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Effect of Sulphur and Iron on chlorophyll Content, Leghaemoglobin Content, Soil Properties and Optimum Dose of Sulphurfor Groundnut (*Arachis hypogaea* L.)

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A B S T R A C T

An experiment was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner during kharif season 2017. The treatments comprising four Sulphur levels (control, 20 kg S/ha, 40 kg S/ha and 60 kg S/ha) and four foliar spray of iron (control, foliar spray of 0.5% $FeSO_4$ at flowering, peg formation and flowering + peg formation) assigned to main and subplots of Randomized Block Design, respectively were replicated thrice. Groundnut variety RG-425(Raj Durga) was used as a test crop. Sulphur fertilization 60 kg/ha significantly increased chlorophyll and leghaemoglobin content but enzymatic activities in soil were found significant at 40 kg S/ha. Soil properties like Available S increases up to 60 kg/ha, but Available N, P, K and Fe did not differ significantly on application of different levels of Sulphur. The foliar spray of 0.5% at flowering + peg formation stage increases chlorophyll and leghaemoglobin content. The available N, P, K, S and Fe in soil as well as dehydrogenase and alkaline phosphates were found non-significant on foliar spray of 0.5% $FeSO_4$ at different stages. Based on response studies, 60.19 kg/ha was found to be the optimum level of S for groundnut.

Introduction

Groundnut is most important oil seed crop of India. It is a world largest source of edible oil, ranks 13th among the food crops as well as 4th most important oilseed crop of the world (Ramanathan, 2001). Groundnut oil is a rich source of vitamin A, B and E and its content MUFA (40-50%) and PUFA (25-35%)that attributes to its relatively longer shelf life. The remaining 50 per cent of the kernel has high quality digestible protein, approximate (25.3 per cent), which is about 1.3 times higher than meat, 2.5 times higher than eggs, carbohydrates (6.0 to 24.9 %), minerals and vitamins (Das, 1997). In India, it was cultivated on an area of 6.6 m ha with production of 4.7 mt and productivity of 1486 kg/ha during 2016-2017 (AICRPG, 2016). In Rajasthan,it is mainly grown in arid and semi-arid districts of Ganganagar, Hanumangarh, Jaipur, Bikaner, Sikar, Churu, Jodhpur, Chittorgarh and Nagaur.

Balanced nutrition is considered as one of the basic needs "to achieve the potential yield"(Yadav *et al*, 2017). Sulphur imparts important and specific role in the synthesis of sulphur containing amino acids like methionine (20%) and cysteine (27%) and synthesis of proteins, chlorophyll and oil content. Moreover, it is also associated with the synthesis of vitamins (biotin, thiamine), co-enzyme-A metabolism of carbohydrates, proteins and fats. Sulphur is also known to promote nodulation in legumes there by N fixation and associated with the crops of spurious nutrition and market quality.

Global reports of sulphur deficiency and consequent crop responses; particularly in oilseed crops like groundnut are quite ostensible (Singh and Bairathi, 1980). Gypsum is another huge material deposit in the state of Rajasthan and being excavated at large scale. SSP is another source containing 12 per cent sulphur in addition to phosphorus. Thus, it is wise to select a relatively cheaper and more effective source of sulphur. In addition, application of sulphur in soil also regulates the pH and increases the availability of other nutrients. Iron is an essential micronutrient takes active part in the metabolic activities of the plant. It acts as activator of dehydrogenase, proteoses and peptidase enzyme, directly or indirectly involved in the synthesis of carbohydrate and protein in plant. It is a structural component of porphyrin molecule, cytochrome, heams, hematin, ferrochrome, and leghaemoglobin involved in oxidation reduction reaction in respiration or in root reduces. It is an important part of the enzyme nitrogenase which is essential for nitrogen fixation bacteria.

Materials and Methods

The present study was conducted at Agronomy Farm field no. 3e of Department of Agronomy and the plant and soil samples were analysed in Department of Soil Science and Agricultural Chemistry, S.K.N. College of Agriculture, Jobner (Rajasthan) during the *kharif* season, 2017. The average rainfall of this region is about 400 to 500 mm. The mean daily maximum and minimum temperatures during the growing crop season of groundnut varied between 31.5 to 36.6 and 13.8 to 26.6 respectively. Similarly, mean daily relative humidity reached between 37 to 81%.The soil of experimental site (before *kharif* 2017) was loamy sand in texture with soil pH 8.2.

