Indian Journal of Agronomy **61** (1): 115–118 (March 2016)

Research Communication

Effect of sulphur and plant-growth regulators on growth, yield and economics of summer groundnut (*Arachis hypogaea*)

CHETRAM SAINI[1], N.K. JAIN[2] AND R.K. MATHUKIA[3]

College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat 362 001

Received : September 2015; Revised accepted : January 2016

ABSTRACT

A field experiment was carried out during summer 2014 at summer Junagadh, Gujarat, to study the effect of sulphur and plant-growth regulators on growth, yield and economics of summer groundnut (*Arachis hypogaea* L.). Sulphur fertilization up to 40 kg S/ha significantly increased plant height, dry-matter accumulation (60 days after sowing, DAS), total chlorophyll content (55 DAS) and mature pods/plant, whereas, dry-matter accumulation at 90 DAS and at harvesting, immature pods/plant, weight of mature and immature pods/plant, and 100-kernel weight increased significantly up to 20 kg S/ha. Significantly higher number of total and effective root nodules/plant (60 DAS), and shelling outturn were recorded at 40 kg S/ha over the control. Significantly higher pod and haulm yields were realized with the application of 20 kg S/ha by 21.9 and 13.0% over the control respectively. An additional net returns of ₹ 18.3 × 10^3/ha were obtained with the application of 40 kg S/ha in comparison to the control with the highest benefit: cost ratio (1.99:1). Maximum plant height, dry-matter accumulation (60 and 90 DAS, and at harvesting), total chlorophyll content (55 DAS), number and weight of mature and immature pods/plant were recorded with the foliar spray of NAA @ 40 ppm twice at 25 and 50 DAS, whereas the maximum number of effective root nodules/plant at 60 DAS and 100-kernel weight were recorded with the application of GA_3 @ 20 ppm twice at 25 and 50 DAS. Application of NAA @ 40 ppm twice at 25 and 50 DAS significantly enhanced the pod and haulm yields by 33.8 and 18.1% over the control, respectively, and was at par with GA_3 @ 20 ppm twice at 25 and 50 DAS. In comparison to the control, the maximum additional net returns of ₹21.2 × 10^3/ha and benefit: cost ratio (2.01:1) were also obtained under this treatment.

Key words : Economics, Plant-growth regulators, Sulphur, Summer groundnut, Yield

Groundnut contains 45–50% edible oil. The oil is generally used in the preparation of vanaspati, soaps, cosmetics and cold creams besides as cooking medium. It is good from both nutritive and culinary points of views, as it contains good quantities of MUFA (oleic acid, 40–50 %) and PUFA (linoleic acid, 25–35%). The remaining 50% of the kernel has high quality protein, on an average 25.3% which is about 1.3 times higher than meat, 2.5 times higher than eggs, carbohydrates (6.0 to 24.9%) and minerals and vitamins (Das, 1997). In India, it is cultivated on an area of 5.53 m ha with production of 9.67 million tonnes and productivity of 1,750 kg/ha during 2013–2014 (AICRPG, 2015). The productivity is low as compared to USA (4,300 kg/ha) and China (3,500 kg/ha). The main reason responsible for low productivity is imbalanced fertilization. Besides NPK, sulphur is one of the essential nutrient elements which plays an important role in carbohydrate metabolism and formation of chlorophyll, glycosides, oils and many other compounds that are involved in N-fixation and photosynthesis of plants. Its nutrition to crops is vital both from quality and quantity point of view. It promotes nodulation in legumes and produces heavier grains of oilseeds (Tandon, 1986). Further, the productivity could be enhanced through use of plant-growth regulators which are organic compounds and in small amount modify a given physiological process. These are known to influence different crop physiological parameters, e.g. alter plant archetype, promote photosynthesis, alter assimilate partitioning, stimulate uptake of mineral ions, enhance nitrogen metabolism, promote flowering, uniform pod formation, increase mobilization of assimilates to defined sinks, improve seed quality, induce synchrony in flowering

Based on a part of M.Sc. thesis of the first author submitted to Junagadh Agricultural University, Junagadh, Gujarat 362 001 (unpublished)

[1]Corresponding author Email: crduhariya143@gmail.com

[1]M.Sc. (Agric.) Scholar, [3]Associate Professor, Junagadh Agricultural University, Junagadh, Gujarat 362 001; [2]Principal Scientist, Human Resource Management Unit, ICAR, Krishi Anusandhan Bhavan II, New Delhi 110 012

and delay senescence of leaves. Menon and Srivastava (1984) emphasized the importance of plant-growth regulators in source and sink relationship leading to enhanced translocation of photosynthates.

