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Evaluation of agronomic traits and assessment of genetic variability in some popular wheat genotypes cultivated in Saudi Arabia

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Abstract

The present study was carried out to evaluate agronomic traits and assessment of genetic variability of some wheat genotypes at Qassim region, Saudi Arabia, during 2010/11 and 2011/12 seasons. Fourteen wheat genotypes including five bread wheat and nine durum wheat genotypes were evaluated in randomized complete block design with three replications. The genotypes were evaluated for ten different yield contributing characters viz., days to heading, days to maturity, grain filling period, grain filling rate, plant height, number of spikes m^{-2}, kernels $spike^{-1}$, 1000-kernel weight, grain yield and straw yield. The combined analysis of variance indicated the presence of significant differences between years for most characters. The genotypes exhibited significant variation for all the characters studied, indicating considerable amount of variation among genotypes for each character. Maximum coefficient of variation was observed for number of spikes m^{-2} (17%), while minimum value was found for days to maturity. Four genotypes produced statistically similar maximum grain yield, out of them two bread wheat genotypes (AC-3 and SD12) and the other two were durum wheat (AC-5 and BS-1). The genotypes AC-3, AC-5 and BS-1 had higher grain yield and stable in performance across seasons. The estimation of phenotypic coefficient of variation in all the traits studied was greater than those of the genotypic coefficient of variation. High heritability estimates (> 0.5) were observed for days to heading, days to maturity and plant height, while the other characters recorded low to moderate heritability. The high GA % for plant height and days to heading (day) was accompanied by high heritability estimates, which indicated that heritability is mainly due to genetic variance. Comparatively high expected genetic advances were observed for grain yield components such as number of kernels $spike^{-1}$ and 1000-kernel weight. Grain yield had the low heritability estimate with a relatively intermediate value for expected genetic advance. The results of principle component analysis (PCA) indicated that the superior durum wheat genotypes for grain yield in the two seasons (AC-5 and BS-1) are clustered in group II (Fig. 2). Also, the superior two bread wheat genotypes (AC-3 and SD12) were in group I.

Key word:*Triticum aestivum* L, *Triticum durum* L, earliness, agronomic traits and genetic variability

Introduction

Wheat is a major cereal and is grown under a wide range of environmental conditions in the world. The main crop species of wheat are bread wheat (*Triticum aestivum* L.) and durum wheat (*Triticum turgidum* L.). Wheat grain is a staple food used to make flour for leavened, flat and steamed breads, biscuits, cookies, breakfast cereal, pasta, noodles, and bio-fuel (Tsegaye and Berg, 2007). Durum wheat has more protein compared to the bread wheat (Zaefizadeh et al., 2011), plus more tolerance to difficult condition such as drought stress. It only has minor importance on the global wheat market (about 5%) compared to bread wheat (FAO, STAT 2015).

By increasing population, demands of wheat are increasing in all countries and introduction of advanced lines by superior traits especially according to yield, is an important issue. The efficiency of selection largely depends upon the magnitude of genetic variability present in the plant population (Farshadfar et al., 2013). Grain yield in wheat is the results of a number of complex processes affecting one another and occurring on different growing stages (Sabaghnia, 2014). Many studies on wheat productivity have attributed yield gains to a number of parameters. Yield component concept in breeding has much importance in improving yield potentiality (Khan et al., 2013). Some studies indicated that the component most affecting wheat productivity is grain number per spike (Avcin et al., 1997) and grain number per square meter (Donmez et al., 2001). In addition, Dogan (2009) reported that three-grain yield components (number of spike per unit, grain number, and thousand-grain weight) generally are the most important determinants of grain yield. However, the majority of studies indicated that productivity can be obtained by increasing harvest index without decreasing biomass (Gummadov et al., 2015).

Breeding programs depend on the knowledge of key traits, genetic systems controlling their inheritance, genetic and environmental factors that influence their expression (Mohammadi et al., 2010; Pour, 2015). Morphological and agronomic characters of wheat have a special role in determining the importance of each trait in increasing yield, so these traits are used in breeding programs, which at least lead to improving yield and introducing commercial varieties (Mollasadeghi et al., 2011).

