Diversity of Agronomic Traits In 225 Tetraploid Durum Wheat Accessions (*Triticum turgidum L. ssp. durum* Desf)

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Abstract: Wheat is one of the most widely grown food grain crop in the world. Approximately five percent of the worldwide wheat production is comprised of durum wheat. Durum wheat (*Triticum durum* Desf.) is mainly produced and consumed in the Mediterranean region, it is used to produce several specific endproducts. Diversity analysis is important for deciphering genetic relationship including parentage and for the efficient management of germplasm and thereby, use in breeding of improved varieties. The aim of this study was to assess some agronomic characters diversity. The main results were summarized as follows: Statistical studies over 200 durum wheat accessions, belonging to 45 countries were evaluated at wheat experimental field, Huazhong Agricultural University, Wuhan, Hubei, China (30o33′N), during two consecutive seasons (2009-10 and 2010-11), by using analysis of variance (ANOVA), correlation and principle component. Data of 13 agronomic traits were presented to understand the phenotypic diversity of these accessions. Statistical analysis revealed differences among the plant materials of diverse origins for all traits. The result indicated that higher variation in the agronomic characters was observed among these accessions of durum wheat. On the grand average, plant height of all materials was 123.18 cm (range 54.25—220.00 cm, coefficient of variance (CV) 7.87 %), the number of spikes / plant was seven (range 1～22, CV 24.54 %), the main spike length was 8.96 cm (range 4.00～31.50 cm, CV 14.73 %), the neck length of master spike was 47.99 cm (range 9.00～146.75 cm, CV 12.47 %) , the neck of spike-flag leaf pillow length of master spike was 21.16 cm (range -5.00～124.00 cm, CV 25.43 %) , the sowing-heading duration was 170 days (range 69～193 day, CV 4.00 %), the spikelets per spike was 22 (range 11～36, CV 22.72 %), the spikelets per plant was 141 (range 23～431, CV 21.05 %), the grains per plant was 234 (range 10～1152, CV 22.85 %) , the 1000 grain weight was 28.45 g (range 7.00～67.46 g, CV 14.97 %), the yield per plant was 6.88 g (range 0.44～56.19 g, CV 22.19 %), the grain protein % was 14.7 % (range 10.6～20.0 %, CV 6.12 %) and the grain starch % was 51.7 % (range 49.0～57.0 %, CV 0 %). Many accessions could be selected based on their single agronomic characters. In both studied season it showed positive correlation between yield and plant height, spikes / plant, master spike length, neck length of master spike, neck of spike-flag leaf pillow length of master spike, spikelets / plant, grains / plant, 1000 grain weight and Starch %, whereas number of spikelets per spike had significant and positive correlation with grain yield in season 2010-11 only, suggesting the usefulness of these parameter for selection to improve grain yield. Grain yield was negatively correlated with protein % and days to heading in both years. Many studied lines could be used as donor parents to increase grain yield.

Index Terms: Agronomic Traits, Durum wheat,

I. Introduction

Durum wheat (*Triticum durum* Desf.) is cultivated on approx 17 million hectares worldwide. The major durum producing countries are UE, Canada, Syria, USA, Algeria and Morocco, while minor production areas include Russia, Turkey, Tunisia, Mexico and India. Italy, for the first time produced pasta from durum wheat in the world and an intense breeding activity has been conducted over the last century to support the long tradition of pasta making. The long-term history of durum breeding has been characterized by the constant release of leading cultivars that in turn become progenitors of new cultivars, selected to perform well under intensive crop management [28]. According to [19], average area planted annually to durum wheat is approximately 18 million hectares, with production averaging about 30 million metric tons annually. The European Union (mainly Italy, Spain, and Greece) is the largest durum wheat producer, averaging eight million metric tons annually. Canada is the second largest producer at 4.6 million metric tons per year followed by Turkey (4 million metric tons) and the USA (3.5 million metric tons) [19].

Durum wheat currently represents 8 to 10% of the wheat grown and produced worldwide [13].It is however, present in relatively small geographical areas where it often plays a major role in the food security of urban populations and in the livelihood and nutrition of urban communities. More than 80% of the spring durum cultivars released in the developing world, covering more than 50% of the area planted to this crop, are semi dwarf types, either from The International Maize and Wheat Improvement Center (CIMMYT) crosses or from crosses involving at least one CIMMYT parent [21].

The productivity of durum wheat is often limited by an array of a biotic stresses that avoid a successful growth and a complete grain filling [35]. 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 [18] and [29]. According to [15], 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. Most research shows that, yield increases to a plateau value dependent on the environmental conditions during crop growth [2]. The selection of adequate genotypes for a specific environment and good crop husbandry are, therefore, of paramount importance for maximizing yield. The number of culms formed depends on the factors including variety, growing conditions, and planting density. Under usual field conditions, a plant may produce a total of three culms in addition to the main shoot, although not all will necessarily produce grain [6]. In durum wheat, proteins are essential for quality, although, it has been shown that grain protein percentage alone does not necessarily determine pasta cooking quality [11] and [4], which is also strongly affected by the allelic composition for endosperm storage proteins, (gliadins and glutenins) largely influencing strength and elasticity of the dough for pasta processing [8]; [10]; [36] and [31]. 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 grain [5].

The observations and results of the present study conducted on over 200 durum wheat accessions from 45 different countries was used to evaluate the accessions on the basis of their agronomic traits, this could assist in selecting the superior quality accessions for doing intensive wheat breeding programme.

II. Materials and Methods

Plant materials

A total of 225 accessions of tetraploid species, durum wheat (*Triticum durum* Desf., 2n=4x=28, AABB) originated from various regions including 15 from north Africa, nine from south and east Africa, 50 from north America, 15 from south America, nine from Australia, 34 from Europe, 27 from The Fertile Crescent, 16 from west Asia, 19 from east Asia, 19 from south and central Asia and 12 from Former Soviet Union zone (Table 1) used in this study were kindly provided by Professor Junhua Peng, at the Wuhan Botanical Garden/Institute Chinese Academy of Sciences 430074,Wuhan, China.

Field trails and traits evaluation

Over 200 accessions of durum wheat were grown to evaluate diversity of some agronomic characters in wheat experimental field at the Huazhong Agricultural University, Wuhan, Hubei, China (30°33′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 1m and spacing 20 cm, each row repeated three times. Sowing and harvesting for both seasons took place at the end of November and in the first half of June, respectively, field management was the same as field production. Occasional weed control and all other cultural practices were performed according to local practices. 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, length of master spike, neck length of master spike, neck of spike-flag leaf pillow Length of master spike (cm), spikelet/spike, spikelet/plant, grains/plant, 1000-grain weight, grain yield/plant, days to heading, grain protein content and grain starch content by using infratec 1241 grain analyzer. The means of the individual plant were utilized for statistical analysis.

Statistical analysis

The computer software SAS (Statistical Analysis System) was used for all computations studies.

III. Results

Performance and variance of agronomic traits of tetraploid durum wheat accessions is shown in Table (1).

Plant height

The statistical analysis revealed a wide range of agronomic traits diversity in the studied durum wheat accessions. During 2009-10 the average plant height was 122.17 cm ranged from 57.50 ~ 174.00 cm, the coefficient of variation was 3.63 % however, in the second season the average plant height was 124.27 cm ranged from 54.25~ 220.00 cm, the coefficient of variation was 10.41 % (Table 1). The combined analysis for the plant height data for the two seasons is shown in Table (1). The average of plant height was 123.18cm ranged from 54.25~ 123.18 cm, the coefficient of variation was 7.87 %. The coefficient of variation explained that there was not a wide range of variance in plant height of tetraploid durum wheat accessions tested.

