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Effect of potash, iron and zinc on growth, yield attributes and yield of *kharif* 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 over two years indicated that the application of 50 kg K_2O ha^{-1} (K_2), 30 kg Fe ha^{-1} (Fe_2), and 16 kg Zn ha^{-1} (Zn_2) significantly enhanced growth parameters (such as plant height), yield attributes (including number of pods per plant, pod weight, and 100-kernel weight), and ultimately improved both pod and haulm yield. Based on the findings, it is concluded that for achieving higher productivity of groundnut in loamy sand soils of North Gujarat, apply 50 kg K_2O ha^{-1}, 30 kg $FeSO_4 \cdot 7H_2O$ ha^{-1}, and 8 kg $ZnSO_4 \cdot 7H_2O$ ha^{-1}, in conjunction with the recommended dose of fertilizer (RDF) comprising 12.5:25:25 kg N:P_2O_5:S ha^{-1}.

Keywords: Groundnut, potash, iron, zinc, yield

1. Introduction

Fertilizers, particularly potassium (K) and micronutrients such as iron (Fe) and zinc (Zn), play a crucial role in sustaining agricultural productivity in India. With the intensification of modern farming practices and heavy use of NPK fertilizers lacking micronutrients, deficiencies of Fe and Zn have become widespread especially in the light-textured soils of North Gujarat. Potassium contributes to various physiological functions like enzyme activation, water regulation, carbohydrate translocation, and enhances crop tolerance to abiotic and biotic stresses. Iron is vital for chlorophyll synthesis and photosynthesis, while zinc is essential for protein synthesis, hormone production, and seed development.

Groundnut (*Arachis hypogaea* L.), a major oilseed crop known as the "king of oilseeds," is highly significant for its high oil and protein content. India ranks first in groundnut cultivation area, with Gujarat being the leading state in both acreage and production. Groundnut is a valuable crop not only for its edible oil, which is rich in MUFA and PUFA, but also for its haulm, used as quality animal feed. Despite its importance, nutrient deficiencies especially of potassium, iron, and zinc are major constraints in achieving optimum yield and quality. Therefore, balanced and integrated nutrient management is essential to enhance groundnut productivity and soil fertility in Gujarat and similar agro-ecological zones.

2. 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.

2. Results and Discussion

2.1 Plant Height and Root Nodulation

The results revealed that plant height at harvest was significantly influenced by potash levels, while the number of root nodules per plant at flowering was not significantly affected by any individual or interactive treatments of potassium, iron, or zinc. Among potassium treatments, the application of 50 kg K_2O ha^{-1} (K_2) recorded the highest pooled plant height (45.48 cm), which was significantly superior to the control (42.48 cm), indicating a positive role of potassium in promoting vegetative growth. Potassium is known to improve cell expansion, turgor maintenance, and enzyme activation, all of which contribute to enhanced plant height. However, plant height differences due to iron and zinc treatments were statistically non-significant, although a slight increase was observed at higher doses.

Regarding root nodulation, although no statistical significance was found across treatments, a numerical increase in nodule number was observed with the highest doses of K, Fe, and Zn, particularly with Zn_2 (16 kg ha^{-1}), which showed a pooled mean of 57.85 nodules per plant. This suggests a possible beneficial influence of micronutrient supplementation on root activity and nitrogen fixation, as iron and zinc are crucial in nodule development and functioning of nitrogenase enzymes. The results corroborate with findings reported by Thesiya *et al.* (2013), Buriro *et al.* (2015) and Meena *et al.* (2018) [2, 4] who observed positive effects of potassium and micronutrients on groundnut vegetative traits and nodulation, though often non-significant due to environmental interactions or adequate background nutrient availability.

Table 1: Effect of potash, iron and zinc on plant height and no. of root nodule per plant (At flowering) of groundnut

