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EVALUATION OF TWENTY TETRAPLOID DURUM WHEAT ACCESSIONS (*TRITICUM TURGIDUM* L. SSP. DURUM DESF) FOR GROWTH, YIELD AND QUALITY CHARACTERISTICS

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Durum wheat, international accession collections, Agronomic traits

ABSTRACT

Background Durum wheat (*Triticum durum Desf.*) is a monocotyledonous plant of *Gramineae* family and a major staple food in many parts of the world, particularly Asia. The main objective of the present study was to evaluate diversity of agronomic traits in twenty tetraploid durum wheat accessions.

Methodology A field experiment with twenty accessions of durum wheat was carried out during 2009-10 and 2010-11 seasons in the experimental field at Huazhong Agricultural University, Wuhan (Hubei), China (30º33′N). The data were collected on four randomly selected plants from each row for different growth and yield characteristics, viz. plant height, spikes plant^{-1}, length of master spike, neck length of master spike, neck of spike-flag leaf pillow length of master spike (cm), spikelets spike^{-1}, spikelets plant^{-1}, grains plant^{-1}, 1000-grain weight, grain yield plant^{-1}, grain protein content and grain starch content by using Infratec 1241 grain analyzer.

Results Statistical analysis revealed significant differences among the plant materials of diverse origins for all traits observed. It was found that accessions of durum wheat exhibited higher variation in the agronomic characters.

Conclusion Many accessions could be selected based on their single agronomic characters and could be used as donor parents to increase grain yield.

INTRODUCTION

Durum wheat (*Triticum durum Desf.*) is a monocotyledonous plant of the *Gramineae* family and of the *Triticeae* tribe and belongs to the genus *Triticum*. For commercial production and human consumption, durum wheat is the second most important *Triticum* species, next to common wheat (*Triticum aestivum L.*). Grain yield in small cereals can be analyzed in terms of three primary yield components (number of spikes m^{-2}, number of grains spike^{-1} and mean grain weight) that appear sequentially with later developing components under the control of earlier developing ones (Garcia del Moral et al. 1991; Simane et al. 1993). Grain yield is the result of many characteristics which are interdependent. Breeders always look for genetic variation among the characteristics to select desirable types. Some of these characters are highly associated among themselves and with grain yield. As in all cultivated plants, the main objective of growing wheat is for high grain yield and high quality crops. Since genotypic and environmental factors are the main components for determining the yield and quality in plants, a primary aim should be the determination of effects of genotypic factors for selection. As the effect of environment on grain yield and quality in plants is not inherited, effect of genotypic factors on grain yield and quality in plant breeding research need to be examined.

In spite of high genetic yield potential of new varieties of bread wheat, durum wheat has special economic importance because of its genetic resistance to rusts and bunt. Thus, durum wheat can increase the sustainability of farming systems under disease prevailing conditions in rain-fed areas under wheat cultivation (Sadeghzadeh and Alizadeh 2005).

Historically, plant breeders have paid insufficient attention to the practical aspects of durum wheat (Sharma and Sain 2004). Grain yield is an important trait as it measures the economic productivity in wheat. For this reason, agronomic and

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breeding studies on increasing grain yield are being conducted intensively, worldwide. For the effective selection, information on nature and magnitude of variation in population, knowledge of correlation among such traits, their contribution towards grain yield and the extent of environmental influence on the expression of these characters are necessary (Yagdi 2009). However, selection for grain yield by considering the morphological and physiological traits as indirect selection criteria is an alternative breeding approach. This has come to be known as an analytical breeding and implies a better understanding of the factors controlling development (Aparicio et al. 2000). Grain yield is a complex polygenic quantitative trait, hence, selection based on the performance of grain yield alone, is usually not very efficient (Singh and Singh 1973). Thus, identifying characters contributing to grain yield is important as it increases breeding efficiency; therefore, easily measurable characters along with the high heritability and having useful relationship with grain yield are of the paramount importance to practice indirect selection for the high yield (Gashaw et al. 2007).

