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Effect of Integrated Nutrient Management on Productivity and Profitability of Maize (Zea mays L.) Under Irrigated Conditions of Punjab

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Abstract

A field experiment was conducted during the Rabi season of 2025-26 at the research farm of Department of Agronomy, Rayat Bahra University Mohali to evaluate the effect of integrated nutrient management on growth, yield, quality, nutrient uptake, soil fertility status, and economics of maize (Zea mays L.). The experiment comprised ten treatments with different combinations of inorganic fertilizers (RDF), organic manures (vermicompost and poultry manure), and biofertilizers (Azotobacter and PSB). The results revealed that the application of 50% RDF + Poultry manure (1.5 t/ha) + Azotobacter + PSB (T_8) recorded significantly higher plant height (207 cm), leaf area index (3.42), chlorophyll content (1.52 mg g^{-1} fresh wt.), grain yield (3693 kg ha^{-1}), and stover yield (5789 kg ha^{-1}). This treatment also demonstrated superior nutrient uptake and crude protein content and maximum economic returns with a B:C ratio of 2.2. The integrated application of organic and inorganic sources with biofertilizers proved more effective than sole inorganic fertilization, highlighting the importance of integrated nutrient management for sustainable maize production.

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1. Introduction: Maize (Zea mays L.) is one of the most important cereal crops globally, serving as a staple food, feed, and industrial raw material. In India, maize ranks third among cereal crops after rice and wheat, with significant potential for enhancing productivity through improved nutrient management practices (Kumar and Thomas, 2017). Maize is grown on over 10.7 million hectares in 2024–2025, with an average productivity of about 3.5 tonnes per hectare and a production of about 43.4 million tons. Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Bihar, and Andhra Pradesh are important states that cultivate maize (Annapure et al., 2026). The productivity of maize is largely dependent on the efficient management of nutrients, as the crop has a high nutrient requirement due to its rapid growth and high biomass production.

The excessive and imbalanced use of chemical fertilizers has led to soil degradation, environmental pollution, and reduced nutrient use efficiency. This has necessitated the adoption of integrated nutrient management (INM) approaches that combine inorganic fertilizers with organic manures and biofertilizers to sustain soil health and crop productivity (Singh et al., 2018). INM not

only supplies essential nutrients but also improves soil physical, chemical, and biological properties, thereby enhancing nutrient availability and uptake by crops (Sharma and Prasad, 2019).

Organic manures such as poultry manure and vermicompost are rich sources of plant nutrients and organic matter. Poultry manure has a narrow C:N ratio, leading to faster mineralization and nutrient release, while vermicompost improves soil structure and water-holding capacity (Patel et al., 2020). Biofertilizers like Azotobacter and phosphate-solubilizing bacteria (PSB) enhance nitrogen fixation and phosphorus solubilization, respectively, making nutrients more available to plants (Rao et al., 2016). The present study was undertaken to evaluate the effect of integrated nutrient management on productivity and profitability of maize under irrigated conditions of Punjab, with the objective of identifying the most efficient nutrient combination for sustainable maize production.

2. Materials and Methods:

2.1 Experimental Site: The field experiment was conducted during the rabi season of 2025-26 at the research farm of the Department of Agronomy, Rayat Bahra University, Mohali, Punjab. The experimental site is located at 30°47'N latitude and 76°43'E longitude at an altitude of 310 m above mean sea level. The soil of the experimental field was sandy loam in texture, with pH 7.2, organic carbon 0.48%, available N 218 kg ha^{-1}, available P_2O_5 21.6 kg ha^{-1}, and available K_2O 202.5 kg ha^{-1}. The agro-meteorological data is presented in Fig. 1.

