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RESPONSE OF GROUNDNUT GENOTYPES TO HIGH AND LOW PHOSPHORUS LEVELS

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ABSTRACT

Groundnut production is often limited by low availability of soil phosphorus. Groundnut genotypes differ in their P efficiency and dry matter production under low P availability. Two Groundnut genotypes were used in this study namely ICG(FDRS)-10 (absorb and translocate large amount of P) and JL-24 (not suitable for P insufficient conditions) to study the response of P availability. Plants were grown in pots with two P levels viz. without P (0 mg P/kg soil, LP) and with P (40mg P/kg soil, HP) and parameters such as shoot length, root length, root volume, no. of lateral roots, nodules per plant, stem weight and leaf weight were recorded. Growth of groundnut genotypes was affected at 60 DAE *i.e.* during pegging stage. Low phosphorus (LP) resulted in reduced stem weight, leaf weight, shoot length and root volume, nodules per plant but root length and lateral roots were increased. Shoot and root characters were significantly associated under LP. There is sufficient genetic variability among groundnut genotypes for LP and this variability is mainly visible during pegging stage.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) an important legume crop and a valuable source of oil and protein is grown predominantly by small farmers in tropical and subtropical countries of the world. Various environmental factors such as water stress, low soil nitrogen (N) and phosphorus (P) levels affect groundnut production (Singh, 2011). Phosphorus is one the most important macro-nutrient required for growing plants as it is involved in various biochemical activities related to growth, development, photosynthesis, reproduction and use of carbohydrates (Singh *et al*., 2004). Inadequate application and low availability of native phosphorus (P) in the soil limit the groundnut productivity in semi-arid tropics (Shenoy and Kalagudi, 2005; Singh *et al*., 2004). The P deficiency in groundnut reduces leaf expansion, auxiliary bud growth, shoot canopy and leaf area (Singh *et al*., 2004). The accumulation of dry matter during different phenophases influences the behaviour of crop growth which in turn decides the final yield (Sudheer *et al*., 2011). Use of nutrients constitutes a major factor governing the dynamics of plant nutrient stores. Amount of nutrients such as phosphorus remobilized was governed by growth demand rather than soil nutrient supply (Milla *et al*., 2005). Hence, in this experiment attempts were made to study the effect of phosphorus supply on biomass accumulation in different plant parts and nodules per plant during different phenophases of crop growth in groundnut.

MATERIAL AND METHODS

Two groundnut cultivars *i.e.* 'ICG (FDRS)-10' and 'JL-24' were used. Cultivar ICG(FDRS)-10 can absorb

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and translocate large amount of P into seeds (Krishna 1997), whereas, JL-24 was identified as not suitable for P insufficient conditions (Amit *et al*., 2009). Two levels of P application (0 mg P/kg soil (LP) and 40mg P/kg soil (HP) were tested by adopting Randomized complete block design and replicated theice Pots were filled with soil (Vertisols) with pH of 7.5 having moderately available phosphorus (15 kg ha^{-1} P). Nitrogen and potash were applied at the rate of 20 mg N/kg soil and 25 mg K/kg soil equally for both the treatments. The experiment was conducted during 2012-13 at ICAR-Directorate of Groundnut Research, Junagadh (latitude 21°31'N, longitude 70°36'E). Plants were harvested at 40 DAE, 60 DAE and 80 days after emergence (Days). At harvest, plants were removed from the containers by carefully sliding out the entire root mass. The stem was cut off, and the root system was first completely immersed in a water-filled container and then cleaned with running tap water until free of soil and sand. Parameters such as shoot length, root length, root volume, number of lateral roots, number of nodules $plant^{-1}$, stem weight and leaf weight were recorded.

