Pak. j. life soc. sci. (2004), 2(2): 159-162

Pakistan Journal of
Life and Social Sciences

Phosphorus Use Efficiency in Wheat Genotypes: II. Chemical Composition

Yaseen, M., M. Sohail, R. Mahmood, S.A. Hussain, A. Rahim , W. Ahmad, and Saif-Ur-Rehman Kashif
Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad-Pakistan

Abstract

Phosphorus (P) availability and uptake influence its utilization with in plant and ultimately plant biomass. Significant differences for P concentration and content in shoots and roots were obvious among 24 genotypes at deficient and adequate P levels. A significantly positive correlation with root dry matter (r = 0.698, p < 0.01) suggested greater P uptake due to greater root biomass at deficient P level. Specific absorption rate also varied significantly among genotypes at adequate level. Specific utilization rate (SUR) was decreased by 60% with the increase in P supply in the growth medium. Maximum SUR was observed in Inqlab 91 and minimum in Pasban and line 88678. Over all, results provide useful information about genetic differences in wheat genotypes with regard to P absorption and utilization. These results suggest that Inqlab 91 performed better at low P level and could be consider as P efficient wheat genotype among the tested genotypes.**

Key words: Phosphorus, Efficiency, Wheat genotypes.

Introduction

Low input sustainable Agriculture (LISA) has increased awareness among scientists for search of crop genotypes which are relatively better tolerant to mineral stress in the soils. Genetic variability and plant's ability to absorb, translocate, accumulate and use of mineral elements are important in adopting plants to a mineral stress environment. These differences are responsible for their survival or failure in a nutrient stress environment. Plants with the ability to perform well with low or limited amounts of phosphorus (P) in soil are considered more efficient (Blume, 1988; Clark and Duncun, 1991; Ahmad *et al*., 1998).

Genetic variability in P nutrition exists among crop plants and these differences are exhibited in terms of morphological and physiological expressions.

Corresponding author: Muhammad Yaseen,
Institute of Soil and Environmental Sciences,
University of Agriculture, Faisalabad, Pakistan

Morphological expressions involved the growth and growth contributing parameters such as root (root geometry, root radius and root hairs) shoot growth, number of tillers and root- shoot ratio while physiological expressions are read out by concentrations, absorptions, translocations, accumulation and utilization of specific nutrient element which is P here (Gerloff, 1987; Yaseen *et al*. 1998).

The experiment was conducted to observe the differential behaviour of wheat genotypes for concentration, absorption, uptake and utilization of P in stress and adequate supply of P in the growth medium.

Materials and Methods

Seed of twenty four wheat genotypes were germinated in plastic trays containing washed gravel. Distilled water was used for irrigation. Twelve days old seedlings were transplanted in foam plugged holes of thermopal sheet floating on continuously aerated modified Johnson's nutrient solution (Johnson *et al*. 1957) in two polyethylene lined iron tubs (200 L capacity). Two levels of phosphorus i.e. stress (25 uM) and adequate (250 uM) were established using $NH_4H_2PO_4$ salt in separate tubs. The pH of the solution was maintained at 5 $\pm$ 0.5 with HCl or NaOH throughout the experiment. Experiment was laid out in Completely Randomized Factorial Design (Steel and Torrie, 1980) with seven repeats. Each hole comprised of two plants represented one repeat.

Plants were harvested twice. Three repeats were taken 30 days after transplanting and phosphorus levels were again maintained to original level. Four repeats were harvested 36 days after transplanting. At each harvest plants were washed with distilled water, separated into root and shoot and dried with tissue paper. Dried samples (in an oven at 70 C for 48 hours) were ground to 40 meshes with a mechanical grinder.

Shoot and root samples @ 0.25 g each was digested in a mixture of H_2SO_4 and H_2O_2 (Jones, Jr. and Case, 1990) Phosphorus contents in the digested extract was determined by Du-64 spectrophotometer by vanadate-molybdate yellow method (Chapman and Pratt, 1961).