Five plants were randomly selected from each plot of every replication. The leg haemoglobin content in root nodules estimated at flowering and peg formation was determined as per method advocated by Wilson and Reisenauer (1963) with Drabkin's solution. Optimum dose of sulphur for yield of groundnut under different sulphur levels will be worked out with the help of quadratic equation. To assess the fertility status of soil, the soil sample (0-15cm depth), from each plot at harvest of crop was taken. The samples were dried and passed through 2.0 mm plastic sieve to avoid metallic contamination for subsequent analysis and the samples were analysed as per standard methods.

Results and Discussion

Effect of Sulphur and iron on chlorophyll content

The data presented in the Table 1 that increasing levels of sulphur significantly increased the total chlorophyll content at flowering stage (2.380 mg/g) increased by 34.69, 22.99 and 6.82 per cent with the application of 0, 20 and 40 kg S/ha, respectively. Foliar application of 0.5% $FeSO_4$ at flowering + peg formation significantly increased the total chlorophyll content (2.419 mg/g) at flowering stage over rest of treatments. Application of 60 kg S/ha significantly increased the total chlorophyll content (2.227 mg/g) at peg formation stage over control, 20 kg and 40 kg S/ha by 20.90, 12.93 and 5.94 percent, respectively. Foliar application of 0.5% $FeSO_4$ at flowering + peg formation significantly increased the chlorophyll content (2.243 mg/g) at peg formation stage over rest of treatments.

Sulphur also plays a vital role in chlorophyll formation as its constituent of succinyl Co-A which is involved in synthesis of chlorophyll (Pirson, 1955). The favourable effect of foliar application of fertilizers might be due to on account of improved photosynthetic efficiency and chlorophyll formation. This might be due to readily available Fe at critical stage of plant growth that facilitated maximum nodulation. Meena *et al.,* (2013) also hold similar view on the plant growth.

Effect of sulphur and iron on leghaemoglobin content

Application of 60 kg S/ha recorded significant increase in leghaemoglobin content (flowering stage) by 39.98, 22.28, and 7.30 percent over control, 20 kg and 40 kg S/ha, respectively. Foliar application of 0.5% $FeSO_4$ at flowering + peg formation significantly increased the leghaemoglobin content (1.876 mg/g) at flowering stage. Application of 60 kg S/ha significantly increased the highest leghaemoglobin content (1.894 mg/g) obtained at peg formation stage. Data (Table 2) further revealed that foliar application of 0.5% $FeSO_4$ at flowering + peg formation recorded significantly higher leghaemoglobin content over control, 0.5% at flowering and 0.5% at peg formation stage representing an increase of 37.64, 21.87 and 7.98 percent, respectively.

Effect of sulphur and iron on soil properties

Application of sulphur upto 60 kg/ha significantly increased the available sulphur in soil at harvest which was maximum 10.82 mg/kg over preceding levels. The application of different levels of sulphur was found non-significant in available N, P, K and Fe. The foliar application of 0.5%$FeSO_4$ at different stages was found non significantly increased in available N, P, K, S, Fe.

Effect of sulphur and iron on enzymatic activities in soil

Results further indicates that Significantly maximum activity of this enzyme (20.71 µg TPF g^{-1} soil h^{-1}) was found at 40 kg S/ha, which was remained at par with 60 kg S/ha. The foliar spray of 0.5% $FeSO_4$ at different stages of crop gave non-significant effect on dehydrogenase activity of soil. The statistical analysis of data (Table 4) showed that successive increase in level of sulphur up to 40 kg S/ha significantly enhanced the alkaline phosphates activity (11.55 µg PNP produced g^{-1} soil h^{-1}) that was increased by 33.37 and 20.06 per cent over control and 20 kg S/ha, respectively. The alkaline phosphates activity in soil was found non-significant on spray of 0.5% $FeSO_4$ at different stages of groundnut.

