LR-5126
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RESEARCH ARTICLE Legume Research- An International Journal

Effect of Gypsum, Nitrogen and Phosphorus on Growth, Yield and Quality of Spring Groundnut

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10.18805/LR-5126

ABSTRACT

Background: Groundnut kernels contain 48-50% edible oil, 25-34% protein, 10-20% carbohydrates and are a rich source of vitamins (E, K and B complex). Groundnut is a legume-oilseed crop, its requirement of phosphorus, calcium and sulphur is quite high. Gypsum is commonly used as a source of calcium and sulphur for groundnut all over the world. Keeping all these points in view the present study was undertaken to find out the optimum mineral nutrition of spring groundnut

Methods: A field experiment was conducted for 2 years at the Students' Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana during spring season of 2018 and 2019. The experiment was laid out in a split plot design replicated three times with four levels of gypsum (0, 125, 175 and 225 kg ha^{-1}) in combination with two gypsum application stages (Full at sowing and 50% at sowing + 50% at flower initiation stage) in the main plot and three levels of nitrogen and phosphorus (15 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1}, 25 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} and 35 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1}) in the sub-plot.

Result: Application of 225 kg ha^{-1} gypsum resulted significantly higher growth parameters, pod yield, haulm yield, kernel yield over other gypsum levels. Growth parameters, pod yield, haulm yield and kernel yield were significantly higher with the split application as compared to basal application of gypsum. Growth parameters *viz.,* emergence count, plant height, number of branches $plant^{-1}$ and dry matter accumulation were increased with increase in the levels of nitrogen and phosphorus up to 25 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}. However, 35 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} resulted significantly higher protein and oil content of kernels over other levels of nitrogen and phosphorus, while pod yield, haulm yield and kernel yield were at par with 25 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} during both the years.

Key words: Groundnut, Gypsum, Nitrogen, Phosphorus, Quality, Yield.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is known as the king of oilseeds and belongs to the family *Leguminosae* and sub-family *Papilionoideae*. Imbalanced and inadequate use of nutrients is the main reason for lower yield of groundnut. Since groundnut is a legume-oilseed crop, its requirement of phosphorus, calcium and sulphur is quite high. Gypsum is commonly used as a source of calcium and sulphur for groundnut all over the world. Deficiency of calcium leads to the production of immature pods, black embryo in seed, weak germination of seeds and increases production of aflatoxin and thus, decays peanut pod (Agasimani *et al.,* 1992; Evanylo, 1989; Grichar, 2002; Murata, 2003). Calcium uptake is highest during the early stages of fruit development mainly pod expansion and seed growth (Boote 1982). It was observed that withholding Ca from the pegging zone (0-8 cm soil depth) during the first 30 days after initial pegging severely reduces seed size and dry weight as compared to withholding Ca at the other stages of growth (Smal *et al.,* 1989). Sulphur is a component of protein and has an important role to play in oil synthesis. It also increases chlorophyll synthesis and decreases chlorosis. Phosphorus plays a significant role in nodule formation and fixation of atmospheric nitrogen (Brady and Well, 2002). Phosphorus application determines plant reproductive efficiency and promotes growth, development and yield of groundnut crop (Savani and Darji, 1995; Bairagi *et al.,* 2017). The nitrogen requirement of nodulated groundnut cannot be met from symbiotic nitrogen fixation alone. However, to meet the nitrogen requirement during early growth stages, nitrogen could be applied as starter dose (Iman and Ahmed, 2014). However, very less information on the balanced nutrition of spring groundnut is available. Therefore, there is a need to develop a nutrient management strategy to achieve the potential production of spring groundnut. Keeping all these points in view the present study was undertaken to find out the optimum mineral nutrition of spring groundnut.

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How to cite this article: Brar, A.S. and Manhas, S.S. (2023). Effect of Gypsum, Nitrogen and Phosphorus on Growth, Yield and Quality of Spring Groundnut. Legume Research. DOI: 10.18805/LR-5126.

