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Variations of Fruit Quality Characteristics and Yield in Okra (Abelmoschus esculentus) Cultivars

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ABSTRACT

Fruit color, length, weight, diameter and marketable yield of four okra hybrids (*Abelmoschus esculentus*) were compared with the same characteristics of 'Clemson Spineless 80' variety under early and late seasons. Cultivars 'Green Best', 'Cajun Delight', and 'North & South' produced most very dark-green, and dark-green fruits; whereas, 'Clemson Spineless 80' and 'Annie Oakley II' produced mostly light-green fruits. It was noticed an increase on weight and number of very small fruits (<4.4 cm) during the late season, and 'Clemson Spineless 80' registered the highest very small fruit yield. The highest production of medium size fruits (>8.9 - <12.7 cm) was recorded during the early season, and 'Annie Oakley II' had better fruit yields. The smallest fruit diameter was observed in 'North & South'. The best fruit length and weight was produced in the early season. Similar marketable fruit yield was found in both season, however, a total of 27 harvests were needed in the early season, and 42 harvests in the late season.

RESUMEN

El verdor, la longitud, el peso y el diámetro del fruto, así como el rendimiento comercial de cuatro híbridos de okra (*Abelmoschus esculentus*) y la variedad 'Clemson Spineless 80', se determinaron en siembra (temporada) temprana y tardía. Los cultivares 'Green Best', 'Cajun Delight' y 'North & South' produjeron mayor fruto verde muy obscuro y obscuro, mientras que 'Clemson Spineless 80' y 'Annie Oakley II' produjeron más frutos verde claro. El mayor peso y el número de frutos de tamaño muy pequeño (<4.4 cm) se registraron en la siembra tardía, donde 'Clemson Spineless 80' mostró el mayor rendimiento. En la siembra temprana se observó mayor producción de fruto mediano (>8.9 - <12.7 cm) y 'Annie Oakley II' tuvo el mayor rendimiento. El fruto de menor diámetro se registró en 'North & South'. La siembra temprana mostró mejor longitud y peso de fruto. El rendimiento de fruto comercial fue similar en ambas temporadas de siembra, aunque en la siembra temprana se realizaron 27 cortes, mientras que en la tardía 42.

Additional index words: Fruit quality parameters, marketable yield, growing seasons.

The okra [*Abelmoschus esculentus* (L.) Moench], also known as "bombo", "bumbo" or "quimbombo" is a Malvaceae cultivated in tropical and subtropical regions. Okra production is exported out of México for fresh, processing, or frozen market (Díaz-Franco and Ortegón-Morales, 1997). Most cultivars grown in northern Tamaulipas are open-pollinated. However, some okra hybrids have been released. Studies (Díaz-Franco and Ortegón-Morales, 1997; Díaz-Franco et al., 1997) have demonstrated that the hybrids have shorter life cycles and higher yield than 'Clemson Spineless 80'. To date, there is limited information about fruit quality characteristics of okra cultivars.

According to Wayne et al. (1984), fruit length, diameter, chlorophyll content (greenness), mucilage, and fiber content determine okra quality. However, excepting fruit length, which is regulated by USDA (Marsh et al., 1990), the rest of those characteristics are not widely used and the norms for measuring them are not clearly established. The okra processing companies in south Texas require dark-green color, small diameter and fruit length between 8.9 to 12.7 cm; smaller fruits are often accepted but bigger fruits are rejected. The norms for determining fruit color and diameter are not well defined, causing them to be arbitrarily measured by the company's standards. For those reasons very often okra fruits are rejected.

It has been stated that fruit color (green to red), length and weight are genetically determinated (Martin et al., 1981). However, studies indicated that fruit length can be modified by planting date (Ortegón-Morales and Díaz-Franco, 1998), and the color can be influenced by the soil nitrogen content (Wayne et al., 1984).

In northern Tamaulipas the planting date for okra is from 15 February to 31 May. Plantings in February and March are known as early season and those from April to May, as late season (Díaz-Franco and Ortegón-Morales, 1997). The objective of the present study was to determine the fruit color, length, weight, diameter, and marketable yield of five okra cultivars under early and late seasons conditions.

MATERIALS AND METHODS

The study was established in a sandy clay soil of "Tenacitas", Río Bravo, Tamaulipas, México. Planting in the early season was on 13 March and in the late season on 15 May 1995. Weeds were controlled with an application of trifluralin (1 kg a. i./ha) at preplant-incorporated. The fertilization was supplemented with N (60 kg/ha) and P (60 kg/ha) incorporated before planting in both sites. Additional N (60 kg/ha) was applied through the irrigation during the first week of harvest. Pest control and other cultural practices were maintained according to standard recommendations (Díaz-Franco, 1992).

