% recommended dose of fertilizer + farm yard manure @ 10 t ha^{-1} + soil application of liquid biofertilizers *Azospirillum*, phosphorous solubilizing bacteria and potassium solubilizing bacteria @ 1.25 litres ha^{-1} each (T_9), 75% recommended dose of fertilizer + poultry manure @ 2 t ha^{-1} + soil application of liquid biofertilizers *Azospirillum*, phosphorous solubilizing bacteria and potassium solubilizing bacteria @ 1.25 litres ha^{-1} each (T_{10}). From the experimental results that the application of 75% recommended dose of fertilizer + poultry manure @ 2 t ha^{-1} + Soil application of liquid biofertilizers *viz*., *Azospirillum*, phosphorus solubilizing bacteria and potassium solubilizing bacteria @ 1.25 litres ha^{-1} each (T_{10}) resulted in the higher microbial population at both flowering and harvesting stages bacteria (70.2 and 60.2 × 10^6 CFU g^{-1} of soil), Fungi(25.3 and 21.6 × 10^3 CFU g^{-1} of soil) and Actinomycetes (30.3 and 22.2 × 10^4 CFU g^{-1} of soil) and higher enzyme activity at both flowering and harvesting stages Acid phosphatase (67.3 and 62.7 µg p-nitrophenol g^{-1} soil h^{-1}), Alkaline phosphatase(100 and 93 µg PNP g^{-1} soil h^{-1}), Dehydrogenase(103 and 90 ug TPF g^{-1} soil day^{-1}) and Urease (69 and 61 µg urea g^{-1} soil h^{-1}) while the highest kernel yield and stover yield were found to be highest with application of 100% recommended dose of fertilizer + soil application of liquid biofertilizers viz., *Azospirillum,* phosphorus solubilizing bacteria and potassium solubilizing bacteria @ 1.25 litres ha^{-1} each (T_5).

Keywords: High genetic yield; environmental problems; microorganisms.

1. Introduction

"Maize is the third most consumed cereal after rice and wheat. It is commonly called as the queen of cereals due to its high genetic yield potential compared to the other cereals. Maize is primarily grown in the *Kharif* season nearly contributing 85 per cent of cultivation during this season. Moreover, maize is also a major source of oil, gluten, and starch, which can be hydrolyzed and enzymatically treated to produce syrups, particularly high fructose corn syrup. Recently, high consumption of the nitrogen fertilizers by new cultivars of maize plant has significantly increased by 59.60% in the last few years, which causes serious environmental problems" (Abdel *et al.* 2000).

"There are reports which suggest that application of fertilizers on continuous basis has resulted in the changed composition and functions of soil microorganisms" (Dong *et al*., 2014). "Hence, in order to maximize the use of fertilizers economically and reduce the traces of chemical fertilizers in the environment, biofertilizers are considered as a promising alternative approach for maize and other crop species production. These biofertilizers are mainly based on beneficial microorganisms in a viable state applied to seed or soil aiming to increase soil fertility and plant growth by increasing the number and biological activity of desired microorganisms in the rhizosphere" (Subba, 1999). "Biological fertilizers play a key role in improving productivity of crop and promotes sustainability of soil by increasing nutrient availability and uptake through biological nitrogen fixation, solubilization and absorption of immobile phosphorus. They also improve soil quality and detoxifies pollutants present in soil such as heavy metals" (Abdel et al. 2000).

"In addition to the biofertilizers, the use of organic fertilizers can also reduce the application of chemical fertilizers to a great extent. Addition of organic fertilizers ensures fertilizers use efficiency, improves soil organic matter, soil properties (Physical, chemical and biological) and soil productivity. There are reports suggesting that conjunctive use of organic manure with chemical fertilizers improve the population of microbes and enzymatic activities" (Mallikarjun & Maity, 2018) . A knowledge of soil biological properties is thus important for maintaining soil quality, plant health, soil resilience, soil fertility and soil sustainability. The present investigation was therefore conducted to determine the effect of integrated use of organic and inorganic fertilizers on biochemical and biological properties of maize (*zea mays* L.)

