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Intra-population variation for agronomic characteristics in the durum wheat landrace "SafraMa'an" (*Triticum turgidum* L. var. *durum*)

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Abstract. Two hundred and eighty six lines from tetraploid wheat (*Triticum turgidum* L. var. *durum*) landrace "SafraMa'an" were selected randomly during 1994-1995 growing season. The entire populations with three commercial check cultivars (Acsad 65, Hourani 27, and Amra) were evaluated at Maru Agriculture Research Station during 1995-1996 growing season for 16 characters including grain yield per plant. The objectives were to assess the magnitude of phenotypic variations for several traits in tetraploid wheat "SafraMa'an" and to evaluate the potential usefulness of some of the traits identified. Results showed wide range of phenotypic variation for most characters. Mono-morphism was common for juvenile growth habit, whereas the rest of the characters exhibited polymorphism in varying degrees. Considering all characters, the average diversity (H′) for "SafraMa'an" landrace was 0.65 ± 0.047. There were 10 lines superior to best check (Hourani 27) for grain yield per plant. Subsequently, the population lines were clustered into six distinct groups at a distance of about 0.55 based on their similarity for all traits. Acsad 65 and Amra were located in separate clusters whereas Hourani 27 cultivar was presented in cluster with most lines of "SafraMa'an". Thirteen lines from the population showed a bluish green cast or glaucousness characters. Glaucous lines have greater kernels per spike. In contrast, this character showed no significant association with grain yield per plant despite the greater grain yield per plant obtained for the glaucous lines. The results are important for the breeding and selection of this crop.

Keywords. Landrace – *Triticum turgidum* – Variation – Agronomic – Glaucous.

Variation intra-population pour les caractéristiques agronomiques de la variété locale de blé dur "SafraMa'an" (Triticum turgidum L. var. durum)

Résumé. *Deux cent quatre-vingt six lignées issues du blé tétraploïde (Triticum turgidum L. var. durum), variétés locales "SafraMa'an", ont été sélectionnées d'une manière aléatoire pendant la saison de végétation 1994-1995. Les populations entières avec trois cultivars commerciaux témoins (ACSAD 65, 27 Hourani, et Amra) ont été évaluées auprès de la Station de recherche agricole de Maru durant la saison de végétation 1995-1996 pour 16 caractères, incluant le rendement en grain par plante. Les objectifs étaient d'estimer l'ampleur des variations phénotypiques de plusieurs traits chez le blé tétraploïde "SafraMa'an" et d'évaluer l'utilité potentielle de certains des caractères identifiés. Les résultats ont montré une grande variabilité phénotypique pour la plupart des caractères. Le monomorphisme était commun pour le mode de croissance juvénile, tandis que le reste des caractères ont montré un degré variable de polymorphisme. Considérant tous les caractères, la diversité moyenne (H′) pour la variété locale "SafraMa'an" était de 0,65 ± 0,047. Il y avait 10 lignées supérieures par rapport au témoin le plus performant (Hourani 27) pour le rendement en grain par plante. Ensuite, les lignées de la population ont été réunies dans six groupes distincts, à une distance d'environ 0,55, sur la base de la similitude de tous les caractères. ACSAD 65 et Amra étaient situées dans des groupes séparés alors que le cultivar Hourani 27 était dans le groupe incluant la plupart des lignées de "SafraMa'an". Treize lignées de la population ont montré une dominante verte bleuâtre ou glauquescence. Les lignées glauquescentes avaient plus de grains par épi. En revanche, ce caractère n'a montré aucune association significative avec le rendement en grain par plante bien qu'on ait observé un rendement en grain par plante plus élevé pour les lignées glauquescentes. Les résultats sont importants pour l'amélioration et la sélection de cette culture.*

Mots-clés. *Variété locale – Triticum turgidum – Variation – Agronomique – Glauquescence.*

I – Introduction

Durum wheat is one of the most important of all crop plants cultivated to meet great demands for human food consumption in the Mediterranean basin, Europe and India (Abaye *et al*., 1997; Nachit *et al*., 1998). The world production of wheat increased by 9.5% during the period 2000-2004 to 2006-2010, while wheat harvested area increased by 2% during the same period. In Jordan, wheat production decreased by 44% while wheat harvested area decreased by 7%, during the same period (FAO, 2011). The major constraint affecting wheat production in Jordan is drought. Different methods could be used to increase cereal production, such as increasing area of production, effective cultural practices, and planting improved varieties (Cassman, 1999). In Jordan, as arable land is limited and most of the production area is under semi-arid conditions, developing high yielding varieties adapted to local conditions could be employed. Therefore, understanding the magnitude of existing variability, proper characterization of the most important physiological traits and their interrelationships with yield and yield components would be extremely helpful in the synthesis of most efficient and highly productive genotypes (Joshi *et al*., 1982). Cereal improvement depends on the continuous supply of new germplasm material to act as donor of various genes of agronomic importance. Landraces are possible source of this germplasm material.

