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# Assessment of genetic variation and selection of most responsive lines for root traits in relation to phosphorous nutrition in groundnut (*Arachis hypogaea* L.)

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**Abstract**

**Genetic studies were conducted to select lines efficient in Phosphorus (P) uptake under the soils with reduced P availability from a set of RILs derived from a cross JL24 x ICGV 86590 in groundnut. ANOVA and genetic variability components revealed significant variations among RILs, phosphorus levels and their interaction for most of the root traits enabling intensive selection. ICGV 86590 showed a higher response to P, while JL 24 recorded negative response for primary root length and shoot length. RILs displayed variable degree of response (in percent). Selected 20 contrasting lines exhibited significant variations with high heritability for P uptake. In both P availability conditions P uptake traits showed significant positive correlation with biomass traits. RILs 1-23 and 1-18 were most responsive based on their *per se* performance and per cent responsiveness over the traits.**

**Key words:** Groundnut, phosphorus, RDW, RP, per cent responsiveness

## Introduction

Among constraints ascribed to the low productivity of groundnut in India include various diseases, insect pests, poor management practices and nutrient availability. Phosphorus (P) is one of the major limiting factor for proper plant growth. Tropical soils where groundnut is cultivated are having higher capacities to fix P. Scarcity of P to the crops in arable agriculture is not due to its absence in the rhizosphere but of its fixation. In order to cope with its high per cent of fixation, plants have developed highly specialized physiological and biochemical mechanisms along with morphological modifications such as increased root to shoot ratio, plant architecture, increased root hair elongation and proliferation [1]. Phosphorus deficiency induces many changes in root morphology and architecture in groundnut. Very few studies have been carried out for evaluating the genotypes with respect to root traits in relation to P response [2-4].

One of the principal component strategies to improve groundnut production with minimum P application is to develop cultivars, which can grow well at lower levels of available soil P or explore fixed P from the soil. Genetic variability for the P deficiency tolerance and the knowledge of heritability are pre-requisites for a successful breeding programme. In present study we assessed heritable nature of variation and correlations in root traits and P uptake traits in response to low P availability condition in 100 Recombinant Inbred Lines (RILs) from segregating population of a cross involving JL 24 and ICGV 86590 identified as most contrasting for P deficiency response [4]. Further highly responsive and least responsive lines among 100 RILs were selected on the basis of root and P uptake traits.

## Materials and methods

A set of 100 RILs obtained from the cross of groundnut (*Arachis hypogaea* L.) cultivar ICGV 86590 and a variety JL 24 which were found to be contrasting for response to reduced phosphorus availability were used in the study. To avoid effect of other soil chemical properties, sand culture experiment was conducted by adopting Randomized Block Design in a factorial experiment with five replications, during summer 2009

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at Botany Garden, Department of Genetics and Plant Breeding, UAS, Dharwad, Karnataka. RILs were sown along with parents as a check.

Under standardization experiment parents were found to show maximum difference for root traits at reduced available P (25 %) as against normal (100 %) provided through 25 ml of Hoagland solution once in three days. Hence, same dosage and concentrations were used for RILs as P insufficient (25 % P) and P sufficient (100 % P) to control the nutrient status and plants were retained for observations at 45 days after sowing. Observations were recorded for root parameters *viz.,* primary root length (PRL), shoot length (SL), root volume (RV), root dry weight (RDW), shoot dry weight (SDW) and total dry weight (TDW). Further, based on *per se* performance and per cent responsiveness over the characters 10 most responsive and 10 least responsive RILs were selected. Selected 20 RILs were further forwarded for evaluating P uptake traits. Phosphorus content in root and shoot sample was estimated by following Vanadomolybdophosphoric yellow colour method in $HNO_3$ system in two replications. For P uptake traits observations were recorded as root P (RP), shoot P (RP), total P (TP) and Internal P Efficiency (IPE). Association analysis was carried out following proper techniques.

