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Full Length Research Paper

Sustainable use of winter Durum wheat landraces under Mediterranean conditions

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This research expected to determine new durum wheat germplasm resistant to biotic and abiotic stress factors. Eighty durum wheat lines selected from eighteen diverse landraces were tested together with eight durum wheat cultivars under reliable yellow rust epidemic during two successive years. Average infection coefficient of populations and cultivars was 32.44 in 2003 and 26.24 in 2004, showing severe epidemic condition which occurred at adult plant stage in 2003. Because of this the number of selected resistant and moderately resistant plant material greatly reduced. According to the yield trial study in which twenty resistant lines selected out of 30 resistant and moderately from sixteen populations were included, only two checks outperformed grand mean (2.48 t ha $^{-1}$) and two lines selected from landrace population followed these with slightly lower yield difference. On the other hand, there were several lines which performed better than the grand mean of protein content (13.24%), SDS sedimentation (28.40 ml) and semolina color (24.35) and they ranked in the first group including the two checks cultivars. Bi- plot analysis showed that some promising lines with reasonable grain yields, good quality parameters, winter hardiness and drought tolerances among yellow rust resistance durum wheat landraces can be selected for semiarid conditions of Mediterranean countries for sustainable production.

Key words: Durum wheat landraces, yellow rust, yield quality, bi-plot and sustainability.

INTRODUCTION

World durum wheat (*Triticum durum* L) production is 31.1 million tons. Turkey with 3.45 million tons of production is the third biggest producer of the world after Italy and Canada (Anonymous, 2000). Durum wheat is main cereal crop in several countries of the Mediterranean region, such as the southern peninsular of Italy (Motzo and Giunta, 2007) and Southern Anatolia of Turkey (Akar and Ozgen 2007). In many part of the region durum wheat production is replaced by modern cultivars; landraces are only cultivated by farmers in very limited areas (Moragues et al., 2006a). This landrace replacement by homogeneous cultivars has resulted in a significant loss of genetic variation in resistance to biotic stresses. Improved cultivars may not possess the combined resistances already present in the landrace that they are intended to replace. Improvement of new cultivars from landrace population is one of the strategies to improve yield and yield stability in less favorable agricultural system with lower input levels. The stagnation of yields in these areas is mainly related to the narrow genetic base of the more recently bred, high-yielding cereals (Pecetti et al., 2002). Nowadays, several breeding programs aim to develop new cultivars as well as release old durum landraces (de Vita et al., 2007). Pecetti et al. (1992) showed that some of the durum wheat material (30%) selected under unfavorable conditions is able to retain its superiority in a more favorable environment. Breeding for specific adaptation is very important especially for the crops which are predominantly grown in unfavorable conditions, because these environments tend to be more different from each other than favorable ones (Ceccarelli and Grando, 1997). The specific adaptation strategy may be explored on the basis of yield response of the germplasm pool that is representative of the available genetic base tested through a representative sample of sites within the target region (Annichiarico, 2002). Landraces and wild relatives of crop plants are very important sources to broaden genetic base (Feldman and Sears, 1981)

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and every trait of these should be characterized (Murphy and Withcomebe 1981).

A lot of studies conducted by Gökgöl (1939), Zhukovsky et al, (1951), Kün (1988) Damania et al (1996; 1997) and Zencirci and Kün (1996) revealed that there has been great amount of variation in terms of agronomic and grain quality traits and disease resistance particularly for yellow rust (Akar and Özgen, 2007) in Turkish durum wheat landraces. Besides drought tolerance and winter hardiness, yellow rust (*Puccinia striiformis* f. sp. tritici) is one of the important constraints for bread and durum wheat production under drylands of Turkey. Consequently, Turkey has witnessed severe yellow rust epidemics on bread wheat cultivars in Central Anatolia and Cukurova regions in 1991 and 1995 (Braun and Saari 1992; Dusunceli et al, 1996). Apart from these, yellow rust epidemic has not been reported on durum wheat cultivars so far, but reaction of grown durum wheat cultivars has been changing from moderately susceptible to susceptible and few germplasm have been determined as resistant and moderately resistant to yellow rust among breeding material on dry lands of Turkey (Cetin et al., 1998). This means that yellow rust epidemic will remain as a threat for the durum wheat production of the country.

Main aims of this study were to screen some durum wheat landraces in order to determine lines resistant to abiotic and biotic stress factors and then to test yield potential and some quality parameters of these germplasm to be used in sustainable durum wheat production under dry-land conditions.

