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Influence of potassium and magnesium sulphate levels on soil properties and nutrient status under maize (*Zea Mays* L.) in Southern Transition Zone of Karnataka

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ABSTRACT

A field experiment entitled “Influence of Potassium and Magnesium Sulphate Levels on Productivity of Maize (*Zea mays* L.)” was conducted during Kharif 2025 at the College of Agriculture, Navile, Shivamogga, under the Southern Transition Zone (Agro-Climatic Zone VII) of Karnataka. The experiment was laid out in a Randomized Complete Block Design (RCBD) with seven treatments and three replications, comprising an absolute control, package of practices (PoP: 100:50:25 kg N:P₂O₅:K₂O ha⁻¹), PoP + magnesium sulphate at 10 and 20 kg ha⁻¹, an elevated potassium level (100 kg N, 50 kg P₂O₅, 50 kg K₂O ha⁻¹) and its combination with magnesium sulphate at 10 and 20 kg ha⁻¹. Post-harvest soil analysis revealed that soil pH, electrical conductivity, organic carbon and DTPA-extractable Zn, Cu, Fe and Mn were not significantly influenced by the treatments, whereas exchangeable magnesium and available sulphur were significantly improved by magnesium sulphate application, particularly at 20 kg ha⁻¹ combined with the higher potassium level (T₇). Available N, P and K₂O were highest under the package of practices and elevated-potassium treatments, while exchangeable calcium remained statistically unaffected despite showing a numerically declining trend with increasing potassium and magnesium supply. Available soil K₂O declined progressively from 30 DAS to harvest across all treatments, reflecting crop uptake, with T₅, T₆ and T₇ maintaining significantly higher residual K status than the control. The results indicate that combined potassium and magnesium sulphate application, especially at higher magnesium levels, improves soil secondary-nutrient status and sustains potassium fertility without adversely affecting the major physico-chemical properties of soil.

Keywords: Maize, Potassium, Magnesium sulphate, Soil properties, Exchangeable magnesium, Available sulphur, Soil fertility

Introduction

Soil fertility management is central to sustaining the productivity of maize (*Zea mays* L.), a crop known for its high biomass production and exhaustive nutrient uptake. Among the major and secondary nutrients, potassium (K) and magnesium (Mg) occupy a distinctive position because of their close physiological and geochemical interaction. Potassium is the most abundant cation in the soil solution available for plant uptake and plays a central role in soil cation exchange dynamics, while magnesium, though required in smaller quantities, is essential for chlorophyll synthesis and enzyme activation and is particularly prone to depletion in light-textured, high-rainfall soils.

The relationship between potassium and magnesium in soil is governed largely by cationic competition for adsorption sites on soil colloids. Excessive or unbalanced potassium fertilization can suppress magnesium availability, while magnesium sulphate application, in addition to correcting Mg deficiency, supplies sulphur and can influence the broader nutrient equilibrium of the soil. Despite the agronomic importance of this interaction, information on how combined potassium and magnesium sulphate application influences soil physico-chemical properties, macro- and micronutrient status under maize in the Southern Transition Zone of Karnataka remains limited.

The present study was therefore undertaken to assess the influence of potassium and magnesium sulphate levels on soil properties and nutrient status - pH, electrical conductivity, organic carbon, available N, P, K, exchangeable Ca and Mg, available S, and DTPA-extractable micronutrients — under maize cultivation.

Materials and Methods

The field experiment was conducted during Kharif 2025 at the College of Agriculture, Navile, Shivamogga, KSNUAHS, situated in the Southern Transition Zone (Agro-Climatic Zone VII) of Karnataka (13°97' N, 75°57' E; altitude 667.5 m MSL). The experimental soil was sandy loam in texture, acidic in reaction (pH 5.63), with an electrical conductivity of 0.13 dS m⁻¹ and organic carbon content of 4.70 g kg⁻¹. Initial

available N, P_2O_5 and K_2O were 287.3, 48.02 and 272.78 kg ha⁻¹, respectively, with exchangeable Ca and Mg of 1.80 and 0.80 cmol(p⁺) kg⁻¹ and available S of 12.10 mg kg⁻¹. DTPA-extractable Zn, Cu, Mn and Fe were 2.94, 2.09, 5.95 and 29.05 mg kg⁻¹, respectively.