Submitted: 01-03-2023 **Accepted:** 07-08-2023 **Online**: 30-09-2023

MATERIALS AND METHODS

The field trials of the present investigation were conducted at the Students' Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana during spring season of 2018 and 2019. Soil of experimental field was normal alkaline in pH (8.17) and electrical conductivity (0.58 dS m^{-1}), low in organic carbon (0.33%), available nitrogen (156.1 kg ha^{-1}) and available calcium (114 ppm) while medium in available phosphorus (16.29 kg ha^{-1}), available potassium (323.5 kg ha^{-1}) and available sulphur (24.8 kg ha^{-1}). The experiment was laid out in a split plot design replicated three times with four gypsum levels (0, 125, 175 and 225 kg ha^{-1}) in combination with two stages of gypsum application (Full at sowing and 50% at sowing + 50% at flower initiation stage) in the main plot and three levels of nitrogen and phosphorus (15 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1}, 25 kg P_2O_5 ha^{-1} and 35 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1}) in the sub-plot. Second split of gypsum was applied at flower initiation stage *i.e.* at 30 days after sowing while all the doses of nitrogen and phosphorus were applied at the time of sowing. Groundnut variety 'TAG 37A' was sown at the spacing of 30 cm × 15 cm on second week of March during both the years. All the recommended packages of practices were adopted. Nitrogen and phosphorus were applied through DAP while the remaining nitrogen requirement was met by using urea. The number of plants per metre row length were counted at 10, 12 and 14 days after sowing (DAS) from two spots in the inner rows of the plot and this was represented as emergence count. Five plants were tagged randomly in each plot and were used to measure the plant height and number of branches $plant^{-1}$ at 30, 60 and 90 DAS and at harvest. One plant was cut at ground level randomly from each plot at 30, 60 and 90 DAS and at harvest to determine dry matter accumulation. After harvesting of the crop, five tagged plants from each plot were selected to count the number of pods $plant^{-1}$ 100-kernel weight, shelling percentage, sound mature kernels percentage. Pod yield, haulm yield and kernel yield were determined on net plot basis and converted into per hectare yield. The economics was calculated based on the standard prevailing market prices of various inputs. Nitrogen content in kernel was determined by Kjeldahl's method and protein content was calculated by multiplying N content with the factor 6.25. Oil content was determined by using standardised Nuclear Magnetic Resonance (NMR) instrument and oil percentage was recorded on weight basis.

RESULTS AND DISCUSSION

Growth attributes

Different levels of gypsum exerted positive influence on the emergence count, plant height, number of branches and dry matter accumulation of spring groundnut (Fig 1 and 2). The maximum emergence count was observed with highest level of gypsum (225 kg ha^{-1}) and lowest with control. The increase in dose of gypsum from 0 to 225 kg ha^{-1} also increased the plant height, number of branches and dry matter accumulation at all the stages of crop growth Maximum plant height, number of branches and dry matter accumulation at 30, 60, 90 DAS and at harvest were obtained with the application of 225 kg ha^{-1} gypsum. Singh (2007), Yadav *et al.* (2015) and Yadav *et al.* (2017) also supported the findings of the current study and reported that the progressive increase in the level of gypsum upto 324 kg ha^{-1} resulted in significantly increased growth parameters over control. Gypsum application stage also influenced emergence count of groundnut and maximum was observed withfull dose of gypsum application at sowing (Fig 1). Split application of gypsum (50% at sowing + 50% at flower initiation stage) resulted in higher plant height, number of branches and dry matter accumulation of groundnut as compared to the application of full dose of gypsum at sowing at all the stages except at 30 DAS. It was due to the reason that the second split of gypsum was applied at flower initiation stage *i.e.* at 30 DAS, therefore its effect could not show up in the data of growth parameters recorded at 30 DAS. The results are in accordance with the findings of Ghosh *et al.* (2015) who observed that the growth parameters were significantly increased with the split application of gypsum (50% basal + 50% top dressing) as compared to the basal application of gypsum. The maximum emergence count was observed with 35 kg N ha^{-1} + 40 kg P_2O_5 $ha^{-1}$and lowest with 15 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1} (Fig 1). Plant height, number of branches and dry matter accumulation were positively affected by different levels of nitrogen and phosphorus (Fig 1 and 2). Maximum plant height of 5.40 cm (30 DAS), 25.75 cm (60 DAS), 43.56 cm (90 DAS) and 52.95 cm (at harvest) was observed with the application of 35 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} and it was followed by 25 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} and 15 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1} (Fig 1). At 30 DAS, 35 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} resulted in significantly higher number of branches as compared to the other levels. Application of 35 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} resulted in maximum number of branches (5.43 at 30 DAS, 9.09 at 60 DAS, 10.57 at 90 DAS and 11.93 at harvest) which was followed by 25 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} and 15 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1}. Application of 35 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} resulted in maximum dry matter accumulation per plant (5.63 g at 30 DAS, 16.94 g at 60 DAS, 30.81 g at 90 DAS and 39.5 g at harvest) which was followed by 25 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} and 15 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1}. Kabir *et al.* (2013) and Hasan and Sahid (2016) also supported same findings and reported that the application of phosphorus and nitrogen @ 82 kg P_2O_5 ha^{-1} and 27 kg N ha^{-1} increased the plant height, number of branches and dry matter accumulation as compared to the lower levels of nitrogen and phosphorus.

