Managing the Variability in Okra Breeding Programs by Considering the Preferences of the Domestic Market

E. Düzyaman and H. Vural
Ege Univ. Fac. of Agriculture
Department of Horticulture
35100 Bornova, Izmir, Turkey
e-mail:duzyaman@ziraat.ege.edu.tr

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Abstract

Two field experiments were conducted to collect data on yield, yield components, plant morphology characteristics and some basic pod quality characteristics. Data were subjected to factor analysis to work out the relationship among variables. Pod characteristics such as pod weight and diameter positively affected total yield, both characteristics less determinative as consumer preferences in the domestic market. Total yield was also highly and negatively related to early flowering behaviour; however, early flowering behaviour might also be integrated to local okras due to the high market prices in the early season. Vegetative plant structures such as final plant height, height of lateral branches and internodes length had no connection to pod yield, implying that selection for semi – dwarf plant structure would not disturb final plant yield.

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is a traditional vegetable crop in Turkey, which is probably cultivated by the local farmers for some several centuries (Martin et al., 1981). The Turkish okra production has some significant differences from the production in some other parts of the world. The opinion prevails that elongated pods are not edible due to strong fibre development, and local consumers usually prefer small pods mostly below 4 – 6 cm in size (Şafak et al., 1993). While irrigation is the most limiting factor in okra production in USA, India and African countries (Düzyaman, 1997), local okra fields are hardly irrigated and are subjected to excessive droughts during the growing season. Farmers are of the opinion that excessive irrigation and plant nutrition result in excessive plant heights and elongated pods (Şafak et al., 1993). As a result, yield of local populations remains mostly as low as 500 kg/1000 m^2 (Inan, 1992) while this is 1.2 or even up to 2.2 tones per 1000 m^2 in many other countries (Blennerhassett and El-Zeftawi, 1986; Maynard, 1987).

By keeping the local approach in mind, an attempt was made to study the relationship among various traits in the current germplasm resources of okra. Twenty-four characteristics were observed in two field experiments and their relationships to each other were determined by applying factor analysis. The aim was to establish a basis for genetic improvement of local okras by considering the expectations of the domestic market.

MATERIAL AND METHOD

Two field experiments were conducted with plants grown on a sandy – loam soil at the Ege University, Faculty of Agriculture, Department of Horticulture at Bornova, Izmir. The experimental material consisted of 18 okra genotypes including pure lines and improved cultivars selected from an introduction program (unpublished data) (table 1). The experiments were established according to a completely randomised block design with 3 replications. The soil was prepared and fertilised according to Siemonsma (1982). Seeds were sown at 45 cm x 90 cm intervals and thinned to one plant per hill when plantlets reached 3-4 leave stage. Insect pests were controlled by applying Cypermetrin

200 EC (5 ml / 10 l) and Diazinon (15 ml / 10 l).

Each plot consisted of 7 plants out of which 5 competitive plants were used for the experiment. Data on plant morphological characteristics were collected directly form the field in a metric basis. Days to flowering was the date when 50 % of the plants in a plot flowered. Some 40-50 pod samples from the same plot were taken to the laboratory for further measurements and analysis. After the pod characteristics were determined, one third of each pod was cut and dried in the oven at 105°C for further analysis.

Basic pod quality properties such as dry matter content, crude fibre, crude protein and crude fat (Candlish et al., 1987) were analysed and each variable expressed as proportion per fresh weight. The Lepper method was used to perform crude fibre analysis whereas the Kjeldal method was used to perform protein analysis (Naumann ve Bassler, 1993). Fat analysis was performed using a Newport Analyser type Nuclear Magnetic Resonance Meter (NMR) (Official Analytical Instruments, 1982). Prior to the analysis the Newport analyser was calibrated with pure okra oil extracted from the seeds in hexan.

The data was subjected to the subroutine "factor analysis" at the SPSS classificatory program (version 5.0). A correlation matrix was first established according to Pearson's correlation quotients. Factor grouping was then initiated by applying "principal component" method and the varimax criterion to the data set (Walton, 1971). Each experiment was separately treated. Factor grouping was cut at a point where eigenvalues exceeded 1.

RESULTS AND DISCUSSION

Factor analysis gives the possibility to investigate the genotypes by their several characteristics. It was possible to explain a significant proportion of the variability created by the genotypes. Five factor groups were formed at the first experiment suggesting the conservation of 80.1 % of the total variability when selection is based on these 5 factor groups. Similarly, it was possible to select for 84.6 % of the total variability when selection is based on the 6 factor groups of the second experiment (table 2).

