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Rohit Kanash
Medicaps University Indore,
Madhya Pradesh, India

Anand Salve
Medicaps University Indore,
Madhya Pradesh, India

Anshul Patidar
Medicaps University Indore,
Madhya Pradesh, India

Effect of natural and organic input-based integrated nutrient management practices on nutrient uptake by maize crops

Rohit Kanash, Anand Salve and Anshul Patidar

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Abstract

Maize is a heavy feeding crop with significant nutrient requirements, which are best addressed through an Integrated Nutrient Management (INM) approach. This strategy combines the use of chemical fertilizers, organic manures, and bio-fertilizers to sustain productivity and enhance soil health. INM has a notable impact on the physicochemical properties of soil, particularly in relation to pH and bulk density, due to the integration of both organic and inorganic inputs. This comprehensive approach not only ensures a consistent supply of nutrients but also improves the soil environment, fostering better root growth for crops. This investigation aimed to examine the impact of an integrated nutrient management system that incorporates natural and organic inputs on the nutrient uptake of maize (*Zea mays* L.) at Medicaps University in Indore during the kharif season. The study involved nine different treatments viz: T₁-100% RDF through vermicompost, T₂-75% RDF through vermicompost + natural inputs (Beejamrit seed treatment + Jeevamrit 50 ml/lit), T₃-75% RDF through vermicompost + 25% RDF, T₄-50% RDF through vermicompost + natural inputs (Beejamrit + Jeevamrit 25 ml/lit) + 50% RDF, T₅-100% RDF through FYM, T₆-75% RDF through FYM + natural inputs (Beejamrit + Jeevamrit 50 ml/lit), T₇-75% RDF through FYM + 25% RDF, T₈-75% RDF through FYM + natural inputs (Beejamrit + Jeevamrit 25 ml/lit) + 25% RDF, and T₉-control (no fertilizer). Results showed that T₄ was most effective, recording maximum nutrient uptake by seeds (N 92.25 kg ha⁻¹, P 19.29 kg ha⁻¹, K 35.24 kg ha⁻¹) and stover (N 38.30 kg ha⁻¹, P 14.00 kg ha⁻¹, K 81.34 kg ha⁻¹), highlighting the benefits of combining organic and inorganic inputs for improved soil health and maize productivity. The lowest nutrient uptake by seeds and stover was recorded in the control T₉ (without fertilizer) treatment.

Keywords: Integrated nutrient management, Nutrient uptake, Organic manures, etc.

Introduction

India's maize production pattern is changing with the growing demand for maize from industries such as poultry, livestock, starch, food processing and ethanol. This crop is changing from a food grain primarily to a valuable industrial product. According to the third advance estimate (2025-26) by Ministry of Agriculture and Farmers Welfare, maize production reached 55.09 million tonnes. A significant incorporation of maize in India food grain production may be due to its high yield capacity, hybrid vigour and better nutrient status of maize crop. Maize is an exhaustive crop with very high nutrient needs (Bharti *et al.*, 2021) ^[7]. Several well-documented harmful impacts on soil health, crop productivity and the broader environment result from the continuous use of chemical fertilizers and the intensive cultivation of maize Howe *et al.*, (2024) ^[4]. Excessive and long-term use of chemical fertilizers may maintain crop yield in the short term, but it may worsen soil quality and damage the environment in the long term. Maize productivity depends largely on nutrient management as maize is a heavy feeder of nutrients (Arthy, 2020) ^[1]. Therefore, it is highly recommended to integrate chemical fertilizers with organic manures, biofertilizers and other ordinary inputs. This combination can improve nutrient availability, soil health and sustainable maize production. By tailoring fertilizer applications to the unique conditions of each field, farmers can optimize nutrient efficiency, strengthen crop growth and productivity, and reduce both waste and environmental impact. Evidence from multiple studies across diverse cropping systems confirms the effectiveness of Site-Specific Nutrient Management in improving yield outcomes and resource use efficiency (Singh *et al.*, 2015 a, b) ^[5, 6].

