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Nodulation, yield and economics of summer Groundnut (*Arachis hypogaea* L.) as influenced by sulphur levels and plant growth regulators

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Abstract
The experiment was conducted during the *Zaid* season of 2018 Prayagraj (U.P.).The experiment was conducted to study the Nodulation, yield and economics of summer Groundnut (*Arachis hypogaea* L.) as influenced by sulphur levels and plant growth regulators. The experiment comprised of 2 factors and 13 treatments *viz*. Sulphur (30, 40, 50 kg ha^{-1}) and Plant growth regulators (NAA 50 ppm (at 20 DAS alone & at 20, 40 DAS), GA_3 30 ppm (at 20 DAS alone & at 20, 40 DAS)) and control. Sulphur and Plant growth regulators application significantly influenced the nodulation, yield attributing characters and economics over control. Addition of sulphur at 40 kg ha^{-1} along with foliar application of 50 ppm NAA twice at 20 DAS and 40 DAS recorded highest Nodulation per plant (30 no.), Shelling out percentage (69.50%), Matured pods per plant (30.25 no.), Kernel yield (1.37 t ha^{-1}), Gross returns (96,333.00 Rs ha^{-1}), Net returns (53,935.00 Rs ha^{-1}) and B:C ratio (1.27).

Keywords: Groundnut, Zaid, sulphur, nodulation, gypsum, kernel yield, B:C ratio

Introduction
Groundnut is also known as the "Wonder nut" or "Poor man's Cashew nut". It is world largest source of edible oil, ranks 13th among the food crops as well as 4th most important oilseed crop of the world. Groundnut accounts for 40 per cent of the area and 30 per cent of the production of total oilseeds grown in the country (Anonymous, 2009-10). In India, it was cultivated on an area of 5.53 m ha with production of 9.67 mt and productivity of 1750 kg ha^{-1} during 2013-2014 (AICRPG, 2015) [1]. Sulphur is now recognized as the fourth major plant nutrient after N, P and K, and also an integral part of balanced fertilization and nutrition for oilseed crops in general and groundnut in particular. Sulphur is also known to promote nodulation in legumes there by N fixation and associated with the crops of spurious nutrition and market quality. Its application increases drought and cold tolerance in plant by process of disulphide linkage. The direct source of sulphur is somewhat costlier than elemental sulphur. Gypsum is another material huge deposits of which are found in the state of Rajasthan and being excavated at large scale. It has been the endeavour of crop physiologists to influence crop growth and production by the exogenous application of the growth regulators. Spraying of NAA during early crop growth stage, especially before flower initiation have been found to result in a higher fertility of flower, early fruit set and increasing the number of filled pods per plant (Gopalakrishnan and Srinivasan, 1975: Valliappan *et al.*, 1985 and Rao, 1997) [7]. Gibberellic acid has been used as a growth regulator to increase yields in different crops like paddy.

Materials and Methods
The experiment was conducted during the *Zaid* season of 2018 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj (U.P.) India. Soil was sandy clay loam having pH 7.2, organic carbon around 0.42%, available nitrogen at 245 kg ha^{-1}, available P_2O_5 at 14.8 kg ha^{-1} and K_2O at 343.2 kg ha^{-1}The experiment was laid out in Randomized Block Design consisting of 13 treatment combinations each replicated three times. Different levels of sulphur (30, 40 and 50 kg ha^{-1}) and different plant growth regulators (NAA 50 ppm at 20 DAS, NAA

50 ppm twice at 20 & 40 DAS, GA_3 30 ppm at 20 DAS, GA_3 30 ppm twice at 20 & 40 DAS). Treatments were randomly arranged in each replication.Data on different growth parameters, yield attributes, yield and economics were recorded from randomly selected ten tagged plants from net plot.

Results and Discussion

At 30, 45 and 60 DAS highest number of Nodules Plant^{-1} was observed in Application of Sulphur at the rate of 40 kg ha^{-1} along with foliar application of GA_3 at the rate of 30 ppm ha^{-1} at 20 & 40 DAS. However, it was statistically at par when Sulphur was applied at the rate of 40 kg ha^{-1} along with foliar application of NAA at the rate of 50 ppm ha^{-1} at 20 & 40 DAS). Maximum mature pods plant^{-1} was recorded in Treatment T6 (Sulphur was applied at the rate of 40 kg ha^{-1} along with foliar application of NAA at the rate of 50 ppm ha^{-1} at 20 & 40 DAS). Maximum shelling percentage was recorded in treatment T6 (Sulphur was applied at the rate of 40 kg ha^{-1} along with foliar application of NAA at the rate of 50 ppm ha^{-1} at 20 & 40 DAS). The improved growth due to S fertilization and GA_3 and NAA coupled with increased photosynthesis on one hand and greater mobilization of photosynthates towards reproductive structures, on the other, might have been responsible for significant increase in yield attributes of groundnut. Supply of sulphur in adequate amount also helps in the development of floral primordial i.e. reproductive parts, which results in the development of pods and kernels in plants. Similar findings have also been reported earlier by Patel *et al.,* (2009) [6] Reddy *et al.,* (1978) [8] in groundnut. Maximum Kernel yield (1.37 t ha^{-1}) was recorded in Treatment T_6 (Sulphur was applied at the rate of 40 kg ha^{-1} along with foliar application of NAA at the rate of 50 ppm ha^{-1} at 20 & 40 DAS). Supply of sulphur and GA_3 and NAA in adequate amount also helps in the development of floral primordial i.e. reproductive parts, which results in the development of pods and kernels in plants. Similar findings have also been reported earlier by Rao *et al*., (1987) [7] Patel *et al*., (2009) [6], Reddy *et al*., (1978) [8]. Gross returns were obtained maximum as ₹96,333.00 in T6 in which Sulphur was applied at the rate of 40 kg ha^{-1} along with foliar application of NAA at the rate of 50 ppm ha^{-1} at 20 & 40 DAS. Net returns was obtained maximum as ₹53,935.00 in T_6 in which Sulphur was applied at the rate of 40 kg ha^{-1} along with foliar application of NAA at the rate of 50 ppm ha^{-1} at 20 & 40 DAS. Highest B:C ratio was found in T_6 in which Sulphur was applied at the rate of 40 kg ha^{-1} along with foliar application of NAA at the rate of 50 ppm ha^{-1} at 20 & 40 DAS.