The experiment was laid out in RCBD with seven treatments and three replications: T₁ – absolute control; T₂ – PoP (100:50:25 kg N:P₂O₅:K₂O ha⁻¹); T₃ – T₂ + MgSO₄ 10 kg ha⁻¹; T₄ – T₂ + MgSO₄ 20 kg ha⁻¹; T₅ – 100 kg N, 50 kg P₂O₅, 50 kg K₂O ha⁻¹; T₆ – T₅ + MgSO₄ 10 kg ha⁻¹; T₇ – T₅ + MgSO₄ 20 kg ha⁻¹. FYM was applied at 10 t ha⁻¹, common to T₂–T₇. Maize hybrid GH-150125 was sown at 60 × 30 cm spacing. Soil samples were collected at 30, 60, 90 DAS and at harvest, and analyzed for pH and EC by potentiometry/conductometry (Jackson, 1973) [1], organic carbon by the wet oxidation method (Walkley *et al.*, 1934) [2], available N by the alkaline permanganate method (Subbiah *et al.*, 1956) [3], available P by Bray's method (Jackson, 1973) [1], available K by flame photometry (Jackson, 1973) [1], exchangeable Ca and Mg by versenate titration (Jackson, 1973) [1], available S by the turbidimetric method (Black, 1965) [4] and DTPA-extractable micronutrients by atomic absorption spectrophotometry (Lindsay *et al.*, 1978) [5]. Data were analyzed following the ANOVA procedure of Gomez and Gomez (1984) [6] with significance tested at 5 per cent.

Results and Discussion

Soil pH, electrical conductivity and organic carbon

Post-harvest soil pH (5.55–5.63), EC (0.11–0.18 dS m⁻¹) and organic carbon (4.59–4.71 g kg⁻¹) were not significantly influenced by potassium and magnesium sulphate levels (Table 1). The narrow numerical range, with slightly higher pH and OC under T₇, suggests that the applied doses of K and MgSO₄, though biologically active, were insufficient over a single season to measurably alter these buffered soil properties. The findings indicate that potassium and magnesium sulphate application at the tested levels had no adverse effect on soil reaction, electrical conductivity and organic carbon under the experimental conditions. Similar findings were reported by Tisdale *et al.* (1993) [7] and Brady and Weil (2017) [8].

Available nitrogen and phosphorus

Available N and P₂O₅ were significantly influenced by the treatments (Table 2), with the package of practices (T₂: 256.57 kg N ha⁻¹; 49.54 kg P₂O₅ ha⁻¹) and the elevated-K treatments recording higher residual values than the absolute control (T₁: 198.03 and 35.98 kg ha⁻¹, respectively). The comparatively lower residual N and P in the MgSO₄-treated plots (T₃, T₄, T₆, T₇) relative to their respective base treatments (T₂, T₅) is attributable to greater crop uptake associated with the improved growth and biomass these treatments supported, rather than to any adverse effect of magnesium sulphate on N or P availability. Similar observations were reported by Marschner (2012) [9] and Havlin *et al.* (2014) [10].

Table 1. Effect of potassium and magnesium sulphate levels on physico-chemical properties of post-harvest soil

Treatment	pH	EC (dS m ⁻¹)	OC (g kg ⁻¹)
T ₁ : Absolute control	5.55	0.11	4.59
T ₂ : N : P ₂ O ₅ : K ₂ O = 100 : 50 : 25 kg ha ⁻¹ (PoP)	5.57	0.13	4.63
T ₃ : T ₂ + magnesium sulphate 10 kg ha ⁻¹	5.59	0.14	4.66
T ₄ : T ₂ + magnesium sulphate 20 kg ha ⁻¹	5.58	0.16	4.68
T ₅ : 100 kg N, 50 kg P ₂ O ₅ and 50 kg K ₂ O ha ⁻¹	5.61	0.17	4.65
T ₆ : T ₅ + magnesium sulphate 10 kg ha ⁻¹	5.60	0.18	4.68
T ₇ : T ₅ + magnesium sulphate 20 kg ha ⁻¹	5.63	0.17	4.71
SEm±	0.04	0.02	0.22
CD @5%	NS	NS	NS

Table 2. Effect of potassium and magnesium sulphate levels on available nitrogen and available phosphorus status of post-harvest soil

Treatment	Avail. N (kg ha ⁻¹)	Avail. P ₂ O ₅ (kg ha ⁻¹)
T ₁ : Absolute control	198.03	35.98
T ₂ : N : P ₂ O ₅ : K ₂ O = 100 : 50 : 25 kg ha ⁻¹ (PoP)	256.57	49.54
T ₃ : T ₂ + magnesium sulphate 10 kg ha ⁻¹	250.20	47.82
T ₄ : T ₂ + magnesium sulphate 20 kg ha ⁻¹	252.27	45.16
T ₅ : 100 kg N, 50 kg P ₂ O ₅ and 50 kg K ₂ O ha ⁻¹	255.33	46.87
T ₆ : T ₅ + magnesium sulphate 10 kg ha ⁻¹	249.72	44.95
T ₇ : T ₅ + magnesium sulphate 20 kg ha ⁻¹	240.61	43.74
SEm±	6.11	1.191
CD @5%	18.82	3.672

