

Original Research Article

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Rhizosphere Dynamics as Influenced by Nitrogen Levels and Plant Geometry in Groundnut (*Arachis hypogaea* L.)

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ABSTRACT

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A field experiment was conducted at Agricultural College Farm, Bapatla, Andhra Pradesh on sandy upland soils during *post-monsoon*, 2018. The experiment consisted of four levels of nitrogen and four population densities laid out in randomized block design with factorial concept. Nutrient content significantly increased with increase in nitrogen levels and higher content of N, P, K, Zn and Fe were obtained with 90 kg N ha⁻¹ which was significantly on par with 60 kg N ha⁻¹. Nutrient content was higher with wider spacing of 30 x 10 cm, which was on par with 25 x 10 cm. The microbial population was significantly influenced by levels of nitrogen fertilization and significantly superior population of fungi, bacteria and actinomycetes was found with 90 kg N ha⁻¹. Microbial responded significantly to population densities and significantly higher microbial count was obtained with 15 x 10 cm spacing.

Introduction

Groundnut (*Arachis hypogaea* L.) is a unique legume cum oilseed crop grown particularly in southern and western parts of India. Groundnut is an important source of edible oil in India and world. Its importance lies in high oil (45%) and protein (26%) content and minerals like iron, calcium and phosphorus.

Rhizosphere is the region of soil in the vicinity of plant roots in which the chemistry and microbiology is influenced by their growth, respiration and nutrient exchange.

Rhizosphere processes such as root-induced changes in pH and root exudates release play a key role in nutrient acquisition. Rhizosphere chemistry can be significantly changed according to the form of N taken up: ammonium supply may reduce rhizosphere pH through promoting proton release and activation of wall-loosening processes, leading to root cell elongation and thus improving the nutrient content. Moreover, ammonium localization together with P caused rhizosphere acidification and increased P availability.

Moreover, bacteria like *Bacillus cereus*, *B. subtilis*, *Pseudomonas fluorescens* occurs qualitatively in the rhizosphere soil than non-rhizosphere soil due to exudates secreted by the plant which could have made rhizosphere samples richer in nutrients there by increasing the diversity of microbes isolated.

In the light of the above knowledge, the experiment was conducted to evaluate rhizosphere dynamics and crop geometry in groundnut.

Materials and Methods

A field experiment was conducted at Agricultural College Farm, Bapatla, Andhra Pradesh on sandy upland soils during *post-monsoon*, 2018 on rhizosphere dynamics and crop geometry in groundnut (*Arachis hypogaea* L.). The experiment was laid out in a randomized block design with factorial concept and replicated thrice, consisting sixteen treatments with four levels of nitrogen (ammonium sulphate as source) *viz.*, 0 kg ha⁻¹, 30 kg ha⁻¹, 60 kg ha⁻¹ and 90 kg ha⁻¹ with 60 kg ha⁻¹ and 90 kg ha⁻¹ given in three splits *i.e.*, 1/3rd basal, 1/3rd @ 30 DAS and 1/3rd @ 60 DAS and four levels of population densities *viz.*, 30 x 10 cm, 25 x 10 cm, 20 x 10 cm and 15 x 10 cm. Phosphorous and potassium was applied at the rate of 40 kg ha⁻¹ and 50 kg ha⁻¹ respectively as basal dose to all the treatments uniformly. Gypsum was applied at early flowering stage @ 500 kg ha⁻¹. The soil was sandy in texture with 85.6 % sand, 5.7 % silt and 8.7 % clay, near neutral in reaction (pH 6.83), low in EC (0.06 dS m⁻¹), low in organic carbon (0.15 %), low in available nitrogen (120 kg ha⁻¹) and medium in available phosphorus (29.2 kg ha⁻¹) and potassium (168 kg ha⁻¹). The rainfall during the crop growth period was 191.2 mm.

The enumeration of total bacteria, fungi and actinomycetes from the soil samples was

estimated by following the standard dilution pour plate count technique. Nutrient agar (NA) for bacteria, Potato dextrose agar (PDA) for fungi and Ken- Knight and Munaier's medium for actinomycetes were used for enumeration. N, P, K, Zn and Fe in haulm and seed were determined according to the standard method described by Jackson. (1973). The observations on nutrient content, and microbial count were recorded and subjected to statistical analysis.

