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Effect of potash, iron and zinc on soil fertility status after harvest of groundnut

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Abstract
A field experiment was conducted during the *kharif* seasons of 2022 and 2023 at the Agronomy Instructional Farm, Department of Agronomy, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, to evaluate the effect of potassium, iron, and zinc on the growth, yield, and quality of groundnut. The study comprised 27 treatment combinations involving three levels each of potassium (K_0: 0, K_1: 25, K_2: 50 kg K_2O ha^{-1}), iron (Fe_0: 0, Fe_1: 15, Fe_2: 30 kg Fe ha^{-1}), and zinc (Zn_0: 0, Zn_1: 8, Zn_2: 16 kg Zn ha^{-1}), laid out in a factorial randomized block design with three replications. The pooled results revealed that application of 50 kg K_2O ha^{-1} (K_2), 30 kg $FeSO_4.7H_2O$ ha^{-1} (Fe_2), and 16 kg $ZnSO_4.7H_2O$ (Zn_2) ha^{-1} significantly improved in available K_2O, DTPA extractable Fe and zinc in soil.

Keywords: Groundnut, Potash, Iron, Zinc, Soil fertility

Introduction

Ensuring sustainable agricultural productivity in India increasingly depends on the judicious use of fertilizers that supply both macronutrients and micronutrients. Among these, potash (K), iron (Fe) and zinc (Zn) are particularly important due to their multifaceted roles in crop development and soil health. The dominance of conventional NPK fertilization, often lacking adequate micronutrients, has led to the emergence of widespread deficiencies especially of Fe and Zn in many intensively cultivated regions. This problem is notably severe in the light-textured, low organic matter soils of North Gujarat, where continuous cropping and limited organic inputs have further depleted nutrient reserves. Potassium is essential for maintaining plant water relations, activating enzymatic systems, enhancing photosynthate translocation, and improving stress resistance. Iron plays a critical role in chlorophyll biosynthesis, respiratory metabolism, and electron transport. Zinc, on the other hand, is involved in a wide range of physiological processes, including protein and nucleic acid synthesis, hormonal regulation, and reproductive development.

Groundnut (*Arachis hypogaea* L.), is a vital component of India's oilseed economy. It is cultivated extensively for its high oil and protein content, with India ranking first globally in groundnut acreage. Gujarat is the leading state in both area and production, contributing significantly to national output. Groundnut oil, rich in heart-healthy monounsaturated and polyunsaturated fatty acids, holds immense nutritional and economic value. Furthermore, groundnut haulm serves as a valuable livestock feed due to its high digestibility and crude protein content, particularly important in mixed farming systems. The crop also contributes to soil fertility through nitrogen fixation, making it an ideal component in sustainable crop rotations. Despite its agronomic and economic importance, groundnut productivity remains sub-optimal in many areas due to imbalanced and insufficient nutrient management. Deficiencies of K, Fe, and Zn are commonly observed, limiting not only yield but also the quality of pods and kernels. Therefore, there is a growing need to adopt balanced and integrated nutrient management practices that include secondary and micronutrients, in order to enhance crop performance, improve soil fertility, and ensure long-term sustainability of groundnut-based cropping systems.

Materials and Methods

The experiment was conducted on plot no. C-13 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, District Banaskantha. The soil of the experimental site was loamy sand in texture, low in organic carbon, available potassium, sulphur, and DTPA-extractable iron (Fe), medium in available nitrogen, phosphorus, sulphur, and DTPA-extractable manganese (Mn) and zinc (Zn), and high in DTPA-extractable copper (Cu). The electrical conductivity (EC) of the soil was within the normal range, indicating no salinity hazard. A recommended dose of fertilizer (RDF) comprising 12.5:25:25 kg N:P_2O_5:S ha^{-1} was uniformly applied to the groundnut crop in all treatments.

Results and Discussion

Available nitrogen, phosphorus and potash

The data on the post-harvest status of available nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) in soil as influenced by varying levels of potassium, iron, and zinc reveal distinct trends. The application of potassium showed a significant effect on soil potassium availability, while its influence on nitrogen and phosphorus remained statistically non-significant. The highest available potassium content in soil (141.2 kg ha^{-1}) was recorded under the K_2 treatment (50 kg K ha^{-1}), which was significantly higher than the control (K_0: 132.6 kg ha^{-1}), indicating a substantial residual contribution of potash to the soil. This is attributable to the fact that applied potassium supplements the soil's exchangeable K pool, especially in light-textured soils like those in North Gujarat, where fixation is limited. On the other hand, available nitrogen content ranged from 250.1 to 255.9 kg ha^{-1}, and phosphorus ranged from 44.00 to 45.05 kg ha^{-1}, with no significant differences among potassium, iron, or zinc levels. However, numerically higher N and P values were observed with Fe_1 (15 kg Fe ha^{-1}) and Zn_1 (8 kg Zn ha^{-1}) treatments, suggesting minor improvements.

