Asian Journal of Plant Sciences

ISSN 1682-3974

Asian Journal of Plant Sciences 3 (4): 512-515, 2004
ISSN 1682-3974

Root Characteristics of Drought Tolerant Bread Wheat (*Triticum aestivum*) Genotypes at Seedling Stage

R.M. Gesimba, [1]E. Njoka and [2]M. Kinyua
Horticulture Department, [1]Agronomy Department,
Egerton University, P.O. Box 536, Njoro
[2]The Kenya Agriculture Research Institute,
The National Plant Breeding Research Station, P. O. Njoro

Abstract: A study was carried out between March 1999 and April 2000 at the National Plant Breeding Research Station Njoro. The aim of the study was to describe the root characteristics of drought tolerant, moderately tolerant, and susceptible bread wheat genotypes at seedling stage (49 days). Three commercial wheat varieties Duma, Kenya mbweha and Mbuni which are tolerant, moderately tolerant and susceptible, respectively were screened together with three lines R830, R831 and R748 which have also been identified to show drought tolerance characters. The six genotypes were planted in boxes measuring 0.03x1x0.3m after being determined as the best box sizes for screening the roots of wheat seedlings. The rooting patterns were studied. Results showed that drought tolerant genotypes had significantly ($p<0.05$) more roots in the crown region with the nodal and seminal roots concentrated closer to the soil surface while the susceptible genotypes had fewer roots in the crown region with most of the roots concentrated away from the soil surface.

Key words: Drought, tolerant, wheat genotype, root, bread

INTRODUCTION

Wheat production in Kenya has not met demand in many years[1]. Self sufficiency in wheat production can achieved through increasing production per unit area in the high potential areas and through the expansion of the existing production areas[2]. Production per unit area in the high potential areas can be increased through reduction of losses caused by poor rainfall distribution[3]. This is possible through the introduction of drought tolerant genotypes[4]. Preliminary selection of these varieties for drought tolerance was based on yield and yield components now it is based on yield comparison of test materials grown in different areas over time[5]. This conventional method is slow and a faster method of evaluating large populations of test material will be of great advantage. Root characteristics have been used successfully to screen for drought tolerance[6]. However such work has not been done on Kenyan bread wheat. Therefore in search for a faster and more effective method of screening drought tolerant wheat genotypes, this study was initiated with the objective of describing the root characteristics of drought tolerant, moderately tolerant and susceptible bread wheat genotypes at seedling stage.

MATERIALS AND METHODS

Root screening experiments were carried out in a complete randomized design with three replicates. To evaluate the rooting pattern, on a two dimensional plane, the root box pin method described by Singh[6] was modified and used. Before conducting root studies the best method to achieve this objective was first determined considering that Singh[6] had worked on cow-pea. Boxes of varying sizes were constructed in each case taking care of Wolfgang's[7] (3 by 30 by 105 cm) and Mac-Key[8] (maximum length of 1.3 m) recommendations. Then one thousand eight hundred boxes similar to the one that had the least interference on root growth were made, i.e. (0.03x1.3x0.3) m. In each box two hand picked seeds were planted in the middle of the box. In this case one planting box accommodated only one genotype. One hundred planting boxes represented one plot and six hundred boxes made one replicate. Randomization was achieved through arrangement of the boxes in the greenhouse. One week after germination one seedling was removed from each box leaving only one healthy seedling per box. An equivalent of 6.5 mm of rainfall was applied per box per week for 49 days from the day of planting which is the end of the seedling establishment[8]. After that the boxes were

Corresponding Author: R.M. Gesimba, Horticulture Department, Egerton University, P.O. Box 536, Njoro
E-mail: gesimb@yahoo.com

opened and nail board fixed to replace the removed side. Then carefully the box was made to rest at an angle of 60^0 on the side with the nail board after which the remaining parts of the box were lifted. Using a hand sprayer, the soil covering the roots was gently washed away making sure minimum damage was done to the roots. Data on root depth, total root length[8], root spread at six centimeters deep widest root spread root concentration[8], relative absorptive surface area[8] and root number was taken.

Data analysis: Data collected was subjected to analysis of variance tests using SAS software[9]. Treatment means that were significant we separated using the Duncans multiple range test at the significant level of $p<0.05$.

RESULTS

The mean root depth, root total length, relative absorptive surface area and number of roots of the six genotypes are shown in Table 1. Significant differences were noted in the rooting depth with the drought susceptible Mbuni having significantly deeper roots than the drought tolerant genotypes (R830, R831 and R748) and also the moderately tolerant Kenya mbweha. However, the rooting depth of Mbuni was not significantly different with that of variety Duma. Root total length for drought tolerant (R830, R831 and R748) and moderately tolerant (Kenya mbweha) genotypes were significantly longer than the roots of the susceptible mbuni.