To make the heritable improvement in characters, estimation of genetic parameters and their transfer index is required (Farshadfar and Estehghari, 2014). The genetic variance, genetic gain and heritability estimations are of great importance in plant breeding programmes (Bilgin et al., 2011). It is necessary to separate the total variation into heritable and non-heritable components with the help of genetic parameters i.e. genotypic and phenotypic coefficient of variation, heritability and genetic advance, can help the breeders to improve the success and efficiency of the selection (Paul et al., 2006). Conventional analysis of variance and statistical parameters like phenotypic (PCV) and genotypic (GCV) coefficients of variability, heritability and genetic advance have been used to assess the nature and magnitude of variation in wheat breeding material (Shankarrao et al., 2010; Afridi et al., 2014; Farshadfar et al., 2013; Farshadfar and Estehghari 2014; Mehari et al., 2015; Mursalova et al., 2015; Ur Rehman et al., 2015; Kamrani et al., 2016 ; Kaya, and Turkoz, 2016).

PCV was higher than the corresponding GCV (Amin et al., 2011; Aharizad et al., 2012). The highest value of PCV related to grain yield, harvest index and number of grains per spike, while day to heading and plant height contained the lowest value (Aharizad et al., 2012). In addition, the highest and lowest amount of GCV was related to grain yield and day to heading, respectively. Amin et al. (2011) found that GCV were high for grain yield per plant and number of tillers per plant. The estimates of GCV were high for grain yield while the remaining traits recorded moderate to low GCV estimates (Lohithaswa et al., 2011). Moreover, Sabaghnia, (2014) observed that estimates of the coefficient of variation were high for spike length and growth vigor.

Heritability estimates provide information about the extent to which a particular character can be transmitted to the successive generations. High heritability coupled with high genetic advance was reported for number of tillers plant^{-1} (Firouzian et al., 2003). Low to moderate heritability and genetic advance was reported for spike length (Safeer-ul-Hassan, 2003). Arshad and Chowdhry (2003) reported the presence of high heritability and genetic advance in various yield related traits in wheat. High estimates of heritability for all the characters studied except number of tillers and number of spikes per plant were reported by Shankarrao et al. (2010), with high genetic advance for plant height, number of spikelets per spike, thousand grain weight and number of days to heading in wheat. On the other hand, Aharizad et al. (2012) reported low heritability for grain. They also reported low value of heritability, moderate genetic efficiency and relatively high amount of (PCV) for number of grains per spike and number of spikes per square meter (Aharizad et al., 2012**).** High heritability accompanied with high expected genetic advance in case of number of grains per spike, grain yield per plant and 1000-grain weight (Amin et al., 2011). Lohithaswa et al. (2011) found high heritability estimates for day to heading, days to maturity, plant height, 1000 grain weight and grain yield. Sabaghnia (2014) reported that heritability estimates were high for 1000 grain weight, while biomass and grain yield showed the lowest heritability values. Menshawy (2007) observed that the heritability estimates in broad sense were high for plant height and number of kernels spike^{-1}, while, it was low for the other yield characters.

The present study was conducted to evaluate the performance of fourteen wheat genotypes to measure the genetic variability, heritability and genetic advance for the traits and their implication in selection of better genotypes of wheat for the development or improvement of cultivars and germplasm.

Results and Discussion

Agronomic and earliness characters of wheat genotypes

Based on the combined analysis of variance, the mean squares of year for earliness traits were significant or highly significant while non-significant for grain filling rate and plant height (Table 2). These results reflected the differences of climatic conditions prevailing during the two growing seasons. Genotype effects were highly significant for all earliness traits; therefore, the comparisons between genotypic means are valid. The combined analysis of variance showed significant differences of interactions between year and genotypes for most studied traits (Table 3). Accordingly, there were differential responses among genotypes to years. Similar results were obtained by Katsileros et al. (2015), Mehari et al. (2015), Mursalova et al. (2015), and Kaya and Turkoz (2016)

The analyses of variance for agronomic characters are presented in Table 3. The combined analysis indicated the presence of significant or highly significant differences between years for most cases. Genotype effects were significant or highly significant for all characters. The results indicate considerable genetic variability among wheat genotypes under study for all agronomic characters. The interactions of season x genotype differed significantly for grain yield only. Many researchers found significant differences among genotypes for agronomic characters (Menshawy et al., 2014; Talukder et al., 2014; Mohammad et al., 2015; Kaya and Turkoz, 2016)

The overall mean effect of seasons for all characters was first assessed by evaluating across all genotypes. The first season had higher mean values of grain filling period, grain filling rate, number of kernels spike^{-1} and grain and straw yields characters compared to the second one. Meanwhile, the second season had higher mean values of other characters. These results were representing seasonal differences and were in agreement with those obtained by Talukder et al., (2014) and Menshawy et al. (2014). In this respect, the first season had higher and lower average temperature during the vegetative and reproductive period in most cases than the second one, respectively (Fig.1). Grain growth was reported to be reduced due the high temperatures during grain filling and consequently, abnormal development and shorted this period (Stone and Nicolas, 1994; Menshawy et al., 2014). The data in Table 4. showed that the first season had great range of days to maturity, number of spikes m^{-2}, number of kernels spike^{-1}, 1000-kernel weight and grain yield, while other characters had reverse trend.

