IDENTIFYING SUPERIOR WHEAT LINES IN PARTICIPATION WITH EXTENSION-RESEARCHES

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Receiving high and stable grain yield in different environments is one of the aims in cereal breeding programs. In order to compare the results of station-researches under on-farm conditions, it is necessary carrying out extension-research projectes to receive high grain yield and introduction lines with superior characteristics. In this study, "CD-92-5" (Lufer-1/Kinaci97) and "CD-92-6" (Guam92//Psn/Bow/3/Thk// 4141W113/Karl) as promising lines and "Mihan" (Bkt/90-Zhong87) and "Haydari" (Ghk"s"/Bow"s"//90Zhong87/3/Shiroodi) as control cultivars sown under irrigated and on-farm conditions in Bukan, Nagadeh, Oshnavieh and Miandoab regions north west of Iran. Planted area for each genotype at per location was 5000m^2. Land preparation and sowing were accomplished according to common regions under on-farm conditions. Seeding rate was based on 1000-kernal weight with 450 seed/m^2 and fertilizer application was based on recommendation of soil and water department according to soil test. Simple and combined analyses of variance showed significant differences for ten measured traits ($p \leq 0.05$). "CD-92-5" and "CD-92-6" promising lines had the Minimum and Maximum variance and standared error within plots for traits of grain yield and total dry matter, respectively. Range of heritibility with 45% and 85% was allocated for traits of 1000-kernal weight and spike per square meter. "CD-92-5" with the highest grain yield (306 g/m^2) was identified as stable genotype based on Equivalance-Rig, Finley and Wilkinson and genotypic coefficient variation indices. Total dry matter and spike weight had positive significant correlations with grain yield at four regions of Bukan, Nagadeh, Oshnavieh and Miandoab. Therefore, these traits can be used as indirect criteria for increasing grain yield in breeding programs.

Key words: Cold climate, Grain yield and its components, On-farm trial, Promising line, Winter wheat.

INTRODUCTION

Since wheat has been sown in more than one hundred thousand hectares in the west of Azerbaijan province of Iran in growing seasons of 2016–2017, it is the first product within crops and one of the main sources of income for farmers

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planting wheat. Therefore, identifying promising lines with high grain yield potential and compatible to limit input production in terms of income and employment is important in this region.

There are different methods and tools for technology transfer to the farmers' field. On-farm research has been known as an essential implement and effective method for developing and transmitting the new applied researchers' results into the farmers' field. It also has an indispensable duty for screening and substantiation of farming applied science under local farmers' conditions. Furthermore, on-farm research creates suitable conditions for participatory management of the researchers, extension agents and farmers for the finding of agricultural problems in the rural areas (27). In order to transmit the new applied researchers' results into farmers' field, Moayedi, (2012) compared promising drum wheat lines in two farmers' field. Results showed that there were significant differences for impact of genotype × location on grain yield. D-84-3 produced the highest grain yield and it might use stable breeding materials under farmers' field conditions (19). Eivazi *et al*. (2017) evaluated wheat-promising lines under on-farm conditions. They introduced C-89-15 with more than 8.0th^{-1} grain yield for cold regions of Iran (10).

Grain yield and its stability of wheat genotypes are important in breeding programs. This can be used to select promising wheat genotypes across multi-environments. Therefore, Aydin *et al*. (2011) sowed different wheat genotypes in seven environments in the central black sea region and selected three genotypes for release procedure with good yield potential and acceptable end use quality (3). Ahmadi *et al*. (2012) in targeting promising bread wheat lines for cold climate environments with using of AMMI and GGE bi-plot analyses found two lines that had high grain yield at different environments. They concluded that AMMI and GGE bi-plots facilitated visual comparison and identification of superior genotypes (1). Khan *et al*. (2014) in evaluating five promising wheat lines revealed that the overall mean grain yield of genotypes across environments ranged from 1198 to 2202 kgh^{-1} at three locations under rainfall conditions of Balochistan, Pakistan (18). Cultivar "AZRC-3" having a regression coefficient close to unity and a higher grain yield showed consistent performance and was considered as stable and widely adopted (10). Khajavi *et al*. (2014) tested genetic diversity of twenty barley lines based on pheno-morphological traits and selected five promising lines. These genotypes were introduced as superior lines for releasing and replacing common cultivars (17). Nabaty and Shaban, (2012) compared barley promising lines under two temperate locations of Iran. Results showed that barley yield in Boroujerd was the highest for "MB83-3" line and in Dorud location was the highest for common "Nosrat" cultivar. They selected "MB83-3" line for complimentary studies (22). Mohammadi and Haghparast (2011) in analyzing the genotype by farmers' field trials data showed that farmers' field main effect was the predominant source of variation (21). Great variations exist in the agro-ecological conditions within the region in terms of altitude, temperature, and soil characteristics etc. therefore

Baig *et al*. (2008) evaluated wheat-promising lines for grain yield over three locations. Results showed that "Chakwal-97" line gave high grain yield with 4955 kgh^{-1} (4). Ramazani and Tajalli (2016) in testing triticale-promising line recommended "ET-83-18" new line could be replaced with "Juanillo-92" as old cultivar under Birjand and similar areas conditions of Iran (24). The objective of this research was comparison of tolerant drought stress in the end-growing season of wheat, including "CD-92-5" and "CD-92-6" as promising lines with "Mihan" and "Haydari" as control and commercial cultivars in Naghdeh, Bukan, Oshnavieh and Miandoab regions. Possibility of replacing them with old conventional cultivars and landraces under on-farm and cold regions of Iran is shown.

