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Artigo

## **YIELD OF ORGANIC OKRA IRRIGATED UNDER DIFFERENT METHODS OF CONDUCTION AND GROWING PERIODS**

PRODUÇÃO DE QUIABOS ORGÂNICOS IRRIGADOS SOB DIFERENTES MÉTODOS DE CONDUÇÃO E PERÍODOS DE CULTIVO

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**ABSTRACT:** Okra is traditionally grown in the summer, but its cultivation in the winter can bring profitability to the producer, due to the low offer of the product, especially if grown in an organic production system. This study aimed to evaluate the yield and fruit quality of okra in organic system, in summer (SM), ratoon (RT) and winter (WN) crops. The field experiments were carried out in the SIPA (Agroecological Production Integrated System) and the total yield, marketable yield, and some quality parameters such as major and minor defects, curvature and size of fruits were evaluated in the three periods. Okra yield and fruit quality were influenced by the growing period and methods of conduction, and marketable yields of 18.3, 3.0 and 10.2 Mg ha<sup>-1</sup> were found for SM, RT and WN, respectively. The producer should opt for a new planting during the winter instead of growing the ratoon from the summer crop.

**KEYWORDS:** *Abelmoschus esculentus*, Planting Periods, Organic Management, Fruit Quality, Yield.

**RESUMO:** A Okra é tradicionalmente cultivada no verão, mas seu cultivo no inverno pode trazer rentabilidade para o produtor, devido à baixa oferta do produto, especialmente se cultivada em um sistema de produção orgânica. Este estudo teve como objetivo avaliar o rendimento e a qualidade dos frutos de quiabos no sistema orgânico, nas culturas de verão (SM), ração (RT) e inverno (WN). Os experimentos de campo foram realizados no SIPA (Sistema Integrado de Produção Agroecológica) e o rendimento total, rendimento comercializável, e alguns parâmetros de qualidade, como defeitos maiores e menores, curvatura e tamanho dos frutos, foram avaliados nos três períodos. O rendimento de quiabos e a qualidade dos frutos foram influenciados pelo período de cultivo e métodos de condução, e os rendimentos comercializáveis de 18,3, 3,0 e 10,2 Mg ha<sup>-1</sup> foram encontrados para SM, RT e WN, respectivamente. O produtor deve optar por um novo plantio durante o inverno em vez de cultivar a ração a partir da safra de verão.

**PALAVRAS-CHAVE:** *Abelmoschus esculentus*, Períodos de Plantio, Manejo Orgânico, Qualidade dos Frutos, Rendimento.



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## 1. Introduction

Okra is a vegetable cultivated for domestic consumption in tropical and subtropical countries (Adekiya, Agbede, Aboyeji, Dunsin, & Ugbe, 2019) and plays an important role in human diet because it is a source of carbohydrates, proteins, fats, minerals and vitamins (Abd El-Kader, Shaaban, & Abd El-Fattah, 2010). Due to its wide adaptability and nutritional importance okra is successfully cultivated in countries as India, China, Thailand, Egypt and others (Bake, Singh, Singh, Moharana, & Maurya, 2017). With great acceptance in the Brazilian market, it adapts very well to areas under higher temperatures, particularly in the Northeast and Southeast regions (Mota, Finger, Silva, Corrêa, Firme, & Neves, 2005), where small producers are responsible for most of the production (Paes, Esteves, & Sousa, 2012). According to Mota, Oliveira, Nobre, e Silva (2017), this crop still does not express its total production potential due to, mainly, the low level of technology adopted by the majority of producers.

The occurrence of consecutive low temperatures causes delay in germination and seedling emergence, which hinders growth, flowering and fruiting (Premsekhar & Rajashree, 2009). For not having long periods with low temperatures, okra cultivation in the autumn and winter has been characterized as an alternative to the farmer of the *Baixada Fluminense* region in Rio de Janeiro, Brazil, making the product available throughout the year. Usually these producers choose to grow the ratoon from the summer crop instead of planting again, due to the lower costs to implement the ratoon cultivation system.