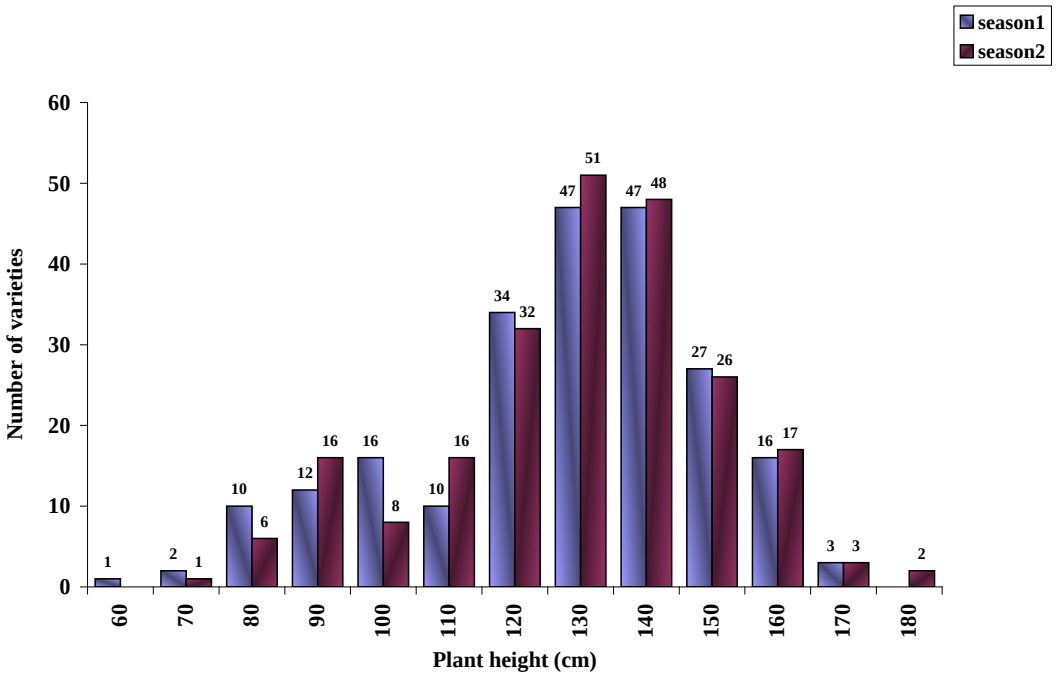

Fig. 1. Plant height frequency distribution of some tetraploid durum wheat accessions.

Table 1. Performance and variance of agronomic traits of tetraploid durum wheat accessions

Parameters Of Index		Plant Height (cm)	Spikes /plant	Master spike length (cm)	Neck length Of master spike (cm)	Neck of spike-flag leaf pillow Length of master spike (cm)	Spikelet /spike	Spikelet /plant	Grain /plant	1000 grain weight (g)	Yield /plant (g)	Days to heading	Protein %	Starch %
Min	Season1	57.50	2	4.00	17.00	-5.00	13	40	36	7.50	0.50	69	10.9	49.0
	Season2	54.25	1	4.88	9.00	-4.25	11	23	10	7.00	0.44	105	10.6	49.2
	combined	54.25	1	4.00	9.00	-5.00	11	23	10	7.00	0.44	69	10.6	49.0
Max	Season1	174.00	20	23.00	75.00	41.00	36	380	678	67.46	20.57	193	20.0	55.1
	Season2	220.00	22	31.50	146.75	124.00	32	431	1152	65.89	56.19	184	20.0	57.0
	combined	220.00	22	31.50	146.75	124.00	36	431	1152	67.46	56.19	193	20.0	57.0
X	Season1	122.17	7	9.13	46.76	19.82	23	141	221	23.60	5.30	175	15.6	50.6
	Season2	124.27	7	8.78	49.20	22.50	21	141	246	33.30	8.46	164	13.9	52.8
	combined	123.18	7	8.96	47.99	21.16	22	141	234	28.45	6.88	170	14.7	51.7
STDEV	Season1	22.38	2.88	1.95	9.21	7.26	8.82	58.33	105.76	6.49	2.88	10.30	1.38	0.80
	Season2	23.50	3.04	2.38	11.28	9.87	2.65	56.91	118.86	8.62	4.90	16.46	1.53	1.57
	combined	22.96	2.97	2.18	10.37	8.77	6.60	57.60	113.14	9.04	4.32	14.89	1.68	1.67
CV (%)	Season1	3.63	15.21	6.32	7.29	15.77	29.59	14.72	15.02	14.91	22.54	4.50	0	2.29
	Season2	10.41	29.93	20.20	15.75	30.71	8.96	25.66	27.19	14.55	20.78	3.35	7.62	4.27
	combined	7.87	24.54	14.73	12.47	25.43	22.72	21.05	22.85	14.97	22.19	4.00	6.12	0

The dwarf or semi-dwarf (90 cm plant height) accessions in the first and second seasons were only 41, accounting for 18.2 % and 31 accounting for 13.8 % of the total materials, respectively (Figure 1). About 184 accessions showed plant height above 100 cm, accounting for 81.8% and 194 accessions accounting for 86.2% of the total materials for the first and second seasons, respectively. Among which the plant height more than 160cm was obtained by three accessions in the first season and five in the second one. Generally, it could be concluded that most of durum wheat accessions tested were high stalk varieties.

Spikes per plant

It showed that the average of spikes per plant in the first season was seven ranged from 2 ~ 20 with coefficient of variation 15.21 %, whereas the same average seven ranged from 1 ~ 22 with coefficient of variation 29.93 % was obtained in the second season (table 1). The combined analysis for spikes per plant for the two season displayed seven as an average, ranged from 1 ~ 22 and coefficient of variation 24.54 %. The coefficients of variation explained that there was a range of variance in spikes per plant of tetraploid durum wheat accessions tested. The most frequent number of spikes per plant in the first season was five, obtained by 46 lines accounting for 20.4 % while in the second season was seven, obtained by 52 lines accounting for 23.1 %. The materials that obtained number of spikes per plant above seven were up to 80, accounting for 35.6 % and 93 accounting for 41.3 % of the total material for the first and second season, respectively. The number of spikes per plant more than 15 was obtained by four lines in the first season however 19 spikes per plant was the maximum in the second season which obtained by two lines (Figure 2).

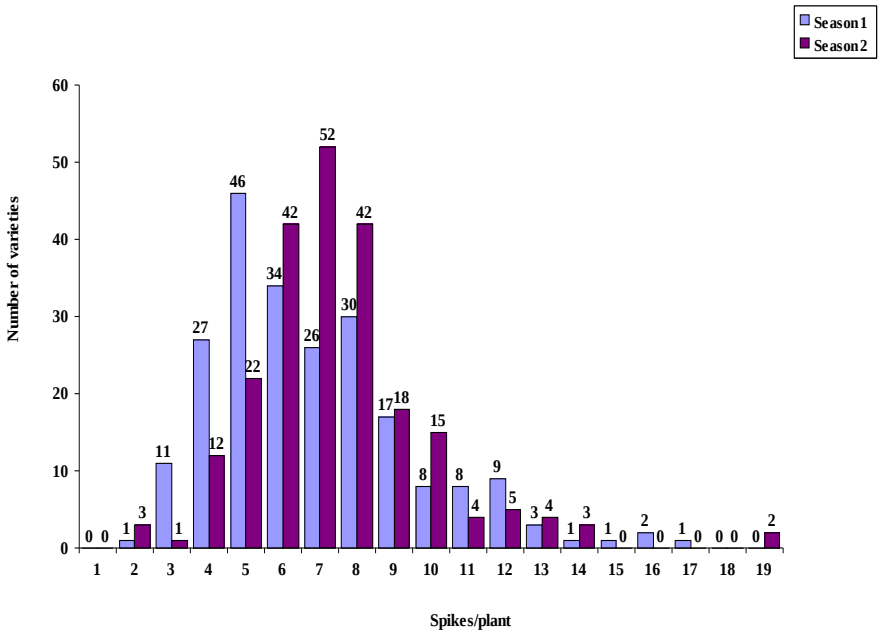

Fig. 2 Spikes per plant frequency distribution of some tetraploid durum wheat accessions.