In durum wheat as in most other grain crops, maximum grain yield results from an optimum balance of three yield components: (i) the number of spikes per unit land, (ii) the number of kernels per spike and (iii) the weight of single kernels (Grafius 1972; Prystupa et al. 2004). According to Freeze and Bacon (1990), these yield components have interdependent action and are able to compensate for one another in order to stabilize yield as cultural or climatic condition changes.

The improvement of durum wheat is based on the use of the genetic variability of the local collections (Blixt, 1988; Damania et al. 1992). These genetic resources contain several important agronomic and resistance genes (Grausgruber et al. 2005; Yahyaoui et al. 2006; Hysing et al. 2007). The availability of such germplasm depends on the identification of the sources of diversification (Devra and Hodgkin 1999), especially within the primary and secondary diversity centers which are characterized by large diversity. The local germplasm is adapted to a wide range of environments and carry a large reservoir of useful genes (Asfaw 1989; Cherdouh et al. 2005).

Population increase and food consumption in china and elsewhere led to changes in the breeding strategy in order to develop more productive and suitable varieties to intensive agriculture. However, in spite of their high genetic potential, these varieties are sensitive to various diseases and drought (Daaloul et al. 1998).

The aim of this study was to evaluate some agronomic traits in twenty tetraploid durum wheat accessions (*Triticum turgidum L. ssp. durum Desf)*. Therefore, in this work the evaluation of crop phenology, grain yield, yield related traits, and grain protein and starch content for different durum wheat accessions grown at the Huazhong Agricultural University, Wuhan, Hubei, China (30º33′N) were reported.

MATERIALS AND METHODS

Twenty accessions of tetraploid species, durum wheat (*Triticum durum Desf.*, 2n = 4x=28, AABB) originated from various regions in the world were used in this study. These accessions of durum wheat were grown to evaluate the diversity of some agronomic characters in wheat experimental field at the Huazhong Agricultural University, Wuhan, Hubei, China (30º33′N) over two consecutive cropping seasons 2009-10 to 2010-11 (first season 2009-10, second season 2010-11). Each accession material was planted in a row, the length of every row is 1 m and spacing 20 cm, each row repeated three times. Sowing and harvesting for both seasons were done at the end of November and in the first half of June, respectively. Occasional weed control and all other cultural practices were performed accordingly. Days to heading was measured of about 50% of the plants. The data were collected on four randomly selected plants from each row for the 13 characters, viz. plant height, spikes plant^{-1}, length of master spike, neck length of master spike, neck of spike-flag leaf pillow length of master spike (cm), spikelet spike^{-1}, spikelet plant^{-1}, grains plant^{-1}, 1000-grain weight, grain yield plant^{-1}, grain protein content and grain starch content by using Infratec 1241 grain analyzer. The means of the individual plant were utilized for statistical analysis. The computer software SAS (Statistical Analysis System) was used for all computations studies.

RESULTS

Growth and yield parameters

The results showed significant differences among treatments for plant height in both seasons. The dwarf or semi-dwarf (90 cm plant height) accessions in the first and second seasons were only 2 (accessions No 11 and 16) accounting for 10% and 2 (accessions No 12 and 16) accounting for 10% of the total materials, respectively (Figure 1). About 18 accessions showed plant height above 100 cm, accounting for 90% in both seasons. While, two accessions attained the plant height of more than 150 cm in the first season and three in the second season. Generally, it could be concluded that most of durum wheat accessions tested were high stalk varieties.