The highest coefficient of variation (CV %) was shown by number of spikes m^{-2}, followed by kernels spike^{-1} and straw yield. The least values were shown by developmental characters such as days to heading, days to maturity and plant height. In this regard, Moghaddam et al. (1997), Menshawy (2007) and Menshawy et al. (2014) found similar results for the coefficient of variation.

Genotypic differences were highly significant for earliness traits and Plant height as presented in Tables (2 and 5), when the data were pooled across years. The observed

Table 1. The name, abbreviation (Abr.) and other information related to 14- wheat genotypes used.

Ser #	Wheat genotypes	Abr.	Species	Source
1	ACSAD 901	AC-1	Bread	ACSAD
2	ACSAD 1135	AC-2	Bread	ACSAD
3	ACSAD 1145	AC-3	Bread	ACSAD
4	Sids 12	SD-12	Bread	Egypt
5	YecoraRojo	YR	Bread	USA
6	ACSAD 1333	AC-4	Durum	ACSAD
7	ACSAD 1105	AC-5	Durum	ACSAD
8	ACSAD 1331	AC-6	Durum	ACSAD
9	BaniSwaf 1	BS-1	Durum	Egypt
10	BaniSwaf 3	BS-3	Durum	Egypt
11	BaniSwaf 4	BS-4	Durum	Egypt
12	BaniSwaf 5	BS-5	Durum	Egypt
13	BaniSwaf 6	BS-6	Durum	Egypt
14	Sohag 3	SH-3	Durum	Egypt

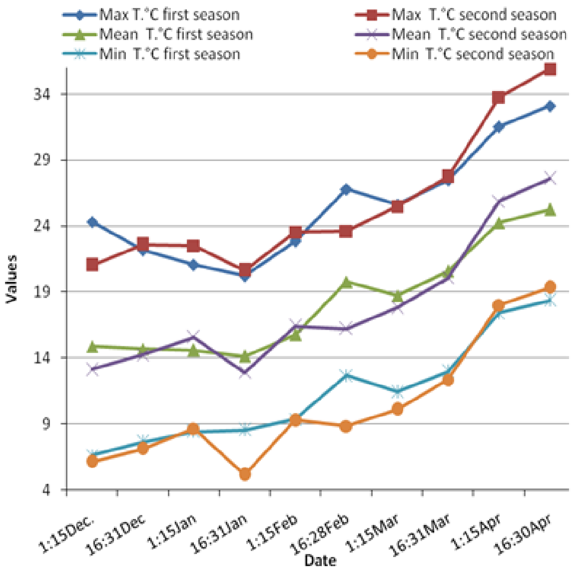

Fig 1. Weather data during two wheat growing seasons (2010/11 and 2011/12).

Table 2. Mean squares from the combined analysis of variance of the earliness and plant height traits of 14- wheat genotypes grown during 2010/11and 2011/12 seasons.

		MS				
SOV	df	DH	DM	GFP	GFR	PH
Year (Y)	1	1071.4**	223.4**	316.3*	120.5^{ns}	2.2^{ns}
Error	4	10.3	6.0	21.5	871.6	110.9
Genotype (G)	13	101.4**	33.6**	35.5**	1665.1**	353.4**
Y×G	13	17.2**	2.0ns	14.1**	1193.4**	37.7**
Error	52	3.6	2.4	4.7	287.0	14.5

ns and** = insignificant and significant at 0.01 levels of probability, respectively. DH= days to heading, DM= days to maturity, GFP= grain filling period, GFR=grain filling rate and PH= Plant height.

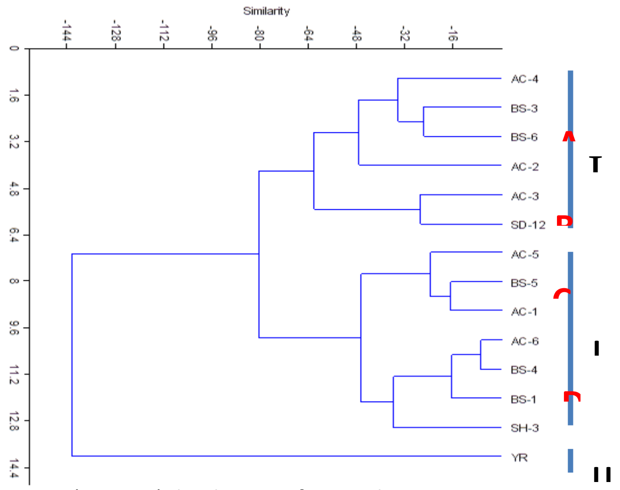

Fig 2 (UPGMA) dendrogram for 14 wheat genotypes.