## Result and discussion

### *Evaluation of RILs for root traits*

Highly significant variations were observed among RILs for all root traits. Phosphorus concentrations were also found to be significant for most of the root traits except primary root length (PRL) and root dry weight (RDW), which signifies the low responsiveness of the RILs for trait PRL and RDW in response to changes in P concentration. Fawole *et al.* [5] observed moderate variations for the primary roots as compared to other traits in P insufficiency condition. Higher mean values were recorded in P insufficiency conditions for all characters (Table 1). Appropriateness of the selected material was confirmed by high estimates of Genotypic Coefficient of Variance (GCV) and Phenotypic Coefficient of Variance (PCV). Wider scope for selection for all the traits was indicated by high heritability and genetic advance as per cent mean (GAM %) estimates. Wide genotypic variation and heritability of root morphology traits provide opportunities for increasing P acquisition [6].

For effective selection, association analysis of root traits was studied. Significant positive association

**Table 1.** Components of variation in the RILs for root traits in sand culture

| Characters | Insufficiency (25% P) | | | | | | | | Sufficiency (100% P) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Minimum | Maximum | PCV | GCV | $h^2$ | GAM | COV | Mean | Minimum | Maximum | PCV | GCV | $h^2$ | GAM | COV |
| P R L | 40.03 | 24.74 | 52.52 | 16.00 | 15.13 | 89.60 | 29.58 | 5.15 | 40.00 | 19.00 | 57.58 | 20.15 | 19.23 | 91.05 | 38.88 | 6.03 |
| S L | 12.84 | 7.22 | 28.00 | 27.14 | 26.43 | 94.82 | 53.15 | 6.18 | 12.37 | 6.10 | 27.20 | 33.87 | 32.39 | 91.42 | 63.95 | 9.92 |
| R V | 8.72 | 4.50 | 15.10 | 26.71 | 24.48 | 84.02 | 46.34 | 10.68 | 8.52 | 3.30 | 13.30 | 26.67 | 24.09 | 81.57 | 44.93 | 11.45 |
| R D W | 0.53 | 0.22 | 0.91 | 29.40 | 24.59 | 69.92 | 42.46 | 16.13 | 0.52 | 0.22 | 0.92 | 29.31 | 24.23 | 68.35 | 41.37 | 16.49 |
| S D W | 1.25 | 0.45 | 2.23 | 30.72 | 25.37 | 68.23 | 43.28 | 17.31 | 1.19 | 0.55 | 2.51 | 35.29 | 30.35 | 73.98 | 53.91 | 18.00 |
| T D W | 1.78 | 0.82 | 2.86 | 26.91 | 21.73 | 65.22 | 36.24 | 15.86 | 1.72 | 0.77 | 3.12 | 30.49 | 25.48 | 69.82 | 43.97 | 16.75 |

PCV- Phenotypic co-efficient of variance; $h^2$ - heritability; COV - Covariance; GCV-Genotypic co-efficient of variance; GAM- Genetic advance over per cent mean

**Table 2.** Correlation among root and P uptake traits in the selected RILs under P insufficiency and sufficiency condition