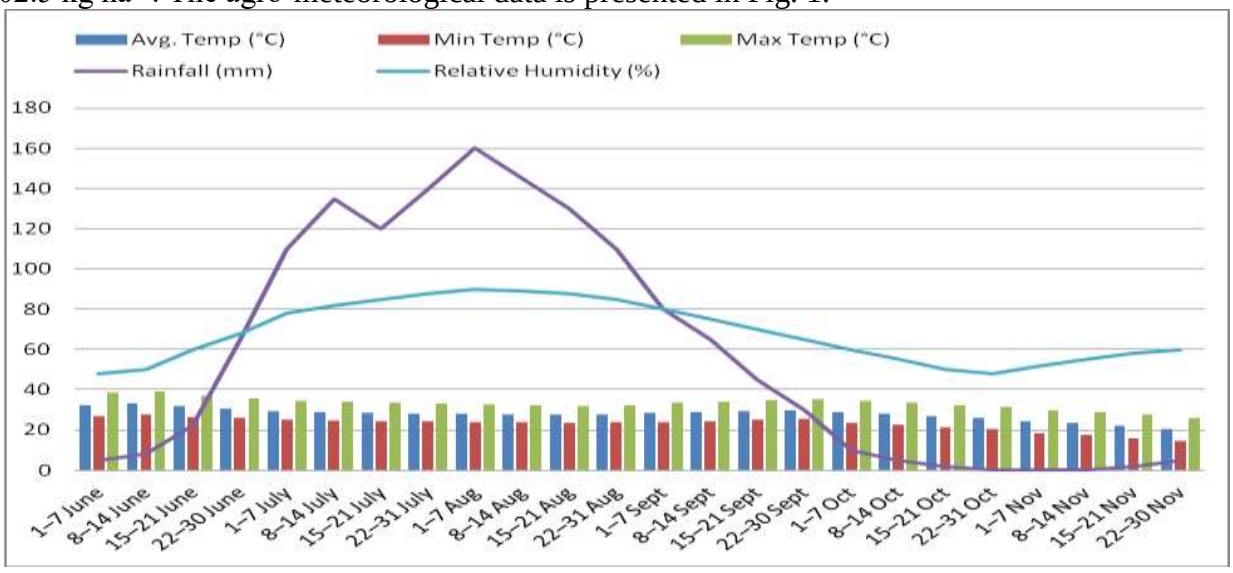

Fig. 1: Meteorological weather prameters recorded during crop growing season kharif, 2025-26

2.2 Experimental Design and Treatments: The experiment was laid out in a randomized block design (RBD) with ten treatments replicated thrice. The treatments comprised different combinations of recommended dose of fertilizer (RDF), organic manures (vermicompost and poultry manure), and biofertilizers (*Azotobacter* and PSB) as follows: T_1: 100% RDF, T_2: 75% RDF, T_3: 50% RDF, T_4: 75% RDF + Vermicompost (1 t/ha) + *Azotobacter* + PSB, T_5: 50% RDF + Vermicompost (1.5 t/ha) + *Azotobacter* + PSB, T_6: 50% RDF + Vermicompost (2.5 t/ha) + *Azotobacter* + PSB, T_7: 75% RDF + Poultry manure (1 t/ha) + *Azotobacter* + PSB, T_8: 50% RDF + Poultry manure (1.5 t/ha) + *Azotobacter* + PSB, T_9: 50% RDF + Poultry manure (2.5 t/ha) + *Azotobacter* + PSB, T_{10}: Control (No fertilizer/organic manure). The RDF for maize was 120:60:40 kg $N:P_2O_5:K_2O$ ha^{-1}. Nitrogen was applied through urea in three splits, while phosphorus and potassium were applied through single super phosphate and muriate of potash, respectively, as a basal dose. Organic manures were applied 15 days before sowing. Biofertilizers (*Azotobacter* and PSB) were applied as seed treatment at the rate of 10 g kg^{-1} of seed.