Treatments	Plant height (cm) At harvest			No. of root nodule per plant (At flowering)		
	2022	2023	Pooled	2022	2023	Pooled
Levels of Potash (K)						
K_0: 00 kg ha^{-1}	41.82	43.15	42.48	52.55	59.96	56.25
K_1: 25 kg ha^{-1}	44.33	44.17	44.25	51.84	60.80	56.32
K_2: 50 kg ha^{-1}	44.87	46.09	45.48	52.68	60.40	56.54
S.Em ±	0.833	0.761	0.564	1.119	1.234	0.833
C.D. at 5%	2.36	2.16	1.58	NS	NS	NS
Levels of Iron (Fe)						
Fe_0: 00 kg ha^{-1}	42.55	44.11	43.33	51.68	59.84	55.76
Fe_1: 15 kg ha^{-1}	44.00	44.45	44.22	51.94	60.61	56.27
Fe_2: 30 kg ha^{-1}	44.47	44.86	44.66	53.44	60.71	57.08
S.Em ±	0.833	0.761	0.564	1.119	1.234	0.833
C.D. at 5%	NS	NS	NS	NS	NS	NS
Levels of Zinc (Zn)						
Zn_0: 00 kg ha^{-1}	43.08	44.35	43.71	51.29	58.96	55.13
Zn_1: 08 kg ha^{-1}	43.60	45.13	44.37	51.60	60.68	56.14
Zn_2: 16 kg ha^{-1}	44.33	43.94	44.14	54.18	61.52	57.85
S.Em ±	0.833	0.761	0.564	1.119	1.234	0.833
C.D. at 5%	NS	NS	NS	NS	NS	NS
Interaction						
K × Fe, K × Zn, Fe ×Zn, K × Fe × Zn	-	-	-	-	-	-
Year and Year interactions						
Y S.Em ±	-	-	0.460	-	-	0.680
C.D. at 5%	NS	NS	NS	NS	NS	1.91
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
C.V.%	9.91	8.89	9.40	11.11	10.62	10.86

Table 2: Effect of potash, iron and zinc on number of pods per plant and pod weight per plant of groundnut

Treatments	Number of pods per plant			Pod weight per plant (g)		
	2022	2023	Pooled	2022	2023	Pooled
Levels of Potash (K)						
K_0: 00 kg ha^{-1}	18.07	19.68	18.88	12.32	13.78	13.05
K_1: 25 kg ha^{-1}	18.16	20.68	19.42	12.93	14.50	13.71
K_2: 50 kg ha^{-1}	18.94	21.02	19.98	13.32	14.74	14.03
S.Em ±	0.249	0.336	0.209	0.191	0.225	0.148
C.D. at 5%	0.707	0.953	0.586	0.542	0.640	0.414
Levels of Iron (Fe)						
Fe_0: 00 kg ha^{-1}	17.89	19.77	18.83	12.39	14.02	13.21
Fe_1: 15 kg ha^{-1}	18.33	20.55	19.44	12.89	14.28	13.59

Fe_2: 30 kg ha^{-1}	18.95	21.07	20.01	13.29	14.72	14.00
S.Em ±	0.249	0.336	0.209	0.191	0.225	0.148
C.D. at 5%	0.707	0.953	0.586	0.542	0.640	0.414
Levels of Zinc (Zn)						
Zn_0: 00 kg ha^{-1}	17.92	19.97	18.95	12.49	14.00	13.25
Zn_1: 08 kg ha^{-1}	18.39	20.51	19.45	12.87	14.27	13.57
Zn_2: 16 kg ha^{-1}	18.85	20.90	19.88	13.20	14.75	13.98
S.Em ±	0.249	0.336	0.209	0.191	0.225	0.148
C.D. at 5%	0.707	0.953	0.586	0.542	0.640	0.414
Interaction						
K × Fe, K × Zn, Fe× Zn, K × Fe × Zn	K x Fe	K x Fe	K x Fe	K x Fe	K x Fe	K x Fe
Year and Year interactions						
Y S.Em ±	-	-	0.171	-	-	0.121
C.D. at 5%	NS	NS	0.48	NS	NS	0.34
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
C.V.%	7.04	8.52	7.91	7.71	8.17	7.98

2.2 Number of pods per plant and Pod weight per plant

Application of potassium, iron, and zinc significantly influenced the number of pods per plant and pod weight. Among potassium levels, 50 kg K_2O ha^{-1} (K_2) recorded the highest number of pods (19.98) and pod weight (14.03 g/plant) in pooled data, showing a clear positive impact of potassium on reproductive development and assimilate translocation. Similarly, the highest iron dose (30 kg Fe ha^{-1}) and zinc dose (16 kg Zn ha^{-1}) also showed significant increases in both traits, likely due to their role in photosynthesis, enzyme activation, and pod filling processes. These results confirm that balanced nutrition with macro- and micronutrients enhances yield attributes of groundnut, in line with earlier findings by Gowthami and Ananda (2017) and Ankesh *et al.* (2023) [1, 3].

