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Morphological and Variability Assessment of (F7) Wheat Lines Under Normal and Rainfed Conditions

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ABSTRACT

A field trial was performed to identify the potential genotypes in 100 wheat lines (96 F7 fixed lines and 4 controls) for yield and yield-associated traits in an augmented design under irrigated and rainfed conditions. These lines/genotypes were analyzed for days to heading, days to maturity, plant height, grain per spike, thousand-grain weight and grain yield. The wheat genotypes showed a significant G×E for all the traits across irrigated and rainfed conditions. The evaluation of variances revealed significant differences among the wheat genotypes for the evaluated morphological traits. According to the findings of the present experiment genotype, the CCRIG7-82 showed the best performance in grain yield under normal conditions. However, wheat lines CCRIG7-1 surpassed all other genotypes in grain yield under rainfed conditions. Furthermore, wheat genotypes CCRIG7-1 showed stability of the traits i.e. days to maturity in both environments i.e. (irrigated and rainfed conditions). Different drought tolerance indices were evaluated for grain yield under rainfed (Ys) and irrigated (Yp) conditions. The stress tolerance (TOL) index identified CCR1G7-82 (8100 Kg ha-1), as the most tolerant, whereas, based on mean productivity, CCR1G7-59 and CCR1G7-60 (5900 Kg ha-1), were tolerant. Similarly, the geometric mean productivity (GMP) identified genotypes CCR1G7-60 (5246 Kg ha-1), as the best tolerant. In the same way, CCR1G7-85 (4716 Kg ha-1) were identified as tolerant genotypes based on harmonic mean (HM). Stress susceptibility index (SSI), grouped genotypes CCR1G7-64 (0.07), were stress tolerant. Stress tolerance index (STI) clustered genotypes CCR1G7-60 (5.87), as the most tolerant, while yield index (YI) ranked genotypes CCR1G7-76, CCR1G7-85 (1.71), as the most tolerant. The yield stability index (YSI) desirable genotypes were CCR1G7-64 (0.90) and were noted as drought tolerance genotypes in stressed conditions.

INTRODUCTION

Cereals are generally regarded as the "staff of life". The three main cereals that make up the staple food of the majority of people on earth are wheat, rice, and maize. Wheat (*Triticum aestivum* L.) sometimes also called the "master of cereals," is a grain that is grown worldwide, particularly in irrigated, dry, and semi-arid areas. Wheat is a self-pollinating annual plant belonging to the family Gramineae having chromosome number 2n=6x=42, [AABBDD] (hexaploid), and is widely cultivated worldwide [1]. One-fifth of the world's wheat production is traded worldwide, making it one of the most important commercial

commodities [2]. Wheat, often known as bread wheat (2n = 42, hexaploid, AABBDD genomes), accounts for 90–95% of the wheat produced worldwide. Depending on the grain hardness, it can be categorized as either soft wheat or hard wheat [3].

According to the Government of Pakistan (2018), the agriculture industry accounts for 42.3% of employment and 18.9% of Pakistan's GDP, which is a significant contribution to the country's economy. In Pakistan, wheat is widely farmed for domestic use on a subsistence basis. The average monthly expenditure on wheat and wheat flour by households is 12.55% of their incomes [4]. Wheat yield in developing nations is reduced by 50-90% possibly due to water scarcity [5]. Stress caused by the environment has an important effect on the yield, which is a complex feature. Unquestionably crucial to addressing the wheat food gap is the growing yield potential.

The primary danger to the production of staple crops under a changing climate is environmental stress. The production of wheat has recently been negatively impacted by the ongoing climatic changes on a global scale, the growing water shortage, and the worsening of the environmental conditions, which has put the expanding population's well-being nutritionally at risk [6]. Since most crop breeding projects are focused on semi-arid and arid regions of the world, increasing crop tolerance to drought is one of their main goals [7]. Physiological responses to testing crop genotypes under drought stress are a possibility for drought tolerance, which is a useful strategy to effectively filter out the production of novel cultivars [8].

Therefore, we evaluated a total of 96 F7 and 4 control wheat lines in irrigated and rainfed conditions. With increased shortcomings associated with drought resistance control through cultural practices and resistant cultivars, there is a prompt need for an effective, eco-friendly, economical approach. To this end, current research deals with the screening of wheat genotypes that will perform well in terms of yield in drought and irrigated conditions.

MATERIALS & METHODS

The current study was carried out at the Pirsabak Nowshera-based Cereal Crop Research Institute (CCRI) in 2021–2022 by sowing 96 F7 fixed lines and four checks in an augmented design under both normal and rainfed conditions. The recommended fertilizer NPK doses were administered at a rate of 120, 90, and 60 kg hectare^{-1}. Every examined genotype had an experimental plot that was two meters long, had two rows, and was spaced 25 cm apart from one another. It will be possible to determine the genetic diversity and morpho-physiological impact of wheat in typical and rainfed situations by analyzing its many traits. Eleven parameters were determined during the current study: days to heading, days to maturity, plant height, grain spike, thousand-grain weight and grain yield.

