ISSN 2229-5518

# Physiological screening of Pakistani wheat germplasms using Relative water content (RWC) water loss rate (WLR) and water use efficiency (WUE)

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**Abstract**

A number of physiological traits such as Relative water content (RWC), water use efficiency (WUE), Leaf water loss rate (LWLR) etc. have been recognized to discuss drought resistance in crop plants. These traits are encouraged to be used as screening criteria and have been suggested to manipulate in crop plants to breed for drought resistance. The present research was designed to screen out the one hundred and three germplasm for drought tolerance. The results showed that RWCN was found in 10824 (98.69), 10730 (95.67), 10848 (94.44), 10818 (94.44), 11877 (94.02) while RWCS in stress conditions the estimated germplasms were 10809 (87.80), 10780 (87.35), Saleem-2000 (87.02), 10819 (86.07), 10814 (85.05). The cultivars 10755 (67.14), PS-85 (67.07), 11867 (67) were showed moderately resistance to drought stress. The lowest WLR in normal condition was observed in 11866 (-1.58), 10808 (0.11), 11867 (0.39), PS-08 (0.41) and Hashim (0.43) while 10803 (-8.71), 11877 (-1.3), 10718 (-1.3), 10740 (0.27), 11876 (0.3) showed the lowest WLR in stress conditions. The highest WUE was observed in 10831 (2.046667), 10825 (2.033333), 10820 (2.033333), 10847 (1.86), 10833 (1.84).

## Introduction

Water is the most important abiotic factor for wheat distribution in water deficit areas. Water may affect the distribution and production of wheat (Mastrangelo *et al.*, 2000). The drought tolerance is measured as an effective breeding target in the maintenance of crop performance, Breeders and molecular biologists, at the instant there is a lack of valid facts to be able to measure with accuracy the plant resistance under drought stress conditions (Blum, 1996). The major goal of breeding programmes is to produce drought tolerant wheat globally (Moustafa *et al*., 1996). A physiological approach would be the most striking approach to develop new varieties (Araus *et al.,* 2008), but breeding for definite, environments involves a deeper understanding of yield-determining process. Water-use-efficiency (WUE), relative water content (RWC) and water loss rate (WLR) has been related to drought tolerance (Johnson *et al.,* 1995). Adequate genetic variation happens for these physiological traits. The techniques for measuring these traits are now easy and fairly standardised. Hence it may be possible to manipulate this variation (Hubick *et al.*, 1988) for developing drought resistant cultivars. Drought being the principle stress, crops has its own specific critical period to affect greatly by water i.e filling of grain (Ashry and Kholy, 2005). The present study was mainly focus to conduct different drought experiments as Relative Water Content (RWC), Water Loss Rate (WLR) and Water Use efficiency (WUE) for determination of moisture content.

**Materials and methods**

The experiment was conducted in greenhouse (2011-2012) at department of Genetics Hazara University Mansehra Pakistan (Latitude 34° 19´ N, Longitude 73° 45´ E). The seeds of 103 Pakistani germplasm were grown in petri plates for 72 hrs at 27 ˚C in Incubator. The seedlings were then transplanted to pots (pot 20 cm high and 10 cm in diameter). Each pot was filled of sand, soil and organic fertilizer in ratio of 2:1:1. The three experiments (water loss rate, relative water content and water use efficiency) was carried out following RCBD in replication of three. The pots used for water use efficiency were covered with polythene sheets. Each pot was watered with 140 ml water. A small pore was made in sheet for evapotranspiration. Three control pots without plants were also made for determination of water loss. The water use efficiency was calculated by the following formula:

Total plant water use = total weight of each pot after no more plant extractable water left – total weight of each pot + harvest shoots and record the fresh shoot wt – (water loss in control pots with no plant × 0.7*).

The Water loss rate was calculated by the formula of (Clarke, 1987)

WLR = (Fresh weight – weight after 24 h /Fresh weight – Dry weight x 100

The Relative Water Content was noted using the formula (Malik, 1995).

RWC % = (FW- DW)/ (TW-DW) x 100

Table 1: chart of wheat germplasm included in the present study

| S.NO | Germplasm | S.NO | Germplasm | S.NO | Germplasm | S.No | Germplasm |
|---|---|---|---|---|---|---|---|
| 1 | 11868 | 27 | 11865 | 53 | 10771 | 79 | Noshera-96 |
| 2 | 10854 | 28 | 10826 | 54 | 10803 | 80 | Khyber-87 |

