The Agriculturists 8(2): 108-116 (2010) ISSN-1729-5211
A Scientific Journal of Krishi Foundation

Evaluation of Chickpea (*Cicer arietinum* L.) Genotypes for Quality Seedlings

Shahrina Akhtar[1], Jalal Uddin Ahmed[1], Abdul Hamid[2] and M Rafiqul Islam[2*]

[1]Department of Crop Botany, [2]Department of Agronomy,
Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh

**Corresponding author and Email*: *rafiarib@yahoo.com*

Received: 16 November 2010 Accepted: 17 March 2011

Abstract

A study was conducted to evaluate 100 chickpea genotypes to explore their genetic diversity in respect of emergence and growth attributes. A high genotypic variation was observed in the characters studied. The highest positive correlation corresponded to the root mass and total plant biomass of the seedlings. Seedling biomass production was highly subjective to seedling vigor. Using discriminant function analysis, the first two functions contributed 46.2 and 39.0%, and altogether 85.2% of the variability among the genotypes. Function 1 was positively related to dry weight of root and total plants. The character with the greatest weight on function 2 was seedling emergence rate. The total dry weight of seedlings played the most dominant role in explaining the maximum variance in the genotypes. The genotypes were grouped into six clusters. Each cluster had specific seedling characteristics and the clusters 5 and 6 were closely related and clearly separated from clusters 1 and 4 for their higher amount of root and total biomass production, and vigorous seedlings, where as, the genotypes in cluster 2 and 3 were intermediate. The genotypes in cluster 5 followed by cluster 6 appeared to be important resources for selecting and developing chickpea variety.

***Keywords*:** Chickpea, genotypes, seedling, quality

1. Introduction

Chickpea is an important pulse crop giving high economic returns to the farmers of Bangladesh (Yusuf Ali *et al*., 2007). It appears to have the greatest yield potential giving 2000 kg $ha^{-1,}$ which is probably the most unstable, and farmers of Bangladesh could hardly realize such a high yield potential (Musa *et al*., 2001). Chickpea is generally grown on residual soil moisture after the harvest of rainfed aman rice and has the high potential for improving the livelihoods of poor farmers in the High Barind Tract (HBT) areas of Bangladesh (Socioconsult, 2006). The area of HGT comprises about 220000 ha which usually remains fallow after the harvest of aman rice, primarily because of the lack of irrigation facilities. Under such a situation, efficient utilization of residual soil moisture by the plant roots is considered to be the practical way of sustainable crop production (Kumar and van Rheenen, 2000). The vigorous seedlings of chickpea have been reported to have the ability to utilize soil moisture more efficiently (Jain *et al*., 1998).

A common reason for failure to obtain satisfactory stands of many legumes is the inability of the seedling plants to become established quickly under unfavorable environmental conditions including drought, and other abiotic stresses (Sleper and Poehlman, 2006). Therefore, proper seedling emergence and early seedling growth are considered critical for raising crops successfully as they indirectly determine the density of crop stands and consequently the yield of crops (Andric *et al*., 2007; Roberts and Osci-Bonsu, 1988). Chickpea is a low risk crop in the rainfed farming environment due to its strong rooting characteristics (Gaur *et al*., 2008). The genotypes having deeper rooting system, greater root length density and root distribution have been reported to be more resistant to moisture deficit (Taiz and Zeiger, 2006). Chickpea cultivar Barichola 5 has been successfully tested in the HBT, where biotic and abiotic constraints were minimal (Uddin *et al*., 2005). However, farmers still have difficulty in finding improved chickpea varieties for the region (Saha, 2002). Identification and development of chickpea genotypes with greater seedling vigor and associated growth characteristics would increase the ability of the seedlings to cope up with the adverse growth conditions. Therefore, identification of appropriate varieties with adequate seedling vigor and other associated characters is essential for alleviating the constraints to wider adoption of chickpea particularly in the HBT of Bangladesh. In this regard, the study was conducted to explore the genetic diversity in seedling quality of 100 chickpea genotypes of diverse growth habits.