Table 3: Effect of potash, iron and zinc on pod and haulm yield of groundnut

Treatments	Pod yield (kg ha^{-1})			Haulm yield (kg ha^{-1})		
	2022	**2023**	**Pooled**	**2022**	**2023**	**Pooled**
Levels of Potash (K)						
K_0: 00 kg ha^{-1}	2027	2190	2108	3195	3542	3369
K_1: 25 kg ha^{-1}	2286	2365	2326	3780	3988	3884
K_2: 50 kg ha^{-1}	2373	2405	2389	3857	4058	3957
S.Em ±	34.97	42.89	27.67	59.79	78.69	49.42
C.D. at 5%	99	122	78	170	223	139
Levels of Iron (Fe)						
Fe_0: 00 kg ha^{-1}	2137	2242	2190	3510	3722	3616
Fe_1: 15 kg ha^{-1}	2259	2304	2282	3578	3882	3730
Fe_2: 30 kg ha^{-1}	2289	2413	2351	3744	3984	3864
S.Em ±	34.97	42.89	27.67	59.79	78.69	49.42
C.D. at 5%	99	122	78	170	223	139
Levels of Zinc (Zn)						
Zn_0: 00 kg ha^{-1}	2156	2248	2202	3487	3732	3609
Zn_1: 08 kg ha^{-1}	2243	2342	2293	3637	3902	3770
Zn_2: 16 kg ha^{-1}	2286	2370	2328	3708	3954	3831
S.Em ±	34.97	42.89	27.67	59.79	78.69	49.42
C.D. at 5%	99	122	78	170	223	139
Interaction						
K × Fe, K × Zn, Fe ×Zn, K × Fe × Zn	K x Fe	K x Fe	K x Fe	K x Fe	K x Fe	K x Fe
Year and Year interactions						
Y S.Em ±	-	-	22.59	-	-	40.35
C.D. at 5%	NS	NS	63.35	NS	NS	113.15
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
C.V.%	8.15	9.61	8.94	8.60	10.59	9.72

2.3 Pod and haulm yield

The results presented in Table 3 indicate that the application of potash, iron, and zinc significantly influenced the pod and haulm yield of groundnut during both years (2022 and 2023) and in pooled data. Among the potash treatments, the highest pod yield (2389 kg ha^{-1}) and haulm yield (3957 kg ha^{-1}) were recorded with the application of 50 kg K_2O ha^{-1} (K_2), which was significantly superior to K_0 and K_1 levels. This improvement in yield could be attributed to enhanced translocation of photosynthates and better root development due to adequate potash nutrition. In case of iron application, 30 kg Fe ha^{-1} (Fe_2) recorded the highest pod yield (2351 kg ha^{-1}) and haulm yield (3864 kg ha^{-1}), significantly outperforming the lower levels of iron. The yield improvement may be due to increased chlorophyll synthesis and enhanced enzymatic activities that favor reproductive growth. Similarly, zinc application at 16 kg Zn ha^{-1} (Zn_2) resulted in the highest pod (2328 kg ha^{-1}) and haulm yield (3831 kg ha^{-1}), which was significantly superior to Zn_0 and Zn_1. This might be due to the crucial role of zinc in auxin production and membrane stability. The interaction effects among potash, iron, and zinc (K × Zn, Fe × Zn, and K × Fe × Zn) were found to be non-significant for both pod and haulm yield except K × Fe, indicating additive rather than synergistic effects. Year-wise interactions (Y × K, Y × Fe, Y × Zn, and higher-order interactions) were also non-significant, indicating a consistent response of treatments across both years. These results clearly suggest that balanced fertilization with potash at 50 kg ha^{-1}, iron at 30 kg ha^{-1}, and zinc at 16 kg ha^{-1} significantly enhances groundnut yield. These results confirm that balanced nutrition with macro- and micronutrients enhances yield of groundnut, in line with earlier findings by Patra *et al.* (1996), Meena *et al.* (2018) and Sakarvadia *et al.* (2020) [4, 5, 6].

3. Summary and conclusion

Based on two years of field experimentation, it is concluded that the application of 50 kg K_2O ha^{-1}, 30 kg $FeSO_4 \cdot 7H_2O$ ha^{-1}, and 8 kg $ZnSO_4 \cdot 7H_2O$ ha^{-1}, in conjunction with the recommended dose of fertilizers (12.5:25:25 kg N:P_2O_5:S ha^{-1}), significantly improves pod and haulm yields of groundnut.

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