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Genotypic Differences Among Cotton Genotypes for Phosphorus Use Efficiency and Stress Factor

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ABSTRACT

A pot experiment was conducted to evaluate six cotton genotypes for their growth behavior at two levels of soil phosphorus, viz. deficient (2.6 ppm) and adequate (26 ppm i.e. original soil P and added P) using 10 kg soil per pot. Genotypes showed differential behavior at both P-levels for all parameters. Shoot dry weight and root dry weight were observed maximum in FH-634 and minimum in NIAB-78 at both P-levels. Maximum root shoot ratio was exhibited by FH-634 and minimum by CIM-443 at deficient P, however, it was non significant at adequate level of P. Difference for phosphorus utilization efficiency and phosphorus stress factor were also observed. Three out of six genotypes realized PSF less than 50% and others more than 50%.

Key Words: Cotton; Phosphorus use efficiency; Genotypic differences

INTRODUCTION

Exploitation of genetic resources of crops to get more yield under resource poor and problem soil environment like Pakistan seems inevitable. Variety and environment are two most important factors, which determine the fate of crop yield (Manjit, 1998). High yielding varieties need suitable soil environment to show their maximum potential. Low fertilizer use efficiency and imbalance use of phosphatic fertilizers are important factors responsible for low yield (Ahmed, 1993). Genetic differences for absorption and utilization of mineral nutrients has received much attention during recent past (Saric, 1987). Differential response of different varieties of a crop to phosphorus (P) has also been reported by Yan *et al.* (1995). Economy of fertilizer application and nutrient use efficiency in crop plants may be improved by understanding internal and external adaptive mechanisms under and adequate levels of nutrient; and comparing and selecting such crop genotypes for commercial cultivation. The objective of this study was to select genotypes of cotton giving good results under deficient and adequate levels of P fertilization.

MATERIALS AND METHODS

A pot experiment for exploitation of genotypic variability of six cotton varieties at two levels of P was conducted in Department of Soil Science, University of Agriculture, Faisalabad in 1997-1999. The P deficient (i.e. 2.6 ppm P) sandy loam soil with pH_s 8.1, EC_e 0.87 dSm^{-1}, organic matter 0.61% and K 129 ppm, was collected from research area of Soil Chemistry section, AARI, Faisalabad. Seeds of six cotton varieties (*viz.* FH-634, CIM-443, CIM-1100, NIAB-92, S-12 and NIAB-78) were collected from NIAB and Plant Breeding and Genetics, Department, University of Agriculture, Faisalabad and were sown in pots filled with 10 kg soil. Nitrogen and potassium were applied as recommended doses with N in two splits i.e. ½ N before sowing and other ½ two weeks after germination. Soil with two levels of P i.e. deficient (2.6 ppm P) original soil P and adequate P (26 ppm P) by adding P was used. Tap water was used as irrigation source. Two plants per pot were allowed to grow after thinning. Insect pests were physically removed and no pesticide was used as a pest control measures. Plants were harvested after 60 days and separated into root and shoot after washing with tap water. Samples were oven-dried at 70°C for 48 hours. P contents of shoot and root were determined according to Chapman and Pratt (1961). Shoot dry weight and root dry weight were recorded while phosphorus utilization efficiency and phosphorus stress factor were calculated and subjected to statistical analysis by using MSTAT-C package of computer software (Russell & Eisensmith, 1983).

RESULTS AND DISCUSSION

Shoot dry weight (SDW). SDW is the best growth indicator parameter for screening purpose because it directly indicates hydraulic conductance (underground growth indicator parameter) of root and is dependent on plant nutrition applied (Durdyev & Khabibullaev, 1992). Cotton genotypes (Table I) showed significant differences in SDW at both P-levels. With deficient P-level, SDW ranged from 0.72 to 2.61 g pot^{-1} and at adequate P-level, it ranged from 3.15 to 4.98 g pot^{-1}. Maximum and minimum SDW were observed in FH-634 (2.61 g pot^{-1}) and NIAB-78 (0.72 g pot^{-1}) at deficient P-level; whereas, with adequate P supply, CIM-443 exhibited maximum (4.98 g pot^{-1}) and NIAB-78 showed minimum (3.15 g pot^{-1}) SDW, respectively. Wide differences in SDW at deficient P-level suggest differential biomass production behavior of cotton genotypes, which can be exploited for further selection, and recommendation of cotton genotypes for areas deficient in soil-P.

Root dry weight (RDW). The growth of plant is diverted from shoot to root under P-deficiency stress. This adaptive mechanism is due to change in internal physiology of the plant (Horst *et al.,* 1993). Data on RDW (Table I) exhibited significant differences at both P-levels. At deficient P-level, it ranged from 0.43 to 1.77 g pot^{-1} and at adequate P-level; it ranged from 1.48 to 2.94 g pot^{-1}. Maximum RDW was observed in FH-634 (1.77 g pot^{-1}) followed by NIAB-92 (1.60 g pot^{-1}) and CIM-1100 (1.13 g pot^{-1}); whereas, minimum RDW was produced by NIAB-78 (0.43 g pot^{-1}). With adequate P supply, RDW was maximum in FH-634 (2.94 g pot^{-1}) and minimum in case of S-12 (1.48 g pot^{-1}).