The main spike length (cm)

The main spike length were 9.13, 8.78 and 8.96 cm on an average, ranged from 4.00 ~ 23.00, 4.88~31.50 and 4.00~31.50 cm, while the coefficient of variation is 6.32, 20.20 and 14.73 % in the first season, the second season and combined analysis, respectively. The spike length of 134 accessions in the first season is below 10 cm, occupying about 60 % of the total number of materials, whereas 176 lines in the second season were obtained less than 10cm spike length, occupying about 78.2 % (Figure 3). This result revealed that most tetraploid durum wheat accessions tested had main spike length less than 10 cm.

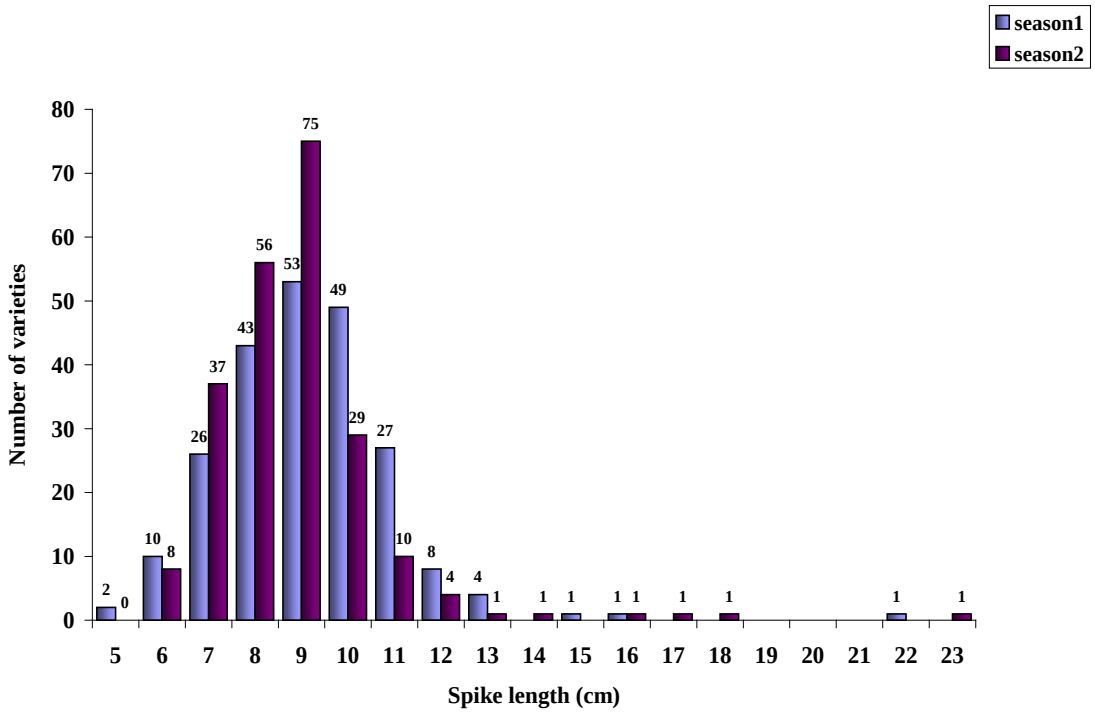

Fig. 3. Spike length frequency distribution of some tetraploid durum wheat accessions.

Neck length of master spike (cm)

Main spike neck internodes' length in season (1) was 46.76 cm on average, ranged from17.0 to 75.0 cm, the coefficient of variation was 7.29 %. For the second season main spike neck internodes' length was 49.20 cm on average, ranged from 9.00 to 146.75 cm, the coefficient of variation was 15.75 %. The combined analysis for neck length of master spike for the two seasons was shown in Table (1). The average of neck length of master spike was 47.99 cm ranged from 9.00~ 146.75 cm, the coefficient of variation was 12.47 %. Figure 4 showed that 173 and 186 accessions of main spike neck internodes' length was more than 40 cm, accounting for the 76.9 and 82.7 % of tested materials in the first and the second season, respectively. This result indicated that most materials had long main spike neck internodes.

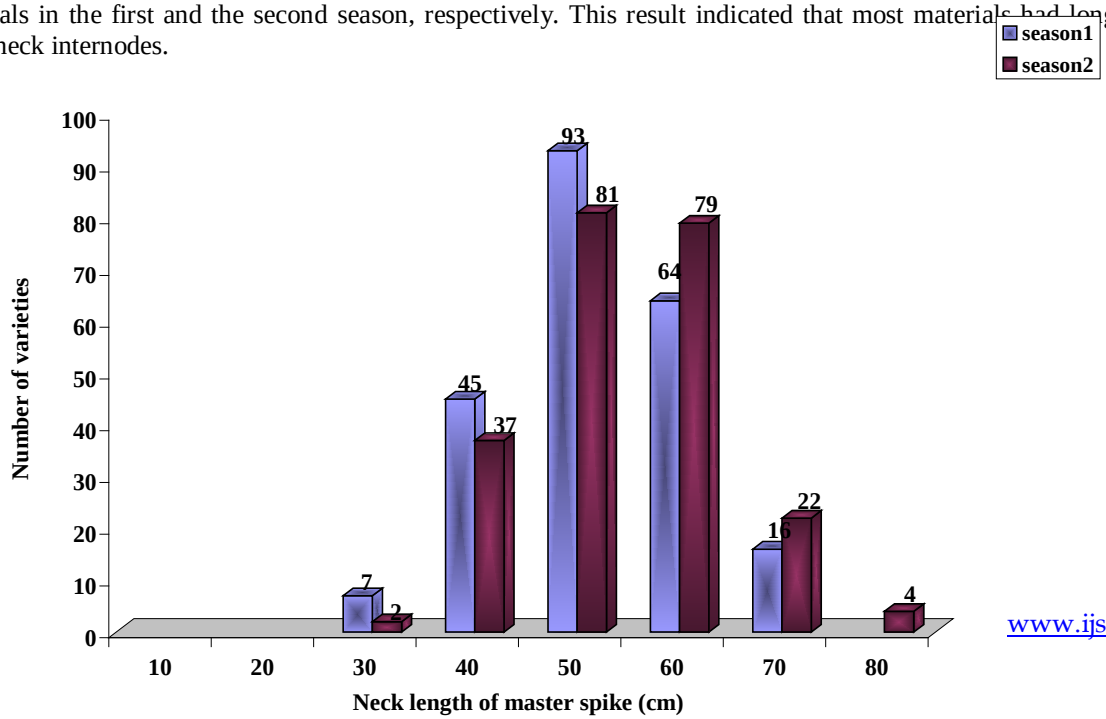

Fig. 4. Neck length of master spike frequency distribution of some tetraploid durum wheat accessions.

Neck of spike-flag leaf pillow Length of master spike (cm)

Main spike neck to flag leaf pillow distance ranges from -5.00 to 41.00 cm, 19.82 cm on average, the coefficient of variation was 15.77 %, in the first season. In the second season main spike neck to flag leaf pillow distance ranges from – 4.25 ~ 124.00 cm, 22.50 cm on average and the coefficient of variation was 30.71 %. While the combined analysis for main spike neck to flag leaf pillow distance data for the two season in Table (1) displayed 21.16 cm as an average ranged from – 5.00 ~ 124.00 cm and coefficient of variation 25.43 %. Figure 5 showed that 172 and 179 accessions, main spike neck to flag leaf distance was above 20.00 cm, accounting for 76.4 and 79.6 % of the total in the first and the second season, respectively indicating that the main spike neck to flag leaf pillow distance of most tetraploid durum wheat accessions tested was long.

