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Drashti A Patel
PG Student, Department of Agronomy, C.P. College of agriculture, S.D. Agricultural University, Sardarkrushinagar, Gujarat, India

MG Chaudhary
Professor, Department of Agronomy, C.P. College of agriculture, S.D. Agricultural University, Sardarkrushinagar, Gujarat, India

Corresponding Author:
Drashti A Patel
PG student, Department of Agronomy, C.P. College of agriculture, S.D. Agricultural University, Sardarkrushinagar, Gujarat, India

Response of groundnut (*Arachis hypogaea* L.) to potassium and sulphur on growth, yield attributes and yield in loamy sand

Drashti A Patel and MG Chaudhary

Abstract
An experiment was conducted during *kharif* 2019 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar to study the "Response of groundnut (*Arachis hypogaea* L.) to potassium and sulphur in loamy sand". The experiment consisted of nine treatment combinations comprised of three levels of potassium (00, 30 and 60 kg K/ha) and three levels of sulphur (20, 40 and 60 kg S/ha) were embedded in randomized block design with factorial concept with four replications. The maximum plant height at 60 DAS and at harvest, number of branches/plant, number of nodules/plant as well as fresh and dry weight of nodules/plant at flowering stage, number of filled pods/plant, pod yield/plant, seed index, pod and haulm yield and shelling percentage of groundnut were recorded with application of potassium @ 60 kg/ha as compared to 00 kg/ha and sulphur @ 60 kg/ha as compared to 20 kg/ha.

Keywords: Potassium, sulphur, growth, yield attributes, groundnut

Introduction

Groundnut (*Arachis hypogaea* L.) is known to be a unique and important legume cum oilseed crop of India accounting 33% of world's groundnut area and about 27.3% production. It belongs to the Leguminosae family. It is also known as peanut, monkey nut, earthnut, manila nut, pindas, jack nuts, pinders and goober.

Groundnut seeds are rich source of edible oil (43-55%) as well as protein (25-28%). It provides 564 kcal of energy from 100 g of kernels. Groundnut oil contains 20% saturated and 80% unsaturated fatty acids, poly saturated fatty acid has 2 type *i.e*. oleic (40-50%) and linoleic (24-35%) (Mathur and Khan, 1997) [10].

India ranks first in the world with respect to area and second in production after Chaina. In India, total groundnut area was 39.31 lakh hectares and production of 68.62 lakh MT with productivity of 1745 kg/ha during the year of 2019. (IOPEPC). In Gujarat, summer and *kharif* groundnut area, production and productivity were 33,920 and 15.52 lakh hectares, 84,000 MT and 29.38 lakh MT and 2476 kg/ha and 1893 kg/ha, respectively, during the year of 2019. (IOPEPC).

Plant requires nutrients for the normal maintenance of their physiological and biochemical processes. The available amount of these elements is often insufficient in soils and must be supplied as fertilizers, essential inputs for the successful crop production. Among the three major nutrients, potassium (K) has a special position as evident by its role in increasing the crop yield (Yadav, *et al*. 2003 and Read, *et al*. 2006) [23, 16] by adding tolerance to various biotic and abiotic stresses.

Potassium is one of the most essential nutrient for plant growth and vital for sustaining productivity in agriculture. Plants need large quantities of potassium, as much as or even more than nitrogen. Potassium improves economic crop produce and its quality. Thus, application of potassium fertilizer results in higher value to product and therefore greater return to the farmer. Potassium is known for its ability to increase yield and improve quality. It is also essential for photosynthesis and pod development in groundnut. Potassium plays a major role in growth and yield as it is involved in assimilation, translocation and tissue development (Cakmak, 2005) [3].

Sulphur is now widely accepted as fourth major plant nutrient along with N, P and K. It involves in the synthesis of essential amino acids and oil in oilseed crops, being vital component of co-enzyme involved in oil synthesis.

It also involves in various metabolic and enzymatic processes including photosynthesis, respiration and legume-rhizobium symbiotic nitrogen fixation. The role of sulphur in plant make it of fundamental importance in increasing the productivity of crops especially legume oilseeds in India, where more than 50% of soils have been reported to be deficient in sulphur (Tewatia, *et al*. 2006) [20].

The groundnut grown on light textured soils generally suffers from sulphur deficiency due to leaching of SO_4^{-2}. The crop responds significantly to the application of sulphur (Singh and Chaudhary, 1995) [15] which is involved in the biosynthesis of primary metabolites such as methionine, cysteine and cystine amino acid for improving the yield and quality of oil seed crops that can able to obtain higher yield under balanced fertilization.

