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Participatory plant breeding approach for identifying the superior rainfed barley genotypes in Egypt

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Abstract

The participatory plant breeding (PPB) approach, in which the selection process is performed in the farmers' fields, is not a widely known strategy in Egyptian agriculture. The objective of this study is to assess the efficiency of farmers', researchers' and engineers' selection in a participatory plant breeding program. Two field experiments have been conducted during 2010/2011 and 2011/2012 seasons to evaluate the performance of six genotypes under rainfed conditions in four locations (Ras El Hekma, Matrouh, El Neguilla and Barrani) in the North Western Coastal Zone of Egypt. For all of the studied locations, the selectors gave the highest score at the Matrouh location in the first season; however, two out of the three selectors (farmers and engineers) gave the highest score at the Barrani location in the second season. Overall, the ICA1 genotype was the one most liked by farmers and researchers in both of the growing seasons and by the engineers in the second season only because of its high yield potential. The results show that the farmers in all the studied locations were as efficient, or more efficient, than the researchers and the engineers in selecting high yielding genotypes. This was evident by the high positive correlation between the farmers' score and the grain yield at all locations ($r^2 > 0.6$). The findings illustrate the importance of farmers' participation in the breeding programs to increase the probability and speed of the adoption of new genotypes and maintain the genetic diversity.

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Introduction

Barley is the predominant crop in Egypt that is grown under rainfed conditions and is, thus, governed by the amount and distribution of rainfall. The North Western Coastal Zone (NWCZ; coastline and inland) is divided to 5 zones, according to the agro-ecological characteristics. Barley is mainly grown in the three zones known as zone 1, 2 and zone 3 which extends 0-7 km to then 7-15 km, and then 15-25 km inland. These three zones receive mean annual precipitation of 140-180 mm, 100-140 mm and 60-100 mm, respectively (Ali *et al.*, 2007). The total cultivated area of barley in the NWCZ is 126 000 ha (300000 Feddans) with an average productivity of 1.29 t ha^{-1} (Noaman 2010). while it occupies an area of 135,000 ha in 2008/2009 season with an average productivity of 3.63 t ha^{-1} (El-Banna *et al.,* 2011) for entire Egypt.

Farmers in the NWCZ grow one or two varieties of barley which are prescribed for the area as being drought resistance cultivars (i.e., Giza 126 and/or Giza 2000). Some studies have been conducted to examine the productivity of different barley varieties under the NWCZ conditions when compared to the Giza 126 cultivar (i.e., Moselhy and Ali 2010, El-sayed *et al.*, 2004, and Afiah and Moselhy 2001). By comparing the grain yield of Giza 126 and other genotypes, results showed that Giza 126 yielded higher than Giza 125 in (Moselhy and Ali 2010), furthermore, El-sayed *et al.*,2004 found no significant difference among the three varieties of Giza 126,Giza 131 and Giza 132 for their grain yields. However, Afia and Moselhy 2001, pointed that Giza 126 ranked the third among the fifteen tested genotypes for the grain yield.

Through the collaboration between the Egyptian Ministry of Agriculture and the International center for Agriculture Research in Dry Areas (ICARDA) and the Arab Center for the Study of Arid Zones and Dry Lands (ACSAD) more than 1200 lines were under trials for many years under different environmental conditions testing against drought, salinity, poor soil fertility and heat stress (Noaman, 2010). A local breeding program, performed by the Barley Research Department; Agriculture Research Center, includes testing more than 500 crosses every year at Giza and Sakha Research stations. Then the population resulting from F2-F3 are tested in the major areas of barley production (i.e., NWCZ, Sinia, Middle Egypt and the new reclaimed lands) to select the superior cultivar for each area. The Sustainable Resources Development of Matrouh Resources (SRDMR) Desert Research Center has a research partnership with ICARDA named the Joint Participatory Barley Improvement Program. The program tests the productivity of 49 new barley genotypes as compared to the local varieties. Farmers' participation in the selection of the highly productive varieties is a targeted approach.