MATERIALS AND METHODS

Plant material

Eight durum wheat cultivars and eighteen very diverse landrace population were sampled from Turkish part of Fertile Crescent (Southern Anatolia), Central Anatolia and Transitional Zones and Black Sea Region. They were winter planted in to 3 m² plots without replications in Haymana Research Station in 2002. Haymana is the main research center of Central Research Institute for Field Crops (CRIFC) and represents Turkish Highlands very well in which temperature sometimes drops -20^{o}C without snow in winter period and at the same season generally drought period occurs in heading time in spring period. Long term average rainfall is around 300-350 mm and its distribution is quite erratic. So for that reason winter hardy and drought tolerant germplasm is naturally selected in the location. In the first year of the experiment two landrace populations were completely discarded due to lack of enough winter hardiness when compared to the common checks. Totally eighty single spikes were selected from each of the sixteen diverse populations considering high winter hardiness and drought tolerance and good agro morphologic characteristics.

Yellow rust tests

In order to find out resistant and moderately resistant yellow rust lines, eighty lines selected from 16 durum wheat landraces and 8 check cultivars were tested at field conditions during 2003 and 2004 seasons under mist irrigated conditions. Each line/cultivar was sown in two rows with 1 m length in mid of October. Two susceptible check cultivars namely, Michigan Amber and Little Club were also sown after every tenth line/cultivar and surrounded area of the experiment to increase epidemics of yellow rust. Yellow rust races with Yr2, Yr6, Yr7 and Yr9 virulence genes used in the trials were collected in early summer of 2003 and 2004 seasons, and stored at -196ºC in liquid nitrogen tank. Fresh leaves multiplied under greenhouse conditions were transferred in to the fields in every spring for inoculation. Susceptible cultivars in the experimental fields and on the border rows were also inoculated by injection (Çetin et al., 1998). Modified Cobb scale was used to quantify the rust performance of lines and cultivars (Stubbs et al., 1986). According to the scale, a nomenclature was employed to determine reaction types as follows; R for resistant (necrotic areas with or without tiny pustules), MR for moderately resistant (small pustules surrounded by necrotic areas), MS for moderately susceptible (pustules with medium size, no necrosis but with some chlorosis, and S for susceptible (no necrosis or chlorosis but with large pustules). In addition to this, disease severity was also determined as percentage of the flag leaf area which is infected by yellow rust. Finally, each of these parameters (R, MR, MRMS MS, S) were multiplied by 0.2, 0.4, 0.6, 0.8 and 1 respectively to find infection coefficient for each lines to make some basic statistic analyses (Cetin et al., 1998).

Yield trial and grain quality tests

In the second stage of the experiment, one year yield trial consisting of 20 resistant or moderately resistant lines selected from these eighty lines and five cultivars assigned in Randomized Complete Block Design with four replications was conducted in 2005. Priority was given to modern cultivars when determining the check cultivars except one old cultivar directly selected from Turkish landraces, Kunduru 1149. Before harvest, plant height (cm), winter hardiness (0-5) and drought tolerance (0-5) were observed (Tahir et al., 1993). For winter hardiness; 0 means no winterkill observed in the plots immediately after winter season while 5 means all plot killed by severe winter damage. For drought tolerance; 0 means no drought stress prone area determined in the plot just before harvest while 5 means almost all plots empty and severely affected by drought. After harvesting, enough amounts of seeds from each line was sub to quality testing for three important selection parameters such as protein content (Anonymous, 2002), SDS sedimentation (Anonymous, 2001) and semolina color (Anonymous, 2002) in the laboratory. Statistical analysis of the data related to disease, yield and quality parameters were performed by using MSTAT-C software program. Finally, the averages of all the parameters were bi-plotted by using MINITAB in order to see the groupings of the plant material and the relationships among the parameters.

RESULTS AND DISCUSSION

The experimental site, Haymana location, and Central Anatolia are characterized by Mediterranean type of climate with severe cold in winters and drought in summer seasons. During the last decade and especially in 2004/05 season yield trial, the amount of rainfall in the fall have dramatically decreased, however maximum temperature increased. In addition to these, minimum temperature sometimes dropped to -18^{o}C (data not shown) in January and February without snow which was very close to long-term extreme minimum temperature (-20^{o}C) (Table 1).