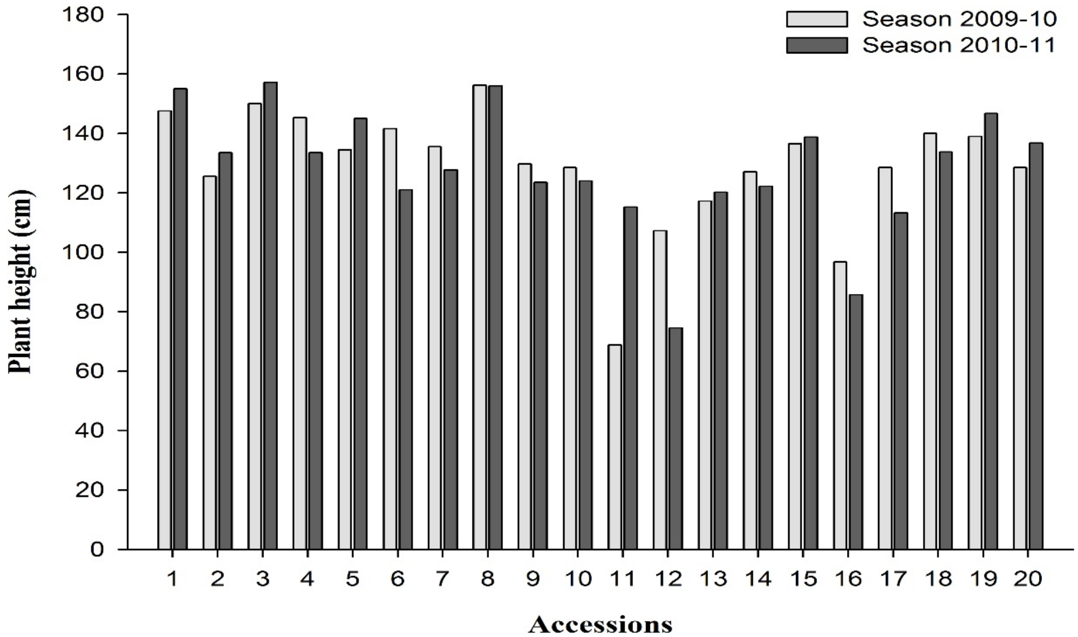

Figure 1 Plant height of twenty accessions of tetraploid durum wheat during season 2009-10 and 2010-11

Table 1 Performance of agronomic traits of twenty tetraploid durum wheat accessions (season 2009-10)

Accessions	Spikes plant^{-1}	Neck length of master spike (cm)	Neck of spike-flag leaf pillow length of master spike (cm)	Spikelets spike^{-1}	Spikelets plant^{-1}	Grains plant^{-1}	1000-grain weight (g)
1	5.5 cde	60.0 a	30.0 a	24.5 b-e	128.5 cde	207.5 b-g	22.9 bc
2	6.2 cde	44.2 de	16.5 fg	21.5 f	132.0 cde	184.0 c-h	21.6 b-e
3	9.7 b	55.7 ab	25.0 a-d	26.5 ab	239.5 a	248.2 b-g	14.5 gh
4	6.2 cde	57.2 ab	28.0 abc	26.0 abc	149.5 cde	258.0 b-f	21.5 b-f
5	6.7 cd	57.2 ab	29.2 ab	27.0 ab	173.5 bc	266.2 b-e	20.0 b-g
6	4.5 de	52.7 bc	25.2 a-d	24.5 b-e	98.5 e	167.2 e-h	19.8 b-g
7	6.5 cde	46.0 cd	23.5 b-e	23.0 def	140.0 cde	297.0 bc	18.2 c-h
8	4.0 e	56.7 ab	26.8 abc	27.5 a	105.0 e	140.7 fgh	23.7 bc
9	4.7 de	49.2 cd	23.5 b-e	26.0 abc	122.0 cde	198.7 b-g	30.6 a
10	7.7 bc	46.7 cd	24.0 a-e	23.0 def	167.5 cd	310.5 b	24.2 bc
11	6.2 cde	29.7 g	9.7 h	24.5 b-e	141.0 cde	128.7 gh	13.6 h
12	4.2 de	34.2 fg	4.0 i	25.5 a-d	108.5 e	75.2 h	19.4 b-h
13	6.5 cde	43.7 de	14.0 gh	22.0 ef	140.0 cde	170.7 d-h	16.1 e-h
14	9.7 b	47.5 cd	19.5 d-g	23.5 c-f	227.0 a	294.7 bcd	20.8 b-f
15	4.7 de	44.0 de	19.2 d-g	22.5 ef	102.0 e	187.2 c-h	22.7 bcd
16	9.2 b	38.0 ef	18.2 efg	25.5 a-d	220.5 ab	427.5 a	24.9 b
17	4.2 de	45.2 d	15.7 g	26.5 ab	107.0 e	177.0 c-h	14.2 gh
18	5.0 de	56.7 ab	26.0 abc	27.0 ab	132.0 cde	206.2 b-g	16.8 d-h
19	5.7 cde	46.0 cd	22.5 c-f	26.5 ab	140.0 cde	183.2 c-h	15.5 fgh
20	13.5 a	35.0 fg	9.0 hi	20.7 f	251.0 a	281.2 b-e	21.5 b-f
Mean	6.5	47.3	20.4	24.6	151.2	220.5	20.1
CV%	23.5	8.9	18.2	7	23.2	33.1	17.8
SE±	0.37	1.05	0.9	0.43	8.8	18.2	0.8
Significant	**	**	**	**	**	**	**

