Evaluation of water use efficiency, biomass production and selected root traits of wheat (*Triticum aestivum* L.) under drought conditions

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Abstract- Water use efficiency (WUE) is an important physiological trait for assessment of biomass production in drought conditions. The present research was designed to investigate the relationship of WUE, biomass production and selected root traits using hundred wheat genotypes cultivated in Pakistan in replication of three. The result showed that WUE is positively correlated (r= 0.982) to biomass production and negatively correlated to selected root traits (No. of saminal root (NSR) r = -.030, root diameter (RD) r = -.030 and Maximum root length (MRL) r = -.068). In drought conditions thirteen out of hundred genotypes viz. Kiran (2.155 g/Kg), Janbaz (1.634 g/Kg), ZA-77 (1.620 g/Kg), AS-2002 (1.612 g/Kg), Dirk (1.593 g/Kg), Zamindar-80 (1.573 g/Kg), Lasani-08 (1.569 g/Kg), Mehran-89 (1.569 g/Kg), Pirsabak-85 (1.561 g/Kg), Iqbal-2000 (1.553 g/Kg), Punjab-76 (1.549 g/Kg), Barani-70 (1.544 g/Kg) and Bakhtawar-94 (1.505 g/Kg) were showed the highest WUE while in Sonalika lowest WUE (0.376g/ Kg) and biomass production (0.197/g) was recorded. The present study reveals that it is needed to improve the root system function rather than a strong root growth for wheat high WUE and biomass production in drought conditions.

Keywords: Biomass, Correlation, Drought, Genotypes, Root traits, *Triticum aestivum*, WUE

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INTRODUCTION

Water is the main abiotic factor reducing plant growth and yield in several countries of the world [1]. The water use (WU) is the water consumed and water use efficiency (WUE) is the efficiency of consumed water to produce biomass or grain yield are serious parameters in water deficient regions. Different Plant traits and micro-nutrients can affect water use efficiency as in isolated plant condition stomatal conductance cause high transpiration and low water use efficiency but in crop condition the vapour pressure rise to reduce transpiration and increase water use efficiency [2]. In crop plants Photosynthesis is a basic component for biological yield. So rate of photosynthesis always show positive correlation with economical yield [3]. Rate of photosynthesis of the flag leaf from anthesis to grain filling may contribute to a great extent to grain development and hence ultimate yield as compared to the other leaves of a plant [4]. Water use efficiency is an important parameter for assessment of crop yield that whether yield is affected by water supply or some other factors [5]. The crop researchers need a better understanding of crop management practices for improved water use efficiency. Sufficient irrigation during the growth season may increase WUE and wheat yield expressively [6], [7], [8].

Earlier studies suggest that high yield of wheat needs early flowering, faster rate of leaf canopy development and early growth of roots when vapor pressure deficit is low. These characteristics as reduce soil surface evaporation and increase water use efficiency for biomass production [9].

Water use efficiency could be increased using nitrogen nutrition [4]. In Pakistan Water stress (drought) is usually a big constrain throughout the growing season in arid and semi-arid regions for wheat crop, resulting to a big loss of both quality and quantity of crops. Therefore, it is needed to increase wheat drought tolerance through genetic tools and techniques for better production of wheat [3], [10]. Older cultivars of wheat as compare to modern cultivars have less WUE because of larger root system growth [11]. The present experiments were carried out to investigate the relationship of WUE, biomass production and root trait system under drought stress conditions using hundred Pakistani wheat genotypes.

MATERIALS AND METHOD: A field experiment was carried out in November 2011 to June 2012 in the experimental field of Hazara

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University Mansehra, Pakistan (Latitude 34° 19´ N, Longitude 73° 45´ E). Hundred different germplasms of wheat collected from PGRI (Plant and Agriculture Research Institute) and NARC (National Agriculture Research Centre) Pakistan were germinated in petri plates containing moistened filter paper at 27 °C for 72 hours. The germinated seedlings were transferred to plastic pots of 20 cm height and 10 cm diameter. Each pot was filled of 1 Kg soil containing clay, sand and organic fertilizer in a ratio of 1:2:1. Water of 0.146 Kg was added to individual pot. All the pots were arranged in Randomized Complete Block Design with three replicates. Fertilizers application was as like local farmer practices. The pots were covered with plastic sheet containing a small pore in the center. The pots were kept in a greenhouse under a control temperature and humidity. All the pots were weighted individually and also set up three control pots without seedlings for guessing water loss via evaporation from the pore in the plastic sheet. The total weight of each pot was recorded when there is no more plant extractable water left. The shoots were harvested and was recorded the fresh weight of shoot. The roots were carefully washed for measurement of root characteristic parameters (Number of Saminal roots (NSR), root diameter (RD), and maximum root length (MRL)). After that water use efficiency was calculated by the following formula:

WUE = total weight of each pot after no more plant extractable water left –total weight of each pot + harvest shoots and record the fresh shoot weight – (water loss in control pots with no plant × 0.7*). The analysis was carried out on computer package SPSS version 16 as shown in table 1.