Table I. Shoot and root dry weights (g pot^{-1}) of cotton genotypes at deficient and adequate P-levels

Genotypes	Shoot dry weight		Root dry weight	
	Deficient P-Level	Adequate P-Level	Deficient P-Level	Adequate P-Level
FH-634	2.61 a	4.92 a	1.77 a	2.94 a
CIM-443	1.86 ab	4.98 a	0.47 b	2.46 ab
CIM-1100	2.38 a	4.79 ab	1.13 ab	1.96 bc
NIAB-92	2.40 a	3.90 bc	1.60 a	1.78 bc
S-12	1.36 bc	3.54 c	0.71 b	1.48 c
NIAB-78	0.72 c	3.15 c	0.43 b	1.81 bc
P-level means	1.88 B	4.21 A	1.02 B	2.07 A
EMS = 0.342	CV = 19	LSD = 0.985	CV = 35	LSD = 0.843

Values in column(s) are significantly different ($P < 0.05$) unless followed by the same letter(s)

Shoot and root P concentration. There were non-significant differences (Table II) among cotton genotypes for their P-concentration at deficient P-level in both shoot and root; however, significant differences were observed among genotypes at adequate P-supply. Maximum and minimum P-concentration was observed in shoot and root, were observed in S-12 and CIM-1100, respectively.

Table II. Shoot and root P-concentrations (mg g^{-1}) of cotton genotypes at deficient and adequate P-levels

Genotypes	Shoot P-concentration		Root P-concentration	
	Deficient Level	P- Adequate P-Level	Deficient P-Level	Adequate P-Level
FH-634	1.20 $^{N.S.}$	2.32 b	2.24 $^{N.S.}$	2.53 ab
CIM-443	1.51	2.51 ab	2.50	2.56 ab
CIM-1100	1.37	2.15 ab	2.22	2.44 b
NIAB-92	1.48	2.85 a	2.07	2.79 ab
S-12	1.24	2.88 a	2.10	3.01 a
NIAB-78	1.46	2.17 a	1.48	2.76 ab
P-level means	1.41 B	2.48 A	2.10 B	2.68 A
EMS = 0.342	CV = 17	LSD = 0.527	CV = 14	LSD = 0.565

Values in column(s) are significantly different ($P < 0.05$) unless followed by the same letter(s)

Phosphorus utilization efficiency (PUE) and stress factor (PSF). P utilization efficiency refers to the biomass production per unit of tissues P concentration. It demonstrates the efficient and non-efficient behavior of species towards P utilization (Siddiqui & Glass, 1981). Data regarding PUE (Table III) show that the most efficient genotype was FH-634 followed NIAB-92 and CIM-1100 at deficient P-level. However, with adequate P, CIM-1100 was the best utilizer of P followed by FH-634 and CIM-443. Statistically significant P-level means suggests that genotypes can extract and use soil P efficiently in P-deficient root medium and wide range of PUE (0.42-1.98) gave a clue of genotypic variability for P-utilization. P stress factor measures the relative reduction (%) in SDW of a plant due to P deficiency compared to its SDW production at adequate P supply. It determines the responsive and non-responsive behavior of a crop towards a nutrient. In general, varieties showing smaller PSF values are preferred in screening programs, because they show lesser decrease in SDW production with decreased nutrient supply in root medium. Genotypes having lesser PSF values are recommended in low soil P areas or soils. The data in Table III showed that lowest PSF value was exhibited by NIAB-92 followed by FH-634 and CIM-1100. It is clear that three genotypes showed PSF less than 50% and other more than 50%.

Table III. Phosphorus utilization efficiency (PUE) {g^2 mg^{-1} P} and phosphorus stress factor (PSF %) of cotton genotypes

Genotypes	PUE (def. P)	PUE (Adeq. P)	PSF %
FH-634	1.98 a	1.57 ab	47
CIM-443	1.18 b	1.56 ab	63
CIM-1100	1.73 ab	1.92 a	48
NIAB-92	1.74 a	1.25 b	40
S-12	1.04 b	1.14 b	61
NIAB-78	0.42 c	1.39 b	77
P-level means	1.34 B	1.47 A	---
EMS = 0.342	CV = 24	LSD = 0.614	---

Values in column(s) are significantly different ($P < 0.05$) unless followed by the same letter(s)

REFERENCES

Ahmed, Z, 1993. Potential for expanding cotton production in Pakistan. Central Cotton Res. Inst., Multan. p. 114.

Chapman, H.D. and P.F. Pratt, 1961. *Methods of Analysis for Soils, Plants and Waters.* Div. Agric. Sci., Uni. Calif., USA.

Durdyev, B. and E. Khabibullaev, 1992. Corrections between leaf area and the productivity of cotton. *Seryia Biologicheskch. Nauk,* 2: 67–9.

Horst, W.J., M. Abdov and F. Wiesler, 1993. Genotypic differences in phosphorus efficiency in wheat. *Plant Sci.,* 155: 292–6.

Manjit, S.K., 1998. Using Genotypic-by-Environment interaction for crop cultivar development. *Adv. Agron.*, 62: 199–252.

Russel, D.F. and S.P. Eisensmith, 1983. MSTAT-C. Crop Soil Sci. Dept. Michigan State Univ. USA.

Saric, M.R, 1987. Progress since the first international Symposium. "Genetic Aspects of Mineral Nutrient". Beagard, 1982 and perspectives of future research, Plant Soil, 99: 197-209.

Siddiqui, M.Y. and A.D.M. Glass, 1981. Utilization index: A modified approach to the estimation and comparison of nutrient utilization efficiency in plants. *J. Plant Nutr.,* 4: 289–302.

Yan, X., S.E. Beebe and J.P. Lynch, 1995. Genetic variation for phosphorus efficiency of common bean in contrasting soil types II. Yield response. *Crop Sci.,* 35: 1094–99.

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