MATERIAL AND METHODS

Experimental locations

Four field experiments were conducted in 2016-17 growing seasons under on-farm conditions. "CD-92-5" (Lufer-1/Kinaci97) and "CD-92-6" (Guam92//Psn/Bow/3/Thk//4141W113/Karl) as promising lines with "Mihan" (Bkt/90-Zhong87) and "Haydari" (Ghk"s"/Bow"s"//90Zhong87/3/Shiroodi) as control and commercial cultivars were sown in Nagadeh, Bukan and Oshnavieh, Miandoab regions, separately, in West Azerbaijan province, north-west of Iran. Each genotype at every region was planted at 5000 m^2 under irrigated growth conditions.

Climatic conditions

Nagadeh, Bukan, Oshnavieh and Miandoab regions were located in the West Azerbaijan province, north-west of Iran and have semi-arid climate. Period of below-freezing temperature is 90 to 100 days, which in seasons of January, February and March reaches its minimum values (Table 1). Autumn precipitation almost starts from late of October and most rainfall occurs when plant growth is slow. With increasing temperature, precipitation interrupts and evaporation rate rises in the second half of May. During grain filling period in May and cut off rainfall, in addition, temperature rises, relative humidity reduces and hot winds start and haying-off damage can be seen in various areas.

Husbandry practices

Husbandry operations were carried out based on conventional methods. Therefore, the field was deep plowing in April and given triple-super-phosphate fertilizer at the rate of 100 kgh^{-1} and then the disc was struck in August. At the sowing time (15 September, 30 October) 200 kgh^{-1} nitrogen fertilizer was applied based on soil test. 70 kgh^{-1} nitrogen was spread at first time and topdressing was added at two stages during stem elongation and heading. Cultivation was carried out with farmers' method. Furrow irrigation was done three-times at different growth stages until physiological maturity. In order to apply drought stress at the grain filling stage, irrigation was interrupted in June until maturity. Seeds were sterilized with Carboxyinthiram fungicide to prevent smut infection before sowing. For weed-controlling Topic and Ganstar toxins were used for board-leaf and grasses weeds at the stem elongation stage, respectively. Germination-time, cold damage, date of tillering, number of days to heading and maturity were recorded during the period of plant growth.

Measured traits

At harvesting-time six samples were randomly selected. Evaluated traits were plant height, spike length, number of spikelets at per spike, grains at per spike, number of spikes at per square meter, 1000-kernal weight, grain yield, total dry matter and harvest index. Grain yield and total dry matter were measured separately from areas of two square meters for each genotype at four locations.

Statistical analysis

The skewness to the right, left and kurtosis of data were calculated with Mstat-C software for regions of Nagadeh, Bukan, Oshnavieh and Miandoab. Simple analysis was done for each region based on randomized complete blocks design with five replications. Before combined analysis of variance, Bartlett's test was performed for approving uniformity error mean squares. Also, the range of variation, standard deviation and coefficient of variations were calculated for each experimental location (Cochran and Cox, 1957) (6).

Genetic analysis

Genotypic ($\sigma^2 g$), genotype by location interaction ($\sigma^2 gl$) and phenotypic variances ($\sigma^2 p$) were obtained according to Comstock and Robinson, (1952) as follows (7):

$$\text{Genotypic variance } (\sigma^2 g) = \frac{MSg - MSe}{lr}$$

where MSg is the mean square of genotype, MSe is the mean square of error, l is number of locations and r is replication.

Genotype by location interaction variance was estimated as:

$$\text{Genotype by location interaction variance } (\sigma^2 gl) = \frac{MSgl - MSe}{r}$$

where $MSgl$ is the mean square of genotype by location interaction, Mse is the mean square of error, and r is replication.

Phenotypic variance ($\sigma^2 p$) = $\sigma^2 g + \sigma^2 e + \sigma^2 gl$

where $\sigma^2 g$ is genotypic variance, $\sigma^2 e$ = environmental variance, and $\sigma^2 gl$ is genotype by location interaction.

Heritability in the broad sense (H^2) was estimated according to Falconer and Mackay (1989) as follows (11):

$$H^2 = \frac{\sigma^2 g}{\sigma^2 p} x^{100}$$

where $\sigma^2 g$ is genotypic variance and $\sigma^2 p$ is phenotypic variance.

The mean values for genetic analyses were used to determine phenotypic coefficient of variation (PCV), environmental coefficient of variation (ECV), and genotypic coefficient of variation (GCV), as described by Choudhury and Singh, (1987) as follows (5):

$$\text{GCV} = \frac{\sqrt{\sigma^2 g}}{\overline{x}} x\, 100$$

where $\sigma^2 g$ is genotypic variance and $\overline{x}$ is grand mean of a character

$$\text{PCV} = \frac{\sqrt{\sigma^2 p}}{\overline{x}} x\, 100$$

where $\sigma^2 p$ is phenotypic variance and $\overline{x}$ is grand mean of a character.

Environmental coefficient of variation (ECV):

$$\text{ECV} = \frac{\sqrt{\sigma^2 e}}{\overline{x}} x\, 100$$

where $\sigma^2 e$ is error variance and $\overline{x}$ is grand mean of a character.

Genetic advance (GA) was calculated with the method suggested by Allard (1960); Choudhary and Singh, (1987) as follows (2 and 5):

$$GA = K \bullet \sqrt{\sigma^2 p\, x}\, H^2$$

where K is 2.06 at 5% selection intensity, $\sqrt{\sigma^2 p}$ is square root of phenotypic variance and H^2 is Heritability.