Table 1. Climatical conditions of the experimental site, Haymana, Ankara

Climate parameters	Month										
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July
Rainfall 2004-05 (mm)	0.0	2.0	35.0	8.0	16.0	35.0	79.0	84.0	37.0	39.0	33.0
Rainfall Long Term Av.(mm)	17.0	27.0	30.0	56.0	49.0	47.0	45.0	50.0	56.0	38.0	11.0
Avg. 2004-05 (^{o}C)	19.0	14.0	7.0	2.0	3.0	1.0	5.0	11.0	16.0	19.0	24.0
Long Term Avg. (^{o}C)	16.6	11.2	6.0	2.8	-1.1	-0.5	4.7	9.2	14.0	17.2	20.3
Max. 2004-05 (^{o}C)	27.0	22.0	12.0	6.0	7.0	7.0	11.0	17.0	23.0	26.0	32.0
Max Long Term Avg. .(^{0}C)	23.8	15.6	11.3	5.2	1.6	5.4	10.1	14.6	20.7	27.0	29.8
Min. 2004-05(^{o}C)	11.0	8.0	2.0	-4.0	-8.0	-7.5	4.4	5.0	9.0	11.0	16.0
Min Long Term Avg. (^{o}C)	4.5	0.1	-4.2	-8.4	-12.6	-10.5	-8.9	-2.3	0.3	6.2	10.1

Table 2. Yield and agronomic performance of durum wheat checks and some selected lines.

Cultivars/ Lines	Yield t ha^{-1}	Plant height (cm)	Winter Hardiness (0-5)	Drought Tolerance (0-5)
Altın	3.260	82.00	4.00	3.50
Kızıltan	3.093	83.00	4.00	3.50
Pop 19.5	2.950	85.00	4.30	4.00
Pop 13.5	2.747	85.00	4.40	4.00
Çakmak	2.637	78.00	3.90	3.20
Ç-1252	2.633	83.00	4.00	3.50
Pop 20.5	2.610	85.00	4.20	4.00
Pop 15.1	2.590	87.00	4.10	3.70
Pop 17.4	2.580	88.00	4.00	3.70
Pop 13.4	2.577	89.00	4.10	3.60
Pop 9.2	2.517	90.00	4.00	3.70
Pop 22.3	2.507	92.00	4.10	3.80
Pop 12.4	2.500	90.00	4.20	4.00
Pop 13.3	2.457	87.00	4.20	4.00
Kunduru	2.320	101.0	4.00	4.00
Pop 11.5	2.310	100.0	3.90	3.70
Pop 18.3	2.297	103.0	3.90	3.70
Pop 21.4	2.297	100.0	3.80	3.70
Pop 22.2	2.270	93.00	3.90	3.60
Pop 14.5	2.243	99.00	3.90	3.80
Pop 22.1	2.237	94.00	3.80	3.50
Pop 17.5	2.203	90.00	3.90	3.00
Pop 16.5	2.173	110.0	3.80	3.00
Pop 21.5	2.113	112.0	4.80	3.00
Pop 18.2	1.920	120.0	3.2	3.00
Grand Mean	2.482	93.04	3.98	3.61
L.S.D (%5)	0.642	0.72	0.31	0.47

These unfavorable conditions restrict the pre-winter root development lead to winter damage of durum wheat genotypes. Landraces and wild relatives of the plant species in general (Feldman and Sears, 1981) durum whealandraces in particular are able to cope with these abiotic stress factors. For instance, some lines in yield trial such as pop 19-5 and 13-5 selected from landrace populations showed normal plant height, better winter hardiness and drought tolerance (Table 2). Additionally, yield performances of these lines were significantly higher than old cultivar Kunduru and slightly lower than commonly cultivated cultivar, Kızıltan (Table 2).

Table 3. Adult plant yellow rust reactions of cultivars/Turkish durum wheat landraces.