Corresponding Author:
Anand Salve
Medicaps University Indore,
Madhya Pradesh, India

Materials and Methods

The present investigation, entitled “Effect of natural and organic input based integrated nutrient system on nutrient uptake by Maize crop,” was carried out at Medicaps University, Indore (M. P.) during the *kharif* season of 2025. The experiment was carried out at the agriculture farm, Medicaps University, Indore (M.P.) It lies in the Malwa Region of Madhya Pradesh between 22.6210° North latitude and 75.8036° East longitude. The altitude of the town is about 570 meters above mean sea level. The surroundings enjoy extreme winter and summer temperatures with an average maximum and minimum temperature of 40°C and 12°C. The major precipitation occurs between June and September, which is perfect for rainfed agriculture, and additional irrigation is needed during the summer season. It obtains average rainfall between 700-1060 mm/year since last year's rainfall was very scant. The average soil pH of the study area is 7.35 with silty clay loam texture having an electrical conductivity of 0.28 dS/m and 0.41% organic carbon. The average bulk density was recorded as 1.18 g/cm³ during research work. The study included nine different treatments. viz: T₁-100% RDF through vermicompost, T₂-75% RDF through vermicompost + natural inputs (Beejamrit seed treatment + Jeevamrit 50 ml/lit), T₃-75% RDF through vermicompost + 25% RDF, T₄-50% RDF through vermicompost + natural inputs (Beejamrit + Jeevamrit 25 ml/lit) + 50% RDF, T₅-100% RDF through FYM, T₆-75% RDF through FYM + natural inputs (Beejamrit + Jeevamrit 50 ml/lit), T₇-75% RDF through FYM + 25% RDF, T₈-75% RDF through FYM + natural inputs (Beejamrit + Jeevamrit 25 ml/lit) + 25% RDF, and T₉-control (no fertilizer). The field was prepared by a tractor drawn disc plough, cross harrowing and levelling, and then manually laid out as per the plan. The experiment was carried out in 27 plots of 5.0m × 4.0m size each (net size 4.0m × 2.20m). The maize variety “GK3122” was sown with seed rate of 25 kg ha⁻¹ with Beejamrit treatment. Inoculated seeds were dried for 30 min and then sown on July 1, 2025, in rows with a pointed stick. FYM and Vermicompost were applied with recommended doses of Nitrogen, Phosphorus, Potassium and Sulphur through Urea, SSP and MOP (120:60:40 kg ha⁻¹) by mixing with soil before sowing. Ten plants per treatment were randomly tagged for nutrient uptake analysis. Samples of grain and stover were collected at harvest, cleaned, oven dried at 60 °C and finely ground to a uniform particle size. Nitrogen: Determined by the micro Kjeldahl method (Jackson, 1973) ^[8] which converts the nitrogen to ammonia for quantification. Phosphorus: Estimated by vanadomolybdo phosphoric acid method (Jackson, 1973) ^[8] values are reliable. Potassium: Determined by flame photometry (Black, 1965) ^[2] a sensitive method for ion concentration. Standard formulas were used to calculate nutrient absorption in grain and stover to compare uptake efficiency among treatments.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (\%)} \times \text{Dry matter yield (kg ha}^{-1}\text{)}}{100}$$

Data recorded on various growth, yield, and quality attributes were subjected to statistical analysis by following Fisher's method (1947) ^[10] of analysis of variance (Panse and Sukhatme method, 1967) ^[9]. The randomized block design (RBD) was adopted for the field experiment.

Results and Discussion

Nitrogen uptake by seed and stover (kg ha⁻¹)