The factor grouping results are given in table 3 and 4 for the first and second experiments, respectively. Variables forming groups under various factors could be outlined as yield components, plant morphology characteristics, flowering behaviour, pod characteristics, pod composition and seed characteristics. There was a connection of almost all characters with others, implying that variables under each group were more or less affected by the others.

Regardless of being correlated to a number of characteristics such as pod composition, yield and plant morphology characteristics in the first and second experiments, flowering behaviour of the plants comprised characters highly correlated to each other. Days to flowering was a less representative character of the flowering behaviour of the plants by possessing low communality values in both experimental years. Selection for these traits should at least be based on flowering hight and / or first flowering node.

Two yield components (pod weight and number per plant) were highly associated with flowering behaviour and pod composition in the first experimental year. Walton et al. (1971) has earlier reported a similar observation on flowering behaviour affecting plant yield. The author outlined days to anthesis as an important trait affecting yield components such as heads per plant and spikelets per plant in wheat.

In the second experimental year, however, pod weight per plant was associated to some pod characteristics such as average pod weight, pod width and flesh thickness. Pod number per plant, on the other hand, grouped with dry matter content only. Regardless, pod characteristics such as pod weight, pod width and flesh thickness were highly associated with each other, by being under factor 2 in and factor 3 in first and second experiments, respectively. The strong correlation between pod weight and pod width and their connection to plant yield in okra has earlier been reported by Ariyo et al. (1987). The same author also outlined pod weight to be the most reliable and effective trait to improve yield in okra plants. By applying factor analysis to a data set in potatoes, Yıldırım et al. (1989) similarly reported that average tuber weight, tuber index and yield were highly associated characteristics.

Ariyo et al. (1987) also reported that other useful characters for indirect selection for yield were number of lateral branches, weight of 100 seeds and edible pod length, which in our case had little or no effect on yield. Number of lateral branches was negatively affecting yield in the first experiment, and weight of 100 seeds was never related to yield. Edible and mature pod lengths were not related to yield by being highly correlated to each other under factor 4 in both experimental years. Ariyo (1990) reported that both mature and edible pod lengths are less reliable characters with less effectiveness of selection due to large genotypic coefficient of variation.

Regardless of dry matter content being correlated to protein and fat contents of the pods only in the first year, protein and fat contents were highly correlated to each other in both experiments.

Another closely related group of morphological plant characteristics with no connection to yield was formed under factor 3 and factor 1 in the first and second experiments, respectively. Final plant hight, length of lateral branches and internode length were highly associated to each other with communality raking as follows: final plant hight > length of lateral branches > internodes length. A similar result has been reported by Yıldırım et al. (1989) where most morphological characteristics like plant height, plant weight and lateral branching formed a single factor with no relation to yield. This latest finding also reveals that a selection against plant hight would result in an overall reduction in the whole vegetative structure of the plant without having a significant effect to yield.

CONCLUSIONS

The findings of this study are important by their relevance to both, consumer preferences and the needs of genetic improvement in okra. It should be pointed out that yield components show high association with pod characteristics such as pod weight and width, both of which are characteristics less determinative as consumer preferences in Turkey. This character group has also nothing to do with the actual pod sizes, namely pod length, which would make them unmarketable at domestic markets. A selection based on higher pod widths and / or pod weights would be an efficient process to increase pod yield per plant. At the same time it shows a potential as a good tool in market diversification.

Early flowering behaviour on the other hand, will certainly adversely affect pod yield when integrated to local lines. However, it should also be taken into account that high prices at the early season are important for the local farmers. Plant height and internode elongation is the most crucial factors to the local farmers who avoid irrigation and plant nutrition to avoid excessive plant heights. Since, according to our results, a disturbance in final yield is not expected when overall vegetative size is reduced, a selection based on semi – dwarf plant structure would be of interest. This should be considered as an important selection criterion for local lines, since at the long term this integration might enhance the improvement of cultural practices in local okra production areas.

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Literature Cited

Ariyo, O.J. 1990. Variation and heritability of fifteen characters on okra (*Abelmoschus esculentus* (L.) Moench). Trop. Agr. 67:213-216.

Ariyo, O.J., Aken'Ova, M.E. and Fatokun, C.A. 1987. Plant character correlations and path analysis of pod yield in okra (*Abelmoschus esculentus*). Euphytica 36:677-686.