Table 1: Nodulation & Yield attributes of Groundnut as influenced by different treatments at Harvest

S. No.	Treatments	Root Nodules plant^{-1} (60 DAS)	Mature pod plant^{-1} (No.)	Shelling out turn (%)	Pod yield (t ha^{-1})	Oil content (%)
1	30 kg ha^{-1} S & NAA 50 ppm at 20 DAS	85.67	23.57	64.33	1.80	43.20
2	30 kg ha^{-1} S & NAA 50 ppm at20 & 40DAS	85.63	23.84	64.15	1.79	42.57
3	30 kg ha^{-1} S & GA_3 30 ppm at 20 DAS	86.38	24.85	64.67	1.79	42.70
4	30 kg ha^{-1} S & GA_3 30 ppm at20& 40 DAS	90.33	23.76	67.20	1.81	45.87
5	40 kg ha^{-1} S & NAA 50 ppm at 20 DAS	87.15	23.44	64.30	1.82	42.70
6	40 kg ha^{-1} S & NAA 50 ppm at 20&40 DAS	96.30	30.25	69.50	1.97	46.80
7	40 kg ha^{-1} S & GA_3 30 ppm at 20 DAS	92.50	25.89	65.97	1.81	45.97
8	40 kg ha^{-1} S & GA_3 30 ppm at 20&40 DAS	97.53	29.52	68.00	1.93	46.21
9	50 kg ha^{-1} S & NAA 50 ppm at 20 DAS	90.77	26.59	66.40	1.89	43.67
10	50 kg ha^{-1} S & NAA 50 ppm at 20&40 DAS	94.67	27.95	67.30	1.90	46.80
11	50 kg ha^{-1} S & GA_3 30 ppm at 20 DAS	96.40	28.51	67.43	1.90	46.10
12	50 kg ha^{-1} S & GA^3 30 ppm at 20&40 DAS	95.67	28.43	67.50	1.92	47.23
13	Control	85.64	23.89	64.12	1.75	44.00
	SEm+	3.54	1.57	1.22	0.03	0.55
	CD (P = 0.05)	10.35	4.60	3.58	0.09	1.61

Table 2: Economics of Groundnut as influenced by different treatments.

S.No	Treatments	Gross returns(□/ha)	Net returns(□/ha)	B:C ratio
1.	30 kg ha^{-1} S & NAA 50 ppm at 20 DAS	88020.00	46109.00	1.10
2.	30 kg ha^{-1} S & NAA 50 ppm at 20 & 40DAS	87531.00	45559.00	1.09
3.	30 kg ha^{-1} S & GA_3 30 ppm at 20 DAS	87531.00	43517.00	0.99
4.	30 kg ha^{-1} S & GA_3 30 ppm at 20 & 40 DAS	88509.00	42331.00	0.92
5.	40 kg ha^{-1} S & NAA 50 ppm at 20 DAS	88998.00	46663.00	1.10
6.	40 kg ha^{-1} S & NAA 50 ppm at 20 &40 DAS	96333.00	53935.00	1.27
7.	40 kg ha^{-1} S & GA_3 30 ppm at 20 DAS	88509.00	44071.00	0.99
8.	40 kg ha^{-1} S & GA_3 30 ppm at 20 &40 DAS	94377.00	47875.00	1.03
9.	50 kg ha^{-1} S & NAA 50 ppm at 20 DAS	92421.00	49662.00	1.16
10.	50 kg ha^{-1} S & NAA 50 ppm at 20 &40 DAS	92910.00	50090.00	1.17
11.	50 kg ha^{-1} S & GA_3 30 ppm at 20 DAS	92910.00	48148.00	1.07
12.	50 kg ha^{-1} S & GA_3 30 ppm at 20 &40 DAS	93888.00	46862.00	1.00
13.	30 kg ha^{-1} S & NAA 50 ppm at 20 DAS	85575.00	44981.00	1.11

Conclusion

Sulphur application significantly influenced the nodulation, yield attributing characters and economics. Treatment in which Sulphur was applied at 40 kg ha^{-1} along with foliar application of 50 ppm NAA twice at 20 DAS and 40 DAS Nodulation per plant, Shelling out percentage, Matured pods per plant, Kernel yield, Gross returns, Net returns and B:C ratio.

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