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# Response of Groundnut (*Arachis hypogaea* L.) to Different Levels and Time of Phosphogypsum Nutrition

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## ABSTRACT

**Background:** Groundnut is one of the most important oilseed crops of India. Improving productivity of groundnut to meet the domestic vegetable oil demand through balanced fertilization is the prime challenge lying before the agronomists in the country. With the aim of evaluating phosphogypsum as a source of sulphur nutrition in groundnut, a field experiment entitled "Response of groundnut (*Arachis hypogaea* L.) to different levels and time of phosphogypsum nutrition" was conducted at Agronomy field unit, University of Agricultural Sciences Bangalore, during *kharif*-2019.

**Methods:** Experiment was laid out in randomised complete block design (RCBD) with eleven treatments, of which eight have different combinations of phosphogypsum applied as basal and in split (30 DAS) and one with gypsum as basal alone. Whereas, the remaining two treatments, without any additional source of sulphur are included for comparison.

**Result:** Among eleven treatments, application of phosphogypsum @ 125 kg S eq $ha^{-1}$ in split recorded highest yield attributes, pod yield (2063 kg $ha^{-1}$), kernel yield (1418 kg $ha^{-1}$) and sulphur uptake (11.33 kg $ha^{-1}$). Which were on par with 100 kg S eq $ha^{-1}$ in split (2014, 1380 and 10.39 kg $ha^{-1}$, respectively). All other treatments recorded lower values with lowest in treatments without any additional sulphur source.

**Key words:** Groundnut, Phosphogypsum, Split application, Sulphur uptake.

## INTRODUCTION

Improving the productivity of oil seeds in general and groundnut in particular is the foremost important task that needs attention. Per capita consumption of oil in India has increased from 3 kg/person/year in 1949 to 18.5 kg/person/year in 2016 against the WHO recommendation of 11 kg/person/year. As a result, India is standing as world's largest importer and third largest consumer after China and EU. To meet the future demands of oil, our domestic production has to improve at a faster pace against existing growth rate. India has marked some remarkable achievements in the recent times when compared to past in terms of area, production and productivity of oilseeds. The area under the oilseeds has increased from 10.07 million ha to 38.4 million ha and the production from 5.26 million metric tonnes to 38.8 million metric tonnes with significant increment in productivity from 522 kg $ha^{-1}$ to 1010 kg $ha^{-1}$ between the years 1949-50 to 2018-19 (Sittal *et al.,* 2019). which needs to be escalated further to meet the domestic needs.

Groundnut is one of the most important oilseed crops of India, it accounts for about 17.3 per cent of area and 24 per cent of production among different oilseed crops grown in the country. In Karnataka it has spread over 5.64 lakh ha with annual production of 5.52 lakh tonnes. Whereas the productivity is very poor which is just 980 kg $ha^{-1}$. It is the need of hour to focus on improving the productivity of groundnut. Groundnut being leguminous oil seed, it responds to sulphur (S) and calcium (Ca) application along with NPK. There are certain positive effects on groundnut with additional supply of Ca and S like improved germination percentage (Murata, 2003), disease resistance (Grichar *et al.*, 2016) in addition to yield (Kannan *et al*., 2017; Kumar *et al.,* 2011; Manaf *et al*., 2017). At the same time S is known to improve sulphur containing amino acids (cysteine and methionine), proteins, chlorophyll, vitamins and oil biosynthesis (Rashmi *et al*., 2018; Rao *et al*., 2013). Inherent soil status of S and Ca is low in most of the Indian soils (Biswas *et al*., 2004). Even though it is present in certain soils it may not be sufficient to meet the crop requirements. So, it is vital to supply S and Ca externally for better results.