2. Materials and Methods

The study was conducted at the Research Farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur under semi controlled environment. One hundred genotypes of chickpea formed the treatment variables. Out of 100 genotypes, 39 originated in India, 23 in Iran, 6 in Afghanistan, 5 in Ethiopia, 4 in Turkey, 3 in Mexico, and the remaining 20 in 18 different other countries. Ten seedlings of each genotype were raised in trays inside a vinyl house with three replications. Seedlings started to emerge mostly 3 days after seeding (DAS). Weeding was done three times during the experimentation to keep the seedlings weed free. Irrigation was applied at every alternate day to maintain optimum soil moisture content during growing of seedlings. Seedling emergence was counted daily and it continued up to 14 DAS, when emergence was almost completed. Seedling emergence rate was calculated as the ratio of the number of normal seedlings emerged to the total number of seeds sown. Shoot and root lengths were measured from selected 5 plants of each replicated tray. These plants were then oven dried for 72 hours at 70^0C to measure the root and shoot dry weight (DW). Total DW of seedlings was calculated by summing root and shoot DW. Seedling vigor was calculated after Copeland (1988).

Descriptive analysis including range and mean of seven plant characters with frequency distribution was employed to describe the performance of the genotypes in terms of each character. Quantitative variables considered in the descriptive and discriminant function analysis (DFA) were, seedling mergence rate, seedling vigor, shoot and root length, shoot and root DW, and total DW. Analysis of genetic variation of the seedlings of 100 genotypes was performed with the program SPSS version 11 following the procedure described by Rojas *et al.* (2000). Estimation of the degree of correlation was estimated among the different plant characters according to Pearson’s co-efficient (Clifford and Stephenson, 1975). Hierarchical clustering was performed to classify the genotypes into a number of groups.

3. Results and Discussion

3.1. Variability in quantitative characters

A wide range of variation was found in all the seedling characters (Fig. 1a-f). The frequency distribution of seedling emergence showed non-normal distribution which was highly skewed towards right indicating that most of the genotypes were more than median. Out of 100, 80 genotypes showed seedling emergence of more than 90%. Vigor index showed comparatively a narrower range following non-normal distribution which was skewed towards right. This indicates that the majority of the genotypes had seedling vigor more than median. Eight genotypes had vigor index more than 24 and the maximum genotypes had in a range between 22 and 23.