The average national yield of okra has not varied expressively in the last ten years, reaching 14.74 Mg ha<sup>-1</sup> in 2005 and 13.24 Mg ha<sup>-1</sup> in 2015. Currently the most planted cultivar is Santa Cruz 47 (Torres, Gomes, Silva, Benedito, & Pereira, 2013) because it is well adapted to the different climate





conditions and has greater fruit diameter and higher number of harvests, compared with the other cultivars (Cardoso & Berni, 2012).

Organic fertilization is normally used in the cultivation of okra and contributes to improving the physical properties of the soil and reducing the production cost (Oliveira et al., 2014). However, combine use of organic and inorganic fertilizers improved more vegetative growth, yield and quality of okra (Kumar, Saikia & Barik, 2017). According to Santos, Pereira, Medeiros, Costa, e Pereira (2019), organic fertilization does not influence the vegetative growth of okra, but it is beneficial to the production of fruits with higher vitamin C content.

Okra is a crop with certain tolerance to drought but requires adequate water supply and relatively wet soils throughout its growth period, in order to obtain high yields (Ghannad, Madani, & Darvishi, 2014). Thus, irrigation is important and its management associated with the use of automatic systems (Romero, Muriel, García, I., & Muñoz de la Peña, 2012) can contribute to the increase in yield and, consequently, in irrigation water use efficiency. Among the systems available in the market, the simplified irrigation controller (SIC) (Medici, Rocha, Carvalho, Pimentel, & Azevedo, 2010) is characterized by its low cost and has been used in different crops and cultivation systems, controlling irrigation based on the variation of soil water content (Gonçalves, Medici, Almeida, Carvalho, Santos, & Gomes, 2014).

Given the above, this study was conducted to evaluate the effect of different growing periods and methods of conduction on the yield and fruit quality of okra, cultivated in organic system and with automatic irrigation.

## **2. Material and Methods**

Two field experiments (summer and winter) were carried out in the SIPA (Agroecological Production Integrated System) at the *Fazendinha*



*Agroecológica* Km 47, Seropédica-RJ, Brazil, from October 2015 to September 2016, in soil classified as dystrophic Red Yellow Argisol, with moderate A horizon and sandy loam texture (Gomes, Carvalho, Almeida, Medici, & Guerra, 2014). The climate of the region is classified as Aw according to Köppen's climate classification, with rainy season in the summer and well-defined dry season in the winter, and July is the driest month.

Along the experimental period, there was regular distribution of rains from November 2015 to April 2016 (summer crop), with 741.8 mm, and from May to September 2016 (ratoon and winter crops), with 254.5 mm. Since rainfalls were above the expected in the autumn-winter period, it has been climatically characterized as atypical. Maximum and minimum temperatures were 40.1 and 17.5 °C from November to April, respectively, with cumulative reference evapotranspiration (ET<sub>o</sub>), estimated by the FAO-56 Penman-Monteith method (Pereira, Allen, Smith, & Raes, 2015), of 741 mm, and mean of 4.1 mm day<sup>-1</sup>. From May to September, temperatures were respectively 37.7 and 10.1 °C, whereas cumulative and mean ET<sub>o</sub> were respectively 475.1 mm and 3.1 mm day<sup>-1</sup>.

Soil tillage consisted of scarification to 0.30 m depth, followed by plowing and harrowing. Fertilization at planting was performed using 100 g per hole of a mixture composed of bovine manure, firewood ash and bone meal, at proportion of 1:1:1. Castor bean cake, at dose of 3.0 Mg ha<sup>-1</sup>, was applied as top-dressing fertilizer at 45, 90 and 135 days after transplanting (DAT).

A randomized block experimental design was adopted and the treatments corresponded to four irrigation depths (33, 67, 100 and 133% of the water depth applied by the SIC) with 5 replicates, totaling 20 experimental plots, with 18 plants per plot.

Transplantation was carried out at spacing of 1.0 m between rows and 0.5 m between plants. Seedlings of the summer crop were transplanted in November 2015 and, when the harvest period ended, after a reduction of



yield was observed (early April 2016), a drastic pruning was carried out in the plants at 0.50 m height, for subsequent cultivation of okra ratoon. Simultaneously, seedlings of the winter crop were transplanted to an adjacent area, characterizing the three growing periods (summer, ratoon and winter). The total area of each crop was 210 m<sup>2</sup>, with 420 plants.

