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Response of Sesame (*Sesamum indicum* L.) to Sulphur and Lime Application under Soil Acidity

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Authors' contributions

This work was carried out in collaboration between all authors. Authors SK, RSM and AP designed the study, performed the laboratory analysis, wrote the protocol and wrote the first draft of the manuscript. Author GSY managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was carried out to study the effect of sulphur and lime application on sesame (*Sesamum indicum* L.) alley cropping. The results revealed that, increased application levels of sulphur up to 30 kg/ha significantly increased the plant height (136.91 and 151.83 cm), leaf area index (2.52 and 1.02), dry matter accumulation in leaves (2.44 and 1.32 g/plant) and dry matter accumulation in roots (2.62 and 2.89 g/plant) at 60 days after sowing (DAS) and at harvest, respectively. Further, increase the level of sulphur up to 45 kg/ha was statically at par with 30 kg sulphur/ha. Similar growth and yield patterns were observed with the application of 250 kg lime/ha in sesame. Moreover, all growth parameters at 30 DAS were observed not-significant sulphur and lime application. Interaction effect was also recorded at *P*=.05 level of significance between sulphur and lime levels on sesame seed (356.00 kg/ha), stalk (386.42 kg/ha) and biological (837.69 kg/ha kg/ha) yield with the application of 45 kg sulphur/ha + 350 kg lime/ha, which were observed to be the highest than all other treatments. The present investigation concluded that sulphur deficiency

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and soil acidity problems negatively affects sesame productivity and it can be overcome with applications of 30 kg sulphur/ha and 250 kg lime/ha in Vindhyan region of India.

Keywords: Lime; sulphur; soil acidity; sesame; yield.

1. INTRODUCTION

Sesame had earned a poetic label "Queen of Oilseeds" because seeds have high-quality poly-unsaturated stable fatty acids, which offer resistance to rancidity. Moreover, the seed is a rich source of edible oil (48-55%) and protein (20-28%), methionine, tryptophane, vitamin (niacine) and minerals (Ca and P) [1]. India is the major producer of sesame and ranks first both in area and production [2]. India grows nearly 25.73 million ha of oilseeds with the annual production of 26.68 million tonnes with the poorer productivity of 10.37 kg/ha [3].

Acid soils make up more or less 30% of the world's total land area and over 50% of the world's potentially arable lands, predominantly in the tropical and subtropical regions [4]. In India, about 49 million ha (30%) of the total cultivated land is acidic, out of this around 26 million ha land have pH below 5.6 and 23 million ha between 5.6 and 6.5 [5]. Soil acidity is one of the problems for sesame production in Vindhyan region, where crop do not give remunerative return rather it lowers down the yield to a great extent. At acid pH levels, organic matter mineralization is slowed down or stopped because of poor microbial activity linked to bacteria [6]. The effects of low soil pH on cation availability deteriorate aggregate stability since divalent cations, such as calcium ions, are absent at low soil pH. The addition of liming materials in soil encourages aggregation of soil particles. It also increases the availability and uptake of essential plant nutrients and the rate of organic matter decomposition by accelerating the activities of the soil microorganisms. The commonly used liming materials for the neutralization of soil solution hydrogen ions are oxides, hydroxides, carbonates (calcite and dolomite) and silicates of calcium and magnesium, slags (blast furnace slag, basic slag, electric furnace slag). The use of finely crushed limestone is one of the most important and practically feasible management practices to ameliorate the soil acidity [7].

Sulphur plays an imperative role towards improving the productivity, quality, and development of seeds of oilseed crops. Sesame is an oilseed crop, so for the enhancing the oil content in seed, sulphur is required. Today, sulphur is recognized as fourth most important nutrient after nitrogen, phosphorus, and potassium whose significance in balanced plant nutrition is increasingly realized with the increase in sulphur scarcity in Vindhyan region of India [8]. It increases root growth and stimulates seed formation and its deficiency results in poor flowering, fruiting, cupping of leaves, reddening of stems, petioles and stunted growth [9]. Scientific research indicated that application of sulphur in oilseeds is highly profitable and seems essential for boosting the seed and oil yield. Since little information is available on the application of sulphur above and lime and consequently their effect on growth, yield and seed quality of sesame under alley cropping in Vindhyan region, India, hence, the present investigation were undertaken to draw conclusive inferences.