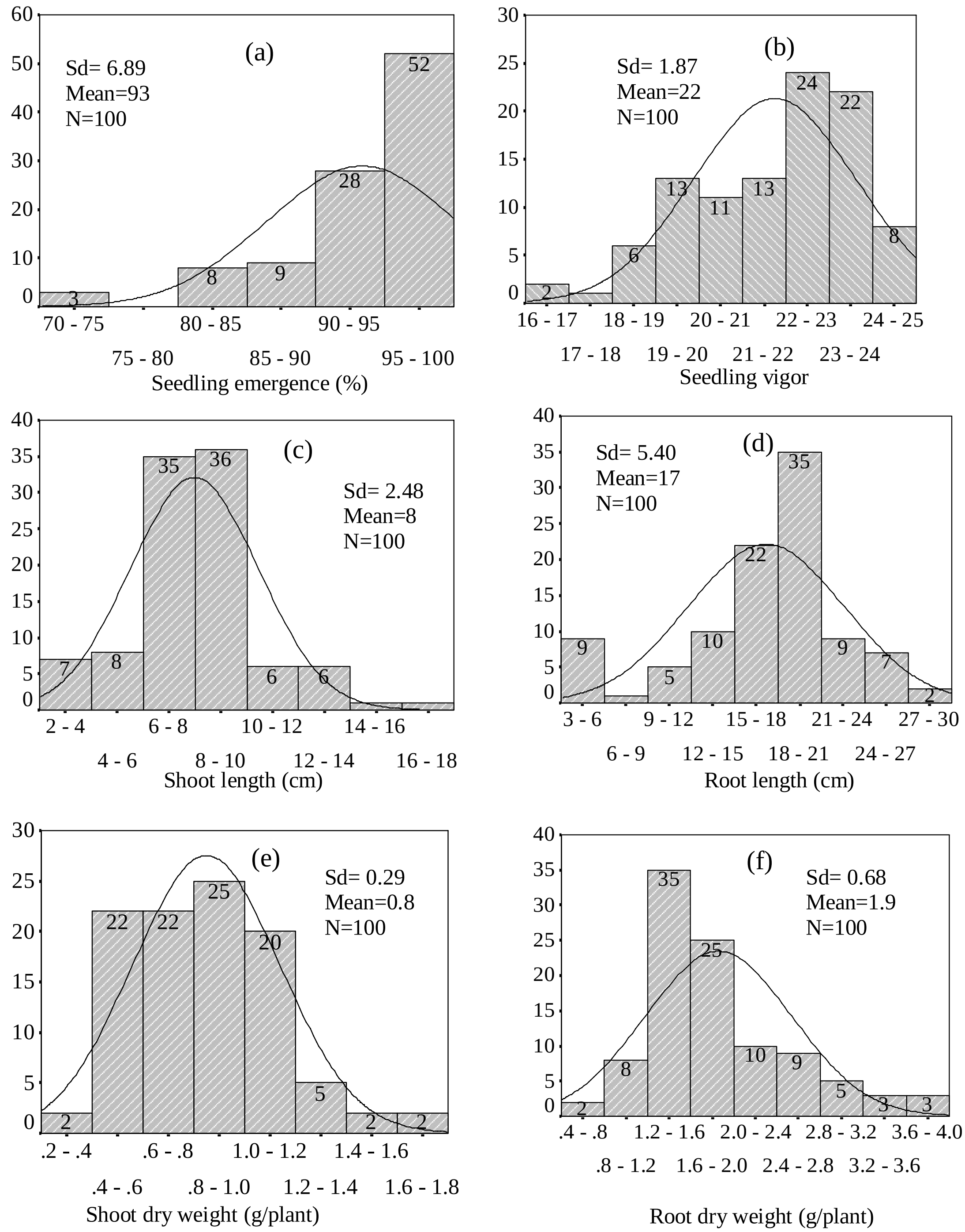

Fig. 1. Frequency distribution of (a) % seeding emergence (b) Seedling vigor (c) shoot length (d) root length (e) shoot dry weight and (f) root dry weight of 100 chickpea genotypes.

The frequency distribution of shoot length followed non-normal distribution and most of the genotypes (71%) showed shoot length in a range between 6 and 10 cm. The genotypes differed in root length and showed nearly a normal distribution, and 57 genotypes exhibited root length ranging from 15 to 21 cm. However, 2 genotypes showed root length of more than 27 cm. There was much variation in biomass production of the seedlings. A distinct variability was observed in shoot DW of the genotypes that exhibited nearly a normal distribution slightly skewed towards the left. The frequency distribution of root DW showed non-normal distribution. Thirty-five genotypes showed root DW ranged from 12 to 16 g plant^{-1} and 30 genotypes ranged from 20 to 40 g plant^{-1}. It was also observed that the frequency distribution of the total DW followed nearly a normal distribution.

