The Pharma Innovation Journal 2021; 10(9): 1114-1118

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(9): 1114-1118

www.thepharmajournal.com
Received: 07-07-2021
Accepted: 18-08-2021

SS Ransing
Ph.D., Scholar, Department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola, Maharashtra, India

PR Kadu
Head, Department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola, Maharashtra, India

RN Katkar
Associate Dean, College of food technology, Yavatmal and Professor, Department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola, Maharashtra, India

VK Kharche
Director of Research, Dr. PDKV, Akola, Maharashtra, India

Corresponding Author:
SS Ransing
Ph.D., Scholar, Department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola, Maharashtra, India

Effect of gypsum and phosphogypsum application on micronutrient status of soil under summer groundnut

SS Ransing, PR Kadu, RN Katkar and VK Kharche

Abstract
The field experiment was conducted during 2017-18, 2018-19 on Inceptisol at Oilseeds Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra). The experiment was laid out in randomized block design with three replications and nine treatments. The treatments were comprise of variable doses of gypsum and phosphogypsum application, recommended dose of fertilizers and an absolute control. During both the years, the DTPA extractable Fe, Mn, Zn and Cu was significantly higher with the application of RDF (S free) along with phosphogypsum @ 400 kg ha^{-1} at 45, 70, 95 DAS and at harvest. However, the micronutrients content was statistically on par with RDF (S free) with soil application of phosphogypsum @ 300 kg ha^{-1} at 45 DAS. With regard to available boron content, slight decline was noted with an advancement of growth stage of groundnut. The available boron in root zone of groundnut was found significantly higher with RDF (S free) with the application of phosphogypsum @ 200, 300 and 400 kg ha^{-1} (0.40 mg kg^{-1}) at 70 DAS.

Keywords: Groundnut, gypsum, phosphogypsum, micronutrients

Introduction
Groundnut is the major oilseed crop in India and it plays a major role in bridging the vegetable oil deficit in the country. In India, groundnut is available throughout the year due to a two-crop cycle harvested in March and October. It is important protein crops in India grown mostly under rainfed conditions. However, Indian soils suffer from low groundnut productivity 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. So, when the farmer has to provide these nutrients, he has to use independent sources which increases the input cost (Chirwa *et al.*, 2017) [1].

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 heavy. In neutral and alkaline soils, calcium deficiency may become serious (Das *et al.*, 2015) [2]. 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. Thus, the phosphogypsum was identified as a source of nutrients. 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 materials/ fertilizers, it is thus very important to use this material for improving productivity of the land resource where it could combat possible pollution hazards (Dash *et al.*, 2013) [3]. In view of above consideration, the present investigation was aimed to study “effect of gypsum and phosphogypsum application on micronutrient status of soil under summer groundnut.

Materials and Methods
A field experiment was conducted at Oilseeds Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 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). The climate of Akola is semi-arid and characterized by three distinct seasons’ *viz.*, hot

and dry summer from March to May, warm and rainy monsoon from June to October and mild cold winter from November to February. Average annual precipitation is 711.1 mm. Most of the rainfall is received from south west monsoon. The texture of soil of experiment field was clay loam with pH value of 7.7, EC 0.2 dSm^{-1}, organic carbon 5.6 g kg^{-1}, available N 181 kg ha^{-1}, available P 17 kg ha^{-1}, available K 332 kg ha^{-1}, available sulphur 10 mg kg^{-1}. The experiment was carried out using randomized block design with three replications and nine treatments. The details of 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 N, P_2O_5, K_2O was applied as urea, diammonium phosphate (DAP) and muriate of potash (MOP), respectively. On an average, gypsum and phosphogypsum contained 23, 18.5 and 22, 15.5% calcium and sulfur, respectively. TAG-24 variety of groundnut was sown in rows, 30 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 yield were recorded. Other agronomic management practices were followed as per the standard recommendation given by university. The treatment wise post-harvest soil samples were collected and analyzed for available micronutrients in soil using DTPA extractant. 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

