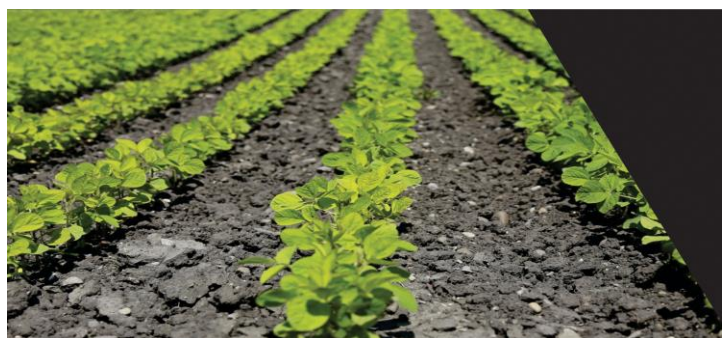




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Effect of integrated nutrient management practices on growth, yield, quality and economics of maize (*Zea mays* L.) Under Kanpur conditions

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Abstract

Maize (*Zea mays* L.) is one of the most productive cereal crops and plays a significant role in ensuring food, feed and nutritional security worldwide. However, continuous dependence on inorganic fertilizers has resulted in declining soil fertility, reduced nutrient-use efficiency and deterioration of soil health. Integrated Nutrient Management (INM), involving the combined use of chemical fertilizers and organic nutrient sources, has emerged as a sustainable strategy to enhance crop productivity while maintaining soil fertility. Keeping this perspective in view, a field experiment entitled “Effect of Integrated Nutrient Management Practices on Growth and Yield of Maize (*Zea mays* L.)” was conducted during Kharif 2025 at the Instructional Farm, Rama University, Kanpur, Uttar Pradesh.

The experiment was laid out in a Randomized Block Design with eleven treatments comprising different combinations of Recommended Dose of Fertilizers (RDF), vermicompost, poultry manure and pressmud. The objective was to evaluate the effect of integrated nutrient management practices on growth parameters, yield attributes, grain yield, nutrient uptake, grain quality, soil fertility status and economics of maize cultivation.

The results revealed that integrated application of inorganic fertilizers along with organic manures significantly improved crop growth, productivity and profitability compared to control and sole fertilizer application. Among various treatments, application of 125% RDF + Poultry Manure @ 2.5 t ha⁻¹ (T₁₀) recorded the highest plant height, leaf area index, dry matter accumulation and crop growth rate throughout the growth period. The same treatment also produced superior yield attributes including cob length, grains cob⁻¹, cob weight and test weight, resulting in maximum grain yield, straw yield and biological yield. Integrated nutrient management practices significantly enhanced nutrient concentration and uptake of nitrogen, phosphorus and potassium by maize crop. Grain quality parameters such as protein content, crude protein yield and chlorophyll content were also improved under integrated nutrient management treatments. Post-harvest soil analysis indicated considerable improvement in soil organic carbon and available nutrient status where organic manures were integrated with inorganic fertilizers. Economic analysis showed that integrated nutrient management practices generated higher gross returns, net returns and benefit-cost ratio compared to conventional fertilizer application. The treatment receiving 125% RDF + Poultry Manure @ 2.5 t ha⁻¹ recorded the highest profitability and economic efficiency.

The study concluded that integrated application of inorganic fertilizers and organic nutrient sources, particularly poultry manure, can substantially improve maize productivity, nutrient-use efficiency, soil fertility and farm profitability under the agro-climatic conditions of Kanpur. Therefore, adoption of integrated nutrient management practices may be recommended for sustainable maize production and long-term soil health improvement.

Keywords: Maize, integrated nutrient management, poultry manure, vermicompost, pressmud, growth parameters, yield attributes, nutrient uptake, soil fertility, economics

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops cultivated throughout the world and is widely recognized as the “Queen of Cereals” because of its exceptional genetic yield potential, wider adaptability and multiple uses. The crop belongs to the family Poaceae and originated in Central America, from where it spread across different continents and became one

of the most extensively cultivated cereal crops worldwide. Owing to its C4 photosynthetic pathway, maize possesses higher photosynthetic efficiency, greater biomass accumulation and superior productivity compared to many other cereal crops. The crop is cultivated under diverse agro-climatic conditions ranging from temperate regions to tropical environments and serves as an important source of food, feed, fodder and industrial raw material. Maize grains contain approximately 70-72 per cent carbohydrates, 8-12 per cent protein, 3-5 per cent oil and appreciable quantities of vitamins and minerals, making it an important component of human and livestock nutrition.

Globally, maize occupies a prominent position among cereal crops and contributes significantly towards food security and agricultural economies. According to the Food and Agriculture Organization (FAO, 2024) ^[6], maize is cultivated on more than 205 million hectares with an annual production exceeding 1.25 billion tonnes. The United States, China, Brazil, Argentina and India are the major maize-producing countries. The increasing demand for maize in feed industries, starch production, ethanol manufacturing and food processing sectors has further enhanced its economic importance. Prasanna *et al.* (2023) ^[16] reported that maize contributes nearly 40 per cent of global cereal production and remains one of the most strategically important crops for meeting future food and energy demands.

India is the third-largest producer of maize after the United States and China. During 2024-25, maize was cultivated on approximately 10.8 million hectares with a production of nearly 39.5 million tonnes and an average productivity of about 3.65 t ha⁻¹ (DES, 2024). Although considerable progress has been achieved through hybrid technology and improved crop management practices, maize productivity in India remains lower than the attainable yield potential under scientific cultivation. The major maize-growing states include Karnataka, Madhya Pradesh, Maharashtra, Bihar, Uttar Pradesh, Rajasthan and Andhra Pradesh. In Uttar Pradesh, maize occupies a significant position in the cropping system and is cultivated extensively during the kharif season under irrigated and rainfed conditions. However, continuous cultivation, declining soil fertility and imbalanced nutrient management have emerged as major constraints affecting productivity and sustainability of maize production systems.