Landraces are comprised of population mixtures that contain a great number of different hereditary types which, due to their genotypic diversity, are especially well adapted to the changes in the environmental conditions of their habitat. Compared to modern cultivars, they deliver only average but reliable yields (Kuckuck *et al.*, 1991; Tahir and Valkoun, 1994; Guarino, 1995). Landraces serve as good reservoir of genetic variability for germplasm collection programs (Welsh, 1981) and represent an important starting point for the successful development of improved varieties (cultivars) by exploiting genetic complexes governing adaptation or adaptability to the often very extreme environmental conditions of these countries (Kuckuck *et al.*, 1991). Gene pools from landraces can be used for further increasing durum wheat yields under rainfed conditions (Duwayri and Nachit, 1989). ICARDA′s cereal breeding efforts have concentrated on developing genotypes with high and stable grain and straw yields. Landraces and derived pure lines are being successfully used in crossing programs to transfer drought tolerance into otherwise adapted germplasm (ICARDA, 1989).Characterization of landraces is carried out by isolating single lines from the mixtures grown by farmers. Seeds of the best-adapted lines can then be multiplied and the lines released as cultivars in their own right. Arta is a typical success of this approach: a single-line selection from Syrian barley landrace *Arabi Abiad,* which currently out-yields any other line or cultivar in its target environment (ICARDA, 1996). Another way of utilizing the specific adaptation of landrace lines is to use them in breeding programs.

There are two main reasons (Tahir and Valkoun, 1994) for giving a special attention to landraces:(i) genetic erosion caused by the replacement of landraces by improved varieties, and (ii) landraces have good adaptation to the stressful and highly variable environments. In Jordan there are several landraces; one of them is “SafraMa’an” which belongs to tetraploid wheat *Triticum turgidum* L. var. *durum,* grown mainly in southern Jordan. There have been no previous studies on “SafraMa’an” landrace in Jordan. “SafraMa’an” has been used in plant breeding programs outside Jordan (Clarke *et al.*, 1994). The main objectives of this research were: (i) to assess the magnitude of phenotypic variation for several traits in the durum wheat landrace “SafraMa’an”, and (ii) to evaluate the potential usefulness of some of the traits identified.

II – Material and methods

Seeds of “SafraMa’an” landrace were obtained from the National Center for Agricultural Research and Extension (NCARE) in 1994. These seeds were collected from farmers’ fields at Al-Shoubak, which is located in the southern part of Jordan in the 1993/1994 growing season. In the 1994/1995 growing season, seeds were space planted in Jubeiha and a random sample of 286 plants were selected, harvested and threshed as individual plants. The study was conducted in 1995/1996 growing season at Maru location (35*55* N latitude and 32*37* E longitude with an elevation of 500m). Detailed information on monthly rainfall and temperatures throughout the 1995/1996 growing season are shown in Table 1. A randomized complete block design (RCBD) with three replications was used. The experimental plot consisted of 1 row, 1 m long. Spacing between rows was 0.3 m and between seeds within row 10 cm. Three commercial durum wheat varieties Acsad 65, Hourani 27, and Amra were used as checks in this study.

Table 1. Distribution of rainfall and temperature regimes during 1995-1996 growing season in Maru agricultural research station.

Duration	Rainfall mm	Temperature C°
Oct, 1995	5.5	20.2
Nov, 1995	77.3	13.8
Dec, 1995	27.7	9.9
Jan, 1996	110.1	9
Feb, 1996	21.5	11.1
Mar, 1996	126.5	11.7
Apr, 1996	18.1	15.5
May, 1996	-	22.5

The following characters were measured in each plot: Early growth vigor (EGV) was recorded on Feb. 29, 1996, in the following three categories (1) weak, (2) intermediate, (3) healthy). Juvenile growth habit (JGH) was recorded on April 22, 1996, classifying plants as (1) erect, (2) semi-erect, and (3) prostrate). Glaucousness (GL) was recorded on April 17, 1996 (as one of the two categories (1) glaucous (2) non glaucous): Heading date (HD) was measured as Number of days from Jan 1 to date when 50% of the heads had emerged from the bootleaf; maturity date (MD) as Number of days from Jan 1 to date when 50% of the row showed physiological maturity - i.e the very first sign of the yellow color appearance on the flag leaf blade); grain filling period (GFP) was calculated as the difference between the (MD) and (HD)).

After physiological maturity (on May 28, 1996), five representative plants from center of each plot were taken and the following measurements recorded: Flag leaf area (FLA) (Calculated as flagleaf width (at the widest point) x flag leaf length (from tip to collar) x 0.65 at the time of physiological maturity); plant height (PH) (Height in centimeters from the soil surface to the tip of the spike (awn excluded) of the tallest culm); number of productive tillers (TN) (Total number of seed-bearing culm for each plant); number of spikelets per main spike (SS) (Total number of seed-bearing spikelets on the main head from each plant); spike length (SL) (Length in centimeters of the spike on the tallest culm): awn length (AWL) (Measured from the tip of the main spike to the end of the awn); spike density (SD) (Calculated as the ratio between the number of spikelets per spike over the spike length); number of kernels per spikelet (KS) (Calculated from each plant as kernels/ spike divided by spikelets/spike); thousands kernel weight (TKW); number of kernels per main spike (NKS) (Total number of kernels on the main spike from each plant); biological yield per plant (BY); number of heads per meter square (HM2); and Grain yield per plant (GYP).