DTPA extractable Iron

The DTPA extractable iron in root zone of groundnut was significantly higher with the application of RDF (S free) along with phosphogypsum @ 400 kg ha^{-1} at 45, 70, 95 DAS and at harvest (5.27, 4.95, 4.85 and 4.82 mg kg^{-1} respectively) during the year 2017-18 (Table 1). However, it was statistically on par with RDF (S free) with soil application of phosphogypsum @ 300 kg ha^{-1} at 45 DAS. The DTPA extractable iron in root zone of groundnut was significantly higher with RDF (S free) with the application of phosphogypsum @ 400 kg ha^{-1} at 45, 70, 95 DAS and at harvest (5.39, 5.12, 4.91 and 4.88 mg kg^{-1} respectively) during the year 2018-19. However, it was statistically on par with RDF (S free) with soil application of phosphogypsum @ 300 kg ha^{-1} at 45 DAS. The similar trend was observed in pooled mean for DTPA extractable iron in root zone of groundout. The periodical DTPA extractable iron was decreased with an increased period of study. It was numerically the least at harvest and higher at 45 DAS. This might be because of uptake of iron by groundnut with advanced age of crop growth during the year 2017-18 and 2018-19. These results are in conformity with the earlier findings of Khalil *et al.* (1990) [6] and Gangadhara *et al.* (1990) [4].

Addition of phosphogypsum showed numerically higher values of periodical DTPA extractable iron during the year 2017-18 and 2018-19. The results found matching with the findings of Pagaria and Totawat (2007) [7]. They reported that metallic cations (Fe, Mn, Zn, Cu) status increased as a consequence of incorporation of either press-mud or spentwash in integration with phosphogypsum.

DTPA extractable manganese

DTPA extractable Mn was significantly higher with the application of RDF (S free) with soil application of phosphogypsum @ 400 kg ha^{-1} at 45, 70, 95 DAS and at harvest (9.52, 9.38, 9.29 and 9.17 mg kg^{-1} respectively) during the year 2017-18 (Table 2). The value of DTPA extractable manganese registered in treatment RDF (S free) with soil application of phosphogypsum @ 400 kg ha^{-1} at 45, 70, 95 DAS and at harvest was higher by 15.96, 15.23, 15.26 and 14.34% respectively, over RDF (S free) during the year 2017-18.

Table 1: Effect of different levels of gypsum and phosphogypsum on periodical DTPA extractable iron (mg kg^{-1}) in root zone of groundnut

Treatment	2017-2018				2018-2019				Pooled mean			
	45 DAS	70 DAS	95 DAS	At harvest	45 DAS	70 DAS	95 DAS	At harvest	45 DAS	70 DAS	95 DAS	At harvest
T_1: Absolute control	5.00	4.36	4.33	4.14	5.09	4.60	4.39	4.15	5.05	4.45	4.36	4.15
T_2: RDF (DAP, urea and MOP) sulphur free	5.12	4.65	4.35	4.18	5.12	4.61	4.43	4.18	5.12	4.64	4.39	4.18
T_3: RDF through urea, SSP, MOP	5.13	4.67	4.39	4.35	5.14	4.65	4.46	4.36	5.14	4.66	4.43	4.36
T_4: T_2 + Soil application of Gypsum @ 200 kg ha^{-1}	5.16	4.69	4.41	4.36	5.16	4.64	4.47	4.38	5.16	4.67	4.44	4.37
T_5: T_2 + Soil application of Gypsum @ 300 kg ha^{-1}	5.10	4.70	4.43	4.37	5.13	4.67	4.48	4.39	5.12	4.69	4.46	4.38
T_6: T_2 + Soil application of Gypsum @ 400 kg ha^{-1}	5.23	4.71	4.45	4.39	5.24	4.72	4.53	4.41	5.24	4.71	4.49	4.40
T_7: T_2 + Soil application of Phosphogypsum @ 200 kg ha^{-1}	5.18	4.72	4.46	4.42	5.27	4.73	4.55	4.43	5.23	4.72	4.51	4.43
T_8: T_2 + Soil application of Phosphogypsum @ 300 kg ha^{-1}	5.20	4.82	4.53	4.49	5.33	4.75	4.57	4.46	5.28	4.80	4.55	4.48
T_9: T_2 + Soil application of Phosphogypsum @ 400 kg ha^{-1}	5.27	4.95	4.85	4.82	5.39	5.12	4.91	4.88	5.34	5.01	4.88	4.85
SE (m) +	0.03	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.03	0.05	0.01	0.01
CD at 5%	0.08	0.07	0.07	0.07	0.06	0.09	0.07	0.06	0.09	0.17	0.03	0.04