2. MATERIALS AND METHODS

A field study was conducted during *Kharif* season of 2014 at Agronomy farm of Rajiv Gandhi South Campus, Banaras Hindu University, India, located on 25º 10’ N latitude 82º 37’ E longitudes and at an altitude of 427 meters above mean Arabian Sea level [10]. The soil of the experimental field was sandy loam in texture, acidic in reaction (pH 4.02) [11], low in EC (0.1 dS/m at 25℃), organic carbon (0.29%) [12], alkaline permanganate oxidizable N (202.36 kg/ha) [13] and available phosphorus (19.55 kg/ha) [14] but moderate in available K (235.75 kg/ha) [15]. The experiment was laid out in factorial randomize block design with three replications assigning 16 treatments combinations consisting four levels of sulphur (Control, 15, 30 and 45 kg/ha) and lime (Control, 100, 250 and 350 kg/ha). Sowing of sesame variety ‘shekhar’ was done on 06 August, 2013 at a row spacing of 30 cm in the agro-horti based system between rows of custard apple tree spacing of 7 X 7 m^2; custard apple trees were seven year old planted in August 2006. The recommended fertilizer dose (i.e. 30 kg N, 60 kg P_2O_5 and 30 kg K_2O/ha) were applied as Urea, DAP and MOP basally in the furrows just before sowing at a depth of 8-10 cm as per package of practices. Lime and sulphur were applied on the soil surface and thoroughly incorporated into soil

Table 1. Mean week-wise meteorological data during crop season *Kharif*, 2013

Standard week no.	Months	Rainfall (mm)	Temperature (℃)		Relative humidity (%)
			Max.	Min.	
32		32.35	34.11	26.55	95.50
33		78.22	33.35	26.23	94.14
34		149.93	33.34	26.21	96.57
35		186.80	32.92	26.02	92.57
36	August	00	34.34	25.67	92.10
37		25.29	34.58	25.91	94.56
38		00	34.95	25.30	92.35
39	September	19.23	32.23	26.35	93.62
40	October	21.98	32.65	26.40	92.36

Source: Observatory, Krishi Vigyan Kendra, R.G.S.C, BHU, Mirzapur (UP), India

at a depth of 15 cm before sowing as per the treatment. Data on growth yield and quality parameters were recorded from 5 randomly selected plants in each treatment plot. All other recommended production and protection practices were uniformly applied. All the data obtained were statistically analyzed using the F-test [16]. Critical difference (CD) values at P=0.05 were used for determining the of differences between mean values of treatments.

2.1 Crop and Weather

Weather parameters are presented in Table 1 (above), standard weak wise meteorological data collected during *Kharif*, 2013; indicate the seasonal maximum temperature during summer is as high as 45℃ and minimum temperature in winter falls beneath 10℃. The rain received during the crop season was 513.8 mm, out of the entirety rainfall over 65.53% received between 34 to 35 Standard Meteorological Weeks (SMW). Maximum and minimum temperature fluctuated between 34.95℃ and 25.30℃ and relative humidity between 96.57 and 92.10%.

3. RESULTS AND DISCUSSION

3.1 Effect of Sulphur Levels

Significant variation in respect of growth attributes *viz.,* plant height, leaf area index, dry matter accumulation in leaves and roots, seed, stalk and biological yield were recorded among the sulphur levels (Table 2 and Fig. 1). The results showed that among the different levels of sulphur, maximum growth and yield were recorded in 30 kg sulphur/ha and it was statistically significant. Sulphur is an essential element found in plants in a variety of compounds with many different functions. Sulphur nutrition is important for plant defence against biotic and abiotic stress and for the quality of sesame crop. The thiol (sulfhydryl) group of cystine in proteins takes the job of maintaining protein structure by forming disulphide bonds between two cystine residues via oxidation [17]. Sulphur plays an imperative role in seed formation of sesame and also responsible for keeping the system operating smoothly of plants and overall an increase in growth and yield parameters of sesame [18]. Thus, the improved growth and development of the crop plant in the present investigation might be the result of enhanced metabolic activities and photosynthetic rate, leading to improvement in the assimilation of dry matter at the successive growth and yield. The present results are also in agreement with the findings on oilseeds crops that have been done by several researchers [19,20,21,22,23].