The irrigation system was automatically managed by the SIC (Medici et al., 2010), composed of a porous ceramic cup (filter candle) connected by a flexible pipe to a pressure switch. The sensor was installed at 0.20 m depth below one seedling and in the direction of the reference dripper. The height difference between sensor and pressure switch was 0.6 m, equivalent to tension of actuation of approximately 6.0 kPa (Medici et al., 2010). At the entrance of the experimental area, a hydrometer was installed, enabling daily monitoring of the volume of water applied.

Two drippers were used per plant, spaced by 0.10 m, with nominal flow rate of 2.0, 4.0, 6.0 (reference) and 8.0 L h<sup>-1</sup>. The water depth applied (mm) was calculated based on the ratio between the volume applied daily (m<sup>3</sup>) and the total area of cultivation (m<sup>2</sup>), considering the location coefficient, which depends on wetted area percentage or percentage of area shaded by the crop (Mello, Carvalho, Medici, Silva, Gomes, & Pinto, 2018).

Harvests were carried out from 2 to 3 times a week, depending on the production period, harvesting all fruits longer than 6 cm. Total and marketable yields were evaluated based on the determination of fresh weight of the fruits, considering as marketable those with no major defects. The following fruit quality parameters were evaluated: curvature, length, major defects (fibrous fruits, with many lumps and deep damages in the tissue) and minor defects (superficial damages in the tissue).

In the analysis of curvature, fruits forming an angle between 10° and 30° with the horizontal plane were considered as slightly curved and those forming angles above 30°, as highly curved. Fruit length (L) was classified into classes according to the length range accepted for each one, namely:





Class 6 =  $0.06 \text{ m} < L \leq 0.09 \text{ m}$ ; Class 9 =  $0.09 \text{ m} < L \leq 0.12 \text{ m}$ ; Class 12 =  $0.12 \text{ m} < L \leq 0.15 \text{ m}$ . Fruits with  $L > 0.15 \text{ m}$  were classified as Without Class. The maximum percentages of major defects, minor defects and curvature allowed for each class were used to classify okra fruits commercially, into the categories Extra, I, II and III, based on the norms of CEAGESP (2015).

The statistical analyses were carried out using the SISVAR statistical program (Ferreira, 2014). The data were submitted to analysis of variance by the F test at 5% probability. The significant means were compared by the Tukey test at 5% probability.

### **3. Results and Discussion**

The duration of okra cycle, in days after transplanting (DAT), and its division into vegetative stage, reproductive stage (first harvest) and yield reduction (last harvest) are presented in table 1. Considering the time in the tray, the vegetative stage lasted 62 and 66 days for the summer and winter crops, respectively. Working in the summer with the cultivar Santa Cruz 47, Galati (2013) observed vegetative stage of 64 DAS, which is within the range observed by Filgueira (2008), who describes 60 to 75 DAS for spring-summer crops, when sown directly in the field. For the summer, ratoon and winter crops, the harvest period lasted 114, 88 and 103 days, respectively. The fruiting period can be longer than 200 days, depending on the growing period, influencing the obtaining of higher yields (Filgueira, 2008).



Table 1 – Period of vegetative stage, beginning and duration of okra harvest, in the three growing periods.

Growing period (Months)	Vegetative stage	First harvest	Last harvest
	Days after transplanting (DAT)		
Summer (Nov/Apr)	30*	38	152
Ratoon (Apr/Aug)	0**	21	109
Winter (Apr/Sep)	34*	52	155

\*32 days in tray before transplantation to the field

\*\*In ratoon cultivation, plants were already in the reproductive stage after their cut.

Source: authors.