RESULTS: The data obtained from table 1 and 2 showed that in drought conditions increase of WUE will increase biomass production. Out of 100 wheat genotypes cultivated in Pakistan, 13 genotypesBakhtawar-94>Punjab-76>Barani-70>ZA-77>AS-2002>Zamindar-80>Iqbal-2000>Pirsabak-85>Dirk>Lasani-08>Kiran>Mehran-89>Janbaz were showed remarkable positive correlation between WUE and Biomass. The genotype Kiran has showed highest WUE (2.155g/kg) as well as biomass production (2.076g) while in Sonalika lowest WUE (0.376g/Kg) and biomass (0.197/g) was recorded as shown in figure 1. Soil drought also affects root characteristic parameters (Number of saminal roots (NSR), root diameter (RD) and maximum root length (MRL)). NSR (r= 0-.030), RD (r=0-.030) and MRL (r=0-.068) were negatively correlated to WUE and biomass but positively correlated to one another as shown in table 2. The shallow rooted system is more powerful in water uptake in drought soil as compare to deep rooted system. The root length is just a drought escape mechanism in drought soil that is why the root traits were showed great variation in drought soil as shown in Fig 4. The maximum root length is very less affected by water stress (Table 1). Therefore the root traits are more tolerant to soil drought.

Table 2: Correlation between WUE, Root parameters and biomass

	WUE	NSR	RD	MRL	Biomass
WUE	1				
NSR	-.030	1			
RD	-.030	.067	1		
MRL	-.068	.036	.177	1	
Biomass	.982**	-.028	-.043	-.047	1

