International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(1): 540-543
www.biochemjournal.com
Received: 22-10-2025
Accepted: 25-11-2025

Tupaki Lokya
Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Antaryami Mishra
Professors, Department of Soil Science and Agricultural Chemistry, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Saren S
Assistant Professor, Department of Soil Science and Agriculture Chemistry, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Corresponding Author:
Tupaki Lokya
Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Effect of integrated nutrient management on macronutrient concentration, uptake and recovery in maize crop grown in acid soil

Tupaki Lokya, Antaryami Mishra and Saren S

DOI: https://www.doi.org/10.33545/26174693.2026.v10.i1Sg.7001

Abstract
A pot culture experiment was carried out during the Kharif season in the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Bhubaneswar, to evaluate the Effect of Integrated Nutrient Management on Macronutrient Concentration, Uptake and Recovery in Maize crop Grown in Acid Soil . The experiment was conducted using an acid sandy loam soil, with hybrid maize as the test crop. Each pot was filled with 5 kg of processed soil, and three seeds were sown per pot. The experimental location is characterized by a warm and humid climate, with hot summers and mild winters. During the cropping period, the mean minimum and maximum temperatures were recorded as 22.1 °C and 31.9 °C, respectively. Observations pertaining to the concentration, uptake, and recovery of primary macronutrients in maize were recorded at appropriate growth stages. The treatments comprised control (T_1), soil test-based recommended dose (STD) (T_2), vermicompost (T_3), lime (T_4), lime + vermicompost (T_5), STD + vermicompost @ 2.5 t ha^{-1} (T_6), STD + lime (T_7), and STD + vermicompost @ 2.5 t ha^{-1} + lime (T_8). The results of the experiment revealed that the combined application of STD + vermicompost @ 2.5 t ha^{-1} + lime significantly improved the concentration, uptake, and recovery of primary macronutrients in maize compared to the other treatments.

Keywords: Pot culture, lime, macro primary nutrients, acid soil, vermicompost, integrated nutrient management

Introduction

Liming materials neutralize soil acidity by reducing the activity of H^+ and Al^{3+} ions, thereby lowering exchangeable acidity to manageable levels and increasing soil pH, depending on the neutralizing capacity of the liming source. Among the materials evaluated, calcium silicate was effective in decreasing exchangeable acidity while significantly improving soil pH. The application of calcium silicate also enhanced plant dry matter production and nitrogen accumulation in the aboveground biomass. The findings of the present study suggest that the combined application of vermicompost, inorganic fertilizers (NPK), and calcium silicate plays a crucial role in improving nutrient recovery from acidic soils.

Soil acidity and the associated elemental toxicities or nutrient deficiencies adversely affect crop growth and productivity across the globe (Eswaran *et al.*, 1997; Rengel *et al.*, 2003) [2, 10]. Acidic soils with pH values below 5.5 are widely distributed and occupy substantial areas of arable land in several countries, including Croatia (Kovačević *et al.*, 1993; Lončarić *et al.*, 2005) [4, 5]. The amelioration of acid soils through liming practices has been widely adopted as an effective approach to improve soil chemical properties and enhance plant growth. Globally, soil acidity is recognized as a major constraint to crop production, affecting nearly 4 billion hectares, which accounts for approximately 30% of the total ice-free land area (Sumner and Noble, 2003) [13].

In tropical regions, prolonged weathering and intensive leaching have resulted in the depletion of basic cations such as calcium, magnesium, and potassium**,** which are subsequently replaced by H^+, Al^{3+}, and Mn^{2+} ions, leading to acid-related stress in crops (Okalebo *et al.*, 2009) [9]. In India, acidic soils cover approximately 90 million hectares, representing nearly 25% of the total geographical area (Sarkar and Sharma, 2005) [11]. In Odisha, about 80% of the soils are acidic, characterized by low water-holding capacity, high bulk density, soil crusting, and several chemical limitations, including low pH, low cation exchange capacity, low base saturation, high aluminum, iron, and manganese saturation, and strong phosphorus fixation (Misra *et al.*, 1989) [8].