3.2 Effect of Lime Levels

The results parented that amongst lime levels, maximum improvement were recorded at the P=0.05 level of significance growth parameters *viz*. LAI (1.04), dry matter accumulation in roots (2.56 and 2.86 g/plant) and leaves (2.46 and 1.31 g/plant), seed (286.08 kg/ha), stalk (358.28 kg/ha) and biological (633.42 kg/ha) yield in sesame with application of 250 kg lime/ha (Table 2 and Fig. 1). Lime is typically added to acid soils to neutralize the soil pH optimum for crop growth and development. Liming in acid soil makes the suitable environment to the root for better plant growth and yield as well as increasing concentration of essential nutrients by raising its pH and precipitating exchangeable aluminum in acid soil [24]. Availability of essential nutrients and biological activity in soils are generally greatest at intermediate pH at which organic matter break down and release of essential nutrients like N, P and S takes place. Further numerous scientific reports substantiated that addition of lime on acid soils is helpful and in agreement of the present researcher's findings [25,26,27].

Table 2. Effect of sulphur and lime levels on growth and yield parameters of sesame

Treatment	Growth parameters							Yield (kg/ha)	
	Leaf area index (LAI) at harvest	Dry matter accumulation in leaves (g/plant)			Dry matter accumulation in root (g/plant)				
		30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	Seed	Stalk
Sulphur levels (kg/ha)									
Control	0.65[b]	0.76[a]	1.75[c]	0.78[c]	0.31[a]	1.85[c]	1.95[b]	198.25[c]	278.75[c]
15	0.89[ab]	0.81[a]	2.12[b]	1.07[b]	0.37[a]	2.25[b]	2.35[b]	240.08[b]	308.85[b]
30	1.02[a]	1.76[a]	2.44[a]	1.32[a]	0.41[a]	2.62[a]	2.89[a]	282.75[a]	359.84[a]
45	1.05[a]	1.66[a]	2.51[a]	1.34[a]	0.42[a]	2.68[a]	2.99[a]	288.83[a]	365.31[a]
SEm±	0.08	0.16	0.10	0.07	0.07	0.10	0.17	2.38	9.26
CD (P=0.05)	0.23	NS	0.29	0.22	NS	0.28	0.48	6.88	26.75
Lime level (kg/ha)									
Control	0.63[b]	0.45[a]	1.72[c]	0.74[c]	0.30	1.89[c]	1.92[b]	183.83[c]	282.66[c]
100	0.89[a]	0.79[a]	2.09[b]	1.08[b]	0.35	2.28[b]	2.37[b]	248.50[b]	309.67[b]
250	1.04[a]	1.85[a]	2.46[a]	1.31[a]	0.43	2.56[ab]	2.86[a]	286.08[a]	358.28[a]
350	1.07[a]	1.91[a]	2.63[a]	1.35[a]	0.44	2.67[a]	2.92[a]	291.50[a]	361.29[a]
SEm±	0.08	0.16	0.10	0.07	0.07	0.10	0.17	2.38	9.26
CD (P=0.05)	0.23	NS	0.29	0.22	NS	0.28	0.48	6.88	26.75