ICARDA has begun to perform most of the selection process of the new cultivars in the farmers' field (participatory plant breeding;PPB). Ceccarelli *et al.* (2001) addressed the participation of local farmers in the selection process in three countries Syria, Tunisia and Morocco. The experiments included evaluating number of barley entries for the two growing seasons of 1996/1997 and 1997/1998 in eleven, five and four sites (and then increased to nine in the second season) in Syria, Tunisia and Morocco, respectively. Number of entries was 208, 25 and 72 in Syria, Tunisia and Morocco, respectively. The yield ranged from 280 to 4495 Kg ha^{-1} in Syria, from 427 to 1343 Kg ha^{-1} in Tunisia and from 516 to 6000 Kg ha^{-1} in Morocco. The selection criteria differed from place to place and from year to year. The results of comparing the selection by farmers and breeders showed that there was a large similarity between breeders' and farmers' selection in Syria. In Morocco, the selection agreement ranged from high to low based on the locations. However, in Tunisia two varieties were selected by both and five were ignored by both. In a similar study, Ceccarelli *et al.* (2000) evaluated the performance of 208 barley entries in eleven locations. The farmers' selection was compared to the breeders' selection at all of the tested locations. The results showed that the highest grain yield was obtained at the Tel Haddya location (4.5 t ha^{-1}). Compared to the farmers' selection, more genotypes were selected by the breeders. . This decentralized, participatory selection is a term that means examining the performance of the crop varieties in the farmers' fields with their participation in the evaluation process Participatory plant breeding allows the farmer to be a major player in the process of developing and adopting new cultivars.

Conventional plant breeding; in which the development of varieties is the responsibility of plant breeders; can be summarized as being more effective for high production environments with the selection process ignoring the vision of the local farmers where the varieties will be adopted in their local environments. However, participatory plant breeding allows the participation of the local farmers in selecting the best cultivars adopted to the marginal environments in their fields (Maurya 1989, Atlin *et al.*, 2001, and Morris and Bellon, 2004). However, Witcombe (1999) later extended the arguments for using participatory breeding to high potential production systems and the process can take place at a number of locations (Ceccarelli and Grando, 2007). Moreover, Witcombe and Virk (2001), pointed out the complementary relationship between classical breeding and PPB. Classical breeding identifies the best parents for the crossing process. Participatory breeding is a promising approach that decreases the number of entries selected and the number of required crosses. Coe (2007a) described the possible analysis of the data produced from on farm participatory trials. The steps to be used for analyzing the data are presented and examples of real experiments are discussed. The same author (Coe 2007 b), in another study, compared different statistical methods for analyzing the resulted data from the participatory on farm trials.

Witcombe *et al.* (2003) compared the outcomes of the two breeding programs; i.e., conventional plant breeding and participatory plant breeding. The conventional method produced no preferred varieties for the local farmers; however, using the participatory approach produced a cultivar (GDRM-187) that is liked by most of the farmers. The cultivar produced a yield 16-19% higher than GM-1 and the other local varieties. Moreover, Mangione *et al.* (2006). analyzed the financial aspects of the two breeding strategies (centralized-non- participatory and decentralized participatory plant breeding) Regardless of the quality of the collected information, their results showed that the participatory breeding program costs US$ 94,000 with one farmer per site and US$ 121,510 with four farmers per site in 16 sites while the centralized breeding program costs US$ 123,000 at the same number of sites.

Some studies (e.g., Sperling *et al.*, 1993) have reported that farmer selections out-yielded those made by breeders. In support of that; Fufa *et al.* (2010) tested the selection made by the farmers and breeders for 181 barley genotypes grown in four locations in Jordan. Their results showed that farmers and breeders selection scores were positively and highly correlated at two locations; i.e., Mohay (r= 0.718) and Ghweer (r=.697). However, Mohammadi *et al.* (2011) reported a weak correlation coefficient of 0.16 between farmers and breeders ranks. Their study used the participatory selection to identity the superior barley genotype among 69 tested genotypes for each location from 3 locations in Iran during the 2006/2007 growing season. The Biplot showed the ability of the farmers to select the best genotype for their environments. An argument for involving farmers in the intervening phases of selection is that sometimes farmers combine high yields with preferred consumption traits (Bertuso *et al.*, 2005).
Ceccarelli *et al.* (2003) evaluated the participatory plant breeding approach from two perspectives: who performs the selection and in which environment. 1348 barley entries were used in eleven locations during the 97/98 season. Grain yield ranged from 400 kg/ha to 3 t/ha. They concluded that the selection environment (farmers field, research stations and years) has larger effect than who performed the selection.