| | Characters | PRL | SL | RV | RDW | SDW | TDW | RP | SP | TP | IPE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | PRL | 1 | | | | | | | | | |
| | SL | -0.311 | 1 | | | | | | | | |
| | RV | 0.482* | -0.113 | 1 | | | | | | | |
| Insufficiency | RDW | 0.357 | -0.110 | 0.937** | 1 | | | | | | |
| | SDW | 0.245 | 0.339 | 0.678** | 0.700** | 1 | | | | | |
| (25% P) | TDW | 0.319 | 0.151 | 0.860** | 0.904** | 0.939** | 1 | | | | |
| | RP | 0.407 | -0.128 | 0.925** | 0.973** | 0.656** | 0.864** | 1 | | | |
| | SP | 0.301 | 0.310 | 0.687** | 0.666** | 0.922** | 0.875** | 0.692** | 1 | | |
| | TP | 0.374 | 0.138 | 0.853** | 0.861** | 0.879** | 0.944** | 0.890** | 0.945** | 1 | |
| | IPE | -0.396 | 0.476* | -0.693** | -0.781** | -0.209 | -0.503* | -0.808** | -0.231 | -0.512* | 1 |
| | PRL | 1 | | | | | | | | | |
| | SL | -0.274 | 1 | | | | | | | | |
| | RV | -0.143 | -0.194 | 1 | | | | | | | |
| Sufficiency | RDW | -0.264 | -0.151 | 0.749** | 1 | | | | | | |
| | SDW | -0.370 | 0.237 | 0.651** | 0.718** | 1 | | | | | |
| (100% P) | TDW | -0.355 | 0.098 | 0.738** | 0.884** | 0.960** | 1 | | | | |
| | RP | -0.301 | -0.121 | 0.820** | 0.953** | 0.731** | 0.874** | 1 | | | |
| | SP | -0.398 | 0.202 | 0.664** | 0.636** | 0.943** | 0.888** | 0.727** | 1 | | |
| | TP | -0.389 | 0.095 | 0.768** | 0.799** | 0.928** | 0.944** | 0.880** | 0.966** | 1 | |
| | IPE | 0.245 | 0.353 | -0.298 | -0.491* | 0.083 | -0.142 | -0.503* | 0.051 | -0.154 | 1 |

*, **- Significant at 5% and 1 % level, respectively; PRL - Primary root length; SL- Shoot length; RV- Root volume; RDW- Root dry weight; SDW-Shoot dry weight; TDW- Total dry weight

**Table 3.** Components of variability in selected RILs for P uptake traits in phosphorus insufficiency and sufficiency conditions

| Characters | Insufficiency (25% P) | | | | | | | Sufficiency (100% P) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Min | Max | PCV | GCV | $h^2$ | GAM | Mean | Min | Max | PCV | GCV | $h^2$ | GAM |
| RP | 0.433 | 0.170 | 0.755 | 39.584 | 37.832 | 91.341 | 74.664 | 0.376 | 0.166 | 0.631 | 37.324 | 33.295 | 79.573 | 61.331 |
| SP | 0.911 | 0.412 | 1.377 | 28.691 | 22.264 | 60.212 | 35.674 | 0.768 | 0.415 | 1.540 | 34.922 | 28.779 | 67.914 | 48.976 |
| TP | 1.344 | 0.673 | 2.132 | 29.511 | 25.444 | 74.335 | 45.300 | 1.144 | 0.613 | 2.171 | 33.269 | 28.508 | 73.429 | 50.446 |
| IPE | 0.913 | 0.785 | 1.108 | 10.121 | 9.009 | 79.238 | 16.560 | 0.926 | 0.799 | 1.172 | 10.969 | 9.525 | 75.399 | 17.079 |

RP - Root P content; SP - Shoot P content; TP - Total P content; IPE - Internal P efficiency

between RV and RDW in both P concentrations denoted consistency of genotypes for respective traits (Table 2) [4]. A significant positive correlation of TDW and SDW with RV and RDW and negative correlation of SL with PRL in phosphorus insufficiency condition indicated increased response of plants to phosphorus stress condition in form of increased accessory roots than primary roots and hence increasing RV, RDW and SDW as a result of internal P efficiency (IPE). Quantitative nature of variation for all the root traits was indicated by near normal to normal frequency distribution curves (Fig. 1). Over both the Phosphorus concentrations, for most traits like SL, RDW, SDW, TDW except PRL and RV significant transgressive segregants were observed with distributed alleles in both the parents [7].