Nutrient management is one of the most important factors influencing growth, development and productivity of maize. Being an exhaustive crop with high biomass production, maize requires substantial quantities of nutrients throughout its growth period. Nitrogen, phosphorus and potassium are the primary nutrients required in large quantities for optimum growth and yield. Nitrogen plays a vital role in chlorophyll formation, protein synthesis and vegetative growth, while phosphorus is essential for root development, energy transfer and reproductive growth. Potassium regulates enzyme activation, osmotic balance, photosynthesis and assimilate translocation. Deficiency of any essential nutrient adversely affects physiological processes, resulting in poor crop growth and reduced grain yield. The intensive use of chemical fertilizers during the Green Revolution era substantially increased crop productivity and helped India achieve food security. However, continuous and indiscriminate application of inorganic fertilizers has led to several problems including nutrient imbalance, decline in soil organic carbon, deterioration of soil structure and reduction in microbial activity. Long-term fertilizer experiments conducted across different agro-ecological regions of India have demonstrated that exclusive dependence on chemical fertilizers adversely affects soil health and sustainability of crop production systems (Jat *et al.*, 2019) ^[9]. Excessive fertilizer use has also contributed to nutrient losses

through leaching, volatilization and runoff, resulting in environmental degradation and reduced nutrient-use efficiency.

To address these challenges, increasing emphasis is being placed on sustainable nutrient management strategies capable of maintaining crop productivity while improving soil health. Integrated Nutrient Management (INM) has emerged as one of the most effective approaches for sustainable crop production. Integrated Nutrient Management refers to the judicious and combined use of chemical fertilizers, organic manures, crop residues and biofertilizers to achieve optimum crop productivity while maintaining soil fertility and environmental quality. The primary objective of INM is to ensure balanced nutrient supply through multiple nutrient sources and improve nutrient-use efficiency while reducing dependence on synthetic fertilizers. Organic nutrient sources such as vermicompost, poultry manure and pressmud play an important role in integrated nutrient management systems. These organic amendments not only supply essential plant nutrients but also improve soil physical, chemical and biological properties. Vermicompost is a nutrient-rich organic manure produced through the activity of earthworms and contains readily available nutrients, beneficial microorganisms and plant growth-promoting substances. Application of vermicompost improves soil aggregation, water-holding capacity and microbial activity, thereby enhancing nutrient availability and crop growth. Norman *et al.* (2015) ^[14] reported significant improvements in plant height, leaf area index and biomass production of maize following integrated application of vermicompost and inorganic fertilizers.

Poultry manure is another valuable organic nutrient source containing substantial quantities of nitrogen, phosphorus, potassium and micronutrients. Due to its narrow carbon-to-nitrogen ratio, nutrients become available rapidly after application. Poultry manure enhances nutrient mineralization, microbial activity and soil fertility, thereby promoting crop growth and productivity. Ali *et al.* (2022) ^[1] observed that integrated application of poultry manure and recommended fertilizer dose significantly improved growth parameters, nutrient uptake and grain yield of maize under subtropical conditions.

Pressmud, a by-product of the sugar industry, is rich in organic carbon, calcium, phosphorus and several micronutrients. Application of pressmud improves soil fertility, enhances microbial activity and increases nutrient availability. Researchers have reported beneficial effects of pressmud on crop growth, yield and soil health under intensive cropping systems. The recycling of such organic wastes through agriculture not only improves soil productivity but also contributes to environmental sustainability. Several researchers have reported positive effects of integrated nutrient management on growth and productivity of maize. Mahajan *et al.* (2012) ^[12] observed that integrated use of organic manures and inorganic fertilizers significantly increased plant height, dry matter accumulation and grain yield compared with sole fertilizer application. Kannan *et al.* (2013) ^[10] reported that integrated nutrient management improved crop growth rate, nutrient uptake and biomass production through enhanced nutrient availability and improved soil conditions. Meena *et al.* (2018) ^[13] found that integrated nutrient management significantly enhanced photosynthetic activity, dry matter accumulation and yield attributes of maize. Prasanna *et al.* (2020) ^[15] further reported that balanced nutrient management improved nutrient-use efficiency and crop productivity while sustaining soil fertility.

The beneficial effects of integrated nutrient management extend beyond crop productivity. Organic amendments improve soil structure by reducing bulk density and increasing porosity, water

infiltration and moisture retention. Enhanced soil biological activity promotes nutrient cycling and availability, thereby improving nutrient-use efficiency. Integrated nutrient management also contributes to carbon sequestration, reduction in fertilizer losses and improvement of environmental quality. According to FAO (2023), integrated nutrient management represents a key component of climate-smart agriculture and sustainable intensification of crop production systems.

Despite the well-recognized advantages of integrated nutrient management, crop response varies considerably depending upon soil type, climatic conditions, cropping systems and nutrient combinations. Under the alluvial soils of Central Uttar Pradesh, information regarding the comparative performance of different organic nutrient sources such as vermicompost, poultry manure and pressmud in combination with graded fertilizer levels remains limited. Therefore, systematic evaluation of integrated nutrient management practices is essential for identifying suitable nutrient combinations capable of improving maize productivity, soil fertility and farm profitability under local conditions.