RESULTS AND DISCUSSION

Analysis of variance indicated that the treatment effect on stem weight was significant for days to emergence (D), phosphorus levels, genotype and D × P interactions (Table 1). Significance of D × P interactions indicate that different crop phenophases respond differentially to P availability. Stem weight exhibited a gradual increase starting from DAE 40 to 80 DAE with the maximum increase during 40 DAE to 60 DAE under high phosphorus (HP). Whereas, under low phosphorus (LP) stem weight was very low and maximum increase was observed from DAE 60 to 80 DAE. Both the genotypes showed reduction in stem weight under LP compared to HP but among two genotypes (Fig 1a), JL-24 exhibited a greater reduction in stem weight. Treatment effect on leaf weight was significant for days to emergence, phosphorus levels, D × P, D × genotype and D × P × G. Significance of D × P × G indicates that response of genotypes to changes in P levels differ across phenophases. Similar to stem weight, leaf weight (Fig. 1b) also showed gradual increase from DAE 40 to 80 DAE under HP, whereas, under LP, an increase in leaf weight was very low upto 80 DAE. Among the two genotypes, JL-24 had higher leaf weight under HP and ICG(FDRS)-10 under LP. Total haulm yield (stem weight and leaf weight) was high under HP compared to LP and ICG(FDRS)-10 had higher total haulm yield under both the situations. The highest increase in total haulm yield (Fig. 1c) was observed from 40 DAE to 60 DAE under HP, whereas, under LP it was observed from 60 DAE to 80 DAE. Treatment effect on shoot length was significant for days to emergence and phosphorus levels. Shoot length among the two treatments (Fig. 1d) was high under HP compared to LP and genotype ICG (FDRS)-10 had higher shoot length compared to JL-24 under both the treatments. Increase in shoot length was maximum at 40 DAE to 60 DAE compared to other phenophases and genotype JL-24 suffered a greater reduction in shoot length due to low P availability.

Root length among the two treatments (Fig. 2a) was high at LP compared to HP and genotype ICG(FDRS)-10 had higher root length at 40 DAE and 60 DAE, whereas, JL-24 had higher root length at 80 DAE. The treatment effect of root volume was highly significant for days to emergence, phosphorus levels and D x genotype interaction. Root volume (Fig. 2b) was high under HP compared to LP and it was higher in ICG(FDRS)-10 under both the treatments upto 60 DAE while at 80 DAE JL-24 had greater root volume. Reduction in root volume was greater at 80 DAE and greater reduction was observed in JL-24. Treatment effect on the number of lateral roots was significant for days to emergence and phosphorus levels (Table 1). No. of lateral roots (Fig. 2c) was high under LP compared to HP and genotype JL-24 had more lateral roots than ICG(FDRS)-10 at 40 DAE and 80 DAE. Lateral roots were high during 40 DAE, while, it was low during 60 DAE. Number of nodules per plant which is an indicator of N mobilization within the plant showed significant difference for days to emergence, phosphorus levels, genotype, D × P, P × genotype and D × P × G. Nodules per plant (Fig. 2d) was high under HP compared to LP and maximum number of nodules was recorded at 60 DAE for both the genotypes under both the treatments.

Correlation analysis under high and low P conditions

Association of root characters, shoot characters and nodules per plant under high P and low P are presented in Table 2. Under HP, a significant positive association was observed for shoot length with root length and stem weight; stem weight with root volume and nodules per plant with leaf weight. Increase in leaf weight with the number of nodules per plant indicates higher nitrogen fixation reflected in leaf weight under HP conditions (Valentine *et al*., 2017). Lateral roots per plant had a significant negative association with nodules per plant, stem weight and leaf weight. Under LP significant positive association was observed for shoot length with root length, root volume, stem weight and leaf weight; leaf weight with root volume and stem weight and root volume with stem weight.

Impact of low P availability on plant growth

The more striking effect of low LP was a reduction in stem weight, leaf weight, shoot length and root volume and increase in root length and lateral roots and is in agreement with the findings of Freeden *et al*. (1989). Significance of D × P interaction indicated that different stages of crop respond differentially to P availability as the effect of low P on plant growth was more evident at 60 DAE when compared to other phenophases. This is in agreement with the findings of Sheoran *et al*. (2000), wherein, phosphorus application had no significant effect on flower initiation and maturity. Different genotypes vary in their ability to allocate their available resources between different plant parts. This variation was evident in the study, wherein, genotypes showed differential allocation of resources between shoots and leaves under differential P availability. When there was high P availability, leaf weight of ICG (FDRS)-10 was lesser than JL-24 but under LP, ICG(FDRS)-10 had high leaf weight compared to JL-24. This difference may be attributed to higher root length, the number of lateral roots and nodules per plant of ICG(FDRS)-10 over JL-24 which enabled them to absorb more nutrients for photosynthesis and in turn for translocation and storage. Further, association studies under LP also indicate that stem weight had a positive association with leaf weight and shoot characters in turn had a significant association with root characters.