3.2. Correlations between seedling characters

The correlation coefficient between the seedling emergence and growth characteristics of seedlings showed that out of 21 coefficients, 7 were highly significant at $p \leq 0.01$. (Table 1). Among all the characters, the highest positive correlation corresponded to root DW and total DW of the seedlings (r=0.96). The root DW had also strong relationship with shoot DW (r=0.53). These indicated that root played the major role in total biomass production of chickpea seedlings. Serraj *et al*. (2004) also observed a linear relationship between root DW and shoot DW in 257 recombinant inbred lines of chickpea at 35 days after sowing. Among the seedling characters, positive significantly correlation corresponded to seedling vigor and total DW (r=0.42). This character also presented a significant correlation with shoot and root DW. Sabaghpour *et al*. (2003) reported that seedling vigor played an important role in the seedling growth and establishment of crops. The relationships among seedling quality revealed that seedling emergence is independent of seedling vigor but biomass production of seedling is highly influenced by seedling vigor. In this study, seedling vigor had no significant role in increasing biomass production of seedlings by increasing shoot and root length, although there was a positive correlation (r=55) between them.

3.3. Variability in the genotypes

The five discriminant functions that differentiated among clusters of 100 chickpea genotypes were obtained by the stepwise procedure. Table 2 summarizes the contribution of each of 5 canonical discriminant functions for explaining the variance along with their Eigenvalues and canonical correlation coefficient. Function 1 alone explained 46.2% and function 2 explained 39.0% of total variance. Hence, the function 1 and function 2 accounted for a cumulative of 85.2% of total variance.

Table 1. Correlation coefficient among six seedling characters of 100 chickpea genotype

Plant characters	Percent seedling emergence	Seedling vigor	Shoot length (cm)	Root length (cm)	Shoot DW (g plant^{-1})	Root DW (g plant^{-1})	Total DW (g plant^{-1})
Seedling emergence (%)	1.00	0.10	-0.14	-0.12	-0.19	-0.17	-0.19
Seedling vigor		1.00	0.06	-0.02	0.32**	0.39**	0.42**
Shoot length (cm)			1.00	0.55**	0.14	0.05	0.09
Root length (cm)				1.00	-0.02	-0.15	-0.12
Shoot DW (g plant^{-1})					1.00	0.53**	0.75**
Root DW (g plant^{-1})						1.00	0.96**
Total DW (g plant^{-1})							1.00

**Correlation is significant at 0.01 level (2-tailed)

Table 2. Discriminant functions that distinguish between clusters of 100 chickpea genotype

Function	Latent root	Variance (%)	
		Function	Cumulative
1	3.25	46.2	46.2
2	2.74	39.0	85.2
3	0.79	11.2	96.4
4	0.17	2.5	98.9
5	0.08	1.1	100.00

Table 3. Coefficients of the seedling characteristics mostly contributed in grouping 100 chickpea accession

Discriminating variables	Discriminant Functions	
	1	2
Seedling emergence (%)	0.510	-0.660
Total DW (g plant^{-1})	-0.493	0.051
Root DW (g plant^{-1})	-0.333	0.070
Root length (cm)	0.427	0.558
Shoot length (cm)	0.241	0.493
Seedling vigor	-0.294	-0.346

All discriminatory functions except function 5 were statistically significant ($P \leq 0.01$) according to chi-square test.

Table 3 summarizes the variables which mostly contributed to the discriminatory functions along with their coefficient under each function. The coefficients of total DW and root DW were higher in function 1 than in function 2. It meant that these two characters of seedlings mostly explained 46.2% of total variance observed in function 1. On the other hand, the coefficients of seedling emergence, shoot length and root length were higher in function 2 indicating that contribution of these variables to function 2 was higher in explaining 39.0% of total variance. The almost similar negative values of vigor index in function 1 and function 2 indicated that this variable was equally important in explaining the total variance in function 1 and function 2. Jomova *et al*. (2005) evaluated 20 morphological and agronomical traits in a set of chickpea genotypes and found greater variations between accessions in seedling and growth characteristics in the vegetative period.

Table 4 describes the coefficient of correlation between 7 discriminatory variables and 2 discriminatory functions. From the results, it was observed that total DW of seedlings was placed at the top of the list of the discriminatory variables with correlation coefficient of –0.679 under function 1. It indicated that total DW of seedlings played the most dominant role out of 7 variables in explaining the maximum variance in 100 genotypes by stepwise DFA. Percent seedling emergence and root length played the secondary important role in defining the variability of the genotypes.

