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Characteristics of Three Promising Durum Wheat Lines Adapted to Rainfed and Supplemental Irrigation in Moderately Cold Winter Areas of Western Iran

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ABSTRACT

The development of cultivars that combine drought resistance, high yielding ability, and yield stability is an important objective targeted by breeding programs in the rainfed areas. Three promising durum wheat lines, namely Syrian-4, Mrb3/Mna-1 and Mna-1/Rfm-7, selected from ICARDA germplasm, were tested in the national uniform yield trials and farmers' fields under rain-fed and supplemental irrigation conditions during five cropping seasons (2000-2005) to evaluate their adaptation to areas with mild cold winters. Under rainfed conditions, Syrian-4 and Mrb3/Mna 1 outyielded both the local durum check Zardak and the bread wheat landrace Sardari. Mna-1/Rfm-7 outyielded Zardak by 14%. Mrb3/Mna-1 and Syrian-4 showed also better grain yield stability and adaptability and good yield performance under supplemental irrigation. These promising durum lines showed better grain quality and protein content and better drought tolerance than Zardak. Syrian-4 and Mrb3/Mna-1 are recommended for the rainfed conditions and under supplemental irrigation in the moderate cold winter areas of Iran. These lines can be used as parental germplasm for generating more adapted germplasm for similar areas in the Central, West Asia and North Africa region.

Keywords: Durum Wheat, Adaptation, Drought Tolerance, Grain Quality, Moderate Cold Winter, Supplemental Irrigation.

1. INTRODUCTION

Durum wheat is grown on 10% of the world wheat area with approximately 11 millions ha grown in the Mediterranean basin under rainfall and temperatures conditions showing large and unpredictable fluctuations over different crop seasons (Nachit *et al.*, 1998). Wheat is the most important food crop grown in Iran and occupies about four million hectares under rain-fed conditions (Tavakoli *et al.*, 2005). In 1992, the Dryland Agricultural Research Institute (DARI) initiated a collaborative research program with ICARDA with the objective to improve and stabilize rain-fed wheat production in Iran through the introduction of suitable genotypes (Tavakoli *et al.*, 2005). Wheat production in

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Iran is prone to drought every five to seven years and supplemental irrigation is practiced to prevent crop failures under severe droughts and to sustain grain yield during the cropping seasons with below average precipitation (Tavakoli *et al.*, 2005). The selection of high grain yielding and stable genotypes in in the target areas remains the main goal of many breeding programmes (Ortiz *et al.*, 2001). In the developing countries, farmers grown traditionally landraces, which are relatively well adapted to harsh cropping conditions. However, these traditional cultivars are less responsive to the improvement of the growing conditions. Osmanzai *et al*. (1987) reported that modern cultivars performed similarly as the landraces under drought conditions, but were more responsive to favorable environments. Breeding for wide adaptation and yield stability have sometimes been considered one and the same, insofar as these two terms indicate a consistently good yield response across environments (Annicchiarico, 2002). However, the stability concept refers to temporal consistency of performances, while the adaptation concept refers to special consistency of performances (Evans, 1993). It is widely acknowledged that only genotype x location (GxL) interaction is useful for depicting adaptation patterns, rather than all kinds of genotype x environment (GxE) interactions. The GxL interaction can be exploited to select for specific or large adaptation (Piepho *et al*., 1998; Annicchiarico, 1997b).

Nonparametric analysis of stability based on ranks provides a viable alternative to existing parametric analyses using absolute data (Kaya and Taner, 2003). Fox *et al*. (1990) suggested a nonparametric superiority measure for selecting for general adaptability using stratified ranking of tested cultivars. Rank-sum is another nonparametric stability statistics which combines both yield and stability variance as a single selection criterion (Kang and Pham's, 1991). This statistical parameter assigns a weight of one to both yield and stability enabling the identification of high yielding and stable varieties. The desirable genotype is the one with the lowest rank-sum (Kaya and Taner, 2003).