Materials and Methods

The field experiment was conducted during *kharif* season of 2019 to find out the effect of potassium and sulphur on growth, yield attributes and yield of groundnut at Agronomy Instructional Farm, Department of Agronomy, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha (Gujarat).

The experiment consisted of nine treatment combinations comprised of three levels of potassium (00, 30 and 60 kg K/ha) and three levels of sulphur (20, 40 and 60 kg S/ha) were embedded in randomized block design with factorial concept with four replications. Groundnut variety TG 37 was used as a test crop. The soil of experimental field was loamy sand in texture, low in organic carbon (0.21%) and available nitrogen (150.90 kg/ha), medium in available phosphorus (46.80 kg/ha) and available potassium (250.20 kg/ha) and low in Sulphur (9.20 ppm) with soil pH of 7.3.

A common dose of nitrogen and phosphorus @ 12.5 kg/ha and 25 kg/ha were applied for all treatments. Potassium and sulphur were applied in the form of muriate of potash and gypsum, respectively as per the treatments. Other agronomic management practices were followed as per standard recommendations.

For all the growth and development studies during the crop growth period, five plants were selected randomly from net plot and tagged in each plot for recording plant height, number of branches per plant, number of filled pods per plant, Pod yield per plant. The numbers of root nodules per plant at flowering stage were counted from five randomly selected plants from ring line of each plot. 100 seeds were randomly taken from the bulk produce of each net plot and weighted. The weight was expressed as seed index in grams. The data on pod and haulm yield were recorded from net plot and converted on hectare basis.

Results and Discussion

Effect of potassium

Application of potassium produced non significant effect on plant population at 30 DAS and at harvest as well as plant height at 30 DAS. Significantly the highest plant height at 60 DAS and at harvest were recorded with application of potassium @ 60 kg K/ha but it was at par with application of potassium @ 30 kg K/ha. This result was due to potassium plays an important role in the hormonal balance, influencing the increase in the level of auxin, an important hormone for plant growth (Rubio *et al*., 2009) [17]. The present findings are in accordance with the findings of Chandra *et al.* (2006) [4] and Hemeid *et al.* (2015) [7].

Application of potassium @ 60 kg K/ha produced significantly maximum number of branches per plant but it was remained at par with application of potassium @ 30 kg K/ha. These results may be due to the high availability of K enhances root development, producing more branching and lateral roots (Egilla, *et al*., 2001) [6]. The results are in conformity with the reports of Hemeid *et al.* (2015) [7] and Patel *et al.* (2018[b]) [13].

Application of potassium @ 60 kg K/ha gave significantly higher number of nodules per plant, but it was remained at par with application of potassium @ 30 kg K/ha. The similar trend was observed in fresh and dry weight of nodules per plant. The improvement in growth parameters by application of higher dose of potassium may be due to decreased transpiration and increased the stomata resistance, solar energy harvesting efficiency and nodulation. These results are accordance with the findings of Chandra *et al*. (2006) [4].

Application of potassium @ 60 kg K/ha gave significantly higher number of filled pods per plant, but it was remained at par with application of potassium @ 30 kg K/ha. Potassium said to be important for quality parameters and helps in balance nutrition of crops, transport sugar and water hence its favourable effects on pod formation is supported by Rathor *et al.* (2014) [15] and Hemeid *et al*. (2015) [7].

significantly maximum pod yield per plant was noted with application of potassium @ 60 kg K/ha but it was remained at par with application of potassium @ 30 kg K/ha. The increase in growth and yield might be due to the fact that K influenced the physiological processes that were directly related to symbiotic N_2 fixation, photosynthesis, and carbohydrate translocation for pod growth and due to increase in pod growth improved pod weight per plant. These results are in accordance with the findings of Singh *et al*. (2007) [21].

Application of potassium @ 60 kg K/ha recorded significantly higher pod yield (2317 kg/ha) but it was at par with application of potassium @ 30 kg K/ha. Beneficial effect of potassium on seed production is attributed to its role in plant nutrition, physiological and metabolic processes, including photosynthesis, transport of nutrients, transport and storage of carbohydrates from which fat has synthesized, nitrogen absorption and synthesis of proteins and starch. The present result is in close agreement with the result obtained by Chandra *et al.* (2006) [4], Hemeid (2015) [7] and Patel *et al.* (2018[b]) [13].

