JOURNAL OF APPLIED BIOANALYSIS, December 2025 p. 652-655
http://doi.org/10.53555/jab.v11si11.1590 (ISSN 2405-710X)
Vol. 11, No. 11s

OPEN ACCESS

# Effect of Integrated Nutrient Management (INM) on Quality of Maize (*Zea mays* L.)

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**Abstract**

**A field experiment was conducted to evaluate the effect of integrated nutrient management (INM) on quality of maize. The study was carried out at the agronomy research farm of IFTM University, Moradabad, Uttar Pradesh, India during the *kharif* season of 2023 and 2024. Twelve treatments comprising varying combinations of recommended doses of fertilizers with organic sources such as biogas slurry, vermicompost, farmyard manure, poultry manure, and green manuring with *Sesbania spp.* were evaluated in randomized block design (RBD) and replicated thrice. Maize variety *VHM-53* was planted with 50 × 20 cm spacing. The soil of experimental field was clay loam. Recommended dose of fertilizers (RDF) was used @ 120: 60: 40 kg/ha. Results revealed that different levels of nutrients and organic manures significantly improved the quality parameters (protein content and protein yield) of maize. Highest protein content (12.24%) in grain as well as protein yield (647.59 kg ha$^{-1}$) was recorded under $T_9$ (75 % RDF + 25 % N through Poultry manure) which was significantly higher over rest of the treatments.**

***Keywords:*** *INM, Maize, Protein content, Protein Yield*

## INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops worldwide and serves as a staple food for a large proportion of the global population (Dagar *et al.,* 2022). In addition to its role inhuman food, maize is a vital source of fuel and a key raw material for several industries, including those producing food sweeteners, alcoholic beverages, protein products, oil, and starch. Owing to its wider adaptability, maize is successfully cultivated under diverse agro-climatic conditions across the world (Hartkamp, 2001; Amanullah *et al.,* 2007). The crop also plays a crucial role in livestock and poultry nutrition, constituting a major component of poultry feed formulations (Naveenkumar *et al.,* 2018).

Globally, maize ranks as the leading cereal crop in terms of total annual production and is the only crop with an annual production exceeding one billion tonnes, estimated at approximately 1.135 billion tonnes (FAOSTAT, 2019). In India, maize occupies about 9.18 million hectares with an average production of 27.23 million tonnes and a productivity level of 2,965 kg ha$^{-1}$, contributing nearly 10.46% to the national food basket (Agricultural Statistics, 2019). Nutritionally, maize is a rich source of energy, containing about 66.3% carbohydrates, 11.1% protein, 3.6% fat, 2.7% fiber, and 1.5% minerals such as calcium, phosphorus, and iron, along with essential vitamins including A, B, and E (Joshi *et al.,* 2017).

Integrated nutrient management (INM) refers to nutrient management systems designed to maintain and enhance soil fertility while sustaining crop productivity. These systems emphasize the combined use of chemical fertilizers and organic manures, which are biologically derived inputs rich in essential nutrients. The integrated application of organic and inorganic nutrient sources has been shown to improve the physico-chemical properties of soil, enhance nutrient availability, and ultimately increase crop productivity (Sharma *et al.,* 2020). Maize, in particular, requires higher amounts of nitrogen and phosphorus compared to other essential nutrients for optimal growth and development throughout its growth stages. Adequate and balanced nutrient supply is therefore essential to maintain soil fertility and achieve higher

yields. Several studies have demonstrated that the balanced integration of organic and inorganic fertilizers significantly improves soil fertility and maize productivity (Almaz *et al.,* 2017a). Furthermore, the incorporation of farmyard manure has been reported to enhance phosphorus availability in the soil, thereby contributing to improved nutrient uptake and crop performance (Hussain *et al.,* 2008).

The combined application of inorganic fertilizers with varying quantities of organic manures from different sources significantly enhances maize yield, nutrient uptake, and soil nutrient status in maize-based cropping systems (Almaz *et al.,* 2017b). After sugarcane, maize is considered one of the most exhaustive crops, requiring both macro and micro-nutrients to realize its full growth and yield potential. Organic manures not only supply essential nutrients but also play a crucial role in maintaining and improving soil health. Integrated nutrient management involves the judicious use of organic and inorganic nutrient sources to sustain soil productivity and crop yields (Bhandari *et al.,* 2021). The adoption of INM practices can address issues related to rising fertilizer costs while maintaining soil fertility and productivity through balanced nutrient application (Sindhi *et al.,* 2018). In view of the above considerations, the present experiment was conducted to assess the effect of the recommended dose of fertilizers in combination with organic manures on the growth and productivity of maize.