Statistical Analysis

Data variance was examined in the manner suggested by Steel and Torri (1980). The least significant difference (LSD) test was used to differentiate between means. Software Statics version 8.1 was used to determine the ANOVA and correlation between traits.

Table 1

SOV	Df	SS	MS	F-RATIO
Blocks w/n Environment	e(b-1)	BSS	BMS= BSS/b-1	BMS/EMS
Environment	e-1	Env. SS	Env. MS= Env. SS/e-1	Env. MS/EMS
Genotypes	g-1	GSS	GMS= GSS/g-1	GMS/EMS
Varieties	v-1	VSS	VMS= VSS/v-1	VMS/EMS
Checks	c-1	CSS	CMS= CSS/c-1	CMS/EMS
Varieties vs Check	1	VCSS	VCMS= VCSS/1	VCMS/EMS
Genotype × Environment (G×E) interaction	(g-1)(e-1)	GESS	GEMS= GESS/ge-1	GEMS/EMS

Anova for Augmented Design

(Several selection indices, including, SSI = Stress susceptibility index Fischer and Maurer (1978) ,RSI = Relative stress index Fischer and Wood (1979),TOL = Tolerance Rosielle and Hamblin (1980) ,MP = Mean productivity Rosielle and

Hamblin (1980) ,YSI = Yield stability index Bouslama and Schapaugh, ,HM = Harmonic mean Bidinger (1987) ,GMP = Geometric mean productivity Fernandez (1992),STI = Stress tolerance index Fernandez (1992) and ,YI = Yield index Gavuzzi *et al*., (1997).

RESULTS AND DISCUSSION

Table 2

Mean Squares of various studied parameter at CCRI-Pirsabak during 2021-22.

SOV	DF	DTH	DTM	PH	GPS	TGWT	GY (kg ha^{-1})
Environment	2	11881.00**	245079.00**	30003.6*	9607.2**	8897.90**	1163000.00**
Block	3	86.25	250	264.18	610.7	239.68	41650
Genotypes	99	34.39*	298.17**	309.05**	326.1**	178.55**	21016.38**
F7 Population	95	35.24*	203.66 **	544.69**	332.7**	185.21**	19689.21*
Checks	3	13.50^{ns}	96.03**	130.48*	47.8ns	8.17ns	2154.17ns
F7 vs Checks	1	25.28	3.35	958.75	536.3	56.58	1683.99ns
Genotype×EnV.(G×E)	99	41.34*	349.91 **	441.22**	540.4**	224.11**	15898.99**
Error	9	9.58	27.78	29.35	67.9	26.63	4627.78
Heritibility (h^2)	--	0.86	0.76	0.86	0.86	0.93	0.93
Coefficient Variation (%)	--	2.7	3.5	5.7	6.8	14.6	9.9

(*, ** significance and ^{ns} = non-significance at 5% and 1%, respectively. DF = Degree of freedom, DTH = Days to Heading, DTM = Days to Maturity, PH= Plant Height, GPS = Grains per Spike, TGWT= Thousand Grain Weight, GY = Grain Yield.

Days to Heading

Wheat lines were significantly varied for heading (P ≥ 0.01) in dry and irrigated conditions with a coefficient of variation (2.7%) and 86% heritability. Variations in wheat lines and interactions between genotype and environment were significant for days before heading. The number of days to heading for wheat lines in irrigated condition ranged from 112 to 130 days with an average of 120 days. [9], also indicated that days to heading are genetically controlled and taken into consideration and highlighted similar heritability.

Days to Maturity

Combined data for days to maturity indicated (P ≥ 0.01) differences between genotypes across rainfed and normal conditions. Variations in wheat lines and interactions between genotype and environment for days to maturity were extremely important. Similarly, days to maturity had a combined coefficient of variation (CV) of 3.5%, and there were 76% heritability Wheat genotype days to maturity for normal conditions ranged from 152 to 168 days, with an average of 160.00 days. This study confirmed that wheat genotypes took fewer days to maturity in dry conditions as compared to irrigated. [10], reported comparable findings and demonstrated that days to maturity affect wheat output.

Plant Height

Wheat lines were significantly validated for plant height (P ≥ 0.01) in dry and irrigated conditions. Wheat genotype variations and interactions between genotype and environment were highly significant on plant height under both conditions (irrigated vs rainfed). Plant height was noted with a (5.7%) coefficient of variation and 86% heritability (Table 4.1). The average plant height of wheat genotypes grown in typical conditions was 104.1 cm; genotypes' heights varied from 78 cm to 135 cm. For wheat genotypes, regular planting resulted in taller plants as opposed to rainfed planting, which resulted in shorter plants. Under normal and rainfed conditions, the average plant height of 96 genotypes of F7 wheat was 104.1 cm and 87.5 cm, respectively. This research revealed a loss of 16.6 cm between irrigated and drought planting. According to [11], plant height is impacted by genetic makeup, environmental factors, and cultural practices.