A field experiment was carried out under irrigated sulphur-deficient conditions in medium black clayey soil with low available nitrogen (237 kg/ha), medium phosphorus (22.5 kg/ha), and high potassium (284 kg/ha), and low sulphur (17.5 kg/ha) during summer 2014 at the Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat). The experiment, consisting of 20 treatment combinations, comprising 4 levels of sulphur (0, 20, 40 and 60 kg S/ha) and 5 levels of plant-growth regulators [Control (water spray at 25 DAS), NAA @ 40 ppm at 25 DAS, GA_3 @ 20 ppm at 25 DAS, NAA @ 40 ppm twice at 25 and 50 DAS, and GA_3 @ 20 ppm twice at 25 and 50 DAS], was laid out in factorial randomized block design with 3 replications. Summer groundnut 'GJG 31' which received 35.9 mm rains during the entire crop-growing period was sown at 30 cm × 10 cm spacing using 100 kg/ha seed rate. During the crop season, 8 irrigations were applied at fortnight intervals. Nitrogen, phosphorus and potassium @ 25, 50 and 30 kg/ha were supplied through urea (after adjusting the quantity supplied by diammonium phosphate (DAP), DAP and muriate of potash, respectively, at the time of sowing. Sulphur was applied through cosavet (90% S) at the time of sowing as per treatments. Weeds were controlled through pre-emergence spray of pendimethalin @ 1.0 kg/ha and 1 hand-weeding and intercultural operations at 25 DAS. The crop was raised as per recommended package of practices. All the data were statistically analysed using the Analysis of Variance Technique as per the procedure given by Panse and Sukhatme (1985). The critical difference (CD) values at P=0.05 were used for determining the significance of differences between treatment means.

Growth parameters, viz. plant height (harvest), dry-matter accumulation (60 DAS), total and effective root nodules/plant (60 DAS), and chlorophyll *a*, chlorophyll *b* and total chlorophyll content (55 DAS) increased significantly with the increase in sulphur levels up to 40 kg S/ha, whereas significant response was obtained up to 20 kg S/ha for dry-matter accumulation at 90 DAS and at harvesting. Therefore, overall growth with application of S in deficient soil could be ascribed to its pivotal role in several physiological and biochemical process which are of vital importance for development of the plants. Thus, the increase in growth parameters owing to application of S enhanced metabolic activities in plants, resulting in higher meristematic activities leading towards increased division, enlargement and elongation of cells which might have helped in attaining higher plant growth. These improvements manifested in terms of yield attributing parameters, viz. number and weight of mature and immature pods/plant, 100-kernel weight and shelling outturn. This could be ascribed to overall improvement in vigour and crop growth, as reflected by plant height, dry-matter accumulation (at all stages), number of total and effective nodules/plant and chlorophyll content in leaves. Dash *et al.* (2013)

Table 1. Effect of sulphur and plant-growth regulators on growth parameters of groundnut