## MATERIALS AND METHODS

A field experiment was conducted during the *kharif* seasons of 2023 and 2024 at the Agronomy Research Farm of IFTM University, Moradabad, Uttar Pradesh, India. The experimental site is located between 28°16' to 28°21' N latitude and 78°04' to 79°00' E longitude at an altitude of 193 m above mean sea level. The soil of the experimental field was clay loam in texture and slightly alkaline in reaction. Prior to sowing, the soil had a pH of 8.0, electrical conductivity of 1.03 dS $m^{-1}$, organic carbon content of 0.62%, available nitrogen of 274.56 kg $ha^{-1}$, available phosphorus of 18.27 kg $ha^{-1}$, and available potassium of 318.83 kg $ha^{-1}$. The region experiences a sub-tropical, semi-arid climate characterized by hot and dry in summers and cold in winters.

The experiment consisted of 12 treatments, *viz.* $T_1$ - RDF (120: 60: 40 kg NPK), $T_2$ - 50% RDF + 50% N through Biogas slurry, $T_3$ - 50% RDF + 50% N through Vermicompost, $T_4$ - 50% RDF + 50% N through FYM, $T_5$ - 50% RDF + 50% N through Poultry manure, $T_6$ - 75% RDF + 25% N through Biogas slurry, $T_7$ - 75% RDF + 25% N through Vermicompost, $T_8$ - 75% RDF + 25% N through FYM, $T_9$ - 75% RDF + 25% N through Poultry manure, $T_{10}$ - 50% RDF + Green manuring with *Sasbania spp.,* $T_{11}$ - 75% RDF + Green manuring with *Sasbania spp.* and $T_{12}$ - 100% RDF + Green manuring with *Sasbania spp.* The treatments were laid out in a randomized block design with three replications. Maize cultivar *VHM-53* was used as the test crop. The crop was sown during the first fortnight of July in both experimental years; using a spacing of 50 cm × 20 cm. Organic manures were incorporated into the soil one month prior to sowing as per treatment specifications, while green manure was incorporated at 45 days after sowing using a weeder. All other agronomic practices were uniformly maintained across treatments.

The NPK, biogas slurry, vermicompost, FYM, poultry manure and green manuring were applied as per the treatment requirements. The sources of NPK taken were urea, diammonium phosphate and muriate of potash. Maize was sown in first fortnight of July in both of the experimental years. Data on various plant growth and yield attributes were statistically analyzed following the procedures described by Gomez and Gomez (1984). Treatment means were compared using the least significant difference (LSD) test at the 5% level of significance. Statistical analysis was performed using OPSTAT software (Sheoran *et al.,* 1998).

## RESULTS AND DISCUSSION

### Protein content in grain (%)

Integrated use of inorganic fertilizers (75% RDF) and poultry manure (25 % N through PM) significantly improved the nutritional quality maize grain by enhancing protein level over the rest treatments in both the years as well as in pooled analysis (Table 1). Nitrogen is an indispensable component of protein, therefore increased grain N content synthesis large amount of protein in plant. The increased grain protein content with the application of 75% RDF + 25% N through poultry manure might be due to increased N availability through organic matter decomposition and balance supply of most of the nutrients that too have role in amino acid and protein synthesis (Survase *et al.,* 1986). Nutrients obtained from organic sources are generally more efficient to produce protein and enzyme than those from chemical sources (Maqshoof *et al.,* 2014). Earlier Pinjari (2007), Paramesh *et al.* (2014),Nagavani and Subbian (2014), Iqbal *et al.* (2017) and Ali *et al.* (2019) also reported similar kind of findings.