Name of Cultivars/ Population	2003		2004	
	Severity and type of infection	Infection coefficient	Severity and type of infection	Infection Coefficient
1-Gokgol (ch)	70 S	70	40 S	40
2-Cakmak (ch)	60 S	60	35 S	35
3-Kunduru (ch)	50 S	50	40 S	40
4-Altıntas (ch)	10 MS	8	5 MR	2
5-C-1252 (ch)	60 S	60	40 S	40
6-Tunca (ch)	40 MS	32	20 MS	16
7-Kızıltan (ch)	40 MS	32	30 MS	24
8-Altin (ch)	20 MS-S	18	10 MS-S	9
9.1 Adıyaman	30 S	30	10 S	10
9.2 Adıyaman	10 MR-MS	6	5 MR-MS	3
9.3 Adıyaman	30 MS	24	10 MS	8
9.4 Adıyaman	40 S	40	30 S	30
9.5 Adıyaman	70 S	70	40 S	40
10.1 Şanlıurfa	60 MS-S	54	20 MS	16
10.2 Şanlıurfa	40 S	40	40 MS	32
10.3 Şanlıurfa	40 MS-S	36	40 MS	32
10.4 Şanlıurfa	30 MS-S	27	20 MS	16
10.5 Şanlıurfa	20 MS	16	10 MR-MS	6
11.1 Şanlıurfa	60 S	60	30 S	30
11.2 Şanlıurfa	20 MS-S	18	20 MS-S	18
11.3 Şanlıurfa	30 S	30	20 S	20
11.4 Şanlıurfa	60 S	60	40 S	40
11.5 Şanlıurfa	10 MS-S	9	10 MR-MS	6
12.1 Kastamonu	30 S	30	10 S	10
12.2 Kastamonu	60 S	60	30 S	30
12.3 Kastamonu	10 S	10	5 MR-MS	3
12.4 Kastamonu	5 S	5	5 MR-MS	3
12.5 Kastamonu	10 MS-S	9	5 MS	4
13.1 Çankırı	20 MR	8	10 MR	4
13.2 Çankırı	30 S	30	10 S	10
13.3 Çankırı	20 MR-MS	12	5 MR	2
13.4 Çankırı	20 MR-MS	12	10 MR	4
13.5 Çankırı	5 MR-MS	3	10 MR	4
14.1 Kastamonu	50 MS-S	45	40 S	40
14.2 Kastamonu	60 MS-S	60	40 S	40
14.3 Kastamonu	30 MS-S	27	20 S	20
14.4 Kastamonu	40 S	40	30 S	30
14.5 Kastamonu	10 MS-S	9	5 S	5
15.1 Tokat	10 MS-S	9	10 MR-MS	6
15.2 Tokat	40 MS-S	36	20 S	20
15.3 Tokat	20 S	20	10 S	10
15.4 Tokat	50 S	50	30 S	30
15.5 Tokat	40 S	40	20 S	20
16.1 Çankırı	10 S	10	5 MR-MS	3
16.2 Çankırı	30 S	30	20 S	20
16.3 Çankırı	40 MS-S	36	40 S	40
16.4 Çankırı	20 MS-S	18	10 S	10
16.5 Çankırı	50 MS-S	45	40 S	40
17.1 Tokat	70 S	70	50 S	50

Table 3. contd.

17.2 Tokat	40 S	40	20 MS	16
17.3 Tokat	70 S	70	40 S	40
17.4 Tokat	10 MS	8	10 MR-MS	12
17.5 Tokat	5 MS	4	5 MR-MS	3
18.1 Çorum	40 MS	32	20 MS-S	18
18.2 Çorum	20 MS	16	10 MS-S	9
18.3 Çorum	5 MS	4	5 MS-S	4.5
18.4 Çorum	10 MS-S	9	10 S	10
18.5 Çorum	50 MS-S	45	20 S	20
19.1 Çankırı	30 S	30	10 MR-MS	6
19.2 Çankırı	40 S	40	10 MS	8
19.3 Çankırı	20 MS-S	18	10 MS-S	9
19.4 Çankırı	30 MS	24	20 MS-S	18
19.5 Çankırı	10 MS	8	5 MR-MS	3
20.1 Çankırı	20 S	20	20 S	20
20.2 Çankırı	30 MS-S	27	20 MS-S	18
20.3 Çankırı	20 MS-S	18	10 MS	8
20.4 Çankırı	30 MS	24	20 S	20
20.5 Çankırı	10 MS	8	5 MS	4
21.1 Çorum	40 S	40	20 S	20
21.2 Çorum	40 S	40	20 MS	18
21.3 Çorum	30 S	30	10 MS-S	9
21.4 Çorum	5 S	5	5 MR-MS	3
21.5 Çorum	5 MS	4	5 MS	4
22.1 Çorum	5 MS	4	10 MR-MS	6
22.2 Çorum	10 MS-S	9	10 MR-MS	6
22.3 Çorum	5 MR	2	5 MR	2
22.4 Çorum	30 MS-S	27	20 MS	16
22.5 Çorum	20 MS	16	10 MR-MS	6
23.1 Sinop	60 S	60	20 S	20
23.2 Sinop	70 S	70	30 S	30
23.3 Sinop	60 S	60	20 S	20
23.4 Sinop	50 S	50	10 MS-S	9
23.5 Sinop	70 S	70	20 MS-S	18
24.1 Sinop	60 S	60	20 S	20
24.2 Sinop	70 S	70	30 S	30
24.3 Sinop	50 S	50	20 S	20
24.4 Sinop	30 S	30	5 MS	4
24.5 Sinop	40 S	40	10 S	10
25.1 Amasya	60 S	60	30 S	30
25.2 Amasya	50 S	50	20 S	20
25.3 Amasya	40 S	40	10 MS-S	9
25.4 Amasya	30 S	30	10 MS-S	9
25.5 Amasya	20 S	20	5 MR-MS	3
26.1 Sinop	50 S	50	20 MS-S	18
26.2 Sinop	70 MS-S	63	40 S	40
26.3 Sinop	60 MS-S	54	30 S	30
26.4 Sinop	70 MS-S	63	30 S	30
26.5 Sinop	20 S	20	10 MR-MS	6

