Screening of groundnut genotypes for sulphur utilization potential

ABSTRACT

A microplot experiment was conducted on a medium black soil for screening of groundnut genotypes for improved S utilization. For this experiment four different S sources viz., Gypsum, SSP, FeSO4, and ZnSO4, were applied at four levels (S @ 0, 20, 30, and 40 kg ha^{-1}). The results revealed that the addition of 40 kg S ha^{-1} as FeSO4 substantially increased the dry matter production and sulphur uptake irrespective of groundnut genotypes. Sulphur application in the form of SSP enhanced the root length and number of pods per plant. Groundnut genotypes CO7, VRI 8, and TMV 14 were categorized as efficient S utilizers, while BSR 2 and ALR 3 were recorded to be inefficient S utilizers.

Key words: Gypsum, $FeSO_4$, black soil and groundnut genotypes.

INTRODUCTION

Groundnut covers 295 million hectares worldwide, producing 487 million tonnes with a productivity of 1647 kg per hectare [1]. India dominates the world in area under groundnut and would be the world's second largest groundnut producer. Groundnut accounts for 19.1% of total oilseeds area and 21.3 percent of total production in India. It is valued for its high-oil edible seeds, making it the world's fourth-largest source of edible oil and third-most source of vegetable protein. Calcium and sulphur, in addition to the essential minerals, play an important role in increasing groundnut production and productivity. Sulphur nutrition is essential for enhancing protein and amino acids contents.

The importance of sulphur nutrition for crop quality and quantity cannot be overstated. It encourages legume nodulation and results in larger oilseed grains [2]. Sulphur shortage, on the other hand, may result in poor blooming fruiting, cupping of leaves, reddening of the stem and petiole, and limited development. As a result, sulphur has become a vital component not only for crop quality but also for economic production. There are numerous sulphur sources in the country, and their efficacy in oil seed crops must be determined. In this present investigation a microplot research was carried out to categorize the utilization efficiency of groundnut genotypes.

MATERIALS AND METHODS

A microplot experiment was conducted in medium black soil in Periyanaickenpalayam, Coimbatore, Tamil Nadu. Groundnut genotypes CO 7, VRI 8, TMV 14, BSR 2, and ALR 3 were used for the study. Treatment schedule compiled of four sulphur sources SSP, gypsum, iron sulphate, and zinc sulphate applied @ 0, 20, 30, and 40 kg ha^{-1}. In microplot size of 1 m x 1 m the treatments were implemented. The design of the study was FRBD and treatments were replicated twice. As urea, DAP, and muriate of potash, the prescribed NPK fertilisers (25:50:75 kg NPK ha^{-1}) were applied. The post-harvest soil samples were collected and analysed for 0.15 % $CaCl_2$ extractable S availability using $BaCl_2$ turbidity method [3]. The experimental soil was slightly alkaline in reaction (8.12) with electrical conductivity (0.4 dS m^{-1}) and organic carbon content (4.6 g kg^{-1}). Initial soil fertility indicated low available N (188 kg ha^{-1}), medium P (13 kg ha^{-1}), low K (211 kg ha^{-1}), and low sulphur (9.8 mg kg^{-1}). Plant protection and production practices were undertaken, and the plants were raised upto maturity phase and harvested. Plant height, root length, and number of pods per plant also were recorded. Plant samples were collected at random during harvest and shade dried then oven dried at 70°C for 48 hours. The dried materials of seeds were ground in a Willey mill and digested in a 15 ml acid mixture (Nitric acid: Perchloric acid in a 5:2 ratio). After digestion, the sulphur content was determined by spectrophotometrically at 420 nm wave lengths using a blue filter. Sulphur assimilation was calculated by multiplying plant sulphur content with DMP.