Means followed by the same letter(s) do not differ significantly according to DMRT 5%.

There were significant differences among treatments for number of spikes plant^{-1} in both seasons. The highest number of spikes plant^{-1} in the first season (13.5 spikes plant^{-1}) was obtained by accession 20 (Table 1), whereas in the second season (8.7 spikes plant^{-1}) was obtained by accession 3 (Table 2). The lowest number of spikes plant^{-1} (4.0 spikes plant^{-1}) was obtained by accession 8 in both seasons. The averages for number of spikes plant^{-1} were 6.5 and 6.2 for the first and the second seasons, respectively. The materials that obtained number of spikes plant^{-1} above 7 were up to 5, accounting for 25% of the total material for the first and second season.

The results showed that there were significant differences among treatments in length of master spike. The spike length of 14 accessions in the first season was below 10 cm, occupying about 70% of the total number of materials, whereas 18 accessions in the second season were obtained less than 10 cm spike length, occupying about 90% (Figure 2). This result revealed that most tetraploid durum wheat accessions tested had main spike length less than 10 cm. It was found that there were significant differences among treatments in neck length of master spike (Table 1 and 2). Main spike neck internodes' length in season-1 was ranged from 29.7 to 60.0 cm with an average of 47.3 cm. For the season-2, main spike neck internodes' length was 51.0 cm on average, ranged from 32.7 to 62.2 cm. Result revealed that most tetraploid durum wheat accessions tested had main spike neck internodes' length more than 40 cm, which indicated that most materials had long main spike neck internodes.

There were significant differences among treatments in neck of spike-flag leaf pillow length of master spike. Main spike neck to flag leaf pillow distance ranges from 4.0 to 30.0 cm with an average of 20.4 cm, in the first season (Table 1). In the second season, main spike neck to flag leaf pillow distance ranges from 10.7 ~ 33.0 cm, with an average of 24.9 cm (Table 2). The result indicating that the main spike neck to flag leaf pillow distance of most tetraploid durum wheat accessions tested was long. The significant differences among treatments for number of spikelets spike^{-1} in both seasons (Table 1 and 2). In season-1, the average number of spikelets spike^{-1} was 24.6 with ranging from 20.7 ~ 27.5. In season-2, the average number of spikelets spike^{-1} was 21.7 with ranging from 19 ~ 25. No accessions obtained more than 27.5 spikelets spike^{-1} in both seasons. Spikelet per plant in season-1 was significantly different, (Table 1). The average number of spikelets plant^{-1} in season-1 was 151.2, ranged from 102.0 ~ 239.5. The number of spikelets plant^{-1} in season-2 was also significantly different (Table 2). The average of spikelets plant^{-1} in season-2 was 121.0, ranged from 78.7 ~ 191.5. Only 4 accessions obtained more than 200 spikelets plant^{-1} in the first seasons, whereas, the highest spikelets plant^{-1} in the second season was 191.5.