Research Gap

Although numerous studies have demonstrated the beneficial effects of integrated nutrient management on maize productivity, limited information is available regarding the comparative performance of vermicompost, poultry manure and pressmud integrated with different fertilizer levels under the agro-climatic conditions of Central Uttar Pradesh. Furthermore, comprehensive information relating to growth, yield, nutrient uptake, soil fertility status and economics under such integrated nutrient management systems is still inadequate.

Justification of the Study

Declining soil fertility, reduction in organic matter content and increasing fertilizer costs have become major challenges in maize production. Integration of organic nutrient sources with chemical fertilizers offers a sustainable alternative for improving nutrient-use efficiency, maintaining soil health and enhancing crop productivity. Evaluation of different integrated nutrient management practices under Kanpur conditions is therefore necessary for developing location-specific nutrient recommendations capable of maximizing productivity, profitability and sustainability of maize cultivation.

2. Materials and methods

The present investigation entitled “**Effect of Integrated Nutrient Management Practices on Growth and Yield of Maize (*Zea mays* L.)**” was conducted during the **Kharif season of 2025** at the Students’ Instructional Farm, Faculty of Agricultural Sciences and Allied Industries, Rama University, Kanpur, Uttar Pradesh. The experimental farm is situated in the Central Plain Zone (Agro-climatic Zone-V) of Uttar Pradesh and falls under a subtropical climate characterized by hot summers, humid monsoon conditions and mild winters.

Prior to sowing, representative soil samples were collected from a depth of 0-15 cm and analyzed for their physico-chemical properties. The soil of the experimental field was sandy loam in texture, slightly alkaline in reaction (pH 7.69), low in organic carbon (0.38%), available nitrogen (167.78 kg ha⁻¹) and available phosphorus (8.15 kg ha⁻¹), while medium in available potassium (189.47 kg ha⁻¹).

The experiment was laid out in a Randomized Block Design (RBD) with three replications comprising eleven treatment combinations involving different levels of recommended fertilizer dose (RDF) integrated with organic nutrient sources.

The treatments consisted of T₁: Control, T₂: 100% RDF, T₃: 75% RDF + Vermicompost @ 2.5 t ha⁻¹, T₄: 100% RDF + Vermicompost @ 2.5 t ha⁻¹, T₅: 125% RDF + Vermicompost @ 2.5 t ha⁻¹, T₆: 75% RDF + Poultry Manure @ 2.5 t ha⁻¹, T₇: 100% RDF + Poultry Manure @ 2.5 t ha⁻¹, T₈: 125% RDF + Poultry Manure @ 2.5 t ha⁻¹, T₉: 75% RDF + Pressmud @ 5 t ha⁻¹, T₁₀: 100% RDF + Pressmud @ 5 t ha⁻¹ and T₁₁: 125% RDF + Pressmud @ 5 t ha⁻¹. The recommended fertilizer dose for maize was 120:60:40 kg N:P₂O₅:K₂O ha⁻¹.

The field was prepared by one deep ploughing followed by two harrowings and planking to obtain a fine tilth. Organic manures were incorporated into the soil fifteen days before sowing according to treatment specifications. Nitrogen was supplied through urea, phosphorus through single super phosphate and potassium through muriate of potash. Half of the nitrogen and the full dose of phosphorus and potassium were applied as basal, while the remaining nitrogen was top dressed in two equal splits at knee-high and tasseling stages.

A suitable high-yielding maize hybrid was sown during the first fortnight of July at a spacing of 60 cm × 20 cm. All recommended agronomic practices including irrigation, weed management and plant protection measures were followed uniformly throughout the crop growth period.

Observations on growth parameters such as plant population, plant height, leaf area index, dry matter accumulation and crop growth rate were recorded at different growth stages. Yield attributes including cob length, cob girth, grains cob⁻¹, cob weight and test weight were recorded at harvest. Grain yield, stover yield, biological yield and harvest index were computed using standard procedures. Grain samples were analyzed for protein content, while nutrient uptake studies were carried out for nitrogen, phosphorus and potassium. Post-harvest soil samples were also analyzed to determine changes in soil fertility status.

Economic analysis was carried out by calculating cost of cultivation, gross return, net return and benefit-cost ratio using prevailing market prices. The experimental data were statistically analyzed using the Analysis of Variance (ANOVA) technique appropriate for Randomized Block Design as described by Gomez and Gomez (1984) [8]. The significance of treatment effects was tested through the F-test at the 5 per cent level of probability, and Critical Difference (CD) values were calculated wherever treatment differences were found significant. Standard Error of Mean [SEm (±)] was also worked out to assess the precision of the experiment.

4. Results and discussion

4.1 Effect of Integrated Nutrient Management Practices on Growth Parameters of Maize

Growth parameters are considered important indicators of crop performance because they directly reflect the influence of nutrient availability on physiological, biochemical and metabolic activities of plants. Integrated Nutrient Management (INM) involving organic and inorganic nutrient sources plays a significant role in improving plant growth through enhanced nutrient availability, improved soil health and greater nutrient-use efficiency. The observations recorded on plant population, plant height, leaf area index, dry matter accumulation and crop growth rate revealed significant variation among different treatment combinations.

Effect on Plant Population

The data presented in Table 1 revealed that plant population at harvest was not significantly influenced by different integrated nutrient management treatments. However, numerically higher

plant population was recorded under T₈ (125% RDF + Poultry Manure @ 2.5 t ha⁻¹), which recorded 77.8×10^3 plants ha⁻¹ compared with 71.2×10^3 plants ha⁻¹ under control. The higher

plant stand under integrated nutrient management treatments may be attributed to improved soil conditions and better seedling establishment resulting from organic matter incorporation.