Genetic advance as percentage of the mean (GAM) was computed as:

$$\text{GAM (\%)} = \frac{GA}{\overline{x}} x\, 100$$

where GA is genetic advance and $\overline{x}$ is grand mean of a character.

Stability analysis

Stability of cultivars was calculated based on three methods of Ecovalancerice (Wi), Wilkinson (Bi) and coefficient of variation (Cvi) for each genotype according to the following formulas: (Finley and Wilkinson, 1963) (12).

$$Wi = \sum_{j=1}^{e} \left(\left(Xij - \frac{Xio}{e} - \frac{Xoj}{g} + \frac{Xoo}{ge} \right) \right)^2$$

Xij = i^{th} mean genotype in j^{th}
Xio = Sum of i^{th} genotype in all environments
Xoj = Sum of j^{th} environment with all genotypes
Xoo = Sum of all data
e = number of environments
g = number of genotypes

$$\mathcal{Y} = \frac{\sum_i^g \sum_j^e xij}{g}$$

$$g = \frac{\sum_i^g \sum_j^e xij}{e}$$

$$bi = \frac{\sum_i^g \sum_j^e xij \times \mathcal{Y}}{\sum_j^e xij \times \mathcal{Y}^2}$$

y = Shows mean environment of genotypes
g = Mean of all genotype
bi = Phenotypic stability (regression of mean genotype on mean environment)

$$CV_i = \frac{\sqrt{S_i^2}}{Y_{io}} \times 100$$

$CV_i = i^{th}$ genotypic coefficient of variation in all environments.

Table 1

Meteorological parameters of Nagadeh, Bukan, Oshnavieh and Miandoab regions in 2016–2017 seasons

					Nagadeh experimental location					
Parameter	**October**	**November**	**December**	**January**	**February**	**March**	**April**	**May**	**June**	**July**
Precipitation (mm)	---	17.4	59.0	13.8	38.2	26.4	38.6	12.0	1.7	2.2
Maximum temp. (C°)	23.8	16.6	6.5	-0.5	1.0	9.0	16.2	24.1	28.5	32.9
Minimum temp. (C°)	6.5	3.4	-5.9	-6.7	-6.3	-1.7	4.6	9.2	11.7	16.2
Maximum humidity (%)	78	87	90	89	93	91	81	76	52	69
Minimum humidity (%)	36	52	53	72	72	61	47	42	36	43
Sunny (h)	293.4	205.1	204.5	103.6	123.9	201.5	239.8	296.8	350.3	348.6
Evaporation (mm)	191.6	75.6	---	---	---	---	107.5	224.9	293.2	266.7
Frosty (day)	---	8	24	30	28	16	---	---	---	---

Table 1 (continued)

Bukan experimental location										
Precipitation (mm)	---	16.8	110.6	24.9	46.0	37.6	68.7	17.8	---	1.6
Maximum temp. (C°)	24.6	17.1	7.1	-0.2	1.9	8.3	15.8	24.6	30.0	35.1
Minimum temp. (C°)	7.8	4.4	-4.3	-8.3	-6.1	-2.8	5.1	10.0	12.9	18.3
Maximum humidity (%)	73	71	78	92	86	85	76	67	42	43
Minimum humidity (%)	31	33	39	68	72	39	24	22	13	15
Sunny (h)	287.7	196.0	187.0	86.6	119.6	200.4	238.0	291.7	386.9	348.1
Evaporation (mm)	150.1	71.1	---	---	---	---	69.6	191.2	322.5	403.4
Frosty (day)	---	4	21	30	30	18	3	---	---	---
Oshnavieh experimental location										
Precipitation (mm)	0.3	42.0	90.3	31.5	48.5	66.6	79.8	29.1	---	---
Maximum temp. (C°)	22.4	17.1	7.0	0.9	1.9	9.6	15.6	22.6	27.0	32.2
Minimum temp. (C°)	4.6	4.1	-5.6	-11.6	-8.3	-4.2	2.9	7.5	9.4	14.6
Maximum humidity (%)	76	81	81	96	93	96	77	78	65	61
Minimum humidity (%)	28	37	41	71	60	50	33	37	22	23
Sunny (h)	288.4	190.2	173.3	109.3	118.7	182.6	207.3	282.7	385.9	362.5
Evaporation (mm)	121.2	35.6	---	---	---	---	112.7	171.9	300.3	296.5
Frosty (day)	11	23	30	30	20	7	---	---	---	---
Miandoab experimental location										
Precipitation (mm)	---	11.2	55.0	17.2	15.0	24.0	46.5	14.7	1.3	1.3
Maximum temp. (C°)	24.5	17.1	7.0	0.2	2.5	10.4	16.4	24.9	30.4	34.3
Minimum temp. (C°)	5.2	2.9	-4.3	-7.5	-5.2	0.0	4.7	9.5	11.4	16.9
Maximum humidity (%)	78	82	80	90	84	82	79	73	60	61
Minimum humidity (%)	25	36	38	59	50	39	34	27	17	21
Sunny (h)	290.6	202.2	183.4	78.8	118.4	194.9	220.7	302.8	400.1	368.8
Evaporation (mm)	123.5	25.7	---	---	---	---	76.4	214.5	291.8	311.0
Frosty (day)	---	11	24	30	30	16	3	---	---	---

RESULTS AND DISCUSSION

Skewness and kurtosis of data were calculated for ten traits of four bread wheat genotypes including “CD-92-5”, “CD-92-6” as promising lines and “Mihan”, “Haydari” commercial check cultivars in Nagadeh, Miandoab, Bukan and Oshnavieh regions. Results showed that each trait was normally distributed and had not statistically significant differences with Student’s t test ($p \leq 0.05$) (Table 2). For achieving the most possible grain yield on a given site, farmers must use promising lines that are adapted to particular environments insisted of landraces and old common commercial cultivars, which fluctuate with different seasons and locations just like our results (Ingver *et al.*, 2008) (15).