In the moderately cold regions of Iran, durum wheat landraces including Zardak are still cultivated in limited arcreage under rainfed conditions where farmers are mainly using Sardari bread wheat landrace, although durum wheat grain price is higher. End-use quality is an important factor in durum wheat production, and if a good grain quality is not fulfilled, then the low production costs and higher yield of bread wheat could lead to the decrease in the remaining acreages of durum wheat (Nachit, *et al.,* 1998). The objective of this study is to evaluate the adaptability of introduced durum wheat genotypes to the moderately cold winter rainfed areas of western Iran.

2. MATERIALS AND METHODS

Durum wheat germplasm introduced from ICARDA is annualy evaluated under rainfed conditions by DARI in Iran. The genotypes outyielding the checks are selected to be evaluated in advanced yield trials in the subsequent two seasons to confirm their superiority. Adaptability and yield stability of the out standing genotypes are tested in the national uniform yield trials and in farmer's fields, and the best ones are proposed for release, after being evaluated for their grain quality, their reaction to major pests and diseases and their response to supplemental irrigation.

During the 2000-01 cropping season, IDYT-MCA[1] ICARDA trial with 24 entries was grown, from which three promising lines were selected based on their grain yields. These lines along with two checks (the local

[1] -International Durum Yield Trial Mediterranean Continent Areas.

durum wheat Zardak and the bread wheat landrace Sardari) have followed the above mentioned procedure. The experiment was laid down in a Randomized Complete Blocks Design (RCBD) with three replications. The plots dimensions were 6 rows of 6m long and 0.20m row spacing. The seeding rate adopted was 350/m^2 and the trials were fertilized with N45P45 kg/ha before sowing and with 45 kg/ha of nitrogen applied a top dressing. Uniform yield trials were conducted at Sararood station in Kermanshah province and at Zanjireh station in Ilam province and on farm trials were carried out at Islam Abad and at Harsin in the Kermanshah province based on RCBD with four replications.

Sararood station (Latitude 34º 19' north and longitude 47º 17' east, altitude 1351 m above the sea level) is located 17 km east of Kermanshah city with deep soils of clay-loam texture. The site is situated in a region with moderately cold winters with minimum air temperature above -15ºC, and 60-100 days of freezing temperatures annually. The average annual precipitation is estimated to 455 mm, consisting of 90% rain and 10% snow (Tavakoli et al., 2005).

Zanjireh station (Latitude 33º 41' north and longitude 46º 35', altitude 975 m above the sea level) is located 55 km west of Ilam city with deep soil clay-loam texture. The site is situated in a region with moderately winter air temperature above -5.4 30-40 days of freezing temratures annually. The average annual precipitation is estimated 520mm, consisting 98% rain and 2% snow.

Yield stability and adaptability estimations were based on per year and location rank of the genotype grain yield average. A rank of 1 is assigned to the genotype with the highest and to the genotype with the lowest stability variance. The yield ranks and the stability variance ranks are summed per genotype to obtain the rank-sum described by Kaya and Taner (2003).

Quality parameters were done at the cereal chemistry and technology unit of the Seed and Plant Improvement Institute, and the relative loss , chlorophyll content and the cellular membrane stability were measured in the field according to the methods outlines by Siddique *et al*. (2000)**,** Yang *et al*. (1991)**,** Ashraf *et al*. (1994) and Ozalp *et al*. (2000).

Because of the growing importance of supplemental irrigation in the dryland regions of Iran, the selected genotypes and the check cultivars were evaluated for their response to supplemental irrigation. Fifty mm were applied at the flowering stage and compared to rainfed treatment in an experiment conducted at Sararood experiment station during the 2003-2004 and 2004-2005 seasons and at Zanjireh station during 2004-2005 season. This experiment has allowed to determine a Stress Tolerance Index (STI) and a Tolerance Index (TOL) for each genotype using the formulae reported by Fernandez *et al*. (1992):

$$STI = \frac{(Yr).(Ysi)}{(\overline{ysi})^2}$$

$$TOL = Ysi - Yr$$

Where Yri and Ysi are grain yield of each genotype under rainfed and supplemental irrigation conditions, respectively and $\overline{Ysi}$ is the overall average of grain yield of the genotypes under supplemental irrigation conditions.

The genotypes were evaluated for their tolerance to drought and coldness using some physiological parameters.