**NS: Non significant, DAS: Days after sowing*

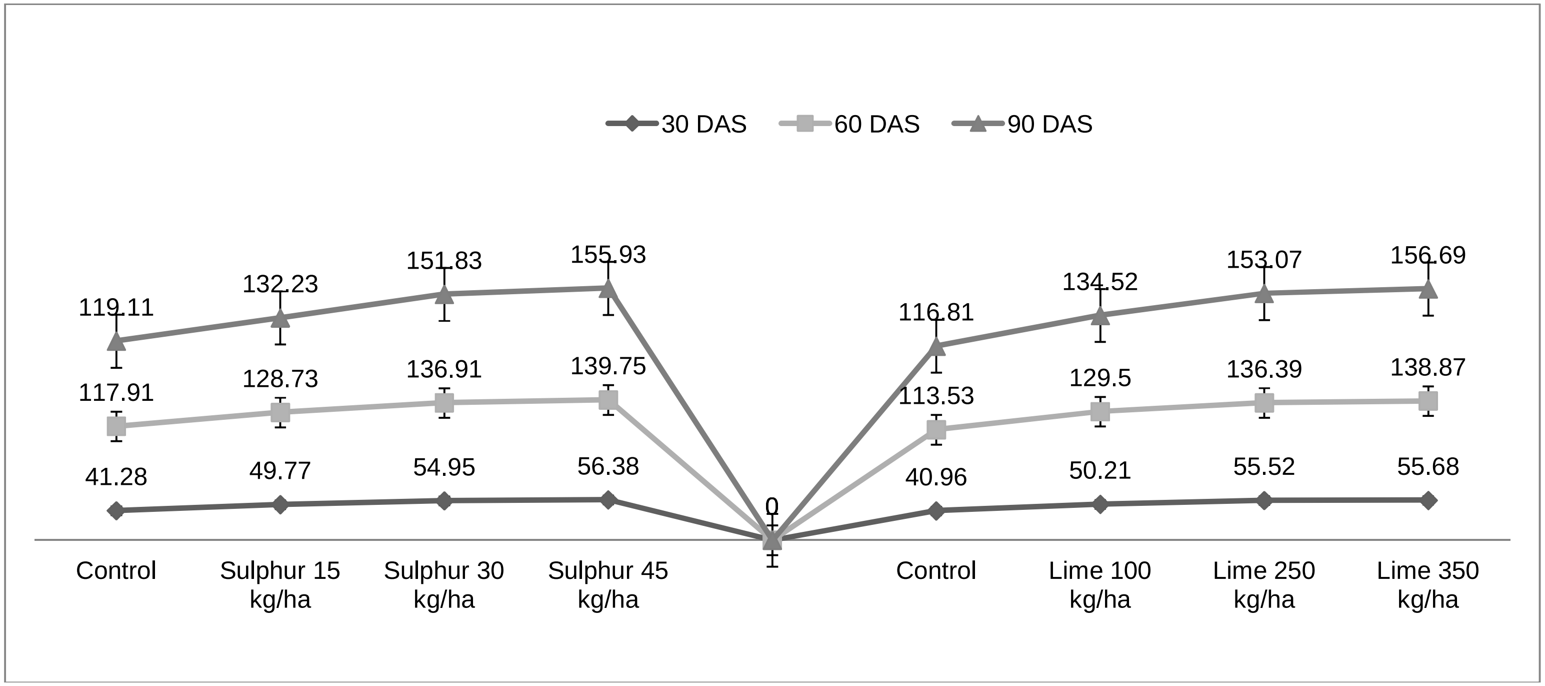

Fig. 1. Effect of sulphur and lime levels on plant height of sesame

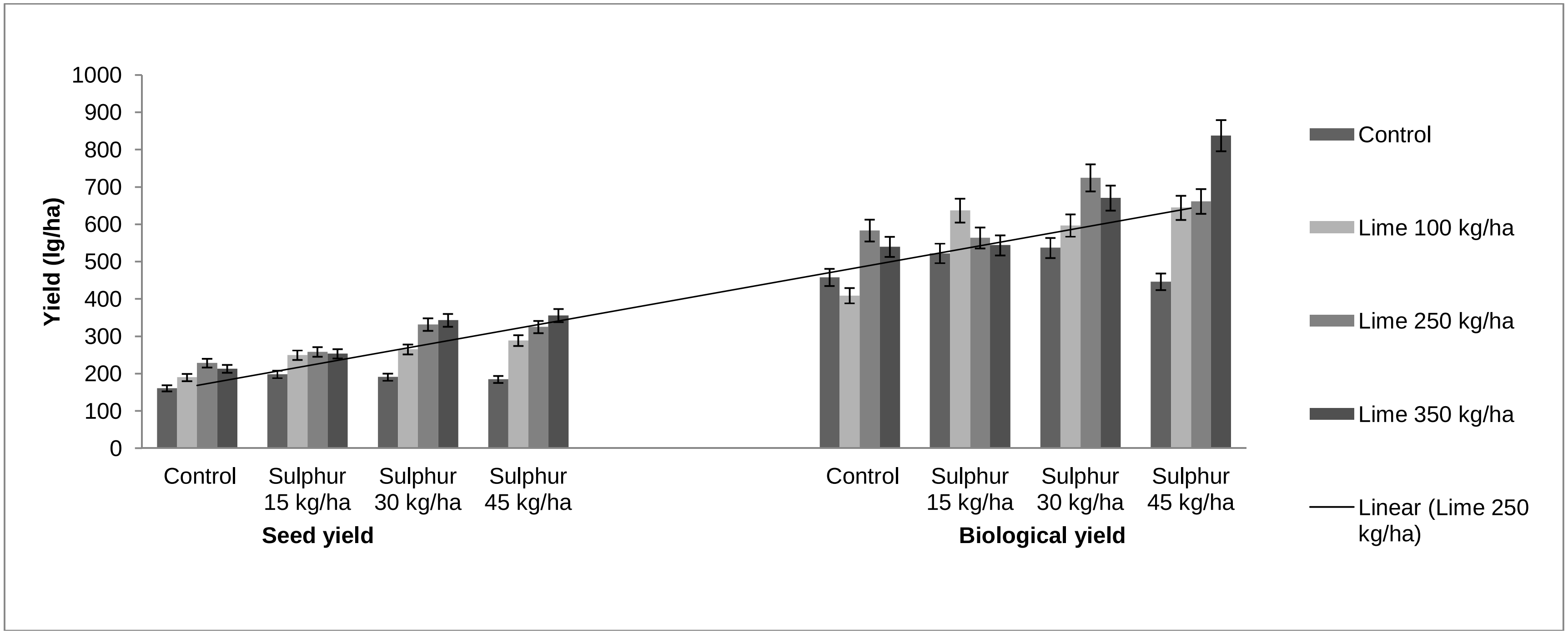

Fig. 2. Interaction effect of sulphur and lime levels on seed and biological yield of sesame