Table 2

Skewness, kurtosis and probability levels of wheat traits under Nagadeh, Bukan, Oshnavieh and Miandoab on-farm conditions in 2016–2017 seasons

CD-92-5 promising line						
Trait	**Skewness**	**t-student value**	**probability**	**Kurtosis**	**t-student value**	**probability**
Total dry matter (g/m^2)	0.760	1.193	0.128	0.841	0.682	0.254
Spike/m^2	0.481	0.755	0.233	-0.015	-0.012	0.495
Grain per spike	-0.286	-0.448	0.331	-1.297	-1.052	0.157
Spikelet per spike	-0.675	-1.059	0.155	1.263	1.025	0.163
Plant height (cm)	0.188	0.295	0.386	-0.430	-0.349	0.366
Spike weight (g)	1.050	1.647	0.063	1.030	0.836	0.21
Grain yield (g/m^2)	0.105	0.165	0.435	-0.449	-0.364	0.361
1000-kernel weight (g)	0.345	0.542	0.299	-1.315	-1.067	0.154
Harvest index (%)	0.661	1.037	0.160	1.744	1.415	0.092
Grain per spiklet	0.080	0.126	0.450	-1.857	-1.507	0.080

Table 2 (continued)

CD-92-6 promising line						
Total dry matter (g/m^2)	0.167	0.262	0.398	-2.051	-1.664	0.062
Spike/m^2	0.425	0.667	0.259	-1.559	-1.265	0.115
Grain per spike	0.033	0.051	0.479	-1.018	-0.826	0.213
Spikelet per spike	0.096	0.151	0.441	-0.669	-0.543	0.299
Plant height (cm)	-0.252	-0.395	0.350	-0.177	-0.144	0.443
Spike weight (g)	0.487	0.765	0.230	-1.233	-1.000	0.169
Grain yield (g/m^2)	0.486	0.761	0.230	-1.307	-1.061	0.155
1000-kernel weight (g)	-0.355	-0.557	0.294	-0.515	-0.418	0.341
Harvest index (%)	0.623	0.977	0.174	1.199	0.973	0.175
Grain per spiklet	0.078	0.123	0.452	-0.721	-0.585	0.284
Mihan commercial cultivar						
Total dry matter (g/m^2)	-0.194	-0.411	0.342	-1.250	-1.362	0.093
Spike/m^2	0.118	0.251	0.402	-1.359	-1.480	0.076
Grain per spike	-0.745	-1.020	0.0827	1.454	1.602	0.0623
Spikelet per spike	0.395	0.836	0.205	-0.641	-0.699	0.245
Plant height (cm)	-0.075	-0.157	0.438	-1.120	-1.220	0.117
Spike weight (g)	-0.143	-0.303	0.382	-0.829	-0.903	0.187
Grain yield (g/m^2)	-0.196	-0.415	0.340	-0.853	-0.929	0.181
1000-kernel weight (g)	-0.577	-1.222	0.117	0.547	0.596	0.278
Harvest index (%)	0.356	0.755	0.228	-0.602	-0.656	0.259
Grain per spiklet	-0.865	-1.722	0.059	0.144	0.157	0.438
Haydari commercial cultivar						
Total dry matter (g/m^2)	-0.276	-0.585	0.282	-0.974	-1.061	0.149
Spike/m^2	-0.499	-1.057	0.150	-0.526	-0.573	0.286
Grain per spike	0.341	0.722	0.238	0.362	0.394	0.348
Spikelet per spike	0.790	1.791	0.167	1.415	1.900	0.094
Plant height (cm)	0.077	0.163	0.435	-1.472	-1.603	0.061
Spike weight (g)	-0.408	-0.865	0.197	-1.029	-1.121	0.136
Grain yield (g/m^2)	-0.529	-1.121	0.136	-1.052	-1.147	0.131
1000-kernel weight (g)	-0.797	-1.690	0.052	1.095	1.283	0.096
Harvest index (%)	-0.105	-0.223	0.412	-0.619	-0.675	0.253
Grain per spiklet	-0.185	-0.393	0.348	0.065	0.071	0.471

Bartlett Test

The variance of experimental errors in each region was analyzed by the Chi-square test. None of traits showed significant statistical differences and that implies the uniformity of mean square errors in each region. So, it was possible for analyzing combined variance of locations (Table 3).

Table 3

Bartlett test of wheat traits under on-farm conditions at four locations in 2016–2017 seasons

Distribute	Total dry matter (g/m^2)	Spike/m^2	Grain per spike	Spikelet per spike	Plant height (cm)	Spike weight (g)	Grain yield (g/m^2)	1000-kernel weight (g)	Harvest index (%)	Grain per spikelet
Nagadeh and Bukan experimental locations										
Chi-square	2.19	1.34	3.63	0.12	3.60	0.13	3.14	2.09	1.63	2.97
Oshnavieh and Miandoab experimental locations										
Chi-square	3.64	0.85	2.16	0.62	3.60	1.89	3.14	2.29	2.18	3.02
Probability	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

Combined analysis of variance

Nagadeh and Bukan regions: Between regions, except for total dry matter and spikelet per spike, were significant differences (Table 4). In addition all traits had statistically significant differences between genotypes. For the impact between them, grain at per spike, plant height, 1000-kernel weight and harvest index had not significant differences. The highest and lowest coefficients of variations have allocated for spike/m^2 (18.81%) and 1000-kernel weight (5.32%), respectively.

