J. Sher-e-Bangla Agric. Univ., 9(2): 29-35, July 2018 ISSN 1997-6038

RESPONSE OF RICE GENOTYPES IN ROOT RELATED TRAITS UNDER WATER DEFICIT CONDITIONS

H. S. Jasmine[1] and K. U. Ahamed[2]

ABSTRACT

The experiment was conducted for varietals screening of root related traits in ten rice genotypes collected from BRRI (BR21, BR24, BRRI dhan42, BRRI dhan43, BRRI dhan48, BRRI dhan55, BR6976-11-1, OM1490, BR6976-2B-15) with two water stress tolerant genotypes Hashikalmi and Dharial used as check. The experiment was carried out at the field of Agricultural Botany in the rain protected polyethylene shed house to avoid rain under natural conditions in root elongation perforated polyethylene tubes which was 70 cm in length. At the beginning the rice seedlings were normally irrigated up to fourteen days for ensuring normal growth. From fifteen days onwards water stress was imposed till thirty days and data were recorded using 30-days old seedlings. The maximum length of root was found in BRRI dhan55 (22 cm), Hashikalmi (22 cm). Genotypes BR21, BR24, BRRI dhan43, BR 6976-11-1 produced shortest roots than the water stress tolerant genotypes, BRRI dhan55, Hashikalmi and Dharial. Under water stress conditions, the root shoot ratio was higher in tolerant genotypes and was lower in genotypes BR21, BR24, BRRI dhan43, BR 6976-11-1. The decreased root shoot ratio indicated that root dry matter rather than shoot dry matter was more affected due to water deficit condition. Our findings suggest that deep root, small shoot and higher root-shoot ratio are the characteristics of water stress tolerant genotypes.

Keywords: Water deficit, cumulative root length, Genotypes, rooting ability.

INTRODUCTION

Water deficit is a major problem of growing rice as it affects directly the growth and development of rice, especially in low rainfall season (Usman *et al.*, 2013). According to the IRRI (2005), water deficit is one of the major constraints for rice (*Oryza sativa* L.) cultivation and production. Rice is more susceptible to drought than any other crops. World wide drought stress is responsible for reducing crop productivity and yield. It is estimated that the world needs to produce 40% more rice to feed the population by 2025 (FAO, 2002). It is expected that if the occurrence of water stress increases like present yield loss will be 30% higher by the year 2025.

Water deficit is one of the one of the severe stresses of Bangladeshi farmers. In agriculture, mild to severe drought has been one of the major production limiting factors. When water deficit occurs, the most effective resistance mechanism available to the rice plant is a deep root system consisting of mostly thick roots that enables the plant to avoid the adverse effects of internal water deficit (Chang, 1972). Soil water is one of the most important factors limiting crop production all over the world, where irrigation is practiced or rainfed crops are grown (Carter, 1989). Drought tolerant genotypes posses deep root, short height of shoot and high root-shoot ratio under water deficit conditions. The importance of root systems in acquiring water has long been recognized. Root size, structure, morphology, depth, length, density and branching or distributions in soil horizons are important in maintaining high leaf water potential against evapotranspiration demand under water deficit (Passioura 1982). Sikuku *et al.* (2010) reported drought tolerant cultivars have deep and thick roots. Wullschleger *et al.* (2005) advocated that the root dry weight was decreased under mild and severe water stress. Mild water stress affected the shoot dry weight, while shoot dry weight was greater than root dry weight loss under severe stress (Mohammadian *et al.*, 2005). An increased root growth due to water stress was reported in sunflower (Tahir *et al.*, 2002) and *Catharanthus roseus* (Jaleel *et al.*, 2008a). The shallower root distribution in the field was thought to be due to genetic predetermination, lack of oxygen, or the

[1]Senior Scientific Officer(Senior Scale), SAURES, [2] Professor, Dept. of Agricultural Botany, SAU, Dhaka

presence of a hardpan (Puckridge and O'Toole, 1981). Asch *et al.* (2005) advocated that drought is a major stress affecting rainfed rice systems. Root characteristics such as root length density, root thickness and rooting depth and distribution have been established as constituting factors of drought resistance.