Table 3. Mean squares from the combined analysis of variance of the agronomic characters of 14- wheat genotypes grown during 2010/11and 2011/12 seasons.

SOV	df	Sm^{-2}	KS^{-1}	KW	GY (t ha^{-1})	SY (t ha^{-1})
Year (Y)	1	18128.0ns	1033.2**	257.3*	17.10**	14.75*
Error	4	39913.8	39.5	22.6	0.76	1.77
Genotype (G)	13	19793.8*	249.9**	125.8**	3.32**	5.36**
Y×G	13	11484.3ns	42.8ns	21.6ns	1.19**	1.93ns
Error	52	8462.3	40.1	17.2	0.48	1.04

ns,* and** = insignificant, significant at 0.05 and 0.01 levels of probability, respectively. Sm^{-2} = number of spikes m^{-2}, KS^{-1} = number of kernels $spike^{-1}$, KW =1000-kernel weight, GY= grain yield and SY = straw yield.

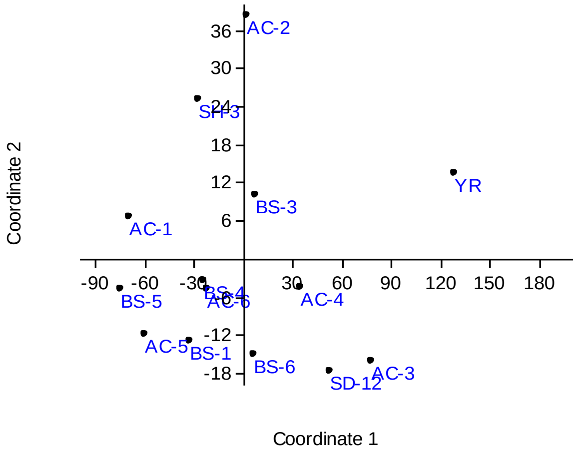

Fig 3. Principal component analysis (PCA) of the 14 wheat genotypes.

Table 4. Basic statistics data of various quantitative characters of 14- wheat genotypes grown during 2010/11 and 2011/12 seasons.

Character	Mean		Range		CV%
	2010/2011	2011/2012	2010/2011	2011/2012	
DH	75.0	82.2	68.7 - 79.3	71.3 – 88.0	2.42
DM	119.6	122.9	114 - 122.3	117.0– 125.0	1.27
GFP	44.6	40.7	41.7 - 48	36.7 - 45.7	5.08
GFR	192.1	189.7	145.7 - 218.3	136.5 - 223.3	8.87
PH	86.9	87.3	62.0– 99.0	69.7 - 100.3	4.37
Sm^{-2}	525.9	555.2	414.3 – 677.0	398.0 - 655.7	17.0
KS^{-1}	58.7	51.7	44.6 - 73.5	41.8 - 60.8	11.5
KW	51.3	54.8	41.3 - 59.5	46.6 - 62.6	7.83
GY (t ha^{-1})	8.6	7.7	6.1 - 10.1	6.2 - 9.2	8.55
SY(t ha^{-1})	10.7	9.8	8.6 - 12.2	7.8 - 12.5	9.96

DH= days to heading, DM= days to maturity, GFP= grain filling period, GFR=grain filling rate, PH= Plant height, Sm^{-2} = number of spikes m^{-2}, KS^{-1} = number of kernels $spike^{-1}$, KW =1000-kernel weight, GY= grain yield and SY = straw yield.

Table 5. Means of earliness and plant height traits for 14- wheat genotypes (a 2-year average) evaluated during 2010/11 and 2011/12 seasons.