Analysis of variance and t-test, were performed using SAS program (SAS, 1985). Estimates of phenotypic diversity index H′, Mean ($\bar{x}$) and standard deviation (S) were calculated for each quantitative trait. The two statistics were used to classify the trait into three groups: less than ($\bar{x}$ - S); between ($\bar{x}$ - S) and ($\bar{x}$ + S), greater than ($\bar{x}$ +S). Shannon´s information statistic ($h_{s.j.}$) (Tesfaye *et al*., 1991) was used to describe phenotypic diversity. The following formula was used for calculating $h_{s.j.}$ for the j^{th} trait with n categories:

$$h_{s.j} = -\sum_{i=1}^{n} P_i \log_2 p_i$$

where p_i is the relative frequency in the category of the j^{th} trait. Each value of $h_{s.j.}$ was divided by its maximum value ($\log_2{}^n$), which ensured that all scaled $h_{s.j.}$ values were in the range 0 to 1. The average diversity (H′) over k traits was estimated as:

$$H' = \sum_{i=1}^{k} h_{s.j} / k$$

The diversity indix (H′) was previously used for measurement and comparison of geographical patterns of phenotypic diversity in germplasm collections of wheat (Tesfaye *et al*., 1991). Cluster analyses were computed by using plant means for all quantitative traits; and plant means were clustered by the unweighted pair group method using arithmetic averages (UPGMA) as described in SAS (2002).

III – Results

1. Phenotypic variation

The results from analysis of variance for the investigated characteristics indicated the presence of a large variation observed for sixteen characters studied (Table 2). Line differences in most of the characters were significant at 0.1% level of probability. Hence a number of different stable lines could be derived from these populations to be utilized in breeding programs. Several lines from "SafraMa'an" landrace were better than the checks studied for several traits (Table 2). Comparisons between the local lines and the improved cultivars revealed that, in general, the former were taller, and had greater number of spikelets per spike, heavier thousands kernel weight and biological yield and, larger flag leaf area than the two checks, cultivars Acsad 65 and Amra. Also, the landraces gave greater grain yield and higher fertile tiller number per plant than Amra; the landraces were later both in heading and maturity time, and had larger awn length than the three check cultivars. The mean values of other characters compared to the three check cultivars are also presented in Table 2. There were ten lines superior to the best check (Hourani 27) for grain yield per plant and taller than other two checks Acsad 65 and Amra, whereas only 2 lines were taller than high yielding check (Hourani 27), one line was glaucous, seven lines had higher fertile tillers and eight lines had larger flag leaf area than the best check cultivar (Hourani 27). Among yield components, most of these ten lines were better than the checks in spike length, thousands kernel weight, and spikelet per spike. The grain yield and other characters of the ten superior plants and check varieties are presented in Table 3.

2. Variation among glacousness

Variation for glaucousness showed that only 4.5% of the in "SafraMa´an" lines were glaucous (Table 4). Glaucous lines gave a grain yield per plant non different from non-glaucous ones. The non-significant association of glaucousness with yield, detected in this study, could be probably due to favorable environmental condition during that specific growing season and to the small number of glaucous lines. Similar patterns have been reported for durum wheat by Clarke *et al.* (1991) and for barley by Baenziger *et al.* (1983).However other reports indicated that glaucous genotypes exhibited higher yield in wheat (Merah *et al*., 2000) and in wild rye (Jefferson,1994). Glaucous lines had greater tiller number, kernels per spike, spikelet fertility, spike density, number of head per meter square, short awn length, small flag leaf area, late in heading, and short in grain filling period than non glaucous lines. Grain yield and other characters of the 13 glaucous and check cultivars are presented in Table 5.

Table 2. Variation for 16 characters in 286 tetraploid "SafraMa'an" landrace compared with mean values of the standard check cultivars (ACSAD 65, HOURANI 27 AND AMRA).