Table 4

Combined analysis of variance for wheat traits under on-farm conditions at four locations in 2016–2017 seasons

		Total dry matter	Spike/m^2	Grain per spike	Spikelet per spike	Plant height	Spike weight	Grain yield	1000-kernel weight	Harvest index	Grain per spikelet
SOV	df	**Nagadeh and Bukan experimental locations**									
Location (L)	1	25921^{ns}	56406^{**}	215^{**}	2ns	367^{**}	29184^{**}	19553^{**}	49^{*}*	56^{*}	0.3^{*}
Error	10	7048	995	39	1	25	2617	882	4	10	0.01
Genotype (G)	2	48627^{**}	10663^{*}	594^{*}	7^{*}	343^{**}	22274^{**}	9872^{**}	368**	36^{*}	0.9^{**}
G×L	2	92343^{**}	8398^{**}	38^{ns}	10^{*}	54^{ns}	15204^{*}	14163^{**}	1^{ns}	6^{ns}	0.2^{*}
Error	20	7461	2220	31	2	33	3631	708	6	9	0.05
CV (%)		11	18	11	8	7	13	7	5	7	9
		Oshnavieh and Miandoab experimental locations									
Location (L)	1	1317904^{**}	163620^{*}*	51^{ns}	10^{ns}	0.4^{ns}	714870^{**}	321867^{*}*	123^{**}	64^{ns}	0.01^{ns}
Error	10	4191	838	95	8	31	5389	1504	7	15	0.13
Genotype (G)	2	119080^{**}	13340^{**}	240^{ns}	7^{ns}	94^{*}	71668^{**}	28001^{**}	16^{ns}	5^{ns}	0.35^{ns}
G×L	2	70153^{**}	3025^{*}	404^{**}	21^{**}	91^{*}	38325^{**}	16554^{**}	124^{*}	20^{ns}	0.50^{ns}
Error	20	4754	874	77	3	19	3856	1522	28	8	0.25
CV (%)		13	15	19	9	6	18	16	12	6	21

ns, * and **: Were not significant and significant at 0.05 and 0.01 probability levels, respectively.

Impact of grain yield is due to the effect of environment on the genotypes which has high performance in one environment and inversely in another environment.

Oshnavieh and Miandoab regions. Interaction of genotype in location except for the harvest index and grain per spikelet were statistically significant differences. The highest coefficient of variation in the number of grain at per spike was 21.28% due to the random selection of spikes in counting spikelets, which is a spike relative to the main stem and has a greater number of spikelets and next spike selected from secondary spike and has fewer spikelets. The lowest amount for plant height, harvest index was 6% that indicates there was high uniformity between replications and plots. Nabaty and Shaban (2013) examined the effects of location and lines on grain yield and other favorable characteristics of wheat genotypes at Aligoodarz and Dorud, Iran conditions. They saw a high coefficient of variation for this trait and finally selected “Homa” genotype to complimentary studies (23).

Mean comparison

Nagadeh and Bukan. Number of grain at per spike, plant height and 1000-kernel weight were higher in Bukan (51 grain/spike, 85 cm, 48 g) region than Nagadeh (49 grain/spike, 79 cm, 45 g) (Table 5). Genotypes had a high harvest index in Naghadeh (45%). “Mihan” had the highest grain at per spike (56), 1000-kernel weight (53 g) and harvest index (45%). Plant height of “Haydari” was the most value (88.3 cm) and “CD-92-5” had the lowest 1000-kernel weight (42 g). Harvest index is one of the most important physiological traits and greater of it shows conversion rate of raw material absorbed by roots into the nutrients produced in stems and leaves. Then they transfer into the spike for storing in grains. In this study, “Mihan” had harvest index of 45% and “Haydari” of 42%. Plant height of “CD-92-5” was about 77 cm, while “Mihan” and “Haydari” were more than 82 cm height. Lodging and subsequently fungal diseases play an important role in reducing grain yield of wheat. Promising lines have shorter height than old cultivars and landraces. Shortening protects cultivars against lodging and fungal diseases and is more responsive to chemical fertilizers. Short-height cultivars store more photosynthetic products into the grains as sources (Garcia Del Mora *et al.*, 1985) (13). Grain yield variability was the result of the potential growing conditions in each location generated by differences in lines and its distribution during the vegetative and reproductive stages (Nabaty and Shaban, 2012) (22).

Oshnavieh and Miandoab. “CD-92-6” promising line in the Miandoab region was the highest value for all traits. Increasing grain yield of this line compared to “Haydari” was 65%. The highest grain yield and total dry matter for all genotypes in Miandoab were attributed to favorable growth conditions for wheat farming. This indicates that environmental effects (one of phenotypic variance components) are very important for expressing agro-morphological traits (Subhashchandra *et al.*, 2009) (25).