Yield attributes

Total number of pods, 100-kernel weight, shelling percentage and sound mature kernels were observed to have been significantly influenced by the use of different levels of gypsum (Table 1). Application of 225 kg ha^{-1} gypsum resulted in significantly higher total number of pods as compared to the other lower doses of gypsum. Application of 225 kg ha^{-1} gypsum resulted in maximum 100-kernel weight (46.23 g) and sound mature kernels percentage (83.04%) which were statistically at par with 175 kg ha^{-1} and 125 kg ha^{-1} gypsum, while significantly higher than that of control. Application of

225 kg ha^{-1} gypsum resulted in maximum shelling percentage (68.38%) which was statistically at par with 175 kg ha^{-1} gypsum, while significantly higher than that of 125 kg ha^{-1} gypsum and control. Mandal *et al.* (2005), Sivanesarajah *et al.* (1995), Thilakarathna *et al.* (2014) and Yadav *et al.* (2015) supported these results by concluding that the application of gypsum up to 500 kg ha^{-1} resulted in maximum yield attributes of groundnut than the lower gypsum doses. Gypsum application stage also had a significant influence on the total number of pods, shelling percentage and sound mature kernels. Split application of gypsum (50% at sowing + 50% at flower initiation stage) gave significantly more total number of pods (46.34), shelling percentage (67.78%) and sound mature kernels percentage (82.74%) as compared to the application of full dose of gypsum at sowing. The maximum test weight (45.91 g) was observed with the split application of gypsum though the differences were non-significant. The results are supported by Jat and Singh (2006) and Ghosh *et al.* (2015) who reported that the number of pods $plant^{-1}$ were significantly increased with the split application of gypsum as compared to application of full dose of gypsum at the time of sowing. Application of 35 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} resulted in maximum number of pods (47.08), shelling percentage (67.9%) and sound mature kernels percentage (83%), which were statistically at par with the application of 25 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} while significantly more than the application of 15 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1}. The effect of nitrogen and phosphorus levels on the 100-kernel weight of groundnut was non-significant. However, an increasing trend was observed in the 100-kernel weight (45.1 g to 45.93 g) with an increase in the levels of nitrogen and phosphorus though the difference was non-significant. Similarly, Meena and Yadav (2015) found that the application of 30 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1} significantly increased the yield attributes over lower doses.