Available potassium at critical growth stages

Available K₂O declined progressively across all treatments from 30 DAS to harvest, reflecting continuous crop removal (Table 3). At every stage, T₅, T₆ and T₇ (elevated-K treatments) recorded significantly higher available K₂O than T₂, T₃ and T₄, which in turn were significantly superior to the control. At harvest, T₅ (296.16 kg ha⁻¹), T₆ (291.18 kg ha⁻¹) and T₇ (289.24 kg ha⁻¹) remained statistically on par, indicating that raising the base K level maintained a more robust residual K pool than magnesium sulphate addition alone. The mar-

ginal decline in K₂O with increasing MgSO₄ dose within a K level (e.g., T₅ > T₆ > T₇) is consistent with K–Mg competitive uptake at root exchange sites, whereby improved Mg availability enhances plant K uptake efficiency and translocation, drawing down soil K slightly faster. These findings are in accordance with those reported by Patil and Basavaraja (2017) [11], Marschner (2012) [9] and Havlin *et al.* (2014) [10], who reported that higher potassium application increases exchangeable soil potassium, whereas balanced nutrition and greater crop productivity lead to higher potassium removal, thereby reducing residual potassium in the soil after harvest.

Table 3. Effect of potassium and magnesium sulphate levels on available K₂O (kg ha⁻¹) status of soil at different growth stages

Treatment	Avail. K ₂ O (kg ha ⁻¹)			
	30 DAS	60 DAS	90 DAS	Harvest
T ₁ : Absolute control	267.19	260.07	258.82	255.07
T ₂ : N : P ₂ O ₅ : K ₂ O = 100 : 50 : 25 kg ha ⁻¹ (PoP)	304.82	293.04	277.15	275.08
T ₃ : T ₂ + magnesium sulphate 10 kg ha ⁻¹	302.79	291.07	275.11	273.04
T ₄ : T ₂ + magnesium sulphate 20 kg ha ⁻¹	300.05	288.43	272.08	269.04
T ₅ : 100 kg N, 50 kg P ₂ O ₅ and 50 kg K ₂ O ha ⁻¹	324.64	305.36	299.33	296.16
T ₆ : T ₅ + magnesium sulphate 10 kg ha ⁻¹	321.07	309.84	295.46	291.18
T ₇ : T ₅ + magnesium sulphate 20 kg ha ⁻¹	317.68	305.91	292.18	289.24
SEm±	5.36	6.52	4.54	5.75
CD @5%	16.51	20.08	14.01	17.73

Exchangeable calcium and magnesium

Exchangeable Ca did not differ significantly among treatments at any growth stage, though it showed a numerically declining trend with higher K and Mg supply (T₇ lowest at harvest: 1.14 cmol(p⁺) kg⁻¹ vs. T₂ highest: 1.38), consistent with cationic competition suppressing Ca retention on exchange sites under intensive K–Mg fertilization. Exchangeable Mg, in contrast, was significantly and consistently improved by magnesium sulphate application at all stages (Table 3). At

harvest, T₇ recorded the highest exchangeable Mg (0.85 cmol(p⁺) kg⁻¹), on par with T₄ (0.83) and T₆ (0.78), and significantly superior to T₃, T₅, T₂ and the control (T₁: 0.59). This confirms the direct and sustained contribution of applied MgSO₄ to the soil-exchangeable Mg pool, with the effect scaling with dose. These findings corroborate those of Ding *et al.* (2006) [12] and Mengel and Kirkby (2001) [13], who reported that magnesium fertilization increases exchangeable soil magnesium, while crop uptake causes a gradual decline during the growing season.

Table 4. Effect of potassium and magnesium sulphate levels on exchangeable Ca and Mg status of soil at different growth stages [cmol(p⁺) kg⁻¹]

Treatment	Exch. Ca [cmol(p ⁺) kg ⁻¹]				Exch. Mg [cmol(p ⁺) kg ⁻¹]			
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest
T ₁	1.74	1.31	1.26	1.11	0.70	0.68	0.63	0.59
T ₂	2.46	1.98	1.43	1.38	0.82	0.76	0.69	0.60
T ₃	2.18	1.58	1.46	1.34	0.87	0.81	0.79	0.75
T ₄	1.96	1.49	1.33	1.28	0.94	0.88	0.80	0.83
T ₅	2.24	1.72	1.58	1.47	0.81	0.78	0.73	0.70
T ₆	1.90	1.50	1.42	1.37	0.89	0.82	0.80	0.78
T ₇	1.81	1.29	1.26	1.14	0.97	0.90	0.87	0.85
SEm±	0.20	0.27	0.24	0.19	0.04	0.06	0.03	0.03
CD @5%	NS	NS	NS	NS	0.13	0.18	0.09	0.10

