Initiation of a pre-breeding effort aimed at water stress resistance traits for yield improvement in wheat

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Introduction

Hexaploid bread wheat (Triticum aestivum L.) and tetraploid durum (Triticum durum) are major wheat cultivars accounts about 95% and 5% respectively of the world production (Peng *et al*., 2011). SA is sitting on the 28th position on countries ranking and contributes 0.24% of global wheat production, however production decreased by 5.8 % year 2013 to 2014 (Index mundi: Wheat production by country in 1000 MT, 2015). Due to ever increasing world population (2.3 % annually) the demand for food increases. By year 2050 prospect demand for food anticipated to escalate up to 60% therefore crop improvement is important to secure food security (FAO). Wheat production is affected by a number of biotic and abiotic factors. Water stress is a major abiotic factor hampering wheat production and other crops (Sivamani *et al.,* 2000) and continues to be the challenge in plant breeding. In developing countries water stress severely affect about 50% of wheat production areas and 70% of developed countries (Trethowan and Pfeiffer, 2000). (Nezhadahmadi *et al.,* 2013) presumed that approximately 1.8 billion people could encounter utterly water scarcity and 65% of the world's population could reside under scarce water environments. Breeding for diseases and water stress resistance under semi-arid to arid regions thereby improving yield are main objectives in plant breeding programs (Sivamani *et al.,* 2000). According to (Blum *et al.,* 1981) genetic improvement of tolerant varieties desire more attention on relevant physiological water stress tolerant mechanism as a selection criteria. Therefore selection criteria by means of plant physiology mechanism are significant for improving productivity. It is postulated that by incorporating potential individuals can lead to the progress of the plant breeding programme (Blum *et al.,* 1983).

Aim and Objectives

The aim of the research project was the initiation of a pre-breeding effort aimed at water stress resistance traits for yield improvement in wheat. Objectives are as follows :-
(a) Identification of water stress resistance traits in wheat genotypes under investigation utilizing reticulated hydroponic system for screening.
(b) Introgression of selected water stress resistance traits from a male plants into a genomic background of recurrent parent thereby improving its genetic value through backcrossing.
(c) Effectively facilitate the crossings of selected parental lines by making use of MS-MARS.

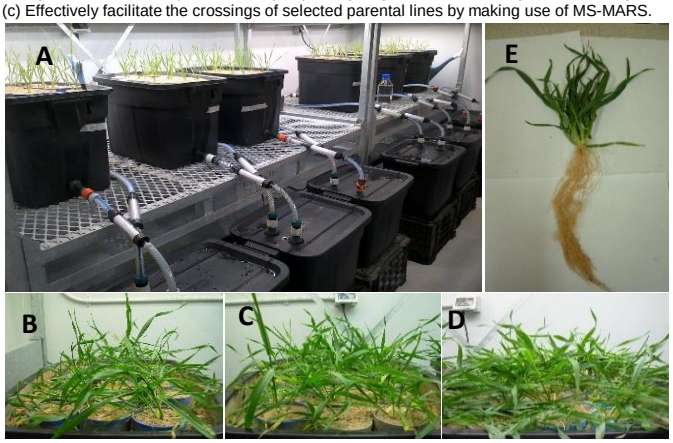


Figure 1: A- Complete RHS with irrigation system installed, B,C &D some effect of water stress results and E- benefits of RHS to effectively uproot plant material.

Material and Methods

Crossing male and female F1 1:1 segregating base population as parental lines previous proved to be improved yield utilizing MS-MARS scheme were made as part of MS-MARS cycle one. Sixty genotypes were screened for water stress resistance utilizing reticulated hydroponic system (RHS). Screening was divided into two sections, 45 genotypes were screened on each section including 15 controls. The experiment was conducted in a growth chamber at Stellenbosch, Welgevallen experimental farm. The temperatures of the growth chamber were 18 0C. Plants were grown under infrared UV light calibrated as long day length. Five Seeds were planted in each PVC column followed by thinning to one plant after 16 days. First week irrigation was manual using standard nutrient solution, followed by programmed timer installed into RHS and three pulses were timed per da. Stress was applied by withholding water supply after 20 days for 14 days. During stress period leaf length, number, rolling, yellowing, drying, tiller and side shoot development were evaluated. The RWC of all genotypes was calculated using protocol by (Barrs and Weatherley, 1962).