ISSN 2229-5518

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 | 10853 | 29 | 10822 | 55 | 10726 | 81 | Wafaq |
| 4 | 10850 | 30 | 11881 | 56 | 10772 | 82 | Hashim |
| 5 | 10849 | 31 | 10828 | 57 | 10727 | 83 | PS-08 |
| 6 | 10825 | 32 | 10824 | 58 | 10718 | 84 | ZAM |
| 7 | 10845 | 33 | 10874 | 59 | 10732 | 85 | Saleem-2000 |
| 8 | 10847 | 34 | 10827 | 60 | 10801 | 86 | PS-05 |
| 9 | 11862 | 35 | 11864 | 61 | 11876 | 87 | Janbaaz |
| 10 | 11860 | 36 | 10820 | 62 | 10808 | 88 | Haider-2000 |
| 11 | 11861 | 37 | 11867 | 63 | 10809 | 89 | ARE-10 |
| 12 | 11866 | 38 | 11882 | 64 | 11863 | 90 | Lasani-08 |
| 13 | 11809 | 39 | 10818 | 65 | 10717 | 91 | Faisalabad-08 |
| 14 | 11873 | 40 | 10821 | 66 | 10735 | 92 | Uqaab-2000 |
| 15 | 10842 | 41 | 10819 | 67 | 10810 | 93 | Gomal |
| 16 | 10841 | 42 | 11879 | 68 | 10759 | 94 | Suleman-96 |
| 17 | 10833 | 43 | 11878 | 69 | 10725 | 95 | NARC-2009 |
| 18 | 10843 | 44 | 10814 | 70 | 10755 | 96 | Sahar |
| 19 | 10848 | 45 | 11875 | 71 | 10733 | 97 | Dera-98 |
| 20 | 10832 | 46 | 10730 | 72 | 10719 | 98 | Atta habib |
| 21 | 10829 | 47 | 10815 | 73 | 10780 | 99 | KT-2000 |
| 22 | 10852 | 48 | 10816 | 74 | 10740 | 100 | Kaghan-93 |
| 23 | 10834 | 49 | 10813 | 75 | 10743 | 101 | PAK-81 |
| 24 | 10831 | 50 | 11877 | 76 | Shafaq-2006 | 102 | PS-85 |
| 25 | 10835 | 51 | 10738 | 77 | PS-2004 | 103 | Tatara |
| 26 | 10830 | 52 | 10817 | 78 | Siran-2010 | | |

**Results**

The Relative Water Content (RWC), Water Use efficiency (WUE) and Water loss rate (WLR) were calculated for all germplasms both in normal (RWCN) and water stress (RWNS) conditions (Table 1). The highest RWCN was estimated for germplasm,10824 (98.69), 10730 (95.67), 10848 (94.44), 10818 (94.44), 11877 (94.02), Shafaq-2006 (93.83), 10814 (92.37), 10738 (91.54), 11875 (90.72) and 11878 (89.95) while RWCS in stress conditions the estimated germplasms were 10809 (87.80), 10780 (87.35), Saleem-2000 (87.02), 10819 (86.07), 10814

(85.05), 10833 (84.78), 10818 (84.66667), 10730 (84.33333), 10743 (84) and 10841 (83.45) while the cultivars 10755 (67.14), PS-85 (67.07), 11867 (67) were showed moderately resistance to drought stress (table 3). The ANOVA analysis of all the germplasms under stress condition showed they are highly significant at ($P < 0.01$) level as shown in table 4. So on the base of above results the germplasm 10809 (87.80), 10780 (87.35), Saleem-2000 (87.02), 10819 (86.07), 10814 (85.05), 10833 (84.78), 10818 (84.66667), 10730 (84.33333), 10743 (84) and 10841 (83.45) are more resistant to drought and the germplasm 10853 (40.48), 10820 (40.48), 10842 (39.32) are sensitive to drought while the 10755 (67.14), PS-85 (67.07), 11867 (67) germplasm were showed moderate resistance to drought stress.

The water loss rate (WLR) was also measured for all the 103 germplasm and the statistical analysis showed that the germplasm, 11866 (-1.58), 10808 (0.11), 11867 (0.39), PS-08 (0.41), Hashim (0.43), 10738 (0.45), Dera-98 (0.45), ARE-10 (0.46), 10740 (0.47) and 11876 (0.47) have lowest WLR rate in normal conditions (table 2) while 10803 (-8.71), 11877 (-1.3), 10718 (-1.3), 10740 (0.27), 11876 (0.3), 10808 (0.31), 11862 (0.31), 10735 (0.31), 10853 (0.33) and Khyber-87 (0.34) showed the lowest WLR in stress conditions (table 2). The germplasm Atta Habib (0.8), 010801 (0.79) and 010743 (0.75) have showed moderate WLR in stress condition while K.T 2000 (0.9) , 010814 (0.88), Saleem 2000 (0.86) showed moderate WLR in normal condition. The ANOVA result showed that WLR is highly significant ($p < 0.000$) under drought stress (table 4). The water use efficiency (WUE) also showed that all the germplasms are highly significant ($p<0.01$) and the germplasm 10831 (2.046667), 10825 (2.033333), 10820 (2.033333), 10847 (1.86), 10833 (1.84), 10842 (1.796667), 11809 (1.773333), 10771 (1.763333), 10772 (1.74) and 10810 (1.716667) have observed highest WUE (table 2) and are considered more resistant to drought while Tatara (1.093333), 10755 (1.056667), 11868 (0.98) were showed lesser resistance to drought on the base of WUE.