Trait	Range	Mean ±SE	Std Dev	F. vlaues	LSD (P-0.05)	CV %	ACSAD 65	HOURANI 27	AMRA
PHt	78.60-118.40	105.15±0.38	6.34	28.14**	2.81	4.42	88.27	111.87	74.6
FN	5.00-11.60	7.96±0.08	1.31	39.88**	0.56	10.2	9.00	8.93	6.00
SL	6.47-10.29	9.19±0.03	0.48	16.38**	0.32	4.99	8.74	8.29	8.28
SS	22.2-27.06	24.49±0.05	0.91	7.24**	0.92	5.31	21.53	24.6	21.53
NKS	33.13-60.40	45.49±0.16	2.72	5.20**	3.29	10.14	52.53	47.80	58.20
KS	1.33-2.58	1.86±0.007	0.1	7.6**	0.13	9.17	2.44	1.925	2.70
TKW	22.78-42.46	33.13±0.23	3.82	5.91**	3.94	18.37	28.33	34.5	26.24
SD	2.36-3.68	2.67±0.008	0.13	14.17**	0.10	5.14	2.47	2.96	2.608
AWL	6.34-14.52	12.59±0.05	0.84	18.11**	0.15	6.10	11.48	10.31	10.15
FLA	31.47-46.99	39.52±0147	2.48	5.70**	2.69	10.19	28.39	37.05	31.86
GYP (g)	3.99-12.32	7.94±0.08	1.42	9.60**	1.19	22.3	8.84	9.74	5.83
GFP	26.33-36.33	29.09±0.07	1.20	17.76**	0.76	3.79	37.67	31.67	28.67
HD	94.33-112.00	107.02±0.08	1.46	27.21**	0.73	1.01	91.3	103.33	102.00
MD	130.67-140.0	136.12±0.05	0.89	32.22**	0.38	0.44	129.00	135.00	130.66
HM^2	167.7-382.23	269.63± 2.49	4289	84.04**	12.47	6.72	301.76	92.33	210
BY	20.77-57.54	37.35±0.41	6.97	27.81**	3.71	13.7	31.3	39.36	26.4

GYP: Grain yield / plant (g); PHt: Plant height (cm); TN: Fertile tillers / plant; FLA: Flag leaf area (cm^2); AWL: Awn length (cm); TKW: 1000 Kernel weight (g); NKS: Kernels / spike; SL: Spike length (cm); SS:Spikelets / spike; KS: Kernels / spikelet; SD: Spike density; GFP : Grain filling period (day); HD: Days to heading (day); MD: Days to maturity (day); HM^2: Head/ meter^2;BY : Biological yield (g).

Table 3. Grain yield per plants and other characters of the ten superior lines and the check cultivars.

Line	GYP	PHt	TN	FLA	AWL	TKW	NKS	SL	SS	KS	SD	GFP	HD	MD
185	12.32	109.80	10.80	43.13	13.16	38.02	45.40	9.60	22.47	2.02	2.62	29.34	107.67	137.00
191	11.42	110.46	10.80	39.21	12.12	34.67	45.67	8.84	23.46	1.95	2.64	27.67	108.67	136.34
113*	11.38	114.60	10.86	44.60	12.15	32.45	55.53	9.68	27.06	2.06	2.80	31.00	106.00	137.00
164	11.19	115.80	09.73	40.30	12.10	38.39	45.93	9.56	24.30	1.89	2.54	27.34	109.34	136.70
091	11.16	109.90	09.80	40.60	12.46	37.98	48.00	9.80	25.40	1.88	2.60	29.67	107.34	137.00
193	11.13	095.06	08.93	46.39	12.03	41.12	45.47	9.65	24.26	1.87	2.53	27.67	110.00	137.67
078	11.09	109.60	09.26	35.53	12.43	36.73	51.67	9.53	26.40	1.95	2.77	31.00	105.00	136.00
196	11.03	109.86	11.60	44.19	10.94	29.89	46.33	9.85	24.46	1.89	2.49	28.67	107.34	136.00
126	10.98	115.20	09.20	46.99	13.45	37.58	48.60	9.81	26.00	1.88	2.65	30.33	106.34	136.67
280	10.92	110.73	10.06	41.23	13.24	40.30	44.46	9.86	24.20	1.83	2.46	29.00	107.00	136.00
L286	07.94	105.15	07.96	39.53	12.59	33.14	45.49	9.19	24.49	1.86	2.67	29.09	107.03	136.12
L287	08.84	88.27	09.00	28.30	11.98	28.30	52.53	8.74	21.53	2.44	2.47	37.70	091.33	129.00
L288	09.74	111.87	08.93	37.05	10.31	34.50	47.80	8.29	24.60	1.93	2.96	31.70	103.30	135.00
L289	05.83	74.60	06.00	31.80	10.15	26.30	58.20	8.28	21.53	2.70	2.61	28.70	102.00	130.78

** Glaucous lines; A = Mean of 286 lines; L287 = line287 from Assad 65; L288 0 line from Hourani 27; L289 = line 389 from Amra GYP: Grain yield / plant (g); PHt: Plant height (cm); TN: Fertile tillers / plant; FLA: Flag leaf area (cm^2); AWL: Awn length (cm); TKW: 1000 Kernel weight (g); NKS: Kernels / spike; SL: Spike length (cm); SS:Spikelets / spike; KS: Kernels / spikelet; SD: Spike density; GFP : Grain filling period (day); HD: Days to heading (day); MD: Days to maturity (day); HM^2: Head/ meter^2; BY : Biological yield (g).*

Table 4.Variation among glaucous (g)/non-glaucous (ng) lines for 16 characters in 286 tetraploid "SafraMa'an" landrace.