Genotype	DH	DM	GFP	GFR	PH
AC-1	73.2	117.7	44.5	189.4	85.3
AC-2	74	120.8	46.8	155.2	97.2
AC-3	76.3	123.0	46.7	199.9	86.3
SD-12	74.5	118.5	44.0	203.3	84.2
YR	70	115.5	45.5	169.9	65.8
AC-4	80.8	122.3	41.5	193.1	98
AC-5	80.5	122.8	42.3	208.1	84
AC-6	80.8	123	42.2	197.4	88
BS-1	81.7	123.5	41.8	207.7	85.8
BS-3	81.8	122.7	40.8	181	88.3
BS-4	81.7	122.3	40.7	196.4	94.2
BS-5	81	121.7	40.7	199.2	90.8
BS-6	81.2	121.5	40.3	205.8	85.5
SH-3	82.8	122.2	39.3	166.2	86
LSD	1.8	1.5	2.0	16.0	3.6
Mean (BW)	73.6	119.10	45.5	183.54	83.76
Mean (DW)	81.7	122.08	40.36	189.72	88.96

DH= days to heading, DM= days to maturity, GFP= grain filling period, GFR=grain filling rate and PH= Plant height.

Table 6. Means of agronomic characters for 14- wheat genotypes (a 2-year average) evaluated during 2010/11 and 2011/12 seasons

Genotype	Sm^{-2}	KS^{-1}	KW	GY (t ha^{-1})	SY (t ha^{-1})
AC-1	470.8	59.5	55.5	8.43	10.27
AC-2	540	43.5	58.1	7.28	10.08
AC-3	619.2	59.7	44	9.32	10.77
SD-12	594	64.1	49.1	9.00	9.98
YR	666.3	44.5	52.5	7.73	8.18
AC-4	576.7	55.6	55.1	7.93	10.75
AC-5	481.8	55.5	59.4	8.75	10.15
AC-6	519	55.9	54.7	8.27	9.87
BS-1	509.5	52.2	59.3	8.67	12.38
BS-3	547.7	49.5	51.6	7.38	9.18
BS-4	517	56.4	54.5	7.95	10.93
BS-5	466.3	66.1	52.1	8.07	10.77
BS-6	547.5	53.1	46.3	8.32	9.90
SH-3	511.8	57.2	50.6	6.48	10.38
LSD	86.7	6.0	3.912	0.65	0.96
Mean (BW)	578.1	54.3	51.8	8.4	9.9
Mean (DW)	518.1	56.5	51.0	7.6	10.2

Sm^{-2} = number of spikes m^{-2}, KS^{-1} = number of kernels $spike^{-1}$, KW =1000-kernel weight, GY= grain yield and SY = straw yield.

Table 7. Means of earliness traits for 14- wheat genotypes evaluated during 2010/11 and 2011/12 seasons.

Genotype	Days to heading		Grain filling period		Grain filling rate	
	2010-2011	2011-2012	2010-2011	2011-2012	2010-2011	2011-2012
AC-1	70.7	75.7	44.3	44.7	213	165.7
AC-2	71.0	77.0	48.0	45.7	173.9	136.5
AC-3	74.3	78.3	48.0	45.3	197.5	202.2
SD-12	71.3	77.7	46.0	42.0	218.3	188.2
YR	68.7	71.3	45.3	45.7	180.3	159.4
AC-4	75.3	86.3	45.0	38.0	175.3	210.8
AC-5	74.3	86.7	46.3	38.3	193	223.3
AC-6	73.7	88.0	47.7	36.7	184.5	210.3
BS-1	79.3	84.0	43.0	40.7	202.9	212.4
BS-3	79.3	84.3	42.3	39.3	188.7	173.4
BS-4	79.0	84.3	42.0	39.3	200.2	192.6
BS-5	77.0	85.0	42.3	39.0	198.7	199.7
BS-6	78.0	84.3	42.3	38.3	217.1	194.4
SH-3	78.3	87.3	41.7	37.0	145.7	186.7
LSD	2.5		2.9		22.6	

Table 8. Means for plant height and grain yield for 14- wheat genotypes evaluated during 2010/11and 2011/12 seasons.

Genotype	Plant height		Grain yield (t ha^{-1})	
	2010-2011	2011-2012	2010-2011	2011-2012
AC-1	84.7	86	9.43	7.43
AC-2	95	99.3	8.33	6.23
AC-3	86.3	86.3	9.47	9.17
SD-12	82.3	86	10.07	7.93
YR	62	69.7	8.17	7.30
AC-4	95.7	100.3	7.90	7.97
AC-5	85.7	82.3	8.97	8.53
AC-6	88.7	87.3	8.80	7.73
BS-1	84	87.7	8.70	8.63
BS-3	92.5	84	7.97	6.80
BS-4	99	89.3	8.43	7.47
BS-5	88.7	93	8.40	7.73
BS-6	86.3	84.7	9.20	7.43
SH-3	86.3	85.7	6.07	6.90
LSD	5.1		0.92	

Table 9. Phenotypic (PCV) and genotypic (GCV) coefficient of variation, variance components, heritability (h^2b) and genetic advance (GA) of agronomic characters (a 2-year average).