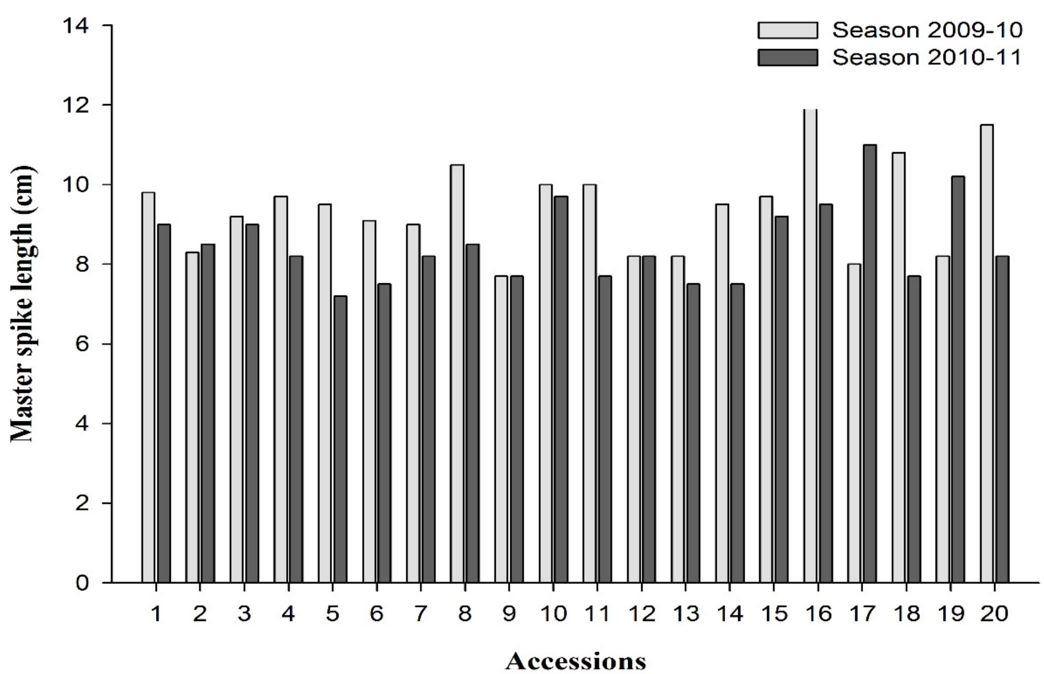

Figure 2 Master spike length of twenty accessions of durum wheat season 2009-10 and 2010-11

Table 2 Performance of agronomic traits of twenty tetraploid durum wheat accessions (season 2010-11)