2. Materials and Methods

A field experiment was conducted during *kharif*, 2024 on sandy clay loam soils of wetland farm of S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University. Geographically situated at 13°36'55.3"N latitude and 79°22'20.2"E longitude with an altitude of 182.9 m above mean sea level, which falls under Southern Agro Climatic Zone of Andhra Pradesh.

"The experiment was laid out in randomized block design with three replications consisting of ten treatments. The field was ploughed and given pre-sowing irrigation. The field was divided into 30 different plots of 6m x 5m size. FYM and poultry manure are applied seven days before sowing. The pretreated seed of variety kaveri 50 was sown by dibbling method in between the rows by using maize seed at the rate of 8 kg per hectare with a spacing of 60cm x 20cm on 25th July, 2024. RDF (Recommended dose of fertilizer) of NPK for maize was 200:60:50 kg ha^{-1}. Nitrogen was applied in the form of urea in two splits, first split at the time of sowing and second split at 30 DAS. Phosporus was applied in the form of SSP and potassium as MOP as a basal dose. Kernel yield and stover yield were collected at the harvesting stage" (Subba, 1999).

"The initial and post harvest soil samples were collected from the experimental field and analysed for soil biological properties. Urease activity was estimated by the procedure as described by Bremner and Douglas (1971). Dehydrogenase activity in the soil sample was determined by following the procedure as described by Casida *et al*. (1964). The acid and alkaline phosphatase activity was determined by the procedure described" by the Tabatabai and Bremner (1969) and Evazi and Tabatabai (1977). Bacteria, fungi and actinomycetes were estimated by serial dilution plate count technique Pramer and Schmidt (1964).

3. Results and Discussion

3.1 Yield

Data depicted in Table.1. showed high kernel yield (4956 kg ha^{-1}) and stover yield (3875 kg ha^{-1}) were recorded with the application of 100 % RDF + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T_5) which were on par with application of 75 % RDF + poultry manure @ 2 t ha^{-1} + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T_{10}), 75 % RDF + FYM @ 10 t ha^{-1} + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T_9) and 100 % RDF (T_2).

Combining of fertilizers with biofertilizers improved nitrogen and phosphorus availability to maize. This led to better root growth, nutrient uptake, and plant development. Overall, the integration resulted in higher kernel and stover yields. (Jat *et al*., 2014).

3.2 Microbial Population

Data depicted in the Table 2 indicates that at flowering stage highest bacteria (70.2 × 10^6 CFU g^{-1} of soil), fungi (25.3 × 10^3 CFU g^{-1} of soil), actinomycetes(30.3 × 10^4 CFU g^{-1} of soil) population and at harvesting stage highest bacteria (60.2 × 10^6 CFU g^{-1} of soil), fungi (21.6 × 10^3 CFU g^{-1} of soil) and actinomycetes(22.2 × 10^4 CFU g^{-1} of soil) population was observed with the application of 75% RDF + poultry manure @ 2 t ha-1 + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha-1 each (T_{10}). This treatment was followed by the application of 75% RDF + FYM @ 10 t ha-1 + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha-1 each (T_9), 100% RDF + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha-1 each (T_5) and 75% RDF + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha-1 each (T_6). This was followed by the application of 75% RDF + poultry manure @ 2 t ha-1 (T_8) which was on par with 75% RDF + FYM @ 10 t ha-1 (T_7). This was followed by the application of poultry manure @ 2 t ha-1 (T_4) which was comparable with FYM @ 10 t ha-1 (T_3). This was followed by the application of 100% RDF (T_2) while the control (T_1) recorded the lowest actinomycetes population in soil.

"The reason for higher microbial population in T_{10} is due to the combined application of biofertilizers and FYM along with inorganic dose of fertilizers was found superior over sole inorganic and inorganic + biofertilizers treated plots. The added biofertilizers promotes the production of phytohormones, antibiotics, enzymes and also helps in decomposition of organic residues. The favourable effects of added FYM helps in proliferation of microbial populations by providing carbon as a source of energy for microbes. There by improving the microbial population" (Madhurya, 2022). **"**The integrated use of organic and inorganic fertilizers enhances beneficial soil microbes and their functions, improving overall soil biological health" (Ingle *et al*., 2014).