There are divergent sources of sulphur available in the market and are in use at different parts of the world. One such source is phosphogypsum. Phosphogypsum, is solid waste by-product of wet phosphoric acid production from rock phosphate. It supplies sulphur (13- 16%), calcium (21%) and phosphorus (0.2-1.2%) in significant quantities. Unlike other sulphur sources which needs microbial action

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phosphogypsum provides readily available sulphate form of sulphur. Because of its low hydrophilic nature sulphate form is kept available for longer time. Most other sulphate forms are quickly soluble in water and are exposed to leaching from soil before plant removes it (Biswas and Sharma, 2008). Not only amount of nutrient but also timing of nutrition is very important in crop husbandry. Since, groundnut plant take-up most of its nutrient requirement (40 - 50%) between vegetative and reproductive stages (Loganathan and Krishnamoorthy 1977), we have designed our experiment to study the effect of phosphogypsum on groundnut growth and yield when applied as basal alone and in split (50% basal + 50% at 30 DAS).

## MATERIALS AND METHODS

An experiment with the objective of evaluating performance of phosphogypsum as nutrient source in groundnut was conducted at Zonal Agricultural Research Station (ZARS), Gandhi Krishi Vignana Kendra (GKVK), University of Agricultural Sciences (UAS), Bangalore, in the Eastern Dry Zone (Zone - V) of Karnataka with a geographical location between 12°58″ N Latitude and 77°33″ Longitude at an altitude of 930 m above mean sea level (MSL) during *kharif*-2019. Soil of the experimental site was red sandy loam with slightly acidic in pH (6.1) with nutrient composition of 247.6, 36.14, 278.41 and 18 kg ha$^{-1}$ of NPK and S, respectively. The experiment was laid out in a randomized complete block design (RCBD), replicated thrice with eleven treatments. In the experimental site, Finger millet (*Eleusine coracana*) was grown during the *kharif*-2018 and left fallow during the *rabi* and summer seasons.

Urea, single super phosphate and muriate of potash were used as source of NPK, respectively. An ICRISAT variety ICGV-91114 was used in the study. Phosphogypsum refers to calcium sulphate hydrate formed as a by-product of the production of phosphorus fertilizer from phosphate rock. It is mainly composed of gypsum ($CaSO_4$. $2H_2O$).

Yield parameters like number of pods plant$^{-1}$, number of kernels plant$^{-1}$, test weight (g), kernel yield plant$^{-1}$, pod yield, kernel yield (kg ha$^{-1}$) and haulm yield (kg ha$^{-1}$) along with sulphur uptake pattern as influenced by different levels and time of phosphogypsum nutrition were studied during the experiment. Sulphur content in digested plant samples were estimated from diluted plant extract calorimetrically as described by Palaskar *et al*. (1981). It is calculated by using the following formula:

$$\text{Sulphur uptake (kg ha}^{-1}) = \frac{\text{Sulphur concentration (\%)}}{100} \times \text{Dry matter (kg ha}^{-1})$$

By using Fisher's method of analysis of variance technique which was given by Gomez and Gomez (1984) the analysis and interpretation of data were done. The level of significance used in "F" and "t" test was p=0.05, Critical difference values were calculated when the "F" test was significant.

Treatment details include, $T_1$: Recommended dose of NPK + 500 kg ha$^{-1}$ of gypsum (PoP) as basal, $T_2$: 50 kg S eq ha$^{-1}$, $T_3$: 75 kg S eq ha$^{-1}$, $T_4$: 100 kg S eq ha$^{-1}$, $T_5$: 125 kg S eq ha$^{-1}$, $T_6$: 50 kg S eq ha$^{-1}$, $T_7$: 75 kg S eq ha$^{-1}$, $T_8$: 100 kg S eq ha$^{-1}$, $T_9$: 125 kg S eq ha$^{-1}$, $T_{10}$: Recommended dose of NPK and $T_{11}$: Recommended dose of N and K alone. In treatments $T_2$ to $T_9$, phosphogypsum was used as source of S equivalent along with RDF. In $T_2$ to $T_5$ entire dose of phosphogypsym was applied as basal whereas and in $T_6$ to $T_9$ phosphogypsum was applied in split *i.e*., as basal and at 30 days after sowing in 50:50 proportion. RDF includes 25:75:37.5 kg ha$^{-1}$ of NPK.

