COMPARATIVE STUDY OF WHEAT GENOTYPES UNDER OPTIMUM AND WATER DEFICIT CONDITIONS

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Abstract

A set of 14 wheat genotypes including two checks were evaluated under irrigated (non-stress) and rainfed (stress) conditions for yield and yield components during 2009-10 at Khyber Pakhtunkhwa Agricultural University, Peshawar. Analysis across two environments revealed highly significant differences ($P \leq 0.01$) between the two production systems for tillers m^{-2} and grain yield, significant differences ($P \leq 0.05$) for number of grain spike $^{-1}$ while non significant differences were observed for 1000-grain weight. Similarly, genetic variation among the genotypes was also highly significant for spike length and 1000-grain weight while non significant for the rest of the parameters. Genotype $\times$ environment interaction was significant for tillers m^{-2} and number of grain spike $^{-1}$ only. Averaged over 14 wheat genotypes, reduction in tillers m^{-2} , spike length, grains spike $^{-1}$ and grain yield under rainfed environment was 127 m^{-2} , 0.9, 7 and 707 $kg\ ha^{-1}$, respectively compared to irrigated environment. For majority of the studied traits heritability was found lower under drought stress conditions compared to non-stressed condition.

Keywords: Grain yield; Optimum; Rainfed; Water deficit; Wheat

Introduction

Climatic change is the major reason of global warming. Most harmful result of these climatic changes will be increasing droughts and this is special challenge for crop scientists, especially for breeders, to develop new cultivars and hybrids of crops that will be able to adapt to the changed climate [1]. So the improvement of tolerant varieties for drought has been a principal goal of the majority of breeding programmes for a long time, as a water deficit in certain stages of wheat growth is common for many wheat growing regions of the world [2]. The ability of a cultivar to produce high and satisfactory yield over a wide range of stress and non-stress environments is very important [3]. Plants tolerate stress conditions at the cost of yield. To cope with this situation the yield losses should be minimized [4]. Drought stress at maturity resulted in approximately 10 % decrease in yield [5], while, moderate stress during the early vegetative period has essentially no effect on yield [5]. Interest in crop response to environmental stresses has increased greatly in recent years because severe losses may result from heat, cold, drought and high concentrations of toxic mineral elements [6]. Particularly Abiotic stresses are the most limiting factors in wheat production improvement of yield under stress conditions therefore must combine the high yield potential and specific factors, which are able to protect the crop against reductions due to different stresses [7]. Genetic increase in yield under less favorable and drought prone environments has been recognized to be a difficult challenge for plant breeders, while progress in grain yield has been much

higher in favorable environments [8]. Grain yield in wheat can be analyzed in terms of three yield components, number of spikes per unit area, number of kernels per spike and kernel weight [9]. So in this regards the following study were conducted to select best genotypes having good production under both conditions.

Materials and Methods

The experiment was conducted at Khyber Pakhtunkhwa Agricultural University, Peshawar, Pakistan during 2009-10. Twelve advanced wheat genotypes and two check cultivars, procured from the Cereal Crops Research Institute (CCRI), Pirsabak, Nowshera, Pakistan were evaluated as independent experiments under irrigated and rainfed production systems. The 12 wheat genotypes were B-IV(N)1, B-IV(N)11, B-IV(N)16, B-IV(N)17, B-VI(N)3, B-VI(N)5, B-RF1, B-RF3, B-RF7, B-RF8, B-RF15, B-RF17 and the two check cultivars were Saleem-2000 and Suliman-96. Cultivars Saleem-2000 is recommended for irrigated and Suleman-96 is recommended for rainfed, regions of Khyber Pakhtunkhwa. A randomized complete block design with three replications was used under both production systems. Both experiments were established adjacently in the same field to avoid environmental bias. However, the rainfed experiment was not irrigated throughout the growing season. A plot for each genotype consisted of 3 rows measuring 3 meters and spaced 0.30 meter apart. Both experiments were planted on 29th October, 2009 with hand hoe, using a seed rate of 110 $kg\ ha^{-1}$. Nitrogen and phosphorous were applied at the rate of 120: 60 $kg\ ha^{-1}$ for irrigated, while 60:30 $kg\ ha^{-1}$ for rainfed

experiment. The fertilizer was applied in split doses in irrigated experiment, while in rainfed experiment it was applied as a single dose at the time of sowing.