Application of potassium @ 60 kg K/ha recorded significantly higher haulm yield which was at par with application of potassium @ 30 kg K/ha. Potassium helps in the resistance to crops against pests and diseases, which, in turn, increased the yield. Potassium also make a pronounced role in carbohydrates synthesis, photosynthesis cell elongation, stomatal activity and higher nutrient uptake under this level resulted in higher plant height and number of branches per plant and ultimately helped in realization of higher haulm yield. The similar result was obtained by Chandra *et al.* (2006) [4], Borah *et al.* (2017) [2] and Patel *et al*. (2018[b]) [13].

Harvest index of groundnut was not influenced significantly due to different levels of potassium. Application of potassium @ 60 kg K/ha gave significantly higher seed index but it was remained at par with application of potassium @ 30 kg K/ha. The improvement in the yield attributing characters like seed index might be due to the fact that potassium acts as a catalytic agent in activating a number of enzymes and synthesis to peptide bonds. Potassium plays a crucial role in meristematic growth through its effect on the synthesis of Phyto hormones. The results so obtained get support with those of Singh *et al.* (2007) [19], Rathore *et al.* (2014) [15] and Patel *et al.* (2018b) [13].

Significantly the higher shelling percentage was obtained under the treatment K_3 (60 kg K/ha) but it was at par with treatment K_2 (30 kg K/ha). Similar findings were observed by Rathore *et al.* (2014) [15], Hemeid (2015) [7] and Borah *et al.* (2017) [2].

Table 1: Effect of potassium and sulphur on growth parameter, yield attributes and yield of groundnut

Treatments	Plant population per metre row length		Plant height (cm)			Number of branches per plant	Number of nodules per plant	Fresh weight of nodules per plant (mg)	Dry weight of nodules per plant (mg)
	At 30 DAS	At harvest	At 30 DAS	At 60 DAS	At harvest				
[A]Potassium levels									
K_1: 00 kg/ha	8.8	8.7	10.70	24.88	37.90	9.81	94.33	196.84	148.67
K_2: 30 kg/ha	9.4	9.2	11.62	25.72	39.11	10.31	97.91	204.24	153.24
K_3: 60 kg/ha	9.6	9.3	12.04	27.23	41.15	11.04	99.91	207.59	158.17
S.Em. ±	0.23	0.19	0.37	0.60	0.73	0.29	1.46	2.98	2.25
C.D. at 5%	NS	NS	NS	1.75	2.13	0.85	4.28	8.70	6.58
[B] Sulphur levels									
S_1: 20 kg/ha	8.9	8.8	10.95	24.62	37.88	9.67	94.50	196.91	149.08
S_2: 40 kg/ha	9.4	9.1	11.50	26.04	39.45	10.65	97.66	202.95	152.03
S_3: 60 kg/ha	9.5	9.3	11.91	27.18	40.82	10.85	100.00	208.80	158.97
S.Em. ±	0.23	0.19	0.37	0.60	0.73	0.29	1.46	2.98	2.25
C.D. at 5%	NS	NS	NS	1.75	2.13	0.85	4.28	8.70	6.58
C.V.%	8.66	7.43	11.30	8.03	6.42	9.71	5.22	5.09	5.09
Interaction (K × S)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Effect of potassium and sulphur on growth parameter, yield attributes and yield of groundnut

Treatments	Number of filled pods per plant	Pod yield per plant (g)	Pod yield (kg/ha)	Haulm yield (kg/ha)	Harvest index (%)	Seed index (g)	Shelling percentage
[A]Potassium levels							
K_1: 00 kg/ha	19.63	9.38	1834	2341	43.89	43.87	59.55
K_2: 30 kg/ha	22.46	11.70	2215	2758	44.57	46.21	60.78
K_3: 60 kg/ha	24.11	11.86	2317	2907	44.40	47.09	62.03
S.Em. ±	0.69	0.34	46.08	69.77	0.87	0.67	0.56
C.D. at 5%	2.04	1.00	134.50	203.62	NS	1.96	1.64
[B] Sulphur levels							
S_1: 20 kg/ha	20.50	10.28	1916	2447	43.82	44.31	59.48
S_2: 40 kg/ha	22.30	11.10	2164	2709	44.37	45.56	60.95
S_3: 60 kg/ha	23.41	11.56	2285	2851	44.65	47.31	61.93
S.Em. ±	0.69	0.34	46.08	69.77	0.87	0.67	0.56
C.D. at 5%	2.04	1.00	134.50	203.62	NS	1.96	1.64
C.V.%	10.97	10.88	7.52	9.05	6.86	5.08	3.20
Interaction (K × S)	NS	NS	NS	NS	NS	NS	NS

Effect of sulphur

Application of potassium produced non significant effect on plant population at 30 DAS and at harvest as well as plant height at 30 DAS. Significantly the maximum plant height was recorded under 60 kg S/ha at 60 DAS and at harvest respectively, which was at par with 40 kg S/ha. The observed improvement might be due to an early and plentiful availability of sulphur leading to better nutritional environment in the root zone for growth and development. As sulphur is one of the secondary essential plant nutrients required for growth. Therefore, overall growth with the application of sulphur in deficient soil could be ascribed to its pivotal role in several physiological and biochemical processes which are of vital importance for development of the plants. The results are in conformity with the reports of Rao *et al.* (2013) [14] and Yadav *et al.* (2017) [22].