3.4. Grouping of the genotypes

A hierarchical cluster analysis was done using 7 quantitative plant characters to identify the desirable traits and grouping the 100 chickpea genotypes through preparing a dendogram on the basis of cluster analysis. The tree was cut at the rescaled distance of 7.5 to produce classes that are maximally related to other specific variables of interest and to serve the purpose better. The genotypes were, therefore, groped into six clusters. Total number of genotypes and mean values of seedling quality for each of 6 clusters are presented in Table 5. The genotypes under each cluster were highly similar. The maximum number of genotype (64) was concentrated in cluster 1 followed by cluster 4 (12), 3(11), 2(9), 5(2), 6(2).

Table 4. Correlations between 7 discriminating variables related to seedling characteristic

Discriminating variables	Discriminant Functions	
	1	2
Total DW (g plant^{-1})	-0.679*	0.092
% Seedling emergence	0.378	-0.622*
Root length (cm)	0.341	0.557*
Root DW (g plant^{-1})	-0.694	0.065
Shoot DW (g plant^{-1})	-0.335	0.094
Vigor index	-0.214	-0.119
Shoot length (cm)	0.138	0.462

Variables ordered by absolute size of correlation within function
*Largest absolute correlation between each variable and any discriminant function

Table 5. Average values of seven quantitative seedling characters for each of the six groups identified in 100 chickpea genotypes. The amount of accessions included in each group is given in brackets

Variables	Group1 (n=64)	Group2 (n=9)	Group3 (n=11)	Group4 (n=12)	Group5 (n=2)	Group6 (n=2)
Seedling emergence (%)	96.27	94.89	91.55	80.58	78.00	95.00
Seedling vigor	21.45	22.85	22.95	20.57	24.30	23.77
Shoot length (cm)	8.06	3.72	10.00	9.58	7.57	4.25
Root length (cm)	18.39	5.66	18.60	19.39	21.02	5.08
Shoot DW (g plant^{-1})	0.75	1.04	1.16	0.89	1.48	0.72
Root DW (g plant^{-1})	1.56	2.04	2.90	1.75	3.51	3.70
Total DW (g plant^{-1})	2.31	3.08	4.06	2.64	4.99	4.41

The genotypes in cluster 1 were characterized with the highest seedling emergence and the lowest root DW and total DW with minimal shoot weight. Cluster 2 was mainly characterized by the genotypes with the lowest shoot length with minimal root length. The genotypes in cluster 3 were characterized with the highest shoot length having substantial amount of shoot, root and total DW with good germination and vigor. Cluster 4 genotypes were mainly characterized by the lowest seedling vigor. The genotypes produced low amount of root, shoot and total plant dry matter with lower seedling emergence. The genotypes in cluster 5 were characterized by the highest seedling vigor, root length, shoot DW and total DW. The genotypes in cluster 6 produced the highest amount of root DW which might have contribution in producing higher total dry matter of the genotypes. The clustering pattern of the genotypes revealed that cluster 5 and 6- genotypes produced almost similar amounts of total dry matter which was much higher compared to the genotypes grouped into other clusters. The genotypes were separated into two clusters because of high variability in seedling emergence, which was found much better in group 6- genotypes. Although, seedling emergence of cluster 5- genotypes was lower, production of vigorous seedlings of the genotypes might have given higher total dry matter. Similarly, the performance of genotypes in cluster 1 and 4 was poor and almost similar with respect to lower total dry matter production. However, they were separated because of higher seedling emergence of cluster 1 genotypes. The genotypes in cluster 2 and 3 were intermediate and produced substantial amount of total dry matter. They produced distinct group as a result of lower shoot and root length of the group 2 genotypes.