Table 5

Mean comparison of wheat genotypes traits under on-farm conditions at four locations in 2016–2017 seasons

Region	Genotype	Total dry matter (g/m^2)	Spike/m^2	Grain per spike	Spikelet per spike	Plant height (cm)	Spike weight (g)	Grain yield (g/m^2)	1000-kernel weight (g)	Grain per spikelet
Nagadeh	Mihan	895^{a}	286^{a}		20^{a}		518^{a}	421^{a}		2.6^{b}
	Haydari	775^{b}	291^{a}		17^{c}		494^{a}	344^{bc}		2.3^{c}
	CD-92-5	719^{bc}	292^{a}		17^{c}		463^{ab}	321^{cd}		2.4^{bc}
Bukan	Mihan	657^{c}	146^{b}		18^{ac}		408^{bc}	299^{d}		3.1^{a}
	Haydari	885^{a}	234^{a}		19^{ab}		518^{a}	356^{b}		2.5^{bc}
	CD-92-5	687^{bc}	251^{a}		18^{ac}		378^{c}	291^{d}		2.4^{bc}
Oshnavieh	Mihan	403^{d}	137^{c}	48^{ab}	20^{a}	70^{ab}	258^{d}	164^{d}	47^{a}	
	Haydari	245^{e}	96^{d}	51^{a}	20^{a}	66^{bc}	141^{e}	107^{e}	40^{b}	
	CD-92-6	313^{e}	155^{c}	$38b^{c}$	16^{b}	70^{ab}	178^{e}	135^{de}	40^{b}	
Miandoab	Mihan	682^{b}	236^{b}	51^{a}	18^{ab}	64^{c}	485^{b}	315^{b}	44^{ab}	
	Haydari	555^{c}	244^{b}	35^{c}	17^{b}	69^{ac}	348^{c}	248^{c}	47^{a}	
	CD-92-6	871^{a}	313^{a}	44^{ac}	18^{ab}	74^{a}	590^{a}	410^{a}	47^{a}	

Means with the same letter(s) were not significant differences at 0.05 probability level.

Characteristics of genotypes

Minimum variance and standard deviation between plots were allocated for grain yield and total dry matter related in “CD-92-5” promising line and maximum amounts observed in “CD-92-6” (Table 6). The highest and lowest grain yield from plots were 78 gm^{-2} for Haydari cultivar and 552 gm^{-2} for “CD-92-6” promising line.

Moayedi and Azizi (2012) in studying improvement of knowledge and skills level of wheat-cultivating farmers using on-farm researches concluded that the new selected promising lines are able to increase their income and productivity (20). Also, our farmers with sowing new cultivars arise the economic level of their family.

Table 6

Statistical parameters of wheat genotypes under on-farm conditions in 2016–2017 seasons

Trait	Minimum	Maximum	Sum	Mean	Variance	Standard error	Standard deviation
CD-92-5 promising line							
Total dry matter (g/m^2)	564	884	8440	703	7285	85	24
Spike/m^2	187	360	3262	271	2546	50	14
Grain per spike	34	54	546	45	44	6	1
Spikelet per spike	15	20	217	18	1.9	1.37	0.39
Plant height (cm)	66	92	932	77	56	7	2
Spike weight (g/m^2)	344	572	5046	420	4415	66	19
Grain yield (g/m^2)	272	350	3672	306	547	23	6
1000-kernel weight (g)	38	46	505	42	7	2	0.80
Harvest index (%)	37	53	527	43	16	4	1
Grain per spike	2.1	2.8	29.5	2.4	0.08	0.28	0.08
CD-92-6 promising line							
Total dry matter (g/m^2)	240	999	7108	592	91207	302	87
Spike/m^2	138	382	2813	234	8027	89	25
Grain per spike	28	54	495	41	73	8	2
Spikelet per spike	15	21	213	17	3	1	0.50
Plant height (cm)	63	80	870	72	23	4	1
Spike weight (g/m^2)	130	808	4615	384	54244	232	67
Grain yield (g/m^2)	128	552	3276	273	23922	154	44
1000-kernel weight (g)	34	52	530	44	27	5	1
Harvest index (%)	38	55	538	44	20	4	1
Grain per spike	1.6	3.0	27	2.2	0.19	0.44	0.12
Mihan commercial cultivar							
Total dry matter (g/m^2)	364	913	15832	659	35665	188	38
Spike/m^2	103	320	4839	201	4739	68	14
Grain per spike	32	69	1281	53	61	7	1
Spikelet per spike	17	22	468	19	2	1	0.30
Plant height (cm)	60	90	1796	74	76	8	1
Spike weight (g/m^2)	238	608	10028	417	13191	114	23
Grain yield (g/m^2)	146	465	7198	299	9211	95	19
1000-kernel weight (g)	34	60	1189	49	34	5	1
Harvest index (%)	40	51	1072	44	11	3	0.68
Grain per spikelet	1.7	3.4	65.5	2.7	0.18	0.43	0.08
Haydari commercial cultivar							
Total dry matter (g/m^2)	174	999	14768	615	67657	260	53
Spike/m^2	63	366	5200	216	6736	82	16
Grain per spike	26	68	1049	43	98	9	2
Spikelet per spike	14	28	443	18	7	2	0.56
Plant height (cm)	60	99	1875	78	150	12	2
Spike weight (g/m^2)	104	604	9019	375	25809	160	32
Grain yield (g/m^2)	78	395	6337	264	11100	105	21
1000-kernel weight (g)	33	52	1077	44	16	4	0.82
Harvest index (%)	38	49	1040	43	8	2	0.59
Grain per spikelet	1.5	3.1	55.7	2.3	0.15	0.38	0.07