Significantly maximum number of branches per plant was recorded under with application of 60 kg S/ha which was remained at par with application of 40 kg S/ha. This result might be due to the fact that sulphur application improved over all nutritional environment of the Rhizosphere as well as plant system which could be more advantageous for profuse vegetative and root growth which activated higher absorption of nutrients from the soil and improved metabolic activities inside the plant. The results are in conformity with the reports of Banu *et al.* (2017) [1] and Patel *et al.* (2018b) [13].

Higher number of nodules per plant at flowering stage was noted with application of 60 kg S/ha which was at par with application of 40 kg S/ha. The similar trend was observed in fresh and dry weight of nodules per plant. Maximum availability of sulphur helps in stimulating photosynthesis as well as synthesis of sulphur containing amino acids, proteins, chlorophyll and promoting nodulation may be assigned to increase in formation of nodules. Similar result was found by Kumar *et al.* (2008) [9] and Yadav *et al.* (2017) [22].

Application of 60 kg S/ha recorded significantly higher number of filled pods per plant but it was at par with application of 40 kg S/ha. This could be due to sulphur plays vital and important role in energy storage & transformation, carbohydrate metabolism and activation of enzymes also

increase the photosynthetic activity of plant. Hence its favourable effects on pod were also observed by Jamal *et al*. (2006) [8], Rao *et al*. (2013) [14] and Banu *et al.* (2017) [1].
Significantly the maximum pod yield per plant recorded with application of 60 kg S/ha, which was statistically at par with application of 40 kg S/ha. Improvement in vegetative structures for nutrient absorption and photosynthesis, strong sink strength through development of reproductive structures and production of assimilates under influence of applied S maintained balance source-sink might have resulted in increased yield attributes. Similar result was found by Patel *et al*. (2008) [12] and Dutta *et al*. (2015) [5].
Significantly higher pod yield was noted with application of 60 kg S/ha but it was at par with application of 40 kg S/ha. Maximum availability of sulphur helps in stimulating photosynthesis and seed formation as well as synthesis of sulphur containing amino acids, proteins, chlorophyll, and promoting nodulation may be assigned to increase total biomass production which was finally reflected in increment in pod yield of groundnut. Similar results were also found by Vaghasia *et al.* (2007) [21], Yadav *et al.* (2017) [22] and Patel *et al*. (2018^{b}) [13].
Significantly higher haulm yield was noted with application of 60 kg S/ha but it was at par with application of 40 kg S/ha. These results can be ascribed to effect of sulphur application on cell division, enlargement and elongation resulting in overall improvement in plant organ associated with faster and uniform vegetative growth of the crop. The results were in line of results of those reported by Rao *et al*. (2013) [14] and Pancholi *et al.* (2017) [11].
Harvest index of groundnut was not significantly influenced due to different levels of sulphur. Significantly higher seed index was noted with application of 60 kg S/ha but it was at par with application of 40 kg S/ha. The positive effect of sulphur fertilization on seed index ascribed to more availability of sulphur during vegetative and reproductive stages of the crop. Sulphur helps in chlorophyll formation, photosynthetic process, and activation of enzymes and grain formation and various metabolic activities. Similar findings were observed by Jamal *et al.* (2006) [8], Rao *et al*. (2013) [14] and Patel *et al*. (2018^{b}) [13].
Significantly higher shelling percentage was observed with application of 60 kg S/ha but it was at par with application of 40 kg S/ha. This may be due to the role of sulphur in various metabolic and enzymatic processes including photosynthesis, respiration and legume-*rhizobium* symbiotic nitrogen fixation. The present results are in close agreement with the result obtained by Banu *et al*. (2017) [1].

Conclusion
Based on the results of one year experimentation, it is concluded that for getting higher yield as well as enhancing quality of groundnut, the crop should be fertilized with 30 kg potassium and 40 kg sulphur per hectare along with common dose of nitrogen and phosphorus @ 12.5 kg/ha and 25 kg/ha.

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