



Optimizing Maize Yield and Nutrient Dynamics Through Integrated Nutrient Management in CP 858 Hybrid under Warangal Region of Telangana

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ABSTRACT

Background: Sustainable maize (*Zea mays* L.) production demands nutrient management strategies that not only boost crop production but also maintain the soil health. Integrated nutrient management (INM), combining both organic and inorganic nutrient sources, plays a vital role in achieving these goals.

Methods: A field experiment was conducted during the both *Kharif* (2024) and *Rabi* (2024-2025) seasons at Experimental Farm of School of Agriculture, SR University, Warangal, Telangana, India. The study was conducted in a Randomized Block Design (RBD) with three replications and eight treatments viz: T₁- Control, T₂- 100% RDF, T₃- 100% RDF + vermicompost @ 5 t ha⁻¹, T₄- 100% RDF + poultry manure @ 2.5 t ha⁻¹, T₅- 100% RDF + pressmud @ 12.5 t ha⁻¹, T₆- 75% RDF + vermicompost @ 5 t ha⁻¹, T₇- 75% RDF + poultry manure @ 2.5 t ha⁻¹ and T₈- 75% RDF + pressmud @ 12.5 t ha⁻¹.

Result: Among the INM treatments, 100% RDF combined with poultry manure at 2.5 t ha⁻¹, proved to be the greatest effective in significantly enhancing the growth parameters and physiological indices, including crop growth rate (CGR), absolute growth rate (AGR) and relative growth rate (RGR). This integrated nutrient management approach also led to improved nutrient uptake, superior yield attributes and recorded the highest grain yield (7201.6 kg ha⁻¹) and stover yield (13,201.1 kg ha⁻¹). Moreover, it exhibited the highest nitrogen efficiency ratio (211.2 kilogram grain kg⁻¹ N) and economic nitrogen use efficiency (2.2 kilogram grain ⁻¹).

Key words: Integrated nutrient management, Maize productivity, Organic amendments, Poultry manure, Soil fertility.

INTRODUCTION

One of the most versatile growing crops, maize (*Zea mays* L.) can flourish in a wide variety of agro climatic situations. The maize crop known as “Queen of Cereals” due to its high potential for hereditary production and necessities in the globally. The world’s maize production is expected to rise from 122.33 mt in 2023-24 to 122.58 mt in 2024-25. According to India, *Rabi* maize has been sown in area around 23.72 lakh ha as on date 2nd February 2024 and noticed that it is higher than 23.00 lakh ha covered during corresponding period of last year. In Telangana maize grown predominantly during the *Kharif* season and to a lesser extent, during the *Rabi* season. The estimated maize production in Telangana for 2023-24 is 24.78 lakh tonnes, it is reflecting the importance of the crop in the state’s agricultural ecosystem. However, the production of maize is heavily reliant on its nutrient management system because it is known to be an intensive crop with a high nutritional requirement. Chemical fertilizers can change the pH of the soil, interfere with the ecology of beneficial microbes, increase insect populations and perhaps contribute to greenhouse gas emissions (Kong *et al.*, 2022).

To achieve sustained production, profitability and soil health, the use of inorganic fertilizers must be limited and supplemented with organic manures, such as FYM, composted chicken manure, pressmud, vermicompost and biofertilizers. To attain good soil health, profitability and

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sustainable output by conserving soil fertility and crop productivity through the integrated nutrient management (INM). Poor fertilizer management causes the low crop output. Hence, utilization of organic sources including FYM, vermicompost, poultry manures, biofertilizer, along with inorganic fertilizer enhanced the nutrients uptake and maximize crop output. One of the most important factors affecting the growth and yield of maize crops is fertilizer management (Adhikary *et al.*, 2020). The precise and combine use of the both organic and inorganic fertilizers in the crop fields to enhancing soil health and meet the nutritional requirement of crop is known as integrated nutrient management. Integrated nutrient management is one of the techniques to address the issues including declining soil fertility and output and rising inorganic

fertilizer costs. Poultry manure enhances maize growth by enriching soil with the essential nutrients and organic matter, which promotes early growth and strong root development.

