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Variability and Relationship Between Morpho-phenological Traits and Grain Yield in Winter and Facultative Barley under Stress Environments

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Abstract

Variability and relationship among different morpho-phenological traits for twenty four lines/varieties in each of the two winter and facultative barley trials were studied at two locations (Tel. Hadya and Breda) in northern Syria. A significant variation was observed in barley lines for grain yield, plant height, days to heading and maturity, grain filling period and growth period. Since the winter during 1994-95 was mild at the both locations and drought and high temperatures were major stresses, most of the high yielding genotypes were facultative types. A significant positive correlation was found between plant height and grain yield. There was, however, significant negative correlation between grain yield and days to heading and maturity. Grain filling period was positively associated with yield (except for winter types at Breda). A negative correlation between growth habit and yield at both locations can be attributed to mild winter and severe drought and high temperatures during crop growth period.

Introduction

Performance of breeding lines/varieties is a product of the expression of morpho-phenological traits of genotypes and surrounding environment. This, in turn, is affected by our testing environment (biotic and abiotic stresses), selection methodologies, expression of genetic traits under a given set of specified conditions (Ceccarelli and Grando, 1991). Cold, drought and heat are the major occurring stresses in Mediterranean areas of West Asia and North Africa (WANA) which affect barley yields in the region (Tahir *et al*., 1983; Tahir and Banisadr, 1991). It is always desirable to have an information on relationship, for diverse material, between yield and yield components in different environments. The morpho-phenological traits associated with yield under stress environments can therefore, be used to increase selection efficiency in breeding material (Van Oosterom and Ceccarelli, 1993; Nachit and Jarrah, 1986). The objectives of this study were to see the relationships between different morphological traits and determine the magnitude of the variation under different environments in indiverse barley germplasm.

Materials and Methods

Plant material and environment: To develop high yielding and resistant material to various biotic and abiotic stresses, winter and facultative barley breeding program at the International Center for Agricultural Research in the Dry Areas (ICARDA) uses two major sites; Tel Hadya (cold and terminal heat) and Breda (terminal drought <250 mm precipitation) for initial screening of breeding material later, of course, selected material (at early generations and advance lines) was sent to the national programs to test under target environments in WANA region.

Twenty four barley lines/varieties with diverse growth habit were grown in each of the two Winter Barley Yield Trial (WBYT) and Facultative Barley Yield Trial (FBYT) at Tel Hadya (36° 10' N, 36° 56' E) and Breda (35° 56' N, 37° 10' E) with the mean annual rainfall 327 mm (13 seasons) and 262 mm (11 seasons), respectively. The planting was done on Dec. 8, 1994 at Tel Hadya and Nov. 13, 1994 at Breda. The plot size at both locations was 4 meter square (8 rows 2.5 meter long with 0.2 meter row to row distance). Central six rows were harvested for grain yield. The experimental design was randomized complete block design with three replications.

Data collected: Data were collected for the following traits:

- Growth Habit (GH) using a visual score 1 to 5:1 = erect to 5 = prostrate.
- Plant Height (PH) in cm from ground level to top of the spike excluding awns.
- Days to Heading (DH) when 50 percent of the spikes had emerged from the plot.
- Days to Maturity (DM) as number of days from planting to physiological maturity of the plants within plot.
- Row Type (RI) i.e. two rows and/or six rows.
- Grain Filling Period (GFP) number of days from heading to maturity.
- Grain Yield (GY) in kg ha^{-1}

Statistical analysis: Data were analyzed using standard ANOVA for RCB design. Coefficients of correlation among grain yield and other morpho-phenological traits were calculated (Gomez and Gomez, 1984).

Results and Discussion

Genetic variability: A significant variation was found for the

Table 1: Range, Mean, Standard deviations (SD), Standard error (SE) and Coefficient of variation (CV%) for winter and facultative barleys at Tel Hadya during 1994-95

Characters		Range	Mean	SD	SE	CV (%)
Grain yield (Kg/ha)	W	3667-7500	5181.5	729.1	85.9	12.4
	F	3667-7233	5504.1	783.8	92.4	13.5
Plant height (cm)	W	50-90	70.1**	7.7	0.9	6.3
	F	60-100	78.4**	9.2	1.1	9.4
Days to heading	W	113-132	122.7**	4.9	0.6	1.4
	F	112-139	122.8**	5.6	0.6	1.9
Days to maturity	W	149-174	159.4**	7.0	0.8	2.6
	F	149-176	160.5**	7.7	0.9	2.3
Grain filling period	W	25-49	36.7**	5.8	0.7	11.5
	F	25-49	37.7**	5.1	0.6	11.2
Growth habit	W	2-5	3.5**	0.7	0.1	9.8
	F	2-4	3.1**	0.7	0.1	12.1