In Bangladesh, usually a little rain occurs during January to March. The season is characterized by early drought even after the seedling establishment. Under long term water stress, plants might permanently wilt or stop growing and eventually die. Severe water stress may result in the arrest of photosynthesis, disturbance of metabolism and finally the death of plant (Jaleel *et al.*, 2008c). Hence, there is an urgent need to increase rice production to meet global demand. Also water stress management strategies need to be taken for better yield and improved varieties that are more resilient to abiotic stresses. Considering the above mentioned facts the present research work was undertaken to study the response of roots of rice genotypes under water stress conditions.

MATERIALS AND METHODS

The experiment was conducted at the Agricultural Botany research field of Sher-e-Bangla Agricultural University, Dhaka -1207. A total of eleven plant materials as BR dhan21, BR dhan24, BRRI dhan42, BRRI dhan43, BRRI dhan48, BRRI dhan55 and lines BR6976-11-1, OM1490, BR6976-2B-15 and two water stress tolerant varieties Hashikalmi, Dharial collected from Genetic Resource and Seed Division, Bangladesh Rice Research Institute.

Seed treatment

Seeds of uniform size and shape of each genotype were treated with Bavistin 5gm for 20 minutes. The solution was prepared by dissolving 5 gm of Bavistin in 1/2 liter of water. Treated seeds were place in the Petridis with water. Pre-soaked six sprouted seeds were grown under rain protected polyethylene shelter under natural light conditions in root elongation tube on September 19, 2012 (Plate 1.1).

Design of the experiment and Preparation of root elongation tube

The experiment was laid out in Randomized Complete Block Design (RCBD) considering four replications. The total number of root elongation tubes was 44. Root elongation tube was 75 cm long and 15 cm in diameter. Perforated polyethylene tubes were filled up with sand (60): soil (40) mixture. Whole soil was mixed with Yoshida nutrient solution (Yoshida *et al.* 1975) so that the soil became wet but not like wet clay (BRRI, 2006). Yoshida's nutrient solution was used as feed of plant.

Preparation of Yoshida's culture solution

Yoshida's culture solution was prepared from the stock solution based on the formula of Yoshida *et al.*, (1975). This solution contains macro and micro elements of plant. Macro elements were NaH_2PO_4 (80.60 g), NH_4NO_3 (182.8g), K_2SO_4 (142.8g), $MgSO_4$ (648g), $CaCl_2$ (177.2g) and micro elements were Mn (3.00 g), Mo (0.148 g), B (1.868 g), Zn (0.070 g), Cu (0.062 g), Fe (15.40 g) with 100 ml H_2SO_4 Yoshida solution mixed with soil and sand. Optimum soil moisture conditions were maintained for the seedling establishment.

Imposing water deficit

The seedlings were normally irrigated up to fourteen days of seedlings for ensuring normal growth. After fourteen days water stress was impose. Water deficit was imposed on 15-30 days old seedlings and data were recorded using 30-days old seedlings. Water deficit treatment was imposed by applying Yoshida's culture solution at the rate of 5 ml per tube (BRRI, 2006).

Collection of seedlings for data recording

Data were recorded using 30-day old seedlings. All of the seedlings of 30 days old were collected (Plate 1.2) and data were recorded. Roots and shoots were separated (joint point of root and shoot) with the help of a sharp knife.

Detailed procedures of recording data

Cumulative root length (root expansion in each 10 cm depth)

After harvest (30 days old seedling) root elongation tube (70 cm) were cut out into seven pieces (each of 10 cm) (Plate 1.3). Then the roots were washed and carefully separated with a strainer and separately collected in seven plastic pots. Cumulative root length (root expansion at 10-70 cm depth of soil) was measured by total number of root which was expanded in every 10 cm depth of root elongation tube out of 70 cm (BRRI, 2006).