Table 1. Initial Physical and Chemical Properties of the Experimental Site

Parameters	Values

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Soil series	periyanaickenpalayam
Soil taxonomy	*Vertic Ustropept*
Texture	Clay loamy
pH	8.12
Electrical conductivity (dS m^{-1})	0.54
Organic carbon (g kg^{-1})	4.8
Available Nitrogen (kg ha^{-1})	196
Available Phosphorus (kg ha^{-1})	12.6
Available Potassium (kg ha^{-1})	440
Available Sulphur (mg kg^{-1})	9.8

RESULTS AND DISCUSSION

Impact of sulphur source and levels on growth attributing characteristics

Effects of various sulphur sources and levels on plant growth parameters varied significantly. The treatment that receiving S @ 40 kg ha^{-1} as $FeSO_4$ recorded the highest plant height (65.0 cm) followed $ZnSO_4$. Among the groundnut genotype, CO7 variety registered the highest plant height, while the lowest plant height was recorded by BSR 2. Plant height, root length, and number of pods per plant were increased significantly as the sulphur level increased from 20 to 40 kg ha^{-1} [4]. Sulphur application increases metabolic activities in plants, resulting in enhanced meristematic activities, which leads to increased cell division, enlargement, and elongation, which could have aided in the attaining of greater plant height and dry matter production.

Regarding root length, CO 7 recorded the highest root length, followed by VRI 8 and ALR 3. The significant effects of sulphur application on root lengths of groundnut genotypes that varied from 8.19 to 22. (Table 2). The maximum root length was registered in the treatment that received S @ 40 kg ha^{-1} as SSP, whereas the shortest root length was recorded in $FeSO_4$ applied treatment. The observed improvement could be attributed to early and copious sulphur availability, resulting in enhanced nutritional environment for root growth and development [5]. Since sulphur is a secondary essential plant nutrient, it must be required for growth. As a result, overall growth with sulphur application in deficient soil might be attributed to its vital function in various physiological and biochemical processes which are essential for plant growth development.

Impact of sulphur source and levels on number of pods per plant

The number of pods per plant increased significantly when sulphur fertiliser levels were increased up to 40 kg ha^{-1} (Table 2). Application of SSP as S source registered the maximum number of the pods per plant (23.5). Gypsum and SSP both have a high calcium content (29 and 19 percent, respectively), which could have enhanced the number of pods. Similar findings were reported by Chaubey et al.,[6] in groundnut. Among the varieties, the CO7 variety and the treatment S @ 40 kg ha^{-1} registered the maximum no of pods per plant followed by VRI 8 (21.8) that received S in sufficient amount aids in the improvement of floral primordial, or reproductive components, which leads to the formation of pods and kernels in plants. Patel et al. (2009) reported similar results. Because of S fertilization's various roles in metabolism as an essential constituent of amino acids, as well as improvements in vegetative structures and assimilates, a balanced source-sink system is maintained [7, 8]. As a result, increasing the pod yield by enhancing the yield attributes of number of pods per plant, seed index, and shelling percentage and also due to early flowering and higher pod setting, sulphur application enhanced the yield.

Table 2. Effect of sulphur source and levels on growth and yield attributing characteristics of groundnut varieties