Grains Spike^{-1}

In both dry and normal conditions, there were significant differences between wheat genotypes for grains spike^{-1} (P ≥ 0.01). In both circumstances (irrigated vs. rainfed), variations in wheat advance lines and interactions between genotype and environment were extremely significant in grains spike-1. The coefficient of variation was (6.8%) and 86% heritability (Table 4.2). On a normal planting date, wheat genotype grains spike^{-1} ranged from 37.3 to 68.3, with 53.0 being the average. This showed a decrease of 8.9 grains spike^{-1} between normal and rainfed planting. Earlier research had looked at similar variations in wheat varieties' grain yield [12]. Higher variation was also noted in the work of [13].

Thousand Grain Weight

The analysis of all the data combined for thousand-grain weight revealed highly significant ($P \geq 0.01$) differences between the drought and normal conditions. Variations in wheat advance lines and interactions between genotype and environment were highly significant in thousand-grain weight in both conditions (irrigated vs rainfed). The combined coefficient of variation (CV) for thousand-grain weight was 14.6%, and heritability was 93%. Wheat lines' thousand-grain weight for irrigated conditions ranged from 28.2 to 58.4, with an average of 44.8. This study confirmed that wheat genotypes produced less thousand-grain weight in dry conditions as compared to irrigated. [14], found that there are differences across wheat genotypes in terms of 1000 grain weight.

Grain Yield

Spring wheat genotypes were significantly varied for grain yield ($P \geq 0.01$) in rainfed and normal condition. Grain yield in both scenarios were highly significant by variations in wheat lines and interactions between genotype and environment (irrigated and rainfed). Coefficient of variation was (9.9%) and 93% heritability shown in (Table 4.2). In normal planting date, wheat genotypes grain yield ranged from 2500 to 9800 kg/ha, with 5569.8 kg/ha being the average. Grain production for different wheat genotypes in rainfed conditions ranged from 500 to 3700 kg/ha, with an average of 2173.4. Under normal and rainfed conditions, the average grain yield of 100 genotypes of wheat was 5569.8 kg/ha and 2173.4 kg/ha, respectively. This showed a decrease of 3396.4 kg/ha wheat grain yield between normal and rainfed. Earlier research had looked at similar variations in wheat varieties' grain yield [12].

Selection Indices

Stress Tolerance (TOL) index identified CCR1G7-82 (8100 Kg ha^{-1}), followed by the genotype CCRIG7-36 (7900 kg ha^{-1}) and CCRIG7-35 (7400 Kg ha^{-1}) as the most tolerant, whereas CCR1G7-64 and CCR1G7-78 (300 Kg ha^{-1}), as the least stress tolerant. Based on Mean Productivity, CCR1G7-59, CCR1G7-60 (5900 Kg ha^{-1}), followed by the genotype CCR1G7-82 (5750 Kg ha^{-1}) were most tolerant, while CCR1G7-79 (1550 Kg ha^{-1}) was the least tolerant to nitrogen stress (Table 4.13). Similarly, geometric mean productivity (GMP) identified genotypes CCR1G7-60 (5246 kg ha^{-1}), followed by the genotypes CCR1G7-47 (5060 Kg ha^{-1}) and CCR1G7-59 (4957 Kg ha^{-1}) as the most tolerant, whereas least tolerant genotypes CCR1G7-79 (1225 Kg ha^{-1}). According to harmonic mean (HM), genotypes CCR1G7-85 (4716 Kg ha^{-1}), followed by the genotypes CCR1G7-60 (4664 Kg ha^{-1}), and CCR1G7-14 (4644 Kg ha^{-1}) were found stress tolerant, whereas genotypes CCR1G7-83 (889 Kg ha^{-1}) was found as least tolerant.

CONCLUSION

According to the findings of the present experiment, genotype CCRIG7-82 showed the best performance in grain yield under normal conditions. Wheat line CCRIG7-01 surpassed all other genotypes in grain yield and tillers per square meter under rainfed conditions. Furthermore, wheat genotypes CCRIG7-01 showed stability for most of the qualities i.e. days to maturity, tillers per square meter, and spike length in both environments i.e. (irrigated and rainfed conditions). Different drought tolerance indices were evaluated for grain yield under rainfed (Ys) and irrigated (Yp) conditions. The stress tolerance (TOL) index identified CCR1G7-82 (8100 Kg ha^{-1}), as the most tolerant, whereas, based on the mean productivity, CCR1G7-59 and CCR1G7-60 (5900 kg ha-1), were tolerant. Similarly, geometric mean productivity (GMP) identified genotypes CCR1G7-60 (5246 kg ha-1), as the best tolerant. In the same way, CCR1G7-85 (4716 kg ha-1) were identified as tolerant genotypes based on the harmonic mean (HM). Stress susceptibility index (SSI), grouped genotypes CCR1G7-64 (0.07), were stress tolerant. Stress tolerance index (STI) clustered genotypes CCR1G7-60 (5.87), as the most tolerant, while yield index (YI) ranked genotypes CCR1G7-76, CCR1G7-85 (1.71), as the most tolerant. The yield stability index (YSI) desirable genotypes were CCR1G7-64 (0.90) and were noted as drought tolerance genotypes in stressed condition.

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