Results and Discussion

Data in Table 1 is the summery of plant growth related parameters discussed in the first paper under sub-title "Plant Growth" (Yaseen *et al*., 2003). Data regarding the growth and phosphorus relations are discussed in this paper. Genotypes, P level and genotype x P level had significant individual and interactive effects (P < 0.01) on P concentration and content in shoots and roots of 24 wheat genotypes (Table 2). Genotypes showed marked differences in P concentration and content at deficient and adequate levels of P. P concentration was 2.6 (9.32 – 3.61) and 5 (7.80- 1.45) fold lower in shoots and roots, respectively while that of P contents 5.7 (14.70 – 2.56) and 3.2 (1.84 – 0.57) fold when P level in growth medium was lowered 10 fold from 250 uM to 25 uM. Phosphorus concentration ranged from 2.53 (4770) to 5.07 mg g^{-1} (6039-4) in shoot at deficient P (25 uM) level. However, P contents were between 1.36 (Pasban) and 4.34 mg 2 $plants^{-1}$ (89626) at this level. Genotypes also differed significantly for specific absorption rate (SAR) and specific utilization rate (SUR) of P at both the P levels (Table 3). However differences among genotypes for SAR at low P level were non significant yet were very wide (approximately 3 fold). SUR ranged from 14.70 (Pasban) to 59.05 mg DM mg^{-1} P day^{-1} at deficient P level which decreased with increase of P supply in growth medium and ranged between 6.60 (90627) and 22.83 mg DM mg^{-1} P day^{-1} (91169). The average over 24 genotypes showed that increase in SUR was 60 % at 25 uM P compared to that at 250 uM P.

Table 1: Highest and lowest dry matter yields of shoot and root, root: shoot ratio phosphorus stress factor and relative growth rate of shoot of twenty four wheat genotypes at stress and adequate P levels.

Plant part	P levels	
	25µ M Avg. (Range)	250µ M Avg. (Range)
Shoot dry matter (g . 2 $plants^{-1}$)	0.72(0.52-1.09)	1.60(1.35-2.03)
Root dry matter (g . 2 $plants^{-1}$)	0.40(0.26-0.55)	0.24(018-0.32)
Total Plant dry matter(g . 2 $plants^{-1}$)	1.16(0.89-1.51)	1.84(1.56-2.25)
P- stress factor (%)	52.53 (28.7-70.1)	-
Root : Shoot Ratio	0.56(0.39-0.70)	0.15(0.11-0.18)
Shoot relative growth rate (mg g^{-1} day^{-1})	60.94(25.0-105.0)	104.48(65.0-182.5)

Table 2: Phosphorus concentration and content in plant shoot and root dry matter of twenty four wheat genotypes at stress and adequate P levels.