## RESULTS AND DISCUSSION

Application of phosphogypsum @ 125 kg S eq ha$^{-1}$ in split together with recommended dose of NPK recorded highest number of pods plant$^{-1}$ (38.33), kernels plant$^{-1}$ (75), kernel yield plant $^{-1}$ (26.08 g), test weight (34.79 g), pod yield (2063 kg ha$^{-1}$), kernel yield (1418 kg ha$^{-1}$) and haulm yield (4004 kg ha$^{-1}$) (Table 1) which recorded on par results with phosphogypsum @ 100 kg S eq ha$^{-1}$ applied in split. At the same time, application of same amount (125 and 100 kg S eq ha$^{-1}$) of phosphogypsum as basal alone recorded significantly lower values than split application in all the parameters except test weight, where difference is not significant (Table 1). These results support the earlier studies made by Kannan *et al*., 2017; Kumar *et al.,* 2011; Manaf *et al*., 2017. As the calcium is key nutrient element which is part of cellular membrane and promotes the tissue growth, has also recorded its importance in pod formation and pod filling (Sahu *et al.,* 1999). Though the present experiment was designed on the basis of sulphur equivalence, phosphogypsum also supplies calcium in substantial amounts. Whereas, sulphur is known for its protein synthesis function (Rashmi *et al*., 2018; Rao *et al*., 2013) which in turn promotes vegetative growth through active photosynthesis thus, the effects of calcium and sulphur synergistically acted upon physiology of the plant to yield present results.

Sufficient number of pods observed in many treatments ($T_9$, $T_8$, $T_5$, $T_4$ and $T_1$) but number of filled pods or number of kernels plant$^{-1}$ varied greatly with different amounts of phosphogypsum. In treatments with split application of 125 and 100 kg S eq ha$^{-1}$, maximum number of kernels were noticed due to sufficient quantities of available S and Ca (which helps in pod filling) in addition to NPK when compared with other treatments. When phosphogypsum was applied in two equal splits (basal and 30 DAS) response was greater than applying entire dose as basal, similar findings were made by Sahu and Das (1997). In each treatment incremental results were noticed with phosphogypsum, compared with treatments without phosphogypsum.

Similar to number of kernels, kernel yield plant$^{-1}$ also followed same trend where split application of phosphogypsum at 125 kg S eq ha$^{-1}$ recorded highest pod yield plant$^{-1}$ followed by 100 kg S eq ha$^{-1}$ in split (Table 1). This is because greater number of filled pods in above

treatments compared with others. Whereas lower yield is due to unavailability of nutrients (Ca and S) responsible for pod filling in sufficient quantities at times of need. This proved that both quantity and time of nutrition are important factors in deciding yield.

At the initial growth stage (30 DAS), treatment receiving phosphogypsum @ 100 and 125 kg S eq ha$^{-1}$ as basal and gypsum @ 500 kg ha$^{-1}$ recoded on par sulphur uptake but the highest uptake (6.84 kg ha$^{-1}$) was noticed with phosphogypsum @ 125 kg S eq ha$^{-1}$ (Table 2) which is due to the presence of greater amounts of available sulphur in soil when compared to other treatments. Whereas, at remaining times of study *i.e.*, 60, 90 DAS and at harvest, treatment with split application of phosphogypsum @ 125 kg S eq ha$^{-1}$ recorded highest sulphur uptake. In all the treatments, sulphur uptake was maximum at initial 30 days and later on it progressively reduced as the growth continues (Fig 1). The reduction was greater in treatments with basal application of phosphogypsum. On the other hand, treatments with split application had advantage over basal application at later growth stages. As the efficient utilisation of nutrients in groundnut commences from peg initiation to