The PPB increases the efficiency of plant breeding in low input environments. Therefore, the objectives of our study are to adopt new barley varieties which are adapted to the rainfed growing environments of Egypt, and to assess the ability of farmers in the NWCZ to conduct efficient visual selection as compared to the researchers' and engineers' selection. In addition, we want to compare the correlation coefficient between the participants' scores and the quantitative traits measured.

Materials and Methods

Locations

Four locations located in the North Western Coastal Zone of Egypt were selected to represent different climate and soil conditions. They were Ras El Hekma (31° 06′ N 27° 39′ E), Marsa Matrouh (31° 21′ N 27° 08′ E), El Negilla (31° 26′ N 26° 30′ E), and Barrani (31° 34′ N 25° 59′ E). Barley is planted in the fall, usually after the first effective rain (mid-October to mid November), and harvested by April or May, depending on the length of the rainy season. The Barrani location recorded the highest rainfall of 154.2 mm and 213.mm for the 2010/2011 and 2011/2012 seasons, respectively. Soil texture is sandy clay loam at all four locations.

Plant materials

Five barley genotypes provided by ICARDA as well as Giza 126 were grown for two seasons and were evaluated by farmers, engineers and researchers. The five barley genotypes were, ICA_1,ICA_2,ICA_3,ICA_4 and ICA_5.The two experiments were laid out in a randomized complete block design in four replicates; each location has 4 blocks and six entries were grown at each block (6 plots). The plot size was 35 m^2 (5 × 7 m).

Selection of the superior genotype

A group of five expert farmers, including the host farmer, gave an agronomic score to each plot in each experimental site (decentralized, farmer groups selection; Ceccarelli *et al.*, 2000). A score from 0 (worst) to 5 (best) was used in all locations. At each site, the same five farmers scored the two trials planted in that area. Selection was conducted in such a way as to reveal the criteria being used by the farmers in making their choices. At the end of the selection, the researcher sat with farmers to discuss the trial, to record their impression about the germplasm, and to discuss with the farmers the sampling procedure. At all locations, the farmers decided to use only the score given at the mature stage for final selection and to keep the entries that received the top scores (5 or 4) by the majority of the group.

Selection by the extension engineers at each experimental site was done when the crop was close to its mature stage and without knowing the selection made by the farmers. Neither the engineers nor the farmers had access to the actual yield data or other objective measurements; therefore, the entire process simulates the visual selection during the breeding program.

Quantitative traits measured

Sixteen yield-related traits were estimated at harvest. These included plant height (PH in cm), spike length (SL in cm), number of grains per spike (NGS), spike weight (SW in g/m^2),1000-grain weight (TKW in g), number of spikes/m^2 , grain yield (GY in kg/ha), weight of grains per spike (WGS in g), tillering index (TI), biological yield (BY in kg/ha), straw yield (SY in kg/ha), harvest index (HI), crop index (CI), and water Use Efficiency (WUE; kg grain/m^3).

Statistical analysis

The average farmers', engineers' and researchers' score for each location and each entry was calculated. The Spearman's rho correlation analysis was used between the selection scores given by the selectors and the objectively measured quantitative traits, and between selectors' scores, themselves. All statistical analyses were performed using the Cropstat version 7.2 statistical software (CropStat, 2009).