Table 1: Effect of Integrated Nutrient Management Practices on Growth Parameters of Maize

Treatment	Plant Population at Harvest ($\times 10^3$ ha ⁻¹)	Plant Height (cm)	LAI at 60 DAS	Dry Matter Accumulation (g plant ⁻¹)	Crop Growth Rate (g m ⁻² day ⁻¹)
T ₁ Control	71.2	178.4	3.62	168.4	18.6
T ₂ 100% RDF	73.6	196.2	4.18	192.8	22.4
T ₃ 75% RDF + VC	74.2	201.8	4.32	205.4	23.8
T ₄ 100% RDF + VC	75.4	214.6	4.68	224.6	25.8
T ₅ 125% RDF + VC	76.2	221.8	4.82	236.8	27.2
T ₆ 75% RDF + PM	75.6	218.2	4.76	232.4	26.8
T ₇ 100% RDF + PM	76.4	228.6	5.02	248.2	28.6
T ₈ 125% RDF + PM	77.8	242.4	5.42	265.8	30.8
T ₉ 75% RDF + Pressmud	74.8	208.6	4.48	214.8	24.6
T ₁₀ 100% RDF + Pressmud	75.8	220.4	4.86	234.6	27.4
T ₁₁ 125% RDF + Pressmud	76.8	232.2	5.08	252.4	29.2
SEm ($\pm$)	1.12	5.42	0.18	6.84	0.96
CD (P=0.05)	NS	15.84	0.52	19.96	2.80

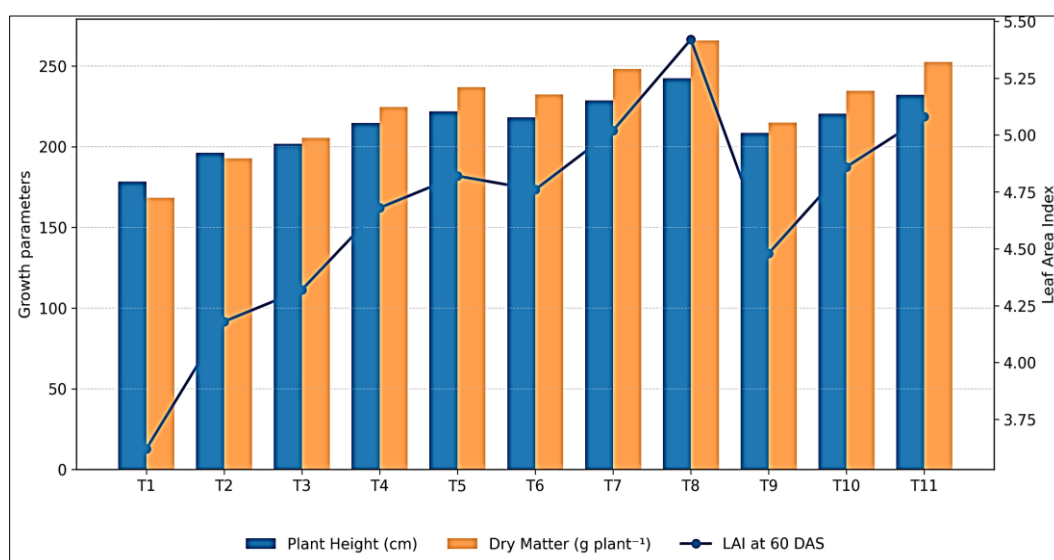


Fig 1: Growth Performance Index of Maize under INM Treatments

Effect on Plant Height: Plant height increased significantly with integrated application of fertilizers and organic nutrient sources. Among the treatments, T₈ (125% RDF + Poultry Manure @ 2.5 t ha⁻¹) recorded the maximum plant height (242.4 cm), which was significantly superior to all other treatments. The lowest plant height (178.4 cm) was recorded under control.

The increase in plant height may be attributed to enhanced nutrient availability, improved root development and greater photosynthetic activity under integrated nutrient management. Poultry manure supplied readily available nutrients and stimulated microbial activity, while higher fertilizer levels ensured continuous nutrient availability throughout the crop growth period. Similar findings were reported by Mahajan *et al.* (2012), Norman *et al.* (2015), Sharma *et al.* (2020) and Ali *et al.* (2022) [1, 12, 14, 18].

Effect on Leaf Area Index: Leaf area index is an important indicator of photosynthetic efficiency and crop growth. The data revealed that LAI increased significantly with integrated nutrient management practices. The highest LAI (5.42) was recorded under T₈, followed by T₁₁ (5.08) and T₇ (5.02), whereas the lowest LAI (3.62) was observed under control.

The improvement in leaf area development under poultry manure treatments may be attributed to balanced nutrient supply and improved physiological activity. Enhanced nitrogen availability promotes chlorophyll formation and leaf expansion, resulting in higher photosynthetic surface area. Similar observations were reported by Meena *et al.* (2018), Prasanna *et al.* (2020) and Kumar *et al.* (2022) [11, 12, 13, 15].

Effect on Dry Matter Accumulation

Dry matter accumulation increased significantly under integrated nutrient management treatments. The highest dry matter accumulation (265.8 g plant⁻¹) was recorded under T₈, followed by T₁₁ (252.4 g plant⁻¹) and T₇ (248.2 g plant⁻¹). The control treatment recorded the lowest dry matter accumulation (168.4 g plant⁻¹).