Root dry weight

After oven dry for 72 hours at 72^{0}C in each sample (10-70) cm depth of total root, root dry weighed (g) was counted by using digital electronic balance of different rice genotypes.

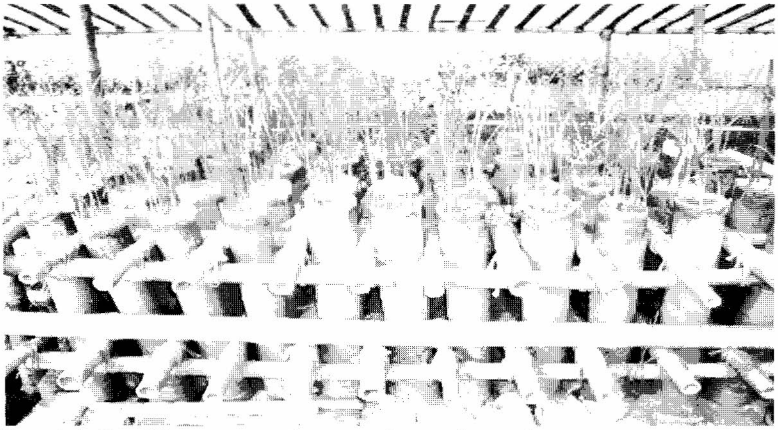

Plate 1.1. Seedlings grown in root elongation tube

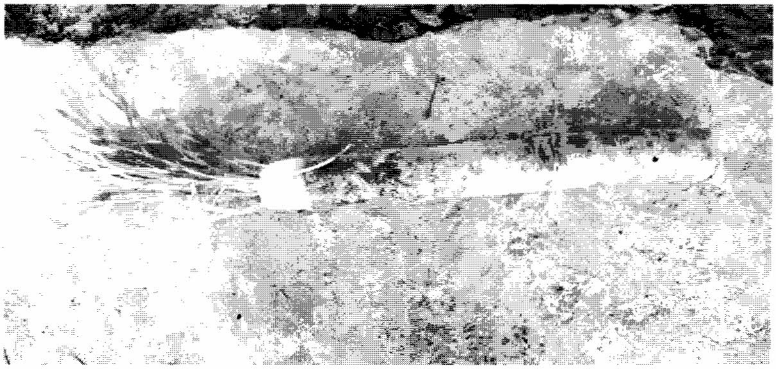

Plate 1.2. Seedlings in root elongation tube (70 cm) for data collection

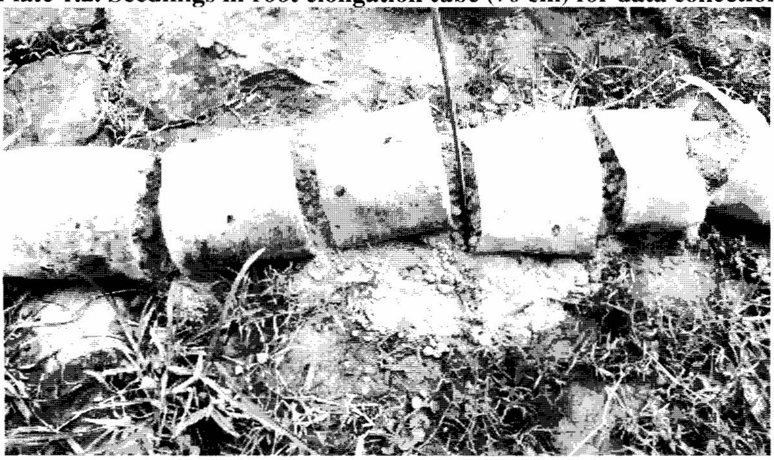

Plate 1.3 Root elongation tube (70 cm) cut into 7 pieces (10 cm/ piece)

Root-shoot ratio

The root shoot ratio (rooting ability) was measured from root dry weight and shoot dry weight.

$$\text{Root shoot ratio} = \frac{\text{Root dry weight}}{\text{Shoot dry weight}}$$

Statistical analysis

The data were statistically analyzed following MSTAT-C software package and the mean differences were adjusted by Duncan's Multiple Range Test (DMRT) at 5% level of significance, Gomez and Gomez, (1984).