Relative Water Content (RWC)

To measure RWC, five randomly selected flag leaves from each genotype per replication were used. Samples were weighed for their Fresh Weight (FW) immediately after collection, and placed in distiller water to obtain the Turgor Weight (TW) for 4 h. The samples were then placed in oven for 48 h at 70 °C to measure their Dry Weight (DW). RWC was calculated for each genotype is determined using the following equation (Siddique, *et al*., 2000).

$$RWC\% = \left[\frac{(FW - DW)}{(TW - DW)}\right] * 100$$

Relative Water Loss (RWL)

Five leaves from each genotype were collected and weighed (W1). The leaves were then wilted at 30 °C and reweighed (W2), transferred to the oven for 24 h and weighed again (W3). RWL was calculated using the formula suggested by Yang *et al*. (1991):

$$RWL = \left[\frac{\frac{W1 - W2}{W3}}{\frac{T2 - T1}{60}}\right]$$

Where T1 and T2 are the time for measuring the initial and wilted weight.

Chlorophyll Content (Chl-a and Chl-b)

Chlorophyll was extracted from the flag leaves of genotypes and measured by spectrophotometer in wave length 663 (k1) and 645 (k2) nm, respectively using the suggested formula by Ashraf *et al*. (1994).

$$Chl - a = \frac{[12.7(k1) - 2.69(k2)] * V}{1000 * W}$$

$$Chl - b = \frac{[22.9(k2) - 4.69(k1)] * V}{1000 * W}$$

Where V and W are the volume and weight of used sample for each genotype.

Cellular Membrane Stability (CMS)

Two samples of flag leaves, 0.1gr each, were weighed and 10 cc distilled water (check), 10 cc polyethylene glycol 40% (stress) were added to each sample, respectively. After 24 h, samples were washed three times in distilled water. Then 10 cc distilled water was added to each sample and after 24 h electric conductivity (EC) of each sample was measured using EC-meter instrument. The samples were then placed in water bath for 30 min and then immediately placed on ice for stopping the reactions, and EC was recorded again for each sample.

CMS % for each genotype was calculated using the formula of Ozalp *et al*. (2000).

$$CMS\% = \left[\frac{1 - \frac{t_1}{t_2}}{1 - \frac{c_1}{c_2}}\right] * 100$$

Where: c1 and c2 are EC at first and second stages under control (check) conditions t1 and t2 are EC at first and second stages under treatment (stress) conditions.

Data analyses were performed using statistical softwares MSTAT-C and SPSS.

3. RESULTS

Grain Yield Performance

The analysis of variance over the twelve environments shows highly significant differences among environments, genotypes and GxE interactions (Table 1). Overall the twelve environments, Syrian-4 and Mna-1/Rfm-7 performed significantly better than Zardak and all the three promising lines were earlier in heading than both Zardak and Sardari. Mrb3/Mna-1 showed the highest 1000 Kernel Weight (TKW) (Table 2). The three lines had higher plant height than Zardak.

The grain yields of tested lines during the three cropping seasons 2000-2001, 2001-2002 and 2002-2003 are given in Table 3. In the first year, the amount of rainfall registered at Sararood station was 369 mm which is below the long-term rainfall average (455mm) and the three promising lines have given moren than 200 kg more grain yield than Zardak, but the differences were not significantly different. In 2001-2002 seasons, the rainfall was 422.7 mm and Mna-1/Rfm-7 and Mrb3/Mna-1 significantly outyielded Zardak. Mrb3/Mna-1 yielded 47% and 12.4% grain yield more than Zardak and Sardari, respectively. The three genotypes expressed higher TKW than the checks. During the third year of testing, the rainfall was 468.2 mm and Mna-1/Rfm-7 outyielded significantly Zardak and Sardari; while the other genotypes outyielded significantly Zardak.

The performances of these genotypes during 2003-2004 and 2004-2005 cropping seasons at two contrasting sites, Sararood (moderately cold winter) and Zanjireh (moderately warm) and under rainfed conditions, are presented in Table 4. Syrian-4 significantly outlyielded Zardak in 2003-04 at Sararood and in 2004-2005 at Zanjireh. Mrb3/Mna-1 performed significantly better than Zardak during both cropping seasons at Sararood and in 2004-2005 at Zanjireh. Mna-1/Rfm-7 showed higher gain yield than the checks in 2003-2004 at Sararood and in 2004-2005 at Zanjireh.