The superior performance of T₈ may be attributed to greater nutrient uptake, improved photosynthetic efficiency and enhanced assimilate production. Poultry manure improved soil biological activity and nutrient mineralization, thereby ensuring continuous nutrient availability during crop growth. Similar findings were reported by Kannan *et al.* (2013), Reddy *et al.* (2021) and Verma *et al.* (2023) [10, 17, 20].

Effect on Crop Growth Rate

Crop growth rate followed a trend similar to dry matter accumulation. The maximum CGR ($30.8 \text{ g m}^{-2} \text{ day}^{-1}$) was recorded under T_8 , whereas the minimum CGR ($18.6 \text{ g m}^{-2} \text{ day}^{-1}$) was observed under control. Higher crop growth rate under integrated nutrient management may be attributed to improved nutrient availability, greater leaf area development and enhanced photosynthetic efficiency.

Discussion

The results clearly indicate that integrated nutrient management significantly improved growth parameters of maize. Among the various treatments, 125% RDF + Poultry Manure @ 2.5 t ha^{-1} (T_8) proved most effective in enhancing plant height, leaf area index, dry matter accumulation and crop growth rate. The superiority of poultry manure-based treatments may be attributed to their higher nutrient content, rapid mineralization and beneficial effects on soil physical and biological properties. The combined application of inorganic fertilizers and organic manures ensured balanced nutrient availability throughout the crop growth period, resulting

in vigorous vegetative growth and greater biomass accumulation. The findings are in close agreement with those reported by Mahajan *et al.* (2012), Norman *et al.* (2015), Jat *et al.* (2019), Sharma *et al.* (2020), Ali *et al.* (2022) and Verma *et al.* (2023)^[9, 1, 12, 14, 18, 20], who observed significant improvements in growth parameters of maize under integrated nutrient management practices.

Effect of Integrated Nutrient Management Practices on Yield Attributes and Yield of Maize

Yield is the ultimate expression of various physiological, biochemical and metabolic processes occurring within the crop throughout its growth period. Yield attributes play a vital role in determining final productivity because they directly influence grain formation, grain filling and biomass accumulation. Integrated nutrient management improves nutrient availability, photosynthetic efficiency and assimilate translocation, which ultimately enhance yield attributes and grain yield. The data pertaining to yield attributes and yield of maize are presented in Table 2.

Table 2: Effect of Integrated Nutrient Management Practices on Yield Attributes and Yield of Maize

Treatment	Cob Length (cm)	Grains Cob ⁻¹	Test Weight (g)	Grain Yield (q ha ⁻¹)	Stover Yield (q ha ⁻¹)	Biological Yield (q ha ⁻¹)	Harvest Index (%)
T ₁ Control	14.8	356	24.8	42.4	78.6	121.0	35.04
T ₂ 100% RDF	16.4	412	27.2	52.8	88.4	141.2	37.39
T ₃ 75% RDF + VC	17.2	438	28.4	56.2	92.6	148.8	37.77
T ₄ 100% RDF + VC	18.6	486	30.6	62.8	99.4	162.2	38.72
T ₅ 125% RDF + VC	19.4	512	31.8	66.8	103.2	170.0	39.29
T ₆ 75% RDF + PM	18.8	498	31.2	65.2	101.4	166.6	39.13
T ₇ 100% RDF + PM	20.6	548	33.6	72.4	108.8	181.2	39.96
T ₈ 125% RDF + PM	22.2	594	35.4	79.8	116.4	196.2	40.67
T ₉ 75% RDF + Pressmud	18.0	468	29.8	60.4	96.8	157.2	38.42
T ₁₀ 100% RDF + Pressmud	20.2	526	32.4	69.2	105.6	174.8	39.59
T ₁₁ 125% RDF + Pressmud	21.0	566	34.2	75.8	112.6	188.4	40.23
SEm (±)	0.62	16.8	1.12	2.04	3.24	4.82	0.84
CD (P=0.05)	1.80	48.96	3.26	5.94	9.42	14.02	NS

Effect on Cob Length: The data presented in Table 3 revealed that cob length was significantly influenced by integrated nutrient management practices. The maximum cob length (22.2 cm) was recorded under T_8 (125% RDF + Poultry Manure @ 2.5 t ha^{-1}), which was significantly superior to all other treatments. The lowest cob length (14.8 cm) was recorded under control.

The increase in cob length under integrated nutrient management may be attributed to enhanced nutrient availability, improved photosynthetic activity and better translocation of assimilates towards reproductive organs. Poultry manure supplied nutrients continuously throughout crop growth and improved soil biological activity, resulting in superior cob development. Similar findings were reported by Sharma *et al.* (2020), Ali *et al.* (2022) and Verma *et al.* (2023)^[1, 18, 20].

Effect on Number of Grains Cob⁻¹: The number of grains per cob increased significantly with integrated nutrient management. The highest number of grains cob⁻¹ (594) was recorded under T_8 , followed by T_{11} (566) and T_7 (548). The lowest value (356 grains cob⁻¹) was observed under control.

The improvement in grain number may be attributed to better pollination, enhanced nutrient uptake and efficient assimilate partitioning under balanced nutrient supply. Integrated nutrient management improved reproductive growth and reduced grain abortion, resulting in higher grain formation. Similar results were reported by Meena *et al.* (2018), Prasanna *et al.* (2020) and Kumar *et al.* (2022)^[11, 12, 13, 15].

Effect on Test Weight

Test weight is an important indicator of grain development and grain filling efficiency. The maximum test weight (35.4 g) was recorded under T_8 , whereas the minimum value (24.8 g) was recorded under control treatment.

The increase in test weight may be attributed to greater photosynthetic activity and efficient translocation of assimilates towards developing grains. Poultry manure improved nutrient availability during grain filling stages and contributed to better grain development. Similar observations were reported by Reddy *et al.* (2021) and Ali *et al.* (2022)^[1, 17].