Except SL, for all traits ICGV 96590 showed higher per cent responsiveness value than mean over the RILs, whereas JL 24 recorded negative responsiveness for PRL (–0.13 %) and SL (–9.62 %) and lower response in other root traits. Over the traits, RILs exhibited much wider variation for per cent change than parents *viz*., PRL (–39.64 to 133.05%), SL (–55.15 to 95.83%), RV (–51.18 to 81.82%), RDW (–59.34 to 104.33%), SDW (–46.09 to 123.34%) and TDW (–51.16 to 95.29%). The higher per cent responsiveness for biomass traits by different RILs was much higher than that of parent ICGV 86590 which showed 9.98, 11.21 and 10.81 per cent responsiveness for RDW, SDW, and TDW respectively.

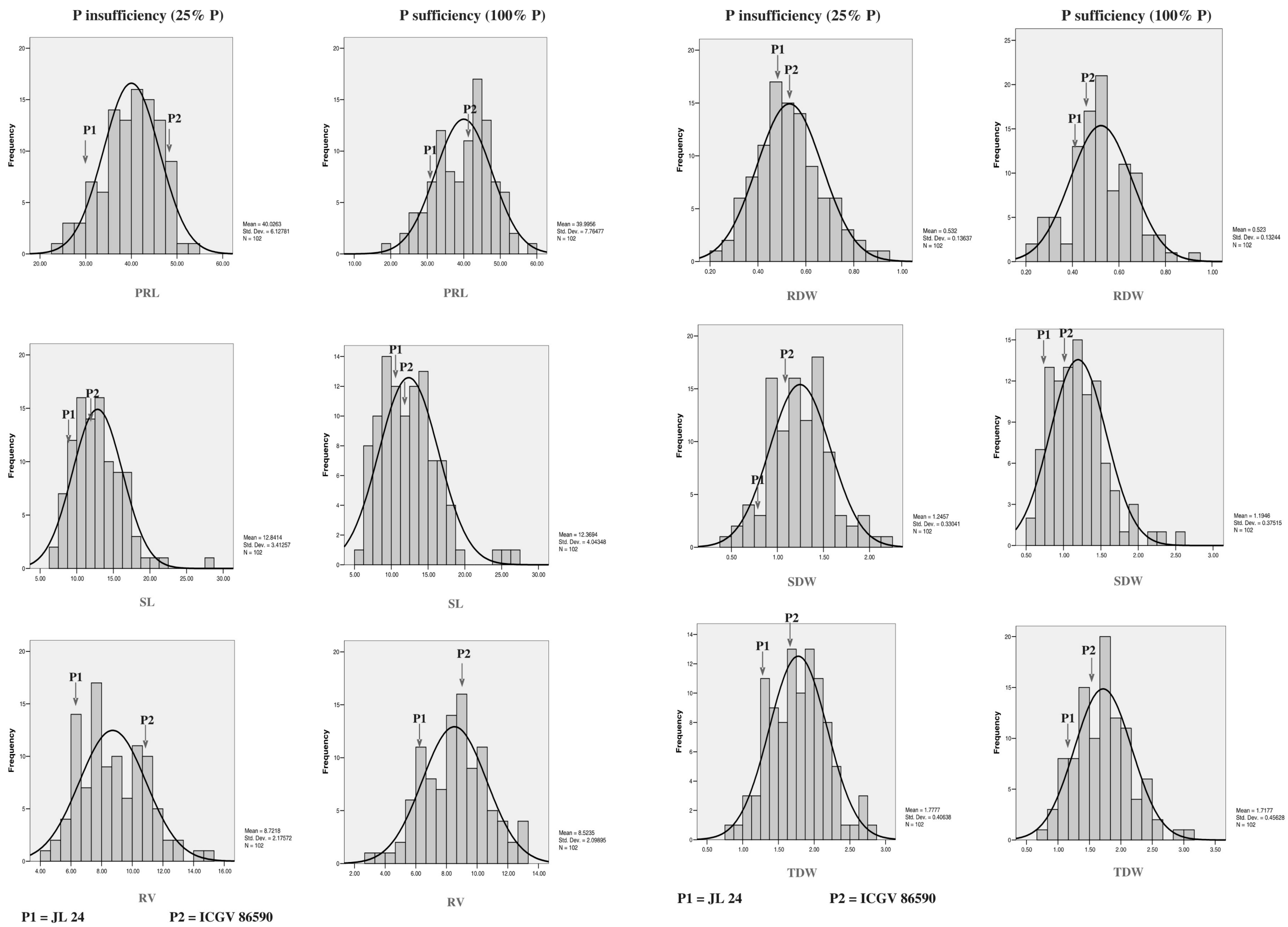


**Fig. 1. Frequency distribution of selected 100 RILs for root traits in variable P concentrations**

Recombinant inbred lines like 6-1, 7-13, 7-12, 1-45, 5-15, 6-3, 6-37, 5-7, 5-3 and 6-8 showed lower *per se* performance and very low or negative per cent change over the traits indicating their non-responsiveness. RV and biomass traits are more preferred traits for evaluating effect of P deficiency. In RV, 17 RILs were equal or superior in mean values, than ICGV 86590 (0.548), the better parent, 64 for SDW, 43 for RDW and 61 for TDW. RILs namely, 1-23, 1-44, 1-34, 1-18, 1-16, 1-19, 1-3, 1-36, 3-11, 1-30 etc., expressed superiority for most of the traits.