The application of S and Fe as soil application resulted in increased microbial population and dehydrogenase enzyme and alkaline phosphatase activities and each additional supplementation of nutrients resulted in higher microbial population and enzyme activities, which was minimum when all the nutrient applied and maximum when all the three- nutrient applied. The result obtained in present investigation are in line with the finding of Kumawat *et al.*, 2008, Kumawat *et al.*, 2009, Mir *et al.*, 2013, Naida and Hala (2013) and Gajera *et al.*, 2014.

Table.1 Effect of sulphur and iron on total chlorophyll content in fresh leaves of groundnut at flowering and peg formation stage

Treatments	Chlorophyll content (mg g^{-1})	
	Flowering	Peg formation
Levels of sulphur (Gypsum)		
S_0 (Control)	1.767	1.842
S_{20} (20 kg S/ha)	1.935	1.972
S_{40} (40 kg S/ha)	2.228	2.102
S_{60} (60 kg S/ha)	2.380	2.227
SEm±	0.041	0.039
CD (P=0.05%)	0.119	0.113
Foliar spray of iron ($FeSO_4.7H_2O$)		
Fe_0(Control)	1.756	1.850
Fe_1(0.5% at flowering stage)	1.960	1.940
Fe_2 (0.5% at peg formation stage)	2.174	2.110
Fe_3 (0.5% at flowering + peg formation stage)	2.419	2.243
SEm±	0.041	0.039
CD (P=0.05%)	0.119	0.113

Table.2 Effect of sulphur and iron on leghaemoglobin content in nodules at flowering and peg formation stages

Treatments	Leghaemoglobin content (mg g^{-1})	
	Flowering	Peg formation
Levels of sulphur (Gypsum)		
S_0 (Control)	1.333	1.376
S_{20} (20 kg S/ha)	1.526	1.554
S_{40} (40 kg S/ha)	1.739	1.754
S_{60} (60 kg S/ha)	1.866	1.894
SEm±	0.043	0.043
CD (P=0.05%)	0.123	0.125
Foliar spray of iron ($FeSO_4.7H_2O$)		
Fe_0 (Control)	1.340	1.374
Fe_1 (0.5% at flowering stage)	1.527	1.560
Fe_2 (0.5% at peg formation stage)	1.721	1.756
Fe_3 (0.5% at flowering + peg formation stage)	1.876	1.888
SEm±	0.043	0.043
CD (P=0.05%)	0.123	0.125

Table.3 Effect of sulphur and iron level on available N, P_2O_5, K_2O, S and Fe in soil at harvest

Treatments	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	Available S (mg kg^{-1})	Available Fe (mg kg^{-1})
Levels of sulphur (Gypsum)					
S_0 (Control)	132.76	14.32	132.18	8.64	3.22
S_{20} (20 kg S/ha)	134.48	14.77	135.39	9.52	3.30
S_{40} (40 kg S/ha)	137.41	14.90	137.19	10.09	3.35
S_{60} (60 kg S/ha)	138.06	14.93	138.99	10.82	3.37
SEm±	1.88	0.33	2.44	0.14	0.06
CD (P=0.05%)	NS	NS	NS	0.41	NS
Foliar spray of iron ($FeSO_4.7H_2O$)					
Fe_0 (Control)	132.65	14.36	132.95	9.58	3.23
Fe_1 (0.5% at flowering stage)	134.86	14.75	135.80	9.68	3.31
Fe_2 (0.5% at peg formation stage)	137.10	14.89	136.20	9.78	3.34
Fe_3 (0.5% at flowering + peg formation stage)	138.10	14.92	138.80	10.01	3.36
SEm±	1.88	0.33	2.44	0.14	0.06
CD (P=0.05%)	NS	NS	NS	NS	NS

NS = Non significant

Table.4 Effect of sulphur and iron on dehydrogenase and alkaline phosphates enzyme activity in soil at harvest