Genotypes	P conc. in shoot mg g^{-1}		P conc. in root mg g^{-1}		P cont. in shoot mg 2 $plants^{-1}$		P cont. in root mg 2 $plants^{-1}$	
	25µ M	250µ M	25µ M	250µ M	25µ M	250µ M	25µ M	250µ M
Blue Silver	2.93 c-f	6.45 j	1.05 b-e	6.91 gh	1.78 b-d	11.52 ij	0.28 f	1.60 f-h
Faisalabad– 83	2.96c-g	7.30 h-j	1.73 a-d	6.67 h	2.17 b-d	13.46 f-i	0.65 a-c	2.14 a-c
Inqlab–91	4.18 a-d	11.63 ab	0.95 c-e	8.15 a-d	3.14 a-d	17.26b-f	0.40 b-f	2.42 a
Punjab-85	4.00 a-e	10.40b-d	1.41 a-c	8.61 ab	2.34 a-d	14.54d-g	0.49 a-f	1.74 d-g
LU 26-S	3.86 a-f	12.14 a	1.02 b-c	8.58 ab	3.29 a-d	17.97 ab	0.56 a-f	1.65 e-h
LU -31	3.62 b-f	11.33a-c	1.86 a-c	8.38 a-c	2.95 a-d	17.80 b	0.86 a	2.37 ab
NF-7, 6039-4	5.07 a	10.60b-d	0.62 c	8.50 ab	3.04 a-d	15.62c-e	0.30 e-f	1.78 d-g
NF-7, 6529-11	3.19 b-f	7.54 h-j	1.92 a-c	7.13 f-h	2.40 a-d	12.99 f-j	0.74 a-c	1.89 c-g
NF-7, 6544-6	2.95 c-f	9.59 d-f	1.36 a-e	7.54 c-h	2.09 b-d	15.80c-e	0.52 a-f	2.01 c-e
4070	3.35 b-f	11.35a-c	1.27 b-e	8.17 a-d	1.83 b-d	19.62 a	0.52 a-f	1.91 c-g
4770	2.53 f	7.31 h-j	1.51 a-e	7.21 d-h	1.51 cd	11.50 ij	0.55 a-f	1.68 e-h
Pasban	2.65 e-f	9.11 e-g	1.17 b-e	7.72 b-g	1.36 d	13.83e-h	0.41 b-f	2.09 b-d
V-89251	4.17 a-d	6.87 ij	1.73 a-d	8.65 ab	2.24 b-d	12.57g-j	0.60 a-f	1.79 c-g
V-89313	2.84 d-f	8.39 f-h	1.56 a-e	7.16 e-h	1.89 b-d	12.61g-j	0.58 a-f	1.38 h
V-91109	3.44 b-f	7.24 h-j	1.07 b-e	8.66 ab	2.43 a-d	11.12 j	0.44 b-f	1.55 g-h
V-91116	3.80 a-f	10.92a-c	1.08 b-e	9.08 a	2.47 a-d	15.94 cd	0.38 c-f	1.88 c-g
V-91141	4.40 ab	11.43a-c	0.77 de	8.30 a-c	3.55 a-c	17.35 bc	0.34 d-f	1.94 c-f
V-91169	3.71 a-f	8.20 g-i	2.27 a	6.89 gh	2.16 b-d	12.12h-j	0.75 ab	1.34 h
V-91173	3.39 b-f	7.93 g-i	1.44 a-e	7.24 d-h	2.45 a-d	14.01d-h	0.55 a-f	1.84 c-g
D-88678	4.32 a-c	10.51b-d	1.90 a-c	6.62 h	2.67 a-d	15.81c-e	0.65 a-c	1.84 c-g
D-89626	4.17 a-d	10.14c-e	1.62 a-d	8.10 b-e	4.34 a	15.88 cd	0.77 ab	1.86 c-g
D90627	4.38 ab	11.47a-c	1.54 a-e	7.90 b-f	3.65 ab	15.48c-e	0.74 a-c	1.63 f-h
D90640	3.63 b-f	7.33 h-j	1.94 a-c	7.45 c-h	2.34 a-d	14.94d-f	0.68 a-d	1.62 f-h
D-91773	3.11 b-f	8.40 f-h	2.02 ab	7.44 c-h	3.38 a-d	13.14 f-i	0.85 a	2.04 cd
Mean	3.61 B	9.32 A	1.45 B	7.80 A	2.56 B	14.70 A	0.57 B	1.84 A

Values followed by the same letter (s) with in a column do not differ significantly by Duncun's Multiple Range Test ($p < 0.05$).

Table 3: Total phosphorus content, specific absorption and utilization rate of P of twenty four wheat genotypes at stress and adequate P levels.