Treatment	Plant height (cm) at harvest	Dry-matter accumulation (g/plant)			Root nodules/plant (60 DAS)		Chlorophyll content (55 DAS) (mg/g)		
		60 DAS	90 DAS	At harvest	Total nodules (Nos.)	Effective nodules (Nos.)	Chlorophyll *a*	Chlorophyll *b*	Total
Sulphur (kg S/ha)									
0 (control)	20.5	9.2	14.9	24.5	87.6	74.6	1.94	0.42	2.36
20	22.8	11.3	17.4	27.6	91.0	77.6	2.57	0.51	3.08
40	24.4	12.3	18.3	29.8	93.7	80.3	3.02	0.64	3.66
60	23.6	11.7	18.0	28.9	91.5	78.5	2.78	0.60	3.38
SEm±	0.55	0.29	0.45	0.79	1.64	1.42	0.04	0.01	0.04
CD (P=0.05)	1.56	0.84	1.27	2.26	4.69	4.07	0.12	0.03	0.11
Plant-growth regulators									
Control (water spray)	20.6	9.5	15.3	24.6	87.7	74.6	1.94	0.45	2.39
NAA @ 40 ppm at 25 DAS	22.7	11.0	17.2	27.8	89.9	76.7	2.57	0.55	3.12
GA_3 @ 20 ppm at 25 DAS	22.5	10.2	16.5	27.0	90.7	77.5	2.49	0.51	3.00
NAA @ 40 ppm at 25 and 50 DAS	24.5	13.0	19.0	29.8	92.4	79.2	3.00	0.64	3.64
GA_3 @ 20 ppm at 25 and 50 DAS	23.9	11.9	17.7	28.9	93.9	80.7	2.87	0.57	3.44
SEm±	0.49	0.26	0.40	0.71	1.47	1.27	0.04	0.01	0.04
CD (P=0.05)	1.40	0.75	1.14	2.02	NS	3.64	0.11	0.02	0.12

and El-Kader and Mona (2013) also reported similar results. A progressive increase in the levels of sulphur fertilization up to 40 kg/ha increased the pod and haulm yields, but significant response was obtained up to 20 kg S/ha and thereafter, a slight reduction was noted at 60 kg S/ha. Thus, application of sulphur @ 20 kg/ha increased the pod and haulm yields by 21.9 and 13.0% over the control respectively. On the other hand, kernel and biological yields increased significantly up to 40 kg S/ha by 44.7 and 24.3% over the control respectively. The increase in yields is mainly ascribed to improvement in yield parameters with S application in addition to its multiple roles in metabolism as an essential constituent of amino acids and also improves vegetative structure and assimilates thereby maintaining balanced source-sink (Patel *et al.,* 2008). This could also be on account of its profound influence in enhancing adequate supply of metabolites and nutrients matching to demands of reproductive structures for their growth and development. Bagarama *et al.* (2012), Dash *et al.* (2013) and El-Kader and Mona (2013) also reported similar results. An additional net returns of ₹18.3 × 10^3/ha was obtained with the application of 40 kg S/ha in comparison to the control (₹28.2 × 10^3/ha) with the highest benefit: cost ratio of 1.99:1. The relationship $Y = b_0 + b_1S + b_2S^2$ describing pod yield of groundnut (Y) as a function of sulphur (S) averaged over 5 levels of plant-growth regulators showed a curvilinear trend expressed as a second polynomial in sulphur.

$Y = 1367.7 + 20.26\ S - 0.23\ S^2$ ($R^2 = 0.9969$)

The optimum level of sulphur as worked out from the production function was 42.4 kg/ha with pod yield of 1,818 kg/ha and average response at optimum level of sulphur was worked out to be 10.62 kg pods/kg S applied.

Application of plant-growth regulators, i.e. NAA @ 40 ppm and GA_3 @ 20 ppm twice at 25 and 50 DAS had favourable effect on growth and biomass production. Maximum plant height, dry-matter accumulation (60 and 90 DAS, and harvesting), and chlorophyll *a*, chlorophyll *b* and total chlorophyll content (55 DAS) were recorded with the foliar spray of NAA @ 40 ppm twice at 25 and 50 DAS closely followed by foliar spray of GA_3 @ 20 ppm twice at 25 and 50 DAS. On the other hand, the maximum number of effective root nodules/plant at 60 DAS were recorded with the application of GA_3 @ 20 ppm twice at 25 and 50 DAS, closely followed by NAA @ 40 ppm twice at 25 and 50 DAS. The improvement in growth parameters may be

Table 2. Effect of sulphur and plant-growth regulators on yield parameters, yields and economics of groundnut