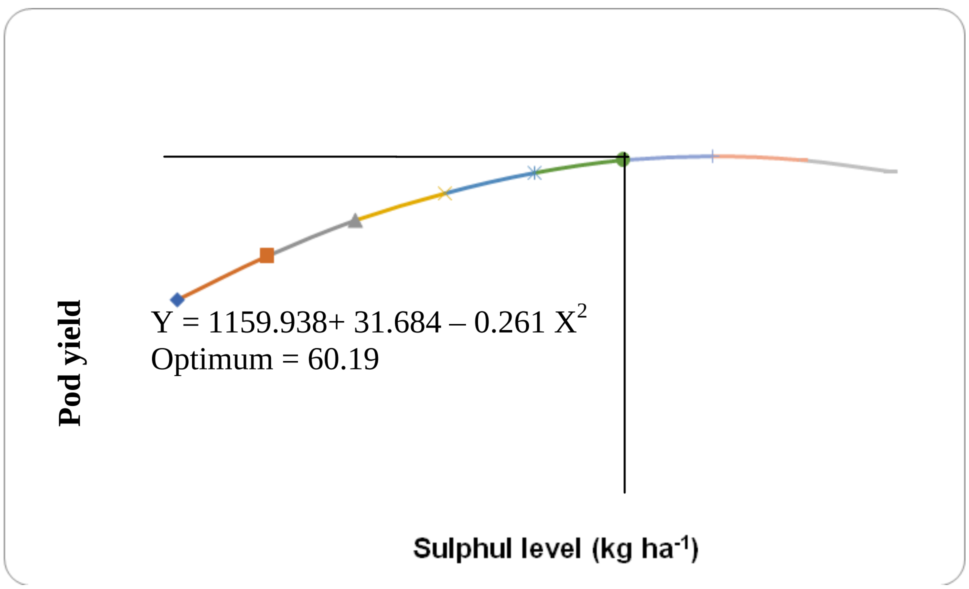
Treatments	Dehydrogenase (µg TPF g^{-1} soil h^{-1})	Alkaline phosphates enzyme (µg PNP produced g^{-1} soil h^{-1})
Levels of sulphur (Gypsum)		
S_0 (Control)	18.23	8.30
S_{20} (20 kg S/ha)	19.56	9.22
S_{40} (40 kg S/ha)	20.66	11.07
S_{60} (60 kg S/ha)	20.71	11.55
SEm±	0.38	0.20
CD (P=0.05%)	1.09	0.58
Foliar spray of iron ($FeSO_4.7H_2O$)		
Fe_0 (Control)	19.27	9.77
Fe_1 (0.5% at flowering stage)	19.69	9.85
Fe_2 (0.5% at peg formation stage)	19.99	10.23
Fe_3 (0.5% at flowering + peg formation stage)	20.21	10.30
SEm±	0.38	0.20
CD (P=0.05%)	NS	NS

Table.5 Seed yield (Y) as a function of sulphur fertilization ($Y = b_0+b_1 X b_2 X^2$)

S.No.	Study parameters	Sulphur
1	Partial regression coefficients	
	b_0	1159.938
	b_1	31.68438
	b_2	-0.26172
2	Coefficients of multiple correlation (R)	0.9965
3	Optimum level of sulphur (kg/ha)	60.19019
4	Yield at optimum level (kg/ha)	2118.86
5	Response at optimum level (kg/ha)	958.92

* significant at 5% levels of significance

Fig.1 Response of groundnut of sulphur fertilization



Optimum dose of sulphur

To be describe the relationship between yield of groundnut (Y) and applied sulphur at different sources. Since the main effect of S on yield of groundnut was found significant (Table 5 and fig 1), it was considered appropriate to establish a relationship describing the yield of groundnut as a function of main effect of S fertilization. The relationship of the type $Y= b_0 + b_1 S + b_2 S_2$ describing yield as a function of S derived from the observed data was curvilinear and presented in Table 4and Fig 1. Response of pod yield to varying level of sulphur was worked out and found to be quadratic Table (5). The perusal of data showed that the economic optimum level of sulphur was found to be 60.19 kg/ha with its corresponding pod yield of 2118.86 kg/ha.

Based on the result of one-year experimentation, it may be concluded that sulphur fertilization at 60 kg/ha and foliar spray of 0.5% $FeSO_4$. $7H_2O$ at flowering + peg formation stage was found to be the most superior treatments for obtaining chlorophyll and leghaemoglobin content. The effect of sulphur and iron on soil properties were found non- significant except available sulphur in case of S fertilization. The application of 40 kg S/ha was found significant increase in enzymatic activities but foliar spray of 0.5% $FeSO_4$ at different stages gave non-significant results. On the basis of production function, application of sulphur @ 60.19 kg/ha was worked out to be the optimum dose for groundnut.

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