**Correlation is significant at the 0.01 level

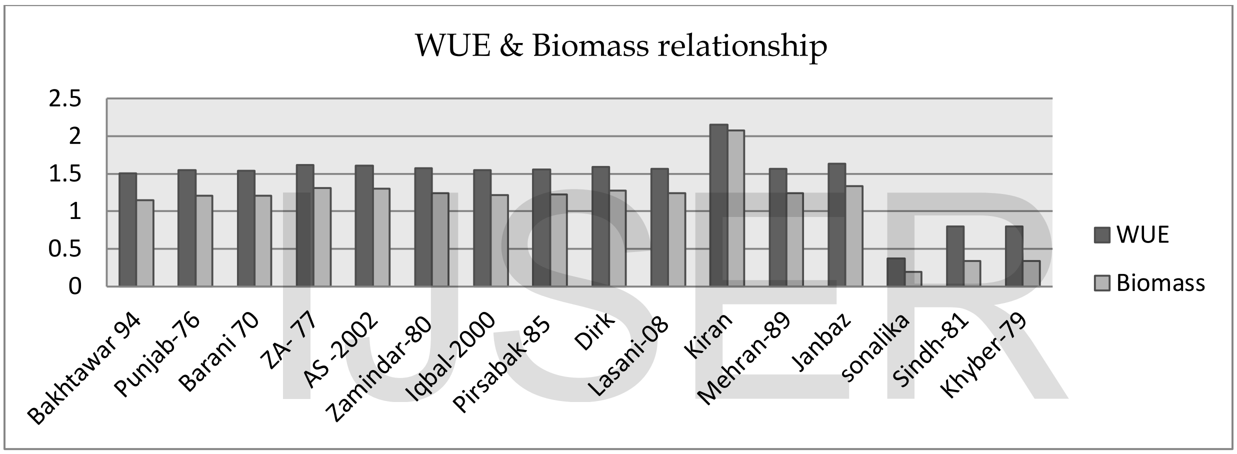

Fig No1: Relationship of WUE and biomass in selected genotypes

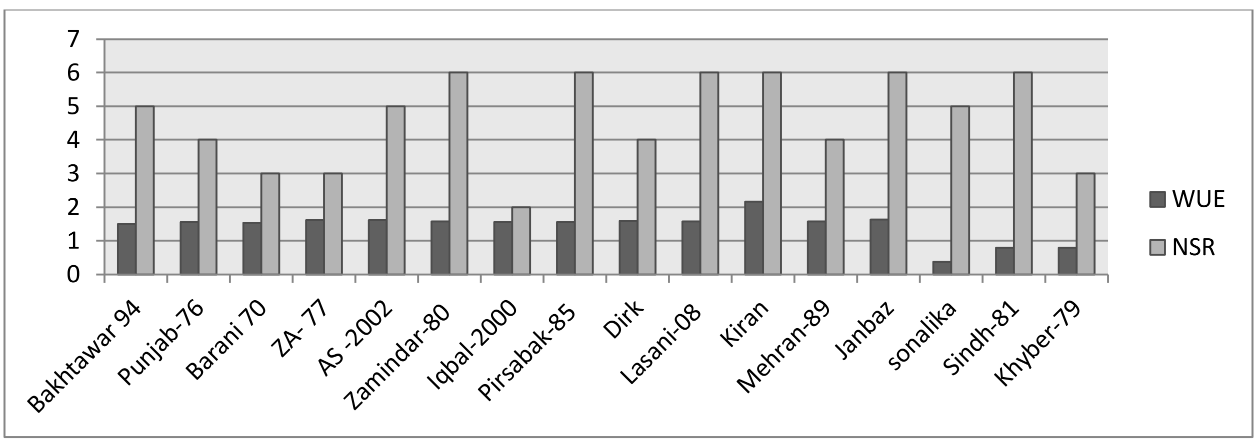

Figure2: graph showing relationship of WUE to Number of saminal roots (NSR)

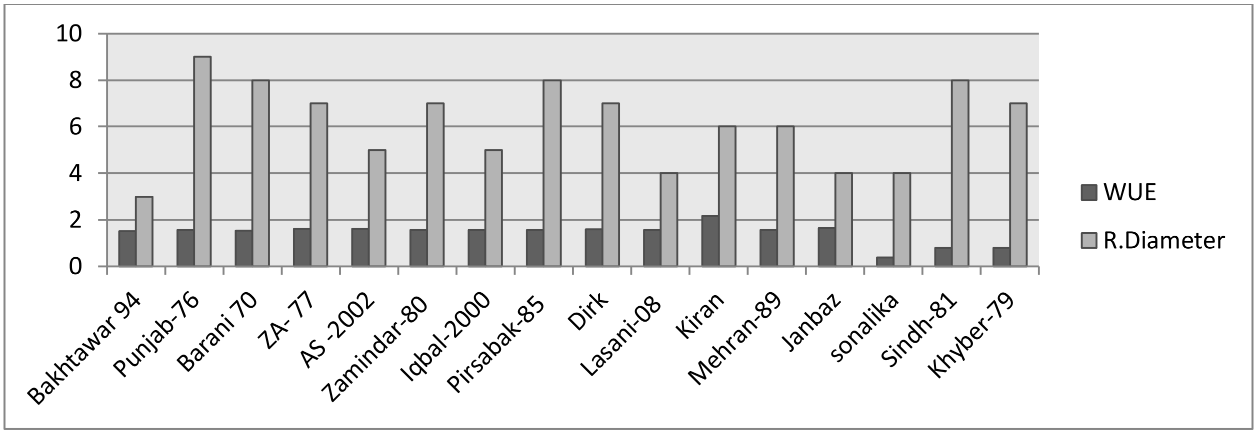

Figure 3: graph showing relationship of WUE to root diameter (RD)