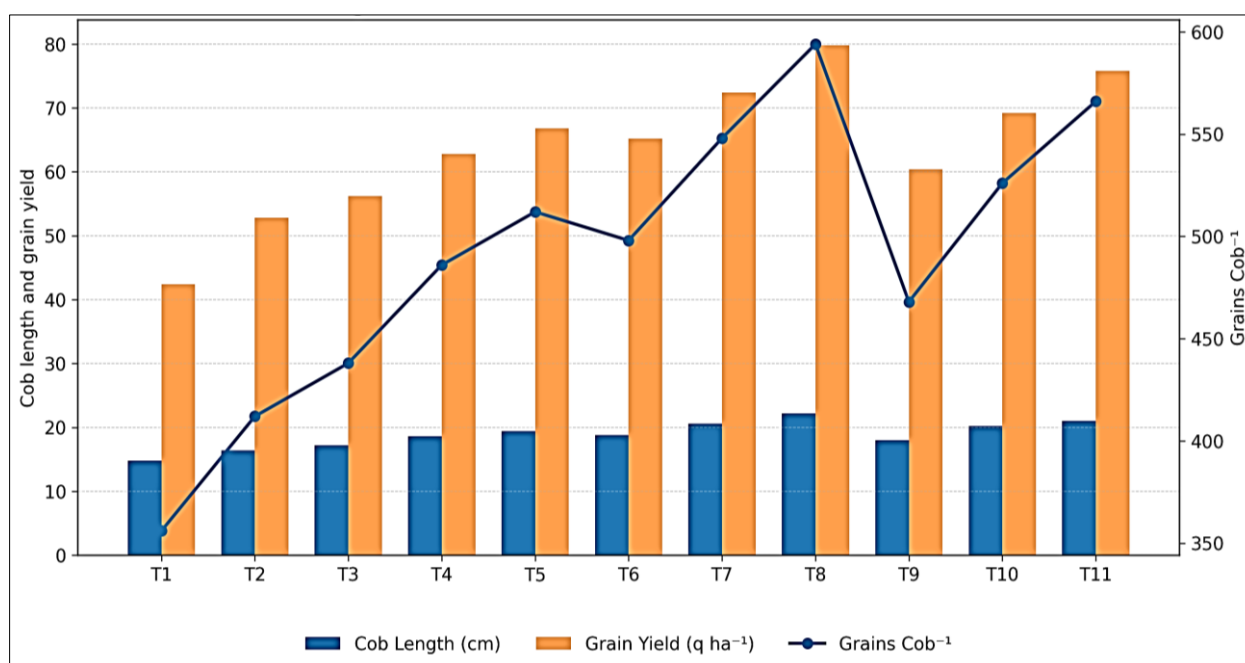


Fig 2: Yield Attributes and Grain Yield of Maize

Effect on Grain Yield

Grain yield is the most important economic parameter and represents the cumulative effect of all growth and yield-contributing characters. Significant differences in grain yield were observed among different treatments.

Among the various treatments, T₈ (125% RDF + Poultry Manure @ 2.5 t ha⁻¹) recorded the highest grain yield (79.8 q ha⁻¹), which was significantly superior to all other treatments. The lowest grain yield (42.4 q ha⁻¹) was recorded under control treatment.

The increase in grain yield under T₈ over control was approximately 88.2 per cent, indicating the remarkable influence of integrated nutrient management on maize productivity. The superior yield may be attributed to higher plant growth, greater leaf area development, increased dry matter accumulation and improved yield attributes under balanced nutrient management.

Poultry manure improved soil fertility, nutrient mineralization and microbial activity, while higher fertilizer levels ensured adequate nutrient availability throughout the crop growth period. Similar findings were reported by Mahajan *et al.* (2012), Sharma *et al.* (2020), Ali *et al.* (2022), Kumar *et al.* (2022) and Verma *et al.* (2023) [1, 11, 12, 18, 20].

Effect on Stover Yield and Biological Yield

Stover yield and biological yield followed trends similar to grain yield. The highest stover yield (116.4 q ha⁻¹) and biological yield (196.2 q ha⁻¹) were recorded under T₈, whereas the lowest values were recorded under control.

The increase in biomass production may be attributed to greater nutrient uptake, improved photosynthetic efficiency and enhanced vegetative growth under integrated nutrient management treatments. Organic nutrient sources improved soil health and nutrient availability, resulting in higher biomass accumulation.

Effect on Harvest Index

Harvest index showed marginal variation among treatments and treatment differences were statistically non-significant. The highest harvest index (40.67%) was recorded under T₈, indicating

efficient conversion of biological yield into economic yield.

The results clearly demonstrated that integrated nutrient management significantly enhanced yield attributes and productivity of maize. Among the various treatments, 125% RDF + Poultry Manure @ 2.5 t ha⁻¹ (T₈) consistently recorded the highest cob length, grains cob⁻¹, test weight, grain yield, stover yield and biological yield. The superiority of poultry manure-based treatments may be attributed to their higher nutrient content, rapid nutrient mineralization and beneficial effects on soil biological activity. The combined application of inorganic fertilizers and poultry manure ensured balanced nutrient availability throughout crop growth stages, resulting in improved source-sink relationship, better grain filling and higher productivity. The findings of the present investigation are in close conformity with those reported by Mahajan *et al.* (2012), Kannan *et al.* (2013), Meena *et al.* (2018), Jat *et al.* (2019), Sharma *et al.* (2020), Ali *et al.* (2022), Kumar *et al.* (2022) and Verma *et al.* (2023) [9, 10], who observed significant improvements in yield attributes and grain yield of maize under integrated nutrient management practices [11, 1, 12, 13, 18, 20].