Reticulated hydroponic system

Addis Rough Tote (ART) 45L were used. Three ART were drilled two holes at the bottom on both sides using a driller. Two openings were made to properly fit 15mm PVC running nipple such it's equally projects on the inside and outside the ART. Rubber insert rings of 21 ID × 37 OD were inserted before inserting the PVC Backnut ½. PVC Backnut ½ were than fastened up on both sides inside and outside of the ART using a shifting spanner to ensure firm structure and to prevent leakage. Vertical length of the rough tote from the base to the top was 36 cm. The bottom part of the ART were half filled with loose stone and gravel of about 19 cm. This was followed by strata of silica sand of 3 cm supplied. Consequently the ART composed of two stratums, loose stones and silica sand respectively. Six metres PVC pipes were cut equal to 15cm length using miter saw. Silica sand layer was thoroughly levelled and 15 PVC pipes (15 cm length × 3.5 radius) of the same length were placed vertically in a same level with ART surface. Fifteen PVC pipes were used per ART. PVC pipes were than fully filled with silica sand growth media. Remained spaces between PVC pipes and ART were virtually filled with loose stones leaving about 3cm enabling PVC pipes to project to the surface of the loose stone layer. Lastly irrigation system was connected.

Results

Combined analysis of variance indicated statistical significance for genotypes under investigation. No significant effect on growth was observed; declined plant water status reduced growth which coincides with considerable increased sugar content. Dry weight accumulation continued throughout the stress period associated with rocketing of sugar content. No increased leaf length and leaf observed which is associated with photosynthesis potential. Typical signs of stress were observed include leaf rolling with respect to reduction of canopy light interception and response to water stress and leaf chlorosis and injuries due to leaf salt accumulation. Reduced plant height was observed found strongly correlated to harvest index, lodging risk and storage carbohydrate capacity. Bottom leaves died at first due to much higher salt concentrations compared to younger leaves. Massive root length and density observed associated with stress; plants attempted to compensate stress by deep root extension. Root length and RWC serve as an indicator of water stress tolerant. Among the genotypes under investigation susceptible, moderate and tolerant genotypes were selected together with control varieties (figure 3 and 4). Root measurement indicated non susceptible genotypes. Control 11US036, and 11US082 showed moderate tolerant and 09US-069 was tolerant to water stress. Studied genotypes showed moderate tolerant and AHYLD14-09 was highly tolerant to water stress. RWC measurements control 11US097 and 07US-002 exhibited low RWC and 07US-007 and 09US-06 controls were moderate tolerant and control 11US036 and 11US089 were found to be tolerant to water stress. No susceptible genotype observed, only moderate SST867 and SST877 and tolerant varieties AHYLD14-12 and SST895.

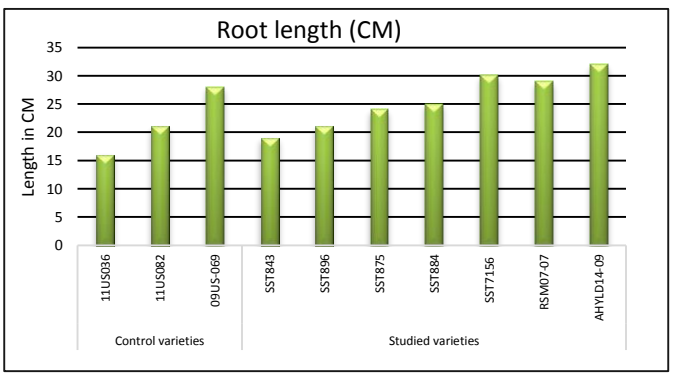


Figure 3: The root length measurements of wheat genotypes under water stress treatment

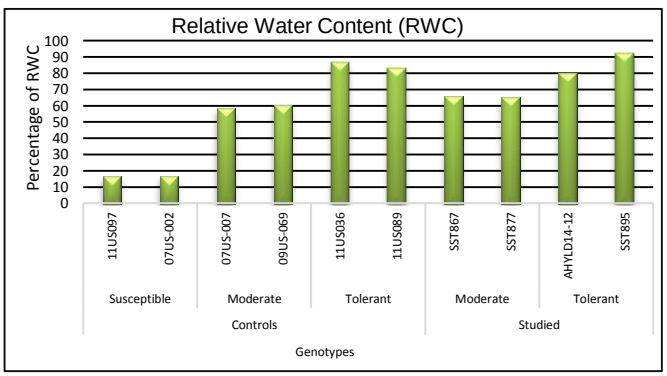


Figure 4: represents the RWC of wheat varieties subjected to water stress treatment

Current and Future Work

Evaluation of 60 genotypes screened for water stress resistance. Best performing top five genotypes will be selected for making crosses using MS-MARS scheme and it will be molecularly screened followed by introgression of selected traits into a genomic background of recurrent parent thereby improving its genetic value through backcrossing.

References

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