3.3 Enzyme Activity

Data depicted in the Table 3 indicates that at flowering stage higher acid phosphatase (67.3

µg p-nitrophenol g^{-1} soil h^{-1}), alkaline phosphatase activity (100 µg PNP g^{-1} soil h^{-1}), dehydrogenase activity (103 ug TPF g^{-1} soil day^{-1}) and urease activity (69 µg urea g^{-1} soil h^{-1}) and at harvesting stage higher acid phosphatase (62.7 µg p-nitrophenol g^{-1} soil h^{-1}), alkaline phosphatase activity (93 µg PNP g^{-1} soil h^{-1}), dehydrogenase activity (90 ug TPF g^{-1} soil day^{-1}) and urease activity (61 µg urea g^{-1} soil h^{-1}) were observed with the application of 75% RDF + poultry manure @ 2 t ha^{-1} + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T_{10}). This treatment was followed by the application of 75% RDF + FYM @ 10 t ha^{-1} + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha-1 each (T_9), 100% RDF + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T_5) and 75% RDF + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T_6). This was followed by the application of 75% RDF + poultry manure @ 2 t ha^{-1} (T_8) which was on par with 75% RDF + FYM @ 10 t ha^{-1} (T_7). This was followed by the application of poultry manure @ 2 t ha^{-1} (T_4) which was comparable with FYM @ 10 t ha^{-1} (T_3). This was followed by the application of 100% RDF (T_2) while the control (T_1) recorded the lowest enzyme activity in soil.

"Dehydrogenase has been found to be significantly increase in soils applied with the combination of organic and inorganic fertilizer. Substitution of 25 percent of NP fertilizers either through manures along with biofertilizers promotes higher levels of dehydrogenase activity. Bulky source of potentially beneficial microbes in the manures may possibly provide microbial diversity and activity of microorganisms accompanied by better dehydrogenase activity". (Nath *et al*., 2011).

"The urease activity was observed to be positively correlated with bacterial population and available nitrogen in soil. Enhancement of urease activity with increased rate of nitrogen application, through manures along with biofertilizers to soil provides a source of carbon and energy for microbes by which their population increases resulting in increased enzymatic activity. Urease enzyme activity was highly related to soil organic matter content and microbial activity of the soils. The urease activity was observed to be positively correlated with bacterial population and available nitrogen in soil" (Janardhan *et al*., 2022). "The increased activity of phosphates enzyme in soil might be due to increased solubilization and mobilization of soil through the activity of phosphatase enzyme which was increased when PSB and AMF were used" (Nath *et al*., 2011). "A positive correlation was observed between alkaline phosphatase activity and the population of phosphorus-solubilizing bacteria (PSB) at all growth stages. The enzyme activity increased with increase in microbial populations, with the highest phosphatase activity levels recorded when PSB was applied in combination with other treatments, enhancing soil microflora" (Janardhan *et al*., 2022).

Table 1. Influence of fertilizers, biofertilizers and organic manures on soil enzyme activity at flowering and harvesting stages of maize

Treatments	**Kernel yield ($kg\ ha^{-1}$)**	**Stover yield ($kg\ ha^{-1}$)**
T_1: Control	2016	2456
T_2: 100% RDF	4626	5497
T_3: FYM @ 10 t ha^{-1}	2736	3156
T_4: Poultry Manure @ 2 t ha^{-1}	3096	3575
T_5: 100% RDF + Soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 lit ha^{-1} each	4956	5875
T_6: 75 % RDF + Soil application of liquid biofertilizers *Azospirillum,* PSB and KSB @ 1.25 lit ha^{-1} each	3560	4275
T_7: 75% RDF + FYM @ 10 t ha^{-1}	3950	4725
T_8: 75% RDF + Poultry Manure @ 2 t ha^{-1}	4250	5025
T_9: 75% RDF + FYM@ 10 t ha^{-1} + Soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 lit ha^{-1} each	4688	5526
T_{10}: 75% RDF + Poultry Manure@ 2 t ha^{-1} + Soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 lit ha^{-1} each	4813	5702
S.Em±	117.5	130.3
CD @ 5%	349	387

Table 2. Influence of fertilizers, biofertilizers and organic manures on soil microbial population at flowering and harvesting stages of maize