Table 2: Effect of different levels of gypsum and phosphogypsum on periodical DTPA extractable manganese (mg kg^{-1}) in root zone of groundnut

Treatment	2017-2018				2018-2019				Pooled mean			
	45 DAS	70 DAS	95 DAS	At harvest	45 DAS	70 DAS	95 DAS	At harvest	45 DAS	70 DAS	95 DAS	At harvest
T_1: Absolute control	8.03	8.00	7.96	7.93	8.52	8.41	8.19	7.95	8.29	8.22	8.05	7.94
T_2: RDF (DAP, urea and MOP) sulphur free	8.21	8.14	8.06	8.02	8.65	8.50	8.32	8.10	8.44	8.33	8.16	8.06

T_3: RDF through urea, SSP, MOP	8.42	8.31	8.28	8.15	8.84	8.57	8.46	8.26	8.64	8.45	8.35	8.20
T_4: T_2 + Soil application of Gypsum @ 200 kg ha^{-1}	8.91	8.74	8.70	8.64	8.88	8.63	8.52	8.34	8.89	8.68	8.63	8.49
T_5: T_2 + Soil application of Gypsum @ 300 kg ha^{-1}	9.02	8.82	8.77	8.72	8.90	8.66	8.58	8.37	8.96	8.74	8.69	8.55
T_6: T_2 + Soil application of Gypsum @ 400 kg ha^{-1}	9.09	8.90	8.84	8.78	8.92	8.70	8.64	8.44	9.00	8.79	8.76	8.61
T_7: T_2 + Soil application of Phosphogypsum @ 200 kg ha^{-1}	9.18	9.06	9.02	8.89	9.98	9.04	8.92	8.72	9.60	9.05	8.98	8.81
T_8: T_2 + Soil application of Phosphogypsum @ 300 kg ha^{-1}	9.38	9.23	9.16	9.08	10.00	9.22	9.05	8.86	9.71	9.22	9.12	8.97
T_9: T_2 + Soil application of Phosphogypsum @ 400 kg ha^{-1}	9.52	9.38	9.29	9.17	10.06	9.52	9.34	9.12	9.80	9.45	9.31	9.15
SE (m) +	0.02	0.03	0.03	0.02	0.02	0.03	0.03	0.02	0.17	0.11	0.09	0.09
CD at 5%	0.07	0.09	0.08	0.05	0.06	0.08	0.10	0.05	0.57	0.37	0.30	0.29

In the year 2018-19, the higher available sulphur was noted with RDF (S free) with soil application of phosphogypsum @ 400 kg ha^{-1} at 45, 70, 95 DAS and at harvest (10.06, 9.52, 9.34 and 9.12 mg kg^{-1} respectively). However, it was statistically on par with RDF (S free) with soil application of phosphogypsum @ 300 kg ha^{-1} at 45 DAS. The value of DTPA extractable manganese registered in treatment RDF (S free) with soil application of phosphogypsum @ 400 kg ha^{-1} at 45, 70, 95 DAS and at harvest was higher by 16.30, 12.00, 12.26 and 12.59% respectively, over RDF (S free) during the year 2018-19.

While in respect of the values observed under pooled mean the similar trend of result was noted. The periodical DTPA extractable manganese was decreased with an increased period of study. It was numerically lower at harvest and the highest at 45 DAS. This might be because of uptake of manganese by groundnut with advanced age of crop growth during the year 2017-18 and 2018-19. These results are in conformity with the findings of Khalil *et al.* (1990) [6] and Gangadhara *et al.* (1990) [4].