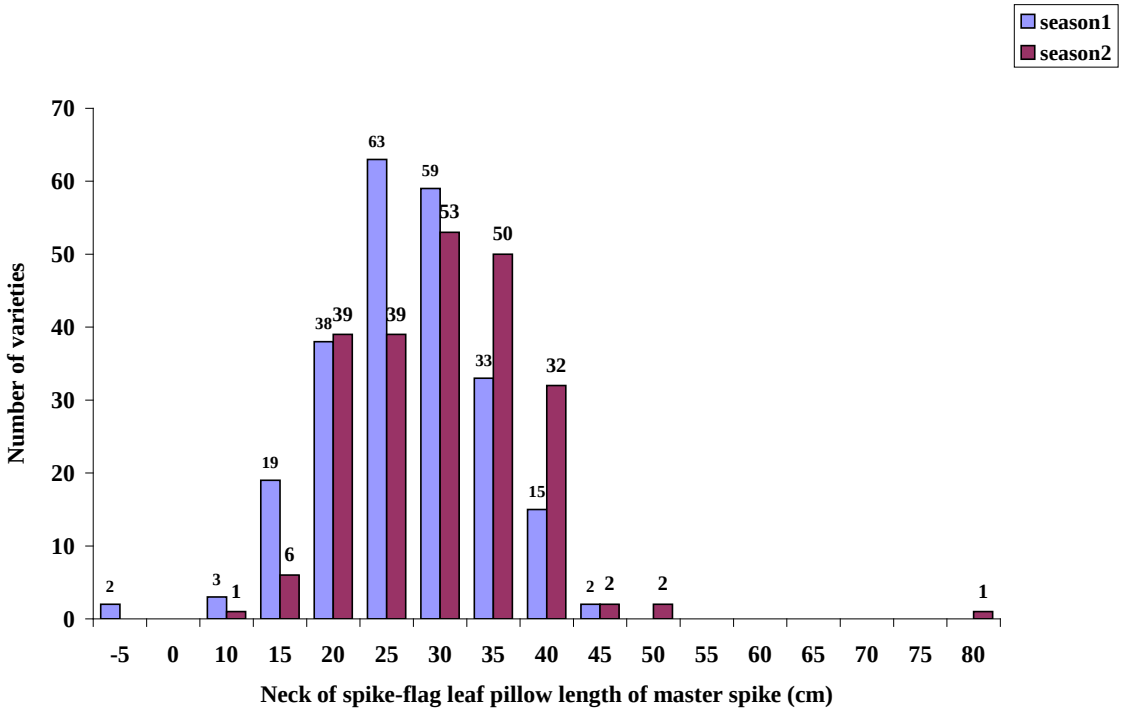

Fig. 5. Neck of spike-flag leaf pillow length of master spike frequency distribution of some tetraploid durum wheat accessions.

Days to heading

The period from sowing to heading is shown in table (1). In connection with first season the average was 175 days ranged from 69 ~ 193 days, the coefficient of variation was 4.50 %. Concerning the second season the average was 164 days ranged from 105 ~ 184 days, the coefficient of variation was 3.35 %. Of the combined analysis the average was 170 days ranged from 69 ~ 193 days; the coefficient of variation was 4.00 %. Only one accession was precocious (< 170 days) in the first season while 24 materials were precocious in the second season. The majority of tested materials were Late-maturing (> 170 d) type, in season one Almost 100 % were Late-maturing type, whereas 89.3 % of tested materials were Late-maturing in second season (Figure 6).

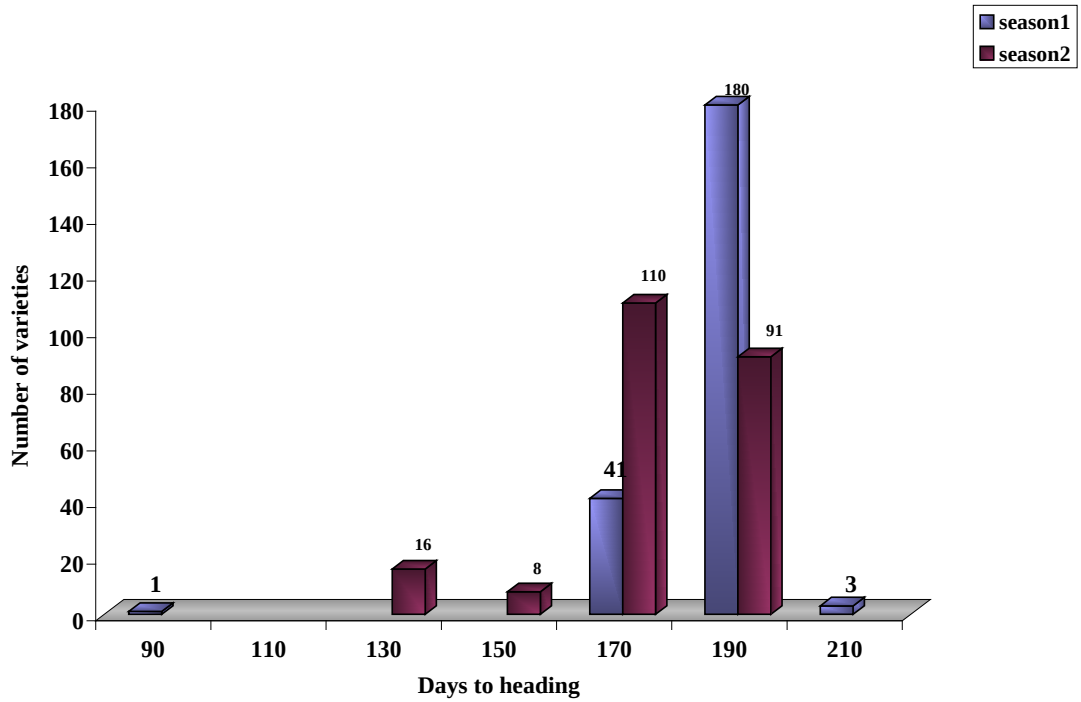

Fig. 6. Sowing-heading duration frequency distribution of some tetraploid durum wheat accessions.

Spikelet per spike

In the first season the average of spikelet per spike was 23 ranged from 13 ~ 36, the coefficient of variation was 29.59 % however, in the second season the average of spikelet per spike was 21 ranged from 11~ 32, the coefficient of variation is 8.96 % (Table 1). The combined analysis for the spikelet per spike data for the two seasons is shown in table (1). The average was 22 ranged from 11~ 36, the coefficient of variation is 22.72 %. The most frequent number of spikelet per spike in the first season was (25) which obtained by 132 lines accounting for 58.7 % while in the second season the same number of spikelet per spike (25) was obtained by 162 lines accounting for 72 %. No lines obtained more than (35) spikelet per spike in the second season as two lines obtained in first season (Figure 7).