Table 1: Effect of potash, iron and zinc on available nitrogen, phosphorus and potash in soil after harvest of groundnut crop

Treatments	Available N (kg ha^{-1})			Available P_2O_5 (kg ha^{-1})			Available K_2O (kg ha^{-1})		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Levels of Potash (K)									
K_0: 00 kg ha^{-1}	264.2	244.6	254.4	45.52	42.49	44.01	134.0	131.2	132.6
K_1: 25 kg ha^{-1}	268.3	238.2	253.2	46.72	43.29	45.00	138.1	140.0	139.1
K_2: 50 kg ha^{-1}	262.8	244.4	253.6	47.00	43.10	45.05	140.0	142.4	141.2
S.Em ±	2.755	2.571	1.884	0.517	0.503	0.361	1.417	1.167	0.918
C.D. at 5%	NS	NS	NS	NS	NS	NS	4.02	3.31	2.57
Levels of Iron (Fe)									
Fe_0: 00 kg ha^{-1}	269.5	240.1	254.8	47.16	42.37	44.77	137.7	138.2	137.9
Fe_1: 15 kg ha^{-1}	264.2	247.6	255.9	46.13	43.00	44.56	136.0	136.4	136.2
Fe_2: 30 kg ha^{-1}	261.5	239.4	250.5	45.96	43.50	44.73	138.4	139.1	138.8
S.Em ±	2.755	2.571	1.884	0.517	0.503	0.361	1.417	1.167	0.918
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of Zinc (Zn)									
Zn_0: 00 kg ha^{-1}	262.0	238.3	250.1	45.78	42.38	44.08	136.8	137.3	137.0
Zn_1: 08 kg ha^{-1}	269.8	241.8	255.8	46.15	43.81	44.98	136.8	137.4	137.1
Zn_2: 16 kg ha^{-1}	263.4	247.1	255.3	47.32	42.68	45.00	138.5	138.9	138.7
S.Em ±	2.755	2.571	1.884	0.517	0.503	0.361	1.417	1.167	0.918
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction									
K × Fe, K × Zn, Fe × Zn, K × Fe × Zn	-	-	-	-	-	-	-	-	-
Year and Year interactions									
Y S.Em ±	-	-	1.538	-	-	0.295	-	-	0.750
C.D. at 5%	NS	NS	4.314	NS	NS	0.826	NS	NS	NS
Y × K, Y × Fe, Y × Zn, Y × K × Fe, Y × K × Zn, Y × Fe × Zn, Y × K × Fe × Zn	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	5.40	5.51	5.46	5.79	6.08	5.93	5.36	4.40	4.90
Initial	260.2	240.5	-	45.78	45.64	-	120.5	131.8	-

The slight increase in nitrogen and phosphorus availability with Fe and Zn application could be due to their role in enhancing root growth and microbial activity in the rhizosphere. Iron is involved in nitrate reduction and other redox reactions that influence nitrogen cycling, while zinc plays a critical role in the activation of enzymes such as phosphatases and supports auxin production, which stimulates root development and better nutrient uptake. Additionally, potassium application enhances translocation of photosynthates and root exudation, which can indirectly support microbial-mediated phosphorus solubilization. Despite these biological interactions, the differences in N and P availability were not statistically significant, possibly due to the short-term nature of the experiment or the buffering capacity of the soil.

No significant interactions were observed among the different nutrient combinations (K × Fe, K × Zn, Fe × Zn, and K × Fe × Zn), indicating independent effects of the nutrients. Year-to-year variations and their interactions with nutrient treatments were also non-significant, except for a slight year effect on available nitrogen and phosphorus in pooled data, likely due to seasonal environmental factors affecting mineralization and microbial dynamics. Compared to the initial soil test values (260.2 kg ha^{-1} N, 45.78 kg ha^{-1} P_2O_5, and 120.5 kg ha^{-1} K_2O), a positive build-up in available potassium was evident under higher K treatments, whereas nitrogen and phosphorus showed relatively stable levels. These findings emphasize the importance of potassium supplementation in maintaining soil fertility, while also highlighting the potential but limited short-term impact of iron and zinc on macro-nutrient availability in groundnut-based cropping systems.

Available sulphur and DTPA extractable Fe and Zn

The post-harvest analysis of soil revealed varied responses of available sulphur and DTPA-extractable micronutrients (iron and zinc) to the application of potash, iron, and zinc fertilizers. The available sulphur content ranged from 8.06 to 8.25 mg kg^{-1} across treatments, showing no significant differences due to any of the applied nutrients. Although statistically non-significant, sulphur availability slightly improved under Zn_1 (8 kg Zn ha^{-1}) and Zn_2 (16 kg Zn ha^{-1}), which may be attributed to enhanced root development and microbial activity that promote sulphur mineralization. Potassium and iron, through their role in stimulating enzymatic processes and root growth, may also contribute to minor improvements in sulphur availability, though the effect was not distinct.