Characteristics of traits

The inheritance of the metric traits depends on the type of trait and amount of it. Estimates of phenotypic (PCV) and genotypic (GCV) coefficients of variations ranged from 9% (for plant height) to 18% (for grain per spike) and 0.2% (for total dry matter) to 14% (for grain per spike) in Nagadeh and Bukan regions. Spike per square meter at four locations had the highest heritability (H^2) (Table 7). Likewise, estimates of environmental coefficient of variation ranged from 6% (for plant height and harvest index) to 21% (for grain per spikelet). The result of GCV expresses the true genetic potential of the genotypes. In the present study, the PCV values were higher than the corresponding GCV. It suggests the existence of substantial environmental variation. This result was completely in agreement with the result of combined analysis of variance. However, traits such as plant height, spikelet at per spike and 1000-kernel weight which showed very small differences between GCP and PCV indicating the observed variations were mostly due to genetic factors with few environmental factors. Tahmasebi *et al.* (2013) with assessing genetic diversity and interrelationship of traits in some promising wheat lines determine the traits effective on grain yield. They observed high genotypic and phenotypic coefficient variations for grain yield, number of spikes and 1000-kernel weight (26).

Heritability estimates are classified as low (5–10%), medium (10–30%) and high (30–60%) (Dabholkar, 1992) (8). The broad sense heritability (H^2) values higher than 80% were observed for 1000-kernel weight. This implies that the expected gain from selection would be high if this trait is used as selection criterion in wheat breeding programs.

Traits having high heritability combined with genetic advance and could result in a better genetic gain through selection since the variation that prevails in such a trait is due to additive gene action (Johnson *et al.*, 1955; Vimal and Vishwakarma, 1998) (16, 28). Spike weight and grain yield at four locations showed high heritability combined with high genetic advance which could be used as a powerful tool in phenotypic selection that is controlled by additive genes and less influenced by the environment.

Table 7

Variance components and their coefficients in wheat traits under on-fam conditions in 2016–2017 seasons

Nagadeh and Bukan experimental locations										
Trait	**σ^2g**	**σ^2gl**	**σ^2e**	**σ^2p**	**GCV (%)**	**ECV**	**PCV (%)**	**H^2 (%)**	**GA**	**GAM**
Total dry matter (g/m^2)	3	14	7461	7478	0.24	11	11	0.04	7	0.92
Spike/m^2	703	1	2220	2924	10	18	3	24	2	1
Grain per spike	46	1	31	79	14	11	18	58	1081	2214
Spikelet per spike	0.44	1	2	3	3	8	10	11	15	82
Plant height (cm)	25	3	33	63	6	7	9	40	668	808
Spike weight (g/m^2)	1553	1	3631	5187	8	13	15	29	4442	958
Grain yield (g/m^2)	763	2	708	1474	8	7	11	51	4096	1209
1000-kernel weight (g)	30	-0.71	6	35	11	5	12	84	1039	2211
Harvest index (%)	2	-0.50	9	11	2	7	4	19	136	310
Grain per spike	0.07	0.02	0.05	0.14	10	9	14	50	38	1487

Table 7 (continued)

Oshnavieh and Miandoab experimental locations

Total dry matter (g/m^2)	9527	10899	4754	25181	19	13	30	37	12366	2415
Spike/m^2	1038	358	874	2272	16	15	24	45	4488	2276
Grain per spike	13	54	77	145	8	19	26	9	231	517
Spikelet per spike	0.36	3	3	6	3	9	13	5	29	155
Plant height (cm)	6	12	19	37	3	6	8	16	207	300
Spike weight (g/m^2)	5651	5744	3856	15252	22	18	36	37	9425	2823
Grain yield (g/m^2)	2206	2505	1522	6234	20	16	34	35	5756	2500
1000-kernel weight (g)	-1	15	28	43	---	12	14	-2	-32	-73
Harvest index (%)	-0.27	1	8	10	---	6	7	-2	-17	-39
Grain per spike	0.08	0.04	0.25	0.29	3	21	22	2	3	129

σ^2g: genotypic variance, σ^2gl: genotypic and location variance interaction, σ^2e: error variance, σ^2p: phenotypic variance, GCV: genotypic coefficient of variation, ECV: environmental coefficient of variation, PCV: phenotypic coefficient of variation, H^2: heritability in broad sense, GA: genetic advance, GAM: genetic advance as the percentage of the mean

Stability parameters

Equivalence-Rig. It shows the contribution of each genotype to total square genotype × environment interaction. Equivalance-Rig percentage has reverse relationship with phenotypic stability and lower percentage indicates a greater stability of the genotype. Within genotypes, "Mihan" has the least amount of Equivalance-Rig and is considered the most stable variety. "CD-92-5" promising line has located in the second group, then "Haydari", and finally "CD-92-6" line, have the highest Equivalence-Rig values (Table 8).

Finley and Wilkinson. In this analysis, two parameters of genotypic mean and regression coefficient are considered as environmental stability. Unit regression coefficient, greater and less than unit have moderate, higher and lower than average stabilities. Among genotypes, "Mihan" and "CD-92-6" promising line had more than a unit regression coefficient. Grain yield of "Mihan" and "CD-92-6" were higher and lower than total average, respectively. So "Mihan" was selected (Table 8). Khan *et al.* (2014) in evaluating five promising wheat lines revealed that the overall mean grain yield of genotypes across environments ranged from 1198 to 2202 kg/ha at three locations under rainfall conditions of Balochistan, Pakistan (18). Cultivar "AZRC-3" having a regression coefficient close to unity and higher grain yield showed a consistent performance and is considered as stable and widely adopted.