Table 4. General yellow rust evaluation of durum wheat cultivars and populations in two seasons together with their geographic data.

Origin of Populations	2003			2004			Elevation (m)
	Mean	C.V. (%)	Number of Selected Lines	Mean	C.V (%)	Number of Selected lines	
1. Cultivars	41.25	6.78	-	25.75	9.03	-	-
2. Adıyaman (Pop.9)	34.00	9.56	1	18.2	14.67	3	525
3. Sanlıurfa (Pop.10)	34.60	7.29	1	20.4	11.04	3	550
4. Sanlıurfa (Pop.11)	35.40	9.19	2	22.8	10.52	2	600
5. Kastamonu (Pop.12)	22.80	14.05	3	10	22.73	4	1500
6. Çankırı (Pop.13)	13.00	16.43	3	4.8	24.26	5	700
7. Kastamonu (Pop.14)	36.20	8.11	1	27	9.54	2	700
8. Tokat (Pop.15)	31.00	8.73	1	17.2	11.95	4	670
9. Çankırı (Pop.16)	27.80	8.99	1	22.6	12.20	3	670
10. Tokat (Pop.17)	38.40	9.86	2	24.2	12.32	3	1610
11. Çorum (Pop.18)	21.20	13.00	3	12.3	13.86	5	1600
12. Çankırı (Pop.19)	24.00	9.69	1	8.8	18.03	5	1600
13. Çankırı (Pop.20)	19.40	9.29	3	14	13.07	5	1050
14. Çorum (Pop.21)	23.80	11.95	2	10.8	17.35	5	1125
15. Çorum (Pop.22)	11.60	18.38	4	7.2	21.21	5	875
16. Sinop (Pop.23)	62.00	3.12	-	19.4	9.42	4	950
17. Sinop (Pop.24)	50.00	5.32	-	16.8	12.63	4	1100
18. Amasya (Pop.25)	40.00	6.65	1	14.2	15.45	4	975
19. Sinop (Pop.26)	50.00	5.63	1	24.8	9.75	1	1050
Total	616.45	182.01	30.00	321.25	269.03	67.00	17850.00
Grand mean	32.44	9.58	1.88	16.91	14.16	3.72	991.67

Grand mean of this trial was 2.48 t/ha. Two check cultivars (Altin and Kızıltan), with average yields of 3.260 and 3.093 t/ha, respectively, were the first and the second in grain yield ranking. They were followed by two lines selected from Pop 19 and 13 and had yield performances better than those of common checks, Cakmak, C-1252 and Kunduru (Table 2). As was mentioned by de Vita et al. (2007), this result evidently shows that high yielding lines can directly be selected from Turkish landraces by durum wheat breeders.

Yellow rust resistance has been ignored when developing new cultivars by durum wheat breeders under Mediterranean conditions (Cetin et al., 1998). Its severity and infection type of lines changed from 5 MR to 70 S in 2003 while they were 5 MR to 40 S in 2004 (Table 3).