Accessions	Spikes plant^{-1}	Neck length of master spike (cm)	Neck of spike-flag leaf pillow length of master spike (cm)	Spikelets spike^{-1}	Spikelets plant^{-1}	Grains plant^{-1}	1000-grain weight (g)
1	4.5 cd	62.2 a	32.2 abc	22.7 abc	99.5 bcd	173.2 de	35.2 d-g
2	7.0 a-d	58.5 abc	28.7 a-d	21.0 bcd	119.5 bcd	225.5 a-e	39.5 bc
3	8.7 a	62.2 a	32.5 ab	25.0 a	191.5 a	321.2 abc	35.5 c-f
4	6.7 a-d	57.0 a-d	33.0 a	20.5 bcd	121.5 bcd	221.7 a-e	31.0 ghi
5	5.5 a-d	57.0 a-d	33.0 a	21.0 bcd	102.5 bcd	173.5 de	34.1 d-g
6	6.0 a-d	47.7 e	21.2 g	19.0 d	97.0 bcd	147.0 e	31.2 f-i
7	7.7 abc	52.0 b-e	27.5 a-e	20.0 cd	148.5 abc	325.0 ab	29.0 hi
8	4.0 d	57.2 abc	29.2 a-d	21.2 bcd	78.7 d	144.0 e	35.1 d-g
9	7.7 abc	51.0 cde	24.5 d-g	22.5 abc	159.5 ab	297.5 a-d	36.2 cde
10	5.7 a-d	53.0 b-e	28.0 a-d	23.0 abc	113.0 bcd	210.2 a-e	38.2 cd
11	5.5 a-d	53.7 b-e	26.7 c-f	20.5 bcd	98.0 bcd	213.0 a-e	48.7 a
12	7.0 a-d	34.7 f	15.0 hi	20.7 bcd	137.2 a-d	262.0 a-e	27.0 i
13	4.7 bcd	49.2 de	21.7 fg	19.0 d	89.0 cd	188.0 b-e	29.0 hi
14	5.0 bcd	47.5 e	19.5 gh	21.5 bcd	93.2 bcd	183.2 cde	28.0 hi
15	5.2 bcd	46.5 e	22.5 efg	23.5 ab	114.0 bcd	216.7 a-e	32.4 e-h
16	6.7 a-d	32.7 f	13.7 i	25.0 a	151.5 abc	329.2 a	29.6 hi
17	7.2 a-d	33.5 f	10.7 i	20.7 bcd	130.0 a-d	202.0 a-e	34.1 d-g
18	8.0 ab	48.0 e	22.5 efg	22.5 abc	152.0 abc	187.2 b-e	27.4 i
19	6.7 a-d	59.5 ab	27.2 b-e	23.0 abc	131.5 a-d	232.7 a-e	34.4 d-g
20	4.5 cd	56.7 a-d	28.7 a-d	23.2 ab	96.0 bcd	168.0 de	42.7 b
Mean	6.2	51	24.9	21.7	121	221	33.8
CV%	31.5	9.2	13.5	8.3	32.8	37.2	11.5
SE±	0.48	1.1	0.8	0.45	9.9	20.5	0.9
Significant	*	**	**	**	*	*	**

Means followed by the same letter(s) do not differ significantly according to DMRT 5%.

Table 3 Variance of grain protein and starch of twenty tetraploid durum wheat accessions

Accessions	Season 2009-10		Season 20010-11	
	Grain protein (%)	Grain starch (%)	Grain protein (%)	Grain starch (%)
1	15.6	50.8	14.7	52.8
2	19.1	49.6	13.5	54.2
3	18.2	50.0	13.9	53.3
4	16.4	51.3	12.9	54.6
5	14.5	51.0	13.7	53.6
6	15.0	51.4	13.7	53.7
7	15.5	51.2	13.3	53.5
8	15.1	51.5	14.2	53.2
9	14.6	51.0	13.1	53.7
10	15.4	49.8	12.7	55.1
11	17.8	49.7	13.3	52.9
12	17.5	49.3	17.5	49.7
13	18.3	49.6	14.3	51.8
14	16.8	50.8	14.0	52.3
15	14.3	50.2	13.1	54.0
16	15.1	50.2	12.3	52.3
17	17.6	50.2	14.7	52.3
18	16.6	50.4	13.6	52.3
19	16.5	50.3	16.5	50.3
20	14.1	50.1	12.6	54.3

