Evaluation of Pod Characteristics and Nutritive Value of Okra Genetic Resources

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Abstract

Numerous okra genotypes of American, African, Indian, European and Turkish origin were examined for their pod properties and nutritive contents. Pod thickness was considerably high in the genetic material from Africa with up to 2.84 cm in diameter in the case of line 1051 from Togo. However, pods of the improved cultivars from the USA and India had a more attractive appearance with diameters varying between 1.15 - 1.50 cm. The improved cultivars from the USA could also be judged as to have slow fibre development. Dry matter accumulation was higher in the Turkish and African material, varying between 18.15 - 17.2 % in the better one's, while this remained between 15.6 - 13.6 % in the Indian material, and 14.4 - 11.7 % in the USA material. Three lines from Turkey had top protein levels up to 4.55, 4.43 and 4.41 % in the case of Batı Trakya, Akköy and Denizli, respectively. Since okra is an important protein source in most developing countries, the material form Turkey might be extensively explored for its nutritive contents.

INTRODUCTION

Okra (*Abelmoschus esculenntus* (L.) Moench) is an important vegetable crop commercially grown in most of the tropics and subtropics with an extension to the Mediterranean climate (Düzyaman, 1997). It is an important crop in most developing countries, covering approximately 4 % of the total vegetable consumption (Simonsma, 1982). Fresh tender pods have been reported to be rich of dietary fibre, protein and vitamin C (Grubben, 1977; Candlish et al., 1987). In recent years okra became more and more popular as a new alternative in market diversification in Europe. It is now available as a boiled and fried vegetable in salad bars and restaurants (Qualiotti and Lotito, 1989; Possingham, 1990).

Pod composition has been pointed out to be an important quality criterion for the consumer. Ames and Mac Leod, (1990) reported some 148 volatile components of okra. It has mainly been investigated in relation with the age of harvested pods. Pods older than 7 days are considered to be low in quality mainly due to excessive increase in crude fibre and gradual reduction of moisture, both important components of the table quality (Sistrumk et al., 1960). Crude protein and starch contents are also reduced by late harvest, while crude oil content increased (Iremiren et al., 1991). Besides the detailed studies on how composition changes in growing pods, no author has so far turned attention to the genetic background of okra. This study was conducted to investigate the pod characteristics and nutritive value of okra genetic material from diverse eco-geographic regions. The aim was to obtain a comparative view of these characteristics of okra genetic material under study.

MATERIAL AND METHOD

Forty-eight okra genotypes from different sources (table 1) were included in a field experiment conducted at the University of Ege, Faculty of Agriculture, Department of Horticulture in Bornova, Izmir in sandy – loam soil. Sixteen improved cultivars form the USA, 7 pure lines and 3 commercial cultivars from the African continent, 9 commercial cultivars form India, and 9 recently released cultivars form Turkey, 2 cultivars from Japan and 2 from Italy were evaluated in this experiment.

The soil was plugged and harrowed in the spring, and seeding was done directly to the field as soon as the soil temperature seemed suitable (Siemonsma, 1982). Three seeds per hill were sown at 45 cm x 90 cm intervals and thinned to one plant per hill when plantlets reached 3-4 leave stage. Each plot consisted of 7 plants while pod samples were only taken from 5 competitive plants. A total of 12 kg of pure nitrogen, 4 kg pure phosphorous and 6 kg calcium were applied to 1000 m^2 soil (Majanbu, et al., 1985). Cypermetrin 200 EC (5 ml / 10 l) and diazinon (15 ml / 10 l) was applied to control insect pests.

Flowers were labelled directly after opening and their age was noticed on this label for each passed day. This process made to pick those pods which are 4 or 5 days in age (Sistrunk et al., 1960; Iremiren et al., 1991). Some 40 – 50 pod samples were taken from each plot at the same week, bulked together and evaluated for their morphological characteristics on a metrical basis. After the initial evaluation one third of each pod was cut and dried in the oven at 105°C for further analysis.

Basic pod quality analyses such as dry matter, crude fibre, crude protein and crude fat contents (Candlish et al., 1987) were performed on the dried samples and each variable was expressed as a proportion per fresh weight. Crude fibre analysis was performed according to the Lepper method (Naumann ve Bassler, 1993). A Newport Analyser type Nuclear Magnetic Resonance meter (NMR) was used for crude fat analysis (Official Analitical Instrumets, 1982). Prior to this analysis the Newport analyser was calibrated with pure okra oil obtained by extraction of okra seeds in hexane. The Kjeldal method was applied to the dried pod samples for crude protein analysis (Naumann and Bassler, 1993).