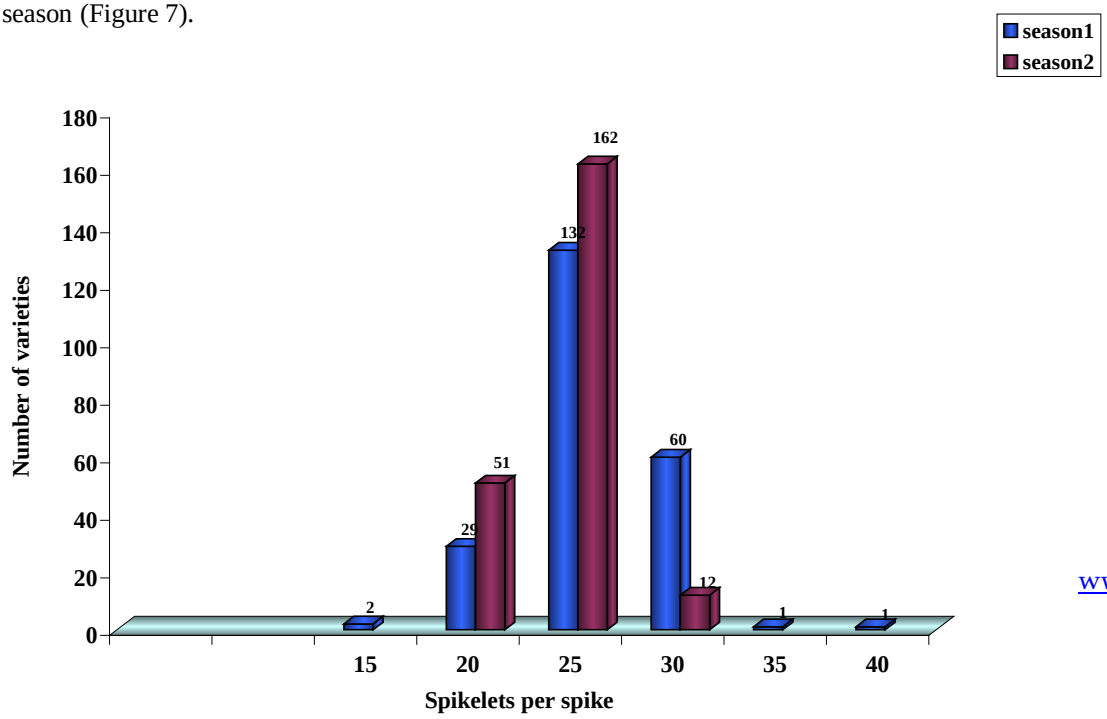

Fig. 7. Spikelet per spike frequency distribution of some tetraploid durum wheat accessions

Spikelet per plant

Spikelet per plant in season (1) was 141 on average, ranged from 40 ~ 380, the coefficient of variation was 14.72%. For the second season spikelet per plant was 141on average, ranged from 23 ~ 431, the coefficient of variation was 25.66 % (Table 1). The combined analysis for spikelet per plant for the two seasons was shown in Table (1). The average of spikelet per plant was 141 ranged from 23 ~ 431, the coefficient of variation was 21.05 %. The most frequent number of spikelet per plant in both seasons was (150~250) which obtained by 160 and 178 lines accounting for 71.1 and 79.1 % in the first and second seasons, respectively. Nine and six lines only obtained more than 300 spikelets per plant in the first and second seasons, respectively (Figure 8).

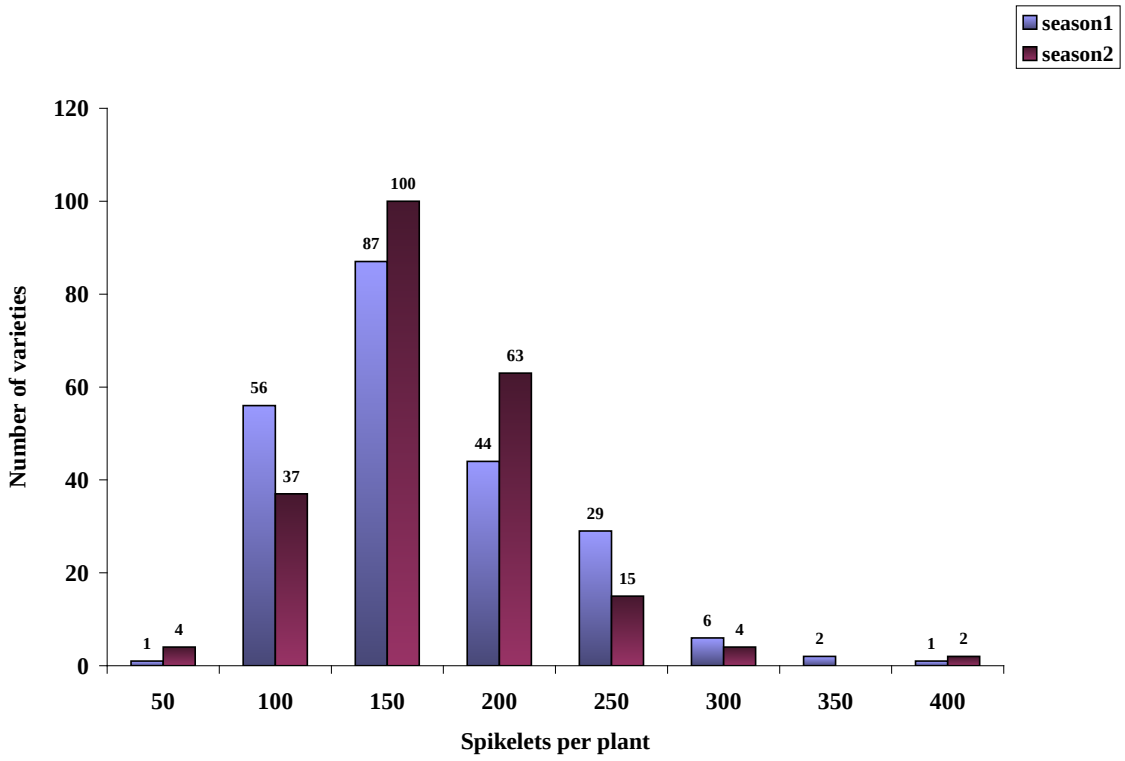

Fig. 8. Spikelet per plant frequency distribution of some tetraploid durum wheat accessions

Grains per plant

The average number of grains per plant in the first and second season was 221 and 246, ranged from 36 ~ 678 and 10 ~ 1152. The coefficient of variation was 15.02 and 27.19 %, respectively (Table 1). The combined analysis for grain per plant for the two seasons is shown in Table (1). The average of grain per plant was 234 ranged from 10 to1152, the coefficient of variation was 22.85 %. The most frequent number of grain per plant in both seasons was (150~300), which obtained by 154 and 174 lines accounting for 68.4 and 77.3 % in the first and second seasons, respectively. 42 and 45 lines only obtained more than 300 grain per plant accounting for 18.7 and 20 % in the first and second seasons, respectively (Figure 9).