Statistical analysis

The data were statistically analyzed across the two production systems appropriate for randomized complete block design to quantify genotype x environment interaction. Data were recorded on tillers m^{-2} , spike length, grains spike^{-1} , 1000-grain weight and grain yield ha^{-1} independently. Analysis was also carried out for each production system to estimate genetic and environmental variances for computing broad-sense heritabilities for various traits.

Results and Discussion

Pooled analysis of variance exhibited significant differences among the two production systems viz. irrigated and rainfed for spikes m^{-2} ($P \leq 0.05$), spike length ($P \leq 0.01$), grains spike^{-1} ($P \leq 0.05$) and grain yield ($P \leq 0.05$). However, no difference was noted among the two environments for 1000-grain weight ($P \geq 0.05$). Genetic variation among the wheat genotypes over the two environments was not evident for spike m^{-2} , grain spike^{-1} and grain yield. Genotype x environment interaction effect was highly significant ($P \leq 0.01$) for two important yield components viz. spike m^{-2} and grains spike^{-1} , indicating change in genotypic ranking for these two traits over the two production environments (Table 1).

Independent analysis of variance showed significant genetic variation among wheat genotypes for spikes m^{-2} both under irrigated and rainfed environments (Table 1). Number of spikes ranged from 392 to 744 m^{-2} under irrigated while 312 to 491 m^{-2} under rainfed condition. Thus all wheat genotype (except BRF3) produced more spikes m^{-2} under irrigated than rainfed condition. Maximum number of spikes were produced by genotype BIV(N)1 both under irrigated (652 spikes m^{-2}) as well as rainfed (491 spikes m^{-2}). Interestingly, check cultivar Suliman-96 which is recommended for rainfed regions of Khyber Pakhtunkhwa, surpassed Saleem-2000 in spikes production under both production systems. Averaged over the 14 wheat genotypes, spikes productions under irrigated and rainfed environment was 537 and 410 m^{-2} , respectively (Table 2). Thus there was a net reduction of spikes m^{-2} under rainfed condition. Similar reduction in tillers or spikes due to drought stress has also been reported by Khaliq et al. [10] and Ihteramullah [11] in wheat. Genetic variances for spikes m^{-2} were greater than the environmental variances under both production systems (Table 4). Broad-sense heritability for spikes m^{-2} was greater in magnitude under irrigated ($h^2 =$

0.60) than rainfed ($h^2 = 0.11$) environment. Thus heritability of spikes m^{-2} was reduced by 49 units due to stress encountered under rainfed production environment. High heritability under irrigated condition indicates effectiveness of genetic improvement of spikes m^{-2} under optimum selection environment. Low heritability for spikes m^{-2} under drought stress conditions has also been reported previously by Manal [12]. Analysis of variance showed highly significant genetic variation among wheat genotypes for spike length both under irrigated and rainfed environment (Table 1). Spike length ranged from 12.4 to 13.2 cm under irrigated while 9.9 to 11.4 cm under rainfed condition. Longest spike were produced by genotype BIV(N)17 both under irrigated (13.2 cm) as well as rainfed (12.4 cm). Check cultivar Suliman-96 which is recommended for rainfed regions exceed in spike length than Saleem-2000 under irrigated condition. Averaged spike length over the 14 wheat genotypes, under irrigated and rainfed environment was 11.4 and 10.5 cm, respectively (Table 2). Data showed overall reduction in spike length under rainfed condition. Similar reduction in spike length due to drought stresses has been reported by Manal [12] in wheat. Genetic variances for spike length were greater than the environmental variances under irrigated production system while in rainfed environmental variances were greater (Table 4). Broad-sense heritability for spike length was greater in magnitude under irrigated ($h^2 = 0.60$) than rainfed ($h^2 = 0.35$) environment. High heritability under irrigated condition indicates effectiveness of genetic improvement of spike length under optimum selection environment particularly under irrigated condition. Separate analysis of variance showed highly significant genetic variation among wheat genotypes for number of grain spike^{-1} both under irrigated and rainfed environment (Table 1). Number of grain spike^{-1} ranged from 40 to 71 under irrigated while 45 to 60 under rainfed condition. Majority of wheat genotypes produced more number of grain spike^{-1} under irrigated than rainfed condition. Maximum number of grain spike^{-1} was produced by genotype BRF1 under irrigated condition. Unusually, check cultivar Suliman-96 which is recommended for rainfed regions, remained best for number of grain spike^{-1} under irrigated condition while Saleem-2000 was almost stable under both condition. Averaged over the 14 wheat genotypes, number of grain spike^{-1} productions under irrigated and rainfed environment was 58 and 51, respectively (Table 2). Average show reduction in number of grain spike^{-1} under rainfed condition.