Trait	g vsng	N	Range	Mean ± SE	Pr> |t|
Plant height (cm)	g	13	79 -114	102.46±2.56	0.12 ns
	ng	273	83-118	105.2±0.37	
Fertile tillers/plant	g	13	6.20 -10.93	8.47±0.0.53	0.18 ns
	ng	273	5.00 -12	7.94±0.08	
Spike length (cm)	g	13	6.47 -9.82	8.70±0.27	0.0001*
	ng	273	7.53 -10.29	9.21±0.03	
Spikelets / spike	g	13	22.80 -27.07	24.33±0.31	0.52 ns
	ng	273	22.20 -26.80	24.50±0.06	
Kernels / spike	g	13	41.66 - 60.40	48.26±1.58	0.0001*
	ng	273	33.13 - 53.8	45.36±0.15	
Kernels / spikelet	g	13	1.70 - 2.58	1.98±0.07	< 0.0001*
	ng	273	1.33 - 2.11	1.85±0.01	
1000 Kernel weight (g)	g	13	22.78-39.37	31.87±1.49	0.23 ns
	ng	273	26.28-42.46	33.20±0.23	
Spike density	g	13	2.53-3.68	2.84 ±0.09	< 0.0001*
	ng	273	2.36 - 3.08	2.66 ±0.01	
Awn length (cm)	g	13	6.34-14.50	11.64± 0.57	< 0.0001*
	ng	273	10.15-14.52	12.63±0.04	
Flag leaf area (cm^2)	g	13	34.63- 44.62	38.09±0.81	0.03*
	ng	273	32.15-46.99	39.59±0.15	
Grain yield / plant (g)	g	13	4.33 -11.37	8.10±0.48	0.67 ns
	ng	273	3.98 -12.32	7.93±0.09	
Grain filling period	g	13	26.33-31.00	29.02±0.70	2.870*
	ng	273	26.33-36.33	29.14±0.06	
Days to heading (day)	g	13	104.60-112.00	106.95±1.10	0.15 ns
	ng	273	94.33-110.33	107.01± 0.08	
Days to maturity (day)	g	13	133.34-139.00	135.37.±0.49	0.53 ns
	ng	273	130.66-140.00	136.17±0.05	
Head/ $meter^2$	g	13	208.89-367.70	292.73±1.54	0.15 ns
	ng	273	167.78-382.20	268.50±2.54	
Biological yield (g)	g	13	23.30-54.93	36.75 ±2.29	0.60 ns
	ng	273	20.77-57.54	36.36±0.42	

** Significant at 5%levelof probability.*

Table 5. Grain yield and other characters of the 13 glaucous lines and the check cultivars

Line*.	GYP	PHt	TN	FLA	AWL	TKW	NKS	SL	SS	KS	SD	GFP	HD	MD	HM²	BY
113	11.38	114.60	10.86	44.60	12.15	32.45	55.53	9.68	27.06	2.06	2.80	31.00	106.00	137.00	313.33	54.94
258	10.19	090.13	09.54	37.26	11.90	38.98	47.50	8.55	23.74	2.00	2.78	28.30	108.00	136.30	322.23	35.10
279	09.29	108.13	10.87	36.42	10.37	31.51	41.66	8.80	24.54	1.69	2.78	28.34	107.66	136.00	366.70	42.66
270	08.79	104.60	06.94	42.11	12.98	37.97	44.53	9.82	24.80	1.81	2.67	28.00	108.34	136.34	235.60	36.54
111	08.34	099.13	09.54	34.63	11.29	30.47	45.86	8.69	25.80	1.78	3.03	29.00	109.67	138.67	324.40	36.56
264	08.17	110.87	10.94	38.54	06.34	22.78	52.20	6.48	23.80	2.19	3.68	27.34	109.00	136.34	367.80	43.93
269	08.12	101.60	08.20	36.79	12.39	33.64	42.80	8.85	23.60	1.82	2.67	29.34	106.67	136.00	278.90	33.27
271	07.91	108.06	07.27	36.11	12.78	31.78	45.60	9.37	24.24	1.83	2.66	29.00	107.67	136.67	254.50	37.59
268	07.79	099.60	07.00	40.19	12.11	39.73	48.67	8.88	23.54	2.07	2.65	27.00	109.34	136.34	236.70	29.44
201	07.10	105.80	09.40	39.74	14.51	26.59	60.40	6.91	23.44	2.58	3.39	26.34	109.67	136.00	313.34	41.14
170	07.08	078.60	06.10	35.19	12.00	31.90	54.07	8.86	22.80	2.37	2.58	36.33	094.34	130.67	201.13	26.24
153	06.85	104.10	06.27	36.83	13.24	33.37	46.07	9.21	24.26	1.89	2.64	29.67	106.60	135.67	218.90	32.09
137	04.33	105.73	07.20	35.94	09.30	23.00	42.60	9.04	24.06	1.77	2.67	27.67	108.00	135.67	242.30	23.30
L286	07.94	105.15	07.96	39.53	12.59	33.14	45.45	9.19	24.49	1.86	2.67	29.09	107.03	136.12	269.60	37.34
L287	08.84	088.27	09.00	28.30	11.98	28.30	52.53	8.74	21.53	2.44	2.47	37.70	091.33	129.00	301.10	31.30
L288	09.74	111.87	08.93	37.05	10.31	34.50	47.80	8.29	24.60	1.93	2.96	31.70	103.30	135.00	307.78	39.36
L289	05.83	074.60	06.00	31.80	10.15	26.30	58.20	8.28	21.53	2.70	2.61	28.70	102.00	130.78	210.00	29.40