	Sulphur sources		Plant height (cm)					Root length (cm)					No of pods per plant			
		S_{0}	S_{20}	S_{30}	S_{40}	mean	S_{0}	S_{20}	S_{30}	S_{40}	mean	S_{0}	S_{20}	S_{30}	S_{40}	mean
CO 7	FeSO4	51.12	60.52	63.70	65.00	63.07	11.91	18.62	20.92	21.34	20.29	20.63	19.42	21.82	22.73	21.32
	$ZnSO_4$	50.06	59.85	63.00	64.29	62.38	11.98	18.51	20.56	20.96	20.01	20.42	20.00	21.74	22.16	21.30
	SSP	50.32	59.19	62.31	63.58	61.69	11.77	20.48	21.56	22.00	21.35	19.70	19.12	21.97	23.50	21.53
	Gypsum	51.66	58.54	61.62	62.88	61.01	11.57	18.26	21.24	21.58	20.36	20.77	19.90	21.87	23.17	21.65
	mean	50.79	59.52	62.66	63.94	62.04	11.81	18.97	21.07	21.47	20.50	20.38	19.61	21.85	22.89	21.45
VRI 8	FeSO4	46.14	55.39	58.31	59.50	57.73	11.30	16.08	18.07	18.43	17.53	17.16	18.02	20.24	21.09	19.78
	$ZnSO_4$	46.80	54.79	57.67	58.85	57.10	10.93	15.98	17.76	18.10	17.28	16.60	18.56	20.17	20.56	19.76
	SSP	47.28	54.18	57.03	58.20	56.47	10.77	17.69	18.62	19.00	18.44	16.45	17.73	20.38	21.80	19.97
	Gypsum	46.47	53.59	56.41	57.56	55.85	10.84	15.77	18.34	18.64	17.58	15.69	18.46	20.29	21.49	20.08
	mean	46.67	54.49	57.35	58.53	56.79	10.96	16.38	18.20	18.54	17.71	16.48	18.19	20.27	21.24	19.90
TMV 14	FeSO4	40.62	50.93	53.61	54.70	53.08	9.14	10.75	12.08	12.32	11.71	15.18	15.37	17.27	17.99	16.88
	$ZnSO_4$	42.04	50.37	53.02	54.10	52.49	8.99	10.68	11.87	12.10	11.55	14.42	15.83	17.21	17.54	16.86
	SSP	40.87	49.81	52.43	53.50	51.92	9.09	11.82	12.45	12.70	12.32	15.47	15.13	17.39	18.60	17.04
	Gypsum	40.08	49.26	51.86	52.91	51.34	8.68	10.54	12.26	12.46	11.75	15.12	15.75	17.31	18.34	17.14
	mean	40.90	50.09	52.73	53.80	52.21	8.98	10.95	12.16	12.40	11.84	15.04	15.52	17.30	18.12	16.98
BSR 2	FeSO4	42.01	49.44	52.04	53.10	51.52	8.90	10.58	11.89	12.13	11.53	14.67	14.21	15.97	16.64	15.61
	$ZnSO_4$	42.04	48.89	51.47	52.52	50.96	8.88	10.51	11.68	11.91	11.37	13.95	14.64	15.91	16.22	15.59
	SSP	41.76	48.35	50.90	51.94	50.40	9.28	11.64	12.25	12.50	12.13	14.11	13.99	16.08	17.20	15.76
	Gypsum	41.30	47.82	50.34	51.37	49.84	9.07	10.38	12.07	12.26	11.57	15.12	14.57	16.01	16.96	15.85
	mean	41.78	48.63	51.19	52.23	50.68	9.04	10.78	11.97	12.20	11.65	14.46	14.35	15.99	16.75	15.70
ALR 3	FeSO4	49.16	52.88	55.66	56.80	55.11	8.19	9.73	10.93	11.16	10.61	14.67	16.53	18.57	19.35	18.15
	$ZnSO_4$	50.25	52.30	55.05	56.18	54.51	8.53	9.67	10.75	10.96	10.46	13.95	17.02	18.50	18.86	18.13
	SSP	49.18	51.72	54.45	55.56	53.91	8.42	10.71	11.27	11.50	11.16	14.11	16.27	18.70	20.00	18.32
	Gypsum	50.46	51.15	53.85	54.95	53.32	8.29	9.55	11.10	11.28	10.64	15.12	16.94	18.62	19.72	18.43
	mean	49.76	52.01	54.75	55.87	54.21	8.36	9.91	11.01	11.22	10.72	14.46	16.69	18.60	19.48	18.26
			SE d	CD (P=0.05)				SE d	CD (P=0.05)				SE d	CD (P=0.05)		
		V	0.27	0.53			V	0.07	0.13			V	0.10	0.20		
		S	0.24	0.47			S	0.06	0.12			S	0.09	0.18		
		V×S×L	1.07	NS			V×S×L	0.27	NS			V×S×L	0.40	NS		

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Impact of sulphur source and levels on available and uptake of Sulphur

The treatment that received 40 kg ha^{-1} S as gypsum increased the available sulphur in post-harvest soil (18.7 mg kg^{-1}). Gypsum, being a sparingly soluble in nature that leads to lower solubility in soil. The reduced solubility of gypsum in soil could have increased the sulphur availability in the post-harvest soil [9]. Enhanced nutrient availability in the root zone, combined with an increasing metabolic activity at the cellular level, would have enhanced nutrient uptake and accumulation in diverse plant parts. Higher nutrient accumulation in vegetative plant parts, together with improved metabolism, resulted in significant nutrient translocation to the reproductive portions of the crop.

