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Root Nodulation in Groundnut as Influenced by varied Dates of Sowing, Plant Densities and Nutrient Levels

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ABSTRACT: Productivity of groundnut is lower than expected due to lack of optimum plant population and imbalanced nutrient application. The efforts to enhance groundnut production can be achieved by increasing the root nodules formation. Various agronomic practices can influence the nodulation process and the consequent nitrogen fixation process which can lead to increased productivity of groundnut. A field experiment was carried out during *rabi,* 2019-20 and *rabi,* 2020-21 on sandy loam soils of Krishi Vigyan Kendra, Utukur, Kadapa, Andhra Pradesh. The experimentation was laid out with three replications by adopting split split design. Groundnut variety Kadiri-6 was used for the investigation. The treatments include combination of three dates of sowing, four plant densities (plant spacing's) and three nutrient levels. Dates of sowing did not exert significant influence on root nodulation in groundnut at all the stages of sampling. Among the different plant densities, 4.44 lakh ha^{-1} of plant population by maintaining plant spacing of 22.5 cm × 10 cm resulted significantly higher number of effective nodules per plant which was however comparable with 6.66 lakh ha^{-1} of plant population attained by maintaining the plant spacing of 15.0 cm × 10 cm. Significantly least nodulation was observed with the two plant spacings that accommodate 8.88 lakh ha^{-1} of plant population. Among the different nutrient levels, application of 150% RDF recorded significantly superior number of effective root nodules per plant which was at par with 125% RDF and both these nutrient levels were significantly superior over 100% RDF.

Keywords: Nodulation, Dates of Sowing, Plant densities, Plant spacing, Nutrient levels, Groundnut.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is a predominant annual legume and protein-rich oil seed crop cultivated in tropical and sub-tropical agro climatic regions of Asia, Africa, and America. In India, groundnut contributes a larger share for the national edible oil economy. It is grown in an area of 4.89 million hectares contributing to the production of 9.25 million tonnes with a mean productivity of 1493 kg ha^{-1}. In Andhra Pradesh, groundnut is cultivated over an area of 0.74 million hectares with a production of 1.05 million tonnes and an average productivity of 1426 kg ha^{-1} (https://www.indiastat.com, 2018). But the productivity of groundnut is lower than expected due to lack of optimum plant population and imbalanced nutrient application. The efforts to enhance groundnut production can be achieved by increasing the root nodules formation. Phosphorus plays a predominat role in the formation of root nodules. Legume plants posses an inherent potential for atmospheric nitrogen fixation when they are in association with a suitable microbial partner, rhizobium Rehman *et al.* (2019). Nitrogen (N) plays a predominat role nutrient in the growth of groundnut, but the availability of Nitrogen is relatively low in most of the soils of India. Among the different soil bacteria, a unique group named Rhizobia has an advantageous effect on the plant growth. Rhizobium lives in the soil or within the root nodules of host plants *i.e.*, legume plants. (Kukkamalla and Vardhan, 2016). The symbiotic relationship between groundnut and the bacteria Rhizobium is the crucial ecological process involved in the nitrogen cycle. This symbiotic relationship facilitates fixing of atmospheric nitrogen gas into ammonia. Groundnut plants possess greater capacity of nitrogen fixation. Nitrogen derived from this symbiosis serves as a cheaper source and also helps in reduction of production costs. Nodulation pattern in groundnut is quite different from that of many other legume crops. Root nodules formation occurs mainly at the sites of lateral root emergence in case of groundnut, whereas in other legumes nodules formation occurs mainly at the sites of root hair formation (Uheda *et al.*, 2001). However, research on root nodulation in groundnut is quite limited compared to other legumes such as soya bean and common bean. (Bell *et al.*, 1994; Khan and Yoshida, 1994; Daimon *et al.*, 1999; Daimon and Yoshikawa 2001). Also, little is studied regarding the time course of development of root nodules with varied management practices in groundnut cultivation. Apart from biological factors like rhizobium strain or host specificity within the crop cultivars, various agronomic practices can influence the nodulation process and the consequent nitrogen fixation process. Those factors include soil temperature, moisture availability, acidity or alkalinity of soils, cropping systems, fertilization, inoculation, crop geometry etc. Hence, research is requisite to assess the impact of agro techniques on the nodulation pattern in groundnut.