Poultry manure also provides a slow-release source of macro-nutrients (OC, nitrogen, phosphorus, potassium) and micro-nutrients which acts as a soil amendment. It improves soil structure, water retention and pH balance, increasing maize's resistance to drought and stress. Its sustainable use reduces dependency on chemical fertilizers, supporting long-term soil health and higher yields. Vermicompost is an environmentally beneficial organic waste by the product of a composting process using earthworms that is converted into organic fertilizer for use in farming and to enhance soil health. Pressmud is a residual by-product of sugarcane industry, is a valuable organic amendment in maize cultivation. It is crucial to use less chemical fertilizer and to balance it with organic manure. Organic manures helps in preserving soil health and achieve long-term profitability and productivity, it enhances soil fertility, promotes healthy root development, improves water retention and increases crop yield while reducing the need for synthetic fertilizers in sustainable farming practices. Hence the present research is to formulate INM practices by combining both inorganic fertilizers and organic manures, which are safe to environment and economical.

MATERIALS AND METHODS

Research field experiment was conducted at the Experimental farm, School of Agriculture, SR University, Warangal during both *Kharif* and *Rabi* season 2024-2025 (18.08°N Latitude, 79.47°E Longitude and 266 MSL). It is Central Telangana Agro Climatic zone of India. Weather of this region during *Kharif* (July to October) experiences the monsoon season, with substantial rainfall and during *Rabi* (October to February) characterized by moderate to heavy precipitation, essential for agricultural activities in the area. The average rainfall during this time contributes significantly to the region's annual total of approximately 550 mm. The temperature during the *Kharif* season usually ranged between (24°C to 34°C), accompanied by relative humidity of 75%. The temperatures during the *Rabi* season usually ranges between (22°C to 33°C), accompanied by high RH of 85%.

This experiment was conducted with eight treatments which laid out in a RBD design with 3 replications (Table 1). Maize hybrid CP 858 is used for study, with a spacing of 40 cm × 25 cm. The sowing was done in July in a plot size of 5 m × 4 m. The RDF was applied for specific treatments through urea, SSP, MOP, vermicompost, poultry manure and pressmud. The crop production guidance was adhered to in terms of crop protection measures and other agronomic techniques.

Plant biometric observations was recorded at 30, 60 DAS and at harvest. LAI estimated at the flowering stage. Dry matter production was recorded by collecting random five plant samples and expressed in t ha⁻¹. Number of leaves

per plant, tasselling and silking data was recorded at 60th and 70th day of flowering. Number of rows/cob, number of kernels/rows, cob length, cob diameter, ear height was recorded at harvest. The matured crop was harvested and cobs were cleaned and dried at 14% moisture level, then yield was recorded, computed as kg ha⁻¹. The stover was sun dried and expressed in kg ha⁻¹. Additionally, to evaluate the nutrient dynamics and utilization efficiency the following various efficiency indices and index were calculated using standard agronomic formulas.

a. Nutrient uptake:

Nitrogen uptake (kg ha⁻¹) =

$$\frac{\text{Per cent nutrient content in grain or straw} \times \text{yield (kg ha}^{-1}\text{)}}{100}$$

b. Nutrient efficiency ratio:

$$\text{Nitrogen efficiency ratio (NER)} = \frac{\text{BY}}{\text{NU}}$$

Where,

BY = Biological yield.

NU = Nutrient uptake.

c. Economic nutrient use efficiency:

Economic nutrient use efficiency: ENUE (kg/`) =

$$\frac{\text{Grain or economic yield (kg/ha)}}{\text{Amount invested on the nutrient (kg/`)}}$$

d. Crop growth rate-CGR:

$$\text{CGR (g m}^{-2} \text{ day}^{-1}\text{)} = \frac{W_2 - W_1}{(t_2 - t_1)S}$$

Where,

W₁ and W₂ = Plant dry weight (g) at time of t₁ and t₂.

S: Land area (m²) = Over which dry matter was recorded.

e. Absolute growth rate-AGR:

$$\text{AGR (g plant}^{-1} \text{ day}^{-1}\text{)} = \frac{W_2 - W_1}{(t_2 - t_1)}$$

Where,

W₂ and W₁ = The total dry weights per plant at time t₂ and t₁.

t₂-t₁ = Time interval (days).

f. Relative growth rate-RGR:

$$\text{RGR (g g}^{-1} \text{ day}^{-1}\text{)} = \frac{\ln W_2 - \ln W_1}{(t_2 - t_1)}$$

Where,

W₁ and W₂ = Plant dry weight at time t₁ and t₂.

t₂-t₁ = Time interval (days).