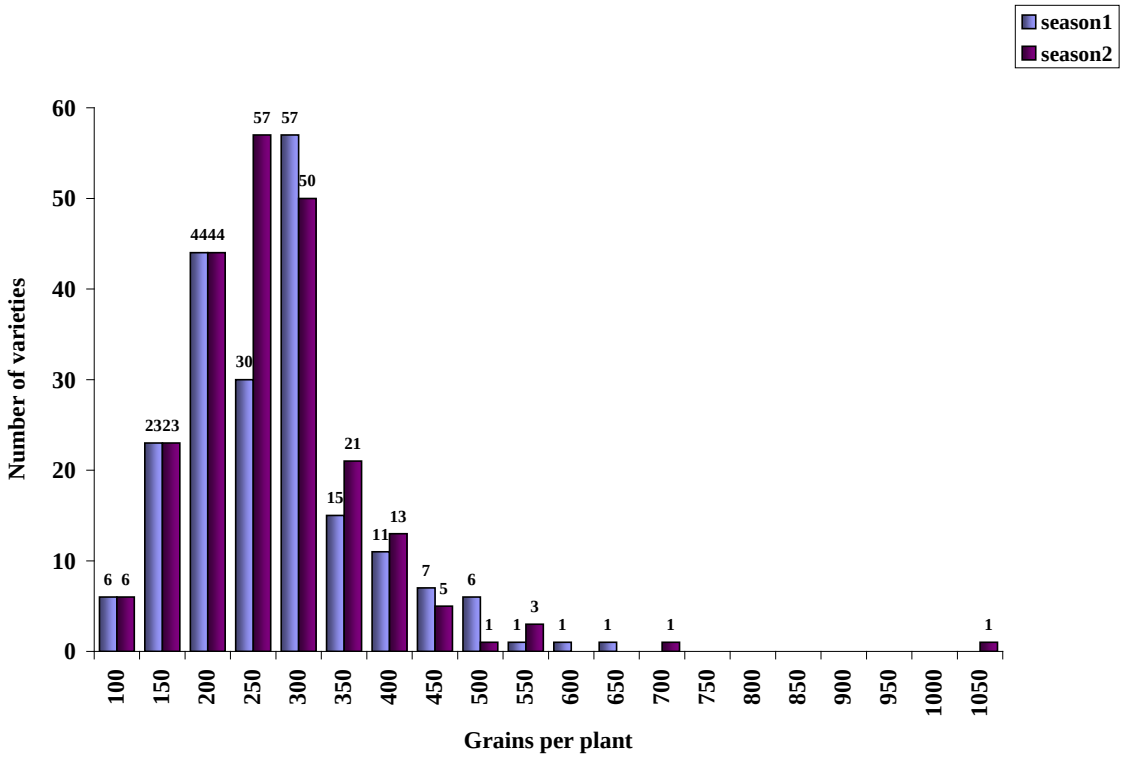

Fig. 9. Grains per plant frequency distribution of some tetraploid durum wheat accessions.

1000 grain weight (g)

1000 Grain weight was 23.60, 33.30 and 28.45 g on average, ranged from 7.50~67.46, 7.00~65.89 and 7.00~67.46 g with coefficient of variation 14.91, 14.55 and 14.97 % for first season, second season and combined analysis, respectively. The most frequent 1000-Grain weight in season (1) was (20~30 g) which obtained by 179 lines accounting for 79.6 %, whereas in season (2) was (30~45 g) which obtained by 185 lines accounting for 82.2 % of total materials tested (Figure 10). No line in the first season obtained more than 45 g as 1000 Grain weight, while there were 11 lines in the second season obtained more than 45 g as 1000 Grain weight (Figure 10).

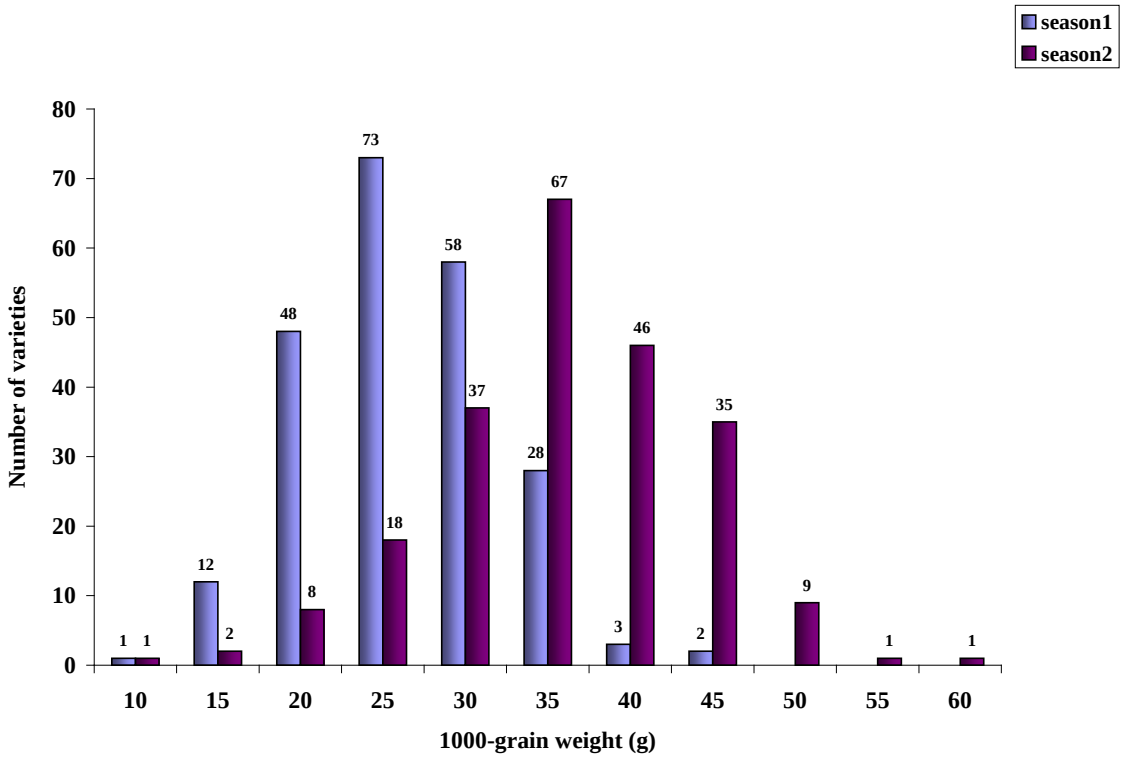

Fig. 10. 1000 grain weight frequency distribution of some tetraploid durum wheat accessions.

Yield per plant (g)

In the first season the average of plant yield (g) was 5.30 g ranged from 0.50~ 20.57 g, the coefficient of variation was 22.54 %, however, in the second season the average of yield per plant was 8.46 g ranged from 0.44~56.19 g, the coefficient of variation was 20.78 % (Table 1). The combined analysis for the plant yield data for the two seasons is shown in Table (1). The average of plant yield was 6.88 g ranged from 0.44~56.19 g, the coefficient of variation was 22.19 %. Figure 11 shows that there were 169 lines accounting for 75.1 % of total materials tested obtained yield per plant ranged from 4 ~ 8g in the first season, while 140 lines accounting for 62.2 % obtained yield per plant ranged from 6 ~ 10g in the second season. No line in the first season obtained more than 16 g as yield per plant, while there were seven lines in the second season obtained more than 16 g as yield per plant (Figure 11).

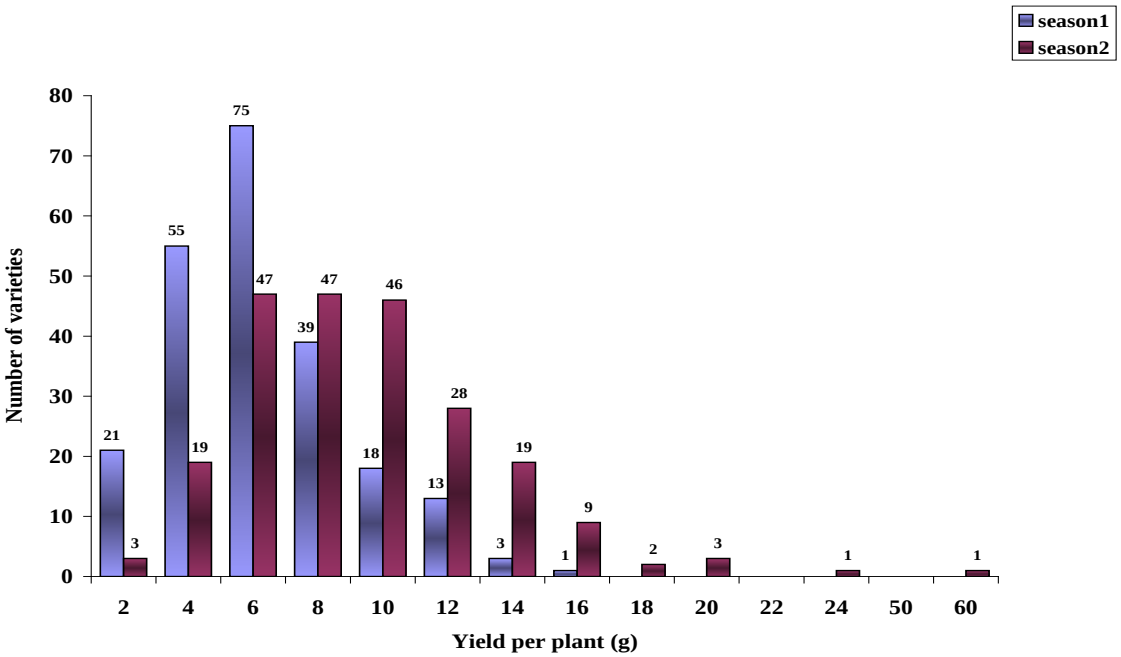

Fig. 11. Yield per plant frequency distribution of some tetraploid durum wheat accessions.