The resulting data was subjected to the (ANOVA) analysis of variance at the SPSS classificatory program (version 5.0). The subroutine general factorial was run for the randomised block design with 3 replications. Significant differences between groups were determined by applying Duncan's multiple range test.

RESULTS AND DISCUSSION

Sultani, Batı Trakya, Akköy-41 and Kabaklı genotypes from Turkey are in the "Sultani" okra group, which are characterised by their thin and small pod types. These genotypes had less then 5.15 g average pod size going down to 3.79 g in the case of Kabaklı, the genotype with the smallest pods in this experiment (mean 7.04 g) (table 2). The same group had also the thinnest pods as shown in the column for pod diameter, which was between 1.22 - 1.37 cm. Balıkesir T-1, Ağlasun / Burdur and Denizli local types are characterised as short and thick pear – shaped pods. They had pod diameters close to the grand mean, which was 1.54 cm, and mature pod lengths of 8.8 to 10.8 cm, which is again far below the grand mean of 13.5 cm.

African genotypes could be characterised to have short and thick pods, reaching up to 13 g of average pod weight in the case of 1051 Togo and 1159 Togo, the heaviest genotypes in this experiment. Except Congolese (1.44 cm) and 2163 Sudan (1.53 cm), which are close to the grand mean of 1.54 cm, all African genotypes had the thickest pods in the experiment with diameters values above 1.73 cm, reaching 2.84 cm pod diameter in the case of 1051 Togo. They had also the shortest pods, which were all below the grand mean of 5.84 cm and 13.50 cm in the case of edible pod and mature pod sizes respectively. It was earlier reported by Hamon and Charrier (1983) and by Hamon et al. (1986) that genetic material originated from West Africa showed great variability regarding fruit shape.

In contrast to the genetic resources from Turkey and Africa, America and India originated genotypes had the longest pods, which made them look more attractive to the consumers. Except of a few genotypes, which remained below the grand average in the edible and mature pod lengths, all genotypes had pod lengths above the grand mean. In the case of edible pod length, Okra Brazil (5.36 cm), Clemson Spineless 80 (5.32 cm) were the commercial cultivars from USA which remained below the grand mean of 5.84 cm. In the case of mature pod length, PSR 1285 (13.40 cm), Annie Oakley II (13.27 cm) were those cultivars from the USA which remained below the grand mean of 13.50 cm..

PSM from India and Sun Perkins Dwarf from the USA were the only cultivars remaining below the grand average for both pod length criteria.

Dry matter contents of the genotypes ranged from 18.15 % to 11.53 % with a grand mean of 15.04 %. The highest dry matter accumulation was observed in the Turkish and African genetic material, varying between 18.15 % - 17.2 % in higher-ranking genotypes. The material from Turkey showed broad variability by ranging from very high (18.15 %) in the case of Batı Trakya to low (12.19 %) in the case of Ağlasun / Burdur. Indian material was intermediate in dry matter accumulation by varying between 15.6 - 13.6 %, and USA material usually low (14.4 - 11.7 %).

Okra has earlier been ranked as having higher crude fibre content among many other vegetables (Candlish et al., 1987). It has often been pointed out that an increase in crude fibre is the most distinguishing factor in okra pod quality by destroying their edibility completely (Sistrunk et al., 1960; Iremiren et al., 1991). There was no eco-geographic specific grouping in crude fibre contents of the genotypes. The genotypes Amasya, and Pakistana turned out to have the most crude fibre content (% 0.89) while this was 0.42 % in the case of Perkins Spineless, the genotype with the leased fibre.

Okra is considered as a significant protein source (Grubben, 1977; Candlish et al., 1987). Crude protein contents of the genotypes varied between 4.55 % and 2.51 % with a grand mean of 3.42 %. The improved material from India had crude protein content mostly between 3.3 – 2.9 %, which was always below the grand mean except cv. T-13. The material from USA distributed throughout the table from high crude protein content (4.13 %) to low (2.5 %), and mostly between 3.2 - 2.5 %. Three lines from Turkey had unusually high protein levels with 4.55 %, 4.43 % and 4.41 % in the genotypes Batı Trakya, Akköy–41 and Denizli, respectively.

Crude fat content of the genotypes varied between 0.65 % to 0.26 % with a grand mean of 0.39 %. Two major groups, with only a limited overlap of one group to the other, could be distinguished: The material from Africa and Turkey could be classified as having high crude fat contents, while the fat content of American and Indian material was usually below the grand mean.