Treatment	Mature pods/ plant	Immature pods/ plant	Weight of mature pods/ plant (g)	Weight of immature pods/ plant (g)	Shelling out-turn (%)	100-kernel weight (g)	Pod yield (t/ha)	Haulm yield (t/ha)	Biological yield (t/ha)	Kernel yield (t/ha)	Net returns (× 10^3₹/ha)	Benefit: cost ratio
Sulphur (kg S/ha)												
0 (control)	10.3	1.9	11.5	1.0	68.4	45.6	1.37	2.38	3.75	0.94	28.2	1.65
20	12.4	3.2	13.2	1.7	71.3	48.7	1.67	2.69	4.36	1.20	40.8	1.90
40	13.4	2.9	14.0	1.5	73.9	50.1	1.83	2.83	4.66	1.36	46.5	1.99
60	12.7	2.7	13.0	1.4	72.5	50.9	1.76	2.73	4.49	1.28	41.1	1.84
SEm±	0.31	0.9	0.44	0.05	1.53	1.1	0.06	0.07	0.09	0.06	1.23	0.06
CD (P=0.05)	0.89	0.27	1.26	0.14	4.36	3.0	0.17	0.21	0.25	0.16	3.50	0.16
Plant-growth regulators												
Control (water spray)	10.5	1.9	11.2	1.1	68.7	45.7	1.36	2.38	3.74	0.94	25.6	1.56
NAA @ 40 ppm at 25 DAS	12.0	2.7	12.9	1.4	71.5	48.3	1.66	2.68	4.34	1.20	39.9	1.87
GA_3 @ 20 ppm at 25 DAS	11.1	2.4	12.2	1.2	71.1	48.9	1.65	2.66	4.30	1.18	38.6	1.84
NAA @ 40 ppm at 25 and 50 DAS	14.3	3.3	14.8	1.7	73.4	50.0	1.82	2.81	4.63	1.34	46.8	2.01
GA_3 @ 20 ppm at 25 and 50 DAS	13.2	3.1	13.6	1.6	72.8	51.1	1.80	2.76	4.56	1.32	44.8	1.94
SEm±	0.28	0.08	0.39	0.04	1.37	0.9	0.05	0.07	0.08	0.05	1.10	0.05
CD (P=0.05)	0.80	0.24	1.12	0.12	NS	2.7	0.15	0.19	0.23	0.14	3.13	0.15
Interaction (S × PGR)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

owing to the stimulating action of auxin (NAA) which softens the cell-wall by increasing its plasticity or may be the oxidative decarboxylation of synthetic auxins which could not be catalyzed by the enzyme peroxidase. Photosynthetic rate integrated over time and leaf area resulted in an increase in dry-matter accumulation. The high chlorophyll content noticed with the application of NAA was attributed to the protection of chlorophyll molecule from photo-oxidation and increased chlorophyll synthesis (Ramesh and Ramprasad, 2015). Foliar application of NAA @ 40 ppm twice at 25 and 50 DAS also recorded the maximum values of yield parameters, viz. number and weight of mature and immature pods/plants over rest of the treatments. However, maximum 100-kernel weight was registered with the foliar application of GA_3 @ 20 ppm twice at 25 and 50 DAS. This could be ascribed to overall improvement in vigour and crop growth, as reflected by plant height, dry-matter accumulation, number of root nodules/plant and chlorophyll content in leaves. This could also be due to reasons that NAA has enhanced the cell elongation, increased flowering and reduced flower drop and helped in fruit setting. The application of NAA @ 40 ppm twice at 25 and 50 DAS, being at par with application of GA_3 @ 20 ppm twice at 25 and 50 DAS, registered significantly higher pod yield over rest of the treatments. Further, single foliar application of either NAA @ 40 ppm or GA_3 @ 20 ppm at 25 DAS was also significantly edge over the control. However, both these were at par with each other. The improvement in pod yield with the application of NAA @ 40 ppm twice at 25 and 50 DAS was 33.8% higher over control. Maximum haulm yield was also obtained with the application of NAA @ 40 ppm twice at 25 and 50 DAS which was 18.1% higher over the control. Application of NAA @ 40 ppm twice at 25 and 50 DAS significantly enhanced the kernel and biological yields by 42.6 and 23.8% over the control respectively, and was on a par with GA_3 @ 20 ppm twice at 25 and 50 DAS. Use of plant-growth regulators early in the life of a plant is considered important in promoting rapid reproductive growth. Thus, plant-growth regulators stimulated pod setting and increased yield parameters of groundnut. Yield mainly depends on source-sink relationship which includes phloem loading at source such as leaf and rapid loading translocation and unloading at sink (kernel and pod). As a result, the economic part will be getting assimilates synthesized by photosynthesis. When nutrients required by plants are supplied through foliar spray, it enhances uptake, translocation and synthesis of photosynthetic assimilates which results in increase in various yield-contributing parameters, viz. weight and number of pods/plant, shelling outturn and 100-kernel weight. Our results confirm findings of Poonia *et al.* (2013) and Rajesh *et al*. (2014) in groundnut and greengram respectively. Additional net returns were obtained with the application of NAA @ 40 ppm and GA_3 @ 20 ppm twice at 25 and 50 DAS in comparison to the control with benefit: cost ratio of 2.01:1 and 1.94:1 respectively.