Blennerhassett, R.M. and El-Zeftawi, B.M. 1986. Productivity and growth of six okra

cultivars. Australian J. Expt. Agr. 26:625-629.
Candlish, J.K., Gourley, L. and Lee, H.P. 1987. Dietary fiber and starch contents of some Southeast Asian vegetables. J. Agr. Food Chem. 35:319-321.
Düzyaman, E. 1997. Okra: Botany and Horticulture. Horticultural Reviews, vol. 21, 41-72. Jules Janick (edt.), John Wiley and Sons, Inc., New York.
Inan, Y. 1992. Balıkesir Bamyası Islahı Sonuç Raporu [Final Report of Breeding Balıkesir Type of Okra]. 14 pp. Atatürk Horticultural Reaserch Institute – Yalova, Turkey.
Martin, F.W., Rhodes, A.M., Ortiz, M. and Diaz, F. 1981. Variation in Okra. Euphytica 30:697-705.
Maynard, D.N. 1987. Performance of okra cultivars in a high management cultural system. Proc. Florida State Hort. Soc. 100:246-249.
Naumann, C. and Bassler, R. 1993. Methodenbuch Band III. Die chemische Untersuchung von Futtermitteln, VDLUFA - Verlag Darmstadt, Deutschland.
Siemonsma, J.S. 1982. La Culture du Gombo (*Abelmoschus* spp.) legume pod tropical avec reference speciale a la Cote d'Ivoire. These Univ. Wageningen, Pays Bas
Şafak, A., Ergun, M.E. and Şimşek, G. 1993. Türkiye'de açıkta yetiştirilen bamyanın üretimi ve pazarlamasının ekonomik yönden değerlendirilmesi üzerine araştırma [Economical evaluation of production and marketing of open field grown okra in Turkey]. Atatürk Horticultural Reaserch Institute – Yalova, Turkey.
Walton, P.D. 1971. The use of factor analysis in determining characters for yield selection in wheat, Euphytica 20, 416-421.
Yıldırım, M.B., Çalışkan, C.F. and Çağırgan, M.İ. 1989. Patateste çeşitli özelliklerin faktör analizi [Factor analysis in several traits in potato], Cumhuriyet University Journal of the Agricultural Faculty 5:1, 93 - 106.

Tables

Table 1. Origin and sources of the okra genotypes used in the experiments.

Genotype	Origin	Source
Annie Oakley II	USA	Petoseed, USA
Emerald	"	San Martin Seed Company, USA
Lee	"	Di.Va.P.R.A. / Italy; Prof. Dr. L. Quagliotti
Red Wonder	"	Di.Va.P.R.A. / Italy; Prof. Dr. L. Quagliotti
UGA Red Okra	"	Univ. of Georgia / USA; Prof. Dr. W. L. Corley
803 Burkina Faso	West-Africa	ORSTOM / France; Dr. S. Hamon
1051 Togo	"	ORSTOM / France; Dr. S. Hamon
Parabhani Kranti	India	ICRISAT / India; Dr. S. Galombek
Pusa Makhamali	"	Di.Va.P.R.A. / Italya; Prof. Dr. L. Quagliotti
Pusa Sawani	"	A.B.K.A.E. / Yalova / Turkey; Y. İnan
Selection 2	"	NBPGR, Yeni Delhi, India
Vaishali Badhu	"	Di.Va.P.R.A. / Italya; Prof. Dr. L. Quagliotti
Japanese	Japan	Hyogo Perfecture / Japan
Ağlasun Burdur	Turkey	Burdur / Turkey / A. Gönenç
Akköy 41	"	A.B.K.A.E. / Yalova / Turkey; Y. İnan
Balıkesir T-1	"	A.B.K.A.E. / Yalova / Turkey; Y. İnan
Batı Trakya	"	A.B.K.A.E. / Yalova / Turkey; Y. İnan
Sultani	"	May Seed Company / Turkey

Table 2. Eigenvalues, percentage of variation for each factor group in the first and second experimental year.

First Experiment				Second Experiment			
Factor	Eigenvalue (%)	Variation Variation (%)	Cumulative (%) Variation (%)	Factor	Eigenvalue	Variation	Cumulative
1	7,72	32,2	32,2	**1**	5,50	22,9	22,9
2	4,78	19,9	52,1	**2**	4,86	20,2	43,2
3	3,51	14,6	66,7	**3**	4,38	18,3	61,4
4	2,10	8,8	75,5	**4**	2,75	11,4	72,9
5	1,12	4,6	80,1	**5**	1,72	7,1	80,0
				6	1,09	4,5	84,6

Table 3. Factor grouping results of the first experiment.