Available sulphur

Available S was significantly influenced throughout the crop period, declining from 30 DAS to harvest in all treatments (Table 5). T₇ recorded the highest available S at every stage (20.52, 20.14, 19.71 and 19.68 mg kg⁻¹), on par with T₄, T₆ and T₃, and significantly superior to T₂ and T₅ (the non-MgSO₄ treatments), which remained on par with each other. This directly reflects the S contribution of mag-

nesium sulphate as a fertilizer source, independent of the K level applied. Treatments receiving magnesium sulphate maintained higher residual sulphur throughout the crop growth period, indicating sustained sulphur availability following fertilizer application. Similar findings were reported by Tiwari (2002) [14] regarding increased soil available sulphur following magnesium sulphate application and its gradual depletion due to crop uptake.

Table 5. Effect of potassium and magnesium sulphate levels on available sulphur status of soil at different growth stages (mg kg⁻¹)

Treatment	Avail. sulphur (mg kg ⁻¹)			
	30 DAS	60 DAS	90 DAS	Harvest
T ₁ : Absolute control	11.42	10.21	9.61	8.94
T ₂ : N : P ₂ O ₅ : K ₂ O = 100 : 50 : 25 kg ha ⁻¹ (PoP)	18.61	17.52	17.00	16.60
T ₃ : T ₂ + magnesium sulphate 10 kg ha ⁻¹	19.53	19.33	18.92	18.48
T ₄ : T ₂ + magnesium sulphate 20 kg ha ⁻¹	20.32	19.87	19.68	19.52
T ₅ : 100 kg N, 50 kg P ₂ O ₅ and 50 kg K ₂ O ha ⁻¹	18.42	17.88	16.92	16.44
T ₆ : T ₅ + magnesium sulphate 10 kg ha ⁻¹	19.69	19.26	18.95	18.71
T ₇ : T ₅ + magnesium sulphate 20 kg ha ⁻¹	20.52	20.14	19.71	19.68
SEm±	0.50	0.46	0.57	0.48
CD @5%	1.53	1.43	1.77	1.47

(continued on next page)

Micronutrient status

DTPA-extractable Zn, Cu, Fe and Mn in post-harvest soil were not significantly affected by treatment (Table 6), though all four showed a consistent numerical peak under T₄ and T₇ — the MgSO₄-supplemented treatments — and the lowest values under the control. This

marginal enrichment is plausibly linked to the sulphur supplied through MgSO₄, which can favour micronutrient availability by maintaining a more reduced soil chemical environment, though the effect did not reach statistical significance within this trial. Similar observations were reported by Havlin *et al.* (2014) [10] and Alloway (2008) [15].

Table 6. Effect of potassium and magnesium sulphate levels on micronutrient status of soil at harvest (mg kg⁻¹)

Treatment	Zn	Cu	Fe	Mn
T ₁ : Absolute control	2.48	1.86	26.84	5.28
T ₂ : N : P ₂ O ₅ : K ₂ O = 100 : 50 : 25 kg ha ⁻¹ (PoP)	2.72	2.01	28.24	5.64
T ₃ : T ₂ + magnesium sulphate 10 kg ha ⁻¹	2.78	2.05	28.58	5.72
T ₄ : T ₂ + magnesium sulphate 20 kg ha ⁻¹	2.84	2.08	28.92	5.80
T ₅ : 100 kg N, 50 kg P ₂ O ₅ and 50 kg K ₂ O ha ⁻¹	2.68	1.98	27.92	5.56
T ₆ : T ₅ + magnesium sulphate 10 kg ha ⁻¹	2.74	2.02	28.30	5.64
T ₇ : T ₅ + magnesium sulphate 20 kg ha ⁻¹	2.80	2.07	28.64	5.72
SEm±	0.150	0.132	0.888	0.291
CD @5%	NS	NS	NS	NS

Conclusion

Application of potassium and magnesium sulphate did not significantly alter soil pH, EC, organic carbon or DTPA-extractable micronutrients, indicating that these treatments are compatible with the inherent physico-chemical buffering of the soil. However, magnesium sulphate application, particularly at 20 kg ha⁻¹ combined with the elevated potassium level (T₇), significantly improved exchangeable magnesium and available sulphur status, while elevated potassium levels (T₅–T₇) sustained higher residual available K₂O than the recommended package of practices. These findings support the combined application of potassium and magnesium sulphate — specifically 100 kg N, 50 kg P₂O₅, 50 kg K₂O ha⁻¹ with MgSO₄ @ 20 kg ha⁻¹ — as a nutrient management strategy that improves soil secondary-nutrient status without compromising major soil properties under maize in the Southern Transition Zone of Karnataka.

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