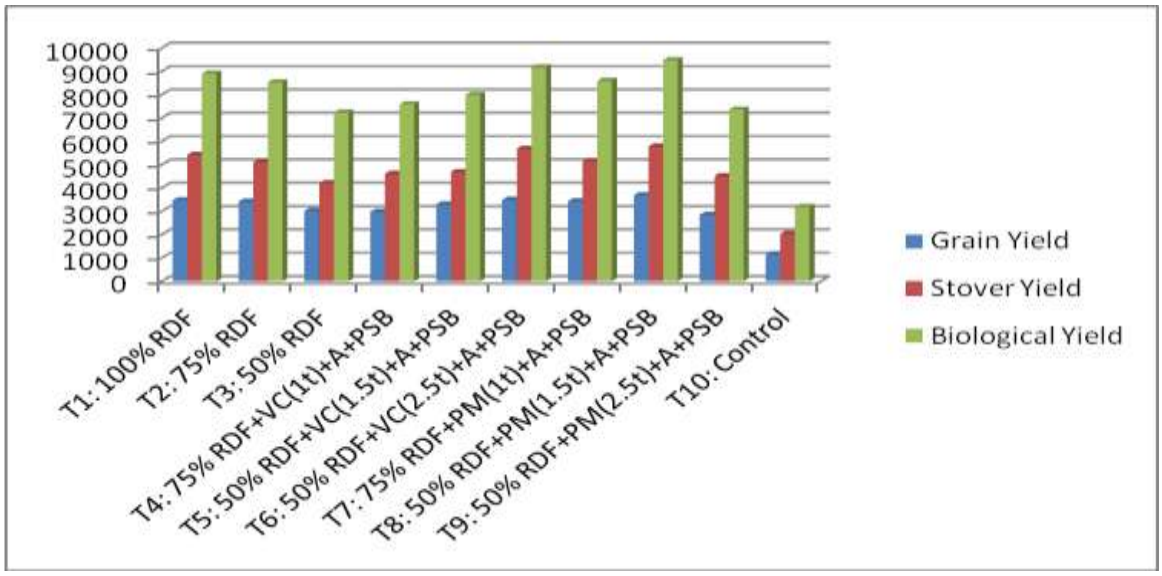

Fig. 2: Effect of integrated nutrient management on grain, straw and biological yield of maize

2.3 Crop Management and observations: Maize variety "PMH-9" was sown with a seed rate of 25 kg ha^{-1} at a spacing of 60 cm × 20 cm. Standard agronomic practices were followed throughout the crop growth period. Irrigation was provided as per the requirement of the crop. Plant height, leaf area index, chlorophyll content, number of cobs per plant, cob length and yield were measured by standard methods. Crude protein content and N, P, and K uptake by grain and stover were analysed in lab by standard methods. The data collected were statistically analyzed using analysis of variance (ANOVA) for randomized block design. The significance of differences between treatment means was tested using the critical difference (CD) at P=0.05.

3. Results and Discussion:

3.1. Effect on Growth Attributes: The data on plant height, LAI and Chlorophyll Content at different growth stages are presented in Table 1. Plant height increased progressively with crop age, with rapid increase between 25 to 75 DAS and marginal increase thereafter. The treatment T_8 (50% RDF + Poultry manure 1.5 t/ha + *Azotobacter* + PSB) recorded the highest plant height at all stages (70, 194, and 207 cm at knee-high, tasseling, and harvest, respectively), which was statistically at par with T_6 (50% RDF + Vermicompost 2.5 t/ha + *Azotobacter* + PSB). The control treatment (T_{10}) recorded the lowest plant height (39, 110, and 121 cm at the respective stages). The magnitude of increase in leaf area index at 45 DAS was 29.95 to 80.00 per cent over control by applying different nutrient treatments. The maximum plant height in integrated treatment T_8 might be due to continuous supply of essential nutrients throughout the growing period, which improved plant metabolic activity, especially in the early growth stage. The synergistic effect of inorganic, organic, and biofertilizers played a very important role, resulting in taller plants. These findings are in conformity with the research outcome of Kumar and Thomas (2017), who reported the highest plant height at harvest with 100% RDF + *Azotobacter* + PSB. The lowest plant height in the control treatment was due to undernutrition and no nitrogen supplementation, which indicated the importance of fertilization in plant metabolism and growth (Singh et al., 2018; Sharma and Prasad, 2019). Maize responds very well to fertilizer application due to its well-developed root system, which absorbs required nutrients for effective growth and yield.