Table 1: Seedling root characteristics of six bread wheat genotypes

Parameter	Duma	R830	R831	R748	Kenya mbweha	Mbuni
Root depth (cm)	108.0ab	79.7c	77.0c	77.9c	93.7bc	114.5a
Root length (cm)	1737.5a	1826.0a	1783.0a	2073.2a	1617.1a	845.3b
Relative absorptive surface area (mm)	6.3b	6.9ab	6.3b	7.9a	5.8bc	5.0c
Root number	20.7a	19.7ab	21.7a	23.0a	18.5b	13.8c

Results also showed that drought tolerant genotypes had significantly higher relative absorptive surface areas than susceptible Mbuni. However this was not the case with moderately susceptible Kenya mbweha since its relative absorptive surface area was in between that of the tolerant genotypes and that of susceptible mbuni. The same trend was observed for root numbers with the drought tolerant genotypes (Duma, R830, R831 and R748) having significantly higher root numbers than susceptible Mbuni. On the other hand moderately susceptible Kenya mbweha's root numbers were not significantly different with either the tolerant genotypes nor those of susceptible Mbuni (Table 1).

Figures 1 and 2 illustrate the root spread at 6 cm depth, widest root spread and root concentration depth results for the six genotypes.

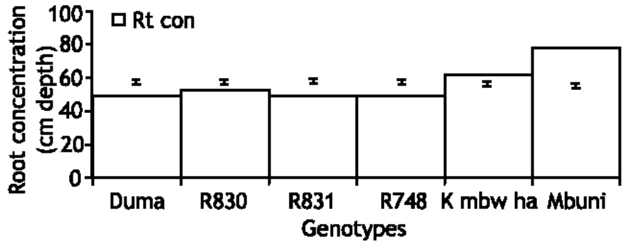

Fig. 1: Seedling root concentration depth of the six bread wheat genotypes

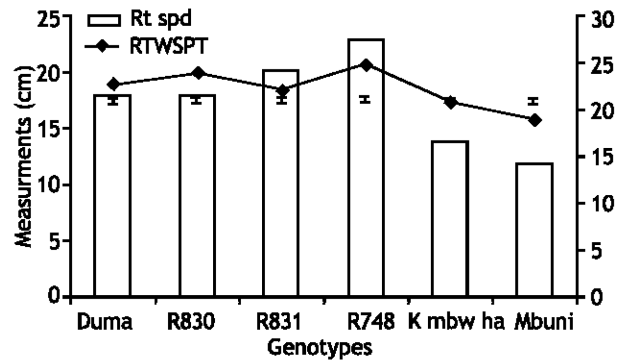

Fig. 2: Seedling root spread 6 cm deep (RTspd) and widest root spread (RTWSPT)

Data on root spread at six centimeters depth and the widest root spread indicated that the drought tolerant genotypes had significantly higher values than the moderately susceptible Kenya mbweha and susceptible Mbuni. On the other hand the root concentration depth for susceptible Mbuni and moderately susceptible Kenya mbweha was significantly higher than that of tolerant genotypes (Fig. 1 and 2).

DISCUSSION

Many plants successful in dry habitats have no specific adaptation for controlling water loss but rely on the development of very extensive and deep root systems that can obtain water from a large volume of soil deep in the water table[10]. In the current study this was true for variety duma however, it wasn't the true entirely since drought susceptible mbuni had significantly deeper roots than the drought tolerant genotypes (R830, R831 and R748) and also the moderately tolerant Kenya mbweha. This is explained in part by Farr[11] and Russel[12] who reports that genotypes differ in their angle and rate of root growth under different soil conditions. It follows therefore, that variety Mbuni may have the deepest roots because of the angle of root growth rather than the rate of elongation. Perhaps this was influenced by the artificial soil conditions in the box.

Nodal and seminal roots are more intolerant genotypes[13]. Also, roots of drought tolerant genotypes elongate at a higher rate per week than the roots of susceptible genotypes[14,10]. With more roots all of them elongating at a higher rate, it is imperative that drought tolerant genotypes should have higher total root lengths. In the present study this was the case as the drought tolerant genotypes Duma, R830, R831 and R748 had significantly higher total root lengths than susceptible Mbuni. These results also suggest that this quality (high total root length) could be shared by the moderately tolerant Kenya mbweha since there was no significant difference and probably the difference between Kenya mbweha and the tolerant genotypes is caused by something different. This is partly explained by Ridge[15] who indicated that drought tolerance is a result of many root factors and among the most important is longevity which has a direct influence on the relative absorptive surface area. As such, a plant with roots that last longer will have a higher relative absorptive surface area. This means that although Kenya mbweha has most of its root characteristics not significantly different with those of some tolerant genotypes, the genotype may be susceptible due to other factors. One such factor is root longevity which affects the relative absorptive surface area which in the present study was not significantly different with that of susceptible Mbuni. Other root factors such as xylem diameter, actual absorptive surface area or root firmness may also be responsible for its susceptibility but all of them were not addressed in this study.