Table-1: Mean squares for tillers m⁻², spike length number of grains spike⁻¹, 1000-grain weight and grain yield of 14 wheat genotypes across two environments (irrigated and rainfed) at Khyber Pakhtunkhwa Agricultural University, Peshawar during 2009-10.

Sources	Degrees of freedom	Tillers m ⁻²	Spike length	Number of grain spike ⁻¹	1000-grain weight	Grain yield
Environments (E)	1	338074.2**	16.47**	1001.19*	6.85 ^{NS}	10502485.76**
Reps w/n E	4	16988.6	6.92	310.72	110.04	1809062.80
Genotypes (G)	13	18597.7**	3.30**	165.12**	52.66**	524160.10 ^{NS}
G x E	13	12538.9**	0.48 ^{NS}	130.44**	9.23 ^{NS}	118682.74 ^{NS}
Error	52	4686.1	0.46	49.80	14.70	321255.64
CV (%)	---	14.44	6.23	12.73	10.612	21.14

Table-2: Means of tillers m⁻², spike length and grain spike⁻¹ of 14 genotypes evaluated under irrigated and rainfed environments at Khyber Pakhtunkhwa Agricultural University, Peshawar during 2009-10.

Genotypes	Spike m ⁻²		Spike length		Grain spike ⁻¹	
	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
BIV(N)1	652	491	10.9	9.9	54	52
BIV(N)11	525	447	10.2	10.1	58	60
BIV(N)16	555	335	11.0	10.0	58	57
BIV(N)17	475	393	13.2	12.4	56	46
BVI(N)3	600	409	12.9	10.8	67	50
BVI(N)5	524	413	11.5	10.3	61	54
BRF1	464	442	12.1	10.5	71	54
BRF15	470	374	11.6	10.1	66	45
BRF7	470	312	10.7	10.5	63	55
BRF3	392	416	11.2	10.2	63	45
BRF7	539	432	10.2	10.1	40	46
BRF8	744	389	12.3	11.4	44	53
Saleem-2000	505	418	10.9	10.4	62	60
Suliman-96	600	469	11.0	10.5	56	46
Average	537	410	11.4	10.5	58	51
LSD (5%)	110.5	119.0	1.12	1.1	14.1	8.9

Table-3: Means table of 1000-grain weight, and grain yield of 14 genotypes evaluated under irrigated and rainfed environments at Khyber Pakhtunkhwa Agricultural University, Peshawar during 2009-10.