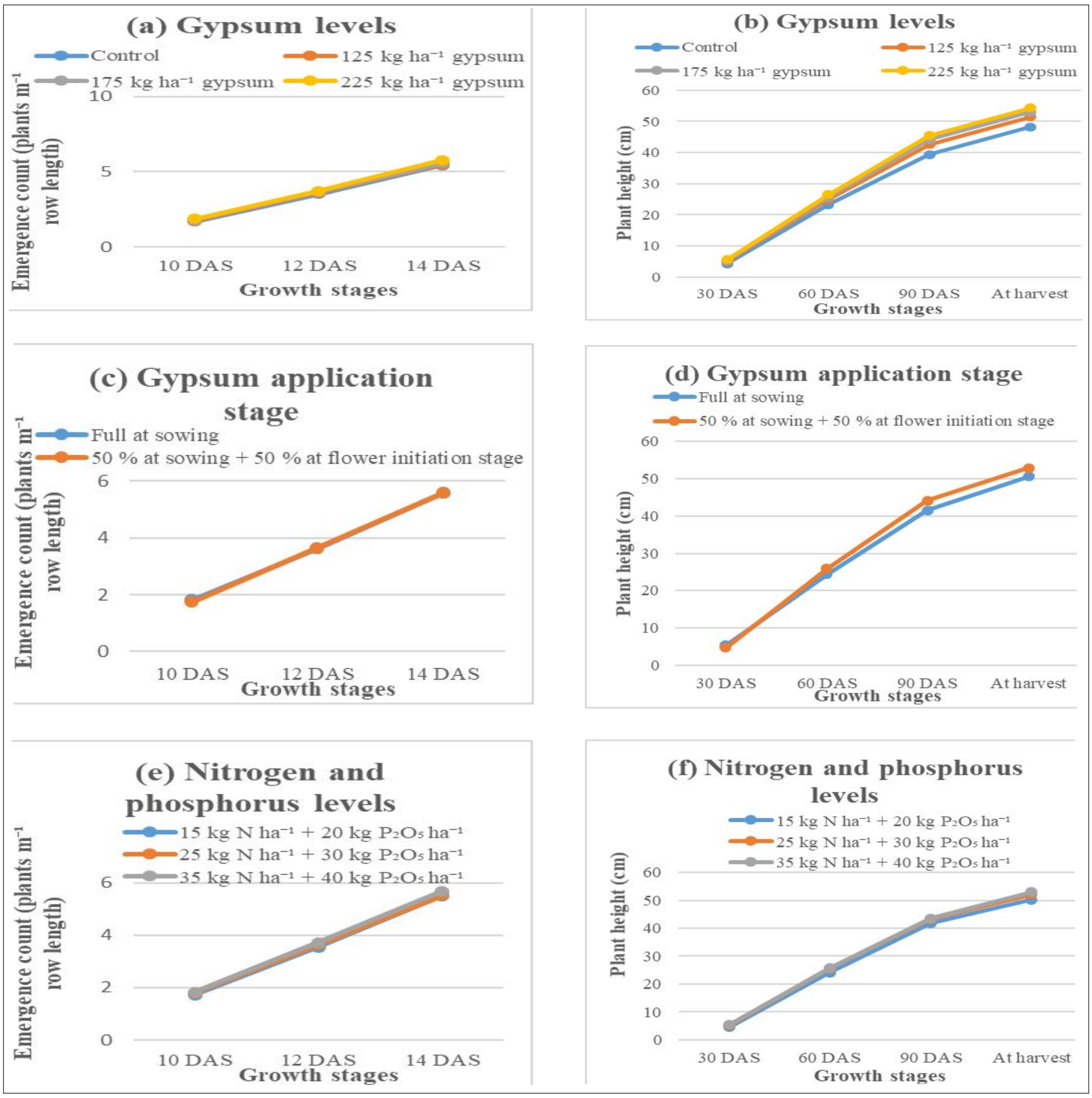

Fig 1: Emergence count and plant height of groundnut as influenced by levels and stage of application of gypsum and nitrogen and phosphorus levels (Pooled data of 2 years).

Table 1: Yield attributes, yield and quality of spring groundnut as influenced by gypsum levels, gypsum application stage and nitrogen and phosphorus levels (Pooled data of 2 years).

Treatments	Total number of pods $plant^{-1}$	100-kernel weight (g)	Shelling percentage (%)	Sound mature kernels (%)	Pod yield ($q\ ha^{-1}$)	Haulm yield ($q\ ha^{-1}$)	Kernel yield ($q\ ha^{-1}$)	Harvest index (%)	Protein content in kernels	Oil content in kernels
Gypsum levels										
Control	38.24	44.00	65.86	79.49	35.21	103.47	23.20	25.45	26.08	46.84
125 kg ha^{-1}	42.61	45.81	67.43	82.27	38.46	111.45	25.94	25.72	26.97	47.21
175 kg ha^{-1}	46.71	46.10	67.73	82.71	41.66	118.98	28.24	25.96	27.03	47.56
225 kg ha^{-1}	50.80	46.23	68.38	83.04	44.94	126.46	30.76	26.25	27.12	47.93
CD (p=0.05)	2.65	1.30	0.83	1.58	2.30	4.83	1.46	NS	0.72	0.23
SE.m (±)	0.873	0.427	0.273	0.520	0.760	1.592	0.483	0.518	0.237	0.074
Gypsum application stage										
Full at sowing	42.83	45.17	66.92	81.00	38.89	112.36	26.07	25.73	26.65	47.31
50% at sowing + 50% at flower initiation stage	46.34	45.91	67.78	82.74	41.24	117.82	28.00	25.97	26.95	47.45
CD (p=0.05)	1.87	NS	0.59	1.12	1.63	3.41	1.04	NS	NS	NS
SE.m (±)	0.617	0.302	0.193	0.368	0.537	1.126	0.341	0.367	0.168	0.053
Nitrogen and phosphorus levels										
15 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1}	41.60	45.10	66.87	79.81	38.01	110.87	25.45	25.61	26.19	47.07
25 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}	45.08	45.57	67.28	82.81	40.52	116.00	27.30	25.90	26.79	47.38
35 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1}	47.08	45.93	67.90	83.00	41.67	118.39	28.34	26.03	27.41	47.71
CD (p=0.05)	2.01	NS	0.79	2.18	1.55	3.29	1.12	NS	0.38	0.18
SE.m (±)	0.697	0.241	0.274	0.755	0.537	1.142	0.389	0.320	0.131	0.064
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Yield