There were significant differences among treatment s for number of grains plant^{-1} in both seasons (Table 1 and 2). The average number of grains plant^{-1} in the first and second season was 220.5 and 221, ranged from 427.5~75.2 and 144.0~329.2, respectively. The most frequent number of grains plant^{-1} in both seasons was (150~300), which obtained by accession number 17 and 18 accounting for 85 and 90% in the first and second seasons, respectively. Only accession 2 and 3 obtained more than 300 grains plant^{-1}

accounting for 10 and 15 % in the first and second seasons, respectively. 1000-grains weight was 20.1 and 33.8g on average, ranged from 13.6~30.6 and 27.0~48.7 g for first season and second seasons, respectively (Table 1 and 2). There were significant differences among treatments for 1000-grains weight in both seasons. 11 accessions obtained more than 20 g for 1000-grains weight accounting for 55% in the first season, whereas 14 accessions obtained more than 30 g for 1000-grains weight accounting for 70% in the second season. Figure 3 showed that there were 7 accessions accounting for 35% of total materials tested obtained grain yield plant^{-1} ranged from 5~9 g in the first season, while 14 accessions accounting for 70% obtained grain yield plant^{-1} ranged from 5~9 g in the second season. No line in the first season obtained more than 10.5 g grain yield plant^{-1}, while there were two accessions in the second season obtained more than 10.5 g grain yield plant^{-1}.

Biochemical parameters

Grain protein content is shown in Table 3. The highest grain protein content in the first season (19.1%) was obtained by accession 2, while in the second was 17.5% obtained by accession 12. The lowest grain protein content in the first season (14.1%) was obtained by accession 20, while in the second season was 12.3% obtained by accession 16. Table 3 showed that there were 4 lines only accounting for 20% of total materials tested obtained grain protein less than 15% in the first season, while 6 accessions accounting for 30% obtained grain protein more than 17%. Grain starch was ranged from 49.3 ~ 51.5 and 49.7 ~ 55.1% for first season and second season, respectively. The most frequent grain starch % in the first season was 50 ~ 51% which was obtained by 15 accessions while 5 accessions obtained grain starch less than 50%. In the second season, more than 50% of total accessions tested obtained grain starch more than 53%.

DISCUSSION

In the present study, diversity of agronomic characters was analyzed in twenty durum wheat accessions which were planted over two seasons to explore the availability of superior genetic resources for wheat breeding. There were wide ranges of agronomic characters variation among twenty durum wheat accessions as shown by the coefficients of variation values (Table 1 and 2). In the first year of investigation, the coefficient of variation was highest for yield plant^{-1} followed by grains plant^{-1}. Plant height had a lowest value for the coefficient of variation. In the second year of investigation, the coefficient of variation was highest for yield plant^{-1} and grains plant^{-1} followed by spikelets plant^{-1} and spikelets plant^{-1}. Plant height also had a lowest value for the coefficient of variation in the second season. Almost, all the characters except protein and starch percentages showed a range of differences among the evaluated genotypes indicating the presence of adequate variability. Tesfaye et al. (1991) evaluated 1,223 entries of durum wheat accessions in Ethiopia for agro-morphological characters and reported a high degree of variation in their accessions, overall means, minimum and maximum values for the quantitative characters measured on 225 genotypes showed that the plant height ranged between 54.25 and 220.00 cm, with a mean value of 123.18 cm. Few short statured lines were identified which could be further utilized to develop fertilizer responsive and lodging resistant wheat cultivars (Oury et al. 1995) and (Masood et al. 2005). The coefficients of variation explained that there was not a wide range of variance in plant height in tetraploid durum wheat accessions studied. Spikelets spike^{-1} and spikelets plant^{-1} were an effective yield component and a greater number would result in more grains per spike and plant, respectively. Therefore, positive heterosis is desirable for these traits, the coefficients of variation values of number of spikelets plant^{-1} showed that there was a wide range of variance in both seasons; some of the accessions had high spikelets plant^{-1}. These accessions could be used as donor parents to improve number of spikelets plant^{-1} which ultimately increase grain yield. The coefficients of variation values explained that there was a wide range of variance in grain yield plant^{-1} accounting for 75% of total accessions studied, while in the second season only one accession accounting for 5% and grains plant^{-1} of tetraploid durum wheat accessions tested. Number of grains plant^{-1} ranged between about 75 and 450 whereas some of the accessions had as high as 400 grains plant^{-1}. These lines could be used as donor parents to improve number of spikes plant^{-1}, which ultimately increased the grain yield. The high variation in number of grains plant^{-1} and yield plant^{-1} observed among accessions, demonstrated that they had different capacities according to climate and environmental conditions. This variation was due, among other causes, to the different origins of the genotypes. Grain yield is a complex polygenic quantitative trait, hence, selection based on the performance of grain yield alone, is usually not very efficient (Singh and Singh, 1973). The average of main spike length was about 9 cm which was considered long. The long spikes with numerous spikelets and large kernels might be the reason for high yield potential. These traits probably resulted in the good yields.