RESULTS AND DISCUSSION

Cumulative root length (CRL)

Root length of different rice genotypes under water stress conditions up to 70 cm depth have been shown in the Fig. 1. At first 1-10 cm depth the highest CRL found was 993.3 cm in BRRI dhan55 and the lowest CRL was 679.7 cm in BR21. At 11-20 cm depth the highest CR L was 629.3 cm in BRRI dhan55 and the lowest CRL found was 138.1 cm in BR21. At 21-30 cm depth the highest CRL was 276 cm in BRRI dhan55 and the lowest CRL found were 139.8 cm in BRRI dhan43. At 31-40 cm depth the highest CRL found was 183 cm in BRRI dhan55 and the lowest CRL found was 115.9 cm in BR6976-11-1. At 41-50 cm depth the highest found was 119 cm in Hashikalmi and the lowest CRL was 62.67 cm in BR 6976-2B-15. At 51-60 cm depth the highest (CRL) was 68.37cm in BRRI dhan55 and the lowest CRL found was 15.30 cm in BR 6976-11-1. At 61-70 cm depth the highest CRL found was 22 cm in BRRI dhan55, Hashikalmi and the lowest CRL found was 6 cm in BR 6976-11-1. In this study it was observed that in 10- 30 cm depth root length was less affected of eleven rice genotypes under water deficit conditions.

In this study, root length was found the highest in BRRI dhan55 and Hashikalmi. The root length decreased in BR21, BR24, BRRI dhan43, BR 6976-11-1 compared to the water stress tolerant genotypes Hashikalmi, BRRI dhan55 and Dharial. These results have got the conformity with the results of Usman *et al.* (2013) who stated that the root length of upland rice varieties exhibited significant reduction at highest water stress level as compared to control. Henry *et al* (2011) stated that genetic variation for deep root growth in drought-stressed rice was observed. Drought tolerant genotypes posses deep root, short height of shoot and high root-shoot ratio under water deficit conditions. Sikuku *et al.* (2010), reported drought tolerant cultivars have deep and thick roots. Asch *et al.* (2005) advocated that drought is a major stress affecting rainfed rice systems. Root characteristics such as root length density, root thickness and rooting depth and distribution have been established as constituting factors of drought resistance. When water deficit occurs, the most effective resistance mechanism available to the rice plant is a deep root system consisting of mostly thick roots that enables the plant to avoid the adverse effects of internal water deficit (Chang, 1972). Root uptake from the lower layers where water is expected to be available, this would help to maintain a good plant water potential which has a demonstrated positive effect on yield under stress reported by Mumbani and Lal (1983).

Root dry weight

Root dry weight (g) of different rice genotypes under drought conditions has been shown (Fig. 2). At 1-10 cm depth the highest root dry weight was 1.75 g in BRRI Dhan55 and the lowest root dry weight was 1.26 g in BR21. At 11-20 cm depth the highest root dry weight was 0.77g in BRRI Dhan55 and the lowest root dry weight was 0.45 g in BRRI Dhan42. At 21-30 cm depth the highest root dry weight was 0.30 g in BRRI Dhan55 and Hashikalmi and the lowest root dry weight was 0.23 g in BR21. At 31-40 cm depth the highest root dry weight was 0.09 g in BRRI Dhan55 and the lowest root dry weight was 0.12 g in BR24 and BR6976-2B-15. At 41-50 cm depth the highest root dry weight was 0.09 g in BRRI Dhan55, Hashikalmi and the lowest root dry weight was 0.05 g in BR6976-2B-15 and BR6976-11-1.

At 51-60 cm depth 0.07g in BRRI dhan55 and Hashikalmi and the lowest root dry weight was 0.04g in BR6976-2B-15 and BR6976-11-1. At 61-70 cm depth the highest root dry weight was 0.05 g in BRRI Dhan55and Hashikalmi and the lowest root dry weight was 0.02 g in BR6976-2B-15 and BR6976-11-1.