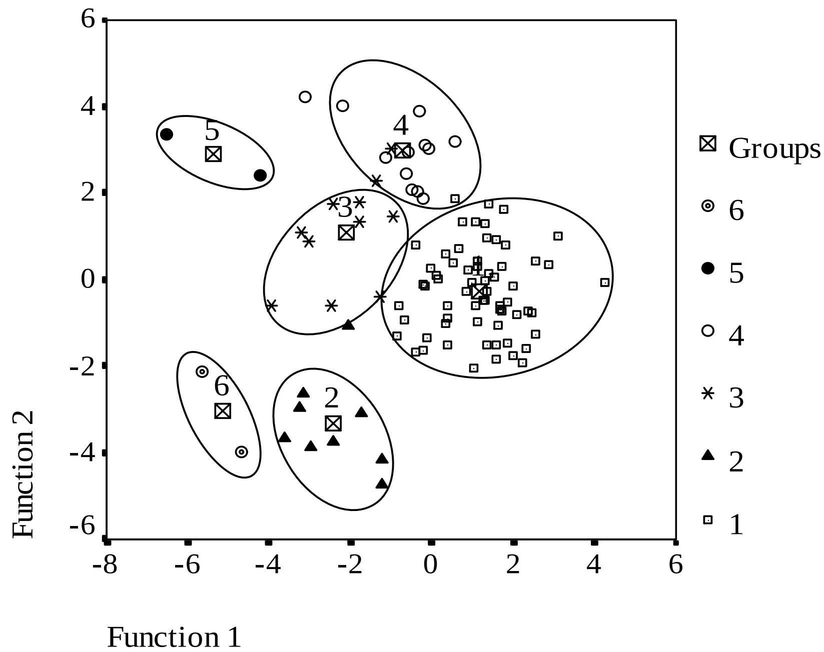

Fig. 2. Discriminant function analysis ordination of 100 chickpea genotypes. The encircled accessions indicate the groups (clusters) obtain through cluster analysis.

Figure 2 shows graphically how the genotypes were classified into six groups according to the first two discriminatory functions. The genotypes which were found scattered on the right side of the diagram produced lower total dry matter and that at the left side produced higher total dry matter based on X ordinate. Therefore, function 1 separated group 5 and 6 very clearly from group 1 and 4 based on total dry matter production. Group 5 and 6 genotypes produced much higher total dry matter resulting from greater vigor index of the seedlings. On the other hand, the genotypes (cluster 4 and 5) scattered on the upper part of the diagram had lower seedling emergence than that of lower part based on Y ordinate. Therefore, function 2 separated groups 2, 6 and 1 from group 4 and 5 based on seedling emergence percentage. Group 2 and 6 had higher seedling emergence. Cluster 3 was intermediate in seedling emergence percentage. The genotypes in response of discriminating variables very close to the group centeroid might be considered as the most representative of that group. Accordingly, the genotype ICC3325 in group 1, the genotype ICC13187 in group 2, the genotype ICC5337 in group 3, the genotype ICC6306 in group 4, the genotype ICC10755 in group 5, and the genotype ICC13461 in group 6, might be considered as more representative of their respective groups.

4. Conclusions

The study revealed the existence of variation in the seedling quality of 100 chickpea genotypes. A greater variation was found in the production of total plant dry matter which is eventually related to root dry matter and seedling vigor. In this study, the multivariate analysis has been effectively used in separating the chickpea genotypes with desirable seedling traits. Thus, the obtained promising genotypes grouped in cluster 5 followed by cluster 6 need further evaluation under variable field conditions associated with various abiotic stresses.

5. Acknowledgement

The authors thank of staff of Gene Bank, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) for supplying the seeds of chickpea germplasm for this study.

References

Andric, L., Teklic, T., Vrataric, M., Sudaric, A. and Duvnjak, V. 2007. Soybean seed vigour and field emergence under influence of cultivar, seed age and planting date. *Cereal Research Communications*, 35: 177-180.