Results and discussion

Location comparison

The differences among all the tested locations were significant for all the studied traits in the two growing seasons. The Matrouh location recorded the highest grain yield (1108.8 Kg/ha) during the first season;

while, the Barrani location recorded the highest grain yield (963.6 Kg/ha) during the second season (Figure 1). The results for the effect of location on all the studied traits of barley yield and its components are found in Gomaa *et al.* (2014).

Genotype comparison

The genotype ICA_1 suggested being the most stable among all of the studied genotypes in regard to its performance in all locations and seasons. ICA_1 recorded the second highest grain yield in the first season (834 Kg/ha) with no significant difference with ICA_1 which ranked first with 836 Kg/ha. In the second season, ICA_1 alone recorded the highest significant yield of 884.4 Kg/ha (Figure 2). The performance of each genotype and its associated agronomic parameters was discussed in detail in Gomaa *et al.* (2014).

Table 1. Average Farmers', Researchers' and engineers' score for each of the studied location in the 2010/2011 and 2011/2012 growing seasons.

Location	FS	RS	ES
2010/2011 season			
Barrani	3.20	3.27	3.4
El Neguila	3.82	3.80	3.88
Matrouh	4.38	4.11	4.19
Ras El Hekma	3.56	3.30	3.22
LSD at 5%	0.29	0.25	0.29
2011/2012 season			
Barrani	3.75	3.40	3.60
El Neguila	3.30	3.44	3.41
Matrouh	3.11	2.91	3.08
Ras El Hekma	2.52	2.44	2.63
LSD at 5%	0.418	0.42	0.34

Whereas; FS, farmer selection, RS, researcher selection, ES, engineer selection.

Table 2. Average Farmers', Researchers' and engineers' score for the tested genotypes in the 2010/2011 and 2011/2012 growing seasons.

Genotype	FS	RS	ES
2010/2011 season			
IC1	3.92	3.83	3.66
IC2	3.73	3.68	3.79
IC3	3.72	3.54	3.58
IC4	3.57	3.50	3.66
IC5	3.76	3.58	3.75
Giza126	3.74	3.60	3.66
LSD at 5%	0.36	0.31	NS
2011/2012 season			
IC1	3.62	3.41	3.45
IC2	3.29	3.30	3.40
IC3	3.45	3.41	3.45
IC4	3.66	2.66	2.75
IC5	3.00	2.66	2.87
Giza126	3.00	2.83	3.16
LSD at 5%	NS	0.52	0.42

Whereas; FS, farmer selection, RS, researcher selection, ES, engineer selection.

Selection score at each location

On average, the selectors gave the highest score in the visual selection at Matrouh location in the first season; however, the lowest score by the farmers and researchers was given to Barrani, and to Ras El Hekma, by the engineers (Table 1). For the second season, the highest score given by the farmers and the engineers was given to Barrani.The researchers gave their highest score to El Negilla with no difference with Barrani. The results show that all selectors gave the lowest score to Ras El Hekma. It can be concluded that the selection of the participants is highly influenced by the average yield at each location, this was clear by selecting the locations with the highest grain yield i.e., Matrouh in the first season and Barrani in the second season.

Selection score for genotypes

For all the studied genotypes, ICA_1 has been given the highest score by the researchers in the two growing seasons (Table 2); moreover, it has been given the highest score by the farmers in the first season and by the engineers in the second season. However the ICA_1 genotype came in third in the first season and according to the engineers' selection with no significant difference with the ICA_2 (ranked first) and the second after ICA_4 according to the farmers' selection, also with no significant difference with ICA_4 which ranked first. The lowest rank was obtained for ICA_4 and ICA_3 in the first season and ICA_4 and ICA_5 in the second season (Table 2). Again results revealed the high correlation between the selector's choice for best genotype and the highest grain yield; therefore, we examined the correlation between the farmers', the researchers' and the engineers' selection and the grain yield and its traits in all locations.

Table 3. Correlation coefficient's between farmers, Engineers and researchers selection scores and 16 quantitative traits in the 2010/2011 season.