The data on nitrogen uptake by seed and stover demonstrated in Table 1 were significantly influenced due to treatments as affected by natural and organic input based integrated nutrient

management practice. A similar trend was observed in nitrogen uptake by seed and stover. The maximum nitrogen (N) uptake by seed (92.25 kg ha⁻¹) and stover (38.30 kg ha⁻¹) was recorded in T₄- 50% RDF through vermicompost + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 25 ml/ lit) + 50% RDF, followed by T₈- 75% RDF through FYM + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 25 ml/ lit) + 25% RDF, where N uptake by seed (79.85 kg ha⁻¹ and stover 36.55 kg ha⁻¹) and treatment T₂- 75% RDF through Vermicompost + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 50 ml/ lit) where N uptake (74.92 kg ha⁻¹ by seed and 34.92 kg ha⁻¹ by stover). The minimum value of nitrogen (N) uptake by seed (19.56 kg ha⁻¹) and stover (18.09 kg ha⁻¹) was recorded in T₉- Control (without fertilizer) treatment. The increased nitrogen uptake under treatment T₄ might be attributed to the balanced and synchronised supply of nutrients through chemical fertilizers and organic sources. Chemical fertilizers give instant nitrogen, vermicompost gives slow release. Application of Jeevamrit and Beejamrit increases microbial activity in the soil which increases availability of nutrients. FYM usually has lesser nutrient concentration, extensive C:N ratio and slower decomposition than vermicompost. Hence, the nitrogen uptake was slightly lower than T₄, while T₉ controls sowing, nutrient deficiencies due to the lack of fertilizer application. Similar findings were also concluded by Kaur *et al.* (2020) ^[11], Darjee *et al.* (2024) ^[12].

Phosphorus uptake by seed and stover (kg ha⁻¹)

The data on phosphorus uptake by seed and stover are illustrated in Table 1. Phosphorus uptake by seeds and stover was significantly influenced by integrated nutrient management practices.

The significant higher phosphorus uptake by seed (19.29 kg ha⁻¹) and was recorded under T₄- 50% RDF through vermicompost + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 25 ml/ lit) + 50% RDF followed the treatment T₈- 75% RDF through FYM + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 25 ml/ lit) + 25% RDF (19.20 kg ha⁻¹) and treatment T₂- 75% RDF through Vermicompost + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 50 ml/ lit) 15.55 kg ha⁻¹ phosphorus uptake recorded by seeds. However, the lowest phosphorus uptake (6.40 kg ha⁻¹) was observed under T₉- Control (without fertilizer) treatment.

The statistically higher value of Phosphorus uptake by stover was noticed under T₄- 50% RDF through vermicompost + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 25 ml/ lit) + 50% RDF (14.00 kg ha⁻¹), followed by T₂- 75% RDF through Vermicompost + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 50 ml/ lit) which yield (13.27 kg ha⁻¹) P uptake by stover and T₈- 75% RDF through FYM + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 25 ml/ lit) + 25% RDF (12.74 kg ha⁻¹), whereas the lowest uptake of phosphorus (5.67 kg ha⁻¹) was recorded under T₉- Control (without fertilizer) treatment. This finding is in close agreement with Adhami *et al.* (2014) ^[13], who described that vermicomposting produces organic acids such as malonic, fumaric, and succinic acids, which help in phosphorus solubilization and increase phosphorus availability in soil. This finding is compatible with Sidhu *et al.* (2025) ^[14].

Potassium uptake by seed and stover (kg ha⁻¹)

The data on potassium uptake by seed and stover are illustrated in Table 1. Potassium uptake by seeds and stover was significantly influenced by integrated nutrient management practices.

Table 1: Effect of natural and organic input-based integrated nutrient management practices on N, P₂O₅ and K₂O uptake by seed and stover

Treatments	Nutrient uptake by seed (kg ha ⁻¹)			Nutrient uptake by stover (kg ha ⁻¹)		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
T ₁ - 100% RDF through Vermicompost	59.73	8.79	23.60	26.20	8.81	57.30
T ₂ - 75% RDF through Vermicompost + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 50 ml/ lit)	74.94	15.55	33.04	34.92	13.27	75.44
T ₃ - 75% RDF through vermicompost + 25% RDF	70.05	12.53	28.99	28.93	10.08	62.35
T ₄ - 50% RDF through vermicompost + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 25 ml/ lit) + 50% RDF	92.25	19.29	35.24	38.30	14.00	81.34
T ₅ -100% RDF through FYM	56.00	8.93	18.99	20.66	7.01	50.24
T ₆ - 75% RDF through FYM + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 50 ml/ lit)	62.80	10.88	24.59	24.92	9.29	58.25
T ₇ - 75% RDF through FYM + 25% RDF	65.85	11.33	19.63	23.13	8.32	53.90
T ₈ - 75% RDF through FYM + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 25 ml/ lit) + 25% RDF	79.85	19.20	33.15	36.55	12.74	72.44
T ₉ - Control (without fertilizer)	19.56	6.40	12.57	18.09	5.67	34.00
S.E(m)±	0.90	0.47	1.17	0.93	0.39	1.84
C.D. at 5%	2.70	1.42	3.50	2.82	1.18	5.55