Table-1: Effect of Integrated Nutrient Management on plant height (cm), LAI and Chlorophyll content of maize crop at different growth stages

Treatments	Knee high	Tasseling	Harvest	Leaf area index at 45 DAS	Chlorophyll (mg g^{-1} f. w.) at 45 DAS
T_1:100% RDF	65	172	184	3.13	1.42
T_2:75% RDF	61	169	182	3.35	1.47
T_3:50% RDF	62	165	180	3.34	1.49
T_4:75% RDF + Vermicompost (1 t/ha) + *Azotobacter* + PSB	46	156	168	3.14	1.44
T_5:50% RDF + Vermicompost (1.5 t/ha) + *Azotobacter* + PSB	51	160	173	2.75	1.13
T_6:50% RDF + Vermicompost (2.5 t/ha) + *Azotobacter* + PSB	66	182	196	3.40	1.50
T_7:75% RDF + Poultry manure (1 t/ha) + *Azotobacter* + PSB	63	175	184	3.19	1.42
T_8:50% RDF + Poultry manure (1.5 t/ha) + *Azotobacter* + PSB	70	194	207	3.42	1.52
T_9:50% RDF + Poultry manure (2.5 t/ha) + *Azotobacter* + PSB	63	172	186	3.12	1.32
T_{10}: Control	39	110	121	2.46	1.29
SEm (±)	2.27	5.70	4.70	0.11	0.03
CD (P=0.05)	6.80	17.40	13.80	0.32	0.10
CV (%)	9.46	8.23	7.54	5.21	6.12

These findings are in conformity with the research outcome of Prabhavathi et al., 2021 and Jadav et al., 2018.

3.2 Effect on Yield Attributes and Yield: The yield attributes of maize were significantly influenced by the treatments (Table 2). T_8 recorded the highest values for number of cobs per plant (2.25), cob length (17.45 cm). Among the treatments, significantly higher seed, straw and biological yield was recorded in T_8, which received 50% RDF + Poultry manure (1.5 t/ha) + *Azotobacter* + PSB. This might be due to nitrogen being the major constituent of chlorophyll, amino acids, and proteins, as well as phosphorus being the component of energy compounds viz., ATP, NADP.

Table-2: Effect of Integrated Nutrient Management on yield attributes, yield and economics of maize crop at different growth stages

Treatments	No. of cobs / Plant	Cob length (cm)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B : C ratio
T_1: 100% RDF	2.05	16.19	3475	5425	8900	81086	47493	1.4
T_2: 75% RDF	2.10	16.64	3423	5107	8530	78526	49367	1.6
T_3: 50% RDF	2.05	17.11	3021	4215	7236	71976	40783	1.3
T_4: 75% RDF + Vermicompost (1 t/ha) + *Azotobacter* + PSB	2.00	16.51	2976	4617	7593	76220	46801	1.6
T_5: 50% RDF + Vermicompost (1.5 t/ha) + *Azotobacter* + PSB	2.00	15.93	3297	4689	7986	86056	56013	1.9
T_6: 50% RDF + Vermicompost (2.5 t/ha) + *Azotobacter* + PSB	2.05	17.37	3494	5682	9176	92371	58411	1.7
T_7: 75% RDF + Poultry manure (1 t/ha) + *Azotobacter* + PSB	2.10	15.10	3435	5156	8591	85275	53716	1.7
T_8: 50% RDF + Poultry manure (1.5 t/ha) + *Azotobacter* + PSB	2.25	17.45	3693	5789	9482	97851	67442	2.2
T_9: 50% RDF + Poultry manure (2.5 t/ha) + *Azotobacter* + PSB	2.00	16.07	2852	4513	7365	88548	58764	2.0
T_{10}: Control	1.05	14.40	1154	2031	3185	64714	35920	1.2
SEm (±)	0.04	2.06	83.12	210.00	0.97			
CD (P=0.05)	0.03	5.95	246.28	627.21	NS			
CV (%)	5.2	6.1	11.51	7.25	7.37			

Also, potassium which serves as an activator or cofactor for various enzymes involved in photosynthesis and carbon dioxide fixation, could have promoted satisfactory plant growth, photosynthetic surface, yield structure, and finally improved cob yield under adequate and balanced supply of nutrients. This is in accordance with the results reported by Adnan et al., 2018; Makwana et al., 2016; Zafar et al., 2020.

