Int.J.Curr.Microbiol.App.Sci (2018) *7*(7): 4290-4296

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 7 Number 07 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.707.500

Root Length and P Uptake Analysis in Five Elite Lentil (*Lens culinaris* Medikus) Lines Suitable for Northeast India Condition

Sapam Rajeshkumar[1*] and V. K. Khanna[2]

[1]Genetics and Plant Breeding, CPGS, CAU (I), Umiam, Meghalaya, India
[2]School of Crop Improvement, CPGS, CAU (I), Umiam, Meghalaya, India

**Corresponding author*

Keywords

Root Length, P Uptake, Elite Lentil, (*Lens culinaris* Medikus)

Article Info

Accepted:
28 May 2018
Available Online:
10 July 2018

A B S T R A C T

In spite of being the most consumed pulse of the NER, lentil is cultivated sporadically on relatively poor soils and in harsh environments with a little or no fertilizer after rice crop. Therefore, there is a need of identifying lentil germplasms that is adapted to low input acidic soils to achieve remunerative productivity. The present study was conducted to evaluate root length and P- uptake of five lentil genotypes under acidic and water acarcity conditions. From the studies of root traits and P-uptake we identified three lines *viz.*, DPL-62, IPL-220 and PL-04 which perform better in the stress conditions. The results of this study suggest that the variation in root morphology of the five varieties is pronounced, without the variation in the ability to induce chemical (rhizosphere pH) and biochemical (Aptase) change in the rhizosphere environment through root exudation.

Introduction

Lentil (*Lens culinaris* Medikus) is a diploid (2n=2x=14) self-pollinating annual cool season grain legume, with a relatively large genome of 4,063 Mbp (Arumuganathan and Earle, 1991). It has great significance in cereal-based cropping systems because it fixes nitrogen. The protein content in the seed is 22 to 35% and it is also rich in Fe, Zn and Vitamins. Lentil is used as food, feed and in sustainable farming systems. Lentils have been grown extensively in the semi-arid parts of the world, where they have slightly lower yields, but good seed quality. High humidity and excessive rainfall during the season encourages vegetative growth, which prevents good yield and can reduce seed quality. Ten to twelve inches of annual rainfall will produce high yields of good quality seed. Excessive drought and/or high temperatures during the flowering and pod-fill period also reduce yields. Almost all soils are phosphorus deficient and large quantities of phosphorus have been added to our agricultural soils since we began farming. Plants absorb phosphorus from the soil solution, but many soils rapidly immobilize phosphorus into insoluble forms.

This happens in both acid and alkaline soils, although different chemical reactions are responsible in each case.

Lentil are typically grown and adapted to neutral to alkaline soils but yields are compromised where soils are acidic, sodic and

saline or have high levels of boron. Alleviating such toxicity problems through soil modification is not an economic or practical solution and therefore growing more tolerant cultivars is considered the best approach to overcoming these constraints (Materne and Siddique, 2009). Rice is one of the major crops of northeast region of India and after harvest most of the land remains fallow during *rabi* season in hilly areas. Rice fallow areas offer a huge potential niche for short season pulses and oilseed crops. There is erratic rainfall during *rabi* and unavailability of irrigation water in hilly regions. In spite of being the most consumed pulse of the NER, lentil is cultivated sporadically on relatively poor soils and in harsh environments with a little or no fertilizer after rice crop. Therefore, there is a need of identifying lentil germplasm that is adapted to low input acidic soils to achieve remunerative productivity. The present study was undertaken analyze the root lengths and phosphorus uptake in elite genotypes and identify better performer under acidic and water scarcity condition.

Materials and Methods

The root growth and length of the five varieties was studied in a pot experiment (Fig. 1) in CPGS, CAU (I), Umiam, Meghalaya. Five elite lentil lines performing well in this region were evaluated for various, Morphological - Root lengths al 40, 65 and 90 DAS; Physiological: Rhizosphere pH, and Exo-cellular phosphatase enzymes

Determination of root growth and length in pot culture

Pots were made by cutting two litre transparent plastic bottles. They were filled with 2.5 kgs of soil (pH 4.5) by shaking to achieve soil bulk density of 1.4 g cm^{-3}. The soil columns of all the pots have to be 25 cm high. The pots were placed in the open, sides of pots were wrapped in black polythene to prevent exposure of roots to light and maintained at 20% soil moisture by weighing and adding water. At 40, 65 and 90 DAS, shoots were cut and stored in paper bags for drying. The total lengths of the root system were measured using Dt-Scan software.