### *Evaluating the selected RILs for P uptake*

Selected RILs along with parents were assessed for P uptake traits like root phosphorus (RP), shoot phosphorus (SP), total phosphorus (TP), and internal P efficiency (IPE). Correlations between root traits and P uptake traits did shed light on the impact of root traits on phosphorus uptake and IPE. PCV, GCV, heritability and GAM % indicated large amount of variation that was highly heritable in nature. Higher mean values and heritability for all traits except IPE in P insufficiency condition denotes the suitability of low P environment for selection (Table 3).

Association analysis among root traits and P uptake traits described significant positive correlation of RP, SP, and TP with RV and biomass characters (RDW, SDW and TDW) in both phosphorus availability conditions was observed. Significant association between root and shoot dry weight and total P is a critical factor in breeding for adaptation to P stress condition [4, 8] as both root and shoot growth mainly determines the total P accumulated in the plant. Trait IPE showed negative association with all root and P uptake traits except SL and hence inferior lines for root traits depicted higher IPE (Table 2).

RIL 7-12 for RP (85.70 %) and 6-37 for SP (98.04 %) and TP (84. 90 %) exhibited maximum per cent responsiveness but their low mean values in P

**Table 4**. Mean performance of selected RILs for P uptake traits over different P concentrations and their responsiveness to P insufficiency