Clifford, H. T. and Stephenson, W. 1975. An Introduction to Numerical Classification. New York: Academic Press, USA, 229 pp

Copeland, L. O. 1988. Principles of Seed Science and Technology. Burgress Publishing Company, India, 165-191 pp

Gaur, P. M., Krishnamurthy, L. and Kashiwagi, J. 2008. Improving drought-avoidance root traits in chickpea (*Cicer arietinum* L.)-current status of research at ICRISAT. *Plant Production Science*, 11: 3-11.

Jain, P. K., Ramgiry, S. K. and Singh, C. B. 1998. Genotype and environmental interaction of seedling character in chickpea. *Crop Research*, 16: 321-324.

Jomova, K. Benkova, M., Zakova, M., Gregova, E. and Kraic, J. 2005. Clustering of chickpea (*Cicer arietinum* L.) accessions. *Genetic Resources and Crop Evolution*, 52: 1039-1048.

Kumar, J. and van Rheenen, H. A. 2000. A major gene for time of flowering in chickpea. *Journal of Heredity*, 91: 67-68.

Musa, A. M., Harris, D., Johansen, C. and Kumar J. 2001. Short duration chickpea to replace fallow after aman rice: the role of on-farm seed priming in the High Barind Tract of Bangladesh. *Experimental Agriculture*, 37: 509-521.

Roberts, E. H. and Osci-Bonsu, K. 1988. Seed and seedling vigor. In: *World Crop Cool Season Legumes* (ed.). R. J. Summerfield, Kluwer Academic, Dordrecht, The Netherlands, 619-625 pp.

Rojas, W., Barriga, P. and Figueroa, H. 2000. Multivariate analysis of the genetic diversity of Bolivian quinua germplasm. Plant Genetic Resources Newsletter, 122: 16-23.

Sabaghpour, S. H., Kumar, J. and Rao, T. N. 2003. Inheritance of growth vigour and its association with other characters in chiackpea. *Plant Breeding*, 122: 542-544.

Saha A. K. 2002. Impact assessment study for the DFID-funded project R7540 Promotion of Chickpea following Rainfed Rice in the Barind Area of Bangladesh. Bangor (UK): CAZS Natural Resources, University of Wales.

Serraj, R., Krishnamurthy, L., Kashiwagi, J., Kumar, J., Chandra, S. and Crouch, J. H. 2004. Variation in root traits of chickpea (Cicer arietinum L.) grown under terminal drought. Field Crops Research, 88: 115-127.

Sleper, D. A. and Poehlman, J. M. 2006. Breeding field crops, 5^{th} edn., Blackwell publishing, Ames, Lown, USA. 10-424 pp.

Socioconsult. 2006. Report on impact assessment study of chickpea in the High Barind Tract (HBT). *Socioconsult Ltd*., SEL Centre, 29 West Panthapath, Dhanmondi, Dhaka.

Tiaz, L. and Zeiger, E. 2006. Stress Physiology. In: *Plant Physiology*, (eds.) L. Tiaz, and E. Zeiger, Sinauer Associates Inc., Sunderland, M. A, 671-681 pp.

Uddin, M. J., Ali, M. O. and Rahman, M. M. 2005. Prospects of chickpea in rice-based cropping systems in Bangladesh. In: *Policy and strategy for increasing income and food security through improved crop management of chickpea in rice fallows in Asia*, (eds), S. Pande, P. C. Stevenson, R. K. Neupane and D. Grzywacz, Summary of a NARC-ICRISAT-NRI Workshop, 17-18 November 2004, Kathmandu, Nepal, 35-46 pp.

Yusuf Ali, M., Ahmed, S., Johansen, C., Harris, D. and Kumar Rao, J. V. D. K. 2007. Root traits of different crops under rainfed conditions in the High Barind Tract of Bangladesh. *Journal of Plant Nutrition and Soil Science*, 170: 296-302.