The cultivars evaluated were: 'Clemson Spineless 80', open-pollinated (Baxter Seed, Co., Weslaco, Tx.), and the hybrids 'Annie Oakley II' (Peto Seed, Saticoy, Ca.), 'Green Best' (Sakata Seed, Inc., Morgan Hill, Ca.), 'Cajun Delight' and 'North & South' (Seminis Vegetable Seed Co., Fleda, Fl.). The experimental plot were three rows of 6 m length in a randomized design with four replications. Plots were hand seeded ≈ 5 cm deep and then thinned to population of 50,000 plants/ha.

The early season harvest was from 10 May to 14 June, and the late season, were from 14 July to 18 October. Total marketable fruit (<12.7cm) yield was obtained from the center rows of each plot in three harvests per week. The relative days to first harvest from planting were registered when at least three replications were in production. The fruit size, weight, and diameter were measured on ten selected harvests in both, early (May 15, 25, 29, 31, June 7, 14, 21, 26, July 3, and 14) and late (July 28, August 11, 23, September 3, 13, 20, 27, October 4, 11, and 18) seasons.

The fruits were qualified for length according to the following scale used by Marsh et al. (1990): very small (<4.4 cm), small (4.4-8.9 cm), medium (>8.9 -<12.7 cm), and large (>12.7 cm). The average fruit diameter was estimated by using a vernier. Fruit color was only determinated during the early season. The fruits were visually classified by color as: very dark-green, dark-green, medium-green, light-green, and chlorotic (Díaz-Franco et al., 1997). Data were subjected to analysis of variance (SAS Institute, Cary, N. C.) and means differences were separated by Tukey's test, P ≤0.05.

RESULTS AND DISCUSSION

Fruit greenness between genotypes. A significant variation in fruit color was observed within genotypes. Most fruits were classified as very dark-green, dark-green, medium-green, and light-green; no chlorotic fruit was observed. The highest yield of very dark-green and dark-green fruits was produced by the hybrids 'North & South', 'Green Best' and 'Cajun Delight'. The largest number of medium-green was produced by 'Annie Oakley II', and the highest yield of light-green was by 'Clemson Spineless 80' and 'Annie Oakley II' (Table 1). Very dark-green and dark-green fruit color is more desirable than medium- and light-green. Although the highest yield was obtained by cultivars that showed medium and light-green fruit color, the processing companies more easily accept the very dark- or dark-green genotypes. The results indicated that an association existed between okra genotypes and fruit greenness. Martin et al. (1981) demonstrated genetic variation of okra fruit color in diverse genetic populations.

The fruit color in the cultivars also fluctuated within harvests and discoloration was particularly observed following the irrigations (data no shown). The intensity of greenness is determined by the chlorophyll content and is very important in marketing. It has been found that the chlorophyll content in spinach (*Spinaca oleracea* L.) leaves determines its quality and is indicative of nutrimental and health status (Santos, 1992).

Size and weight of fruit production. Variation in length, weight and fruit diameter was significant among genotypes and seasons. Interaction occurred only between genotypes and seasons for weight and total number of very small and medium-size fruits (Table 2).

Genotypes. The weight and number of small fruits were higher during the late season than in the early season. 'Clemson Spineless 80' showed the highest weight and number of small fruits in both seasons (Fig. 1). However, these are not desirable characteristics since the market requires medium size fruits (>8.9 - >12.7 cm). Better number of medium size fruits was registered by 'Annie Oakley II' during the early season (Fig. 2).

Significant differences between cultivars were detected in weight of small fruits, number of large fruits, fruits diameter and total number of fruits. The results indicated that 'Clemson Spineless 80' showed the highest yield of small fruits; the hybrids yielded mostly large fruits. The cultivar 'North & South' produced the smallest fruit diameter (Table 2). In general, it was observed that hybrids tend to produce longer fruits with small diameters, as well as better yield. The companies involved in marketing of okra in south Texas prefer

Table 1. Fruit greeness intensity of five okra cultivars.

Cultivar	Fruit greenness				
	Very dark	Dark	Medium	Light	Chlorotic
	----------(x 1000/ha)----------				
C. Spineless 80	0 b	861 b	4500 b	4666a	0
Annie Oakley II	27 b	1861 b	8861a	5027a	0
Green Best	197a	5111a	4888 b	250 b	0
North & South	108ab	5500a	5750 b	1138 b	0
Cajun Delight	197a	4862a	5303 b	1527 b	0
Significance	*	***	**	***	NS

[z]Means separation within columns by Tukey's test, P ≤0.05.