Responses of the check cultivars to the yellow rust populations including Yr2, Yr6, Yr7 and Yr9 virulence genes were always higher than those of lines selected from landraces in the first years. They changed from 10 MS to 70 S in the first year but had almost no change in 2002 such as SMR to 40 S (Table 3).

Grand mean of infection coefficient of all plant material was 32.44 for 2003 which doubled the value for 2004. Because the infection co-efficient was very high in 2003, resistant and medium resistant lines were able to be selected based on the data of 2003 (Table 4). Totally 30 lines selected in 2003 showing relatively high resistance indicates the effectiveness and the success of the artificial epidemics. Ineffective epidemic conditions in 2004 led to selecting some moderately susceptible lines which are going to be eliminated in successive generations. Grand mean infection coefficient of the germplasm changed between 11.60 in Çorum (Pop.22) and 62.00 in Sinop (Pop.23) during 2003 season (Table 4). Variations even in the most tolerant populations such as Pop 22 and 13 were considerably high with the values of 18.38 and 16.43%, respectively (Table 4). This situation which was also reported by Akar and Özgen (2007) clearly demonstrates great potentials in populations which can directly or indirectly contribute to develop yellow rust resistant durum wheat germplasm.

Grain quality is another important parameter for adaptation of the genotypes especially to stressful environments. There was a great amount of variation among the lines and cultivars in terms of protein content (11.1-14.8%), SDS sedimentation (22.0-36.0 ml) and semolina color (14.0-28.0) in the landrace lines (Table 5). Nowadays, international macaroni industry in Turkey in particular requires high semolina color rate in combination with high SDS sedimentation value in order to meet demand of consumers abroad. For that reason some spring type durum wheat cultivar was imported into Turkey and they have been widely cultivated (Akar and Özgen, 2007). In order to increase and develop semolina

Table 5. Some quality parameters of durum wheat cultivars and selected lines.

Cultivars/Lines	Protein content (%)	SDS Sedimentation (ml)	Semolina color
Kunduru (ch)	13	30	24
Cakmak (ch)	12.1	30	14
Kızıltan (ch)	13.7	32	24
C-1252 (ch)	12.6	24	18
Altın(ch)	14.3	28	26
pop9.2	13.8	26	28
pop11.5	13.5	30	26
pop12.4	15	32	22
pop13.3	14.6	26	26
pop13.4	14.7	28	24
pop13.5	14.4	30	26
pop14.5	13.7	26	24
pop15.1	14.8	28	29
pop16.1	12.7	30	28
pop17.4	14	24	26
pop17.5	14.7	26	24
pop18.2	12.2	22	26
pop18.3	12.3	24	24
pop19.5	12.3	30	26
pop20.5	11.1	28	24
pop21.4	13.4	28	29
pop21.5	13.5	26	28
pop22.1	11.7	32	26
pop22.2	11.3	34	26
pop22.3	11.5	36	26
Mean	13.24	28.40	24.35
St. deviation	1.19	3.37	4.68
C.V (%)	3.69	2.89	3.96

color rate of winter type durum wheat cultivars, these germplasm can be used as parental lines in breeding program (Table 5).

As indicated by Murphy and Withcomebe (1981), each trait of landraces is very important for plant breeding programs and they should be studied on carefully. Use of these germplasm in breeding program can contribute to broaden genetic background of new cultivars in terms of grain quality (Feldman and Sears, 1981).

According to the principal component analysis, 32.1 and 56.3% of total variations owing to all traits (yield, yellow rust resistance (YRR), semolina color, protein and SDS sedimentation, winter hardiness, and drought tolerance) were explained by the first PC and the first plus second PCs, respectively. The first three PCs explained 72% of the all variations. First PC was related to the difference between grain yield and plant height. Second PC was related mainly to the difference between semolina color and yellow rust. A bi-plot (Gabriel, 1971) display constructed (Figure 1) on the first two PCs indicated that Çakmak and Ç-1252 cultivars possessed high yellow rust susceptibility and low semolina color index. Kızıltan, Altın, pop 19.5, 13.5 and 12.4 were the leading cultivars with regard to winter hardiness and drought tolerance, yield, SDS sedimentation and protein content. We can see from the bi-plot presentation (Figure 1) that grain yield was highly and positively correlated with SDS sedimentation, winter hardiness and drought tolerance, but high but negatively correlated with the plant height.

Pop 19.5 and 13.5 with their high winter hardiness and drought tolerances and reasonable yield levels are the promising lines in terms of adverse climatic conditions in the semiarid areas such as Mediterranean countries.