Different gypsum levels exerted a significant influence on the pod yield, haulm yield and kernel yield of groundnut (Table 1). With an increase in the levels of applied gypsum, an increasing trend in the pod yield, haulm yield and kernel yield was observed. Application of 225 kg ha^{-1} gypsum resulted in maximum pod yield (44.94 q ha^{-1}) and haulm yield (126.46 q ha^{-1}), which was significantly higher as compared to the other doses (Control, 125 and 175 kg ha^{-1}) of gypsum. Application of 225 kg ha^{-1} gypsum resulted in maximum kernel yield (30.76 q ha^{-1}), which was at par with 175 kg ha^{-1}gypsum while significantly higher as compared tocontrol and 125 kg ha^{-1} of gypsum. Gashti *et al* (2012), Yadav *et al.* (2015) and Pancholi *et al.* (2017) confirmed the above results and reported that 200 kg ha^{-1} gypsum application upto 400 kg ha^{-1} resulted in maximum pod yield and straw yield of groundnut. Gypsum application stage significantly influenced the pod yield, haulm yield and kernel yield of spring groundnut. The split application of gypsum (50% at sowing + 50% at flower initiation stage) gave significantly higher pod yield (41.24 q ha^{-1}), haulm yield (117.82 q ha^{-1}) and kernel yield (28 q ha^{-1}) as compared to the application of full dose of gypsum at sowing. Harvest index was non-significantly affected by gypsum application stage. However, split application of gypsum gave higher harvest index (25.97) as compared to the basal application of gypsum (25.73). The findings are in line with the results of Jat and Singh (2006) who reported that the split application of gypsum @ 250 kg ha^{-1} at sowing + 125 kg ha^{-1} at flowering significantly increased the pod yield and kernel yield over gypsum application at sowing time. Nitrogen and phosphorus levels had a significant effect on the pod yield, haulm yield and kernel yield of spring groundnut. Application of 35 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} gave maximum pod yield