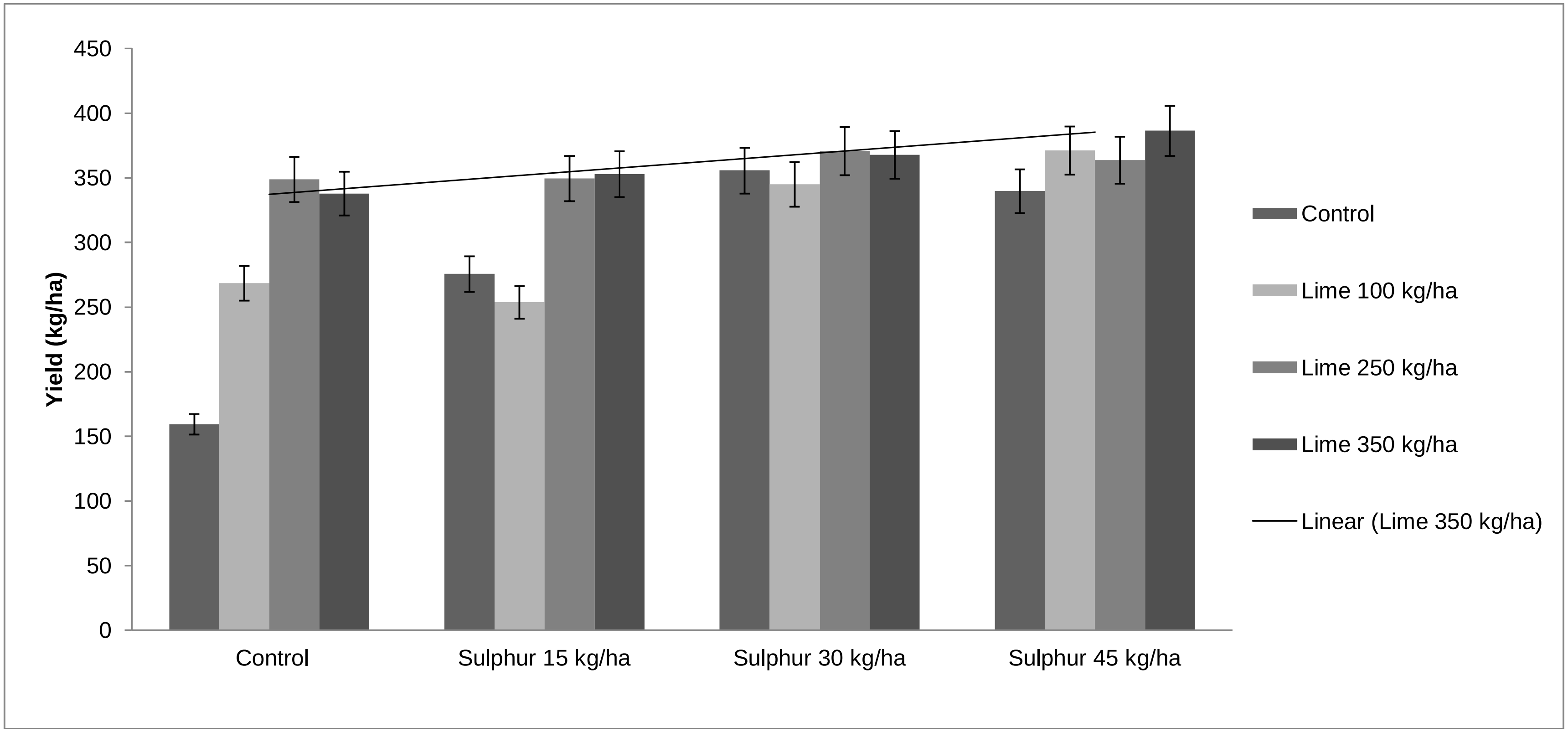

Fig. 3. Interaction effect of sulphur and lime levels on stalk yield of sesame

3.3 Interaction Effect

Interaction effect was recorded at *P*=0.05 level of significance between sulphur and lime levels on seed, stalk and biological yield of sesame with 45 kg sulphur/ha + 350 kg lime/ha, which were observed highest than all other treatments (Figs. 2 and 3). This shows that supplement of sulphur would increase the both seed and biological yield of sesame. Role of sulphur in improving the productivity, quality and development of seeds in sesame also been illustrated by several researchers [9,18]. Liming can be used to neutralize acidic soils and therefore to improve soil physical, biological and chemical properties. Lime may have enhanced soil SO_4-S by releasing S from the soil organic S which thereafter enhances the crop yield. It has both direct and indirect positive effect on soil acidity, mobilization of plant nutrients, soil aggregates, structure and soil microbial functionaries [28,29,30,31].

4. CONCLUSION

The results of the present study suggest that the sulphur nutrition deficiency and soil acidity negatively affects the sesame productivity, it can be overcome with applications of 30 kg sulphur/ha and 250 kg lime/ha in Vindhyan region, India. Results of the study demonstrated that significant improvement in growth attributes *viz*., plant height (151.83 cm), leaf area index (1.02), dry matter accumulation in leaves (1.32 g/plant), dry matter accumulation in roots (2.89 g/plant) etc. at harvest stage and seed (282.75 kg/ha) and stalk (359.84 kg/ha) yield were recorded in 30 kg sulphur/ha. Similar results were observed with application of 250 kg lime/ha in sesame. Soil acidity have a major impact on sesame productivity for sustainable farming systems, and acidification can also extend into subsoil layers posing hazardous for plant root development and their functionaries. On the basis of conducted field experiment recommended that the applications of 30 kg sulphur/ha + 250 kg lime/ha is the only practical way to neutralize the soil acidity and manage sulphur deficiency for sustain sesame productivity in acidic soil.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Nagaraj. Quality of oilseeds. Directorate of Oilseeds, Hyderabad, India. 1995;32-34.