Character	PCV	GCV	**Variance components**			**h^2b**	GA	GA %
			Vp	Vg	Ve			
DH	6.0	4.8	22.2	14.0	3.6	0.63	6.1	7.8
DM	2.3	1.9	7.5	5.3	2.4	0.70	4.0	3.3
GFP	7.9	4.4	11.4	3.6	4.7	0.31	2.2	5.1
GFR	13.5	4.6	667.7	78.6	287.0	0.12	6.3	3.3
PH	9.9	8.3	74.9	52.6	14.5	0.70	12.5	14.4
Sm^{-2}	19.3	6.9	10854.6	1384.9	8462.3	0.13	27.4	5.1
KS^{-1}	15.7	10.6	75.5	34.5	40.1	0.46	8.2	14.8
KW	11.3	7.9	36.1	17.4	17.2	0.48	6.0	11.2
GY(t ha^{-1})	12.8	7.4	1.1	0.4	0.5	0.33	0.7	8.7
SY(t ha^{-1})	13.5	7.4	1.9	0.6	1.0	0.30	0.9	8.3

DH= days to heading, DM= days to maturity, GFP= grain filling period, GFR=grain filling rate, PH= Plant height, Sm^{-2} = number of spikes m^{-2}, KS^{-1}= number of kernels spike^{-1}, KW =1000-kernel weight, GY= grain yield and SY = straw yield.

significant variation among the genotypes might reflect, partially, their different genetic backgrounds.

Days to heading ranged between 70 days in YR to 82.8 days in SH-3. Bread wheat genotypes under study were headed earlier than durum wheat based on the mean for each species (Table 5). Plant breeders are interested in development of new genotypes, which reach maturity earlier. Maturity period is one of the important trait that help genotypes in different ways to cope with various abiotic and biotic stresses. Early maturing genotypes could escape heat and drought stresses by completing their life cycle earlier. Days to maturity ranged from 115.5 days (YR) to 123.5 days (BS-1) among the genotypes with (Table 5). Grain filling period varied from 39.3 days for SH-1 to 46.8 days for AC-2. However, grain filling rate was ranged from 155.2 (AC-2) to 208.1 (AC-5). The genotype AC-2 which had longest grain filling period possessed the lowest grain filling rate. Based on the mean of each species bread wheat genotypes had long grain filling period and low grain filling rate, while the reverse was found for durum wheat genotypes (Table 5). These results are in accordance with the findings of Menshawy (2007) who reported that the genotypes which had long grain filling periods showed low grain filling rate in general. Plant height ranged from 65.8 cm in YR to 98 cm in AC-4. These results are supported by other researchers who created a high genetic variability among wheat genotypes in many of the traits included in their studies (Mohammad et al., 2015; Mursalova et al., 2015; Pour, 2015; Kaya and Turkoz, 2016)

Yield characters are important parameters and plant breeders are interested in evolving new genotypes with high yield. Highly significant genotype differences occurred for most yield characters when the data were pooled across years (Tables 3 and 6). Number of spikes m^{-2} varied from 466.3 in BS-5 to 666.3 in YR. Highest number of kernels spike^{-1} was displayed by BS-5 (66.1) followed by SD-12 (64.1), while AC-2 had lowest number (43.5). 1000-kernel weight among the genotypes ranged from 59.4g (AC-5) to 44 g (AC-3). Grain yield among the genotypes ranged from 6.48 t ha^{-1} to 9.32 t ha^{-1}. AC-3 produced higher and statistically similar with genotypes SD-12, AC-5 and BS-1. These genotypes were considered the best genotypes for grain yield, as they showed maximum grain yield compared to other genotypes. Straw yield among the genotypes ranged from 12.38 t ha^{-1} (BS-1) to 8.12 t ha^{-1} (YR). Four genotypes produced statistically similar maximum grain yield. They were two bread wheat genotypes (AC-3 and SD12) and the other two were durum wheat (AC-5 and BS-1). These genotypes showed highest grain yield over the grand mean. They are considered as wide adaptive for Qassem Region and the most appropriate commercial varieties for farmers. Therefore, they could be considered promising for to develop new high yielding genotypes in bread and durum wheat in future breeding program. Bread wheat genotypes possessed highest number of spikes m^{-2}, heaviest kernel weight and highest grain yield while durum wheat had higher values for other two yield traits based on the mean for each species (Table 6). Many researchers reported significant differences for yield characters among the wheat genotypes (Amir et al., 2014; Mehari et al., 2015; Ur Rehman et al., 2015; Kaya and Turkoz, 2016)