Effect of P availability on root development

The number of lateral roots and root length were higher at low-P than at high-P treatments, while the root volume decreased when grown under low-P availability. These results indicated that there can be considerable variation in number of lateral roots depending on the amount of available P. In the high nutrient environment, maybe lateral root growth was inhibited by high-N concentration in the plant (Zhang and Forde, 1998). These variations in the root morphology will help the plants to adapt to available P conditions. A longer root with reduced root volume indicates that root diameter has decreased *i.e.* development of fine roots under LP and these fine roots are efficient in acquiring P than a plant with short, thick ones (Ciro *et al*., 1999; Xie and Yu, 2003). Root volume has decreased under LP indicating the decrease in root diameter. This reduced root diameter helped in acquiring P efficiently and as a result root volume under low P had a positive association with leaf weight and stem weight. Increase in lateral root density under low-P condition may reflect that root proliferation is important when plants are grown in environments with low available nutrients (Robison, 1994). Morphological plasticity in lateral roots is, thus a functional response to P availability. Increase in lateral roots also promotes more nodule formation which would inturn help in N-mobilisation. Under LP, lateral roots and root length has increased and stem weight and leaf weight has decreased which indicates that root development under LP occurs at the expense of shoot development which is in agreement with the earlier studies (Boutra, 2009).

However, Keerthisinghe *et al*. (1998) concluded that the formation of roots does not necessarily occur at the expense of dry matter production. Under LP, the export of photo-assimilates from leaves allow continued root growth and thus increases in root fraction (Cakmak *et al*., 1994). The P levels are highly correlated with (Fig 2d) nodules per plant as they increased with the increase in availability of P. This is in agreement with the works of Valentine *et al*. (2017) who showed that under low P availability nodules largely decrease the utilization of atmospheric nitrogen as the nitrogen source and utilize more soil nitrogen (such as NO_3^- and NH_4^+).

Table 1. Analysis of variance of two Groundnut genotypes grown with high P and low P

Source of variance	Root length	Shoot length	Lateral roots	Nodules plant^{-1}	Root volume	Stem weight	leaf weight
Days to emergence (D)	**	**	*	**	**	**	**
Phosphorus (P)		**	**	**	**	**	**
Genotype (G)				*		*	
D × P				**		**	**
D × G					*		**
P × G				*			
D × P × G	*			*			*

*, ** significant at P<0.05 and P <0.01, respectively

Table 2. Association among root characters, shoot characters and nodules under HP (below diagonal and LP (above diagonal)

	Root length	Shoot length	Lateral roots	Nodules plant^{-1}	Root volume	Stem weight	Leaf weight
Root length		0.58*	-0.09	0.11	0.18	0.14	0.11
Shoot length	0.69*		-0.25	0.12	0.76**	0.83**	0.72**
Lateral roots	-0.05	-0.31		-0.51	-0.21	-0.43	-0.36
Nodules plant^{-1}	-0.02	0.33	-0.77**		0.01	0.32	0.42
Root volume	-0.02	0.47	-0.51	0.28		0.75**	0.69**
Stem weight	0.38	0.66*	-0.60*	0.40	0.65*		0.94**
Leaf weight	-0.03	0.39	-0.71*	0.92**	0.43	0.56	