Thus, summer groundnut fertilized with 40 kg S/ha and foliar spray of NAA @ 40 ppm twice at 25 and 50 DAS gave the maximum yield and economic returns under irrigated sulphur deficient conditions of South Saurashtra Agro-climatic Zone.

REFERENCES

AICRPG. 2015. *Annual Report (kharif, 2014),* All India Coordinated Research Project on Groundnut. ICAR-Directorate of Groundnut Research, Junagadh, Gujarat.

Bagarama, F.M., Shenkalwa, E. and Matata, Z.P. 2012. The effect of gypsum and NPK fertiliser on groundnut performance in Western Tanzania. (In) *Third RUFORUM Biennial Meeting,* held during 24–28 September, 2012 at Entebbe, Uganda, pp. 389–94.

Das, P.C. 1997. *Oilseeds Crops of India*, pp. 80–83. Kalyani Publishers, Ludhiana, Punjab, India.

Dash, A.K., Nayak, B.R., Panigrahy, N., Mohapatra, S. and Samant, P.K. 2013. Performance of groundnut (*Arachis hypogaea*) under different levels of sulphur and irrigation. *Indian Journal of Agronomy* **58**(4): 578–82.

El-Kader, A. and Mona, G. 2013. Effect of sulfur application and foliar spraying with zinc and boron on yield, yield components, and seed quality of peanut (*Arachis hypogaea* L.). *Research Journal of Agriculture and Biological Sciences* **9**(4): 127–35.

Menon, K.K.G. and Srivastava, H.C. 1984. Increasing plant productivity through improved photosynthesis. (In) *Proceedings of the Indian Academy of Sciences-Plant Sciences* **93**(3): 359–78.

Panse, V.G. and Sukhatme, P.V. 1985. *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi.

Patel, G.N., Patel, P.T. and Patel P.H. 2008. Yield, water use efficiency and moisture extraction pattern of summer groundnut as influenced by irrigation schedules, sulfur levels and sources. *Journal of Semi-Arid Tropical Agricultural Research* **6** : 1–4.

Poonia, B.S., Singh, P., Rajput, O.P. and Sumeriya, H.K. 2013. Response of groundnut (*Arachis hypogaea* L.) in rainfed condition under the influence of sulphur, PSB and growth regulators. *Annals of Agriculture Bio Research* **18**(3): 336–38.

Rajesh, K., Reddy, S.N., Reddy, A.P.K. and Singh, B.G. 2014. A comparative study of plant growth regulators on morphological, seed yield and quality parameters of greengram. *International Journal of Applied Biology and Pharmaceutical Technology* **5**(3): 103–09.

Ramesh, R. and Ramprasad, E. 2015. Effect of plant growth regulators on morphological, physiological and biochemical parameters of soybean (*Glycine max* L. Merrill). (In) *Biotechnology and Bioforensics*, pp. 61–71, Springer, Singapore.

Tandon, H.L.S. 1986. *Sulphur Research and Agricultural Production in India*. Edn 2. Fertilizer Development and Consultation Organization, New Delhi.