Traits/selection	Ras El Hekma			Matrouh			El Negilla			Barrani		
	FS	RS	ES	FS	RS	ES	FS	RS	ES	FS	RS	ES
GY (Kg/ha)	0.636**	0.771**	0.262	0.776**	0.673**	0.664**	0.826**	0.759**	0.816**	0.601*	0.378	0.434
PH (cm)	0.390	0.116	0.384	0.385	0.455	0.239	0.548**	0.650**	0.720**	0.475	0.290	0.560
SL (cm)	0.499	0.374	0.604*	0.289	0.382	0.441*	0.609**	0.612**	0.781**	0.430	0.162	0.277
NOT	0.114	0.006	0.178	-0.141	0.161	0.008	-0.372	-0.444*	-0.412	-0.126	-0.112	-0.079
NOS	0.739**	0.456	0.281	-0.251	-0.266	-0.010	-0.110	-0.205	-0.137	0.072	0.225	0.195
TI (%)	0.646**	0.520*	0.057	-0.503*	-0.498**	-0.619*	0.319	0.235	0.303	0.391	0.657**	0.534*
NGS	0.672**	0.602*	0.090	0.578*	0.589	0.307	0.206	0.423*	0.595*	-0.071	-0.236	-0.207
WGS (g)	0.591**	0.414	0.166	0.558*	0.569	0.306	0.325	0.449*	0.418	0.279	0.188	0.222
1000-GW (g)	-0.228	-0.283	0.291	0.066	0.065	0.086	0.177	0.171	-0.044	0.071	0.253	0.150
BY (Kg/ha)	0.595**	0.424	0.348	0.491*	0.486	0.401	0.565	0.455*	0.658**	0.461	0.082	0.132
SY (Kg/ha)	0.292	-0.097	0.274	0.181	0.177	0.124	0.245	0.138	0.379	0.239	-0.173	-0.141
HI (%)	0.325	0.697**	-0.004	0.416	0.418	0.366*	0.427	0.479*	0.290	0.363	0.563*	0.579*
CI (%)	0.306	0.705**	0.015	0.373	0.378	0.317	0.405	0.457	0.255	0.307	0.497*	0.532*
WUE	0.635**	0.771**	0.262	0.753**	0.753**	0.610**	0.826**	0.759**	0.816**	0.601*	0.378	0.434
RS	0.777**	------	0.355	0.844**	0.829**	------	0.730**	------	0.718**	0.555	------	0.872**
ES	0.414	------	------	0.796**	0.818**	------	0.778**	------	------	0.624**	------	------

GY, grain yield; PH, plant height; SL, spike length, NO.T, number of tillers/m2, NOD; number of spikes/m2,TI;tillering index, NGS; number of grains per spike, WGS, weight of grains per spike,1000-GW; 1000-grain weight, BY, biological yield, SY, straw yield, HI, harvest index, CI, crop index, WUE, water use efficiency, FS, farmer's selection score, Rs; researcher selection score and ES, Engineer selection score, The correlation is significant at *P≤0.05, P** at ≤ 0.01, and NS ,non-significant.

Correlation of farmers', engineers' and researchers' visual selections with GY and other traits

Data presented in tables 3 and 4 show that in all locations, except at El Negilla in the second season, the farmers' selection was significantly and positively correlated with grain yield with the correlation coefficient ranging from 0.601 at Barrani and 0.826 at El Negilla in the first season. However, it ranged from 0.729 at El Negilla and 0.964 at Barrani in the second season. The correlation with researcher's score was significant at most of the studied locations except at Barrani in the first season. The engineer selection also highly agreed with the researcher selection at all locations except at Ras El Hekma in the first season. Some traits seemed to be not affecting the selections at all locations, for example, the number of tillers, tillering index, spike length, number of spikes per m^2, and 1000-grain weight. At

Marsa Matrouh in the first season the correlation between farmers', researcher's and engineer's selection and the tillering index was negative and significant. High correlations between the selection and the grain yield is associated with a high correlation with the yield-related traits i.e., water use efficiency and harvest index. A high correlation, especially in the second season, was recorded between the score given to the genotype and its plant height which caused a high correlation with the straw yield.