Conclusion

Promising performance of durum wheat lines selected from landraces was very striking in terms of yield, yellow rust and abiotic stress resistances and grain quality under stressful Mediterranean environments. Sustainable durum wheat production under these areas can be ensured

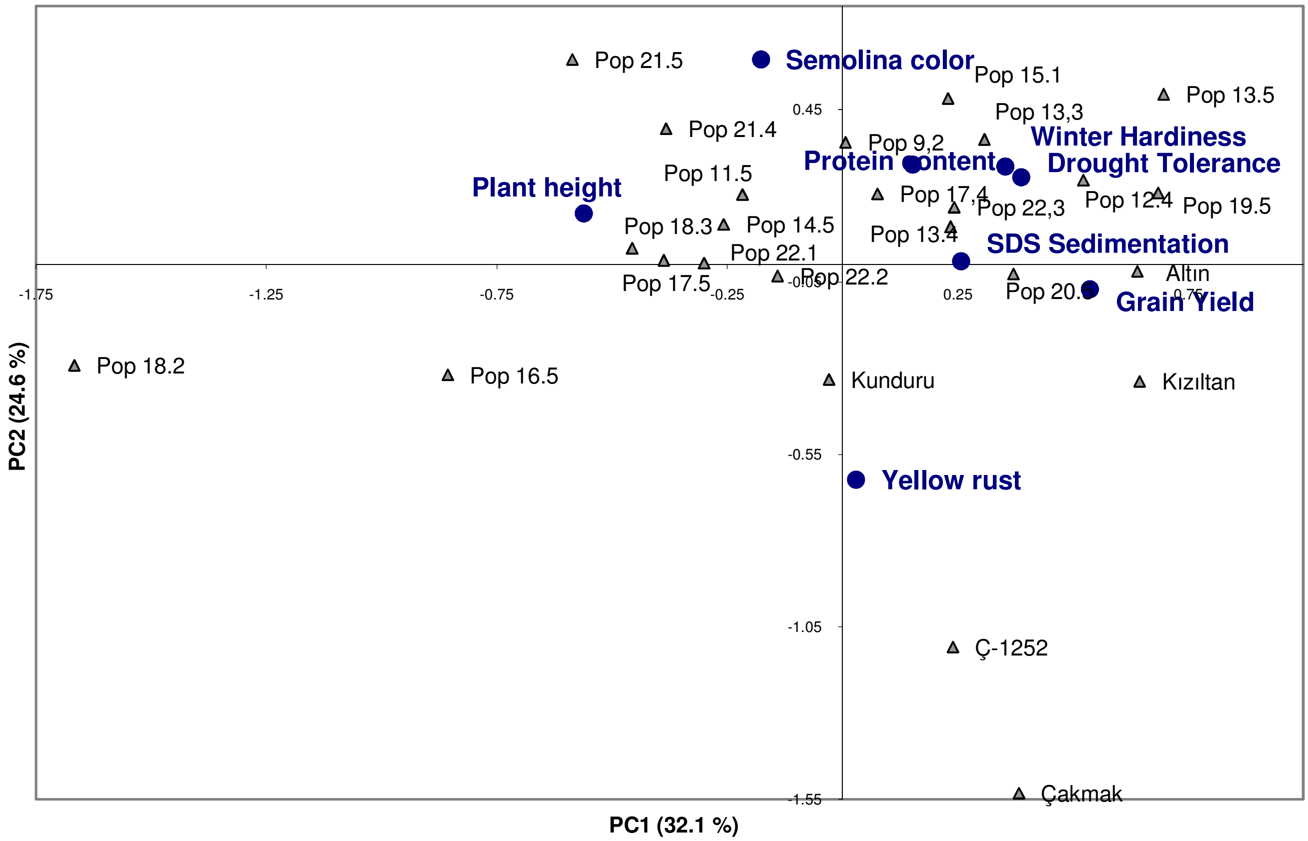

Figure 1. Biplot display of principal component analysis of durum wheat lines and cultivars with some important traits.

giving first priority to selection of landraces by following the specific adaptation strategy (Ceccarelli and Grando, 1997; Annichianrico, 2002). In order to realize these goals, further studies employing considerable amount of population to be provided under very diverse agro ecologies of Turkey are required. These germplasm should also be exploited for low input and organic agriculture.

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