**Table 1:** Yield components of groundnut as influenced by different levels and time of phosphogypsum nutrition.

| Treatments | Yield parameters | | | | Yield | | |
|---|---|---|---|---|---|---|---|
| | No. of pods plant$^{-1}$ | No. of kernels plant$^{-1}$ | Kernel yield plant$^{-1}$ (g) | Test weight (g) | Pod yield (kg ha$^{-1}$) | Kernel yield (kg ha$^{-1}$) | Haulm yield (kg ha$^{-1}$) |
| $T_1$ | 32.33 | 60.67 | 20.34 | 34.08 | 1808 | 1214 | 3498 |
| $T_2$ | 26.33 | 50.00 | 16.55 | 33.05 | 1501 | 960 | 3053 |
| $T_3$ | 29.00 | 55.67 | 18.42 | 33.10 | 1607 | 1060 | 3187 |
| $T_4$ | 32.00 | 60.33 | 20.09 | 34.02 | 1770 | 1189 | 3480 |
| $T_5$ | 34.00 | 64.67 | 22.12 | 34.15 | 1836 | 1239 | 3504 |
| $T_6$ | 28.67 | 54.00 | 17.82 | 33.06 | 1670 | 1074 | 3304 |
| $T_7$ | 31.67 | 58.67 | 19.41 | 33.14 | 1735 | 1146 | 3410 |
| $T_8$ | 36.33 | 71.00 | 24.18 | 34.20 | 2014 | 1380 | 3863 |
| $T_9$ | 38.33 | 75.00 | 26.08 | 34.79 | 2063 | 1418 | 4004 |
| $T_{10}$ | 25.33 | 46.67 | 15.32 | 32.50 | 1360 | 843 | 3003 |
| $T_{11}$ | 22.33 | 40.00 | 12.77 | 31.74 | 1194 | 724 | 2740 |
| S.Em± | 1.39 | 2.30 | 1.05 | 0.94 | 63 | 18.77 | 162 |
| C.D. (p=0.05) | 4.10 | 6.79 | 3.08 | 2.76 | 187 | 55.36 | 479 |

