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Effect of conjoint use of fertilizers and soil amendments on soil fertility and yield of groundnut (*Arachis hypogaea L.*)

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ABSTRACT

The field experiment was conducted during 2017-18 and 2018-19 at Oilseeds Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) to study the effect of fertilizer and soil amendment on soil fertility and yield groundnut (Arachis hypogaea L.). The experiment was laid out in randomized block design with three replications and nine treatments. The pooled data revealed that the application of gypsum and phosphogypsum did not influence significantly the soil pH, EC, organic carbon and calcium carbonate content. However, the fertility status of soil in terms of available nitrogen, phosphorus, potassium and sulfur as well as exchangeable calcium, magnesium was found significantly higher with the application of RDF-sulfur free + 400 kg phosphogypsum ha^{-1}. The available nitrogen, phosphorus, potassium, sulfur, exchangeable calcium and magnesium contents were increased by 10, 23, 7, 122, 42, and 14% with RDF-sulphur free + 400 kg phosphogypsum ha^{-1} as compared to control, respectively. Significantly higher pod (2.0 t ha^{-1}) and haulm yield (2.5 t ha^{-1}) of groundnut was observed with RDF-sulphur free + 400 kg phosphogypsum ha^{-1}. Similarly, the oil and protein contents were also increased with phosphogypsum level and maximum oil (51%) and protein (29.4%) contents were observed with RDF-sulphur free + 400 kg phosphogypsum ha^{-1} treatment. This treatment was statistically at par in terms of soil fertility, yield, oil and protein content of groundnut with RDF-sulphur free + 300 kg phosphogypsum ha^{-1}.

Keywords: Groundnut, gypsum, phosphogypsum, soil fertility, yield

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is the major oilseed crop in India and it plays a major role in bridging the vegetable oil deficit in the country. It is important oilseed crop in India grown mostly under rainfed conditions. However, in India groundnut productivity is low due to several production constraints, which include poor and imbalanced nutrition of crop and growing crop on marginal lands. Therefore, it is most essential to pay greater attention to the nutrition of the groundnut to enhance its productivity. Most of the Vertisols in Vidarbha found to be deficit in calcium, sulphur, phosphorus and zinc nutrients. These nutrients have to play an important role in the plant metabolisms and physiology of groundnut crop. The primary nutrients i.e. nitrogen, phosphorus and potassium are given the priority and very little attention is paid toward the secondary nutrients and micronutrients which are of prime importance for the nutrition of groundnut. Calcium and sulphur requirements of groundnut are quite high. In neutral and alkaline soils, calcium deficiency may become serious. Previously, no special efforts were made to supplement these nutrients to soils, since, these nutrients got added inadvertently through single super phosphate as a byproduct with 11% S and 18% Ca in the form of calcium sulphate i.e. gypsum. Hence, it was decided to identify the cheap and combined source of essential nutrients and other secondary nutrients and micronutrients for the oil seed crop. Phosphogypsum is available in many states and widely used as a source of nutrients to oilseed crops. Since India is the net importer of sulfur containing fertilizers, it is thus very important to use this material for improving productivity of the land resource where it could combat possible pollution hazards. In view of above consideration, the present investigation was aimed to study the effect of conjoint use of fertilizers and soil amendments on soil fertility and yield of groundnut.

MATERIALS AND METHODS

A field experiment was conducted at Oilseeds Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during **S.S.**

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2017-18 and 2018-19. Experimental field is situated at the latitude of $22^0$42' 19.2'' North and 77^0 03' 43.2'' East at the altitude of 307.8 (m) above mean sea level (MSL). Average annual precipitation is 711.1 mm. Most of the rainfall is received from south west monsoon. The texture of soil was clay loam with pH 7.7, organic carbon 5.6 g kg^{-1}, available N 181 kg ha^{-1}, P 17 kg ha^{-1}, K 332 kg ha^{-1} and sulphur 10 mg kg^{-1}. The experiment was carried out using randomized block design with three replications and nine treatments. The treatments were: T1 control, T2 recommended dose of fertilizer (RDF) (DAP, urea and MOP) sulphur free, T3 RDF through urea, SSP, MOP, T4 RDF sulfur free + 200 kg gypsum ha^{-1}, T5 RDF sulfur free + 300 kg gypsum ha^{-1}, T6 RDF sulfur free + 400 kg gypsum ha^{-1}, T7 RDF sulfur free + 200 kg phosphogypsum ha^{-1}, T8 RDF S free + 300 kg phosphogypsum ha^{-1}, T9 RDF S free + 400 kg phosphogypsum ha^{-1}). Soil application of gypsum and phosphogypsum was done at 45 days after sowing.