CONCLUSIONS

Selection programs for pod length and probably also slow fibre development have apparently been the scope of most okra breeding programs in the past in the USA and India. Those cultivars may also be judged as to have slow fibre development, which is an important consumer criterion for pod quality. However, no attention has been drawn to the multitude pod types in the genetic background of okra so far. It also turned out that scant attention was given to improve the nutritive value, especially to the protein content, in current cultivars. The exploited material in this study has shown the potential to improve both, nutritive value and diversification in pod types in modern cultivars. The genetic material from West – Africa might be considered as a new source of pod diversity in current okra cultivars. The thick and heavy pods of both genotypes, 1159 Togo and especially 1051 Togo might be considered as having the potential for market diversification. The material originated from Turkey was interesting for it’s high nutritive content. The genotypes Batı Tarkya, Akköy–41 and Denizli were classified as having comparatively higher protein contents. This material might be deeply exploited in further studies.

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Tables

Table 1. Origins and sources of the okra genotypes under study

Genotype	Source
*American Continent**	
Cajun Queen	Di.Va.P.R.A., Italy; Prof. Dr. L. Quagliotti
Dixie Spineless	Di.Va.P.R.A., Italy; Prof. Dr. L. Quagliotti
Dwarf Long Good Green	Di.Va.P.R.A., Italy; Prof. Dr. L. Quagliotti
Lee	Di.Va.P.R.A., Italy; Prof. Dr. L. Quagliotti
Red Wonder	Di.Va.P.R.A., Italy; Prof. Dr. L. Quagliotti
Okra Brazil	Di.Va.P.R.A., Italy; Prof. Dr. L. Quagliotti
Velvet Round	Di.Va.P.R.A., Italy; Prof. Dr. L. Quagliotti
UGA Red Okra	University of Georgia, USA; Prof. Dr. W. L. Corley
Perkins Spineless	Asgrow, USA
Annie Oakley	Petoseed, USA
Annie Oakley ll	Petoseed, USA
PSR 1285	Petoseed, USA
PSR 2186	Petoseed, USA
Clemson Spineless 80	Sun Seed Company, USA
Sun Perkins Dwarf	Sun Seed Company, USA
Emerald	San Martin Seed Company, USA
African Continent	
Green Balady	Ain Shams University, Egypt
Red Balady	Ain Shams University, Egypt
Congolese	Di.Va.P.R.A., Italy; Prof. Dr. L. Quagliotti
NH94, 29	NIHORT, Ibadan, Nigeria; Dr. N. Q. Ng
NH94, 250	NIHORT, Ibadan, Nigeria; Dr. N. Q. Ng
NH94, 285	NIHORT, Ibadan, Nigeria; Dr. N. Q. Ng
803 Burkina Faso	ORSTOM, France; Dr. S. Hamon
1051 Togo	ORSTOM, France; Dr. S. Hamon
1159 Togo	ORSTOM, France; Dr. S. Hamon
2163 Sudan	ORSTOM, France; Dr. S. Hamon
India	
Pusa Sawani	A.B.K.A.E., Yalova, Turkey; Y. İnan
Pusa Makhamali	Di.Va.P.R.A., Italy; Prof. Dr. L. Quagliotti
Vaishali Badhu	Di.Va.P.R.A., Italy; Prof. Dr. L. Quagliotti
PSM	Di.Va.P.R.A., Italy; Prof. Dr. L. Quagliotti
T-13	Di.Va.P.R.A., Italy; Prof. Dr. L. Quagliotti
Pakistana	Di.Va.P.R.A., Italy; Prof. Dr. L. Quagliotti
Parbhani Kranti	ICRISAT, India; Dr. S. Galombek
Selection-2	NBPGR, New Delhi, India
Arka Anamika	Maharashtra Seed Company, India; Dr. R. S. Raut
Italy	
Okra Corto	Di.Va.P.R.A., Italy; Prof. Dr. L. Quagliotti
Okra Lungo 2	Di.Va.P.R.A., Italy; Prof. Dr. L. Quagliotti
Japan	
Holiday	Gunma Perfecture, Japan; Dr. M. Horigome
Japanese	Hyogo Perfecture, Japan
Turkey	
Akköy-41	A.B.K.A.E., Yalova, Turkey; Y. İnan
Amasya	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

Kabaklı-ll	A.B.K.A.E., Yalova, Turkey; Y. İnan
Denizli	A.B.K.A.E., Yalova, Turkey; Y. İnan
Denizli (uzun boylu)	A.B.K.A.E., Yalova, Turkey; Y. İnan
Ağlasun, Burdur	Burdur, Turkey; Ahmet Gönenç
Sultani	May Seed Company, Turkey