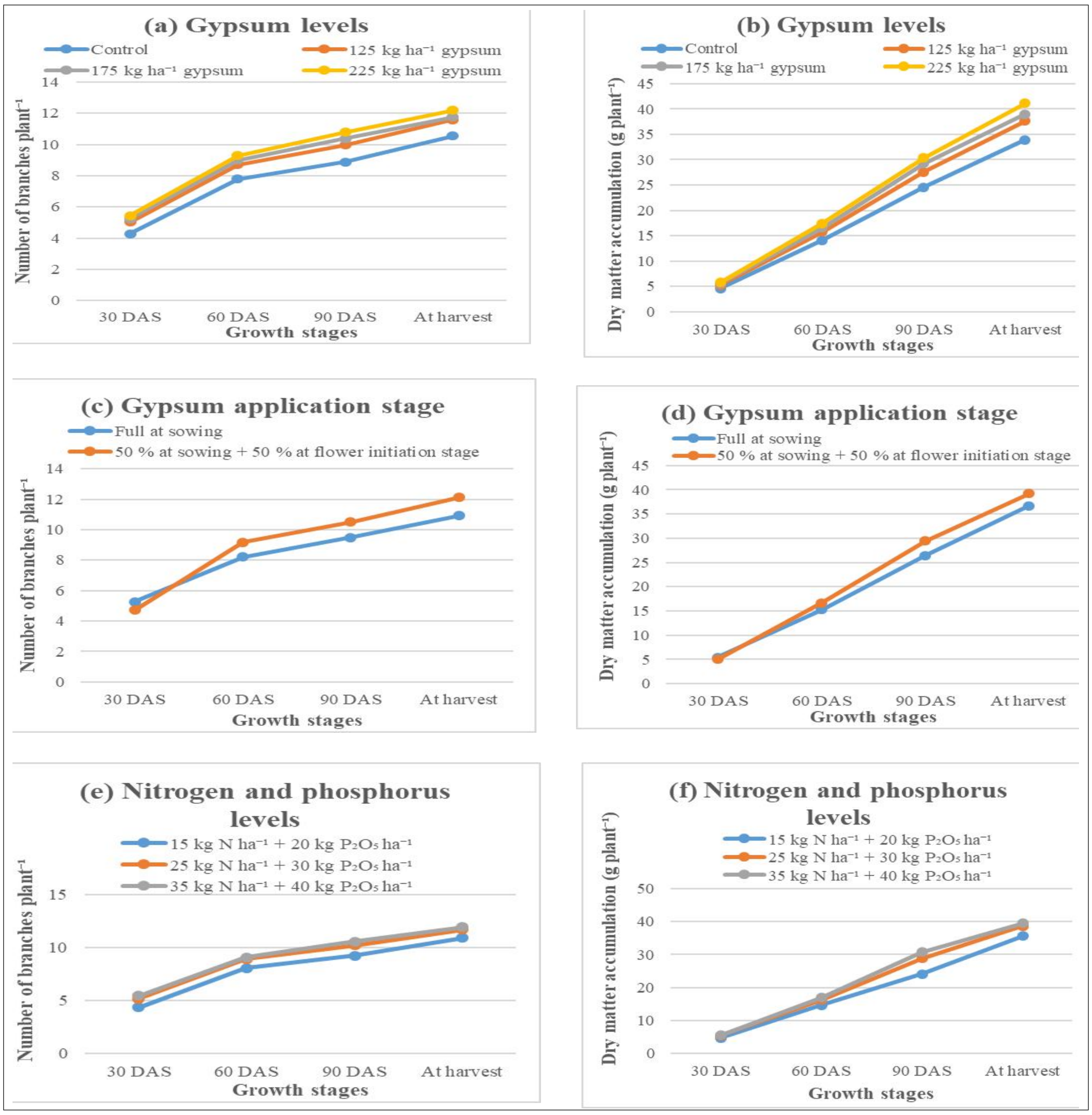

Fig 2: Number of branches and dry matter accumulation of groundnut as influenced by gypsum levels, gypsum application stage and nitrogen and phosphorus levels (Pooled data of 2 years).

(41.67 q ha^{-1}), haulm yield (118.39 q ha^{-1}) and kernel yield (28.34 q ha^{-1}), which were statistically at par with 25 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} (38.68 q ha^{-1} in 2018 and 42.36 q ha^{-1} in 2019) while significantly higher than that of 15 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1}. Nitrogen and phosphorus levels had a non-significant effect on harvest index, however an increasing trend in harvest index was observed with increase in the levels of nitrogen and phosphorus. Similarly, Meena and Yadav (2015) found that the application of 30 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1} significantly increased the pod yield, haulm yield and kernel yield of groundnut over lower doses of nitrogen and phosphorus.

Quality attributes

Different gypsum levels exerted a significant influence on the protein and oil content of kernels (Table 1). Application of 225 kg ha^{-1} gypsum resulted in maximum protein content (27.12%) which was statistically at par with that of 175 kg ha^{-1} and 125 kg ha^{-1} gypsum while significantly higher than control. Application of 225 kg ha^{-1} gypsum gave maximum oil content of 47.93%, which was significantly higher as compared to the other doses of gypsum. Rao and Shaktawat (2001), Rao and Shaktawat (2005) and Thilakarathna *et al.* (2014) also reported that application of 250 kg gypsum ha^{-1} significantly improved the protein content and oil content as compared to control. The effect of gypsum application stage on the protein content and oil content of groundnut kernels was non-significant. The maximum protein content and oil content was observed with the split application of gypsum as compared to full gypsum application at sowing time though the difference was non-significant. Different levels of nitrogen and phosphorus exerted a significant effect on the protein and oil content of groundnut kernels. Application of 35 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} gave maximum protein content (27.41%) and oil content (47.71%), which was significantly higher than the other two levels of nitrogen and phosphorus. Similarly, Shinde *et al* (2000) and Hasan and Sahid (2016) revealed that the increase in levels of nitrogen and phosphorus increased the protein and oil content in the kernels of groundnut.

Economics

Gypsum levels influenced gross returns, net returns and benefit cost ratio significantly (Table 2). Application of 225 kg ha^{-1} gypsum resulted in maximum gross returns (` 172786.9 $ha^{-1}$), net returns (` 119313.2 ha^{-1}) and benefit cost ratio (3.23), which were significantly higher than other levels of gypsum. Gypsum application stage significantly influenced the gross returns, net returns and benefit cost ratio. Split application of gypsum (50% at sowing + 50% at flower initiation stage) gave significantly higher gross returns (` 158645.6 $ha^{-1}$), net returns (` 105992.2 ha^{-1}) and benefit cost ratio (3.00) as compared to the application of full dose of gypsum at sowing during both the years. Nitrogen and phosphorus levels influenced gross returns and net returns significantly. Application of 35 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} gave maximum gross returns (` 160303 $ha^{-1}$) and net returns (` 106042.8 ha^{-1}), which were at par with 25 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}, but significantly higher than 15 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1}. Nitrogen and phosphorus levels influenced the benefit cost ratio non-significantly. However, an increasing trend in the value of benefit cost ratio was observed with increase in the levels of nitrogen and phosphorus.