Grain Protein %

From table (1) grain protein % was 15.6, 13.9 and 14.7 % on average, ranged from 10.9~ 20.0, 10.6~20.0 and 10.6~20.0 % with coefficient of variation 0, 7.62 and 6.12 % for first season, second season and combined analysis, respectively. Figure 12 showed that there were 169 lines accounting for 75.1 % of total materials tested obtained grain protein ranged from 15 to 17 % in the first season; also only 23 lines accounting for 10.2 % of total accessions tested obtained Grain protein less than 15 %, while 33 lines accounting for 14.7 % obtained grain protein more than 17 %. In the second season the most frequent grain protein % was 13 to 16 % which obtained by 183 lines accounting for 81.3 % of total accessions tested, only 22 lines accounting for 9.8 % of total materials tested obtained grain protein less than 13 %, while 20 lines accounting for 8.9 % obtained grain protein more than 16 %.

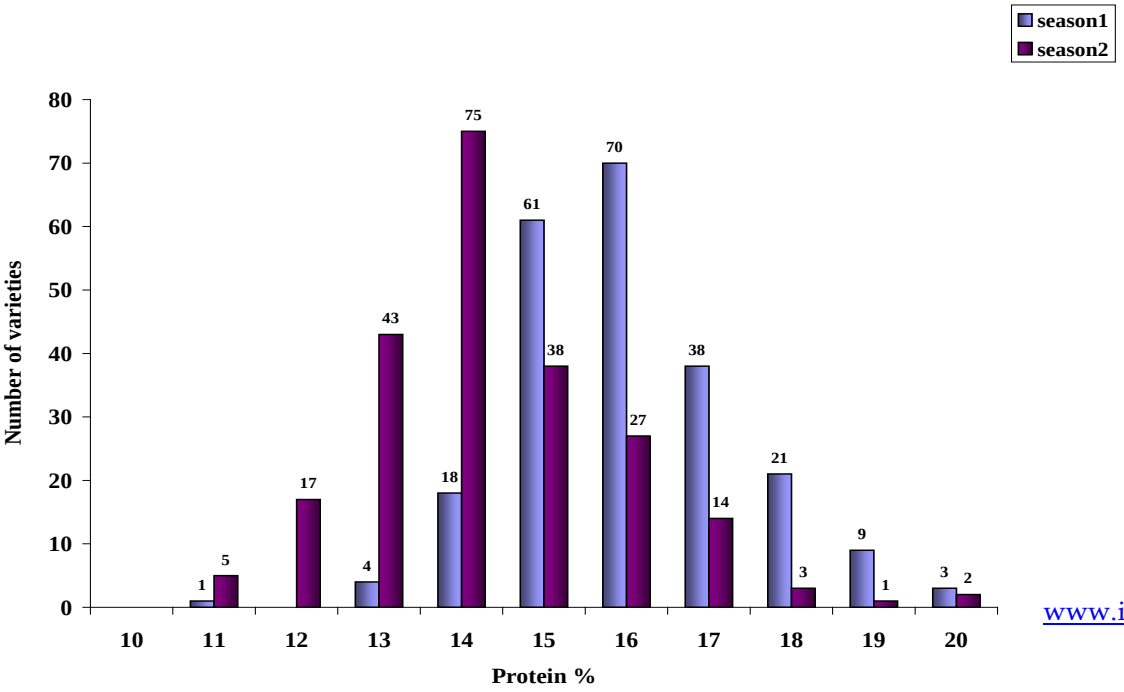

Fig. 12. Grain protein % frequency distribution of some tetraploid durum wheat accessions.

Grain Starch %

From table (1) grain starch % was 50.6, 52.8 and 51.7 % on average, ranged from 49.0~ 55.1, 49.2~57.0 and 49.0~57.0 % with coefficient of variation 2.29, 4.27 and 0 % for first season, second season and combined analysis, respectively. Figure 13 showed that the most frequent grain starch % in the first season was 50 ~ 51 % which obtained by 178 lines accounting for 79.1 % of total accessions studied, while in the second season 102 lines accounting for 45.3 % obtained grain starch % 52 ~ 53 %. 50 ~ 51 and 54 ~ 55 grain starch % were obtained equally by 57 lines accounting for 25.3 % of total materials tested for each one. This finding explained that there was not a wide range of variance in grain starch % of tetraploid durum wheat accessions tested.

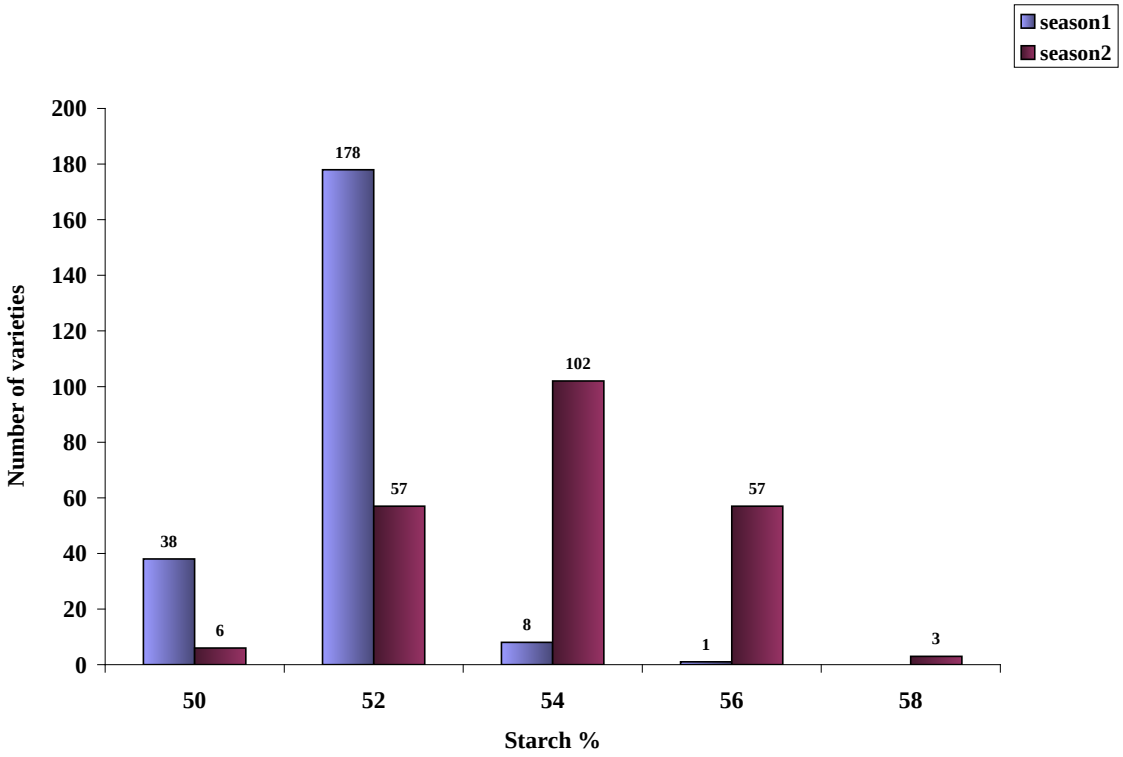

Fig. 13. Grain starch % frequency distribution of some tetraploid durum wheat accessions.