Addition of phosphogypsum showed numerically higher values of periodical DTPA extractable manganese during the year 2017-18 and 2018-19. The results are in agreement with the findings of Pagaria and Totawat (2007) [7]. They reported that metallic cations (Fe, Mn, Zn, Cu) status increased as a consequence of incorporation of either press-mud or spentwash in integration with phosphogypsum.

DTPA extractable Zinc

The DTPA extractable zinc in root zone of groundnut was recorded significantly higher with the application of RDF (S free) along with phosphogypsum @ 400 kg ha^{-1} at 45, 70, 95 DAS and at harvest (0.60, 0.59, 0.58 and 0.56 mg kg^{-1} respectively) during the year 2017-18 (Table 3). However, it was statistically on par with RDF (S free) with the application of phosphogypsum @ 200, 300 kg ha^{-1} at 45, 70 DAS and RDF (S free) with the application of phosphogypsum @ 300 kg ha^{-1} at 95 DAS and at harvest.

The DTPA extractable zinc in root zone of groundnut was found significantly higher with RDF (S free) with the application of phosphogypsum @ 400 kg ha^{-1} at 45, 70, 95 DAS and at harvest (0.54, 0 49, 0.48 and 0.44 mg kg^{-1} respectively) during the year 2018-19. However, it was found statistically on par with RDF (S free) with the application of phosphogypsum @ 300 kg ha^{-1} at 45, 95 DAS and at harvest and RDF (S free) with the application of phosphogypsum @ 200, 300 kg ha^{-1} at 70 DAS.

Table 3: Effect of different levels of gypsum and phosphogypsum on periodical DTPA extractable zinc (mg kg^{-1}) in root zone of groundnut

Treatment	2017-2018				2018-2019				Pooled mean			
	45 DAS	70 DAS	95 DAS	At harvest	45 DAS	70 DAS	95 DAS	At harvest	45 DAS	70 DAS	95 DAS	At harvest
T_1: Absolute control	0.48	0.42	0.40	0.32	0.40	0.38	0.35	0.34	0.44	0.39	0.38	0.33
T_2: RDF (DAP, urea and MOP) sulphur free	0.49	0.43	0.42	0.41	0.41	0.39	0.36	0.35	0.45	0.40	0.39	0.37
T_3: RDF through urea, SSP, MOP	0.50	0.45	0.44	0.42	0.42	0.40	0.37	0.35	0.46	0.41	0.41	0.38
T_4: T_2 + Soil application of Gypsum @ 200 kg ha^{-1}	0.51	0.46	0.45	0.43	0.43	0.41	0.39	0.36	0.47	0.42	0.42	0.39
T_5: T_2 + Soil application of Gypsum @ 300 kg ha^{-1}	0.52	0.46	0.44	0.43	0.45	0.43	0.40	0.38	0.49	0.44	0.42	0.40
T_6: T_2 + Soil application of Gypsum @ 400 kg ha^{-1}	0.53	0.48	0.45	0.43	0.46	0.44	0.41	0.39	0.50	0.45	0.43	0.41
T_7: T_2 + Soil application of Phosphogypsum @ 200 kg ha^{-1}	0.57	0.55	0.51	0.49	0.49	0.46	0.42	0.40	0.53	0.48	0.47	0.44
T_8: T_2 + Soil application of Phosphogypsum @ 300 kg ha^{-1}	0.59	0.58	0.54	0.52	0.51	0.47	0.46	0.42	0.55	0.50	0.50	0.46
T_9: T_2 + Soil application of Phosphogypsum @ 400 kg ha^{-1}	0.60	0.59	0.58	0.56	0.54	0.49	0.48	0.44	0.57	0.52	0.53	0.49
SE (m) +	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.02
CD at 5%	0.05	0.05	0.05	0.04	0.03	0.03	0.03	0.03	0.01	0.04	0.03	0.06

The similar trend was observed in pooled mean for DTPA extractable zinc in root zone of groundnut. The periodical DTPA extractable zinc was decreased with an increased period of study. In general lower DTPA extractable zinc at harvest and higher was observed at 45 DAS. This might be due to uptake of zinc by groundnut with advanced age of crop growth during the year 2017-18 and 2018-19. These results are in close association with the findings of Khalil *et al.* (1990) [6] and Gangadhara *et al.* (1990) [4]. Addition of phosphogypsum showed numerically higher values of periodical DTPA extractable zinc during the year 2017-18 and 2018-19. These results are in conformity with the findings of Pagaria and Totawat (2007) [7].