* Origins of genotypes

Table 2**.** Pod characteristics and nutritive value of genotypes from American continent, African continent, India, Italy, Japan and Turkey

Genotype	Pod Weight (g)		Pod Diameter (cm)		Pod Length (cm)		Mature Pod length (cm)		Dry Matter (%)		Crude Fibre (%)		Crude Protein (%)		Crude Fat (%)	
American Continent																
Annie Oakley	7,39	f-I*	1,32	m-s	6,71	b-f	14,93	h-l	12,98	m-r	0,71	c-h	2,90	p-t	0,29	p-u
Annie Oakley II	6,53	jkl	1,41	i-r	6,25	fgh	13,27	n-r	13,43	l-p	0,67	d-j	3,07	m-r	0,36	h-p
Cajun Queen	8,38	de	1,38	k-r	7,19	ab	17,73	cd	16,02	b-h	0,67	d-k	3,37	i-p	0,35	i-r
Clemson Spineless 80	6,54	jkl	1,53	f-l	5,32	jk	14,20	j-o	13,75	j-o	0,70	c-j	3,40	i-p	0,28	stu
Dixie Spineless	6,71	i-l	1,30	n-s	6,69	b-f	13,97	k-p	14,41	h-n	0,61	f-m	3,19	k-p	0,28	r-u
Dwarf Long G. Green	6,36	klm	1,40	i-r	6,75	b-f	17,33	cde	15,77	c-i	0,61	f-m	3,92	c-h	0,40	g-l
Emerald	6,89	h-k	1,30	n-s	7,12	abc	21,73	a	13,37	l-r	0,46	nop	3,03	n-s	0,34	k-t
Lee	9,79	b	1,53	e-l	6,99	a-d	13,73	l-p	12,95	n-r	0,62	e-m	2,60	rst	0,27	tu
Okra Brazil	5,30	n-r	1,39	j-r	5,36	jk	14,87	h-m	17,77	ab	0,61	f-m	4,13	abc	0,51	cde
Perkins Spineless	8,53	cde	1,50	g-m	6,99	a-d	16,70	c-f	11,72	pr	0,42	p	2,51	t	0,26	u
PSR 1285	7,81	efg	1,39	j-r	6,44	d-g	13,40	m-r	12,95	n-r	0,59	g-o	2,98	o-t	0,28	r-u
PSR 2186	6,35	klm	1,15	s	6,82	a-e	17,80	c	18,15	a	0,57	j-o	4,09	bcd	0,33	l-u
Red Wonder	6,83	i-l	1,32	m-s	6,55	c-f	15,33	f-k	14,00	i-o	0,70	c-j	3,18	k-p	0,34	k-t
Sun Perkins Dwarf	5,11	opr	1,61	d-h	4,57	mn	9,77	v-y	15,77	c-i	0,57	j-o	3,55	f-m	0,47	def
UGA Red Okra	8,79	cd	1,45	h-p	7,10	abc	21,10	a	13,46	l-p	0,59	g-n	3,22	j-p	0,33	l-u
Velvet Round	6,67	i-l	1,22	rs	6,76	b-f	14,73	i-n	12,32	opr	0,57	j-o	2,97	o-t	0,29	o-u
African Continent																
Congolese	5,72	mno	1,44	h-p	5,21	kl	11,67	stu	15,07	g-l	0,72	c-g	3,58	f-l	0,39	g-n
Green Balady	6,36	klm	2,33	b	3,62	op	9,70	v-y	17,51	a-d	0,80	abc	4,08	b-e	0,54	cd
NH94/29	7,18	g-j	1,72	de	4,26	mn	9,33	wxy	14,09	h-o	0,46	op	3,32	j-p	0,52	cd
NH94/250	7,76	efg	2,00	c	3,39	pr	6,90	z	17,61	abc	0,57	j-o	3,55	f-m	0,62	ab
NH94/285	5,56	nop	2,30	b	3,03	r	7,23	z	17,96	a	0,58	i-o	3,44	h-o	0,53	cd
Red Balady	7,96	ef	2,03	c	4,79	lm	9,57	v-y	15,46	f-k	0,52	l-p	3,70	c-j	0,45	efg
803 (Burkina Faso)	9,14	bc	1,71	def	5,61	ijk	13,73	l-p	15,71	d-i	0,66	d-k	3,60	e-k	0,34	k-t
1051 (Togo)	12,98	a	2,84	a	4,08	No	9,63	v-y	14,57	h-n	0,52	m-p	3,08	l-r	0,39	g-m
1159 (Togo)	13,32	a	2,19	b	5,34	jk	10,27	u-y	18,08	a	0,71	c-i	3,82	c-i	0,61	ab
2163 (Sudan)	6,48	j-m	1,53	f-l	5,15	kl	10,87	tuv	14,73	h-n	0,74	b-f	3,62	d-k	0,43	fgh