MATERIALS AND METHODS

A field investigation was carried out during *rabi*, 2019-20 and *rabi*, 2020-21 at Krishi Vigyan Kendra, Utukur campus of Acharya N.G. Ranga Agricultural University, Andhra Pradesh which is geographically located at 14.4^{o} N latitude and 78.8^{o} E longitude at an altitude of 147.0 meters above mean sea level categorised as Southern Agro Climatic Zone of Andhra Pradesh. The soil of experimental field was sandy loam in texture, soil reaction is neytral, organic carbon and available nitrogen are low in availability and available phosphorus and potassium are medium in availability. The investigation was laid out in a split-split plot design which was replicated thrice. The treatments include combination of three dates of sowing viz., I fortnight of October (D1), II fortnight of October (D2) and I fortnight of November (D3), four plant densities or plant spacings that include 22.5 cm × 10 cm (4.44 lakh ha^{-1}), 15.0 cm × 10 cm (6.66 lakh ha^{-1}), 15.0 cm × 7.5 cm (8.88 lakh ha^{-1}) and criss cross sowing with 22.5 cm of row spacing in both the directions and three levels of nutrients of 100% RDF, 125% RDF and 150% RDF. RDF was fixed based on soil test results. As per the soil test results of the experimental field, available nitrogen was low and therefore, additional 30% over the recommended dosage of nitrogenous fertilizer was applied. Whereas available phosphorous and potassium were medium, hence recommended doses were applied. Nitrogen was supplied to the crop in the form of urea, phosphorous through single super phosphate and potassium by using murate of potash. Phosphorous and potassium fertilizers were applied as basal application whereas, nitrogen was applied in 2 splits *viz* two third of nitrogen was applied as basal at sowing time and remaining one third of nitrogen was applied as top dressing at 30 DAS. Gypsum was applied @ 500 kg ha^{-1} at 40 days after sowing. Required quantity of sound Kadiri-6 kernels were selected based on the crop geometry adopted and utilised for sowing after carrying out seed treatment with Mancozeb @ 3g kg^{-1} of seed as a prophylactic measure against seed borne diseases. Groundnut plants were destructively sampled at 20, 40, 60, 80 DAS and at harvest and the number of nodules were counted and expressed as number of effective nodules plant^{-1}.

RESULTS AND DISCUSSION

Table 1: Effective root nodules plant^{-1} of Groundnut at 20, 40 and 60 DAS as influenced by varied dates of sowing, plant densities and nutrient levels.

Treatments	20 DAS			40 DAS			60 DAS		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Dates of sowing									
D_1: I Fortnight of October	24.8	21.4	23.1	45.3	42.2	43.8	70.2	62.9	66.6
D_2: II Fortnight of October	23.6	22.5	23	47.2	40.7	44	72.4	60.9	66.7
D_3: I Fortnight of November	24.9	22.9	23.9	46.9	42.6	44.8	73.4	64.7	69.1
SEm ±	0.5	0.64	0.42	0.41	0.5	0.46	0.8	0.63	0.59
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Plant densities (Plant spacings)									
P1: 22.5 cm × 10.0 cm (4.44 lakh ha^{-1})	25.6	23.2	24.4	49.5	45.5	47.5	76.9	67.0	72.0
P2: 15.0 cm × 10.0 cm (6.66 lakh ha^{-1})	24.5	22.6	23.6	48.8	44.0	46.4	76.0	66.1	71.1
P3: 15.0 cm × 7.5 cm (8.88 lakh ha^{-1})	23.5	21.1	22.3	43.2	38.3	40.8	67.2	58.3	62.8
P4: Cross cross sowing with 22.5 cm Row spacing in both the directions	24.1	22.1	23.1	44.3	39.5	41.9	68.1	60.1	64.1
SEm ±	0.64	0.47	0.56	0.71	0.74	0.72	2.06	1.41	1.79
CD (P = 0.05)	NS	NS	NS	2.1	2.2	2.1	6.1	4.2	5.3
Nutrient levels									
N_1 : 100% RDF	23.2	21.3	22.2	44.3	39.2	41.8	67.1	57.5	62.3
N_2 : 125% RDF	24.6	22.4	23.5	46.7	42.9	44.8	73.7	64.6	69.2
N_3 : 150% RDF	25.4	23.1	24.3	48.3	43.4	45.9	75.3	66.6	70.9
SEm ±	0.39	0.29	0.32	0.74	1.13	0.95	1.90	2.11	1.87
CD (P = 0.05)	1.1	0.8	0.9	2.1	3.2	2.7	5.4	6.0	5.3
Interaction									
D × P									
SEm ±	1.10	0.81	0.96	1.18	1.32	1.20	2.21	1.76	1.78
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
D × N									
SEm ±	0.68	0.50	0.55	0.96	0.81	0.81	1.45	1.89	1.60
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
P × N									
SEm ±	0.79	0.58	0.64	1.11	0.94	0.94	1.68	2.18	1.84
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
D × P × N									
SEm ±	1.36	1.01	1.10	1.93	1.63	1.62	2.91	3.78	3.20
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Irrespective of the imposed treatments, there was a progressive increase in total number of effective nodules of groundnut up to 80 DAS then declined at harvest which might be due to degeneration of nodules as the crop advances in age. Varied dates of sowing did not exert significant influence on total number of effective nodules per plant at all the sampling stages during both the years of investigation.