Treatments	Bacteria (× 10^6 CFU g^{-1} of soil)		Fungi (× 10^3 CFU g^{-1} of soil)		Actinomycetes (× 10^4 CFU g^{-1} of soil)	
	Flowering Stage	Harvest stage	Flowering Stage	Harvest stage	Flowering Stage	Harvest stage
T_1: Control	33.9	28.2	10.3	7.3	8.4	6.2
$T_{2,,}$: 100% RDF	37.7	32.4	12.3	9.4	11.2	8.6
T_3: FYM@ 10 t ha^{-1}	41.9	36.7	14.7	11.2	14.3	10.6
T_4: Poultry manure@ 2 t ha^{-1}	44.2	39.2	15.6	12.0	16.1	11.7
T_5: 100% RDF + soil application of liquid biofertilizers *Azospirillum*, PSB & KSB @ 1.25 litres ha^{-1}	60.7	51.7	21.4	18.4	24.7	18.0
T_6: 75 % RDF + soil application of liquid biofertilizers *Azospirillum*, PSB & KSB @ 1.25 litres ha^{-1}	56.8	48.1	19.7	16.7	22.3	16.3
T_7: 75% RDF + FYM@ 10 t ha^{-1}	49.9	42.8	17.5	14.5	18.4	13.6
T_8: 75% RDF + poultry manure@ 2 t ha^{-1}	52.9	44.0	18.1	15.0	19.0	14.3
T_9: 75% RDF + FYM@ 10 t ha^{-1} + soil application of liquid biofertilizers *Azospirillum*, PSB & KSB @ 1.25 litres ha^{-1}	65.9	56.1	23.3	20.0	27.2	20.0
T_{10}: 75% RDF + poultry manure @ 2 t ha^{-1} + soil application of liquid biofertilizers *Azospirillum*, PSB & KSB @ 1.25 litres ha^{-1}	70.2	60.2	25.3	21.6	30.3	22.2
SE.m±	1.25	1.19	0.49	0.50	0.74	0.52
CD@5%	3.7	3.5	1.5	1.5	2.2	1.6

Table 3. Influence of fertilizers, biofertilizers and organic manures on enzyme activity at flowering and harvesting stages of maize

Treatments	Acid phosphatase activity (µg p-nitrophenol g^{-1} soil h^{-1})		Alkaline phosphatase activity (µg PNP g^{-1} soil h^{-1})		Dehydrogenase activity (µg TPF g^{-1} soil day^{-1})		Urease activity (µg urea g^{-1} soil h^{-1})	
	Flowering Stage	Harvest stage	Flowering Stage	Harvest stage	Flowering Stage	Harvest stage	Flowering Stage	Harvest stage
T_1: Control	35.1	28.9	44	38	48	39	35	17
T_2: 100% RDF	40.2	33.7	51	46	58	45	39	23
T_3: FYM @ 10 t ha^{-1}	44.0	38.3	58	54	66	51	43	29
T_4: Poultry manure @ 2 t ha^{-1}	44.1	38.9	60	58	69	55	43	30
T_5: 100% RDF + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1}	56.8	51.5	86	81	92	77	58	50
T_6: 75 % RDF + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1}	52.7	47.4	78	74	87	72	52	43
T_7: 75% RDF + FYM @ 10 t ha^{-1}	47.4	43.0	67	65	77	61	47	36
T_8: 75% RDF + poultry manure @ 2 t ha^{-1}	48.1	43.1	70	68	80	64	48	36
T_9: 75% RDF + FYM @ 10 t ha^{-1} + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1}	62.7	57.5	93	87	98	84	62	56
T_{10}: 75% RDF + poultry manure @ 2 t ha^{-1} + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1}	67.3	62.7	100	93	103	90	69	61
SE.m±	1.26	1.35	1.9	1.6	1.2	1.2	0.9	1.3
CD @ 5%	3.8	4.0	6	5	4	4	3	4

4. Conclusion

Microbial populations and soil enzyme activities in the soil rhizosphere were significantly increased when 75% RDF was combined with organic amendments, such as poultry manure (2 t ha^{-1}) or FYM (10 t ha^{-1}), and liquid biofertilizers (*Azosprillum*, PSB and KSB). Higher organic carbon inputs from the manures act as substrates and energy sources for microbes which promote the synthesis of important soil enzymes like dehydrogenase, phosphatase, and urease and are responsible for the increase in enzyme activity. Furthermore, active microbial strains are released by biofertilizers, which speed up nutrient mineralization processes and aid in enzymatic secretion. When compared to RDF alone, this combined effect enhances soil biological functioning and nutrient turnover, leading to superior microbial and enzymatic activity. Therefore, a sustainable and efficient way to conserve soil fertility and improve soil biological health in a maize production system is to combine reduced dosage of chemical fertilizers with organic manures and biofertilizers.