The data of the on-farm validation trials, conducted in two locations, Islam Abad and Harsin dring 2003-2004 season are given in Table 5. Syrian-4 was top yielding at both sites, outyielding both checks, while Mrb3/Mna-1 and Mna-1/Rfm-7 yielded significantly more than Zardak at Islam Abad only (Table 5). Under rainfed conditions, Syrian-4 yielded 20.3% and 6% more grain than Zardak and Sardari, respectively. Mrb3/Mna-1 showed 15.4% and 2% grain yield increase over Zardak and Sardari, respectively, and Mna-1/Rfm-7 gave a 14% yield advantage over Zardak.

Response to Supplemental Irrigation

Mna-1/Rfm-7 and Syrian-4 responded better than the checks to the supplemental irrigation at Sararood during 2003-2004 season (Table 6). In 2004-2005, Syrian-4 showed the best yield performance and showed also the best STI at Sararood. At Zanjireh, the three promising lines outyielded the checks under supplemental irrigation and showed high STI. On average over the two sites and seasons, Mna-1/Rfm-7 and Syrian-4 were more responsive compared to the checks.

Stability and Adaptability

Rank-mean, common variance of ranking scores (S^2) and rank-sum statistics were used to assess the yield stability of the tested genotypes (Table 7). The three promising durum lines showed better grain yield stability during the five cropping season in Sararood. Mrb3/Mna-1 and Mna-1/Rfm-7 were equal regarding to rank mean, but, Mrb3/Mna-1 had better performance and was the genotype of choice for grain yield stability with the lowest when considering Rank-S^2.

Syrian-4 and Mna-1/Rfm-7 had the highest general and rainfed adaptability, respectively (Table 8). Under supplemental irrigation the highest adaptability was observed for Mna-1/Rfm-7 and Syrian-4. This later genotype had the highest stability and adaptability while Zardak check had the lowest stability and adaptability (Figure 1).

Other Attributes of the Promising Lines

Syrian-4 and Mb3/Mna-1 showed better overall grain quality and higher protein content than Zardak (Table 9). All the three promising lines had higher sedimentation and hardness values and had given high semolina percent. Gluten index was the highest for Syrian-4.

The promising lines showed the lowest relative water loss (RWL), higher chlorophyll content and higher Cellular Membrane Stability (CMS), and were earlier in days to heading than the check Zardak (Table 10).

4. DISCUSSION

The main objective of Iran-ICARDA collaborative durum wheat breeding program is to develop new cultivars with better performance and good grain quality under rainfed conditions of Iran with a special focus on adaptation to moderately cold winter areas. The new cultivars must perform better than bread wheat, mainly Sardari landrace to convince farmers to grow more durum wheat. The three lines Syrian-4, Mna-1/Rfm-7 and Mb3/Mna-1 are the first outcome of breeding efforts for moderately cold winter areas. They have shown higher performances than both Zardak and Sardari checks under rainfed conditions and they have also better response to one supplemental irrigation. In Iran dryland, Supplemental Irrigation (SI) is practiced by farmers when precipitation is less than the long-term average to ensure economic yield and minimize the risks due to temporal variability of precipitation (Tavakoli *et al*., 2005). The application of only one irrigation (50mm) to wheat increased grain yield by 50 to 100% (Tavakoli *et al*., 2005).

Syrian-4 and Mna-1/Rfm-7 showed better yield stability and adaptability which could be partially attributed to their better drought tolerance shown by the physiological attributes measured in this study. Therefore, these lines are combining good drought and cold tolerances. In addition, these two lines have also better pasta quality than Zardak and Sardari.

Based on these results, Syrian-4 and Mna-1/Rfm-7 are proposed for release in the moderately cold rainfed regions of Iran. These promising lines have shown good tolerance to the most prevailing stresses (drought and mild cold winters) as well as good grain quality. Therefore, they can be used as parental germplasm by ICARDA and national breeding programs to generate adapted varieties which will contribute to the expansion of durum wheat cultivation into regions with mild cold winters in CWANA region where most of the durum wheat is mainly grown in the Mediterranean type of climate (Nachit et *al*., 1998). More research is still needed to improve the winter hardness of durum wheat in cold and mild cold winter areas.