2. Karuppaiah V, Nadarajan L. Host plant resistance against sesame leaf webber and capsule borer *Antigastra catalaunalis* Duponchel (Pyraustidae: Lepidoptera). Afr. J. Agric. Res. 2013;8(37):4674-4680.
3. MOA. Ministry of Agriculture, Government of India. Ann. Rep. 2015;23-25.
4. Kochian LV, Hoekenga OA, Piners MA. How do crop plants tolerate acid soils: Mechanism of aluminum tolerance and phosphorus efficiency. Ann. l Rev. Plant Biol. 2004;55:459-493.
5. Meena RS, Yadav RS. Phenological performance of groundnut varieties under sowing environments in hyper arid zone of Rajasthan, India. J. of App. Nat. Sci. 2014; 6(2):344-348.
6. Lambridge CJ, Godwin ID. Mungbean. In: Kole C, editor. Genome mapping and molecular breeding in plants: Pulses, sugar, and tuber crops. Heidelberg: Springer Verlag. 2007;3:69-90.
7. Alleoni LRF, Cambri MA, Caires EF, Garbuio FJ. Acidity and aluminum speciation as affected by surface liming in tropical no-till soils. Soil Sci. Soci. Amer. J. 2010;74:1010-1017.
8. Singh S, Kumar P. Soil fertility status of vegetables growing areas of Varanasi and pulse growing areas of Mirzapur. J. Ind. Soc. Soil Sci. 2012;60:233-236.
9. Salwa AIE, Mohsen MA, Behary SS. Amelioration productivity of sandy soil by using amino acid, sulphur and micronutrients for sesame production. J. Amer. Sc. 2010;6:250-257.
10. Meena KK, Meena RS, Kumawat MS. Effect of sulphur and iron fertilization on yield attribute, yield, nutrient uptake of Mungbean (*Vigna radiata* L.). Indian Journal of Agricultural Sciences. 2013; 83(4):108-112.
11. Jackson ML. Soil chemical analysis. Prentice Hall of Inc. Engle Chiffs. New Jersey; 1973.
12. Walkley A, Black IA. Rapid titration method for organic carbon of soils. Soil Scie. 1947; 37:29-32.
13. Subbiah BV, Asija GL. A rapid procedure for the determination of available nitrogen in soils. Curr. Sci. 1956;25:259-260.

14. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circ. No. 939, Washington; 1954.
15. Stanford S, English L. Use of flame photometer in rapid soil tests for K and Ca. Agron. J.1949;41:446–7.
16. Gomez KA, Gomaz AA. Statistical procedures for agricultural research. John Wiley and Sons, Singapore; 1984.
17. Leustek T, Saito K. Sulfate transport, and assimilation in plants. Plant Physiology. 1999;120:637–643.
18. Mondal Mab, Badruddin M, Malek Ma, Hossain Mb, Puteh Ab. Optimization of sulphur requirement to sesame (*Sesamum Indicum* L.) genotypes using tracer techniques. Bang. J. Bot. 2012;41(1):7-13.
19. Meena H, Meena RS, Rajput, BS and Kumar S. Response of bio-regulators to morphology and yield of clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] under different sowing environments. Journal of Applied and Natural Science. 2016;8(2):715–718.
20. Meena KK, Meena RS. Effect of sulphur and iron fertilization on yield attributes, yields and net returns of Mungbean (*Vigna radiata* L.) in Arid Western Rajasthan*.* Indian Journal of Ecology. 2013;40(1): 165-166.
21. Meena RS, Yadav RS, Meena H, Kumar S, Meena YK, Singh A. Towards the current need to enhance legume productivity and soil sustainability worldwide: A book review. J. Cle. Prod. 2015a;104:513-515.
22. Meena RS. Response to different nutrient sources on green gram (*Vigna radiata* L.) productivity. Ind. J. Ecol. 2013;40(2):353-355.
23. Pavani S, Rekha KB, Babu SNS, Moguloju M. Effect of nitrogen and sulphur on growth, yield and quality of sunflower (*Helianthus annuus* L.). Crop Res. (Hisar). 2013;45(1-3):152-154.
24. Wang J, Raman H, Zhang G, Mendham N, Zou M. Aluminum tolerance in barely (*Horidium vulgarize* L.): Physiological mechanisms, genetics and screening methods. J. Zhej. Univ. Scie. 2006;7:769-787.
25. Bekere W. Liming effects on yield and yield attributes of nitrogen fertilizer and bradyrhizobia inoculated soybean (*Glycine max* L.) grown in acidic soil at Jimma, South Western Ethiopia. J. Bio. 2013;3: 59-93.
26. Fodor L, Kadlicsko B. Effect of NPK fertilization and liming on the growth of white mustard varieties. Cer. Res. Comm. 2006;34(1-2):445-448.
27. Munda GC, Patel DP, Mokidul I. Effect of macro and micronutrients on growth and yield of groundnut. Ann. Plant Phys. 2004; 18(1):9-12.
28. Bolan NS, Adriano DC, Curtin D. Soil acidification and liming interactions with nutrient and heavy metal transformation and bioavailability. Adv. Agron. 2003;78: 215–272.
29. Meena RS, Varma D. Mungbean yield and nutrient uptake performance in response of NPK and lime levels under acid soil in Vindhyan region, India. Journal of Applied and Natural Science. 2016;8(2): 860-863.
30. Meena RS, Dhakal Y, Bohra JS, Singh SP, Singh MK, Sanodiya P. Influence of bioinorganic combinations on yield, quality, and economics of Mungbean*.* Amer. J. Exp. Agri. 2015;8(3):159-166.
31. Tyler G, Olsson T. Concentrations of 60 elements in the soil solution as related to the soil acidity. Europ. J. Soil Sci. 2001; 52:151–165.

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