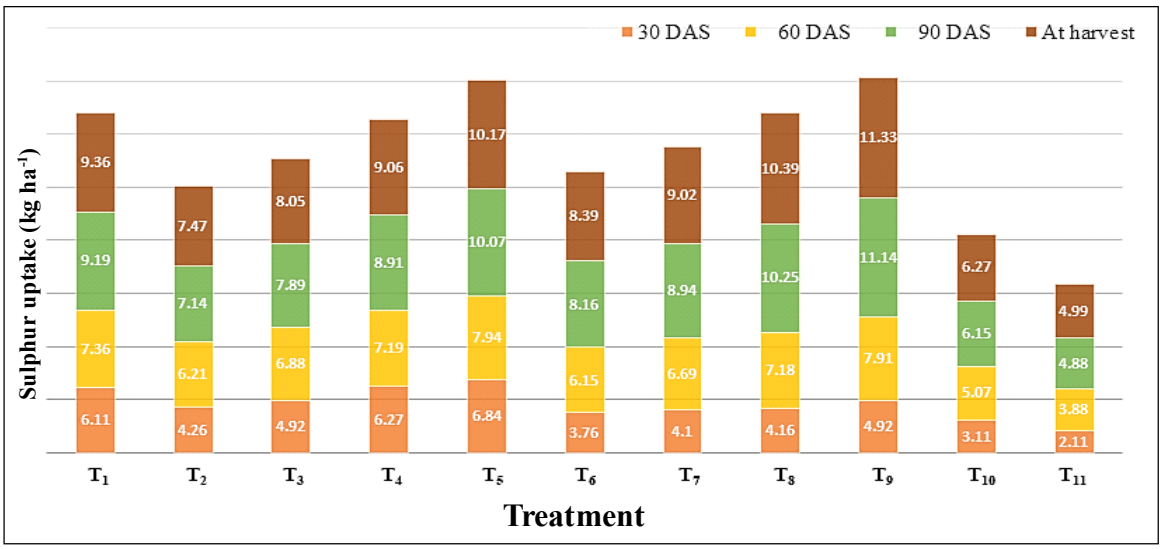



**Fig 1:** Sulphur uptake of groundnut as influenced by different levels and time of phosphogypsum nutrition.

Legend: $T_1$: Recommended dose of NPK + 500 kg ha$^{-1}$ of gypsum (pop), $T_2$: 50 kg S eq ha$^{-1}$ (100% at the time of sowing), $T_3$: 75 kg S eq ha$^{-1}$ (100% at the time of sowing), $T_4$: 100 kg S eq ha$^{-1}$ (100% at the time of sowing), $T_5$: 125 kg S eq ha$^{-1}$ (100% at the time of sowing), $T_6$: 50 kg S eq ha$^{-1}$ (50 % at the time of sowing + 50% at 30 days after sowing), $T_7$: 75 kg S eq ha$^{-1}$ (50% at the time of sowing + 50% at 30 days after sowing), $T_8$: 100 kg S eq ha$^{-1}$ (50% at the time of sowing + 50% at 30 days after sowing), $T_9$: 125 kg S eq ha$^{-1}$ (50% at the time of sowing + 50% at 30 days after sowing), $T_{10}$: Recommended dose of fertilizers (NPK only), $T_{11}$: Recommended dose of fertilizers (N and K only).

**Table 2:** Sulphur uptake pattern of groundnut as influenced by different levels and time of phosphogypsum nutrition.

| Treatments | Sulphur uptake pattern (kg ha$^{-1}$) | | | |
|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | At harvest |
| $T_1$ | 6.11 | 7.36 | 9.19 | 9.36 |
| $T_2$ | 4.26 | 6.21 | 7.14 | 7.47 |
| $T_3$ | 4.92 | 6.88 | 7.89 | 8.05 |
| $T_4$ | 6.27 | 7.19 | 8.91 | 9.06 |
| $T_5$ | 6.84 | 7.94 | 10.07 | 10.17 |
| $T_6$ | 3.76 | 6.15 | 8.16 | 8.39 |
| $T_7$ | 4.10 | 6.69 | 8.94 | 9.02 |
| $T_8$ | 4.16 | 7.18 | 10.25 | 10.39 |
| $T_9$ | 4.92 | 7.91 | 11.14 | 11.33 |
| $T_{10}$ | 3.11 | 5.07 | 6.15 | 6.27 |
| $T_{11}$ | 2.11 | 3.88 | 4.88 | 4.99 |
| S.Em± | 0.30 | 0.36 | 0.35 | 0.36 |
| C.D. (p=0.05) | 0.90 | 1.06 | 1.04 | 1.06 |

DAS: Days after sowing.

pod filling (Kumar and Shivakumar, 1990), split application of sulphur source (phosphogypsum here) ensured sufficient quantities of sulphur at times of crop requirement, which has been evidenced in the experiment. Gypsum also followed similar pattern like phosphogypsum in terms of sulphur uptake but gypsum was applied as basal alone so, its uptake values are comparatively lower than split applied phosphogypsum. While supplying sulphur through SSP alone without any additional source, recorded very low values of uptake which suggests its inadequacy.

## CONCLUSION

Significant difference was observed between the treatments with sulphur and without sulphur. Highest pod and kernel yield (2063 and 1418 kg ha$^{-1}$) were recorded with application of 125 kg S eq ha$^{-1}$ in split. However, it was on par with application of 100 kg S eq ha$^{-1}$ in split. In the interest of environmental aspects, applying 100 kg S eq ha$^{-1}$ of phosphogypsum in split dose may be considered to be optimum.

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