The statistically higher potassium uptake by grain was found under T₄- 50% RDF through vermicompost + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 25 ml/ lit) + 50% RDF (35.24 kg ha⁻¹), followed by T₈- 75% RDF through FYM + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 25 ml/ lit) + 25% RDF (33.15 kg ha⁻¹) which was statistical at par with treatment T₂- 75% RDF through Vermicompost + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 50 ml/ lit) shows 33.04 kg ha⁻¹ potassium uptake by seeds. The lowest value of potassium uptake (12.5 kg ha⁻¹) by seed was recorded under T₉- Control (without fertilizer) treatment. Maximum phosphorus uptake by stover was highest under T₄, followed by T₂ and T₈ treatments, indicating that phosphorus solubilization and a decrease in P fixation are facilitated by organic acids and phosphatase enzymes released during the decomposition of vermicompost. Thus, T₂ (75% RDF through vermicompost + Beejamrit + Jeevamrit) may have provided more plant-available P during the growing period than T₈ (FYM-based treatment).

While the maximum value of potassium uptake (81.34 kg ha⁻¹) by stover was recorded in treatment T₄- 50% RDF through vermicompost + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 25 ml/ lit) + 50% RDF, followed by the treatment T₂- 75% RDF through Vermicompost + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 50 ml/ lit) which shows (75.44 kg ha⁻¹) K uptake by stover and treatment T₈- 75% RDF through FYM + Natural farming inputs, Beejamrit (Seed Treatment) Jeevamrit (spraying 25 ml/ lit) + 25% RDF (72.44 kg ha⁻¹) K uptake by stover. The lowest value of potassium uptake (34.00 kg ha⁻¹) by stover was observed in treatment T₉- control (without fertilizer).

The maximum uptake of potassium under T₄ could be due to the cumulative effect of vermicompost, inorganic fertilizers and natural farming inputs which could have maintained a continuous supply of nutrients during the growth of the crop. Potassium is quite mobile in soil, but uptake is mainly a matter of a well developed root system and adequate soil moisture. Nisar *et al.* (2025) [15] also reported that the application of organic manures along with the recommended fertilizer dose improves potassium uptake and nutrient efficiency in maize, primarily due to the improvement of soil health and the provision of a balanced nutrient supply. T₂ sowing lesser potassium uptake may be due to the absence of inorganic fertilizer. Under T₈ treatment FYM slower release of nutrients due to a slower decomposition rate than vermicompost. The minimum uptake of N, P, and K in T₉ (control) is due to no external nutrient inputs, which resulted in

less nutrient availability for crop growth and development. Singh *et al.* (2021) [16], Gogoi *et al.* (2022) [17], Patel *et al.* (2024) [18].

Conclusion

Integrated nutrient management, a combination of organic manures, natural farming inputs and chemical fertilizers, resulted in significantly higher nutrient absorption in maize than the unfertilized control group, according to the study. Integrated nutrient management (INM) significantly amended the uptake of nitrogen, phosphorus and potassium in maize as compared to control. Among the treatments T₄ (50% RDF through vermicompost + Beejamrit + Jeevamrit + 50% RDF) recorded the highest nutrient uptake in grain and stover followed by T₈ and T₂. T₄ performed better because of synergic effect of vermicompost, natural farming inputs and inorganic fertilizers which enhanced nutrient availability and nutrient use efficiency. To summarize, the present study demonstrated that 50% RDF along with vermicompost and natural inputs was a sustainable and effective approach for enhancing nutrient uptake and soil fertility in maize.

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