Nutrient uptake analysis for Phosphorus

Shoots of the pot experiment at flowering stage (60 DAS) were dried at 60^{o}C until it attains constant weight. Nutrient analysis for phosphorus were done. Nitrogen (N) was not analyzed, because lentil, a legume, can fix Atmosperic N_2.

Digestion of plant material

Shoots of the pot experiment at flowering stage (60 DAS) was dried at 60^{o}C until constant weight was recorded. The plant material (0.5 g) was digested using 70 mL test tubes with di-acid mixtures. The dry weight was taken for the leaf and was digested in di-acid (HNO_3: $HCLO_4$) at 3:1 ratio and incubated for one month for complete digestion of leaves of each samples. 1 ml of digested sample was diluted to 50 ml and filtered through watman paper. Again now 10 ml reaction mixture was prepared by adding 2 ml Ammonium vanadate, 1 ml sample and 7 ml Millipore water. Blank was prepared by adding 2 ml Ammonium Vanadate and 8 ml H_2O. The standard curve for P was prepared in a concentration range of 0, 0.1, 0.2, 0.3., 0.4, 0.5, 0.6, 0.7, 0.8, 09 and 1 ppm. P **%** = {Concentration / wt. of sample (g)} x {100 / Aliquote (ml) taken} x {Volume of digest (ml)/10,000}. P Uptake = Plant dry weight (g) x P content (mg).

Determination of rhizosphere pH

Root induced rhizosphere pH is known to influence availability of soil inorganic

phosphorus and micro-nutrients to plants. The roots of 10-days-old seedlings of the five lentil varieties were embedded in agar containing pH indicator dye Bromocresol purple and adjust to pH 6 (Marschner and Romheld, 1983). The root-induced pH changes, revealed by colour change were recorded after one hour following the agar embedding (Fig. 3.6)

Rhizosphere acid phosphatase (Aptase) activity

Aptase catalyzes the conversion of soil organic phosphorus into plant available inorganic phosphorus. Intact roots of 10-days-old seedlings were sandwiched between two layers of filter papers, soaked in a mixture of Fast Red TR (dye) and 1-naphtylphosphate (substrate). If the roots release phosphatase enzymes then it will give a range of brownish red colour (Dinkelaker and Marschner, 1992).

Results and Discussion

The root length recorded a continuous increase throughout the period of observation. Among the genotypes highest root length at 40 DAS was recorded by G1 (DPL-62) and it was at par with G3 (PL-8) showing that these genotypes have early root growing habit and has potential of high root length. At 65 DAS and 90 DAS genotypes G1 (DPL-62) and G3 (PL-8) had higher root length than others indicating that these genotypes have high root lengths irrespective of acidic levels and water deficit levels (Table 1). Ahmed *et al.,* (2014) and Gahoonia *et al.,* (2005) also reported similar findings with the present study.

For the five genotypes under study, root growth rate from 40 DAS to 65 DAS is higher than from 65 DAS to 90 DAS, while for the genotype LRIC-560335, and L-4581 the change in root length from 65 DAS to 90 DAS is almost the same indicating that there is not much growth in root length after rapid growth till 65 DAS. Alami-Milani *et al.,* (2013) also reported similar results with the current findings about yield related traits.

Root length recorded throughout the crop growing period under irrigated condition (B2) is higher than water deficit condition (B1) whereas root length recorded in normal soil pH is higher than in acidic pH soil.

Among the interactions, at 40 DAS, the highest root length was shown by the interaction PL-8 which had the highest root length under water deficit and normal soil pH conditions which are at par with the root length of genotypes LRIC-560335, DPL- 62 and L-4581 under water deficit and acidic conditions.