Acid soils are commonly deficient in essential nutrients such as Ca, Mg, P, Mo, B, and Si**,** while the availability of Fe, Mn, Cu, and Zn may be excessively high, sometimes reaching toxic concentrations. These constraints can be mitigated through the application of both inorganic and organic soil amendments. The use of lime as an inorganic ameliorant increases soil pH, base saturation, and cation exchange capacity, while reducing aluminum, iron, and manganese toxicity and phosphorus fixation (Misra *et al.*, 1989; Mishra and Pattanayak, 2002; Sethi, 2015) [8, 6, 12]. Organic amendments such as farmyard manure or compost contribute to the reduction of exchangeable aluminum through hydroxyl ion-mediated precipitation reactions (Sethi, 2015) [12]. The integrated application of organic and inorganic ameliorants has been shown to effectively regulate soil acidity, alleviate metal toxicities, enhance nutrient availability, and improve overall soil conditions for crop growth (Misra and Das, 2000) [7]. Based on these considerations, the present study proposes to conduct pot culture and incubation experiments using industrial by-products and organic residues that have potential liming properties, with the objective of improving soil acidity management and nutrient availability in acidic soils.

Materials and Methods

Soil samples were collected from the Central Horticultural Research Station, OUAT. The collected soil was air-dried and processed by removing plant residues, stones, and other extraneous materials. Each pot was filled with 5 kg of processed soil. Prior to sowing, the calculated quantities of calcium silicate, chemical fertilizers, and vermicompost were thoroughly mixed with the soil according to the respective treatments. Subsequently, three seeds were sown in each pot. The treatments comprised control (T_1), soil test-based recommended dose (STD) (T_2), vermicompost (T_3), lime (T_4), lime + vermicompost (T_5), STD + vermicompost @ 2.5 t ha^{-1} (T_6), STD + lime (T_7), and STD + vermicompost @ 2.5 t ha^{-1} + lime (T_8). At harvest, three plants from each treatment were randomly selected for analysis. Root samples were collected by gently moistening the rhizosphere and carefully uprooting the plants using a spade to avoid root damage. The entire root system, along with adhering soil, was immersed in a bucket of water to loosen soil particles and recover the roots. The roots were then thoroughly washed with clean water and air-dried. Plant parts, namely stems and roots, were separated, placed in labeled envelopes, and dried in a hot air oven at 65 °C until a constant weight was attained. The dried samples were finely ground separately and used for chemical analysis.

The ground stem and root samples were analyzed for nitrogen (N), phosphorus (P), and potassium (K) concentrations. Nitrogen content was determined using the Kjeldahl digestion method as outlined by AOAC (1960). For phosphorus and potassium estimation, the samples were digested using a di-acid mixture of HNO_3:$HClO_4$ (3:2). Phosphorus concentration was measured spectrophotometrically, while potassium content was estimated using a flame photometer, following the procedure described by Jackson (1973) [3].

Nutrient uptake (kg ha^{-1}) = Dry matter (q/ha) x nutrient concentration (%)

$$\text{Apparent Recovery of Nutrient (\%)} = \frac{\text{Uptake of nutrient in desired treatment-Uptake in absolute control}}{\text{Amount of nutrient added}} \times 100$$

Results & Discussion

The pot experiment was conducted in an acid sandy loam soil with Maize as the test crop (Hybrid). The experiment was conducted by applying inorganic and organic fertilizer and the soil was ameliorated with a liming materials (Calcium-silicate @ 0.2LR) added with soil test based dose with or without Vermicompost (VC) @ 2.5 t/ha.

Concentration, uptake and recovery of the nutrients as influenced by INM practices

Nitrogen

The concentration N in different maize plant parts and uptake through these parts have been presented in Table-1.

Table 1: Concentration, uptake and recovery of the Nitrogen as influenced by INM practices

	Treatments	Concentration (%)		Uptake (mg/pot)			Apparent N recovery (%)
		Shoot	Root	Shoot	Root	Total	
T_1	Absolute control	1.1	0.8	85.1	37.72	122.82	
T_2	Soil test based recommended dose (STD)	1.2	1.01	150.16	57	207.16	120.49
T_3	Vermiculite @ 2.5 t ha^{-1}	1.31	1.06	167.9	66.4	234.3	136.00
T_4	Ca-Silicate @ 0 .2 LR	1.34	1.09	198.7	74.6	273.3	150.48
T_5	VC @ 2.5t ha^{-1}+ Ca-Silicate @ 0 .2 LR	1.39	1.13	255.4	83.5	338.9	198.67
T_6	STD + VC @ 2.5 t ha^{-1}	1.33	1.08	237	76.1	313.1	260.66
T_7	STD + Lime	1.12	1.12	276.5	84	360.5	339.54
T_8	STD + VC @ 2.5 t ha^{-1}+ Ca-Silicate @ 0 .2 LR	1.4	1.18	306.4	96.3	402.7	383.40