Table 4. Correlation coefficient's between farmers, Engineers and researchers selection scores and 16 quantitative traits in the 2011/2012 season.

Traits/selection	Ras El Hekma			Matrouh			El Negilla			Barrani		
	FS	RS	ES	FS	RS	ES	FS	RS	ES	FS	RS	ES
GY (Kg/ha)	0.794**	0.504*	0.768**	0.888**	0.878**	0.766**	0.729**	0.634**	0.545*	0.964**	0.886**	0.928**
PH (cm)	0.596**	0.584*	0.674**	0.745**	0.673**	0.474*	-0.453	-0.381	-0.542*	-0.096	-0.001	0.116
SL (cm)	0.307	0.494	0.232	0.376	0.284	0.063	-0.115	0.395	0.396	0.448*	0.474ns	0.431*
NOT	0.544*	0.241	0.559*	0.356	0.295	0.469*	0.072	-0.259	-0.223	0.744**	0.636**	0.778**
NOS	0.506*	0.131	0.526*	0.342	0.290	0.403*	-0.033	-0.298	-0.337	0.788**	0.739**	0.812**
TI (%)	0.219	-0.216	0.225	-0.034	-0.005	0.040	-0.131	-0.116	-0.236	0.647*	0.637*	0.660*
NGS	0.193	0.363	0.195	0.575*	0.573*	0.293	0.224	0.506*	0.515*	0.255	0.214	0.293
WGS (g)	0.209	0.326	0.157	0.074	0.136	-0.190	0.345	0.637**	0.680**	0.528*	0.474*	0.533**
1000-GW (g)	0.094	0.072	-0.012	-0.185	-0.086	-0.332	0.337	0.564**	0.599**	0.588*	0.513	0.605**
BY (Kg/ha)	0.692**	0.361	0.653**	0.784**	0.723**	0.711**	0.251	0.249	0.211	0.858**	0.871**	0.821*
SY (Kg/ha)	0.535*	0.234	0.496	0.664**	0.597**	0.623**	0.133	-0.113	-0.102	0.590*	0.671**	0.550*
HI (%)	0.300	0.306	0.328	0.399	0.513	0.284	0.138	0.587*	0.525*	0.621*	0.469*	0.627**
CI (%)	0.314	0.314	0.344	0.363	0.480	0.222	0.144	0.597*	0.518*	0.582	0.423*	0.587**
WUE	0.869**	0.596**	0.781**	0.789**	0.765**	0.654**	0.235	0.593*	0.423	0.950**	0.892**	0.916**
RS	0.848**	------	0.792**	0.918**	------	0.868**	0.557*	------	0.736**	0.941**	------	0.926**
ES	0.908**	------	------	0.850**	------	------	0.566*	------	------	0.972**	------	-------

GY, grain yield; PH, plant height; SL, spike length, NO.T, number of tillers/m2, NOD; number of spikes/m2,TI;tillering index, NGS; number of grains per spike, WGS, weight of grains per spike,1000-GW; 1000-grain weight, BY, biological yield, SY, straw yield, HI, harvest index, CI, crop index, WUE, water use efficiency, FS, farmer's selection score, Rs; researcher selection score and ES, Engineer selection score, The correlation is significant at *P≤0.05, P** at ≤ 0.01, and NS ,non-significant.

Taller plants have been selected by all of the selectors at the El Neguilla location in the first season, which recorded the lowest rainfall of 73.3 mm. Farmers usually prefer taller plants in the dry environments (Fufa *et al.*, 2010 and Ceccarelli *et al.*, 2001), because they expect a very low grain yield and that could be compensated for by a high straw yield that is later used as animal feed. For other traits, the farmers' score is highly correlated with biological yield at most of the studied locations in both of the growing seasons. Only a few genotypes were selected based on the number of tillers, number of spikes and 1000-grain weight.