**Table 1: Protein content in maize grain (%) as influenced by integrated nutrient management.**

| Treatments | Protein content in grain (%) | | |
|---|---|---|---|
| | 2023 | 2024 | Pooled |
| $T_1$- RDF (120: 60: 40 kg NPK) | 11.44ab | 11.55b | 11.49b |
| $T_2$- 50 % RDF + 50 % N through Biogas slurry | 10.85bc | 10.93bc | 10.89c |
| $T_3$ - 50 % RDF + 50 % N through Vermicompost | 11.20b | 11.29b | 11.25bc |
| $T_4$ - 50 % RDF + 50 % N through FYM | 10.89bc | 10.94bc | 10.91cd |
| $T_5$- 50 % RDF + 50 % N through Poultry manure | 11.38ab | 11.46b | 11.42bc |
| $T_6$- 75 % RDF + 25 % N through Biogas slurry | 11.70ab | 11.77ab | 11.73ab |
| $T_7$ - 75 % RDF + 25 % N through Vermicompost | 12.02ab | 12.11ab | 12.07a |
| $T_8$ - 75 % RDF + 25 % N through FYM | 11.40ab | 11.47b | 11.43bc |
| $T_9$ - 75 % RDF + 25 % N through Poultry manure | **12.16a** | **12.33a** | **12.24a** |
| $T_{10}$ - 50 % RDF + Green manuring with *Sasbania spp.* | 10.03c | 10.23c | 10.13d |
| $T_{11}$ - 75 % RDF + Green manuring with *Sasbania spp.* | 10.84bc | 10.92bc | 10.88cd |
| $T_{12}$ - 100 % RDF + Green manuring with *Sasbania spp.* | 12.00ab | 12.08ab | 12.04ab |
| **CD at 5%** | **0.908** | **0.766** | **0.57** |
| **SE(m)±** | **0.308** | **0.260** | **0.28** |

**Protein yield (kg ha$^{-1}$)**

Protein yield (kg ha$^{-1}$) of maize was significantly increased with the application of treatment $T_9$ - 75% RDF + 25% N through poultry manure (Table 2). It might be attributed due to the application of treatment $T_9$ - 75% RDF + 25% N through poultry manure was significantly increased the grain yield (t ha$^{-1}$), N uptake and protein content in grain (%) ultimately protein yield (kg ha$^{-1}$) was increased significantly with the this treatment. Same findings also reported by Nagappa and Biradar (2007), Paramesh *et al.* (2014) and Nagavani and Subbian (2014).

**Table 2: Protein yield (kg ha$^{-1}$) by maize crop as influenced by integrated nutrient management.**

| Treatments | Protein yield (kg ha$^{-1}$) | | |
|---|---|---|---|
| | 2023 | 2024 | Pooled |
| $T_1$- RDF (120: 60: 40 kg NPK) | 510.53cd | 516.32d | 513.42d |
| $T_2$- 50 % RDF + 50 % N through Biogas slurry | 440.49f | 448.03f | 444.26e |
| $T_3$ - 50 % RDF + 50 % N through Vermicompost | 470.58d | 477.61de | 474.09de |
| $T_4$ - 50 % RDF + 50 % N through FYM | 447.12ef | 452.31e | 449.71e |
| $T_5$- 50 % RDF + 50 % N through Poultry manure | 482.14de | 490.26d | 486.20d |
| $T_6$- 75 % RDF + 25 % N through Biogas slurry | 531.18c | 537.33cd | 534.26c |
| $T_7$ - 75 % RDF + 25 % N through Vermicompost | 579.56b | 585.47b | 582.52bc |
| $T_8$ - 75 % RDF + 25 % N through FYM | 488.30d | 493.20de | 490.71d |
| $T_9$ - 75 % RDF + 25 % N through Poultry manure | **642.04a** | **653.13a** | **647.59a** |
| $T_{10}$ - 50 % RDF + Green manuring with *Sasbania spp.* | 307.62h | 317.06g | 312.34g |
| $T_{11}$ - 75 % RDF + Green manuring with *Sasbania spp.* | 411.70g | 416.57f | 414.14f |
| $T_{12}$ - 100 % RDF + Green manuring with *Sasbania spp.* | 549.97bc | 557.36bc | 553.66c |
| **CD at 5%** | **40.079** | **44.099** | **28.77** |
| **SE(m)±** | **13.578** | **14.939** | **14.27** |

**Conclusion**

This study clearly demonstrated the significant beneficial effects of INM in maize on enhanced quality of maize grain. Application of 75% RDF + 25% N through poultry manure was found a better combination of nutrient integration with respect to quality of maize. This is an important finding for increased nutrient availability and sustaining soil fertility for long term productivity of maize. For future research, it is essential to gain a deeper understanding of the INM in maize will provide valuable insights for advancing sustainable agricultural practices.

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