[NS,*,**,***] No significant or significant at P ≤0.05, 0.01 and 0.001, respectively.

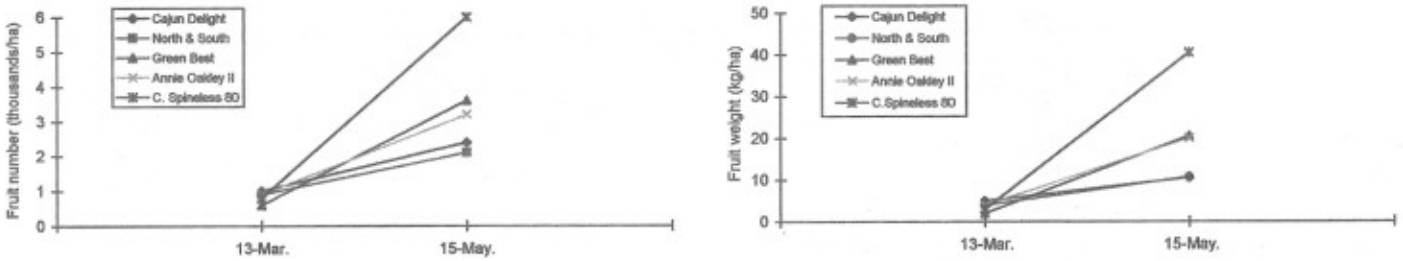

Fig. 1. Effect of early (13/Mar) and late (15/May) season on very small size fruit yield (<4.4 cm) of five okra cultivars.

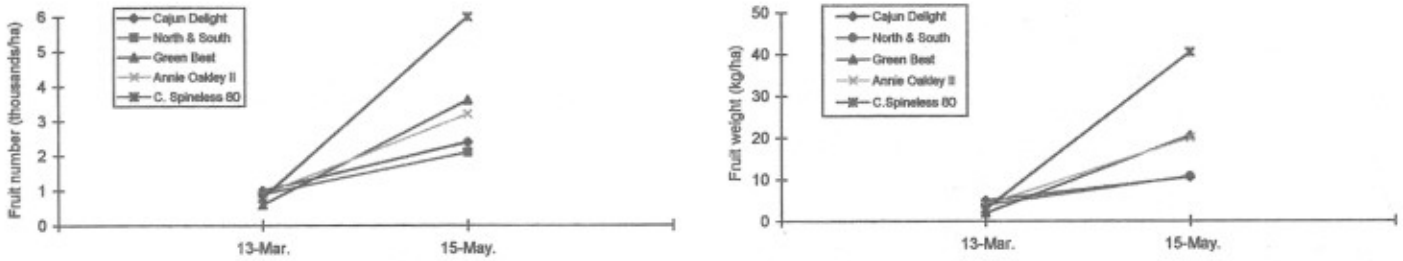

Fig. 2. Effect of early (13/Mar) and late (15/May) seasons on medium size fruit yield (>8.9 - <12.7 cm) of five okra cultivars.

thin fruits, but it is arbitrarily indicated. Recent studies (Díaz-Franco and Ortegón-Morales, 1997; Díaz-Franco et al., 1997) have stated that hybrids yield better than 'Clemson Spineless 80' in Tamaulipas, México. However, in Valle del Yaqui, Sonora, México, 'Clemson Spineless 80' yields were similar to hybrids (Guerrero et al., 1993). We believe that an economic study is needed in order to estimate the benefit of using hybrids as a component of the technology to produce okra in Tamaulipas.

Seasons. Table 2 shows the influence of growing season on fruit characteristics. Most traits were influenced by season, excepting weight of small and large fruits. The highest weight and number of very small fruit were registered on late season (Fig. 1). The best desirable quality for most the characteristics was produced in the early season. No previous studies about the influence of planting season on fruit quality were found in the literature. However, the present study confirm that season has an important effect on fruit length variations, which have been observed by okra growers in Tamaulipas. Regarding fruit weight, Ortegón-Morales and Díaz-Franco (1998) have detected interaction between planting date and cultivars, due to environmental factors (climate and agronomy) and crop physiology. In Sonora, however, Guerrero et al. (1993) reported no significance's in yield between planting date, okra cultivars and their interaction.

It is speculated that the differences in temperature between seasons might be a determining factor on fruit quality. The average temperature for the two months following planting was 24.3 °C during the early season, and 28 °C during the late season; however, temperatures clearly decreased during the

Table 2. Length, weight and diameter of fruits of five okra cultivars planted in early and late seasons.