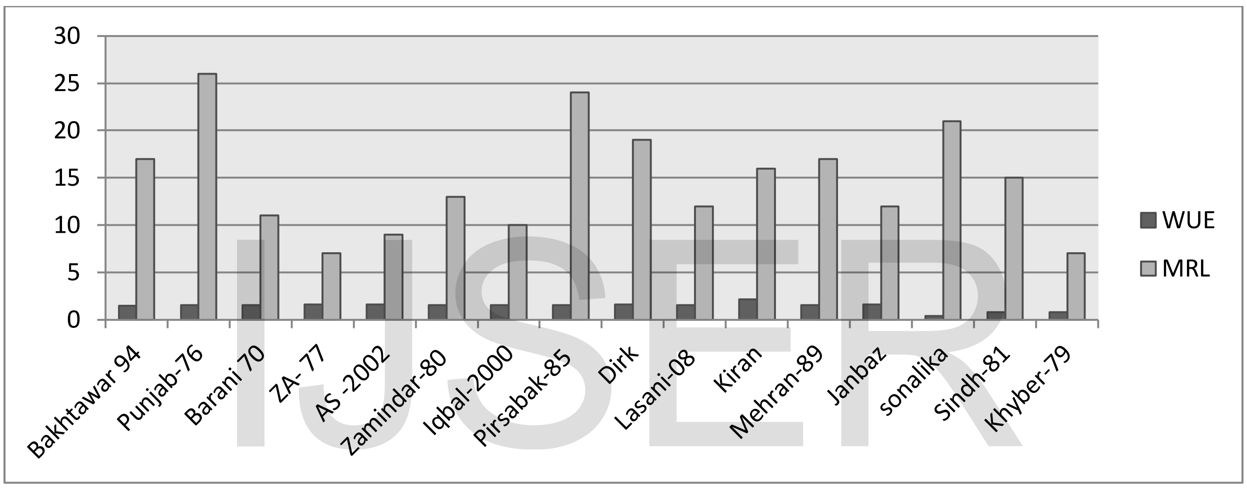

Figure 4: graph showing relationship of WUE to maximum root length (MRL)

DISCUSSION: The continuous root growth in drought soil is very important to avoid drought stress [12]. When plants are exposed to a drying soil, root morphology and growth can change to the extent that the potential root length, whether it is short or long, becomes irrelevant [13]. Modern wheat cultivars invest less in roots and have a higher water use efficiency compared to old cultivars [11]. Passioura, 1983[14] pointed out that drought resistance might be improved by decreasing the size of the root system. Wheat WUE was negatively correlated with root system growth in wheat evolution, and WUE decreased with the increase of root system growth [15]. The experiment results of Li et al. (1999) [16] by using 6 spring wheat genotypes showed that root system growth of spring wheat has an adverse redundancy for yield in the semi-arid area.

The results of present research were in accordance to the earlier researches related with WUE, Biomass, yield and root characteristic traits. The present research supports the earlier experiments that WUE is positively correlated with biomass (r= 0.982). The higher WUE in drought conditions would mean strong stomatal and mesophyll resistance in the given genotypes. The results of present study confirm that root traits are negatively correlated with WUE (No. of saminal root r = 0-.030, root diameter r = 0-.030 and Maximum root length r = 0-.068). The strong root system will reduce the WUE and hence will reduce biomass production. Therefore, it is needed to improve the root system function rather than a strong root growth for wheat survival in drought conditions. Thirteen out of hundred Pakistani wheat genotypes viz. Kiran (2.155 g/Kg), Janbaz (1.634 g/Kg), ZA- 77 (1.620 g/Kg), AS- 2002 (1.612 g/Kg), Dirk (1.593

g/Kg), Zamindar- 80 (1.573 g/Kg), Lasani- 08 (1.569 g/Kg), Mehran- 89 (1.569 g/Kg), Pirsabak- 85 (1.561 g/Kg), Iqbal- 2000 (1.553 g/Kg), Punjab- 76 (1.549 g/Kg), Barani- 70 (1.544 g/Kg) and Bakhtawar- 94 (1.505 g/Kg) were showed the highest WUE. Therefore, these genotypes have also showed a positive correlation to biomass production and can strongly be recommended for arid and semi-arid areas for high yield.

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Table 1: WUE, biomass and characteristics root traits of Pakistani wheat genotypes under drought conditions