**Means significantly different ($p<0.001$); W = WBYT; F = FBYT

Table 2: Range, Mean, Standard deviations (SD), Standard error (SE) and Coefficient of variation (CV%) for winter and facultative barleys at Breda 1994-95

Characters		Range	Mean	SD	SE	CV (%)
Grain yield (Kg/ha)	W	833-4200	2467.6**	932.8	109.9	18.0
	F	333-4333	2319.0**	1097.4	129.3	26.7
Plant height (cm)	W	35-70	52.1**	7.2	0.8	8.8
	F	35-70	52.9**	9.5	1.1	12.7
Days to heading	W	132-162	149.4**	6.3	0.7	1.7
	F	126-162	147.0**	9.9	1.2	1.9
Days to maturity	W	170-193	179.9**	7.3	0.9	3.9
	F	170-195	176.4**	6.9	0.8	1.8
Grain filling	W	14-52	30.4**	7.1	0.8	24.1
period	F	18-50	29.4**	8.0	0.9	14.2
Growth habit	W	2-4	3.2**	0.7	0.1	10.3
	F	2-4	3.0**	0.7	0.1	10.8

**Means significantly different ($p<0.001$); W = WBYT; F = FBYT

Table 3: Mean grain yield of five best performing lines/varieties from WBYT and FBYT at Tel Hadya and Bred during 1994-95

Line/variety	Grain yield (Kg/ha)
Tel Hadya Site	
Roho/MazurkalICB-103020	6355
Rihane 03	6344
CWB 117-77-9-7/ICB-102893	6111
ICB-105981/5/Pitayo/Cam/Avt/RM1508/4/por//	6011
DS/3/CM67/D	
YEA 932/YEA 557.6	5966
Breda Site	
Rihane 03	3988
Lignee131/5/Cq/Cm//Apm/3/12410/4/Giza134-2L	3788
Roho/Mazurka//ICB 103020	3722
ICB-101719/ICB-105932	3277
5, Rihane/Lignee 640//ICB 102854	3188

Table 4: Correlation coefficients between traits in WBYT and FBYT lines at Tel Hadya during 1994-95

	2	3	4	5	6	7
w	0.575**	0.072	-0.252*	-0.142*	0.661**	-0.201
F	0.749**	0.037	-0.176	0.094	0.372**	-0.231*
w		0.134	0.002	0.729**	0.475**	0.057
F		0.156	0.013	0.718**	0.367**	-0.045
w			0.424**	0.102	-0.044	0.361**
F			0.351**	0.217	-0.205	0.318**
w				0.213	-0.069	0.234*
F				0.204	-0.224*	0.186
w					0.021	0.237*
F					0.187	0.164
w						-0.158
F						-0.033
w						
F						

*,**Significant at the 5% and 1% level, respectively. W = winter barley yield trial (WBYT), F = facultative barley yield trial (IBYT), 1 = days to heading, 2 = days to maturity, 3 = plant height, 4 = row type, 5 = grain filling period, 6 = growth habit, 7 = grain yield

Table 5: Correlation coefficients between traits in WBYT and FBYT lines at Breda during 1994-95

		2	3	4	5	6	7
1.	W	0.462**	-0.462**	-0.030	-0.405**	0.572**	-0.408**
	F	0.601**	-0.494**	-0.179	-0.730**	0.624**	-0.442**
2.	w		-0.372**	-0.114	0.624	0.317**	-0.514**
	F		-0.420**	-0.103	0.107	0.623**	-0.465**
3.	w			0.121	0.023	-0.392**	0.579**
	F			0.295**	0.255*	-0.466**	0.617**
4.	w				-0.092	-0.109	0.070
	F				0.139	-0.335**	-0.073
5.	w					-0.177	-0.170
	F					-0.246*	0.151
6.	w						-0.370**
	F						-0.349**
7.	w						
	F						

*,**Significant at the 5% and 1% level, respectively, W = winter barley yield trial (WBYT) May 22, 1999, F = facultative barley yield trial (FBYT), 1 = days to heading, 2 = days to maturity, 3 plant height, 4 = row type, 5 = grain filling period, 6 = growth habit, 7 = grain yield

traits studied. This shows that winter and facultative project at ICARDA has been successful in maintaining genetic variability, a pre-requisite for a breeding program, for different morpho-phenological traits among its germplasm pool. Genetic variation in plant height, grain filling period, growth habit, days to heading and maturity in the material tested indicates more selection opportunity and hence, suitability of the material for diverse environments in WANA region. Although magnitude of the variation was similar among the material at both locations (Tel Hadya and Breda), differences in grain yield, plant height, days to heading and maturity are evident (Table 1 and 2). Both environments are considered independent for both types of stresses and performance of genotypes or expression of genetic traits per se. at each site. Ceccarelli *et al.* (1992) have defined Tel Hadya (high yielding site) and Breda (low yielding site) based on average grain yield in different seasons.