Table 2: **comparative performance of wheat germplasm on the base of physiological parameters**

| Germplasm /Accession | RWCS | Germplasm /Accession | RWCN | Germplasm /Accession | WLRS | Germplasm /Accession | WLRN | Germplasm /Accession |
|---|---|---|---|---|---|---|---|---|
| 10809 | 87.80 | 10824 | 98.69 | 10803 | -8.71 | 11866 | -1.58 | 10831 |
| 10780 | 87.35 | 10730 | 95.67 | 11877 | -1.3 | 10808 | 0.11 | 10825 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Saleem-2000 | 87.02 | 10848 | 94.44 | 10718 | -1.3 | 11867 | 0.39 | 10820 |
| 10819 | 86.07 | 10818 | 94.44 | 10740 | 0.27 | PS-08 | 0.41 | 10847 |
| 10814 | 85.05 | 11877 | 94.02 | 11876 | 0.3 | Hashim | 0.43 | 10833 |
| 10833 | 84.78 | Shafaq-2006 | 93.83 | 10808 | 0.31 | 10738 | 0.45 | 10842 |
| 10818 | 84.66667 | 10814 | 92.37 | 11862 | 0.31 | Dera-98 | 0.45 | 11809 |
| 10730 | 84.33333 | 10738 | 91.54 | 10735 | 0.31 | ARE-10 | 0.46 | 10771 |
| 10743 | 84 | 11875 | 90.72 | 10853 | 0.33 | 10740 | 0.47 | 10772 |
| 10841 | 83.45 | 11878 | 89.95 | Khyber-87 | 0.34 | 11876 | 0.47 | 10810 |



Table 3: comparative performance of moderate wheat germplasm on the base of physiological parameters

| **Germplasm /Accession** | **RWC S** | **Germplasm /Accession** | **RWC N** | **Germplasm /Accession** | **WLR S** | **Germplasm /Accession** | **WLR N** | **Germplasm /Accession** |
|---|---|---|---|---|---|---|---|---|
| 10755 | 67.14 | 11809 | 70.53 | Atta habib | 0.8 | KT-2000 | 0.9 | 10874 |
| PS-85 | 67.07 | PS-85 | 70.37 | 10801 | 0.79 | 10814 | 0.88 | 10801 |
| 11867 | 67 | 10853 | 70.27 | 10743 | 0.75 | Saleem-2000 | 0.86 | 11867 |

Table 4: analysis of variance of physiological traits (normal and stress) of wheat germplasm

| **ANOVA** | | | | | | |
|---|---|---|---|---|---|---|
| | | Sum of Squares | df | Mean Square | F | Sig. |
| relative water content stress | Between Groups | 108211.833 | 102 | 1060.900 | 1060.900 | .000 |
| relative water content normal | Between Groups | 92496.668 | 102 | 906.830 | 906.830 | .000 |
| water loss rate stress | Between Groups | 317.749 | 102 | 3.115 | 3.115 | .000 |
| water loss rate normal | Between Groups | 278.348 | 102 | 2.729 | 2.729 | .000 |
| water use efficiency | Between Groups | 11.588 | 102 | .114 | 1.724 | .001 |
| yield per plant | Between Groups | 2434.115 | 102 | 23.864 | 5.589 | .000 |

The correlation analysis revealed that yield per plant is negatively correlated with relative water content (stress), relative water content (normal) and water loss rate (normal) while positively correlated with water loss rate (stress) and water use efficiency.

Table 5: statistical analysis of physiological traits on the base of correlation

| **Correlations** |
|---|

| | relative water content stress | relative water content normal | water loss rate stress | water loss rate normal | water use efficiency | yield per plant |
|---|---|---|---|---|---|---|
| relative water content stress | 1 | | | | | |
| relative water content normal | .442** | 1 | | | | |
| water loss rate stress | .002 | -.073 | 1 | | | |
| water loss rate normal | -.015 | -.072 | .864** | 1 | | |
| water use efficiency | -.020 | .067 | .111 | .145* | 1 | |
| yield per plant | -.200** | -.159** | .025 | -.005 | .088 | 1 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | | |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | | | |



**Discussion:** The relative water content (RWC) and leaf water potential decreased with the increase of leaf temperature on exposure to drought stress (Siddique *et al.,* 2000). The seedlings of *Triticum* and *Aegilops* showed different response to drought stress at the physiological as well as molecular level and this may suggest that resistant and susceptible genotypes may firstly base on their relative water content (Rampino *et al.,* 2006). The physiological parameters related with drought in plants should be identified for screening of drought genotypes (Malik, 1995). The reduction in yield and yield related parameters due to decrease of water supply may be recognised as reduction in the growth parameters (Naceur *et al.,* 1999). Our results support the previous research (Clark and Townley, 1986) that low rate of water loss and high relative water content is associated with high grain yield potential under drought stress. Clark and Romagosa (1989) reported the association of low rate of excised leaf water loss with improved yields under very dry environments in wheat. Our results also agree that on increase of water loss rate will decrease the yield of wheat in drought stress. Our results also support that the varieties with high water use efficiency produced high yield (Sing *et al.,* 1990).

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