| RIL No. | RP (µg) | | | SP (µg) | | | TP (µg) | | | IPE (g/µg) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 (%) | 100 (%) | Per cent responsiveness | 25 (%) | 100 (%) | Per cent responsiveness | 25 (%) | 100 (%) | Per cent responsiveness | 25 (%) | 100 (%) | Per cent responsiveness |
| 1-36 | 0.478 | 0.468 | 2.189 | 0.818 | 0.754 | 8.472 | 1.296 | 1.222 | 6.068 | 0.867 | 0.872 | -0.555 |
| 1-23 | 0.755 | 0.618 | 22.276 | 1.377 | 1.052 | 30.951 | 2.132 | 1.669 | 27.741 | 0.853 | 0.870 | -1.979 |
| 1-18 | 0.561 | 0.329 | 70.256 | 1.270 | 0.751 | 69.090 | 1.830 | 1.080 | 69.445 | 0.884 | 0.966 | -8.465 |
| 1-44 | 0.647 | 0.608 | 6.355 | 0.922 | 0.891 | 3.513 | 1.569 | 1.499 | 4.667 | 0.815 | 0.815 | 0.010 |
| 3-11 | 0.545 | 0.631 | -13.615 | 1.227 | 1.540 | -20.313 | 1.772 | 2.171 | -18.367 | 0.914 | 0.985 | -7.168 |
| 1-3 | 0.596 | 0.404 | 47.505 | 1.261 | 0.941 | 34.070 | 1.858 | 1.345 | 38.108 | 0.880 | 0.873 | 0.795 |
| 1-19 | 0.617 | 0.405 | 52.365 | 0.846 | 0.668 | 26.521 | 1.463 | 1.074 | 36.275 | 0.785 | 0.871 | -9.834 |
| 1-30 | 0.590 | 0.368 | 60.101 | 0.932 | 0.645 | 44.684 | 1.522 | 1.013 | 50.289 | 0.820 | 0.799 | 2.546 |
| 1-16 | 0.561 | 0.344 | 62.988 | 1.218 | 0.697 | 74.729 | 1.779 | 1.041 | 70.847 | 0.870 | 0.864 | 0.697 |
| 1-34 | 0.606 | 0.508 | 19.326 | 0.868 | 0.775 | 11.931 | 1.474 | 1.283 | 14.857 | 0.800 | 0.820 | -2.472 |
| Mean (superior) | 0.596 | 0.468 | 27.183 | 1.074 | 0.871 | 23.238 | 1.670 | 1.340 | 24.617 | 0.849 | 0.874 | -2.828 |
| 6-8 | 0.275 | 0.357 | -22.919 | 0.724 | 0.590 | 22.611 | 0.999 | 0.948 | 5.444 | 1.008 | 0.813 | 23.937 |
| 5-3 | 0.232 | 0.249 | -7.195 | 0.757 | 0.889 | -14.832 | 0.989 | 1.139 | -13.159 | 1.049 | 0.986 | 6.412 |
| 5-7 | 0.170 | 0.216 | -21.250 | 0.865 | 0.665 | 30.023 | 1.034 | 0.881 | 17.472 | 1.108 | 1.012 | 9.509 |
| 6-37 | 0.333 | 0.210 | 58.909 | 0.821 | 0.415 | 98.036 | 1.154 | 0.624 | 84.902 | 0.950 | 0.888 | 6.949 |
| 6-3 | 0.258 | 0.380 | -32.236 | 0.799 | 1.050 | -23.877 | 1.057 | 1.430 | -26.099 | 1.064 | 1.062 | 0.162 |
| 5-15 | 0.284 | 0.362 | -21.571 | 0.859 | 0.796 | 7.864 | 1.143 | 1.159 | -1.344 | 0.965 | 0.977 | -1.241 |
| 1-45 | 0.291 | 0.411 | -29.186 | 0.740 | 0.847 | -12.664 | 1.031 | 1.258 | -18.056 | 0.930 | 0.986 | -5.657 |
| 7-13 | 0.262 | 0.175 | 49.357 | 0.412 | 0.437 | -5.882 | 0.673 | 0.613 | 9.917 | 0.865 | 1.046 | -17.333 |
| 7-12 | 0.309 | 0.166 | 85.698 | 0.853 | 0.569 | 49.990 | 1.162 | 0.735 | 58.072 | 0.965 | 1.172 | -17.661 |
| 6-1 | 0.343 | 0.306 | 11.955 | 0.807 | 0.565 | 42.960 | 1.150 | 0.871 | 32.065 | 0.959 | 0.932 | 2.954 |
| Mean (inferior) | 0.276 | 0.283 | -2.648 | 0.764 | 0.682 | 11.930 | 1.039 | 0.966 | 7.600 | 0.986 | 0.987 | -0.111 |
| ICGV 86590 | 0.452 | 0.432 | 4.584 | 1.037 | 0.813 | 27.466 | 1.489 | 1.245 | 19.524 | 0.868 | 0.873 | -0.584 |
| JL 24 | 0.354 | 0.339 | 4.354 | 0.630 | 0.536 | 17.413 | 0.984 | 0.876 | 12.351 | 0.870 | 0.884 | -1.590 |
| MEAN | 0.433 | 0.377 | 18.648 | 0.911 | 0.768 | 23.761 | 1.344 | 1.144 | 21.865 | 0.913 | 0.926 | -0.935 |
| MIN | 0.170 | 0.166 | -32.236 | 0.412 | 0.415 | -23.877 | 0.673 | 0.613 | -26.099 | 0.785 | 0.799 | -17.661 |
| MAX | 0.755 | 0.631 | 85.698 | 1.377 | 1.540 | 98.036 | 2.132 | 2.171 | 84.902 | 1.108 | 1.172 | 23.937 |
| CV (%) | | 14.172 | | | 18.883582 | | | 15.96271 | | | 5.048852 | |
| CD% (RILs) | | 0.10918 | | | 0.301737 | | | 0.378042 | | | 0.088363 | |
| CD% (P conc.) | | 0.032919 | | | 0.090977 | | | 0.113984 | | | 0.019944 | |
| CD% (G x P) | | 0.154404 | | | 0.319431 | | | 0.534633 | | | 0.124964 | |