As indicated earlier many plants successful in dry habitats rely on the development of very extensive and deep root systems that can obtain water from a large volume of soil deep in the water table[10]. When root spread at six centimeters depth and widest root spread was considered similar findings were made as tolerant genotypes (Duma, R830, R831 and R748) had significantly higher root spreads at 6 cm depth, widest root spreads than the moderately tolerant Kenya mbweha and susceptible mbuni.

Light precipitation only wets soil surface and as such it follows that only genotypes that have more roots next to the soil surface can benefit[4]. Volkmar[13] reported that nodal roots also located near the soil surface are more in tolerant genotypes. This finding suggests that since the susceptible and moderately susceptible genotypes had higher root concentration depths, their relative absorptive surface areas were further away from the moisture zone hence their susceptibility.

Root characteristics correlate strongly with shoot characteristics which in turn correlate strongly with yield[5]. Since yield comparison results of test material grown in different areas over time are used currently to screen for drought tolerance in Kenya. Correlation studies between root characteristics such as total length, relative absorptive surface area, root number, root spread at 6 cm depth, widest root spread and root concentration depth and yield or yield components should be done. In molecular studies, markers for these characteristics should be sought. In doing so an alternative faster method of evaluating large numbers of possible candidates of test material for drought tolerance can be developed. Such a method can be used for preliminary tests and as such only the very promising genotypes will be taken for field tests thus reducing time and saving on costs.

ACKNOWLEDGMENTS

This research was supported by the International Atomic Agency. Authors gratefully acknowledge the helpful co-operation of the Kenya Agricultural Research Institute staff as well as Egerton University.

REFERENCES

1. Ndegwa, C.M., 1992. Current Status of Wheat Seed Maintenance and Production in Kenya. In: Turner, D.G. and W.J. Mwangi, (Eds.), The Seventh Regional Workshop for Eastern, Central and Southern Africa. Nakuru. Kenya, pp: 39.
2. Khamidi, M., 1992. A Review on Production Constraints in Wheat. In: Turner, D.G. and W.J. Mwangi, (Eds.), The Seventh Regional Workshop for Eastern, Central and Southern Africa. Nakuru. Kenya, pp: 60.
3. Pleifer, W.H., 1991. Triticale Improvement Strategy of CYMMYT. Exploiting Adaptive Patterns and Use Orientation. In: Turner, D.G. and W.J. Mwangi, (Eds.), The Seventh Regional Workshop for Eastern, Central and Southern Africa. Nakuru. Kenya, pp: 27.
4. Gesimba, R.M., 2000. Selection of drought resistant bread wheat through shoot and root characteristics at seedling stage. M.Sc. Thesis, Submitted to Egerton University Graduate School, pp: 1-100.
5. Kinyua, M.G., 1991. Genotypex Environmental Effects in Bread Wheat from Multiple Locations and Years in Kenya. In: Turner, D.G. and W.J. Mwangi, (Eds.), The Seventh Regional Workshop for Eastern, Central and Southern Africa. Nakuru. Kenya, pp: 101.
6. Singh, B.B., 1998. Simple Screening Method for Drought Tolerance Root Characteristics in Cow Pea. International Institute of Agriculture, Kano Station, Nigeria, pp: 1-5.

7. Wolfgang, B., 1979. Methods of Studing Root Systems. Springer-Verleg. Berlin, pp: 1-110.
8. Mac-Key, J., 1980. Plant Roots. Methods of Studing Plant Roots. Iowa State University Press. In: Garber, R.T. 1982. Ames Iowa, pp: 95.
9. SAS., 1995. Intitute Inc. : SAS/STAT Users Guide Release 6.13. Cary N.C. U.S.A
10. Hamlyn, G.J., 1996. Plants and Microclimate. Cambridge University Press, pp: 1-262.
11. Farr, C.H., 1925. Root hair elongation in Knops solution in tap water. American J. Bot., 12: 372-383.
12. Russel, E.W., 1995. Soil Conditions and Plant Growth. Longman. London, pp: 1-989.
13. Volkmar, K.M., 1997. Water stressed nodal roots of wheat effects on leaf growth. Australlian J. Plant Physiol., 24: 35-41.
14. Gardner, F.P., R.B. Peace and R.L. Mitchel, 1985. Physiology of Crop Plants. Iowa State University Press. Ames., pp: 1-270.
15. Ridge, I., 1991. Plant Physiology. Hodder and Stoughton. The Open University. Milton Keynes.