Nitrogen concentration in maize was consistently higher in the stover than in the root, with values ranging from 1.1 to 1.4 percent in the shoot and from 0.8 to 1.18 percent in the root across treatments. The combined application of soil test-based fertilizer dose along with vermicompost at 2.5 t ha^{-1} and calcium silicate at 0.2 LR resulted in the highest nitrogen concentration in both shoot (1.40%) and root (1.18%), whereas the lowest concentration was recorded under the absolute control. A similar trend was observed for nitrogen uptake, wherein the integrated treatment registered maximum uptake in shoot (306.4 mg pot^{-1}) and root (96.3 mg pot^{-1}), while the minimum uptake occurred in the control treatment. Consequently, total nitrogen uptake was significantly higher under the integrated nutrient management practice compared to other treatments. Apparent nitrogen recovery was also markedly enhanced under the combined application of fertilizer, vermicompost, and calcium silicate, recording a maximum value of 383.40

percent, whereas the lowest recovery was observed in the absolute control.

Phosphorus

The phosphorus concentration and uptake by maize as influenced by integrated nutrient management practices are presented in Table 2. Across treatments, phosphorus concentration was higher in the stover than in the roots, ranging from 0.040 to 0.161 percent in the shoot and from 0.013 to 0.052 percent in the root. The combined application of soil test-based fertilizer dose with vermicompost at 2.5 t ha^{-1} and calcium silicate at 0.2 LR recorded the maximum phosphorus concentration in both shoot (0.161%) and root (0.052%), while the minimum concentration was observed under the absolute control. Phosphorus uptake followed a similar trend, with the integrated treatment registering the highest uptake in shoot (35.24 mg pot^{-1}) and root (4.244 mg pot^{-1}), whereas the lowest uptake was recorded in the control treatment. Consequently, total phosphorus uptake was significantly greater under the integrated nutrient management practice compared to other treatments. Apparent phosphorus recovery was also highest under the combined application of fertilizer, vermicompost, and calcium silicate (49.68%), while the lowest recovery was observed in the absolute control.

Table 2: Concentration, uptake and recovery of the Phosphorus as influenced by INM practices

	Treatments	Concentration (%)		Uptake (mg/pot)			Apparent P recovery (%)
		Shoot	Root	Shoot	Root	Total	
T_1	Absolute control	0.040	0.013	3.09	0.613	3.71	
T_2	Soil test based recommended dose (STD)	0.098	0.021	12.26	1.185	13.45	13.91
T_3	Vermiculite @ 2.5 t ha^{-1}	0.118	0.027	15.12	1.691	16.82	17.81
T_4	Ca-Silicate @ 0 .2 LR	0.134	0.034	19.87	2.327	22.20	18.49
T_5	VC @ 2.5t ha^{-1}+ Ca-Silicate @ 0 .2 LR	0.141	0.043	25.91	3.177	29.08	40.97
T_6	STD + VC @ 2.5 t ha^{-1}	0.133	0.038	23.70	2.678	26.38	31.48
T_7	STD + Lime	0.144	0.047	29.28	3.525	32.80	41.56
T_8	STD + VC @ 2.5 t ha^{-1}+ Ca-Silicate @ 0 .2 LR	0.161	0.052	35.24	4.244	39.48	49.68

Potassium

The potassium concentration and uptake by maize as influenced by integrated nutrient management practices are presented in Table 3. Potassium concentration was consistently higher in the stover than in the roots, with values ranging from 0.72 to 1.51 percent in shoot tissues and from 0.13 to 0.56 percent in the roots across treatments. The highest potassium concentration in both shoot (1.51%) and root (0.56%) was recorded under the combined application of soil test-based fertilizer dose, vermicompost at 2.5 t ha^{-1}, and calcium silicate at 0.2 LR, whereas the lowest concentration occurred in the absolute control. Potassium uptake followed a similar pattern, with the integrated treatment registering maximum uptake in shoot (330.47 mg pot^{-1}) and root (45.70 mg pot^{-1}), while minimum uptake was observed in the control treatment. As a result, total potassium uptake was significantly greater under the integrated nutrient management practice compared to other treatments. Apparent potassium recovery was also highest under the combined application of fertilizer, vermicompost, and calcium silicate, whereas the lowest recovery was recorded in the absolute control.