DTPA extractable Copper

The DTPA copper varied between 2.53 to 2.96 mg kg^{-1}, 2.82 to 3.40 mg kg^{-1} at 45 DAS however, the DTPA extractable copper decreased slightly at harvest (Table 4). Based on the observations it was observed that the periodical DTPA extractable copper in root zone of groundnut was significantly influenced with the different levels of gypsum and phosphogypsum. The higher DTPA extractable copper was recorded with the application of RDF (S free) along with phosphogypsum @ 400 kg ha^{-1} at 45, 70, 95 DAS and at harvest (2.96, 2.92, 2.86 and 2.84 mg kg^{-1} respectively) during the year 2017-18. However, it was statistically on par with RDF (S free) with the application of phosphogypsum @ 300 kg ha^{-1} at 45 DAS. The value of DTPA extractable copper registered in treatment RDF (S free) with soil application of phosphogypsum @ 400 kg ha^{-1} at 45, 70, 95 DAS and at harvest is higher by 9.63, 21.67, 23.77 and 25.66% respectively, over RDF (S free) during the year 2017-18. While during the second year of experimentation i.e. the year 2018-19 similar trend was noticed. The higher available sulphur was noted with RDF (S free) with soil application of phosphogypsum @ 400 kg ha^{-1} at 45, 70, 95 DAS and at harvest (3.40, 3.24, 3.10 and 3.06 mg kg^{-1} respectively).

The DTPA extractable copper was 18.06, 35.00, 30.80 and 42.99% higher with the combined application of RDF (S free) and phosphogypsum @ 400 kg ha^{-1} over RDF (S free) alone at 45, 70, 95 DAS and at harvest during the year 2018-19.

The pooled mean of DTPA extractable copper registered the similar trend data as 2017-18 and 2018-19. The periodical DTPA extractable copper was decreased with an increased period of study. The trend was declining however, the lower DTPA extractable copper was recordrd at harvest and higher at 45 DAS. The uptake of copper by groundnut.

Table 4: Effect of different levels of gypsum and phosphogypsum on periodical DTPA extractable copper (mg kg^{-1}) in root zone of groundnut

Treatment	2017-2018				2018-2019				Pooled mean			
	45 DAS	70 DAS	95 DAS	At harvest	45 DAS	70 DAS	95 DAS	At harvest	45 DAS	70 DAS	95 DAS	At harvest
T_1: Absolute control	2.53	2.10	2.08	2.00	2.82	2.30	2.27	2.07	2.68	2.20	2.15	2.03
T_2: RDF (DAP, urea and MOP) sulphur free	2.70	2.40	2.32	2.26	2.88	2.40	2.37	2.14	2.80	2.40	2.34	2.21
T_3: RDF through urea, SSP, MOP	2.72	2.42	2.39	2.35	2.92	2.46	2.45	2.38	2.83	2.44	2.41	2.36
T_4: T_2 + Soil application of Gypsum @ 200 kg ha^{-1}	2.76	2.47	2.41	2.38	2.96	2.56	2.52	2.42	2.87	2.51	2.45	2.40
T_5: T_2 + Soil application of Gypsum @ 300 kg ha^{-1}	2.71	2.50	2.45	2.42	3.02	2.62	2.60	2.46	2.87	2.56	2.51	2.44
T_6: T_2 + Soil application of Gypsum @ 400 kg ha^{-1}	2.82	2.60	2.52	2.49	3.08	2.79	2.65	2.64	2.96	2.69	2.57	2.55
T_7: T_2 + Soil application of Phosphogypsum @ 200 kg ha^{-1}	2.88	2.74	2.62	2.55	3.19	2.86	2.80	2.69	3.04	2.80	2.69	2.60
T_8: T_2 + Soil application of Phosphogypsum @ 300 kg ha^{-1}	2.94	2.84	2.74	2.68	3.28	3.00	2.94	2.82	3.12	2.92	2.82	2.73
T_9: T_2 + Soil application of Phosphogypsum @ 400 kg ha^{-1}	2.96	2.92	2.86	2.84	3.40	3.24	3.10	3.06	3.19	3.08	2.95	2.92
SE (m) +	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.04	0.05	0.03	0.05
CD at 5%	0.05	0.05	0.04	0.04	0.05	0.05	0.06	0.05	0.13	0.15	0.10	0.16