A high correlation between farmers', researchers' and engineers' selection is very noticeable at locations where all the genotypes performed well. However, low correlation is recorded at locations with large differences among the genotypes (Fufa *et al.*, 2010). A difference in the correlation between the breeders' and farmers' selection related to the environment under study is reported by (Ceccarelli *et al.*, 2001). The importance and the efficiency of the farmers' selection were evident from the high correlation between the farmers' high score and the grain yield at most of the studied locations. However, a low correlation was recorded between the researchers' selection and the grain yield (r=0.351) at Barrani in the first season (Table 3).

The results showed that regardless of the comparison method used in the selection process, the farmers were as efficient as the researchers in identifying the high yielding genotypes. Researchers more often use traits other than grain yield for identifying superior genotypes; this was noticeable in Ras El Hekma in the first season whenthe researchers' score was highly correlated to the tillering index (r=0.646) (see Table 3). From this study, we noticed that farmers have diverse selection criteria; i.e., plant height, spike shape, grain size, use and ease of processing (sheep feeding traits), market demand and quality traits. These criteria are usually unique to their environments; however, researchers' selection considers much broader target environments.

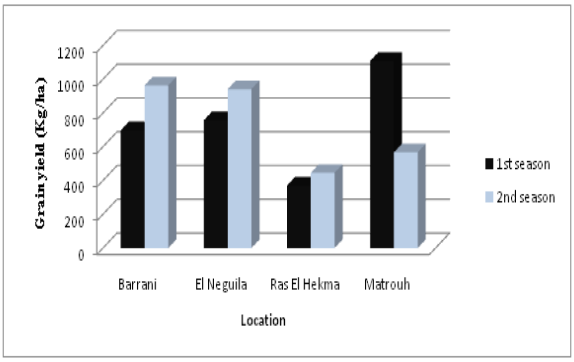

Fig. 1. Comparison of barley grain yield (Kg/ha) across locations in 2010/2011 and 2011/2012 growing seasons.

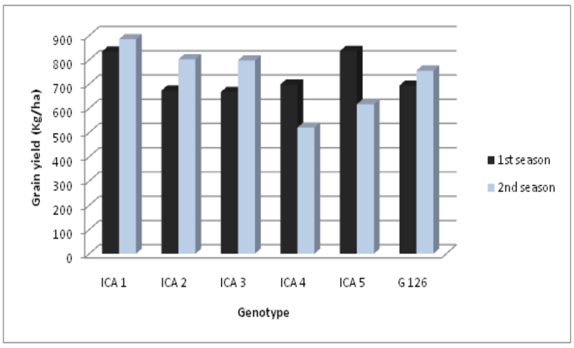

Fig. 2. Grain yield (Kg/ha) of barley genotypes in 2010/2011 and 2011/2012 growing seasons.

Comparison of farmers', researchers' and engineers' selection for quantitative traits

The results shown in Tables 3 and 4 reveal that the farmers are efficient enough in their selection for the high yielding genotypes at all tested locations; however, the researchers used traits other than the grain yield in their selection. These findings support the idea that farmers usually build their selection on the market demands and quality traits; however, the researchers usually consider a more diverse target environment and use traits necessary for extended breeding activities. The selector's score for the farmers and the researchers was highly correlated at all if the tested locations during the two growing seasons with a correlation coefficient higher than 0.6. These results are similar to those obtained by Fufa *et al.* (2010) and unlike those obtained by Mohammadi *et al.* (2011).

Conclusion

In this study, the farmers in the North Western Costal Zone of Egypt participated in the selection process of superior rainfed barley genotypes. The results showed that farmers are skilled and efficient enough in selecting the high yielding genotypes; this was clear because of the high score given to the high yielding genotype (ICA_1) at both locations (Matrouh in the first season and Barrani in the second season). The experiments revealed that farmers in this area tend to heavily consider the straw productivity which is the main source of animal feed in the summer. The approach is not often practiced in Egypt so it can be considered as new in plant breeding in Egypt. This study is a pioneer study in applying this approach for adopting new genotypes. We suggest that further work is needed to take the full advantage of farmers' participation by increasing the number of entries. In conclusion, participatory plant breeding is an effective strategy in improving crop production in the marginal areas in Egypt such as the NWCZ.

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