Effect of Integrated Nutrient Management Practices on Nutrient Uptake, Soil Fertility Status and Economics of Maize

Efficient nutrient uptake is essential for achieving higher crop productivity and maintaining soil fertility. Integrated nutrient management practices improve nutrient availability, root development and nutrient-use efficiency, thereby enhancing nutrient uptake by crops. Organic manures not only supply nutrients but also improve soil physical, chemical and biological properties, resulting in better nutrient absorption and utilization. The combined use of organic and inorganic nutrient sources also contributes to the maintenance of soil fertility after crop harvest. In addition, the economic viability of nutrient management practices is an important consideration for their adoption by farmers. Therefore, nutrient uptake, post-harvest soil fertility status and economics were evaluated under different integrated nutrient management treatments.

Table 3: Effect of Integrated Nutrient Management Practices on Nutrient Uptake and Soil Fertility Status of Maize

Treatment	N Uptake (kg ha ⁻¹)	P Uptake (kg ha ⁻¹)	K Uptake (kg ha ⁻¹)	Organic Carbon (%)	Available N (kg ha ⁻¹)	Available P (kg ha ⁻¹)	Available K (kg ha ⁻¹)
T ₁ Control	84.6	18.4	72.6	0.36	158.2	7.2	182.4
T ₂ 100% RDF	108.4	24.2	96.8	0.38	172.4	9.4	194.6
T ₃ 75% RDF + VC	116.8	26.4	102.2	0.42	178.8	10.6	198.8
T ₄ 100% RDF + VC	128.6	29.8	114.6	0.46	186.2	11.8	205.4
T ₅ 125% RDF + VC	136.4	32.6	122.8	0.49	192.4	12.8	211.8
T ₆ 75% RDF + PM	132.8	31.6	120.4	0.48	189.6	12.4	209.2
T ₇ 100% RDF + PM	145.6	35.2	132.8	0.52	198.4	13.8	218.4
T ₈ 125% RDF + PM	158.4	38.8	145.6	0.56	208.6	15.2	228.6
T ₉ 75% RDF + Pressmud	122.6	28.4	108.2	0.44	182.6	11.2	202.8
T ₁₀ 100% RDF + Pressmud	140.2	33.8	126.4	0.50	194.2	13.2	214.2
T ₁₁ 125% RDF + Pressmud	151.8	37.2	139.8	0.54	204.6	14.8	224.4
SEm (±)	4.26	1.12	3.84	0.02	5.42	0.54	6.28
CD (P=0.05)	12.40	3.26	11.18	0.06	15.78	1.58	18.28

Effect on Nutrient Uptake

The data presented in Table 4 revealed that integrated nutrient management significantly influenced nitrogen, phosphorus and potassium uptake by maize. Among all treatments, T₈ (125% RDF + Poultry Manure @ 2.5 t ha⁻¹) recorded the highest nitrogen uptake (158.4 kg ha⁻¹), phosphorus uptake (38.8 kg ha⁻¹) and potassium uptake (145.6 kg ha⁻¹), whereas the lowest nutrient uptake was observed under control treatment. The higher nutrient uptake under T₈ may be attributed to enhanced root growth, improved nutrient availability and greater biomass production. Poultry manure supplied nutrients gradually and

improved microbial activity, which enhanced nutrient mineralization and nutrient absorption by crop plants. Similar findings were reported by Sharma *et al.* (2020), Ali *et al.* (2022) and Kumar *et al.* (2023) [11, 1, 18].

Effect on Soil Fertility Status

Post-harvest soil analysis revealed significant improvement in soil fertility status under integrated nutrient management treatments. The highest organic carbon content (0.56%), available nitrogen (208.6 kg ha⁻¹), available phosphorus (15.2 kg ha⁻¹) and available potassium (228.6 kg ha⁻¹) were recorded under T₈.

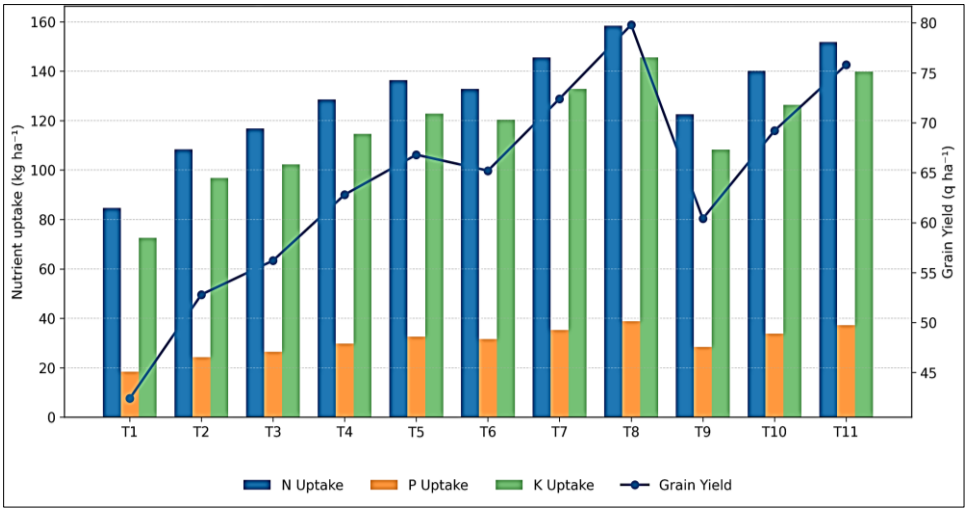


Fig 3: Nutrient Uptake and Grain Yield Relationship

The increase in soil fertility parameters may be attributed to the addition of organic matter through poultry manure, which improved nutrient retention, microbial activity and nutrient cycling in soil. Organic amendments also reduced nutrient losses

and enhanced nutrient availability. Similar observations were reported by Jat *et al.* (2019), Verma *et al.* (2023) and Meena *et al.* (2024) [9, 13, 20].