Table 2: Cost of cultivation, gross returns, net returns and benefit cost ratio of spring groundnut as influenced by gypsum, nitrogen and phosphorus (Pooled data of 2 years).

Treatments	Cost of cultivation (` ha^{-1})	Gross returns (` ha^{-1})	Net returns (` ha^{-1})	Benefit cost ratio
Gypsum levels				
Control	51505.0	135561.3	84056.3	2.63
125 kg ha^{-1}	52598.8	148026.6	95427.8	2.81
175 kg ha^{-1}	53036.3	160265.5	107229.2	3.01
225 kg ha^{-1}	53473.8	172786.9	119313.2	3.23
CD (p=0.05)	-	8593.0	8593.0	0.16
SE.m (±)	-	2832.989	2832.989	0.054
Gypsum application stage				
Full at sowing	52653.4	149674.5	97021.1	2.83
50% at sowing + 50% at flower initiation stage	52653.4	158645.6	105992.2	3.00
CD (p=0.05)	-	6076.2	6076.2	0.12
SE.m (±)	-	2003.226	2003.226	0.038
Nitrogen and phosphorus levels				
15 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1}	51046.6	146280.6	95234.0	2.86
25 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}	52653.4	155896.5	103243.1	2.95
35 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1}	54260.2	160303.0	106042.8	2.95
CD (p=0.05)	-	5934.1	5934.1	NS
SE.m (±)	-	2059.976	2059.976	0.039
Interaction	-	NS	NS	NS

CONCLUSION

The application of higher level of gypsum @ 225 kg ha^{-1} resulted in significantly maximum yield and also improved growth and quality parameters of spring groundnut over lower levels. In spring groundnut, gypsum should be applied in two split doses *i.e.* half at sowing time and remaining half at flower initiation stage to get more growth, yield and quality of groundnut. To get maximum growth, yield and quality of spring groundnut, the crop should be applied with 25 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}.

Conflict of interest: None.

REFERENCES

Agasimani, C.A., Bablad, H.B., Hosmani, M.M. (1992). Response to time, form and level of calcium application in groundnut (*Arachis hypogaea*). Indian Journal of Agronomy. 37: 493-495.

Bairagi, M.D., David, A.A., Thomas, T., Gurjar, P.C. (2017). Effect of different levels of N P K and gypsum on soil properties and yield of groundnut (*Arachis hypogaea* L.) var. Jyoti. International Journal of Current Microbiology and Applied Sciences. 6(6): 984-991.

Boote, K.J. (1982). Growth stages of peanut (*Arachis hypogaea* L.). Peanut Science. 9(1): 35-40.

Brady, N.C., Well, R.R. (Eds). (2002). The Nature and Properties of Soils. 13th Ed. Pearson Education (Singapore) Pvt. Ltd. Indian Branch. 105-08 pp.

Evanylo, G.K. (1989). Amelioration of subsoil acidity by gypsum. The Vegetable Growers News 44(2): 3-4.

Gashti, A.H., Mohammad, N., Safarzadeh, V., Mohammad, H.H. (2012). Effect of potassium and calcium application on yield, yield components and qualitative characteristics of peanut (*Arachis hypogaea* L.) in Guilan Province, Iran. World Applied Sciences Journal. 16 (4): 540-546.

Ghosh, A., Singh, V.J., Srihima, G., Sahoo, P. and Chakraborti, S.K. (2015). Effect of gypsum and lime on seed yield parameters of groundnut (*Arachis hypogaea*). Journal Crop and Weed. 11(Special Issue): 5-9.

Grichar, W.J., Besler, B.A., Brewer, K.D. (2002). Comparison of agricultural and power plant by- product gypsum for South Texas peanut production. Texas Journal of Agriculture and Natural Resources. 15: 44-50.

Hasan, M. and Sahid, I.B. (2016). Evaluation of rhizobium inoculation in combination with phosphorus and nitrogen fertilization on groundnut growth and yield. Journal of Agronomy. 15(3): 142-146.