Results and Discussion

Nutrient Contents

Nitrogen Content (%)

Nitrogen content was estimated on seed and haulm. The content data presented in table 1, indicated significant differences due to levels of nitrogen and population densities. The interaction was however found to be non-significant.

Among the levels of nitrogen, nitrogen content was significantly higher with 90 kg N ha⁻¹ and on par with 60 kg N ha⁻¹ as compared to 30 and 0 kg N ha⁻¹. Among the population densities significantly higher content of nitrogen was observed with wider spacing of 30 x 10 cm and it was on par with 25 x 10 cm. Moreover, the data reveals that the content of nitrogen was more in seeds than that of haulms. Steady supply of nutrients throughout the crop growth period might have resulted in increasing the nutrient availability for uptake and better utilization by the crop which in turn produced more photosynthates and better partitioning of dry matter from source to sink. Localised placement of P and ammonium fertilizer might have modified the rhizosphere processes by stimulating root proliferation and by ammonium induced rhizosphere acidification, thereby increasing N acquisition by plants as reported by Jing *et al.*, 2010.

These results are in conformity with the findings of Chavan *et al.*, 2014, El- Habbasha *et al.*, 2013 and Elayaraja *et al.*, 2009.

Phosphorus content (%)

Levels of nitrogen had significant effect in phosphorus content of groundnut crop. Phosphorus content was noticed to be significantly higher with 90 kg N ha⁻¹ when compared to 30 and 0 kg N ha⁻¹ and was on par with 60 kg N ha⁻¹. Population densities responded significantly to phosphorus content in groundnut. Results revealed that significantly higher content of P was observed with 30 x 10 cm, however, it was on par with 25 x 10 cm. The interaction between nitrogen levels and population densities was not significant. Further, the data reveals that the content of phosphorus was more in seeds than that of haulms. Improved root growth and its functional activity helped in greater extraction of nutrients due to acidification of rhizosphere which might have increased the availability of phosphorus and N-driven mining of nutrients. These results are in conformity with the findings of Chavan *et al.*, 2014, El- Habbasha *et al.*, 2013 and Jing *et al.*, 2010.

Potassium content (%)

The data on potassium content due to levels of nitrogen and population densities is presented in table 1. Results indicated that levels of nitrogen and population densities had significant effect in potassium content of groundnut crop. Application of 90 kg N ha⁻¹ resulted in significantly higher K content which was on par with 60 kg N ha⁻¹ and 30 kg N ha⁻¹. Population densities did not respond significantly to potassium content. The interaction between nitrogen levels and population densities did not differ significantly. Higher nutrient concentrations in plants might be because of increased nutrient availability due to modification of

rhizosphere. Further, improved root growth and its functional activity also helped in greater extraction of potassium. These results are in conformity with the findings of Chavan *et al.*, 2014 and El- Habbasha *et al.*, 2013.

Zinc content (mg kg⁻¹)

The results pertaining to zinc content indicated that levels of nitrogen and population densities had significant effect on the crop. Zinc content increased with increase in levels of nitrogen. Application of 90 kg N ha⁻¹ resulted in significantly higher content of Zn over 30 and 0 kg N ha⁻¹, however it was on par with 60 kg N ha⁻¹. Zinc content responded significantly to population densities. Wider spacing of 30 x 10 cm resulted in significantly higher zinc content which was on par with 25 x 10 cm. Ammonium-induced rhizosphere acidification in the localized fertilizer zone significantly enhanced Zn availability and acquisition, resulting in improved growth and Zn uptake. These results are in conformity with the findings of Ma *et al.*, 2013 and Qinghua *et al.*, 2014.

Iron content (mg kg⁻¹)

The data pertaining to iron content due to levels of nitrogen and population densities are presented in table 2. Iron content was significantly influenced with levels of nitrogen. Nitrogen application with 90 kg N ha⁻¹ resulted in more content of iron over 30 and 0 kg N ha⁻¹; however it was on par with 60 kg N ha⁻¹. Population densities and their interaction, however, did not influence iron content. Increased iron availability might have increased nodulating bacteria as iron is a constituent of ferridoxin and leghaemoglobin which might have increased the yield of groundnut with higher uptake of iron. Non-graminaceous plants increase iron availability by releasing protons that lower the soil pH

and organic acid anions. Ammonium-induced rhizosphere acidification in the localized fertilizer zone significantly enhanced Fe availability and acquisition, resulting in improved growth and Fe nutrition. These results are in conformity with the findings of Ma *et al.*, 2013 and Qinghua *et al.*, 2014.