Recommended dose of 25:50:30 kg N, P_2O_5 and K_2O ha^{-1} was applied as urea, diammonium phosphate and muriate of potash, respectively. On an average, gypsum and phosphogypsum contained 23 and 18.5 and 22 and 15.5% calcium and sulfur, respectively. Tag 24 variety of groundnut was sown in rows, 20 cm apart using 100 kg seeds ha^{-1} in the first week of February during both the years. Crop was harvested during last week of May in both the years at physiological maturity and yields were recorded. The post-harvest soil samples were collected and analyzed for pH, EC, organic carbon, available nitrogen, phosphorus and potassium using standard procedures (Jackson, 1973. Exchangeable calcium and magnesium were determined in NH_4OAc extract using atomic absorption spectrophotometer and available sulphur by turbidimetric method (Chesnin and Yien, 1951). Protein content was calculated by multiplying nitrogen content with a factor of 6.25. Oil content in seeds was estimated by NMR (Nuclear magnetic resonance) technique (bench top pulse nuclear magnetic resonance spectrometer-model MQC OXFORD**)**. The mean data on various parameters obtained from consecutive two years were statistically analyzed as per procedure given by Gomez and Gomez (1984). Least significant difference (LSD) values at P = 0.05 were used to determine the significance of difference between treatment means.

RESULTS AND DISCUSSION

Soil fertility

It was observed that the changes in soil pH and organic carbon were non-significant due to various treatments (Table 1). Soil pH decreased up to RDF sulfur free + 200 kg gypsum ha^{-1} and thereafter it was constant in all treatments, indicating that application of gypsum or phosphogypsum did not affect the soil pH to great extent. Organic carbon content of soil increased from control to RDF sulfur free + 400 kg phosphogypsum ha^{-1} but the difference was statistically non significant. These results are in conformity with the findings of Meena *et al.* (2007). The available nitrogen, phosphorus and potassium contents were found significantly higher in RDF sulfur free + 400 kg phosphogypsum ha^{-1} and were statistically at par with RDF sulfur free + 300 kg phosphogypsum ha^{-1}. The available nitrogen content ranged from 142.9 to 157.7 kg ha^{-1}. It was increased by about 10% in RDF sulfur free + 300 kg phosphogypsum ha^{-1} as compared to control. These results are in conformity with the findings of Hoon *et al.* (2009) and Naresha *et al.* (2017). The available phosphorus ranged from 12.6 to 15.5 kg ha^{-1} and significantly higher amount was observed with RDF sulfur free + 400 kg phosphogypsum ha^{-1}. It was 23 and 20% higher in RDF sulfur free + 400 kg phosphogypsum ha^{-1} and RDF sulfur free + 400 kg phosphogypsum ha^{-1} as compared to control, respectively. This implies that addition of phosphogypsum had a significant effect in reducing the exchangeable acidity which is the major production constraint in soils. Similar results were also reported by Hoon *et al.* (2009) and Naresha *et al.* (2017). Significantly highest improvement was observed in potassium content of soil with gypsum and phosphogypsum application. The available potassium content of soil ranged from 286.6 to 307.2 kg $ha^{-1}$and significantly higher amount was observed with RDF sulfur free + 400 kg phosphogypsum ha^{-1} as compared to control. Similar results were also reported by Naresha *et al.* (2017). The available sulfur in soil ranged from 8.8 mg kg^{-1} in control to 19.6 mg kg^{-1} in RDF sulfur free+ 400 kg phosphogypsum ha^{-1}

(Table 2). The next best treatment was RDF sulfur free + 300 kg gypsum ha^{-1}. Being an oilseed crop, sulphur requirement of groundnut is relatively higher and application of 400 kg phosphogypsum ha^{-1} and 400 kg gypsum ha^{-1} helped in maintaining sulphur status of soil. The results are in agreement with the findings of Biswas and Sharma (2008), Prasad and Sah (2006). The exchangeable calcium in soil ranged from 21.7 to 30.9 cmol (P^+) kg^{-1} and maximum value was recorded with RDF sulfur free + 400 kg gypsum ha^{-1}. The higher exchangeable calcium particularly with RDF sulfur free + 400 kg gypsum ha^{-1} may be because of gypsum contains 23% calcium as well as it also acts as a soil amendment which ultimately enhance flocculation and enhance the draining ability of soil. The improved drainage and aeration in soil supports transformation of calcium. The results are in association with the findings of Walia and Dick (2016). The exchangeable magnesium content in soil ranged from 7.8 to 8.9 cmol (p^+) kg^{-1} with maximum value under RDF sulfur free + 400 kg phosphogypsum ha^{-1}. In general, the application of RDF sulfur free together with 200, 300 and 400 kg phosphogypsum ha^{-1} (T7, T8 and T9, respectively) had higher exchangeable magnesium content as compared to application of RDF sulfur free with 200, 300 and 400 kg gypsum ha^{-1} (T4, T5, and T6, respectively) as well as recommended dose of fertilizer (T2). These results are in agreement with the findings of Hoon *et al.* (2009) and Naresha *et al.* (2017).