with growth stages might be the reason for lowering status of DTPA extractable copper. These results are in conformity with the findings of Khalil *et al.* (1990) [6] and Gangadhara *et al.* (1990) [4]. Application of various levels of phosphogypsum and gypsum showed numerically higher values of periodical DTPA extractable copper during both the year 2017-18 and 2018-19. These results are in agreement with the findings of Pagaria and Totawat (2007) [7].

Available boron: The available boron in general ranged between 0.40 to 0.44 mg kg^{-1}, 0.39 to 0.43 mg kg^{-1} and 0.40 to 0.44 mg kg^{-1} at 45 DAS during 2017-18, 2018-19 and pooled mean respectively (Table 5). However, slight decline in available boron was noted with an advancement of growth stage of groundnut. The available boron in root zone of groundnut was found significantly higher with RDF (S free) with the application of phosphogypsum @ 200, 300 and 400 kg ha^{-1} (0.40 mg kg^{-1}) at 70 DAS. However, it was statistically on par with all the treatments except absolute control. The available boron in root zone of groundnut was recorded significantly higher in RDF (S free) with the application of phosphogypsum @ 300, 400 kg ha^{-1} (0.36 mg kg^{-1}).

However, it was statistically on par with all the treatments except absolute control, RDF (S free) and RDF at 95 DAS.

The available boron in root zone of groundnut was found significantly higher during the year 2018-19. RDF (S free) with the application of phosphogypsum @ 400 kg ha^{-1} at 95 DAS and at harvest (0.41 and 0.40 mg kg^{-1}). However, it was statistically on par with all the treatments except absolute control, RDF (S free) and RDF at 95 DAS, and with RDF (S free) along with gypsum @ 400 kg ha^{-1} and RDF (S free) with the application of phosphogypsum @ 200, 300 kg ha^{-1}.

The available boron in root zone of groundnut in pooled mean was found significantly higher with the application of RDF (S free) along with gypsum @ 400 kg ha^{-1} (0.44 mg kg^{-1}). However, it was statistically on par with all treatments except absolute control at 45 DAS. The available boron in root zone of groundnut was found significantly higher in RDF (S free) with soil application of gypsum @ 400 kg ha^{-1} and RDF (S free) with soil application of phosphogypsum @ 200, 300, 400 kg ha^{-1} (0.41 mg kg^{-1}). The available boron in root zone of groundnut was found significantly higher with RDF (S free) with the application of phosphogypsum @ 400 kg ha^{-1} at 95 DAS and at harvest (0.39 and 0.37 mg kg^{-1}).

Table 5: Effect of different levels of gypsum and phosphogypsum on periodical available boron (mg kg^{-1}) in root zone of groundnut