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Table (1): Combined analysis for grain yield, TKW and PLH for five varieties across 12 environments.

S.O.V.	df	MS (Mean Squares)		
		Yield (kg/ha)	TKW (gr)	PLH (cm)
Environment (E)	11	15529357.3**	411.0**	3879.44**
Error-1	24	346539.1	2.1	2.033
Genotype (G)	4	1092503.7**	57.4**	3819.964**
G*E	44	668345.1**	30.3**	123.512**
Error-2	96	145620.5	1.2	1.7
Total	179			

** Significant at 1% level of probability .

Table (2): The overall averages of grain yield, TKW and PLH of three promising lines and two checks across 12 environments.

Genotype	Yield (kg/ha)	TKW (gr)	PLH (cm)
Syrian-4	3000	34.03	88.08
Mrb3/Mna-1	2849	36.56	84.64
Mna-1/Rfm-7	2904	33.83	80.72
Zardak	2537	33.53	101.7
Sardari	2860	35.31	103.6
LSD%5	388.3	2.67	5.279
LSD%1	518.8	3.495	7.052

Table (3): Grain Yield (GY), (TKW) and Plant Height (PH) of three durum promising lines and two checks at Sararood experiment, Kermanshah during 2001-2003 seasons.

Genotype	Traits	Cropping season			Mean
		2000-2001	2001-2002	2002-2003	
Syrian-4	GY (kg/h)	2160 C	2563 C	2480 B	2401.0
	TKW (gr)	22	33	34	29.7
	PH (cm)	76	97	90	87.7
Mrb3/Mna-1	GY (kg/h)	2270 C	3201 A	2528 B	2666.3
	TKW (gr)	29	35	34	32.7
	PH (cm)	75	94	84	84.3
Mna-1/Rfm-7	GY(kg/h)	2370 C	2822 B	2816 A	2669.3
	TKW (gr)	23	30	33	28.7
	PH (cm)	74	87	66	75.7
Zardak	GY (kg/h)	1930 C	2178 C	2060 C	2056.0
	TKW (gr)	22	26	35	27.7

Genotype	Traits	Cropping season			Mean
		2000-2001	2001-2002	2002-2003	
	PH (cm)	66	106	94	88.7
Sardari	GY (kg/h)	-	2847 A	2293 C	2570
	TKW (gr)	-	29	34.2	31.6
	PH (cm)	-	112	95	103.5
Rainfall(mm)	-	369.0	442.7	468.2	421.6
Grain Yield		LSD1%=630 LSD5%=470	LSD1%=665 LSD5%=498	LSD1%=505.3 LSD5%=378.7	

C: Not significantly different from local check (Zardak) for grain yield.

B and A: Significantly superior to Zardak at 5% and 1% levels, respectively.

Table (4): Grain Yield (GY), (TKW) and Plant Height (PH) of three durum promising lines and two checks evaluated at national uniformity yield trials in Sararood and Zanjireh stations during 2003-2005 seasons.

Genotype	Traits	Location-Year					Mean
		Sararood station			Zanjireh Station		
		2003-2004	2004-2005		2003-2004	2004-2005	
Syrian-4	GY (kg/h)	2165 B	2724 C		1627 C	2574 C	2272.5
	TKW (gr)	35	34		32	33	33.5
	PH (cm)	70	72		69	90	75.3
Mrb3/Mna-1	GY (kg/h)	1793 C	3029 C		1606 C	2606 C	2303.5
	TKW (gr)	39	36		36	33	36
	PH (cm)	74	70		61	90	73.8
Mna-1/Rfm-7	GY (kg/h)	2131 B	1674 E*		1979 C	2688 C	2118.0
	TKW (gr)	34	32		34	33	33.3
	PH (cm)	70	70		50	93	63.3
Zardak	GY (kg/h)	1654 C	3022 C		1983 C	2438 C	2274.3
	TKW (gr)	43	34		30	31	34.5
	PH (cm)	96	97		94	115	100.5
Sardari	GY (kg/h)	2013 C	3236 C		1766 C	2641 C	2369.0
	TKW (gr)	43.4	38		29	30	35.1
	PH (cm)	86	93		97	108	96
Rainfall(mm)	-	597.1	431.5		590	552	542.6
Grain Yield		LSD1%=458.7 LSD5%=618.9	LSD1%=761.1 LSD5%=564.3		LSD1%=808.9 LSD5%=605.1	LSD1%=946 LSD5%=708	

* E; Significantly less than local check (P≤1%).