Sulphur concentration in groundnut kernels was influenced by varying sources and levels of sulphur in the same way as growth parameters were influenced (Table 3). Sulphur concentrations in groundnut pods increased significantly as sulphur levels increased up to 40 kg ha^{-1}. Application sulphur at 40 kg ha^{-1} increased S content in kernel. The uptake of S in the kernel was found to be the lowest in control (5.28 kg ha^{-1}). Application of $FeSO_4$ had the highest total uptake of S (14.66 kg ha^{-1}), which was significantly higher than the other treatments. The gypsum corrected only sulphur chlorosis. However, iron sulphate corrected iron and sulphur and zinc sulphate corrected zinc and sulphur chlorosis. Among the different fertilizer amendments, iron sulphate application showed significant groundnut responses and higher Fe and S uptake than the other treatments.

The following genotypes had the maximum sulphur uptake: CO 7> VRI 8 > TMV 14. BSR 2 and ALR 3 varieties had the lowest sulphur uptake in the kernel. This trend could be attributed to the enhanced growth and yield characteristics, total dry matter production, and yield as a result of adequate sulphur availability, which aided in better absorption and translocation [10]. Higher plant growth and yield parameters owing to sulphur application up to 40 kg ha^{-1} could be attributed to increased nutrient uptake. Furthermore, in the presence of sulphur, higher nutrient uptake and better use of radiant energy resulted in higher vegetative and reproductive growth, hence increasing biological yield. The findings of this study in groundnut corroborate those of Giri et al.,[11] and Kader and Mona [12].

Table 3. Effect of sulphur source and levels on available and uptake sulphur of groundnut varieties

			Available sulphur (mg kg^{-1})					Sulphur uptake (kg ha^{-1})			
	S source	S_0	S_{20}	S_{30}	S_{40}	mean	S_0	S_{20}	S_{30}	S_{40}	mean
	FeSO4	9.63	13.20	16.70	18.40	16.10	9.34	12.00	13.80	14.66	13.50
	ZnSO4	9.90	13.10	16.20	18.20	15.80	9.55	11.10	13.00	14.50	12.90
CO7	SSP	9.88	14.10	16.60	18.50	16.40	9.29	10.30	13.00	14.30	12.60
	Gypsum	9.82	15.30	17.60	18.70	17.20	9.42	9.80	12.60	14.20	12.20
	mean	9.81	13.93	16.77	18.43	16.40	9.40	10.81	13.12	14.42	12.80
	FeSO4	8.73	12.20	15.50	17.00	14.90	8.96	10.80	12.40	13.20	12.10
	ZnSO4	8.93	12.10	15.00	16.80	14.60	9.18	10.00	11.70	13.10	11.60
	SSP	8.88	13.10	15.40	17.10	15.20	9.02	9.30	11.70	12.90	11.30
VRI8	Gypsum	9.02	14.10	16.30	17.30	15.90	9.11	9.40	11.40	12.80	11.20
	mean	8.89	12.89	15.52	17.05	15.20	9.07	9.87	11.82	12.98	11.60
	FeSO4	8.28	12.00	15.20	16.70	14.60	7.08	8.20	9.40	10.00	9.20
	ZnSO4	8.52	11.90	14.70	16.50	14.40	7.01	8.00	8.90	9.90	8.90
	SSP	8.43	12.90	15.10	16.80	14.90	6.96	7.70	8.90	9.80	8.80
TMV14	Gypsum	8.44	13.90	16.00	17.00	15.60	7.26	7.30	8.60	9.70	8.50
	mean	8.42	12.67	15.25	16.75	14.90	7.08	7.79	8.95	9.84	8.90
	FeSO4	8.29	11.90	15.10	16.60	14.50	6.28	8.10	9.30	9.92	9.10
	ZnSO4	8.25	11.80	14.60	16.40	14.30	6.23	7.50	8.80	9.80	8.70
	SSP	8.50	12.80	15.00	16.70	14.80	5.92	7.00	8.80	9.70	8.50
BSR2	Gypsum	8.23	13.80	15.90	16.90	15.50	5.70	6.70	8.50	9.60	8.30
	mean	8.32	12.59	15.16	16.66	14.80	6.03	7.31	8.88	9.76	8.70
	FeSO4	8.69	12.00	15.20	16.70	14.60	5.28	7.60	8.80	9.34	8.60