There were no significant differences in total, marketable and unmarketable yields between the water depths applied, in the three crops (table 2). This result was influenced by the high frequency and good distribution of rains occurred during the growing periods, inhibiting possible effects of the different irrigation depths on okra yield. The occurrence of a mild drought period contributed to such absence of water stress along the experimental period. In response to crop development and edaphoclimatic conditions of the region, the automatic irrigation controller applied 90% cumulative ETo in the summer crop (mean of 4.1 mm day<sup>-1</sup>) and 142% cumulative ETo in the winter crop (mean of 3.1 mm day<sup>-1</sup>). It is worth highlighting that the SIC is influenced by soil water tension, which in turn is related to the rainfall occurred in the period.

Table 2 – Total, marketable and unmarketable yields of okra for different irrigation depths, in summer, ratoon and winter crops.

Irrigation depth (mm)	Yield (Mg ha <sup>-1</sup> )		
	Total	Marketable	Unmarketable
Summer crop			
143	18.75	17.82	0.93
286	18.71	17.78	0.93
430	19.83	18.63	1.20
573	19.76	18.84	0.92
Ratoon crop			
92	2.88	2.39	0.49
185	4.02	3.32	0.70
278	4.26	3.52	0.73
371	3.47	2.78	0.69
Winter crop			
113	10.77	9.72	1.04





225	11.24	10.30	0.93
340	11.20	10.40	0.80
452	11.32	10.35	0.97

Source: Authors.

In the summer, ratoon and winter crops, significant differences were observed in total and marketable yields of okra (table 3). The marketable yield obtained in the summer crop (18.26 Mg ha<sup>-1</sup>) is within the range from 15 to 20 Mg ha<sup>-1</sup>, expected for the crop (Galati et al., 2013). In organic cultivation of okra in northern Minas Gerais, under different soil covers by perennial herbaceous legumes, Silva, Oliveira, Graziotti, Favero, e Quaresma (2013) obtained maximum yield of 16.23 Mg ha<sup>-1</sup>, using perennial soybean as cover. In the experimental period the accumulated rainfall was 722 mm.

Table 3 – Yield (Mg ha<sup>-1</sup>) of okra in summer, ratoon and winter crops.

Yield (Mg ha <sup>-1</sup> )	Growing period		
	Summer	Ratoon	Winter
Total	19.26a	3.65c	11.13b
Marketable	18.26a	3.00c	10.19b
Unmarketable	0.99a	0.65a	0.93a

Means followed by the same letter in the row do not differ significantly by Tukey test at 0.05 probability level.

Source: Authors.

The yield obtained in the winter crop (10.19 Mg ha<sup>-1</sup>) was significantly lower than that of the summer crop but was considered as satisfactory because, according to Filgueira (2008), the temperature in this period is a limiting factor for the continuous production of okra. The dry season also favors the development and proliferation of powdery mildew (*Erysiphe cichoracearum*), which is the reason why this disease began to be considered as the most important one in the winter (Cividanes, Cividanes, & Matos, 2007), leading to the largest losses in marketable yield.

During the winter period in North regions of Rio de Janeiro State, Brazil, Paes et al. (2012) conducted irrigation management also based on soil water



balance and obtained yield of  $11.3 \text{ Mg ha}^{-1}$ , with total depth of 520 mm. In Sergipe state, Brazil, Farias et al. (2019) founded  $18.2 \text{ Mg ha}^{-1}$  when 100% of crop evapotranspiration was supplied using drip irrigation, from March to May. Since all results cited were obtained in conventional production system, it becomes evident that good yields of okra can be obtained in organic system provided that adequate managements are performed with respect to fertilization, irrigation and control of pests and diseases.

The marketable yield in the ratoon crop was approximately  $3.0 \text{ Mg ha}^{-1}$ . Planting again in the winter instead of growing the ratoon from the summer crop allowed higher yield than that obtained by regrown plants, in a period of low offer of the product and high prices practiced in the market. This result can be attributed to the shorter harvest period for ratoon plants in comparison to the winter and summer crops, due to their greater contact with pests and diseases, which had already affected these plants since the summer crop, and their more advanced physiological age compared with plants from the winter crop.

In summer and winter crops, no fruits were lost in the first weeks of production, which only occurred over time, due to the increase in the incidence of pests and diseases in the area, unlike the ratoon crop, in which unmarketable yields were found since the beginning.