The data in Table 7 showed that days to heading was lower in the first season than second in all genotypes. This result could be due to differences between weather data of two seasons (Fig. 1). The YR was the earliest genotype in two seasons which statistically differed from all genotypes in the second season, whereas AC-6 was the latest in the second season. The temperature was high at grain filling (Fig. 1) in second season, which shortened the duration of grain filling in most genotypes. AC-6 had the shortest grain filling period in the second season, meanwhile, AC-2 and YR had the longest grain filling period in the two seasons. The grain filling rate ranged from 136.5 to 223.3 kg h^{-1} day^{-1} for AC-2 and AC-5 in the second season, respectively. AC-2, which had lowest grain filling rate, possessed longest grain filling period. On other hand, YR, which was the earliest genotype for days to heading, had the longest grain filling period. These results are confirmed by the previous results, which indicated that early genotypes had long grain filling period and low grain filling rate and the reverse for late genotypes. These results agreed with those obtained by Menshawy (2007) and Menshawy et al. (2014), while Talukder et al. (2014) reported an opposite trend. This discrepancy may be due to the use of different genotypes and environments.

Interactions between seasons and genotypes were highly significant for plant height and grain yield (Tables 2 and 3). As shown in Table (8), plant height ranged from 62 cm to 100.3 cm for YR in the first season and AC-2 in the second one, respectively. Grain yield ranged from 6.07 to 10.07 t ha^{-1} for SH-3 in the first season and SD-12 in the second one, correspondingly. AC-3 produced higher grain yield in two seasons (almost the same) than the other genotypes and significantly similar with SD-12 in the first season. In addition, AC-5 and BS-1 had high and almost the same grain yield in two seasons. The superior grain yield in the two seasons was recorded by AC-3, followed by AC-5 and BS-1. Moreover, SD-12 was the highest in the first season. These results confirm previous results, indicating two bread wheat genotypes (AC-3 and SD12) and two durum wheat (AC-5 and BS-1) as superior. Similar results were obtained by El-Sarag and Ismaeil (2013); Hossain et al. (2013); Rahmani et al. (2013) and Talukder et al. (2014).

Genetic variability of wheat genotypes

The data of phenotypic (PCV) and genotypic (GCV) coefficients of variation, estimates of the components of variance, broad-sense heritability (h^2) and genetic advance (GA) are shown in Table 9. In general, PCV was higher than GCV for all studied characters. The highest values of PCV were found for number of spikes m^{-2} followed by number of kernels $spike^{-1}$. Moreover, the highest values of GCV were found for number of kernels $spike^{-1}$ followed by plant height. Meanwhile, the lowest values of PCV and GCV were obtained for days to maturity. The smallest differences between PCV and GCV are found in days to maturity followed by days to heading and plant height, pointing a greater effect of genetic variance within the total phenotypic variance. These results are in accordance with many researchers (Afridi et al., 2014; Mursalova et al., 2015; Ur Rehman et al., 2015; Pour, 2015).

The variations exhibited by the 14 wheat genotypes indicating that the selection for several of these characters might be effective. The heritability estimates ranged from 12% for grain filling rate to 70% for days to maturity and plant height. Heritability estimates in broad-sense were high for days to heading, days to maturity and plant height, while the other characters recorded low to moderate heritability (Table 9). Heritability expresses the reliability of the phenotypic value as a guide to the selection program. These results suggest that earliness traits could be modified by selection. Menshawy (2005), Afridi et al. (2014), Mursalova et al. (2015), Ur Rehman et al. (2015) and Pour (2015) reported similar results.

The expected genetic advance, expressed as a percentage of the mean (GA%) varied from 3.3 for days to maturity to 14.8 for number of kernels $spike^{-1}$ (Table 9). The high GA% for plant height and days to heading (day) was accompanied by high heritability estimate, which indicated that heritability is mainly due to genetic variance. It can be observed from Table 9 that days to maturity, showed high values of heritability estimates accompanied by low GA%. This could be attributed to the fact that phenotypic and genotypic variances were low for these characters. Number of spikes m^{-2} showed low heritability estimates coupled with high values of PCV and moderate values of GA%, which suggested that selection gains through conventional breeding methods may not be substantial for this character. Comparatively, high expected genetic advances were observed for grain yield components such as number of kernels $spike^{-1}$ and 1000-kernel weight. As in many other crops, grain yield had the lowest heritability estimates with relatively intermediate values for expected genetic advance. Similar findings were also reported by Verma et al. (2013), Farshadfar and Estehghari (2014), Mursalova et al. (2015) and Pour (2015).