Genotypes	1000-grain weight		Grain yield	
	Irrigated	Rainfed	Irrigated	Rainfed
BIV(N)1	35.3	34.2	2963	2493
BIV(N)11	34.2	37.0	3926	2543
BIV(N)16	32.6	31.3	2864	1950
BIV(N)17	39.5	40.5	2913	2494
BVI(N)3	34.1	35.1	2778	2234
BVI(N)5	36.7	36.8	3234	2592
BRF1	36.7	34.0	3419	2308
BRF15	40.8	37.1	2617	2074
BRF7	33.9	38.0	2703	2185
BRF3	41.8	40.5	3148	2654
BRF7	32.2	35.3	2740	2173
RF8	38.0	38.2	2506	1938
Saleem-2000	28.4	32.9	3506	2642
Suliman-96	37.2	38.8	3148	2284
verage	36.4	35.8	3033	2326
LSD (5%)	6.7	6.1	766.2	1105.7

Similar reduction in number of grain spike⁻¹ due to drought stress has been published by Manal [12] in wheat. Genetic variances for number of grain spike⁻¹ were greater than the environmental variances under irrigated condition while under rainfed condition environmental variances were greater (Table 4). Broad-sense heritability for number of grain spike⁻¹ remained the same ($h^2 = 0.39$) under both

Table-4: Genetic, environmental variances and heritability estimates of 14 wheat genotypes under irrigated rainfed condition.

Trait	Irrigated			Rainfed		
	Vg	Ve	h^2	Vg	Ve	h^2
Tillers m ⁻²	6613.2	4341.49	0.60	6414	5030	0.11
Spike length	0.68	0.44	0.60	0.27	0.49	0.35
Grains spike ⁻¹	4606	71.47	0.39	18.6	28.13	0.39
1000-grain wt.	7.8	15.9	0.32	3.02	13.47	0.18
Grain yield	83963.0	208446.7	0.28	-83852	434064.5	-0.67

environments. Analysis of variance showed significant genetic variation among wheat genotypes for 1000-grain weight both under irrigated and rainfed environments (Table 1), however, Ganbalani et al [13] published non significant result for this parameter. 1000-grain weight ranged from 28.4 to 41.8 g under irrigated while 32.9 to 40.5 g under rainfed condition. Wonderful result was that saleem-

2000 show lowest 1000-grain weight under irrigated condition while it is recommended for irrigated condition. Maximum 1000-grain weight was produced by genotype BRF3 both under irrigated (41.8 g) as well as rainfed (40.5 g). Averaged over the 14 wheat genotypes, 1000-grain weight under irrigated and rainfed environment was 36.4 and 35.8 g, respectively (Table 3). There was a little reduction (0.6 g) in 1000-grain weight under rainfed condition. Environmental variances for 1000-grain weight were greater than the genetic variances under both production systems (Table 4). High environmental variances indicate less effectiveness of genetic improvement of 1000-grain weight under optimum selection environment. So improvement through selection is not possible for this trait. Broad-sense heritability for 1000-grain weight was greater in magnitude under irrigated ($h^2 = 0.32$) than rainfed ($h^2 = 0.18$) environment. Thus heritability of 1000-grain weight was reduced by 14 units due to stress under rainfed production environment. Analysis of variance showed significant genetic variation among wheat genotypes for grain yield under irrigated while non significant under rainfed environment as well as under pooled analysis (Table 1). Improvement in grain yield is the ultimate target of majority of the plant breeders. While non significant result means that these genotypes are same under stress condition and further improvement through selection is not possible. Similar result for grain yield was also reported by Rasul et al [14]. Grain yield ranged from 2506 to 3926 kg under irrigated condition. Maximum grain yield was produced by genotype BRF3 both under irrigated (3148 kg) as well as rainfed (2654 kg). Averaged over the 14 wheat genotypes, grain yield under irrigated and rainfed environment was 3033 kg and 2326 kg, respectively (Table 3). Genetic variances for grain yield were smaller than environmental variances under irrigated while negative genetic variance under rainfed condition. It indicates that selections for improvement of grain yield in these genotypes are not possible particularly under rainfed condition (Table 4). Broad-sense heritability for grain yield under irrigated condition was ($h^2 = 0.28$) while in rainfed ($h^2 = -0.67$) it show that the variances were totally environmental. Selection for grain yield under drought stress conditions is difficult due to its low heritability resulting from variations in the intensity of the stress throughout the field [5, 15].

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