These results corroborate with the results of study conducted by Gahoonia *et al.,* (2005) in lentil and Kumar *et al., (*2013) in paddy.

At 65 DAS, LRIC-560335, DPL-62 and PL-8 had higher root length under water deficit and acidic soil conditions. Also these genotypes had nearly same root lengths under acidic conditions showing that they are less affected by soil acidic conditions.

Interaction studies of genotypes x water deficit levels x soil acidity levels for root length after 90 DAS showed that IPL-220, DPL-62 and PL-8 had higher root length under water deficit and normal pH soil conditions (Table 2). Genotypes DPL-62, PL-8 and IPL-220 had higher root length under water deficit and acidic conditions suggesting that these genotypes are well adapted to drought and acidic soils. DPL-62 and LRIC-560335 had higher root length under irrigated and normal pH soil conditions and PL-8, IPL-220 and DPL-62 showed higher root length under irrigated and acidic soil pH conditions. These results are in conformity with the findings of Roy *et al.,* (2009).

Table.1 Root length, P-content and P-uptake parameters of lentil genotypes as influenced by soil acidity levels and water deficit levels

Sl. No.	Treatments	Root length after			P- Content (% of dry matter)	P- Uptake
		40 DAS	70 DAS	90 DAS		
	Genotypes					
1	G1	10.399	18.566	26.655	0.138	0.734
2	G2	8.898	15.186	23.861	0.129	0.736
3	G3	10.190	18.513	25.674	0.142	0.729
4	G4	6.417	16.135	15.840	0.135	0.451
5	G5	5.571	12.888	14.581	0.070	0.229
	CD 5%	**2.046**	**3.449**	**2.804**	**0.290**	**0.170**
	Water deficit levels					
1	B1	9.581	14.018	17.988	0.122	0.494
2	B2	7.009	18.498	24.657	0.127	0.658
	CD 5%	**1.294**	**2.181**	**1.773**	**0.19**	**0.108**
		Soil acidity levels				
1	C1	8.780	17.402	22.555	0.150	0.696
2	C2	7.810	15.113	20.090	0.095	0.456
	CD 5%	**1.294**	**2.181**	**1.773**	**0.19**	**0.108**

Table.2 Interaction effect (Genotypes X Water deficit level X Soil acidity levels) on five parameters of lentil

Sl. No.	A X B X C	Root length after			P- content (% of dry matter)	P- Uptake
		40 DAS	65 DAS	90 DAS		
1	G1B1C1	11.225	20.245	29.020	0.111	1.115
2	G2B1C1	13.850	20.980	29.350	0.156	0.720
3	G3B1C1	7.814	15.630	30.000	0.102	1.215
4	G4B1C1	8.706	17.410	20.250	0.171	0.485
5	G5B1C1	10.330	14.570	18.350	0.102	0.495
6	G1B1C2	12.005	19.665	29.650	0.169	1.100
7	G2B1C2	5.815	18.625	29.455	0.150	1.685
8	G3B1C2	7.443	14.885	28.540	0.166	1.065
9	G4B1C2	12.690	21.235	23.100	0.121	0.675
10	G5B1C2	11.475	19.625	24.100	0.110	0.730
11	G1B2C1	8.209	16.420	28.435	0.198	0.625
12	G2B2C1	8.385	16.770	23.510	0.181	1.985
13	G3B2C1	5.835	13.840	21.700	0.107	1.230
14	G4B2C1	4.800	20.640	26.900	0.173	0.630
15	G5B2C1	5.885	11.765	17.045	0.093	1.175
16	G1B2C2	9.149	18.295	25.715	0.179	1.170
17	G2B2C2	6.485	18.170	28.350	0.169	1.210
18	G3B2C2	7.115	16.005	26.125	0.178	1.260
19	G4B2C2	3.814	7.630	13.210	0.051	0.160
20	G5B2C2	4.871	9.745	20.640	0.080	0.285
	CD 5%	**4.091**	**6.898**	**5.607**	**0.590**	**0.340**

Where, G1: DPL-62, G2: IPL-220, G3: PL-8, G4: LRIC 560335, and G5: L-4581, B1: water deficit, B2: Irrigated, C1: Normal Soil pH and C2: Acidic soil pH.