A = Mean of 286 lines; L287 = line287 from Assad 65; L288 0 line from Hourani 27; L289 = line 389 from Amra

GYP: Grain yield / plant (g); PHt: Plant height (cm); TN: Fertile tillers / plant; FLA: Flag leaf area (cm^2); AWL:Awn length (cm); TKW: 1000 Kernel weight (g); NKS: Kernels / spike; SL: Spike length (cm); SS:Spikelets / spike; KS: Kernels / spikelet; SD: Spike density; GFP : Grain filling period (day); HD: Days to heading (day); MD: Days to maturity (day); HM^2: Head/ $meter^2$; BY : Biological yield (g)

3. Trait distribution

Frequencies of plants in desirable classes and the two additional classes are presented in tables 6 and 7. The desirable classes ranged from low of 4.6% for glaucousness to 100% for erect juvenile growth habit. Most lines (73%) had excellent early growth vigor and al (100%) had erect juvenile growth habit, two of the most important traits for drought tolerance. Plant height and tillering capacity of these lines indicated their adaptability to semiarid environments, where grain and straw yield are equally important (Jaradat, 1992b). Similarly, high frequency of lines with excellent agronomic score (27%) may suggest that "SafraMa′an" population have high genetic diversity. Frequencies in desirable classes of spike related traits reflect the high level of adaptability of this population to semiarid environment. The high frequency of long spike (50.7) and the low frequency (17.8) of high 1000 kernel weight (10.9) of high number of kernels/spike and dense (9.1) spikes demonstrate the selective pressure in this population. Frequency of this population with early heading, early maturity and long grain filling period are considered as indicators of increase tolerance to drought (Blum *et al.,* 1989; Jana *et al.,* 1990).

4. Estimates of Diversity Indices (H′)

Variation or polymorphism was common, with different degrees, for most traits, indicating a wide variability within population of "Safra Ma´an" landrace. Estimates of (H′) for individual traits are presented in Table 6 and 7. These estimates ranged from 0.0 (monomorphic) for Juvenile growth habit to 0.91 (highly polymorphic) for spike length, while most traits showed relatively high levels of polymorphism. Few of these traits (e.g. early growth vigor and glaucousness) displayed low (H′) estimates. However, a low (H′) estimate may reflect unequal frequencies of different class rather than the absence of the desirable class for a particular trait.

Average (H′) estimate for "SafraMa´an" landrace population, based on traits evaluated in this study, was 0.65 ± 0.047. However, when only drought-related traits were considered, as done by Blum *et al.* (1989), Jana *et al.*(1990; and Jaradat (1992a), (H′) estimate dropped to (0.61±0.08). Similar pattern of reduction was obtained by Jaradat (1992a).

5. Cluster Analysis

Cluster analysis was performed with the quantitative data only according to Weltzien (1989). This analysis resulted in 6 clusters (Table 8). The means are presented for each quantitative trait for all clusters. Cluster 1 contains most lines of the population including Hourani. The landraces in this cluster were moderate in heading and maturity, shorter in grain filling period, taller than the mean, higher in grain yield per plant, lower number of tillers than the mean and larger flag leaf and taller awn length. Cluster 2 contains one line from "Safra Ma′an" population and Acsad 65, which is a check variety. Lines in this cluster, characterized by shorter, less number of tillers than those in the first cluster, showed longer grain filling period, earlier in heading and maturity, taller awn length and smaller flag leaf area than the first cluster. Cluster 3 had only one line characterized by low number of kernel, large thousand kernel weight. It was shorter than the mean, and has long awn length and large flag leaf area than the first two clusters. Cluster 4 contains only Amra, cultivated in Jordan, and characterized by low number of tillers and short plant, medium in filling period, heading and maturity dates. Amra yielded less than "Safra Ma′an" landrace population and was shorter in awn length and had smaller flag leaf area compared to "Safra Ma'an" landrace population. In cluster 5 there was only one line which was characterized by taller than the mean, longer awn length and larger flag leaf area than the mean of the landrace. Cluster 6, characterized by taller in height but shorter in awn length than the mean of "Safra Ma′an" landrace, had greater flag leaf area and grain yield per plant than mean of landrace.