Table 1: Effect of conjoint use of fertilizers and soil amendments on soil fertility (mean of two years)

Treatments	pH	EC (dSm^{-1})	Organic carbon ($g\ kg^{-1}$)	Calcium carbonate ($g\ kg^{-1}$)	Available nutrients ($kg\ ha^{-1}$)		
					Nitrogen	Phosphorus	Potassium
T1	7.5	0.20	5.3	46.5	142.9	12.6	286.6
T2	7.5	0.20	5.3	45.9	154.9	14.1	304.1
T3	7.5	0.20	5.3	45.9	155.8	14.2	304.6
T4	7.5	0.20	5.3	45.5	156.2	14.3	304.5
T5	7.5	0.20	5.4	45.4	156.0	14.4	304.6
T6	7.5	0.21	5.4	45.2	156.5	14.5	304.9
T7	7.5	0.20	5.5	45.8	154.9	15.0	305.9
T8	7.5	0.21	5.5	45.4	157.0	15.1	306.0
T9	7.5	0.21	5.6	45.1	157.7	15.5	307.2
SE (m) $\pm$	0.00	0.00	0.02	0.01	0.5	0.2	0.3
CD (P=0.05)	NS	NS	NS	NS	1.5	0.5	0.8

T_1 control, T_2 recommended dose of fertilizer (RDF) (DAP, urea and MOP) sulphur free, T_3 RDF through urea, SSP, MOP, T_4 RDF sulfur free + 200 kg gypsum ha^{-1}, T_5 RDF sulfur free + 300 kg gypsum ha^{-1}, T_6 RDF sulfur free + 400 kg gypsum ha^{-1}, T_7 RDF sulfur free + 200 kg phosphogypsum ha^{-1}, T_8 RDF S free + 300 kg phosphogypsum ha^{-1}, T_9 RDF S free + 400 kg phosphogypsum ha^{-1})

Yield and quality of groundnut

The pod yield of groundnut was significantly higher with RDF sulfur free + 400 kg phosphogypsum ha^{-1} over control (Table 2). Similarly, the haulm yield of groundnut was 92% higher with RDF sulfur free + 400 kg phosphogypsum ha^{-1} as compared to control. The results revealed that the soil application of 200, 300 kg either gypsum or phosphogypsum ha^{-1} along with RDF sulfur free are equally beneficial for pod yield of groundnut. This might be due to gypsum and phosphogypsum which contains sufficient amount of calcium, required by groundnut for proper shell formation. The added calcium maintained the Ca:B ratio in soil for proper growth and development of groundnut flower induction, peg formation, pollen viability etc. and ultimately reflected in higher yield of groundnut. The gypsum and phosphogypsum both are also act as soil amendments and improves the soil physical, chemical and biological condition, which might help to improve the nutrient availability in soil for groundnut for enhancing the pod yield. These observations are in conformity of Naresha *et al.* (2014).

The higher values of oil and protein contents were recorded with RDF sulfur free + 400 kg phosphogypsum ha^{-1}. However, it was statistically at par with RDF sulfur free + 300 kg phosphogypsum ha^{-1}. The sulphur requirement of oilseeds is relatively higher than any other crops for its growth and development. The application of sulphur to groundnut ultimately improve oil recovery of groundnut. Similarly, gypsum, phosphogypsum and SSP play important role in formation of glucosides or glucosinolates which on hydrolysis increase the oil content (Patel *et al.* 2019). The results are in conformity with the findings of Jena *et al.* (2006).

Table 2: Effect of conjoint use of fertilizers and soil amendments on secondary nutrients, yield, oil and protein content of groundnut (Mean of two years)

Treatments	Exchang. Ca (cmol (p^+) kg^{-1})	Exchang. Mg (cmol (p^+) kg^{-1})	Avail. S (mg kg^{-1})	Pod Yield (t ha^{-1})	Haulm yield (t ha^{-1})	Oil content (%)	Protein content (%)
T1	21.7	7.8	8.8	1.0	1.3	49.8	27.8
T2	25.7	8.4	9.2	1.6	2.0	49.9	28.3
T3	26.8	8.4	9.5	1.7	2.2	50.2	28.3
T4	28.0	8.4	16.8	1.8	2.3	50.2	28.5
T5	28.9	8.5	18.7	1.9	2.4	50.2	29.0
T6	30.9	8.5	19.6	2.0	2.5	50.6	29.3
T7	27.8	8.7	14.4	1.8	2.3	50.2	28.9
T8	30.0	8.8	16.4	2.0	2.5	50.6	29.2
T9	30.7	8.9	18.6	2.1	2.5	51.0	29.4
SE (m) $\pm$	0.32	0.07	1.2	0.05	0.09	0.12	0.38
CD (P=0.05)	1.04	0.23	3.8	0.1	0.22	0.40	0.45

From the results, it may be concluded that significantly higher available N, P, K, S and exchangeable Mg were observed with RDF sulfur free with soil application of 400 kg phosphogypsum ha^{-1}. Whereas, the significantly higher exchangeable calcium was recorded with RDF-sulphur free with soil application of 400 kg gypsum ha^{-1}. Therefore, application of RDF-sulphur free with 400 kg phosphogypsum ha^{-1} was found very promising in improving the soil fertility, oil and protein content and yield of groundnut.

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