Fig.1 A) Transparent plastic bottle experiment B) Five genotypes of lentil grown under acidic soil conditions

DPL-62	PL-8	IPL-220	LRIC-560335	L-4581

Significant higher P-content was recorded with lentil genotype PL-220 and it is at par with lentil genotypes DPL-62 and LRIC-560335. Lentil genotype PL-8 scored highest in P-uptake and is at par with genotypes DPL-62 and PL-220 Indicating that these genotypes can give high yield even in lesser input (Phosphorus) soil conditions. Reports from the experiment conducted by Gahoonia *et al.,* (2001) also corroborate with the results of the present study.

From the interaction studies of genotypes x water deficit levels x soil acidity levels for P-content and P- uptake Interactions, genotypes IPL-220 and DPL-62 had higher P- content under water deficit and normal soil pH conditions. Genotypes IPL-220 and DPL-62 showed higher P-uptake under water deficit and normal soil pH conditions suggesting that these genotypes can perform well under such

stress conditions. Krasiliniko *et al.,* (2003) also reported similar results in Cowpea.
Among water deficit and acidic soil conditions DPL-62, IPL-220 and PL-8 had higher P-content, while lentil genotypes DPL-62, PL-8 and IPL-220 had higher P-uptake. Genotypes DPL-62, IPL-22 and LRIC-560335 recorded high P-content under irrigated and normal soil pH conditions indicating that these genotypes perform better under well irrigated and normal soil pH conditions whereas PL-8, IPL-220 and LRIC-560335 had higher P-uptake under similar conditions.

Among irrigated and acidic soil conditions IPL-220, PL-8 and DPL-62 scored higher in both P- content and P-uptake indicating that these genotypes can give high yield also under low P- input acidic soils. Alami-Milani *et al.,* (2013) also reported similar results.

In pot experiment, DPL-62, PL-8 and IPL-220 absorbed significantly higher amount of P-nutrients and such ability of these genotypes may have supported them to produce higher grain yields in field trials. Lentil is a rain-fed winter crop and winter is dry in Northeast India.

Therefore, in addition to higher absorption of soil P-nutrients, better capture of soil moisture might have played a role in better performance of these genotypes, which was not investigated in the present study.

The results of this study suggest that the variation in root morphology of the five varieties is pronounced, without the variation in the ability to induce chemical (rhizosphere pH) and biochemical (Aptase) change in the rhizosphere environment through root exudation. Root induced rhizosphere pH is known to influence availability of soil inorganic phosphorus (Gahoonia and Nielsen, 1992) and micro-nutrients to plants (Marschner and Romheld, 1996). The role of Aptase for catalyzing the conversion of soil organic phosphorus into plant available inorganic phosphorus is also reported (Asmar *et al.,* 1995).

The lack of variation in the rhizosphere pH and Aptase among the five varieties and P-nutrient mobilizing processes, suggested that root morphology traits enhancing the exploration of soil for P-nutrients and water might be a criterion worth giving more attention for the selection of P-nutrient efficient and drought tolerant varieties for nutrient limiting and dry soils. This finding is supported by the results of other recent studies where genetic diversity was found in root size of lentil (Sarker *et al.,* 2005) and soybean (Wang *et al.,* 2004), common bean (Yan and Lynch, 1998) and cowpea (Krasilniko *et al.,* 2003).

From the studies of root traits and P-uptake we identified three lines *viz.,* DPL-62, IPL-220 and PL-04 which perform better in the stress conditions.

The results of this study suggest that the variation in root morphology of the five varieties is pronounced, without the variation in the ability to induce chemical (rhizosphere pH) and biochemical (Aptase) change in the rhizosphere environment through root exudation.

References

Ahmed, B., Pramanik, M.E.A., Sultana, D., Rahman, M.M. and Choudhury, R.U. (2014). Study of Selected Lentil Genotypes against Rainfed in Barind Drought. *Int. J. Bus. Soc. Sci. Res.,* 2(2): 145-147.