Protein and starch % ranged from 12.3~19.1 and

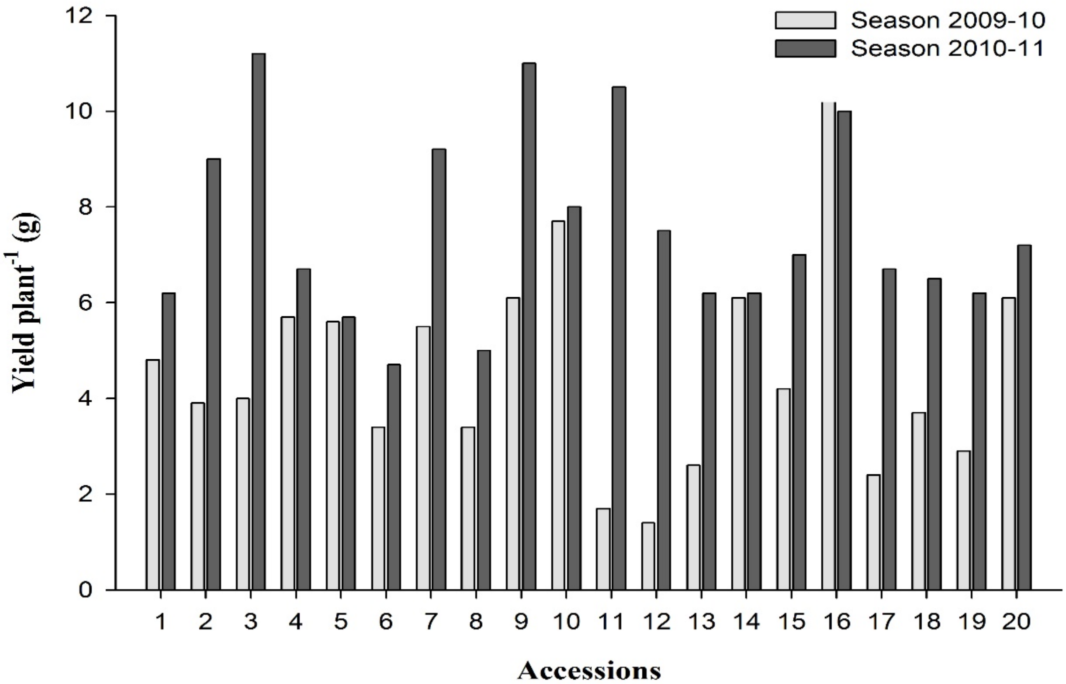

Figure 3: Yield of 20 accessions of durum wheat during season 2009-10 and 2010-11

49.3~55.1, respectively. To some extent, this result was consistent with Belderok et al. (2000) who reported that the protein content of wheat grains may vary between 10-18% of the total dry matter whereas the amount of starch contained in a wheat grain may vary between 60 and 75% of the total dry weight of the grains.

CONCLUSION

The higher variation in the agronomic characters was observed among these accessions of durum wheat indicating the presence of adequate variability. Many lines could be used as donor parents to improve the grain yield of durum wheat. This study suggested that agronomic traits could play a vital role in increasing the grain yield of durum wheat.

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