Table 4: Effect of Integrated Nutrient Management Practices on Economics of Maize

Treatment	Cost of Cultivation (₹ ha ⁻¹)	Gross Return (₹ ha ⁻¹)	Net Return (₹ ha ⁻¹)	B:C Ratio
T ₁ Control	48,200	84,800	36,600	1.76
T ₂ 100% RDF	54,600	1,05,600	51,000	1.92
T ₃ 75% RDF + VC	58,400	1,12,400	54,000	1.92
T ₄ 100% RDF + VC	61,200	1,25,600	64,400	2.05
T ₅ 125% RDF + VC	64,800	1,33,600	68,800	2.06
T ₆ 75% RDF + PM	59,600	1,30,400	70,800	2.19
T ₇ 100% RDF + PM	62,800	1,44,800	82,000	2.31

T ₈ 125% RDF + PM	66,200	1,59,600	93,400	2.41
T ₉ 75% RDF + Pressmud	60,400	1,20,800	60,400	2.00
T ₁₀ 100% RDF + Pressmud	63,400	1,38,400	75,000	2.18
T ₁₁ 125% RDF + Pressmud	66,800	1,51,600	84,800	2.27

Effect on Economics

Economic analysis revealed that integrated nutrient management significantly influenced profitability of maize cultivation. Among

all treatments, T₈ (125% RDF + Poultry Manure @ 2.5 t ha⁻¹) recorded the highest gross return (₹1,59,600 ha⁻¹), net return (₹93,400 ha⁻¹) and benefit-cost ratio (2.41).



Fig 4: Economic Performance of Maize under INM Treatments

Although poultry manure treatments involved slightly higher cultivation costs, the substantial increase in grain and stover yield compensated for the additional investment and generated significantly higher returns. The control treatment recorded the lowest gross return, net return and benefit-cost ratio owing to poor crop growth and lower productivity.

The superior profitability under T₈ may be attributed to enhanced nutrient availability, higher nutrient uptake, improved yield attributes and greater grain yield. Similar findings were reported by Sharma *et al.* (2020), Ali *et al.* (2022), Kumar *et al.* (2023) and Verma *et al.* (2024)^[1, 18, 20].

Discussion

The present investigation clearly demonstrated that integrated nutrient management significantly improved nutrient uptake, soil fertility status and economics of maize cultivation. The treatment receiving 125% RDF + Poultry Manure @ 2.5 t ha⁻¹ (T₈) consistently recorded the highest nutrient uptake, improved soil fertility parameters and maximum profitability.

The beneficial effect of poultry manure may be attributed to its higher nutrient content, rapid mineralization, improvement in soil biological activity and enhancement of nutrient-use efficiency. The combined application of organic and inorganic nutrient sources ensured continuous nutrient availability throughout crop growth stages and improved soil health after harvest. The findings of the present study corroborate the reports of Mahajan *et al.* (2012), Jat *et al.* (2019), Sharma *et al.* (2020), Ali *et al.* (2022), Kumar *et al.* (2023) and Verma *et al.* (2024)^[9, 1, 12, 18, 20], who reported significant improvements in nutrient uptake, soil fertility and profitability of maize under integrated nutrient management practices.

Conclusion: The present investigation revealed that integrated nutrient management practices significantly influenced growth, yield attributes, yield, nutrient uptake, soil fertility status and

economics of maize. Among the various treatments, application of 125% RDF + Poultry Manure @ 2.5 t ha⁻¹ (T₈) proved superior by recording the highest plant height, leaf area index, dry matter accumulation, grain yield (79.8 q ha⁻¹), nutrient uptake and profitability.

The treatment also recorded the highest gross return (₹1,59,600 ha⁻¹), net return (₹93,400 ha⁻¹) and benefit-cost ratio (2.41). Improvement in crop performance under this treatment may be attributed to balanced nutrient availability, enhanced nutrient-use efficiency, improved soil health and greater assimilate translocation.

Therefore, application of 125% RDF integrated with Poultry Manure @ 2.5 t ha⁻¹ may be recommended for achieving higher productivity, profitability and sustainability of maize cultivation under the agro-climatic conditions of Central Uttar Pradesh.

Recommendation: Based on the findings of the present investigation, it may be recommended that application of 125% RDF + Poultry Manure @ 2.5 t ha⁻¹ (T₈) should be adopted for maize cultivation under the agro-climatic conditions of Central Uttar Pradesh for obtaining higher productivity, profitability and improved soil fertility. The treatment produced the highest grain yield, nutrient uptake, economic returns and benefit-cost ratio compared with other nutrient management practices.

Integrated use of organic manures and inorganic fertilizers not only enhanced crop productivity but also improved soil organic carbon and available nutrient status, thereby contributing towards sustainable crop production. Therefore, integrated nutrient management involving poultry manure and chemical fertilizers may be considered an efficient and environmentally sound nutrient management strategy for maize cultivation.

Further research may be undertaken to evaluate long-term effects of integrated nutrient management on soil health, nutrient dynamics and sustainability of maize-based cropping systems under different agro-climatic regions.

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