The experimental data were analysed using ANOVA at 5% significance level and Critical Difference (CD) value was calculated at a (p≤0.05) to compare treatment means.

RESULTS AND DISCUSSION

Growth parameters

The plant height, leaf area index, DMP and number of leaves/plant showed a significant change between the treatments in the pooled data (Table 1). The highest plant height of 191.1 cm, leaf area index of 4.8, DMP of 232.15, 541.85, 1659.1 g m⁻² at 30, 60 and at harvest and 14.8 leaves per plant were noted along with the application of 100% RDF+ poultry manure @ 2.5 t ha⁻¹ (T₄). Whereas the control plot had the lowest plant height of 152.9 cm, LAI of 2.8, DMP of 388.0, 412.3, 1302.8 g m⁻² at 30, 60 and at harvest and 9.2 leaves per plant, respectively. The combined application of composted poultry manure and inorganic fertilizers enhanced nutrient uptake and availability, promoting better root and vegetative growth, resulting in increased plant height (Khushboo and Nirmali, 2024). Composted poultry manure and vermicompost, rich in primary and secondary nutrients, improved soil structure, facilitating root development. Similarly, higher leaf area index (LAI) observed with integrated nutrient management (INM) was due to enhanced nutrient availability, contributing to better leaf development and increased photosynthetic potential (Jinjala *et al.*, 2016). The gradual nutrient release from poultry manure and vermicompost supported continuous nutrient supply throughout the crop growth stages, improving dry matter production. Furthermore, the increased number of leaves per plant was connect to the nutrient-rich and soil-enhancing properties of organic amendments, which improved microbial activity, water retention and overall plant vigour, resulting in enhanced leaf development and crop growth.

Yield parameters

The pooled data of various treatments of nutrient application were significantly influenced the number of days to tasselling, silking, ear height, number of rows/cob, number of kernels/row, cob length, diameter, grain and stover yield of maize (Table 1 and 2). The application of 100 % RDF+ poultry manure @ 2.5 t ha⁻¹ (T₄) recorded the more days to tasselling (73.7), silking (76.4), highest ear height of (148.8), number of rows/cob (18.7), number of kernels/row (42.2), cob length (20.1 cm) and cob diameter (6.2 cm). The least days to tasselling (51.3), silking (56.2), lowest ear height of 123.3, number of rows/cob (14.6) and number of kernels/row (23.7), least cob length (15.8 cm), cob diameter (5.4 cm), lowest grain yield and stover yield of 1851.2 kg ha⁻¹ and 4288.7 kg ha⁻¹, respectively were noted in the non-fertilized plot (T₁). The combined application of poultry manure, vermicompost and inorganic fertilizers significantly improves soil fertility and provides a continuous supply of essential nutrients, enhancing maize reproductive growth and development. Poultry manure, rich in N, P and K, plays a key role in regulating hormones linked to flowering, with nitrogen being vital for enzymes and proteins involved in cell division, improving plant vigour and delaying tasselling for better synchronization with silking (Kalyanasundaram

and Augustine, 2021). Vermicompost boosts microbial activity, promoting nutrient mineralization and utilization, which supports reproductive development. The enhanced microbial biomass from organic inputs increases phytohormone production like cytokinin and auxin, critical for flowering and silk formation (Oyege and Balaji, 2024). Balanced nutrition from these sources enhances ear and grain development. A notable improvement in cob size in treatment T₄ (100% RDF + poultry manure @ 2.5 t ha⁻¹) is attributed to increased nutrient availability, particularly nitrogen. Grain yield improved significantly due to better root development, nutrient uptake and reproductive traits (Ram *et al.*, 2023), while the control plot showed the lowest yield. Enhanced biomass from integrated nutrient sources was also observed due to improved soil health and nutrient availability.