Iman, A.A.F., Ahmed, A.Z. (2014). Groundnut (*Arachis hypogaea* L.) growth and yield responses to seed irradiation and mineral fertilization. IOSR Journal of Agriculture and Veterinary Science. 7(5): 63-70. DOI: 10.9790/2380-07536370.

Jat, R.L., Singh, P. (2006). Effect of gypsum and plant growth regulators on yield attributes and yields of groundnut (*Arachis hypogaea* L.). International Journal of Agricultural Sciences. 2(1): 228-230.

Kabir, R., Yeasmin, S., Islam, A.K.M.M., Sarkar, M.A.R. (2013). Effect of phosphorus, calcium and boron on the growth and yield of groundnut (*Arachis hypogea* L.). International Journal of Bio-Science and Bio-Technology. 5(3): 51-60.

Mandal, S., Samui, R.C., Mondal, A. (2005). Growth, yield and yield attributes of groundnut cultivars as influenced by gypsum application. Legume Research. 28: 119-121.

Meena, R.S., Yadav, R.S. (2015). Yield and profitability of groundnut (*Arachis hypogaea* L.) as influenced by sowing dates and nutrient levels with different varieties. Legume Research. 38: 791-797. Doi: 10.18805/lr.v38i6.6725.

Murata, M.R. (2003). The Impact of Soil Acidity Amelioration on Groundnut Production on Sandy Soils of Zimbabwe. Ph.D. Thesis, University of Pretoria, Zimbabwe.

Pancholi, P., Yadav, S.S., Gupta, A. (2017). The influence of weed control and sulphur fertilization on oil content and production of groundnut (*Arachis hypogaea* L.) in semi-arid region of Rajasthan. Journal of Pharmacognosy and Phytochemistry. 6(4): 677-679.

Rao, S.S., Shaktawat, M.S. (2001). Effect of organic manure, phosphorus and gypsum on growth, yield and quality of groundnut (*Arachis hypogaea* L.). Indian Journal of Plant Physiology. 6(3): 306-311.

Rao, S.S., Shaktawat, M.S. (2005). Effect of organic manure, phosphorus and gypsum on nutrient uptake in groundnut. Agropedology. 15(2): 100-106.

Savani, V.N., Darji, V.B. (1995). Statistical estimation of relative changes in phosphorus content with different levels of applied phosphorus in groundnut. Gujarat Agricultural University Research Journal. 21: 119-123.

Shinde, S.H., Kaushik, S.J., Bhilare, R.L. (2000). Effect of level of fertilizer, plastic film mulch and foliar spray on yield and quality of summer groundnut. Journal of Maharashtra Agricultural University. 25(2): 227-229.

Singh, R.A. (2007). Effect of variable doses of potassium, sulphur and calcium on pod yield of short duration summer groundnut (*Arachis hypogaea* L.). International Journal of Agricultural Sciences. 3(1): 196-98.

Sivanesarajah, K., Sangakkara, U.R., Sandanam, S. (1995). Effects of plant density, nitrogen and gypsum on yield parameters of groundnut (*Arachis hypogea* L.) in Regosols of Batticaloa District. Tropical Agricultural Research. 7: 112-123.

Smal, H., Kvien, C.S., Sumner, M.E., Csinos, A.S. (1989). Solution calcium concentration and application date effects on pod calcium uptake and distribution in Florunner and Tifton-8 peanut. Journal of Plant Nutrition. 12(1): 37-52.

Thilakarathna, S.M.C.R., Kirthisinghe, J.P., Gunathilaka, B.L., Dissanayaka, D.M.P.V. (2014). Influence of gypsum application on yield and visual quality of groundnut (*Arachis hypogaea* L.) grown in Maspotha in Kurunegala District of Sri Lanka. Tropical Agricultural Research. 25(3): 432-436. DOI: 10.4038/tar.v25i3.8050.

Yadav, N., Yadav, S.S., Yadav, N., Yadav, M.R., Kumar, R., Yadav, L.R., Yadav, L.C., Sharma, O.P. (2017). Growth and productivity of groundnut (*Arachis hypogaea* L.) under varying levels and sources of sulphur in semi-arid conditions of Rajasthan. Legume Research. 41(2): 293-298. DOI: 10.18805/LR-3853.

Yadav, R., Jat, L.K., Yadav, S.N., Singh, R.P., Yadav, P.K. (2015). Effect of gypsum on growth and yield of groundnut (*Arachis hypogaea* L.). Environment and Ecology. 33(2): 676-679.