Table 3: Concentration, uptake and recovery of the Potassium as influenced by INM practices

	Treatments	Concentration (%)		Uptake (mg/pot)			Apparent K recovery (%)
		Shoot	Root	Shoot	Root	Total	
T_1	Absolute control	0.72	0.13	55.70	6.13	61.83	
T_2	Soil test based recommended dose (STD)	1.10	0.28	137.65	15.80	153.45	152.70
T_3	Vermiculite @ 2.5 t ha^{-1}	1.16	0.35	148.67	21.92	170.60	140.64
T_4	Ca-Silicate @ 0 .2 LR	1.19	0.39	176.46	26.69	203.15	141.32
T_5	VC @ 2.5t ha^{-1}+ Ca-Silicate @ 0 .2 LR	1.31	0.43	240.70	31.77	272.48	311.50
T_6	STD + VC @ 2.5 t ha^{-1}	1.29	0.38	229.87	26.78	256.65	324.70
T_7	STD + Lime	1.44	0.47	292.76	35.25	328.01	443.64
T_8	STD + VC @ 2.5 t ha^{-1}+ Ca-Silicate @ 0 .2 LR	1.51	0.56	330.47	45.70	376.18	498.96

Conclusion

Efficient crop production under an optimum growing environment enables better utilization of applied inputs and resources, whereas the presence of soil-related constraints limits their effective use, resulting in reduced productivity. In the present study, the application of soil ameliorants, both inorganic (lime) and organic (vermicompost), significantly influenced maize growth and enhanced the uptake of nitrogen, phosphorus, and potassium. Nutrient recovery efficiency, particularly for phosphorus and potassium, was markedly improved by soil amelioration practices, with phosphorus recovery increasing from 13.91 to 49.68 percent and potassium recovery from 152.70 to 498.96 percent. Although maize is an exhaustive crop and continuous removal of nutrients—especially basic cations—tends to increase soil acidity even with fertilizer, lime, and vermicompost application, frequent intercultural operations may have accelerated carbon oxidation, leading to a decline in soil organic carbon status. Post-harvest available nitrogen decreased under the control treatment where no nutrients were applied, while its status was maintained or marginally improved in the remaining treatments compared to the initial level, although these values still fell within the low fertility rating.

Reference

1. AOAC. Official methods of analysis of the Association of Official Agricultural Chemists. 9th ed. Washington (DC): AOAC; 1960. p. 12-13.

2. Eswaran H, Reich P, Beinroth F. Global distribution of soils with acidity. In: Moniz AC, Furlani AMC, Schaffert RE, Fageria NK, Rosolem CA, Cantarella H, editors. Plant-soil interactions at low pH. Campinas (Brazil): Brazilian Society of Soil Science; 1997. p. 159-164.
3. Jackson ML. Soil chemical analysis. 2nd ed. New Delhi: Prentice Hall of India Pvt. Ltd.; 1973. p. 69-182.
4. Kovacevic V, Bertic B, Grgic D. Response of maize, barley, wheat and soybean to liming on acid soils. Rostlinna Vyroba. 1993;39(1):41-52.
5. Loncaric Z, Karalic K, Vukadinovic V, Bertic B, Kovacevic V. Variation of liming recommendation caused by calculation approach. In: Li CJ, *et al.*, editors. Plant nutrition for food security, human health and environmental protection. Beijing (China): Tsinghua University Press; 2005. p. 1042-1043.
6. Mishra M, Pattanayak SK. Response of crops to graded doses of lime amended with or without FYM in different crops grown in acid soil. Professor IFFCO Chair Report. Bhubaneswar: OUAT; 2002. p. 1-65.
7. Misra UK, Das N. Phosphorous availability to maize as influenced by organic amendments. J Indian Soc Soil Sci. 2002;48:298-305.
8. Misra UK, Satpathy S, Panda N. Characterization of some acid soils of Orissa. I. Nature of soil acidity. J Indian Soc Soil Sci. 1989;37:22-28.
9. Okalebo JR, Othieno CO, Nekesa AO, Ndungu-Magiroi KW, Kifuko-Koech MN. Potential for agricultural lime on improved soil health and agricultural production in Kenya. Afr Crop Sci Conf Proc. 2009;9:339-341.
10. Rengel Z, editor. Handbook of soil acidity. New York: Marcel Dekker; 2003. p. 1-624.
11. Sarkar AK, Sharma PD. Managing acid soils for enhancing productivity. New Delhi: National Resource Management Division, ICAR; 2005. p. 1-23.
12. Sethi D. Effect of LD slag as soil ameliorant and its impact on native PSB population in acid Alfisols of Bhubaneswar [MSc thesis]. Bhubaneswar: OUAT; 2015. p. 1-120.
13. Sumner ME, Noble AD. Soil acidification: the world story. In: Rengel Z, editor. Handbook of soil acidity. New York: Marcel Dekker; 2003. p. 1-28.