Treatment	2017-2018				2018-2019				Pooled mean			
	45 DAS	70 DAS	95 DAS	At harvest	45 DAS	70 DAS	95 DAS	At harvest	45 DAS	70 DAS	95 DAS	At harvest
T_1: Absolute control	0.40	0.33	0.30	0.29	0.39	0.37	0.31	0.30	0.40	0.35	0.31	0.30
T_2: RDF (DAP, urea and MOP) sulphur free	0.41	0.36	0.32	0.30	0.41	0.40	0.34	0.32	0.41	0.38	0.33	0.31
T_3: RDF through urea, SSP, MOP	0.43	0.37	0.32	0.30	0.43	0.42	0.35	0.33	0.43	0.40	0.34	0.32
T_4: T_2 + Soil application of Gypsum @ 200 kg ha^{-1}	0.40	0.37	0.33	0.31	0.41	0.40	0.37	0.35	0.41	0.39	0.35	0.33
T_5: T_2 + Soil application of Gypsum @ 300 kg ha^{-1}	0.40	0.38	0.33	0.31	0.42	0.41	0.38	0.36	0.41	0.40	0.36	0.34
T_6: T_2 + Soil application of Gypsum @ 400 kg ha^{-1}	0.44	0.39	0.34	0.32	0.44	0.43	0.38	0.37	0.44	0.41	0.36	0.35
T_7: T_2 + Soil application of Phosphogypsum @ 200 kg ha^{-1}	0.42	0.40	0.35	0.33	0.42	0.41	0.39	0.37	0.42	0.41	0.37	0.35
T_8: T_2 + Soil application of Phosphogypsum @ 300 kg ha^{-1}	0.41	0.40	0.36	0.33	0.42	0.41	0.40	0.39	0.42	0.41	0.38	0.36
T_9: T_2 + Soil application of Phosphogypsum @ 400 kg ha^{-1}	0.42	0.40	0.36	0.34	0.44	0.42	0.41	0.40	0.43	0.41	0.39	0.37
SE (m) +	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CD at 5%	NS	0.04	0.03	NS	NS	NS	0.04	0.03	0.02	0.02	0.02	0.03

The periodical available boron was decreased with growth stages of groundnut. It was numerically lower at harvest whereas noted higher at 45 DAS. This might be because of removal of boron through the uptake process by groundnut with advanced age of crop growth during the year 2017-18, 2018-19 and pooled mean the results are in conformity with the findings of Gangadhara *et al.* (1990) [4]. They reported that sulphur levels 0, 2.5, 5 and 10 kg S ha^{-1} significantly increased the concentration of micronutrients.

Conclusion
The significantly higher periodic DTPA-extractable micronutrients (Fe, Mn, Zn, Cu and B) in root zone was recorded in RDF-sulphur free with soil application of phosphogypsum @ 400 kg ha^{-1}.

References

1. Chirwa M, Mrema JP, Mtakwa PW, Kaaya AK, Lungu OI. The effect of combining calcium, nitrogen and phosphorus fertilizer application on groundnut yield in smallholder farmers' sole cropping system. Int. J Curr. Res. Biosci. Plant Biol 2017;4(4):83-91.
2. Das S, Chowdhuri TK, Singh AK. Effect of calcium and sulphur based fertilizers on yield and quality of groundnut in red and lateritic belt of Benkura district of West Bengal. Journal of Krishi Vigyan. 2015b;(2):35-38.
3. Dash AK, Nayak BR, Panigrahy N, Mohapatra S, Samant PK. Performance of groundnut (*Arachis hypogaea* L.) under different levels of sulphur and irrigation. Indian Journal of Agronomy 2013;58(4):578-582.
4. Gangadhara GA, Manjunathaiah HM, Satyanarayana T. Effect of sulphur on yield, oil of sunflower and uptake of micronutrients by plants. J Indian Soc. Soil Sci 1990;38:692-695.
5. Gomez KA, Gomez AA. Stastical procedure for agricultural Research Jhon Wiely and Sons, Newyork 1983.
6. Khalil Nabeel F, Nazar M Alnuaimi, Mohammed A Jamal. Agricultural uses of phosphogypsum on calcareous soil. In, proceedings of the third international symposium on phosphogypsum. Orlando, FL, FIPR. Pub. No. 01-060-083, 1990;1:337.
7. Pagaria P, Totawat KL. Effect of pressmud and spentwash in integration with phosphogypsum on metallic cations build-up in the calcareous sodic soil. J Indian Soc. Soil Sci 2007;55(1):52-57.