In this study, tolerant genotypes BRRI Dhan55 and Hashikalmi have been shown the highest root dry matter at 1 to 70 cm depth of soil and the lowest root dry weight was 0.02g in BR6976-2B-15 and BR6976-11-1. The results have the infirmity with the results of Lum (2014) who reported that eight local upland rice (*Oryza sativa* L.) varieties that were drought affected, Kusam (drought-sensitive variety) was markedly affected than the drought tolerant varieties in the activities of root dry matter. The root dry weight was decreased under mild and severe water stress in *Populus* species (Wullschleger *et al.*, 2005). Asch *et al.* (2005) advocated that rice reacted to drought stress with reductions biomass production, changes in root dry matter and rooting depth. Deep rooting cultivars are more resistant to drought, changes in root dry matter and rooting depth. Asch *et al.* (2005) stated that drought effect assimilate accumulation between root and shoot.

Root shoot ratio

Root shoot ratio of different rice genotypes under drought conditions has been shown (Fig. 3). Significant differences were found among the genotypes for Root shoot ratio. The highest Root shoot ratio found was 0.07 in BRRI dhan55 and Hashikalmi and the lowest Root shoot ratio was found 0.04 in BR21 and BR 6976-2B-15.In this study, water stress tolerant genotypes showed higher root shoot ratio compared to susceptible genotypes. Here, the highest root shoot ratio was found in BRRI dhan55 followed by in Hashikalmi and the lowest root shoot ratio was found in BR 6976-2B-15. The results of the experiment was in agreement with Mohammadian *et al.* (2005), who reported that mild water stress affected the shoot dry weight, while shoot dry weight was greater than root dry weight loss under severe stress in sugar beet genotypes. Sharp *et al.*,(2004) in maize who reported that the root shoot ratio was increased when the soil was subjected to water deficit condition. Under drought condition, the root shoot ratio was lower and the root shoot ratio was higher in drought tolerant genotype. Jawi Lanjut varieties showed high root shoot ratio than the other varieties under the water stress treatment. Kulkarni *et al.* (2008) reported that the root shoot ratio was reduced when the soil was subjected to water deficit condition.

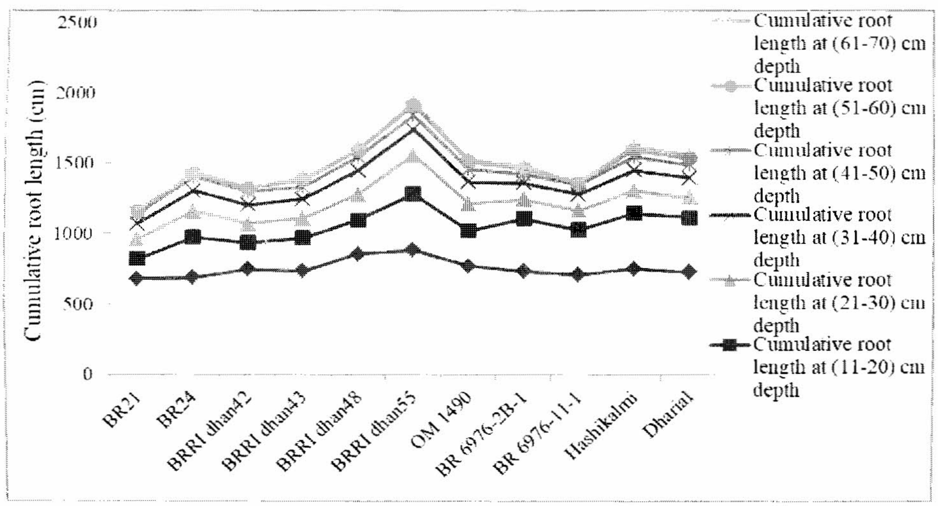

Fig. 1. Cumulative root length of rice genotypes at (10-70) cm depth in soil under water deficit conditions