Disclaimer (Artificial Intelligence)

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

Competing Interests

Authors have declared that no competing interests exist.

References

Abdel Monem, M. A. S., Khalifa, H. E., Beider, M., El Ghandour, I. A., & Galal, Y. G. M. (2000). Using biofertilizers for maize production: Response and economic return under different irrigation treatments. *Journal of Sustainable Agriculture*. https://doi.org/10.1300/J064v19n02_05

Bremner, J. M., & Douglas, L. A. (1971). Inhibition of urease activity in soils. *Soil Biology and Biochemistry*. https://doi.org/10.1016/0038-0717(71)90039-3

Casida, L., Klein, D., & Santoro, T. (1964). Soil dehydrogenase activity. *Soil Science*. https://journals.lww.com/soilsci/citation/1964/12000/Soil_Dehydrogenase_Activity.4.aspx

Dong, W., Zhang, X. Y., Dai, X. Q., Fu, X. L., Yang, F. T., & Liu, X. Y. (2014). Changes in soil microbial community composition in response to fertilization of paddy soils in subtropical China. *Applied Soil Ecology*. https://doi.org/10.1016/j.apsoil.2014.06.007

Evazi, F., & Tabatabai, M. A. (1977). Phosphatase in soil. *Soil Biology and Biochemistry*. https://doi.org/10.1016/0038-0717(77)90070-0

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*. https://tinyurl.com/2jenv9es

Janardhan, S., Prasad, P. R. K., Venkatasubbaiah, P., Venkateswarlu, B., & Ramesh, D. (2022). Effect of different levels of fertilizers in combination with biofertilizers on biological properties of soil under maize. *International Journal of Plant & Soil Science*. https://hal.science/hal-05204164/

Madhurya, P. (2022). *Effect of integrated nutrient management on soil properties, growth and yield of rabi maize* (Doctoral dissertation, Guntur). https://krishikosh.egranth.ac.in/items/42c5e243-5fe7-4346-893a-24d3a9fe49ec/full

Mallikarjun, M., & Maity, S. K. (2018). Effect of integrated nutrient management on soil biological properties in kharif rice. *International Journal of Current Microbiology and Applied Sciences*. https://doi.org/10.20546/ijcmas.2018.711.176

Nath, D. J., Ozah, B., Baruah, R., Barooah, R. C., & Borah, D. K. (2011). Effect of integrated nutrient management on soil enzymes, microbial biomass carbon and bacterial populations under rice (*Oryza sativa*)-wheat (*Triticum aestivum*) sequence. *Indian Journal of Agricultural Sciences*. https://www.researchgate.net/publication/286951145_Effect_of_integrated_nutrient_management_on_soil_enzymes_microbial _biomass_carbon_and_bacterial_populations_under_rice_Oryza_sativa-wheat_Triticum_aestivum_sequence

Pramer, D., & Schmidt, E. L. (1964). Experimental soil microbiology. *Soil Science*. https://journals.lww.com/soilsci/citation/1964/09000/experimental_soil_microbiology.26.aspx

Subba Rao, N. S. (1999). *Soil microbiology* (4th ed.). Science Publishers.

Tabatabai, M. A., & Bremner, J. M. (1969). Use of p-nitrophenyl phosphate for assay of soil phosphatase activity. *Soil Biology and Biochemistry*. https://doi.org/10.1016/0038-0717(69)90012-1

Jat, M. K., Purohit, H. S., & Singh, P. (2014). Effect of farm yard manure, fertility levels and bio-fertilizers on growth, yield and quality of sorghum. *Research on Crops, 15(*1), 78-83. DOI: 10.5958/j.2348-7542.15.1.010

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