Association between grain yield and other traits

Simple correlations were computed between grain yield and other traits of the 225 genotypes for each sowing date across the two seasons. Grain yield in both years was significant positively correlated with plant height, spikes/plant, length of spike, peduncle length, and neck of spike-flag leaf pillow Length , spikelet/plant, grain/plant, 1000 grain weight and Starch %. Therefore, increases in every trait mentioned above, will result in increases in grain yield (table2). Grain yield in second season was positive correlated with Spikelet / spike, while it was significant and negative in the first season. Grain yield was in both seasons negatively correlated with protein % and days to heading. It could be concluded that by increasing protein % and days to heading, grain yield decreases and reverse (table2).

Table 2. Correlation coefficients of grain yield per plant of 225 tetraploid durum wheat accessions with 12 deferent traits under tow seasons.

	Grain yield / plant (g)	
	Season 1	Season 2
Plant height(cm)	0.116**	0.134***
Spikes/plant	0.570***	0.623***
Master spike length (cm)	0.216***	0.043
Neck length Of master spike (cm)	0.208***	0.191***
Neck of spike-flag leaf pillow length of master spike (cm)	0.290***	0.246***
Spikelet/spike	-0.056	0.051
Spikelet/plant	0.570***	0.636***
Grain/plant	0.863***	0.845***
1000grain weight (g)	0.504***	0.457***
Protein %	-0.236***	-0.099*
Starch %	0.083*	0.062
Days to heading	-0.099*	-0.065*

IV. Discussions

Genetic diversity, relatedness and structure of parental germplasm are important for breeders to design strategy in breeding programme. Diversity analysis is important for deciphering genetic relationship including parentage and for the efficient management of germplasm and thereby, use in breeding of improved varieties. Establishing the identity of crop variety using diversity study has assumed greater importance for protecting plant breeders and farmers rights. In the present study, diversity of agronomic characters was analyzed in the 225 durum wheat genotypes which were planted over two seasons to explore the availability of superior genetic resources for wheat breeding and provided reference to study the genetic diversity, germplasm resource, and genetics and breeding of wheat. There were wide ranges of agronomic characters variation among 225 durum wheat accessions for the thirteen characters as shown by the coefficients of variation values (Table 1). In the first year of investigation the coefficient of variation was highest for spikelet per main spike followed by yield per plant. Protein % had a lowest value followed by starch %, Plant height, days to heading, main spike length and neck length of master spike. Spikelet per plant, 1000 seed weight, grains per plant, number of spike per plant and neck of spike-flag leaf pillow length showed moderate values for the coefficient of variation. In the second season the highest coefficient of variation had a neck of spike-flag leaf pillow length followed by spike per plant, grains per plant, spikelet per plant, spike length and yield per plant while the days to heading had a lowest value followed by starch %, protein % and spikelet per main spike. Plant height, 1000 grain weight and main spike length and neck length of master spike showed moderate values for the coefficient of variation (Table 1). Almost, all the characters except protein and starch % considered showed range of differences among the evaluated genotypes indicating the presence of adequate variability (Table 1). [34] 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.

This is a typical feature of genotypes, which excel in capacity to support panicle growth by large stem reserve mobilization. Few short statured lines were identified which could be further utilized to develop fertilizer responsive and lodging resistant wheat cultivars [25] and [23]. The coefficients of variation explained that there was not a wide range of variance in plant height in tetraploid durum wheat accessions studied. The coefficients of variation values explained that there was a wide range of variance in number of spikes per plant of tetraploid durum wheat accessions tested. Number of spikes per plant ranged between one and 22 with a mean value of seven whereas some of the lines had as high as 20 spikes per plant. These lines could be used as donor parents to improve number of spikes per plant, which ultimately increase grain yield. In connection with main spike length, the coefficients of

variation values explained that there was a wide range of variance in second season and the combined analysis while there was not variance in first season. The average of main spike length was about 9 cm which was considered long. The long spikes with numerous spikelet and large kernels suggested that the yield potential was high. These traits probably resulted in the good yields. The coefficients of variation explained that there was a wide range of variance in neck length of master spike and main spike neck to flag leaf pillow distance, the result showed that most tetraploid durum wheat accessions tested had long main spike neck internodes and main spike neck to flag leaf pillow distance. Spikelet / spike and spikelet / plant 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 spikelet per spike showed that there was a wide range of variance in first season and the combined analysis while there was no variance in second season, some of the lines had high spikelet per spike. These lines could be used as donor parents to improve number of spikelet per spike which ultimately increase grain yield. The coefficients of variation values of number of spikelet per plant explained that there was a wide range of variance among materials tested. The high variation in number of grain / plant and yield / plant observed among genotypes, 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.

Some of the lines had thousand kernel weights as high as 50 g. These lines could be used as donor parents to improve seed weight which ultimately increase grain yield. Days to heading ranged from 69 ~ 193, with a mean value of 170 days. Some of the accessions in this category could be used in breeding programme to develop early maturing varieties. According to coefficients of variation values there was no variation in grain protein and grain starch % among genotypes. Protein and starch % ranged from 10.6 ~ 20.0 and 49.0 ~ 57.0, with a mean value of 14.7 and 51.7, respectively. To some extent, this result is consistent with [5] 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 grain.

There was a positive and significant correlation between thousand kernel weight and grain yield per plant confirming the findings of [20], that thousand kernel weight increased the yield. Plant height, was significantly and positively correlated with grain yield per plant. [17] showed also that plant height and thousand kernels weight had significant positive correlation with grain yield and suggested that these traits could be used as a direct criterion for improving yield of durum wheat. Number of spikelet per spike had significant and positive correlation with grain yield in second season, and this maybe was due to much rain during grain filling period in the first season. The findings of these results emphasized the role of number of spikelet per spike upon ultimate increase of grain yield. Protein content was negatively correlated with grain yield. The inverse relationship between protein content and grain yield was found in numerous works in bread wheat [7] and [27], triticale [16] and durum wheat [30]. Main spike neck to flag leaf pillow distance, spikelet per plant and starch % had significant positive correlation with grain yield so that these traits could be used as a direct criterion for improving yield of durum wheat. Days to heading was negatively correlated with grain yield, corresponding well to previous reports [3] and [9] under drought condition for wheat, and they were reported negative correlation between neck length of master spike and grain yield those are in contrast with the findings of our study. There was a positive and significant correlation between number of spikes per plant and grain yield, [32] reported positive and significant correlation for this trait with grain yield. Positive correlation between spike per plant with grain yield by [22] and lack of significant genetic correlation of this trait with grain yield by [24] have been reported. Genetic correlation analysis of kernel number to its direct effects on grain yield showed that it had a high and direct positive effect on grain yield. Existence of positive correlation between kernel number and grain yield is contrary with the findings of [14], [33], [12], [32], [26] and [24]. Main spike length was positively correlated with grain yield. This result was in accordance with the previous study of [1] that showed in rainfed condition spike length had more direct positive effects on grain yield.

V. Conclusions

It is therefore, concluded that almost, all the characters except protein and starch % considered showed range of differences among the evaluated genotypes indicating the presence of adequate variability. Many lines could be used as donor parents to improve and increase grain yield of durum wheat. Significant positive correlations between plant height, spikes/plant, length of spike, peduncle length, neck of spike-flag leaf pillow, Length of master spike, spikelet/plant, grain/plant, 1000 grain weight and Starch % were positive and yield were found. This study suggested that by increasing these traits grain yield of durum wheat increases. Grain yield was negatively correlated

with protein % and days to heading. It could be concluded that by increasing protein % and days to heading, grain yield decreases.

VI. References

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