Genotypes	Total P contents mg 2 plants^{-1}		Specific absorption rate u Mol P g^{-1} RDM day^{-1}		Specific utilization rate mg DM mg^{-1} P day^{-1}	
	25µ M	250µ M	25µ M	250µ M	25µ M	250µ M
Blue Silver	2.06 c	13.11 kl	26.12 NS	191.5 g-j	25.10 f-i	19.45 ab
Faisalabad– 83	3.15 a-c	15.50 e-i	51.36	128.8 h	55.47 ab	16.10 a-c
Inqlab–91	3.55 a-c	19.69 ab	41.04	318.0 bc	59.05 a	10.20 bc
Punjab-85	2.99 a-c	16.28 a-h	37.97	321.2 bc	35.03d-f	12.13 a-c
LU 26-S	3.92 a-c	20.89 ab	30.72	240.3 e-h	29.63 dg	9.67 bc
LU -31	3.81 a-c	19.15 ab	34.10	306.6 b-d	32.80 df	10.18 bc
NF-7, 6039-4	3.34 a-c	17.40 c-e	28.70	263.40 de	18.52g-i	8.12 bc
NF-7, 6529-11	3.14 a-c	14.89 g-k	23.38	151.70 jk	26.27e-h	12.57 a-c
NF-7, 6544-6	2.38 bc	17.82 cd	35.49	337.10 bc	46.17 bc	18.38 a-c
4070	2.38 bc	21.53 a	29.26	421.20 a	40.78 cd	12.63 a-c
4770	2.06 c	13.18 kl	19.83	206.10 f-l	51.90 ab	16.85 a-c
Pasban	1.91 c	15.93 d-i	18.86	249.5 ef	14.70 i	15.57 a-c
V-89251	3.16 a-c	14.37 h-l	36.69	266.4 de	24.92 f-i	17.30 a-c
V-89313	2.74 bc	13.99 i-l	24.91	242.8 e-g	28.70 e-h	15.80 a-c
V-91109	3.05 a-c	12.67 l	26.44	188.6 h-j	35.60 c-f	13.13 a-c
V-91116	2.86 b-c	17.82 cd	31.85	328.5 bc	36.92 c-e	9.52 bc
V-91141	3.88 a-c	19.30 bc	41.92	331.7 bc	27.57 e-h	7.75 bc
V-91169	3.15 a-c	13.46 j-l	30.07	356.5 b	17.86 hi	22.83 a
V-91173	3.00 a-c	15.86 b-i	39.83	214.4 e-i	30.95 d-f	14.48 a-c
D-88678	3.32 a-c	17.65 cd	20.64	179.7 ij	15.13 i	9.00 bc
D-89626	5.11 a	17.53 c-e	38.05	104.7 ij	28.03 e-h	8.42 bc
D90627	4.39 ab	17.11 d-f	41.28	299.8 cd	31.17 d-f	6.60 c
D90640	4.45 a-c	16.56 d-g	37.32	205.1 f-i	29.98 d-f	12.90 a-c
D-91773	4.54 ab	15.18 f-j	39.91	111.5 k	37.13 c-e	8.57 bc
Mean	3.24 B	16.53 A	32.74 B	248.54 A	32.47 A	12.84 B

Values followed by the same letter (s) with in a column do not differ significantly by Duncun's Multiple Range Test ($p < 0.05$).

Phosphorus availability and absorption tended to influence the P utilization and ultimate plant biomass. About 50 % differences in P contents in shoot of genotypes grown with deficient P supply could be explained due to differences in root dry matter of the genotypes ($r = 0.69$ **, $P<0.01$). This suggested that greater P uptake was associated with genotypes having large root system. The importance of a larger root system become even greater in soil grown plants, where P supply is more diffusion limited (Jungk *et al*., 1990; Gill *et al*., 2002; Kosar *et al*., 2002). It is interested to note that P contents of shoots at deficient P levels differed significantly. This indicates that wheat genotypes which accumulated more P in their shoots from a deficient growth medium were more tolerant to P deficiency stress. Haynes *et al.* (1991) also observed similar responses. This differential P uptake had close link with differences in P uptake of roots which were mainly associated with differences in root P concentration ($r=0.880$ **, $P<0.01$) in the genotypes given deficient P supply because magnitude of differences in P concentration were much wider compared to differences in their root dry matter. Further more shoot P contents at deficient P level had a significant correlation with SAR. The similar relationship had true in genotypes given with adequate P supply. This observation pointed out that the genotypes with higher P absorption rate per unit root dry matter were relatively more tolerant to P deficiency stress. Schenk and Barber (1979) and Coltman *et al*. (1985) reported that differences between genotypes in P absorption were due to morphological and physiological root characteristics. High SUR in deficient P supply further conferred the root characteristics and functioning of roots to transport P to shoot under stress conditions. The results of this study provide useful information about the genetic differences in wheat with regards to P relation. Among all the genotypes Inqulab-91 showed better uptake and utilization of P.