Variables	Communality	Factor1	Factor2	Factor3	Factor4	Factor5
Factor 1						
Yield components						
Pod number per plant	0,841	-0,880	-0,196	0,104	-0,135	-0,008
Pod weight per plant	0,796	-0,868	-0,018	0,179	-0,099	0,006
Flowering behaviour						
Hight at flowering	0,919	0,824	0,336	0,231	0,215	0,163
First flowering node	0,887	0,878	0,199	0,113	0,153	0,203
Days to flowering	0,873	0,816	0,300	0,060	0,219	0,258
Pod composition						
Dry matter (%)	0,732	0,692	-0,187	0,311	-0,114	-0,331
Fat (%)	0,750	0,824	-0,115	0,183	-0,130	-0,088
Protein (%)	0,786	0,784	-0,357	0,060	0,047	-0,195
Plant morphology						
No. of lateral branches	0,822	0,612	-0,162	-0,255	0,063	0,594
Factor 2						
Pod characteristics						
Pod weight	0,861	-0,290	0,862	0,078	0,152	0,068
Pod width	0,917	0,169	0,862	0,031	0,380	-0,029
Flesh thickness	0,929	-0,058	0,907	0,162	0,239	0,142
Plant morphology						
Leave area	0,850	0,312	0,864	0,047	-0,018	0,060
Petiol length	0,706	0,122	0,612	0,340	0,428	0,138
Factor 3						
Plant morphology						
Final plant hight	0,892	0,150	0,219	0,901	0,029	-0,089
Hight of lateral branches	0,862	-0,025	0,088	0,923	0,027	0,040
Internode length	0,673	-0,026	0,092	0,721	-0,253	-0,282
Factor 4						
Pod characteristics						
Edible pod length	0,873	-0,485	-0,292	0,307	-0,668	0,108
Mature pod length	0,814	-0,116	-0,221	0,269	-0,760	0,317
Seed characteristics						
100 seed weight	0,591	0,285	-0,065	0,437	-0,542	-0,143
Seed number per pod	0,692	0,092	0,215	0,095	0,792	-0,037
Plant morphology						
Final stem thickness	0,785	0,305	0,247	0,316	0,593	0,423
Factor 5						
Plant morphology						
Pedicel length	0,695	-0,238	-0,001	-0,343	-0,191	0,696
Pod composition						
Crude fibre (%)	0,677	-0,134	-0,389	-0,008	0,027	-0,712

Table 4. Factor grouping results of the second experiment.

Variables	Communality	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6
Factor 1							
Plant morphology							
Final plant height	0,947	0,955	0,025	0,095	0,096	0,128	0,009
Height of lateral branches	0,907	0,866	0,047	-0,036	0,273	0,184	0,213
Internode length	0,830	0,851	0,009	0,139	-0,085	-0,214	0,181
No. lateral branches	0,782	-0,649	0,377	0,298	0,096	-0,082	0,337
Pod characteristic							
Pedicel length	0,873	-0,720	-0,256	0,319	0,404	-0,036	-0,151
Pod composition							
Crude fibre (%)	0,706	-0,626	0,088	0,107	-0,002	0,543	-0,013
Seed characteristic							
100 seed weight	0,875	0,771	0,024	0,116	0,250	-0,309	-0,329
Factor 2							
Flowering behaviour							
Height at flowering	0,913	0,017	0,915	-0,212	0,078	-0,011	0,154
First flowering node	0,928	-0,084	0,915	-0,230	0,039	-0,019	0,173
Days to flowering	0,649	-0,125	0,772	-0,082	-0,174	-0,024	0,018
Plant morphology							
Final stem thickness	0,809	0,145	0,872	0,129	0,094	-0,026	-0,047
Leave area	0,889	0,176	0,760	0,432	-0,026	-0,233	-0,198
Factor 3							
Yield components							
Pod weight per plant	0,946	-0,186	-0,251	0,765	0,307	0,405	-0,071
Pod characteristics							
Pod weight	0,945	0,143	-0,088	0,929	-0,186	-0,135	-0,018
Pod width	0,931	0,175	-0,150	0,736	-0,553	-0,161	-0,061
Flesh thickness	0,888	-0,034	-0,019	0,905	-0,249	-0,065	-0,023
Plant morphology							
Petiol length	0,811	-0,254	0,358	0,692	0,150	-0,167	-0,298
Factor 4							
Pod characteristics							
Edible pod length	0,776	0,145	-0,120	-0,294	0,752	0,260	0,146
Mature pod length	0,863	0,159	0,173	-0,143	0,851	-0,046	0,248
Factor 5							
Yield components							
Pod number per plant	0,867	-0,272	-0,267	0,168	0,512	0,652	0,074
Seed characteristic							
Seed number per pod	0,730	-0,063	0,184	0,260	-0,058	-0,774	-0,149
Pod composition							
Dry matter (%)	0,780	0,086	0,240	-0,162	0,061	0,602	0,569
Factor 6							
Pod composition							
Fat (%)	0,806	0,073	-0,086	0,022	0,254	0,092	0,848
Protein (%)	0,849	0,006	0,309	-0,476	0,125	0,156	0,698