Assessment of CFU of total fungi, bacteria and actinomycetes

Total fungal count (CFU g⁻¹)

The results pertaining to total fungal count presented in table 3 indicated significant difference in fungal population with various nitrogen levels and population densities. The interaction between levels of nitrogen and population densities however failed to produce any significant result. Application of 90 kg N ha⁻¹ recorded significantly highest number of fungal count compared to 30 and 0 kg N ha⁻¹; however it was on par with 60 kg N ha⁻¹.

It might have resulted due to presence of organic substance from the root exudates and dead root cells and decrease in rhizosphere pH which favoured the growth of fungi. This is in line to the results reported by Aliyu and Oyeyiola, 2012 and Oyewole *et al.*, 2012. Higher population density with 15 x 10 cm resulted in more population of fungi, however, it was found to be on par with 20 x 10 cm spacing.

Lowest population was observed with lower population density of 30 x 10 cm. Root exudation is positively correlated with root growth; it means that actively growing root systems secrete more exudates. Root exudates mediate positive interactions which include symbiotic associations with beneficial microbes, such as mycorrhizae, rhizobia and plant growth-promoting rhizobacteria (PGPR), thereby increasing fungal count. This

is in agreement with Badri and Vivanco, 2009 and Garcia *et al.*, 2001.

Total bacterial count (CFU g⁻¹)

The data on total bacterial count indicated (Table 3) significant difference in bacterial population with various nitrogen levels and population densities, however, their interaction failed to produce significant result. Significantly superior number of bacterial cfu g⁻¹ was observed at 90 kg N ha⁻¹ as compared to other levels of nitrogen. This might be a result of the additional nitrogen provided by the additives which the bacteria breakdown for plant use resulting to the release of more exudates and plant products for the diazotrophs, hence, increasing in rhizosphere bacterial biomass as reported by Das and Dkhar, 2011. Population densities responded significantly to bacterial population. Narrower spacing with 15 x 10 cm resulted in higher population of bacteria, however it was found to be on par with 20 x 10 cm spacing. The plant root–soil interface is an environment with high microbial inoculum, composed of both pathogenic and beneficial microbes. If a microscopic organism is sensed by the roots possibly because of specific receptors, then the presence of a macroscopic neighboring root might be better perceived by the plant. Interaction of roots of a plant with its neighboring plant might have increased bacterial population with closer density. This result is in agreement with Badri and Vivanco, 2009 and De-la-Pena *et al.*, 2008.

Total actinomycetes count (CFU g⁻¹)

The perusal of data presented in table 3, pertaining to total actinomycetes count indicated significant difference in actinomycetes population with various nitrogen levels and population densities, their interaction however failed to produce significant result.

Table.1 N, P, K content (%) of groundnut as influenced by nitrogen levels and population densities

Treatments	Content (%)					
	N		P		K	
	Haulm	Seed	Haulm	Seed	Haulm	Seed
Nitrogen levels (N)						
N1: 0 kg N ha⁻¹	1.74	3.08	0.12	0.26	1.19	0.70
N2: 30 kg N ha⁻¹	2.05	3.39	0.15	0.29	1.39	0.79
N3: 60 kg N ha⁻¹	2.09	3.61	0.18	0.34	1.49	0.87
N4: 90 kg N ha⁻¹	2.16	3.74	0.19	0.35	1.54	0.91
SEm±	0.05	0.10	0.01	0.01	0.06	0.04
CD (P=0.05)	0.16	0.28	0.02	0.03	0.18	0.12
Population densities (D)						
D1: 30 x 10 cm	2.17	3.69	0.18	0.34	1.54	0.87
D2: 25 x 10 cm	2.05	3.57	0.17	0.32	1.40	0.84
D3: 20 x 10 cm	1.96	3.35	0.15	0.30	1.35	0.82
D4: 15 x 10 cm	1.86	3.21	0.14	0.28	1.32	0.73
SEm±	0.05	0.10	0.01	0.01	0.06	0.04
CD (P=0.05)	0.16	0.28	0.02	0.03	NS	NS
Interaction (N x D)						
SEm±	0.11	0.20	0.01	0.02	0.12	0.08
CD (P=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	9.29	9.81	15.1	12.6	15.0	17.3