References

Ahmad, N. Plant nutrition management for sustainable agricultural growth in Pakistan. Proc. of symp. On" Plant Nutrition Management for Sustainable Agricultural Growth", December, 1998, Islamabad, Pakistan. pp: 11-21. 1998.

Blume, A. Plant breeding for stress environment. CRC Press, Inc., Boca Raton, Florida USA. 1988.

Chapman, H.D. and Pratt, P.F. Phosphorus. P.160-170. In "Methods of Analysis for Soil, Plants and Waters". Div. of Agri. Sci., Uni. California, USA. 1961.

Clark, R.B. and Duncun, R.R. Improvement of plant mineral nutrition through breeding. Field crop Res., 1991. 27: 219-246.

Coltman, R.R., Gerloff, G.C. and Gabelman, W.H. Differential tolerance of tomato strains to maintained and deficient levels of phosphorus. J. Am. Soc. Hort. Sci., 1985. 110(12): 140-144.

Gerloff, G.C. Intact plant screening for tolerance of nutrient deficiency stress. Plant Soil, 1987. 99: 3-16.

Gill, M.A., Mansoor, S., Aziz, T., Rahmatullah and Akhtar, M.S. Differential growth response and phosphorus utilization efficiency of rice genotypes. Pakistan J. Agric. Sci., 2002. 39(2): 83-87.

Gill, M.A., Rahmatullah and Saleem, M. Growth responses of twelve wheat cultivars and their P utilization from Rock phosphate. J. Agron. Crop Sci., 1994. 173(3-4): 204-209.

Haynes, B.R., Koide, T. and Elliott, G. Phosphorus uptake and utilization in wild and cultivated oats (*Avena* spp.) J. Plant Nutr., 1991.14: 105-118.

Johnson, C.M., Stout, P.R., Broyer, T.C. and Carlton, A.B. Comparative chlorine requirements of different plant species. Plant Soil, 1957. 8: 327-353.

Jones, Jr. J.B. and Case, V.W. Sampling, handling and analyzing plant tissue samples. P.389-427. In: R. L. Westerman (ed.), Soil testing and plant analysis, 3rd. Soil Sci. Soc. Am., Inc., Madison, Wisconsin, USA. 1990.

Jungk, A., Asher, C.J., Edwards, D.G. and Meyer, D. Influence of phosphate status on phosphate uptake kinetics of maize (*Zea mays* L.) and soybean (*Glycine max*). p. 135-142. In: M. L. V. Beusichem (ed.), Plant nutrition, Physiology and Applications. Kluvar Acadamic Publisher, Inc., New Yark. 1990.

Kosar, H.S., Gill, M.A., Rahmatullah, Aziz, T., Akhtar, M.S. and Imran, M. Solubilization of tri-calcium phosphate by different wheat genotypes. Pakistan J. Agric. Sci., 2002. 39(4): 273-277.

Schenk, M.k. and Barber, S.A. Root characteristics of corn genotypes as related to P uptake. Agron. J., 1979. 7: 921-924.

Stee, R.G.D. and Torrie, J.H. Principles and Procedures of Satistics. McGraw Hill Book Co. New York, USA. 1980.

Yaseen, M., Gill, M.A., Siddique, M., Ahmad, Z., Mahmood, T. and Hamud-ur-Rehman. Phosphorus deficiency stress tolerance and phosphorus utilization efficiency in wheat genotypes. Proc. Symp. Plant Nutrition Management for Sustainable Agricultural Growth. NFDC. Islamabad pp: 211-215.1998.

Yaseen, M., Sohail, M., and Saif- ur- Rehman Kashif. Phosphorus use efficiency in wheat genotypes: I. Plant growth. Pakistan J. life Soc. Sci., 2003. 1(1): 75-77.