	Very small (<4.4 cm)		Small (4.4 – 8.9 cm)		Medium (>8.9 – <12.7 cm)		Large (>12.7 cm)		
Treatment	No. (x 1000/ha)	Weight (kg/ha)	No. (x 1000/ha)	Weight (kg/ha)	No. (x 1000/ha)	Weight (kg/ha)	No. (x 1000/ha)	Weight (kg/ha)	Diameter (cm)
Cultivar									
C. Spineless 80	3.3 a[z]	23.3 a	17.5	168.6a	10.0b	149.6b	2.8 b	55.8	1.70 a
A. Oakley II	2.0 b	11.1 b	20.1	165.5ab	17.1a	203.6a	4.5 ab	70.1	1.66 ab
Green Best	2.3 ab	14.1 b	18.1	141.3ab	12.6b	148.5b	4.3 ab	78.5	1.54 bc
North & South	1.3 b	9.0 b	16.8	135.8ab	12.0b	139.1b	5.8 a	84.5	1.47c
Cajun Delight	1.6 b	9.0 b	17.8	128.1b	13.0b	154.0b	5.5 a	86.5	1.55bc
Season									
Early (13/Mar)	0.7	22.3	20.3	142.8	20.1	235.3	6.3	95.8	1.66
Late (15/May)	3.5	24.3	16.0	153.0	5.6	82.6	2.8	57.0	1.51
Significance									
Cultivars (C)	**	***	NS	*	***	**	***	NS	***
Season (S)	***	**	***	NS	***	***	***	***	***
C x S	**	***	NS	NS	**	*	NS	NS	NS

[z]Means separation within columns by Tukey's test, P ≤0.05.

NS,*,**,*** No significant or significant at P ≤0.05, 0.01 and 0.001, respectively.

Table 3. Harvest and marketable fruit yield of okra cultivars in two seasons.

	Season				
	Early (13/Mar)		Late (15/May)		Average yield
Cultivar	DFH[z]	Kg/ha	DFH	Kg/ha	(kg/ha)
Annie Oakley II	58	18256 a[y]	67	16736	17496
Cajun Delight	58	17563 ab	65	16633	17098
North & South	58	16735 ab	60	16543	16639
Green Best	58	16421 ab	60	15803	16112
C. Spineless 80	61	16273 b	67	14995	15634
Significance					
Cultivar (C)		*		NS	NS
Season (S)					NS
C x S					NS
Total number of harvests		27		42	

[z]Relative days to first harvest from planting.

[y]Means separation within columns by Tuley's test (P ≤0.05).

[NS,*] No significant or significant at P ≤0.05.

final developmental stages of 15 May planting. Díaz-Franco and Ortegón-Morales (1997) and Ortegón-Morales and Díaz-Franco (1998), cited that high temperatures have an influence on reducing the vegetative stage of okra, whereas the reproductive stage is mostly influenced by length day.

Marketable yields. During the early season, all hybrids took 58 days to first harvest. There were statistically significant differences in marketable among cultivars. 'Annie Oakley II' had the highest fruit yield. The yield data in the early season was obtained from 27 harvests. In the late season, the relative days to first harvest ranged from 60 to 67 days and no significant differences in fruit yield were registered among genotypes. Total late season harvests period were 42 (Table 3). Ortegón-Morales and Díaz-Franco (1998) reported that the long harvest period and highest plant in okra were from plantings of April and May compared with plantings from February and March; those effects were associated to photoperiod. In each season, yields fluctuated within harvests (data not shown), and it was related to the physiological state of the crop. Marsh et al. (1990), showed that this yields variations in okra indicates adjusts to the reduced source capacity and lower sink potentials (setting of new fruits).

No significant differences in cultivars, seasons, and the interaction between cultivar and season were found (Table 3); it was evident that the early season had better marketable fruit yields in a short harvest time. This is associated to the cited higher number and weight of fruits that was, in general, registered in the early season.

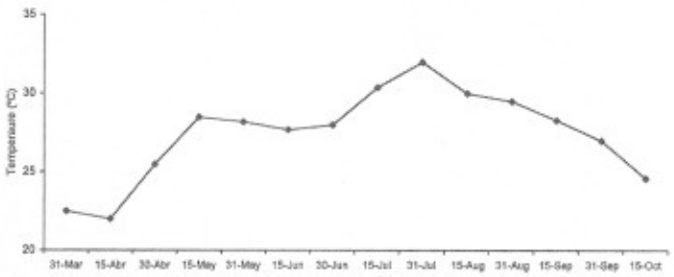

Fig. 3. Average air temperature during the growing of okra in the two seasons.

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