3.3 Effect on Quality Parameters: The crude protein content of maize (Table 3) was significantly influenced by application of organic and inorganic sources of nutrients. The highest protein content (12.0%) was observed in T_8 (50% RDF + Poultry manure 1.5 t/ha + *Azotobacter* + PSB). This might be due to combined application of inorganic, organic, and biofertilizers, which was associated with higher N availability in soil and thereby greater N uptake by crop. Nitrogen, being the principal constituent of protein, might have substantially increased the protein content of the kernel due to increased uptake of nitrogen under higher availability. The effective translocation of photosynthates from source to sink might have further improved the protein in kernels. Similar trend was also reported by Patel et al. (2020).

Table-3: Effect of Integrated Nutrient Management on nutrient uptake, crude protein content and economics of maize crop at different growth stages

Treatments	N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		K uptake (kg ha^{-1})		Crude protein content (%)
	Grain	Stover	Grain	Stover	Grain	Stover	
T_1: 100% RDF	57.69	45.03	12.16	11.39	14.60	72.15	10.38
T_2: 75% RDF	59.22	44.94	12.67	13.28	17.12	72.52	10.81
T_3: 50% RDF	54.08	39.20	12.08	12.22	16.62	62.80	11.19
T_4: 75% RDF + Vermicompost (1 t/ha) + *Azotobacter* + PSB	52.68	41.55	11.61	12.47	15.77	67.87	11.06
T_5: 50% RDF + Vermicompost (1.5 t/ha) + *Azotobacter* + PSB	59.35	45.95	14.18	15.00	18.79	72.68	11.25
T_6: 50% RDF + Vermicompost (2.5 t/ha) + *Azotobacter* + PSB	62.19	53.98	12.58	12.50	16.42	79.55	11.13
T_7: 75% RDF + Poultry manure (1 t/ha) + *Azotobacter* + PSB	64.23	51.56	13.05	12.89	18.21	79.92	11.69
T_8: 50% RDF + Poultry manure (1.5 t/ha) + *Azotobacter* + PSB	70.91	60.78	15.88	16.79	22.16	94.36	12.00
T_9: 50% RDF + Poultry manure (2.5 t/ha) + *Azotobacter* + PSB	53.62	46.48	11.69	12.19	16.54	72.21	11.75
T_{10}: Control	22.27	21.73	5.08	6.50	7.15	33.11	12.06
SEm (±)	2.7	2.5	2.2	2.4	1.2	2.8	0.09
CD (P=0.05)	7.3	5.2	3.5	2.4	5.3	7.5	0.07
CV (%)	5.2	8.3	9.6	8.9	7.1	8.5	4.2

The N, P, and K uptake by grain and stover were significantly influenced by the treatments (Table 3). T_8 recorded the highest N uptake in grain (70.91 kg ha^{-1}) and stover (60.78 kg ha^{-1}), P uptake in grain (15.88 kg ha^{-1}) and stover (16.79 kg ha^{-1}), and K uptake in grain (22.16 kg ha^{-1}) and stover (94.36 kg ha^{-1}). The control treatment recorded the lowest nutrient uptake. Higher biomass production might be the most pertinent reason for the higher uptake of nutrients in the treatments which received higher levels of recommended nitrogen. This was evident from the highly significant relation between soil available nitrogen with dry matter production, grain and stover yields at harvest. Similar results were also reported by Singh et al. (2018).