sufficiency revealed their lower per se performance in natural condition, whereas 3-11 showed higher mean values but with negative responsiveness (Table 4).

Considering several characters *viz*., RP, SP and TP, RILs 1-23 and 1-18 were found to be more responsive along with higher mean values in P sufficiency. RIL 5-3 in spite of having very low or negative responsiveness had consistently higher performance in both P availability conditions. RIL 7-13 was selected as most inferior line owing to its lowest performance over different traits like, RP, SP and TP and very low per cent responsiveness.

Performance of ICGV 86590 was at par with superior genotypes for IPE, but was surpassed by lines 1-23 and 1-18 for P content. Very less variation among selected lines and parents for IPE could be due to complex mechanism involved in regulation of this trait like phosphorus uptake kinetics, which used to get affected by many environmental factors.

Evaluation of selected lines for other response mechanisms for P insufficiency stress, such as root hair development, exudation of organic acids, protons, chelates, rhizosphere interaction, hormone signalling etc. would help understand detail mechanism of P uptake in groundnut.

**References**


1. **Raghothama K. G.** 1999. Phosphate acquisition. Ann. Rev. Plant Physiol. Plant Mol. Biol., **50**: 665-693.
2. **Wissuwa M. and Ae N.** 1999. Genotypic variation for phosphorus uptake from hardly soluble iron-phosphate in groundnut (*Arachis hypogaea* L.). Plant and Soil, **206**: 163-171.
3. **Tamboli B. D. and Daftardar S.Y.** 2001. Effect of phosphorus sources on root characteristics, yield and P uptake by legumes. J. Mah. Agri. Uni., **26**: 243-246.
4. **Kumar A.** 2007. Screening groundnut (*Archis hypogaea* L.) germplasm for tolerance to phosphorus deficiency. M.Sc. Thesis. University of Agricultural Sciences, Dharwad.
5. **Fawole I., Gabelman W. H. and Gerloff G. C.** 1982. Genetic control of root development in beans (*Phaseolus vulgaris* L.) grown under phosphorus stress. J. Amer. Soc. Hort. Sci., **107**: 98-100.
6. **Gahoonia T. S. and Neilson N. E.** 2004. Root traits as tool for creating phosphorus efficient crop varieties. Plant and Soil, **260**: 47-57.
7. **Zhang Z., Qu S., Xin W., Shan, Chen, LI H. and Zhu Y. G.** 2005. Comparison of QTL controlling seedling vigour under different temperature conditions using recombinant inbred lines in rice (*Oryza sativa*). Ann. Bot., www.aob.oupjournals.org
8. **He Y., Liao H. and Yan X.** 2003. Localized supply of phosphorus induces root morphological and architectural changes of rice in split and stratified soil cultures. Plant and Soil, **248**: 247-256.