Alami-Milani, M., Amini, R., Mohammadinasab, A.D., Shafagh-kalvanegh, J., Asgharzade, A. and Emaratpardaz, J. (2013). Yield and yield components of lentil (*Lens culinaris*

Medick.) affected by drought stress and mulch.

Arumuganathan, K. and Earle, E.D. (1991). Nuclear DNA content of some important plant species. *Plant molecular biology reporter*, *9*(3): 208-218.

Asmer F, Gahoonia T.S and Nielsen N.E. (1995). Barley genotypes differ in activity of extracellular phosphatase and depletion of organic phosphorus in the rhizosphere soil. *Plant Soil* 172, 117–122.

Dinkelaker, B. and Marschner, H. (1992). *In vivo* demonstration of acid phosphatase activity in the rhizosphere of soil-grown plants. *Plant and Soil*, 144(2): 199-205.

Gahoonia T S and Nielsen N E 1992. The eff ect of root induced pH changes on the depletion of inorganic and organic phosphorus in the rhizosphere. Plant Soil 143, 185–189.

Gahoonia, T.S., Ali, O., Sarker, A., Nielsen, N.E. and Rahman, M.M. (2005). Genetic variation in root traits and nutrient acquisition of lentil genotypes. *Journal of Plant Nutrition*, 29(4), 643-655.

Gahoonia, T.S., Nielsen, N.E., Joshi, P.A. and Jahoor, A. (2001). A root hairless barley mutant for elucidating genetics of root hairs and phosphorus uptake. *Plant Soil*, 235, 211–219

Krasiliniko, G., Gahoonia, T.S. and Nielsen, N.E. (2003). Variation in phosphorus uptake of cowpea genotypes (*Vigna unguiculata*) due to differences in root and root hair length and root-induced rhizosphere processes. *Plant Soil*, 251: 83–91.

Kumar, A., Pandey, A. and Pattanayak, A. (2013). Evaluation of rice germplasm under jhum cultivation in North East India and breeding for Aluminium tolerance. *Indian Journal of Genetics and Plant Breeding*, 73: 153-161.

Marschner, H and Ro¨ mheld, V. (1983). In vivo measurements of root induced pH change at soil–root interface. Eff ect of plant species and nitrogen source. Z. Pflanzenphysiol. 111, 241–251

Marschner, H. and Romheld, V. (1996). Root included changes in the availability of micronutrients in the rhizosphere. In Plant Roots: The Hidden Half. Eds. Y. Waisel, A. Eshel and U. Kafkaki, pp. 557–580. Marcel Dekker, Inc. New York, basel, Hong Kong.

Materne, M. and Siddique, K.H.M. (2009). Agroecology and crop adaptation. The lentil: botany, production and uses. MPG Books Group, London, pp.47-63.

Roy, A., Aich, S.S., Bhowmick, M.K. and Biswas, P.K. (2009). Response of lentil varieties to sowing time in plains of West Bengal. *Journal of crop and weed*, 5 (2): 92-94.

Sarker, A., Erskine, W. and Singh, M. (2005). Variation in shoot and root characteristics and their association with drought tolerance in lentil landraces. *Genetic Resources and Crop Evolution*, 52(1): 89-97.

Wang, L., Liao, H., Yan, X., Zhuang, B. and Dong, Y. (2004) Genetic variability for root hair traits as related to phosphorus status in soybean. *Plant Soil*, 261: 77–84.

Yan, X. and Lynch, J.P. (1998) Genetic variation for root hair density and length in common bean in response to low phosphorus availability. In Phosphorus in Plant Biology: Regulatory Roles in Molecular, Cellular, Organisms and Ecosystem Processes. Eds. J P Lynch and J. Deikman. American Society of Plant Physiologist, Vol.19, Rockville, Maryland, USA.

How to cite this article:

Sapam Rajeshkumar and Khanna V. K. 2018. Root Length and P Uptake Analysis in Five Elite Lentil (*Lens culinaris* Medikus) Lines Suitable for Northeast India Condition. *Int.J.Curr.Microbiol.App.Sci.* 7(07): 4290-4296. doi: https://doi.org/10.20546/ijcmas.2018.707.500