Table (5): Grain Yield (GY), Thousand Kernel Weight (TKW) and Plant Height (PH) of three durum promising lines and two checks evaluated in farmer's fields in Kermanshah province during 2004-2005 season.

Genotype	Traits	Islam Abad	Harsin	Mean
Syrian-4	GY (kg/h)	6458 A	2267 B	4362.5
	TKW (gr)	38	26	32
	PH (cm)	97	67	82
Mrb3/Mna-1	GY (kg/h)	5830 A	1130 C	3480
	TKW (gr)	38	34	36
	PH (cm)	82	59	70.5
Mna-1/Rfm-7	GY (kg/h)	5872 A	1362 C	3617
	TKW (gr)	30	30	30
	PH (cm)	88	64	76
Zardak	GY (kg/h)	3937 C	1595 C	2766
	TKW (gr)	24	36	30
	PH (cm)	105	77	91
Sardari	GY (kg/h)	4358 C	1752 C	3055
	TKW (gr)	30	28	29
	PH (cm)	98	84	91
Rainfall (mm)	-	514.3	474.5	494.4
Grain Yield		LSD1%=1252 LSD5%=905	LSD1%=760 LSD5%=550	

Table (6): Grain Yields under rainfed and supplemental irrigation conditions and drought tolerance indices of three durum promising lines and two checks at Srarood and Zanjireh stations during 2003-2004 and 2004-2005 seasons.

Genotype	Location-year											
	Sararood station (Kermanshah Province)								Zanjireh station (Ilam Province)			
	2003-2004				2004-2005				2004-2005			
	Yr *	**Ysi**	**STI**	**TOL**	**Yr**	**Ysi**	**STI**	**TOL**	**Yr**	**Ysi**	**STI**	**TOL**
Syrian-4	2165B	3462B	0.677	1297	2724C	3864C	0.785	1140	2574C	3650C	0.742	1076
Mrb3/Mna-1	1793C	3309C	0.536	1516	3029C	3186C	0.719	157	2606C	3697C	0.760	1091
Mna-1/Rfm-7	2131B	3889A	0.749	1758	1674E	3180C	0.397	1506	2688C	4065C	0.862	1377
Zardak	1654C	2768C	0.414	1114	3022C	3464C	0.780	442	2438C	3413C	0.657	975
Sardari	2013C	3208C	0.583	1195	3236C	4618B	1.114	1382	2641C	2972C	0.620	331
Rainfall (mm)	587.6 587.6+50				431.5 431.5+50				552 552+50			
Grain Yield	LSD1%=618.9				LSD1%=761.1				LSD1%=946			

Genotype	Location-year											
	Sararood station (Kermanshah Province)								Zanjireh station (Ilam Province)			
	2003-2004				2004-2005				2004-2005			
	Yr *	Ysi	STI	TOL	Yr	Ysi	STI	TOL	Yr	Ysi	STI	TOL
(Rainfed)	LSD5%=458.7				LSD5%=564.3				LSD5%=708			
GrainYield	LSD1%=918.8				LSD1%= 1337.7				LSD1%=890			
(Supplemental Irrigation)	LSD5%=681.3				LSD5%=991.7				LSD5%=666			

*Yr and Ysi are grain yield under rainfed and supplemental irrigation conditions respectively; STI and TOL: Stress Tolerance Index and Tolerance Index, respectively.

Table (7): Yield ranks and yield stability parameters of the genotypes based on ranking score in Sararood station during the five years (2000-2005) period.