3.4 Effect on Economics: The economics of different nutrient management treatments are presented in Table 2. The highest gross return (Rs. 97,851 ha^{-1}), net return (Rs. 67,442 ha^{-1}), and B:C ratio (2.2) were obtained with T_8 (50% RDF + Poultry manure 1.5 t/ha + *Azotobacter* + PSB). This was followed by T_6 (Rs. 92,371 ha^{-1} gross return, Rs. 58,411 ha^{-1} net return, B:C 1.7) and T_9 (Rs. 88,548 ha^{-1} gross return, Rs. 58,764 ha^{-1} net return, B:C 2.0). The control treatment recorded

the lowest economic returns (Rs. 64,714 ha^{-1} gross return, Rs. 35,920 ha^{-1} net return, B:C 1.2). This can be attributed to higher cost of cultivation of vermicompost. This was prominent in B:C ratio. The highest B:C ratio (2.2) was observed in T_8, while the lowest (1.2) was observed in T_{10} (control). Similar reports of higher B:C ratio and net returns in maize by application of poultry manure compared to FYM were recorded by Kumar and Thomas (2017) and Patel et al. (2020).

Conclusion: The treatment receiving 50% RDF + Poultry manure (1.5 t/ha) + *Azotobacter* + PSB (T_8) proved to be the most effective, recording the highest growth attributes, yield parameters, nutrient uptake, and economic returns. This treatment was statistically at par with 50% RDF + Vermicompost (2.5 t/ha) + *Azotobacter* + PSB (T_6) for most parameters. The integration of organic sources with reduced inorganic fertilizer doses (50% RDF) and biofertilizers not only maintained higher productivity but also improved soil fertility status, indicating the sustainability of this approach. The highest B:C ratio of 2.2 in T_8 highlights its economic viability and potential for adoption by farmers. Therefore, integrated nutrient management with 50% RDF + Poultry manure (1.5 t/ha) + *Azotobacter* + PSB is recommended for sustainable and profitable maize production in the irrigated conditions of Punjab.

References:

1. Adnan, M., Fahad, S., Iqbal, S., Arshad, M., Muhammad, D., Wahid, F and Noor, M. N. 2018. Integrated application of phosphorus (P) and phosphate solubilizing bacteria (PSB) improve maize yield. Pure and Applied Biology. 7(2): 494-499.
2. Annapure, U. S., Kaur, P., Irom, B. S., & Das, T. (2026). Introduction to Major and Minor Millets. In Millets: A Sustainable And Nutritious Crop (pp. 3-46). Cham: Springer Nature Switzerland.
3. Jadav, V.M., Patel, P.M., Chaudhari, J.B., Patel, J.M and Chaudhari, P.P. 2018. Effect of integrated nutrient management on growth and yield of rabi forage maize (Zea mays L.). International Journal of Chemical Studies. 6(1): 2160-2163.
4. Kumar, R. and Thomas, A. (2017). Integrated nutrient management in maize-wheat cropping system. Journal of Agricultural Research, 45(3): 234-241.
5. Makwana, N.D, Thanki, J.D., Der, P.B and Nandaniya J.K. 2016. Grain yield, nutrient uptake and economics of rabi maize under different fertilizer levels and organic sources in south Gujarat condition. Advances in Life Sciences. 5(5): 1661-1664.
6. Patel, R.K., Singh, D.K., and Kumar, S. (2020). Effect of organic manures and biofertilizers on growth, yield and quality of maize. Indian Journal of Agronomy, 65(2): 189-195.
7. Prabhavathi, N., Nagaraju, K., Madhuri, K.N and Prasad, P.R. 2021. Effect of INM on growth and physiological parameters of maize in maize-groundnut cropping system. The pharma Innovation Journal. sp.10(5): 250-253.
8. Rao, A.S., Reddy, G.S., and Sharma, K.L. (2016). Biofertilizers in sustainable agriculture. Journal of Soil Biology, 12(1): 45-58.
9. Sharma, P.K. and Prasad, R. (2019). Integrated nutrient management for sustainable crop production. Current Agriculture, 28(4): 301-315.
10. Singh, V.P., Kumar, A., and Meena, R.S. (2018). Integrated nutrient management in cereals. Indian Journal of Agricultural Sciences, 88(2): 187-194.
11. Zafar, N., Munir, M.K., Ahmed, S and Zafar, M. 2020. Phosphorus solubilizing bacteria (PSB) in combination with different fertilizer sources to enhance yield performance of chickpea. Life Science Journal. 17 (8): 84-88.

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