Genotypic coefficient variation. A cultivar based on genotypic variation coefficient is stable and has higher grain yield than total mean (284 g/m^2) and the lowest genotypic variations among genotypes (Table 8). This criterion is independent of the evaluated genotypes. Therefore, "CD-92-5" had 6.9% genotype variation and 306g/m^2 mean grain yield the highest stability. "Mihan" ranked in the second group and, finally, "CD-92-6" had the highest genotypic variation (70.9%) and less than mean total grain yield.

"Mihan" and "CD-92-5" promising lines were selected stable genotypes based on three stability parameters. In addition, they had the highest grain yield (306 g/m^2) and even more than total mean (284 g/m^2).

Table 8

Stability parameters components of wheat genotypes under on-farm conditions in 2016–2017 seasons

Genotype	Mean (g/m^2)	W_i	W_i (%)	Reg	GCV (%)
Mihan	300	3707	14.1	Y=2.65+1.04X	35.1
Haydari	264	7055	26.8	Y=-1.54+0.93X	43.6
CD-92-5	306	6178	23.5	Y=50.11+0.90X	6.9
CD-92-6	273	9337	35.5	Y=-74.04+1.22X	70.9

W_i: Equivalence-Rig, W_i (%): Equivalence-Rig based on percentage, Reg: Finley and Wilkinson regression equation, GCV: Genotypic coefficient variation

Simple correlation coefficient

Nagadeh and Bukan. Grain yield was positively and significantly correlated with the total dry weight ($r = 0.90^*$) and spike weight ($r = 0.85^*$) (Table 9). In addition, total dry matter with spike weight had a positive and significant correlation ($r = 0.89^*$). In contrast, there was a significant negative correlation between grain per spikelet and spike/m^2 ($r = -0.84^*$). Having a significant positive relationship between grain yield and other traits (spike weight and total dry matter), it means that, with enhancing them grain yield will increase. Therefore, increasing total dry matter through application of nitrogen fertilizers will subsequently increase the grain yield.

Oshnavieh and Miandoab. Total dry matter ($r = 0.99^{**}$), spike/m^2 ($r = 0.96^{**}$) and spike weight ($r = 0.99^{**}$) were positively and significantly correlated with grain yield. In most cases, there is a negative correlation between grain yield components, and it is difficult to select all the desirable traits that have positive correlations with grain yield (Gupta *et al*., 1999) (14). 1000-kernel weight is expressed at maturity stage. Therefore, spray application of plant nutrients at grain filling stage can be effective in increasing it and subsequently the grain yield (Dawari and Luthara, 1991) (9).

Traits that had positive and significant correlation with grain yield in four growth regions were total dry matter and spike weight. Therefore, these traits can be used as indirect criterion in increasing grain yield in plant breeding programs.

CONCLUSION

Wheat breeders need to select appropriate responses to environmental changes for improving grain yield and its components. Most of new high performance cultivars are selected under research-station conditions. Therefore, on-farm extension-researches can help release of promising lines. Among evaluated genotypes, promising line of “CD-92-5” with the highest grain yield (306 gm^{-2}) was determined based on Equivelance-Rig, Finley, Wilkinson and genotypic coefficient variation indices as a stable line. With regard to other factors such as disease resistance, especially yellow and brown rust and tolerant to low irrigation “CD-92-5” can replace traditional old cultivars such as “Mihan”, “Urum”, “Zare”, “Pishgam” and “Zarrin” in the wheat fields of West Azerbaijan province and similar climates. One thousand spikes of "CD-92-5" were selected and sown in the next year for propagating breeder seed and consequently producing certificate seeds between wheat farmers.

Table 9

Simple correlation coefficient of wheat traits under on-farm conditions in 2016–2017 seasons

Trait	Total dry matter (g/m^2)	Spike/m^2	Grain per spike	Spikelet per spike	Plant height (cm)	Spike weight (g/m^2)	Grain yield (g/m^2)	1000-kernel weight (g)	Harvest index (%)
	Nagadeh and Bukan experimental locations								
Spike/m^2	0.43								
Grain per spike	-0.43	-0.72							
Spikelet per spike	0.51	-0.20	0.69						
Plant height (cm)	0.46	-0.32	0.08	0.29					
Spike weight (g/m^2)	0.89*	0.48	-0.16	0.17	0.29				
Grain yield (g/m^2)	0.90*	0.46	0.11	0.55	0.17	0.85*			
1000-kernel weight (g)	0.10	-0.67	0.87*	0.57	0.31	0.06	0.27		
Harvest index (%)	-0.20	0.10	0.32	0.03	-0.71	-0.36	0.22	0.33	
Grain per spikelet	-0.31	-0.84*	0.92**	0.38	-0.01	-0.30	-0.14	0.84*	0.37
	Oshnavieh and Miandoab experimental locations								
Spike/m^2	0.95**								
Grain per spike	-0.04	-0.31							
Spikelet per spike	-0.22	-0.46	0.84*						
Plant height (cm)	0.31	0.40	-0.53	-0.27					
Spike weight (g/m^2)	0.99**	0.93**	0.02	-0.18	0.24				
Grain yield (g/m^2)	0.99**	0.96**	-0.04	-0.22	0.30	0.99**			
1000-kernel weight (g)	0.65	0.62	-0.18	-0.05	0.47	0.63	0.61		
Harvest index (%)	0.57	0.64	-0.12	-0.45	-0.20	0.58	0.61	-0.13	
Grain per spikelet	0.08	-0.15	0.90*	0.52	-0.62	0.16	0.09	-0.28	0.15

* and **: were significant differences at 0.05 and 0.01 probability levels, respectively.

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