Drought and high temperatures were the major stresses to the crop during 1994-95. The total precipitation during season (Sept.-June) was 313 mm at Tel Hadya as compared to 373 mm during 1993-94 crop season. The total rainfall at Breda was 244 mm during 1994-95 which is -50 mm less compared to 1993-94 crop season. Absolute maximum temperature during the month of May (grain filling period) went up to 41.8°C and 41.6°C at Tel Hadya and Breda, respectively. These temperatures were 2-4°C high as compared to the temperatures during the month of May 1993-94 at both the locations (Fig. 1 and 2). In spite of severe drought and high temperatures, best

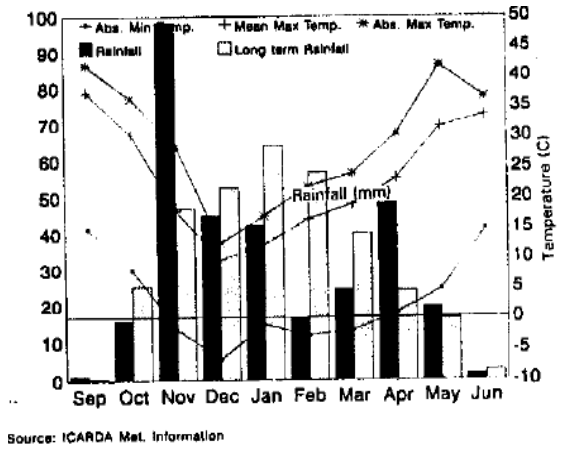

Fig. 1: Meteorological data for Tel Hadya site during 1994-95 season

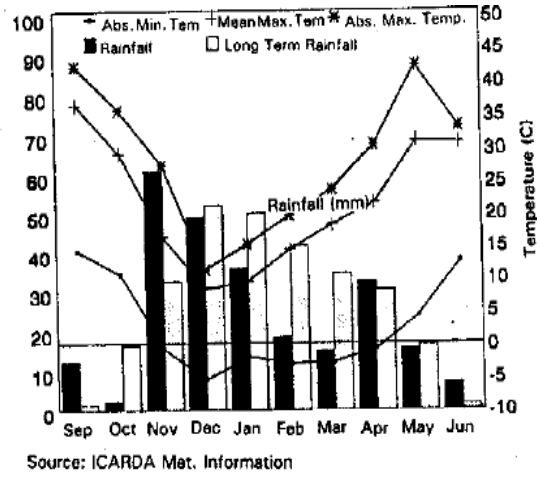

Fig. 2: Meteorological data for Breda site during 1994-95 season

performing genotypes were identified from winter and facultative material which produced about 6000 kg/ha average yield at Tel Hadya and 3000 to 4000 kg/ha at Breda (Table 3), which shows adaptation of the material under stress conditions. Most of the high yielding genotypes, however, were with the growth habit of 2-1 Facultative types, therefore, were more productive under these two environments. This agrees with the results at genotypes with strong vernal gene(s) were lower yielding than spring and facultative types due to their longer growing period (ICARDA, 1993; Cai *et al*., 1993).

Relationship between morpho-phenological traits: The magnitude of relationship with different characteristics winter and facultative types was almost similar (Table 4 and 5). A significant positive correlation was found between plant height and yield at both locations. There was however, significant negative correlation between grain yield and days to heading and maturity. Similar results was reported by Samarrai *et al*., (1987) indicating that are emergence and maturity with more plant height perform or better under semi-arid conditions in northern Syria. A strong positive correlation between grain filling period with days maturity and also with grain yield at Tel Hadya suggest selected materials considering grain filling period will more appropriate than using days to maturity alone at selection criterion to increase grain yield. The genotype with greater variability for grain filling period could prove more selection opportunity to select material for term drought and heat stresses like in Tel Hadya and Breda also for other parts of the region with similar stresses. A negative association was found between growth and yield at both locations. Careful interpretation need be made regarding this trait. The positive and significant association of growth habit under cold stress and negative significant association of this trait under drought and terminal heat conditions can be attributed to the d of vernalization requirements of the genotypes (Ortiz-Ferrara *et al*., 1989). Since the winter was mild at both local during 1994-95 and drought and high temperatures the main stresses, the winter types with longer period heading and maturity suffered the most. A need of test of the material under different environments over the time extremely important to observe the variable response genotypes under those conditions. Therefore, winter facultative barley breeding program at ICARDA uses test of sites with different biotic and abiotic stresses prevalence the region to ensure differentiation for response to stress among germplasm. Major sites for screening to tolerance are used in Turkey, Iran and Krasnodar-Russia a result, germplasm with wider genetic base is provide the national programs.

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