Genotype	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	Stability			
						Rank Mean	S^2	Rank- S^2	Rank–Sum
Syrian-4	3	4	3	1	4	3.0	1.49	2	5.0
Mrb3/Mna-1	2	1	2	4	3	2.4	1.30	1	3.4
Mna-1/Rfm-7	1	3	1	2	5	2.4	2.79	5	7.4
Zardak	4	5	5	5	2	4.2	1.69	4	8.2
Sardari	-	2	4	3	1	2.5	1.66	3	5.5

1 is the best and 5 is the worst based on grain yield of the genotypes, S^2 is the common variance, Rank-sum is sum of rank mean and rank-S^2.

Table (8): Adaptability of the genotypes based on ranking score in different locations.

Genotype	Sararood station		Zanjireh Station		Islam abad (On-farm)	Harsin (On-farm)	Adaptability Ranking score		
	Rainfed (2000-2005)	SI (2003-2005)	Rainfed (2003-2005)	SI (2004-2005)	Rainfed (2003-2004)	Rainfed (2003-2004)	General	Rainfed	SI
Syrian-4	3.0	2.0	3.5	3	1	1	2.25	2.13	2.50
Mrb3/Mna-1	2.4	3.5	3.5	2	5	5	3.56	3.97	2.75
Mna-1/Rfm-7	2.4	3.0	1.5	1	4	4	2.65	2.97	2.00

Genotype	Sararood station		Zanjireh Station		Islam abad (On-farm)	Harsin (On-farm)	Adaptability Ranking score		
	Rainfed (2000-2005)	SI (2003-2005)	Rainfed (2003-2005)	SI (2004-2005)	Rainfed (2003-2004)	Rainfed (2003-2004)	General	Rainfed	SI
Zardak	4.2	4.0	3.0	4	3	3	3.53	3.30	4.00
Sardari	2.5	2.5	3.5	5	4	2	3.25	3.00	3.75

Table (9): Quality parameters of three durum promising lines and two checks.

Traits	Syrian-4	Mrb3/Mna-1	Mna-1/Rfm-7	Zardak	Sardari
Kernel colour	Yellow	Yellow	Yellow	Yellow	Yellow
Protein%	13	12.1	11.7	12	10.9
Sedimentation test	69	60	54	57	-
Moisture content%	10.5	9	9.5	10.5	11.2
Hardness index	60	62	59	57	49
Wet gluten %	40	32	30	30	28
Gluten elasticity	Normal	Normal	Normal	Normal	Normal
Gluten index	59	41	46	57	52
Dry Gluten %	14	11	10	10	9
Semolina color	8	5	5	5	-
Semolina percent	51	55	52	50	-

Table (10): Physiological characteristics of three durum promising lines and two checks measured at Sararood under rainfed conditions.

Genotype	RWC (%)	RWL (gr/gr.h)	Chl-a (mlgr/gr)	Chl-b (mlgr/gr)	CMS (%)	DH (Day)
Syrian-4	91.0	2.283	0.540	0.297	23	194
Mrb3/Mna-1	92.0	2.267	0.513	0.287	12.7	194
Mna-1/Rfm-7	92.2	2.377	0.453	0.253	15.2	193
Zardak	92.1	2.447	0.420	0.233	10.1	196
Sardari	89.0	2.530	0.437	0.242	7.4	199
LSD5%	8.309	0.279	0.052	0.106	11.33	0.016

RWC= Relative water content, RWL= Relative water loss, Chl-a = Chlorophyll of a , Chl-b= Chlorophyll of b, CMS= Cellular membrane stability, DH= Days to heading.