In contrast, DTPA-extractable iron in soil increased significantly with iron application, with the highest Fe availability (3.986 mg kg^{-1}) recorded under Fe_2 (30 kg Fe ha^{-1}), as compared to Fe_0 (3.564 mg kg^{-1}). This clearly demonstrates the residual benefit of iron fertilization in replenishing plant-available Fe, especially in the light-textured soils of North Gujarat where Fe deficiency is common due to high pH and low organic matter. Iron also supports microbial decomposition and redox reactions, contributing to greater Fe solubility. The outcomes corroborate the earlier findings of Yadav *et al.* (2011) [3] and Salwa *et al.* (2011).

Table 2: Effect of potash, iron and zinc on available sulphur and DTPA extractable Fe and Zn in soil after harvest of groundnut crop

Treatments	Available S (mg kg^{-1})			Fe (mg kg^{-1})			Zn (mg kg^{-1})		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Levels of Potash (K)									
K_0: 00 kg ha^{-1}	7.64	8.81	8.22	3.588	3.950	3.769	0.614	0.706	0.660
K_1: 25 kg ha^{-1}	7.62	8.59	8.11	3.620	3.963	3.791	0.618	0.713	0.666
K_2: 50 kg ha^{-1}	7.83	8.58	8.20	3.662	4.085	3.873	0.630	0.704	0.667
S.Em ±	0.086	0.093	0.063	0.053	0.047	0.036	0.006	0.004	0.004
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of Iron (Fe)									
Fe_0: 00 kg ha^{-1}	7.68	8.57	8.13	3.313	3.815	3.564	0.622	0.709	0.665
Fe_1: 15 kg ha^{-1}	7.69	8.66	8.17	3.732	4.036	3.884	0.628	0.711	0.670
Fe_2: 30 kg ha^{-1}	7.71	8.75	8.23	3.825	4.147	3.986	0.611	0.703	0.657
S.Em ±	0.086	0.093	0.063	0.053	0.047	0.036	0.006	0.004	0.004
C.D. at 5%	NS	NS	NS	0.150	0.134	0.100	NS	NS	NS
Levels of Zinc (Zn)									
Zn_0: 00 kg ha^{-1}	7.57	8.55	8.06	3.593	3.963	3.778	0.539	0.625	0.582
Zn_1: 08 kg ha^{-1}	7.73	8.77	8.25	3.628	3.950	3.789	0.568	0.656	0.612
Zn_2: 16 kg ha^{-1}	7.79	8.66	8.22	3.648	4.085	3.866	0.754	0.842	0.798
S.Em ±	0.086	0.093	0.063	0.053	0.047	0.036	0.006	0.004	0.004
C.D. at 5%	NS	NS	NS	NS	NS	NS	0.018	0.010	0.010
Interaction									
K × Fe, K × Zn, Fe × Zn, K × Fe × Zn	-	-	-	-	-	-	-	-	-
Year and Year interactions									
Y S.Em ±	-	-	0.052	-	-	0.029	-	-	0.003
C.D. at 5%	NS	NS	0.144	NS	NS	0.081	NS	NS	0.008
Y × K, Y × Fe, Y × Zn, Y × K × Fe, Y × K × Zn, Y × Fe × Zn, Y × K × Fe × Zn	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	5.82	5.57	5.69	7.60	6.15	6.85	5.20	2.71	4.00
Initial	7.25	8.02	-	3.41	3.81	-	0.601	0.690	-

Zinc application had a significant and pronounced effect on DTPA-extractable Zn, with the highest value (0.798 mg kg^{-1}) under Zn_2 (16 kg Zn ha^{-1}), which was statistically superior to the lower levels and control. The build-up of extractable Zn indicates that applied zinc remained available in the upper soil layers, due to its limited mobility and low leaching losses. The increased Zn availability is critical for maintaining soil fertility and ensuring sufficient micronutrient supply for subsequent crops. The results align well with earlier observations reported Patel *et al.* (2007) [1].

Potassium application, while not having a statistically significant impact on S, Fe, or Zn availability, showed a slight numerical improvement in DTPA-extractable Fe and Zn with increasing doses. This may be due to potassium's role in enhancing root vigor, enzyme activation, and nutrient translocation, which can indirectly support better micronutrient cycling and availability in soil. No significant interactions were observed among the nutrient combinations (K × Fe, K × Zn, Fe × Zn, or K × Fe × Zn), and the year × treatment interactions were also non-significant. However, a significant year effect was observed for pooled available sulphur and zinc, possibly due to variations in climatic conditions influencing mineralization rates and microbial activity across seasons. Compared to the initial values of S (7.25–8.02 mg kg^{-1}), Fe (3.41–3.81 mg kg^{-1}), and Zn (0.601–0.690 mg kg^{-1}), the post-harvest nutrient levels under respective fertilized treatments showed measurable improvements, especially for Fe and Zn.

Summary

The application of 50 kg K_2O ha^{-1}, 30 kg $FeSO_4.7H_2O$ ha^{-1}, and 16 kg $ZnSO_4.7H_2O$ ha^{-1} significantly improved the post-harvest soil fertility by increasing available potassium and DTPA-extractable iron and zinc, indicating the beneficial effect of balanced nutrient management on sustaining soil health and productivity in groundnut cultivation.

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