Table 6. Frequency in three class's and diversity index (H′) estimates for 16 quantitative plant characters in "SafraMa'an" landrace population

Trait	N	Desirable Class	$C_1 \leq \bar{X} - S_d$	$\bar{X} - S_d < C_2 < \bar{X} + S_d$	$C_3 \geq \bar{X} + S_d$	H′
Plant height (cm)	286	Tall	14.70	72.00	13.30	0.72
Tillers/plant	286	High	13.60	68.90	17.50	0.76
Spike length (cm)	286	Tall	15.00	34.00	50.70	0.91
Spikelets/sp ke	286	High	16.40	66.40	17.10	0.79
Kernels/spike	286	High	10.20	78.90	10.90	0.61
1000 KW (g)	286	Heavy	15.70	66.40	17.80	0.79
Kernels /sp kelet	286	High	9.40	80.40	10.10	0.57
Spike density	286	Dense	13.30	77.60	9.10	0.67
Awn length (cm)	286	Tall	10.10	77.60	12.20	0.62
Flag leaf area (cm^2)	286	Large	15.70	68.20	16.10	0.77
Grain yield (g)	286	High	15.40	69.90	14.70	0.75
Grain filling period (day)	286	Long	12.50	71.90	15.40	0.71
Days to heading (day)	286	Early	10.80	78.70	10.50	0.60
Days to maturity (day)	286	Medium	9.10	74.50	16.40	0.66
Head per $meter^2$	286	High	14.00	68.90	17.10	0.76
Biological yield (g)	286	High	15.70	68.20	16.10	0.77

Table 7. Percentage of each category of the qualitative traits to the total number of cases of"Safra Ma′an" lanrace population

Trait	Desirable class	Category 1	Category 2	category 3	H′
Early growth vigor	Exellent	4	23	73	0.63
Juvenile growth habit	Erect	100	0	0	0
Glaucousnes VS. non glaucousnes	Glaucous	4.6	95.4	0	0.27

Table 8. Quantitative plant characteristics in 289 lines, aggregated into 6 clusters

Cluster	Lines	PHt	TN	SL	SS	NKS	KS	TKW	SD	AWL	FLA	GYP	GFP	DH	DM	HM²
1	283	105.3	07.9	09.2	24.5	45.4	1.90	33.2	2.70	12.6	39.5	7.90	20.09	107.0	136.0	269.3
2	2	083.4	07.5	08.8	22.2	53.3	2.40	30.1	2.50	11.8	31.8	7.90	37.00	092.8	129.8	251.0
3	1	089.9	08.5	08.8	24.8	33.1	1.33	41.2	2.81	14.0	43.3	7.30	29.60	110.3	140.0	290.0
4	1	074.6	06.0	8.28	21.5	58.2	2.70	26.3	2.60	10.1	31.9	5.82	28.60	102.0	130.7	210.0
5	1	105.8	09.4	06.9	23.5	60.4	2.50	26.6	3.40	14.5	39.7	7.10	26.40	109.7	136.0	313.3
6	1	110.9	10.9	06.5	23.8	52.2	2.19	22.8	3.70	06.3	38.5	8.20	27.40	109.0	136.3	368.0
Mean		095.0	08.4	8.08	23.4	50.4	2.17	30.1	2.95	11.5	37.5	7.40	28.10	105.0	135.0	283.3

PHt: Plant height (cm); TN: Fertile tillers / plant; SL: Spike length (cm); SS: Spikelets / spike; NKS: Kernels / spike; KS: Kernels / spikelet; TKW: 1000 Kernel weight (g); SD: Spike density; AWL: Awn length (cm); FLA: Flag leaf area (cm²); GYP : Grain yield / plant (g); GFP : Grain filling period (day); HD: Days to heading (day); MD: Days to maturity (day); HM²: Head/ meter² .

able 9. Quantitative plant characteristics in 289 lines, aggregated into 11 clusters

Cluste	Line	PHt	TN	SL	SS	NKS	KS	TKW	SD	AWL	FLA	GYP	GFP	DH	DM	HM²
1	278	105.3	07.95	09.21	24.49	45.5	1.86	33.16	2.67	12.65	39.5	7.95	29.08	107.1	136.3	269.4
2	2	110.7	07.95	08.82	24.4	46.1.	1.89	34.1	2.77	11.48	38	8.45	30.5	105.5	136	275
3	1	105.7	07.2	09.05	24.6	42.6	1.78	23.0	2.66	9.3	35.94	4.33	22.7	108	135.6	242.3
4	1	114.0	10.87	09.68	27.1	55.53	2.06	32.6	2.81	12.15	44.62	11.38	31	106.0	137.0	358.9
5	1	89.9	8.47	08.84	24.8	33.13	1.33	41.28	2.81	14.05	43.1	7.31	29.67	110.3	140.0	290.0
6	1	105.8	9.4	06.92	23.5	60.4	2.57	26.6	3.39	14.51	39.74	7.1	26.33	109.6	136.0	313.3
7	1	110.9	10.94	6.48	23.8	52.2	2.19	22.8	3.68	6.34	38.54	8.16	27.33	109	136.3	367.8
8	1	78.6	6.07	8.87	22.8	54.1	2.38	31.9	2.58	12.1	35.2	7.9	36.33	94.3	130.7	201
9	1	92.4	6.0	7.54	23.2	43.2	1.86	33.7	3.08	13.2	40.1	5.52	29.7	108	137.7	205.6
10	1	88.2	9.0	8.74	21.5	52.5	2.44	28.3	2.47	11.9	28.3	8.84	37.7	91.3	129	301.1
11	1	74.6	6.0	8.28	21.5	58.2	2.70	26.3	2.61	10.15	31.8	5.83	28.7	102	130.8	210
Mean		095.0	08.4	8.08	23.4	50.4	2.17	30.1	2.95	11.5	37.5	7.40	28.10	105.0	135.0	283.3