*, ** significant at P<0.05 and P <0.01, respectively

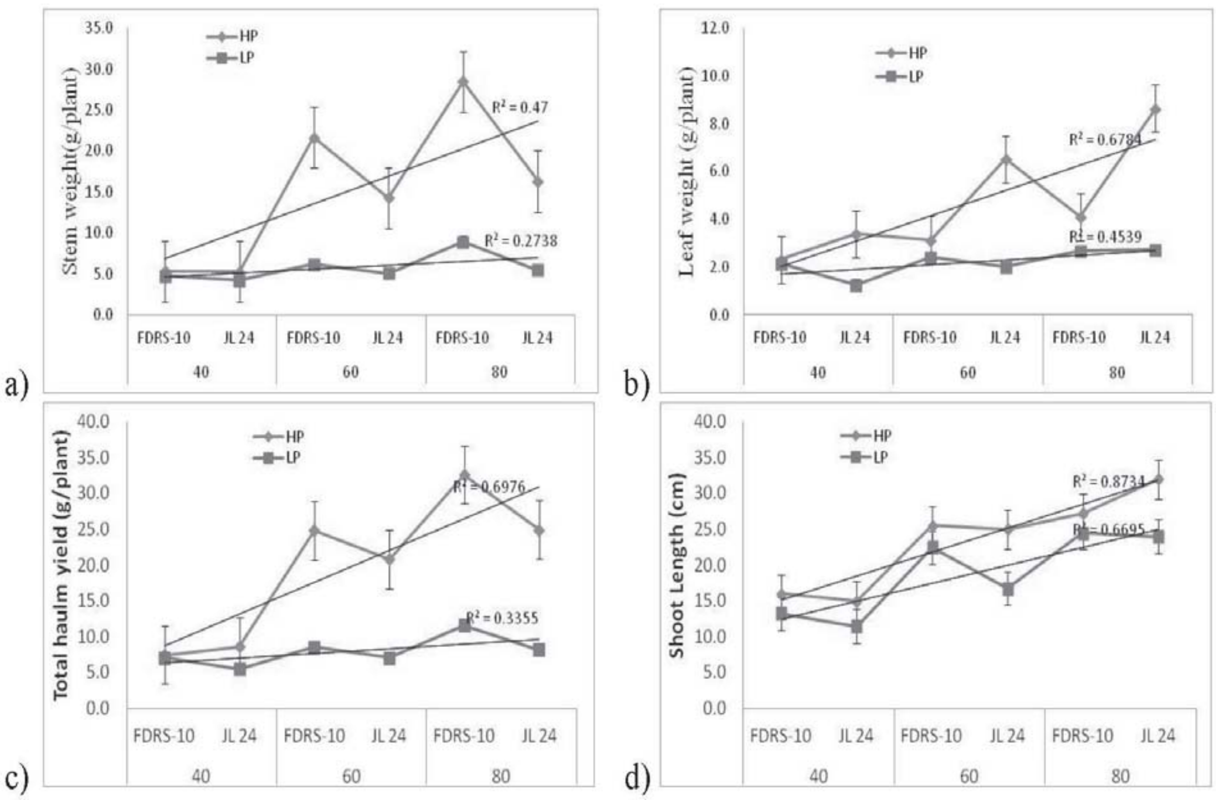

Fig. 1. Effect of P treatment at 40 DAE, 60 DAE and 80 DAE on shoot weight without leaf lets (a), weight of leaflets (b), total haulm yield (c) and shoot length (d) in high phosphorus (40 mg P/kg soil) and low phosphorus (0mg P/kg soil). Vertical bars represent SE.