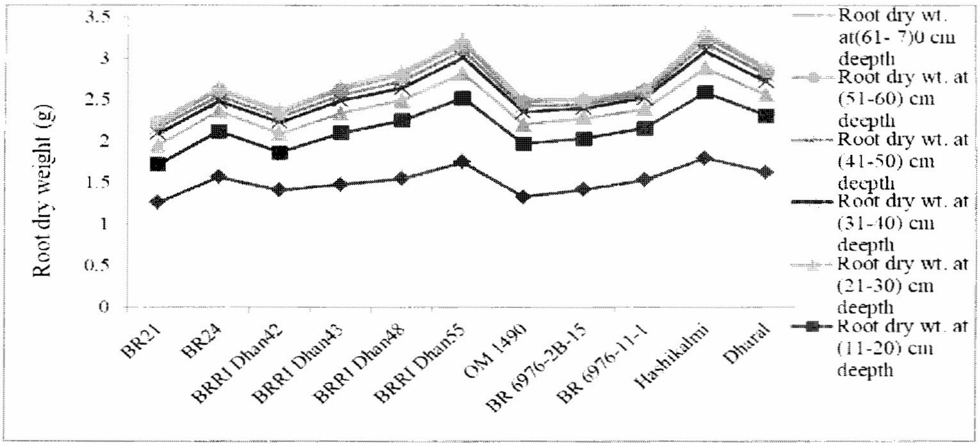

Fig. 2. Root dry weight (g) of rice genotypes at 10 cm to 70 cm depth in soil under water deficit conditions

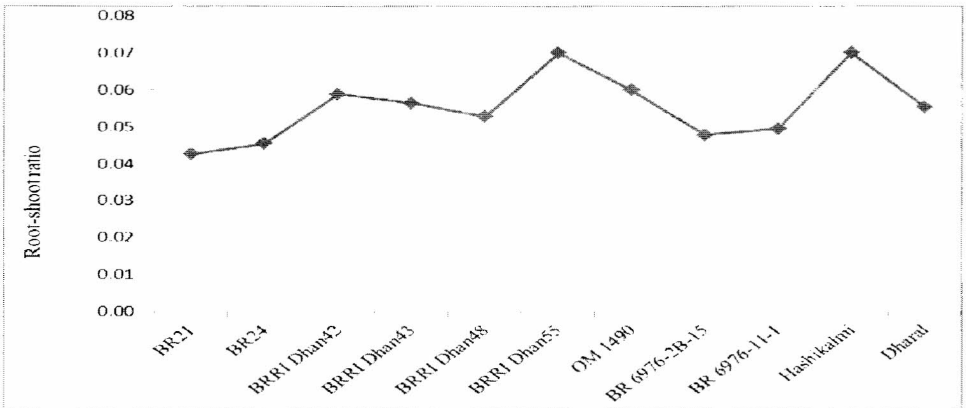

Fig. 3. Root shoot ratio of different rice genotypes under water deficit conditions

CONCLUSION

However, to reach a specific conclusion of the experiment with based on the result of the present study, the following conclusion may be done. When water deficit effects, soil moisture decreases, root can not uptake water. The water stress tolerant genotypes produced the maximum length of root compared to other genotypes. Drought tolerant genotypes posses deep root, short height of shoot and high root-shoot ratio under water deficit conditions. Decreased root shoot ratio indicated that root dry matter rather than shoot dry matter was more affected due to water deficit conditions.

REFERENCES

Asch , F., Dingkuhn, M., Sow, A. and Audebert, A. (2005). Drought-induced changes in rooting patterns andassimilate partitioning between root and shoot in upland rice. *Field Crops Res.*.93(2-3): pp.223-236.

BRRI (2006). (Bangladesh Rice Research Institute). Annual Report for 2005-2006. Bangladesh Rice Research Institute, Gazipur, Bangladesh.