Among the plant spacings, no significant influence on number of effective nodules was observed at 20 DAS, thereafter wider plant spacing of 22.5 cm × 10 cm (P1) that accommodate 4.44 lakh ha^{-1} of plant population registered significantly higher number of effective root nodules than nodules resulted with closer spacings of 15.0 cm × 7.5 cm (P3) and 22.5 cm of row spacing in both the directions (P4) but was at par with that of nodules resulted at 15 cm × 10 cm (P2) plant spacing (6.66 lakh ha^{-1}) at all the stages of observations. The two closer spacings that accommodate higher plant density of 8.88 lakh ha^{-1} recorded lowest number of effective nodules per plant which are comparable with each other. Limited competition at low and medium plant densities encouraged the crop for efficient utilization of nutrients especially phosphorous which play predominant role in nodule formation, thereby resulted in higher number of effective root nodules plant^{-1}. Similar results were also reported by Pawar and Khuspe (1976); Kumar (2020).

Table 2: Effective root nodules plant^{-1} of Groundnut at 80 DAS and at harvest as influenced by varied dates of sowing, plant densities and nutrient levels.

TREATMENTS	80 DAS			At Harvest		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Dates of sowing						
D_1: I Fortnight of October	82.9	72.4	77.7	39.4	35.9	37.7
D_2: II Fortnight of October	83.2	73.2	78.2	38.4	37.8	38.1
D_3: I Fortnight of November	84.8	73.5	79.2	40.2	38.7	39.5
SEm ±	0.91	0.56	0.69	0.45	0.75	0.42
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
Plant densities (Plant spacings)						
P1: 22.5 cm × 10.0 cm (4.44 lakh ha^{-1})	88.5	78.1	83.3	41.6	39.9	40.8
P2: 15.0 cm × 10.0 cm (6.66 lakh ha^{-1})	86.4	76.1	81.3	40.9	38.6	39.7
P3: 15.0 cm × 7.5 cm (8.88 lakh ha^{-1})	79.8	68.5	74.2	37.2	35.4	36.3
P4: Criss cross sowing with 22.5 cm Row spacing in both the directions	79.9	69.4	74.7	37.5	36.1	36.9
SEm ±	2.03	1.96	1.93	1.05	0.81	0.86
CD (P = 0.05)	6.0	5.8	5.7	3.1	2.4	2.5
Nutrient levels						
N_1 : 100% RDF	78.1	67.5	72.8	36.3	34.9	35.6
N_2 : 125% RDF	85.0	74.6	79.8	39.7	38.6	39.2
N_3 : 150% RDF	87.9	77.0	82.5	42.1	38.9	40.6
SEm ±	2.18	2.25	2.11	1.08	0.75	0.86
CD (P = 0.05)	6.2	6.4	6.0	3.1	2.1	2.4
Interaction						
D × P						
SEm ±	1.95	1.86	1.85	1.83	1.68	1.48
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
D × N						
SEm ±	1.44	1.45	1.43	1,87	1,30	1.48
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
P × N						
SEm ±	1.66	1.67	1.65	2.16	1.50	1.71
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
D × P × N						
SEm ±	2.87	2.89	2.85	3.75	2.60	2.96
CD (P = 0.05)	NS	NS	NS	NS	NS	NS

Among the different nutrient levels tried, application of 150% RDF (N_3) registered significantly higher total number of nodules compared to 100 % RDF (N_1) but found at par with 125% RDF (N_2). This trend was persistent throughout all the sampling stages during both the years of trial and in pooled mean. The total number of nodules plant^{-1} was least with 100 % RDF (N_1). These observations indicate indispensable role of nutrients especially phosphorous in formation of root nodules as well as influencing the efficiency of the rhizobium-legume symbiosis thereby enhancing the process of nitrogen fixation. These findings were in proximity with based on research by Yakubu *et al.* (2010); Amba *et al.* (2013); Hasan and Ismail (2016); Amruth *et al.* (2017).

CONCLUSION

From the present experimentation, it was concluded that among different plant densities, plant density of 4.44 lakh ha^{-1} by maintaining plant spacing of 22.5 cm × 10 cm resulted significantly higher number of effective nodules per plant which was closely followed by the plant density of 6.66 lakh ha^{-1} attained by maintaining the plant spacing of 15.0 cm × 10 cm. Among various nutrient levels, higher level of nutrients *i.e.*, 150% RDF resulted in significantly superior number of effective root nodules plant^{-1}, however at par with those resulted by application of 125% RDF to the groundnut crop. Future research can take in to consideration of seasonal variations and multilocations with a view to derive concrete recommendations for groundnut growers.

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Conflict of Interest. None.

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