Principle Component Analysis (PCA) of wheat genotypes

The dendrogram was confirmed by PCA (Fig. 2). Wheat genotypes in the PCA scatter plot (Fig. 3), indicated by the ellipses numbered with A, B, C, and D, seemed to form a very close grouping in the dendrogram (Fig. 2). The genotypes clustered in ellipses A, B, C, and D belonged to groups I and II of the dendrogram, respectively. It is interesting that the superior genotypes for grain yield in the two seasons (AC-5 and BS-1) are clustered in group II (Fig. 3). Moreover, the results indicated that the superior two bread wheat genotypes (AC-3 and SD12) were in group I.

Materials and Methods

Plant material

This investigation was conducted in the Experimental Farm of the College of Agriculture and Veterinary Medicine, Qassim University during 2010/11 and 2011/12 seasons. The geographical position of the area lies between 26º 18' N latitude and 43º 58' E longitude, and 725 m above sea level, in Central Saudi Arabia.

A set of fourteen diverse wheat genotypes including five bread wheat and nine durum wheat from Saudi Arabia, Egypt and ACSAD was evaluated during two successive seasons. The name, abbreviation (Abr.) and other information related to 14- wheat genotypes used are given in Table 1.

Experimental design

A randomized complete block design with three replications was used. The area of each plot was 2 m^2 and consisted of five rows, 2 m long and 20 cm apart. Seeds were sown at 400 seeds m^{-2}. The genotypes were sown in the second week of December 2010 and 2011. All other cultural practices were applied as recommended for wheat cultivation in Qassem Region.

Traits measured

In both seasons, measurements of earliness and agronomic characters were taken. The earliness traits were the number of days to heading and maturity, grain filling period (GFP, equal to the number of days from heading to maturity) and grain filling rate (GFR, equal to grain yield (kg ha^{-1}) divided by GFP). The agronomic characters that measured were plant height, number of spikes m^{-2}, kernels $spike^{-1}$, 1000-kernel weight, grain yield and straw yield. Grain yield was estimated from the three central rows to eliminate the border effect of each plot and converted into ton $hectare^{-1}$. Straw yield was measured using the same way as grain yield. The weather data during 2010/11 and 2011/12 are illustrated in Figure 1.

Statistical analysis

The collected data for all variables were statistically analyzed by "MSTATC" microcomputer program (MSTATC, 1990) via analysis of variance using randomized complete block design, one factor model, combined over years. The means of genotypes were obtained and differences were assessed with LSD at 5% level of probability. Phenotypic (PCV) and genotypic (GCV) coefficients of variation were calculated according to Singh and Narayanan (2000). Variance components and heritability were calculated for studied characters using multi – location trials model according to Singh and Ceccarelli (1996). A principal component analysis (PCA) was also carried out to show multiple dimensions of the distribution of the accessions in a scatter-plot using the PAST software version 1.62 (Hammer et al., 2001).

Conclusion

The results of the experiments showed significant differences between seasons for most characters. The genotypes exhibited significant variation for all the characters studied indicating considerable amount of variation among genotypes for each character. Four genotypes produced statistically similar maximum grain yield and, out of them two bread wheat genotypes (AC-3 and SD12) and the other two were durum wheat (AC-5 and BS-1). The genotypes AC-3, AC-5 and BS-1 had higher grain yield and stable in performance across seasons. The estimate of PCV in all the studied traits was greater than those of the GCV. High heritability estimates (> 0.5) were observed for days to heading, days to maturity, and plant height, while the other characters recorded low to moderate heritability. The high GA % for plant height and days to heading was accompanied by high heritability estimate, which indicated that heritability is mainly due to genetic variance. Comparatively, high expected genetic advances were observed for grain yield components such as number of kernels $spike^{-1}$ and 1000-kernel weight. Grain yield had the low heritability estimate with a relatively intermediate value for expected genetic advance. The superior genotypes for grain yield in the two seasons (AC-3, AC-5 and BS-1) are considered as adaptive to Qassem Region and the most appropriate commercial varieties for farmers. Therefore, they could be considered as promising high yielding genotypes to develop new in bread and durum wheat in future's breeding programs.

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