Carter, T.E.Jr. (1989). Breeding for drought tolerance in soybean: where do we stand. In: World Research Conference. Association Argentina Dela Soja, Buenos Aires Argentina.

Chang, T.T., Lorest, G.C. and Tagumpay, O. (1972). Agronomic and growth characteristics of upland and lowland varieties. In: Rice breeding, IRRI, Los Banos, Philippines. pp. 645-661.

FAO (2002). Crops and drops making the best use of water for agriculture. Food and Agriculture Organization of the United Nations. Rome.

Gomez, K.A. and Gomez, A.A. (1984).Statistical procedure for agricultural research.Second Edn. International Rice Research Institute. John Wiley and Sons. New York. pp. 1-340.

Henry. A. (2011). IRRI's drought stress research in rice with emphasis on roots: accomplishments over the last 50 years. *Plant Root*.7: 92-106.

Lum, M.S. (2014). Effect of drought stress on growth, proline and antioxidant enzyme activities of upland rice. *J. Anim. Plant Sci.* 24(5):1487-1493.

IRRI(International Rice Research Institute). (2005). Annual Report for 2004., Loss Banos, Leguna, Philippines.

Jaleel, C.A., Gopi, R. and Panneerselvam, R., (2008a).Growth and photosynthetic pigments responses of two varieties of *Catharanthusroseus*to triadimefon treatment.*Comp. Rend. Biol.* 331: pp. 272–277.

Jaleel, C.A., Manivannan, P., Murali, P.V., Gomathinayagam, M. and Panneerselvam, R.(2008c). Antioxidant potential and indole alkaloid profile variations with water deficits along different parts of tow varieties of *Catharanthus roseus*. *Colloids Surf. B: Biointerfaces*. 62:312-318.

Kulkarni, M., Borse, T. and Chaphalkar, S. (2008). Mining anatomical traits: A novel modelling approach for increased water use efficiency under drought conditions in plants. *Czech J. Genet.Plant Breed*.44(1):11–21.

Mohammadian, R. (2005).Effect of early season drought stress on growth characteristics of sugar beet genotypes. *Turkish J. Agric. Forestry*. 29(5): 357.

Puckridge, D.W. and O'Toole, J. (1981). Dry matter and grain production of rice, using a line source sprinkler in drought studies. *Field Crops Res*. 3: 303-319.

Sharp, R.E. Poroyko, V., Hejlek, L.G., Spollen, W.G., Springer, G.K., Bohnert, H.J. and Nguyen, H.T. (2004). Root growth maintenance during water deficits: physiology to functional genomics. *J. Expt. Bot.* 55(407): 2343-2351.

Sikuku, P.A., Netondo, G.W., Onyango, J.C. and Musyimi, D.M. (2010). Chlorophyll fluorescence, protein and chlorophyll content of three NERICA rainfed rice varieties under varying irrigation regime. *Agril. Biol. Sci*.5(2): 19-25.

Tahir, M.H.N.. Imran, M. and Hussain, M.K. (2002).Evaluationof sunflower (*Helianthus annuus*L.) inbred lines for drought tolerance. *Intl. J. Agric. Biol.* 3: 398-400.

Usman, M., Raheem, Z.F., Ahsan, T. Iqbal, A. Sarfaraz, Z.N. and Haq, Z. (2013). Morphological, physiological and biochemical attributes as indicators for drought tolerance in rice (*Oryza sativa*L.). *European J. Biol. Sci.* 5 (1): 23-28.

Wullschleger, S.D., Yin, T.M., DiFazio, S.P., Tschaplinski, T.J. Gunter, L.E., Davis, M.F. and uskan, G.A. (2005). Phenotypic variation in growth and biomass distribution for two advanced-generation pedigrees of hybrid poplar. *Canadian J. Res*. 35: 1779-1789.

Yoshida, S., Forno, D.A. Cook, J.H. and Gomez, K.A. (1975). Routine procedure for growing rice plant in culture solution. In: Laboratory manual for physiological studies for rice. IRRI, Los Banos, Philippines. p.61- 66.