SNo	genotypes	WUE	Biomass	NSR	RD	MRL	S No	genotypes	WUE	Biomass	NSR	RD	MRL
1	sonalika	0.376	0.197	05	04	21	29	Zamindar-80	1.573	1.246	06	07	13
2	Merco- 2007	1.392	0.988	04	04	11	30	Iqbal-2000	1.553	1.217	02	05	10
3	Manther	1.148	0.639	05	02	12	31	SH-2003	1.487	1.123	04	07	08
4	Lr-230	1.230	0.756	06	04	12	32	Anmol-91	1.165	0.664	05	06	24
5	KSK	0.899	0.284	04	06	14	33	LU-26	1.430	1.042	04	05	15
6	Maxi pak	1.270	0.813	04	08	11	34	Chenab-96	1.049	0.498	07	05	18
7	Indus- 79	1.362	0.945	05	04	04	35	Faisalabad-83	1.473	1.103	05	05	10
8	Bakhtawar- 94	1.505	1.149	05	03	17	36	Zarghoon-79	1.293	0.846	05	05	14
9	Wadanak- 85	0.989	0.412	06	05	14	37	C-228	1.295	0.849	04	04	37
10	Abdaghar- 97	1.093	0.565	05	06	`15	38	Shahkar- 95	1.229	0.755	06	05	17
11	Margalla- 99	1.266	0.807	05	05	13	39	Punjab-88	1.140	0.628	04	07	12
12	Uqab- 2000	1.078	0.539	05	06	12	40	Nuri-70	1.287	0.837	06	09	21
13	Raskoh	1.171	0.672	06	03	08	41	Punjab-81	1.409	1.011	07	05	23
14	Haider- 2002	1.134	0.619	03	04	14	42	C-591	1.376	0.965	02	06	08
15	Local white	1.069	0.527	04	04	24	43	Sutlag-86	1.387	0.986	06	03	12
16	MH-97	0.846	0.209	08	07	11	44	C-250	1.205	0.721	05	06	12
17	Zarlashta- 90	0.950	0.356	04	08	24	45	Blue silver	0.838	0.297	04	05	12
18	Punjab-76	1.549	1.211	04	09	26	46	RWP-94	1.110	0.585	06	11	06
19	Faisalabad- 85	1.367	0.951	05	07	16	47	Sariab-92	1.293	0.846	06	06	17
20	Barani- 70	1.544	1.204	03	08	11	48	Wafaq-2008	1.204	0.719	05	05	14
21	Rawal- 87	1.005	0.435	05	05	15	49	Anza+2NS	1.221	0.743	04	06	09
22	NIAB- 83	1.223	0.746	05	06	09	50	LR51-YR	1.336	0.907	03	06	13
23	GA- 2002	1.093	0.567	06	03	15	51	AUP- 5000	1.124	0.605	05	05	03
24	Chenab- 79	1.171	0.672	04	05	17	52	WL-711	1.225	0.749	06	06	11
25	Saleem- 2000	1.311	0.872	07	03	10	53	SA-75	1.085	0.549	05	05	07
26	Shalimar- 88	1.097	0.567	04	03	12	54	SA-42	1.204	0.719	05	07	23
27	Khyber- 83	1.278	0.824	03	03	06	55	Marwat-01	0.985	0.407	06	11	12
28	Chenab- 70	1.091	0.558	04	04	07	56	Barani-83	0.945	0.349	04	07	17
57	Soghat- 90	1.425	1.035	04	03	04	79	Potohar-93	1.117	0.595	07	10	18
58	Pari -73	1.306	0.865	03	06	19	80	Kohinoor-83	1.301	0.858	04	06	14
59	Chakwal- 86	1.282	0.837	04	04	03	81	Potohar-70	1.167	0.667	03	10	13
60	Wadanak- 98	1.210	0.727	04	07	13	82	Pak-81	1.177	0.686	05	07	15
61	ARE -70	1.136	0.622	05	06	11	83	Pirsabak-85	1.561	1.229	06	08	24
62	ZA- 77	1.620	1.313	03	07	07	84	C-273	1.470	1.098	06	09	18
63	Kaghan- 93	1.353	0.932	06	05	11	85	Tandojam-83	1.236	0.765	05	07	17
64	Dawar- 96	1.102	0.573	04	03	04	86	Dirk	1.593	1.274	04	07	19

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65	Sulaiman- 96	1.111	0.586	02	05	22	87	Bahlwapur-79	1.152	0.645	06	08	15
66	AS -2002	1.612	1.301	05	05	09	88	Lasani-08	1.569	1.241	06	04	12
67	LYP -73	1.226	0.758	05	07	06	89	Sussi	1.328	0.896	06	03	06
68	Noshera- 96	1.100	0.573	04	04	21	90	Khyber-79	0.796	0.337	03	07	07
69	Sindh- 81	0.796	0.337	06	08	15	91	FPD-08	1.254	0.791	03	04	16
70	Fakhri sarhad	1.043	0.489	04	07	14	92	Sandal	1.201	0.715	06	05	14
71	Yr +5	1.152	0.645	07	05	09	93	Kiran	2.155	2.076	06	06	16
72	Durum wheat	0.800	0.343	06	09	15	94	Wardak-85	1.161	0.658	04	04	11
73	Chinese spring	1.340	0.913	04	05	05	95	Meraj-08	1.379	0.969	04	06	07
74	1036-Lr51+Yr	1.011	0.444	05	04	21	96	C-518	0.899	0.284	02	05	22
75	Bakhar- 2008	1.454	1.076	06	07	18	97	potohar-90	0.945	0.349	06	05	11
76	Pirsabak- 2008	1.406	1.007	03	07	17	98	Mehran-89	1.569	1.241	04	06	17
77	Punjab-96	0.757	0.282	05	06	`15	99	Janbaz	1.634	1.332	06	04	12
78	Mumal-2002	1.186	0.694	05	03	08	100	AUP-4008	1.225	0.749	06	05	24