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ALR3	ZnSO4	8.70	11.90	14.70	16.50	14.40	5.54	7.10	8.30	9.20	8.20
	SSP	8.34	12.90	15.10	16.80	14.90	5.72	6.60	8.30	9.10	8.00
	Gypsum	8.83	13.90	16.00	17.00	15.60	5.62	6.30	8.00	9.00	7.80
	mean	8.64	12.67	15.25	16.75	14.90	5.54	6.89	8.36	9.19	8.10
			SE d	CD (P=0.05)				SE d	CD (P=0.05)		
		V	0.07	0.14			V	0.05	0.11		
		S	0.06	0.12			S	0.05	0.09		
		V×S×L	0.27	NS			V×S×L	0.21	NS		

CONCLUSION

The present study found that sulphur source and levels had a significant positive effect on groundnut varieties growth and yield-related parameters. Sulphur biofortification of groundnut varieties revealed that CO 7, VRI 8, TMV 14 seemed to have the highest sulphur uptake, while BSR 2, ALR 3 had the lowest. S @ 40 kg ha^{-1} as $FeSO_4$ had a significantly greater sulphur uptake in all varieties when compared to other sources. As sulphur levels increased up to 40 kg ha^{-1}, the amount of sulphur uptake increased in groundnut.

REFERENCE

[1] Food and Agriculture Organization (FAO). FAOSTAT Statistical Database of the United Nation Food and Agriculture Organization (FAO) statistical division. Rome; 2019.

[2] Tandon HLS. Sulphur Research and Agricultural Production in India. FDCO, New Delhi, (3rd Ed.); 1991.

[3] Williams CH, Steinbergs A. 1959. Soil sulphur fractions as chemical indices of available sulphur in some Australian soils. *Australian Journal of Agricultural Research*. 1959; 10(3): 340-352.

[4] Singh RA. Effect of variable doses of potassium, sulphur and calcium on pod yield of short duration summer groundnut (Arachis hypogaea L.*). International Journal of Agricultural Sciences*. 2007; 3(1): 196-198.

[5] Kalaiyarasan C, Vaiyapuri V, Chandrasekharan MVS. Effect of sulphur sources and levels on nutrient uptake, crop quality and use in groundnut. *Journal of International Academia*. 2007; 11(1): 55-58.

[6] Chaubey AK, Singh SB, Kaushik MK. Response of groundnut (Arachis hypogaea) to source and level of sulphur fertilization in mid-western plains of Uttar Pradesh. *Indian Journal of Agronomy*. 2000; 45(1), 166-169.

[7] Patel GN, Patel P, Patel DM, Patel DK, Patel R. Yield attributes, yield, quality and uptake of nutrients by summer groundnut, (Arachis hypogaea L.) as influenced by sources and levels of sulphur under varying Irrigation schedule. *Journal of oilseed Research*. 2009; 26(2): 119-122.

[8] Jat R A, Ahlawat IPS. Effect of farm yard manure, source and level of sulphur on growth attributes, yield, quality and total nutrient uptake in pigeonpea (Cajanus cajan) and groundnut (Arachis hypogaea) intercropping system. *Indian Journal of agricultural Science*. 2009; 79(12): 1016-1019.

[9] Humair Ahmed. Yield and quality of groundnut genotypes as affected by different sources of sulphur under rainfed conditions. *Soil Environ*. 2017; 36(2): 146-153.

[10] Sisodiya RR, Babaria NB, Parmar TN, Parmar KB. Effect of sources and levels of sulphur on yield and micronutrient (Fe, Mn, Zn and Cu) absorption by groundnut (Arachis hypogaea L.). *International Journal of Agriculture Sciences*. 2017; 9(32):4465-4467.

[11] Giri U, Kundu P, Chakraborty A, Bandyopadhyay P. Effect of sulphur and different irrigation regimes on groundnut. *Journal of Crop and Weed*. 2011; 7(2): 80-83.

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[12] Kader ELA, Mona G. Effect of sulphur application and foliar spraying with zinc and boron on yield, yield components, and seed quality of peanut (Arachis hypogaea L.). Research *Journal of Agricultural Bio Science*. 2013; 9(4): 127-135.

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