Significantly superior number of actinomycetes cfu g⁻¹ was observed at 90 kg N ha⁻¹ as compared to other levels of nitrogen which can be attributed to higher root proliferation resulting in greater root mass, thereby increasing the release of organic substance from the root exudates and dead root cells. This is in line to the results reported by Oyewole *et al.*, 2012 and Aliyu and Oyeyiola, 2012. Population of actinomycetes increased with increasing population density and greater population was obtained with 15 x 10 cm, however, it was on par with 20 x 10 cm spacing. Lowest population was observed with wider spacing of 30 x 10 cm.

This might be due to secretion of phytochemicals and proteins from roots,

which is an important way for plants to respond to and alter their environment, thus helping in enhancing production by favouring association with beneficial soil microbes. This was reported by Badri and Vivanco, 2009. Thus, it can be concluded that localized placement of ammoniacal nitrogen and phosphorous produced significant acidification in rhizosphere region, resulting in greater root proliferation and thereby, increasing content of macro and micro nutrients (*viz.*, N, P, K, Zn and Fe) in the crop. Microbial count was found to be maximum with 90 kg N ha⁻¹. Nutrient content per plant was higher with wider spacing of 30 x 10 cm. Closer spacing of 15 x 10 cm was found to be optimum for higher microbial population.

Table.2 Zn and Fe content (ppm) of groundnut as influenced by nitrogen levels and population densities

Treatments	Content (ppm)			
	Zn		Fe	
	Haulm	Seed	Haulm	Seed
Nitrogen levels (N)				
N1: 0 kg N ha ⁻¹	32.8	10.8	152.1	49.8
N2: 30 kg N ha ⁻¹	42.1	14.9	185.7	61.9
N3: 60 kg N ha ⁻¹	45.8	16.1	212.2	67.6
N4: 90 kg N ha ⁻¹	50.1	17.1	219.3	73.3
SEm±	2.1	0.5	8.9	3.1
CD (P=0.05)	6.2	1.5	25.8	9.1
Population densities (D)				
D1: 30 x 10 cm	46.7	15.7	208.7	68.2
D2: 25 x 10 cm	44.3	15.4	198.8	65.3
D3: 20 x 10 cm	41.7	14.5	188.8	63.4
D4: 15 x 10 cm	38.2	13.4	173.0	55.7
SEm±	2.1	0.5	8.9	3.1
CD (P=0.05)	6.2	1.5	NS	NS
Interaction (N x D)				
SEm±	4.3	1.0	17.9	6.27
CD (P=0.05)	NS	NS	NS	NS
CV (%)	17.3	12.0	16.1	17.2

Table.3 Total fungal, bacterial and actinomycetes count (x 10⁴) per gram of soil as influenced by nitrogen levels and population densities (CFU g⁻¹)

Treatments	Fungal count (x 10 ⁴)	Bacterial count (x 10 ⁴)	Actinomycetes count (x 10 ⁴)
Nitrogen levels (N)			
N1: 0 kg N ha ⁻¹	11.5	107.7	84.4
N2: 30 kg N ha ⁻¹	15.6	151.0	119.6
N3: 60 kg N ha ⁻¹	18.2	210.4	175.5
N4: 90 kg N ha ⁻¹	19.5	252.2	200.0
SEm±	0.4	6.4	4.2
CD (P=0.05)	1.3	18.6	12.3
Population densities (D)			
D1: 30 x 10 cm	14.0	147.2	119.1
D2: 25 x 10 cm	15.5	156.6	125.2
D3: 20 x 10 cm	17.2	207.4	163.3
D4: 15 x 10 cm	18.2	210.1	171.8
SEm±	0.4	6.4	4.2
CD (P=0.05)	1.3	18.6	12.3
Interaction (N x D)			
SEm±	0.9	12.9	8.5
CD (P=0.05)	NS	NS	NS
CV (%)	9.6	12.4	10.2

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