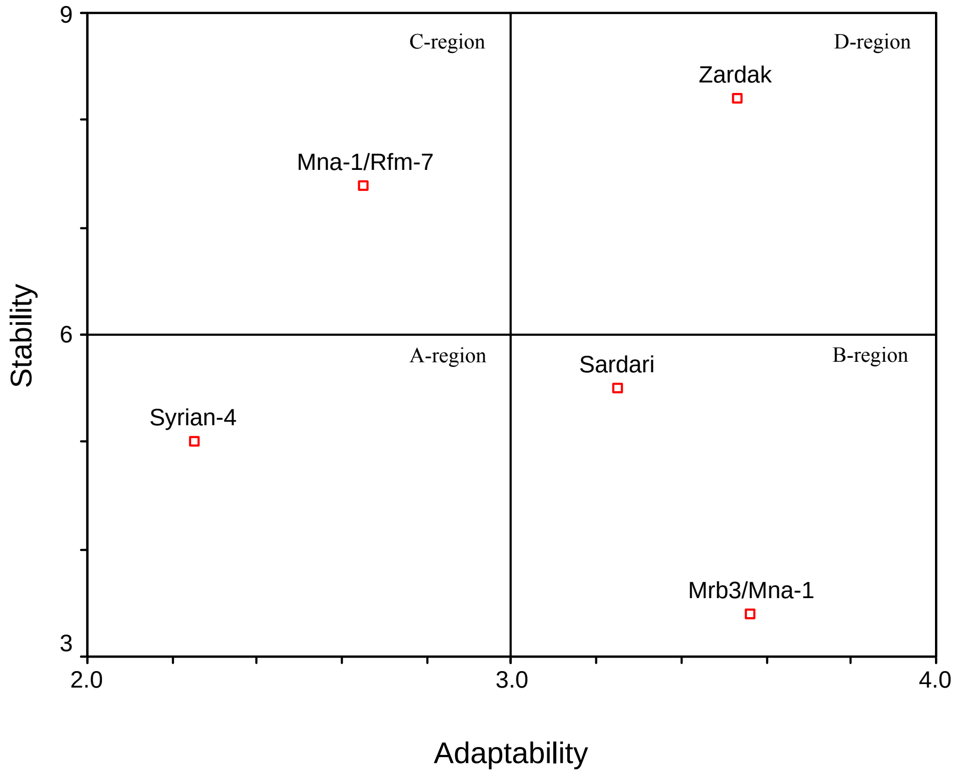

Fig. (1): Comparison of stability and adaptability of the three durum promising lines and two checks.
A-region: region of high adaptability and stability.
B-region: region of low adaptability and high stability.
C-region: region of high adaptability and low stability.
D-region: region of low adaptability and stability.

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خصائص ثلاث سلالات من القمح القاسي المتأقلمة مع الظروف المطرية والري التكميلي في المناطق الباردة في غرب إيران

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ملخـص

يشكل استنباط أصناف مقاومة للجفاف وذات مردودية وتأقلم عاليين أهم أهداف برامج التحسين الوراثي في المناطـق الجافة. ثلاث سـلالات من القمح القاسي (Syrian 4, Mrb-3/Mna-1, Mna-1/Rfm-7)، منتخبة من تجارب إيكاردا، تم تقييمها في التجربة الوطنية للإنتاجية وفي حقول المزارعين تحت الظروف المطرية وتحت الري التكميلي في منطقة غرب إيران الباردة خلال خمسة مواسم زراعية (2000-2005). وقد أظهرت السلالتان Mrb-3/Mna-1 و Syrian 4 تفوق انتاجيتهما على الشاهدين Zardak من القمح القاسي و Sardari من القمح الطري تحت الظروف الجافة المطرية. كما ان سلالة Mna-1/Rfm-7 أعطت 14% زيادة في المردودية على الصنف المحلي Zardak. وتحت ظروف الري التكميلي أظهرت السلالتان Mrb3/Mna-1 و Syrian 4 مردودية وتأقلماً أعلى من الأصناف الأخرى، ويمكن اعتمادهما من طرف المزارعين في المناطق ذات فصل شتاء متوسط البرودة تحت الظروف المطرية أو باستعمال الري التكميلي. كما ان لهذه السلالات جودة عالية للحبوب ونسبة بروتين عالية، كما ان لها تحملاً أفضل للجفاف مقارنة مع الصنف المحلي Zardak. هذه السلالات الجديدة يمكن استعمالها كأصناف معتمدة أو كمصادر وراثية في المناطق ذات الظروف المناخية المتشابهة في وسط وغرب آسيا وشمال إفريقيا.

الكلمـات الدالـة: القمح القاسي، التأقلم، مقاومة الجفاف، نوعية الحبوب، الشتاء متوسط البرودة، الري التكميلي.

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