PHt: Plant height (cm); TN: Fertile tillers / plant; SL: Spike length (cm); SS: Spikelets / spike; NKS: Kernels / spike; KS: Kernels / spikelet; TKW: 1000 Kernel weight (g); SD: Spike density; AWL: Awn length (cm); FLA: Flag leaf area (cm²); GYP : Grain yield / plant (g); GFP : Grain filling period (day); HD: Days to heading (day); MD: Days to maturity (day); HM²: Head/ meter² .

The above results indicate that “Safra Ma′an” landrace population is similar to Hourani 27, at a distance of 0.55, but different from the other cultivated checks Acsad 65 and Amra, at a distance of 0.48: Hourani 27 locate at separate cluster with one line from “Safra Ma′an” population and the population with 3 checks will separate into 11 clusters (Table 9). The run of cluster analysis over the complete data sets resulted in 82 clusters at a distance of 0.25; more the 50% of clusters consisted of one or two plants only. This was considered systematically unreasonable although it demonstrated the magnitude of polymorphism in this population. The presence of several clusters in this population at the 48% of the total Euclidean distance indicates the high variability within this population.

IV Discussion

The variation exhibited by the lines in 16 quantitative characters indicates that “Safra Ma’an” landrace population is a heterogeneous population, which includes a number of genotypes differing for quantitative characters of agronomic importance as well as for morphological and quality characters; thus, selection for several of these characters may be effective. Plant height is believed to be an important character for adaptation in non-irrigated areas under late season water stress condition (Okuyama *et al*., 2005) because one of the main effects of a dry spell during the growing season is a drastic reduction of stem elongation with a reduction of straw yield and the impossibility of combine harvesting the crop (Ceccarelli *et al.*, 1987). Therefore, it was interesting to find a large number of lines significantly taller than the tallest local cultivar Hourani. The finding ws expected since several studies have indicated the presence of variation within landrace populations in quantitative and qualitative traits (Poiarkova and Blum, 1983; Ceccarelli *et al.,* 1987; Ehdaie and Waines, 1989; Jaradat, 1992a; Jaradat, 1992b; Jaradat *et al*.,2004; Al-Nashash *et al*.,2007). Drought stress is probably the most important environmental factor affecting plant productivity. Because of the prevalence of drought, plants have various morphological and physiological characteristics that enable them to grow and reproduce in low rainfall environment. Studies with isogenic lines have shown that glaucousness out yielded non-glaucousness especially under stress condition. Glaucousness reduced residual transpiration (Clarke and Richards, 1988) and thus represents a desirable character for plant adaptation to drought. Thus, selection for glaucousness may be a goal in breeding programs. The greatest difference between the glaucous and non-glaucous lines for most characters must have resulted from better water use efficiency, as a result of low residual transpiration rates (Clarke and Richards, 1988). These results indicate that under dry land conditions the breeding programs should be directed toward the increase of glaucous lines in order to increase these characters. Frequencies in desirable classes of traits that are known to confer drought tolerance in wheat (Blum *et al.*, 1989; Jana *et al.,* 1990; Jaradat, 1992b) were relatively low, especially when compared with Jordan landraces. These results indicate a low pressure for selection compared to selection pressure obtained by Jaradat (1992b) in Jordan landraces. Estimates of diversity indices (H′) is relatively smaller than the one reported for Jordan wheat landraces (0.707 ± 0.05) which was based on 24 morphological traits (Jaradat, 1992a). Also, (H′) estimate for “Safra Ma′an” population is lower than that reported for Mediterranean region (0.792±0.04) (Jana *et al.,* 1990), which was based on 27 traits most of which were include in this population. From this result, we can conclude that “Safra Ma´an” wheat landrace population could be an important source of genetic variability for selection procedure, the initial stage of wheat breeding.

V Conclusions

This study was conducted to assess the magnitude of phenotypic variation for several traits in tetraploid “SafraMa‘an” wheat landrace and to evaluate the potential usefulness of several traits after planting 286 lines from “Safra Ma‘an” landrace wheat and three check cultivars during 1995/1996 growing season at Maru Agriculture Research Station.

Polymorphism was common, in varying degrees, for most traits as indicated by a wide phenotypic variation within population of “Safra Ma‘an” landrace. Lines with glaucousness character were found in this population without being significantly different from non glaucous lines in grain yield per plant. Extensive variation is found in this landrace population and thus improvement in this wheat landrace may be possible.

The information generated in this study can be utilized in a breeding program in at least two different ways. First is the release of the highest yielding lines as pure line varieties, after testing their stability in different environments (locations and years). Second is the utilization of superior plants, for yield as well as for other characters, as parents in the crossing program to introduce additional desirable characters in an adapted genetic background.

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