* Column next to the variable shows Duncan's multiple range test *To be continued on the next page*

Table 2 continued

Genotype	Pod Weight (g)		Pod Diameter(cm)		Pod Length (cm)		Mature Pod length (cm)		Dry Matter (%)		Crude Fiber (%)		Crude Protein (%)		Crude Fat (%)	
India																
Arka Anamika	6,43	j-m*	1,27	o-s	7,11	abc	17,27	cde	15,04	g-l	0,76	bcd	3,29	j-p	0,39	g-m
Pakistana	6,03	lmn	1,37	k-r	7,05	abc	16,27	d-h	14,66	h-n	0,89	a	3,25	j-p	0,32	m-u
Parbhani Kranti	7,39	f-i	1,26	prs	7,05	abc	16,00	e-i	14,92	g-m	0,75	b-e	3,25	j-p	0,32	m-u
PSM	6,80	i-l	1,49	g-m	5,80	hij	12,07	rst	13,59	k-p	0,53	k-p	2,94	o-t	0,32	n-u
Pusa Makhamali	8,37	de	1,46	g-o	7,34	a	15,07	g-l	14,28	h-n	0,66	d-k	3,23	j-p	0,30	o-u
Pusa Sawani	8,39	de	1,47	g-n	7,33	a	16,67	c-f	14,73	h-n	0,68	c-j	3,09	l-p	0,35	j-s
Selection-2	6,77	i-l	1,32	m-s	7,20	ab	19,60	b	15,62	e-j	0,69	c-j	3,24	j-p	0,33	l-u
T-13	5,52	nop	1,43	h-p	6,57	c-f	15,17	g-l	15,01	g-l	0,75	b-e	3,48	g-n	0,35	j-r
Vaishali Badhu	7,84	efg	1,34	l-r	7,03	abc	14,83	h-m	13,71	j-o	0,62	e-m	3,03	n-s	0,32	n-u
Italy																
Okra Corto	6,34	klm	1,58	d-j	5,19	kl	11,50	stu	13,91	i-o	0,72	c-h	3,45	h-o	0,32	m-u
Okra Lungo 2	4,73	r	1,55	d-k	3,58	p	6,60	z	15,23	g-l	0,85	ab	3,25	j-p	0,43	fgh
Japan																
Holiday	8,15	def	1,58	d-j	6,33	efg	14,37	j-o	16,79	a-g	0,51	m-p	3,71	c-j	0,41	f-k
Japonya	6,46	j-m	1,41	i-r	6,29	e-h	13,37	m-r	11,53	r	0,67	d-k	2,58	st	0,33	l-u
Turkey																
Ağlasun/Burdur	8,83	cd	1,53	e-l	5,91	ghi	10,80	t-w	12,19	opr	0,66	d-l	3,08	l-r	0,36	h-o
Akköy-41	4,83	pr	1,37	k-r	5,18	kl	12,67	prs	17,20	a-f	0,59	g-n	4,43	ab	0,38	g-n
Amasya	7,59	fgh	1,64	d-g	6,55	c-f	13,10	pr	13,68	j-o	0,89	a	3,40	i-p	0,52	cd
Balıkesir T-1	5,60	no	1,46	g-o	4,30	mn	10,60	u-x	13,33	l-r	0,70	c-j	3,36	i-p	0,31	n-u
Batı Trakya	4,57	r	1,28	o-s	6,32	e-h	15,63	f-j	18,15	a	0,66	d-l	4,55	a	0,65	a
Denizli	6,53	jkl	1,73	d	4,42	mn	8,83	y	17,61	abc	0,51	m-p	4,41	ab	0,56	bc
Denizli (uzun boylu)	5,58	nop	1,58	d-i	4,58	mn	9,17	xy	17,42	a-e	0,58	h-o	3,98	b-f	0,58	bc
Kabaklı	3,76	s	1,27	o-s	4,66	m	12,57	prs	18,02	a	0,66	d-l	3,94	c-g	0,42	f-j
Sultani	5,15	opr	1,22	Rs	6,46	def	16,43	c-g	15,61	e-j	0,68	c-j	3,36	i-p	0,43	f-i
Grand mean:	**7,04**		**1,54**		**5,84**		**13,50**		**15,04**		**0,64**		**3,42**		**0,39**	

* Column next to the variable shows Duncan's multiple range test