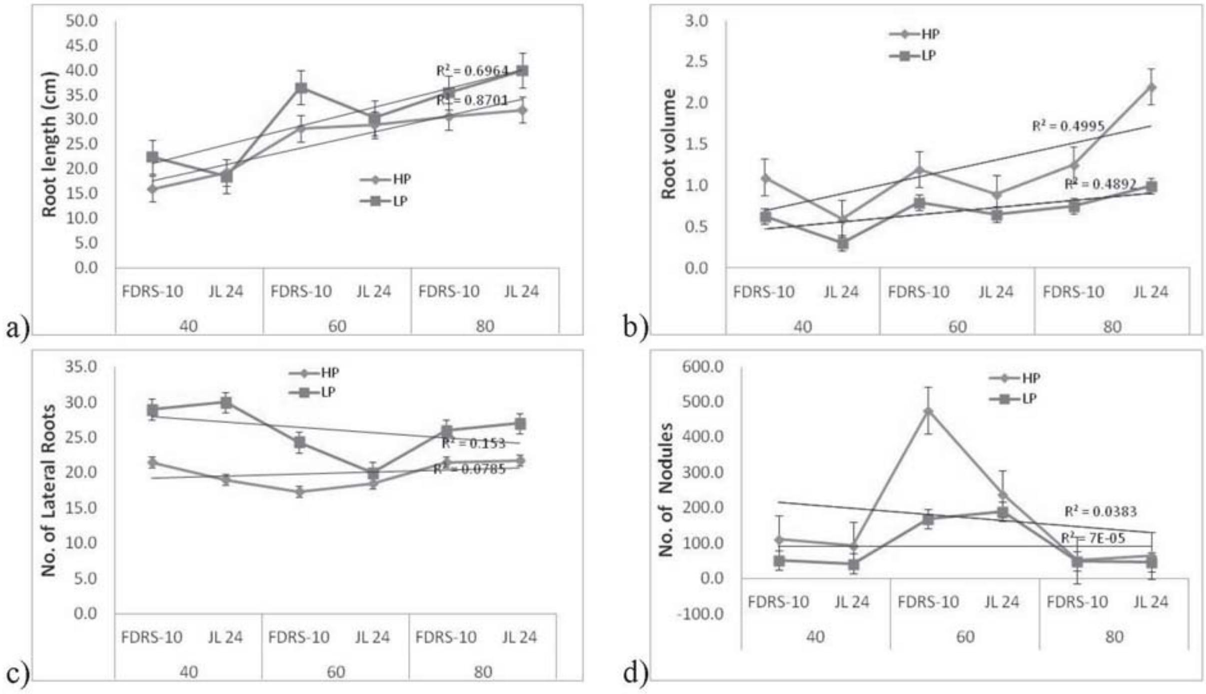

Fig. 2. Effect of P treatment at 40 DAE, 60 DAE and 80 DAE on root length (a), root volume (b), number of lateral roots (c) and (d) number of nodules per plant in high phosphorus (40 mg P/kg soil) and low phosphorus (0mg P/kg soil). Vertical bars represent SE.

CONCLUSION

Results confirmed that genotypes and yield components respond differently to P supply. The low P availability significantly affected the growth of groundnut genotypes mainly at 60 DAE *i.e.* during the pegging stage.

REFERENCES

Amit, K., Kusuma, P and Gowda, M.V.C. 2009. Genotypic variation for root traits in groundnut germplasm under phosphorus stress conditions. SAT e- journal. 7: 1-4.

Boutraa, T. 2009. Growth and carbon partitioning of two genotypes of bean *(Phaseolus vulgaris)* grown with low phosphorus availability. EurAsian Journal of Biosciences. 3: 17-24.

Cakmak, I., Hengeler, C and Marchner, H. 1994. Partitioning of shoot and root dry matter and carbohydrates in bean plants suffering from phosphorus, potassium and magnesium deficiency. The Journal of Experimental Botany. 45: 1245-1250.

Ciro, A.R., Joao, P.T.W., Silvelena, V and Valdir, J.R. 1999. The significance of root growth on cotton nutrition in an acidic low-P soil. Plant and Soil. 212: 185–190.

Fredeen, A.L., Rao, I.M. and Terry, N. 1989. Influence of phosphorus nutrition on growth and carbon partitioning in *Glycine max*. Plant Physiology. 89: 225-230.

Keerthi singhe, G., Hocking, P.J., Ryan, P.R. and Delhaize, E. 1998. Effect of phosphorus supply on the formation and function of proteoid roots of white lupin (*Lupinus albus* L.). Plant Cell and Environment. 21: 467–478.

Krishna, K.R. 1997. Phosphorus uptake and utilization efficiency in Groundnut. Peanut Science. 24: 1-6.

Milla, R., Castro-Díez, P., Maestro-Martínez, M and Montserrat-Martí G. 2005. Relationships between phenology and the remobilization of nitrogen, phosphorus and potassium in branches of eight Mediterranean evergreens. New Phytologist.168: 167–17.

Robison, D. 1994. Resource capture by single roots. Resource Capture by Crops. Nottingham University Press, Nottingham. pp. 56–76.

Shenoy, V.V and Kalagudi, G.M. 2005. Enhancing plant phosphorus use efficiency for sustainable cropping. Biotechnology Advances. 23: 501-513.

Sheoran, R.S., Sharma, H.C., Panuu, P.K and Niwas, R. 2000. Influence of sowing time and phosphorus on, phenology, thermal requirement and yield of fenugreek (*Trigonella foenum-graecum* L.) genotypes. Journal of Spices Aromatic and Crop. 9: 43-46.

Singh, A.L. 2011. Physiological basis for realizing yield potentials in groundnut. In: Advances in Plant Physiology [(Hemantranjan, A (Editor.)] Advances in Plant Physiology. 12: 131-242.

Singh, A.L., Basu, M.S and Singh, N.B. 2004. In: Mineral Disorders of Groundnut. National Research Centre for Groundnut (ICAR), Junagadh. pp. 85.

Sudheer, K.V.S., Narasimha Rao, S.B.S and Radhakrishna Murthy, V. 2011. Behaviour of growth of groundnut under different environments and row spacing. Crop Research. 42: 120-124.

Valentine, A.J., Kleinert, A and Benedito, V.A. 2017. Adaptive strategies for nitrogen metabolism in phosphate deficient legume nodules. Plant Science. 256: 46–52.

Xie, Y and Yu, D. 2003. The significance of lateral roots in phosphorus (P) acquisition of water hyacinth (*Eichhornia crassipes*). Aquatic Botany. 75: 311–321.

Zhang, H and Forde, B.G. 1998. An Arabidopsis MADS box gene that controls nutrient-induced changes in root architecture. Science. 279: 407–409.

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