Physiological growth indices

Regarding the nutrient uptake the significant impact was showed in the pooled data by the various nutrient management methods. The highest NPK uptake of 96.6 N, 15.8 P, 27.5 K kg ha⁻¹, nutrient efficiency ratio of nitrogen of 211.2 kg/kg, economic nitrogen use efficiency of 2.2 kg/°, CGR (10.12 and 32.10 g/m²/day), AGR (1.02, 3.21 g/plant/day), RGR (0.028, 0.034 g/g/day at 30-60 and 60-90 days, respectively was noted in the treatment-T₄. The lowest uptake of NPK was observed in control plot (T₁) with 34.0, 4.1 and 7.2 NPK kg ha⁻¹, least NER of 180.9 kg/kg, ENUE of 0.6 kg/°, lowest CGR (7.68 and 22.17 g/m²/day), AGR (0.77, 2.22 g/plant/day), RGR (0.027, 0.032 g/g/day at 30-60 and 60-90 days, respectively. Poultry manure is abundant in nutrients that enhances soil fertility and promotes nutrient uptake in crops. Maize plants absorb and utilize nitrogen more efficiently when poultry manure is applied. This improvement may be attributed to the manure's gradual nutrient release, which aligns more closely with the crop's nutrient demand and improved root growth resulting from better soil structure. Abid *et al.* (2020) further supported this finding, stating that combining recommended doses of fertilizers (RDF) with poultry manure maximizes crop yield and nutrient use efficiency through integrated nutrient management. INM capitalizes on the complementary benefits of organic and inorganic inputs, where organic manure enhances soil properties and nutrient retention, while inorganic fertilizers supply readily available nutrients. The organic content in poultry manure lowers nutrient losses through leaching or volatilization, increasing fertilizer usage efficiency and lessening environmental effect. Wang *et al.* (2024) highlighted that poultry manure is also rich in micronutrients, phosphorus, potassium and calcium, which collectively improve crop nutrient status and enhance nitrogen use efficiency. A high CGR signifies strong yield potential. Increased AGR under poultry manure and vermicompost + 100% RDF may result from enhanced soil fertility and moisture retention, ensuring consistent nutrient availability throughout growth stages. Plants with early biomass accumulation maintain high absolute growth

Table 1: Effect of various nutrient management practices on plant height (cm), LAI and DMP (g m^{-2}), number of leaves per plant, days to tasselling, silking, ear height (cm), number of rows per cob, kernels per row, cob length and diameter (cm) of maize (CP 858). (Pooled data of *Kharif* and *Rabi*).

Treatments	Plant height (cm)	LAI	Dry matter production (g m^{-2})			Number of leaves/plant	Number of days to tasselling	Number of days to silking	Ear height (cm)	Number of rows/cob	Number of kernels/row	Cob length (cm)	Cob diameter (cm)
	60 DAS	60 DAS	30 DAS	60 DAS	At harvest								
T ₁ - Control	152.9	2.8	182.05	412.3	1302.8	9.2	51.30	56.2	123.3	14.6	23.7	15.8	5.4
T ₂ - RDF 100%	182.5	3.9	219.95	491.2	1473.05	13.9	69.10	72.3	143.1	17.6	38.5	19.7	5.9
T ₃ -RDF100%+ vermicompost @ 5 t ha ⁻¹	184.8	4.4	223.9	502	1558.5	14.3	71.60	74.6	146.3	18.2	40.4	19.9	6.0
T ₄ -RDF100%+ poultry manure @ 2.5 t ha ⁻¹	191.1	4.8	232.15	541.85	1659.1	14.8	73.70	76.4	148.8	18.7	42.2	20.1	6.2
T ₅ -RDF100%+ pressmud @ 12.5 t ha ⁻¹	177.3	3.7	212.3	479.85	1505.45	13.6	65.30	68.4	140.7	17.3	35.9	19.6	5.8
T ₆ -RDF75%+ vermicompost @ 5 t ha ⁻¹	171.2	3.2	197.65	456.65	1381.15	12.6	61.80	65.5	133.1	16.5	31.7	18.9	5.6
T ₇ -RDF 75%+ poultry manure @ 2.5 t ha ⁻¹	173.9	3.6	203.5	466.25	1409.6	13.1	62.60	67.1	137.5	16.8	34.5	19.3	5.7
T ₈ -RDF75%+ pressmud @ 12.5 t ha ⁻¹	167.3	2.9	194.05	441.9	1328.8	11.4	58.90	62.2	129.1	15.2	27.2	18.1	5.5
S. Em±	3.70	0.09	3.09	9.06	21.43	0.27	1.17	1.76	2.67	0.36	0.55	0.34	0.07
CD (P = 0.05)	7.93	0.19	6.63	19.44	45.97	0.59	2.52	3.78	5.74	0.78	1.18	0.73	0.15

Table 2: Effect of various nutrient management practices on grain, stover yield (kg ha⁻¹), nutrient uptake (kg ha⁻¹), nitrogen efficiency ratio (kg/kg) and Economic nitrogen use efficiency (kg grain/Rs.), CGR (g/m²/day), AGR (g/plant/day) and RGR (g/g/day) of maize (CP 858). (Pooled data of *Kharif* and *Rabi*).

Treatments	Grain yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	Nutrient uptake (kg ha ⁻¹)			Nitrogen efficiency ratio (kg/kg)	Economic nitrogen use efficiency (kg grain/Rs.)	CGR (g/m ² /day)			AGR (g/plant/day)			RGR (g/g/day)		
			Nitrogen	Phosphorus	Potassium			30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS	
T ₁ - Control	1851.2	4288.7	34.0	4.1	7.2	180.9	0.6	7.68	22.17	0.77	2.22	0.027	0.032			
T ₂ - RDF 100%	5585.7	9502.2	73.8	12.2	21.1	204.4	1.7	9.04	27.38	0.90	2.74	0.027	0.033			
T ₃ - RDF100%+ vermicompost @ 5 t ha ⁻¹	6370.4	11280.8	85.1	13.9	23.9	207.4	2.0	9.27	29.87	0.93	2.99	0.027	0.034			
T ₄ - RDF100%+ poultry manure @ 2.5 t ha ⁻¹	7201.6	13201.1	96.6	15.8	27.5	211.2	2.2	10.12	32.10	1.02	3.21	0.028	0.034			
T ₅ - RDF100%+ pressmud @ 12.5 t ha ⁻¹	4890.45	8320.4	64.55	10.7	18.7	204.7	1.5	8.92	28.84	0.89	2.88	0.027	0.034			
T ₆ - RDF75%+ vermicompost @ 5 t ha ⁻¹	4100.7	7119.5	55.8	8.9	15.6	201.1	1.3	8.63	25.47	0.86	2.55	0.028	0.033			
T ₇ - RDF 75%+ poultry manure @ 2.5 t ha ⁻¹	4220.8	7342.4	57.4	9.2	16.0	201.4	1.3	8.76	26.10	0.88	2.61	0.028	0.033			
T ₈ - RDF75%+ pressmud @ 12.5 t ha ⁻¹	3875.8	6587.8	52.8	8.6	14.8	198.2	1.2	8.26	24.38	0.83	2.44	0.027	0.033			
S. Em±	105.86	235.76	1.87	0.26	0.33	5.27	0.03	0.16	0.65	0.01	0.05	0.0005	0.0006			
CD (P = 0.05)	227.06	505.66	3.95	0.58	0.68	11.07	0.06	0.34	1.30	0.04	0.11	0.0011	0.0012			

despite lower relative growth rates (RGR) between 30-60 DAS. Lichaom *et al.* (2024) also noted that poultry manure-inclusive INM promotes higher RGR during reproductive phases.

CONCLUSION

The results of the experimental study confirmed that integrated nutrient management (INM) significantly improves maize productivity, nutrient uptake and nutrient use efficiencies compared to sole application of inorganic fertilizers. Among all the treatments that have been tried, the combination of 100% RDF with poultry manure @ 2.5 t ha⁻¹ consistently outperformed others by enhancing key growth and yield attributes, maximizing grain yield and improving nutrient uptake and nitrogen use efficiency, hence it offers a sustainable and economically viable nutrient management strategy for improving maize productivity and soil health under semi-arid conditions of Telangana region.

Conflict of interest

The authors have no conflicts of interest to declare. The co-author has seen and agree with the contents of the manuscript and there is no financial interest to report.

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