Considering the total production of the cycle, there were significant differences in the percentage of unmarketable fruits, which was 5, 18 and 8.5% of all fruits in the summer, ratoon and winter crops, respectively. These results demonstrate that the growing period influences the production of marketable fruits, i.e., the largest losses of marketable production occurred in periods unfavorable to the full development and fruiting of okra plants.

Highest percentages of fruits with minor defects, major defects, highly curved and slightly curved were obtained in the ratoon crop, due to the more advanced physiological age of the plants and their phytosanitary condition, because they have already been damaged by the occurrence of pests and



diseases before being pruned (table 4). Significant differences in major and minor defects were only observed in the ratoon crop because in this cultivation the defects occurred with high intensity since the first week of harvest.

Table 4 – Percentages of defects, curvature and size of okra fruits in summer, ratoon and winter crops.

Quality parameters (%)		Growing period		
		Summer	Ratoon	Winter
Defects	Major	1.64b	17.23a	5.16b
	Minor	3.81b	21.15a	4.86b
Curvature	Highly curved	2.90c	17.12a	10.35b
	Slightly curved	6.14c	35.37a	20.29b
Size	6	5.55b	16.84a	7.34b
	9	28.05c	46.92a	39.93b
	12	39.71a	28.11b	36.56a
	Without class	26.24a	6.15c	15.95b

Means followed by the same letter in the row do not differ significantly by Tukey test at 0.05 probability level.

Source: Authors.

In the three growing periods were found significant differences for fruit curvature. Leaf crumpling, known as Hibiscus erinose, was the main cause for the increase in fibrous and curved fruits, caused by a toxin released by the *Aceria esculenti* mite when feeding on the sap, which causes proliferation of cells with consequent formation of galls, which will serve as shelter and protection for the mite (Silva & Pereira, 2008). Consequently, the fruits formed close to these leaf galls grow curved and often become fibrous, unsuitable for marketing. According to these authors, this mite proliferates more easily during dry periods and that is the reason why the occurrence of fibrous and curved fruits is higher in the winter and ratoon crops.

Regarding fruit size, higher percentage of fruits in the Class 12 and Without Class were found in the summer crop, due to the occurrence of higher temperatures, which accelerate fruit growth. During this growing period, harvests were carried out three times a week and, despite that, it showed higher percentages of fruits within the classes of largest size (Class





12 and Without Class), compared with the winter and ratoon crops, in which harvests were carried out twice a week.

Highest percentages of fruits in the classes of smallest size (Class 6 and Class 9) were found in winter and ratoon crops, due to the lower rate of fruit growth at low temperatures.

The joint evaluation of occurrence of defects allowed us to classify the fruits according to the commercial classification of CEAGESP. Total yield, expressed in number of boxes (15 kg) per hectare, in the categories Extra, I, II and III, is presented in Table 5. There were significant differences in the percentages of boxes in the categories Extra, II and III, between the growing periods evaluated. Higher percentages of boxes in the quality category Extra, which has greater economic value in the conventional market, were found in the summer crop, due to the lower occurrence of major damages in the fruits compared with the other defects. The category I was the only one in which the percentages of boxes did not differ significantly between the three crops. In ratoon and winter crops, the category II had the highest proportion of boxes, due to the greater occurrence of fruits with minor defects and slightly curved, according to the range accepted in this category. Higher proportion of boxes in the category III, of lowest economic value, were found in the ratoon crop due to the higher occurrence of all defects, and its production reached the lowest value paid by the conventional wholesale market, according to the commercial classification of CEAGESP.

Table 5 – Number of boxes with 15 kg of okra, for an area of 1 ha, in the categories Extra, I, II and III, for the three growing periods.

Nº of fruits	Summer				Total
	Extra	I	II	III	
Un	792	187	265	2	1246
%	62.56a	14.81a	22.24b	0.3c	100
Nº of fruits	Ratoon				Total
	Extra	I	II	III	
Un	48	32	81	29	190
%	21.45c	17.09a	44.66a	16.78a	100
Nº of fruits	Winter				Total
	Extra	I	II	III	



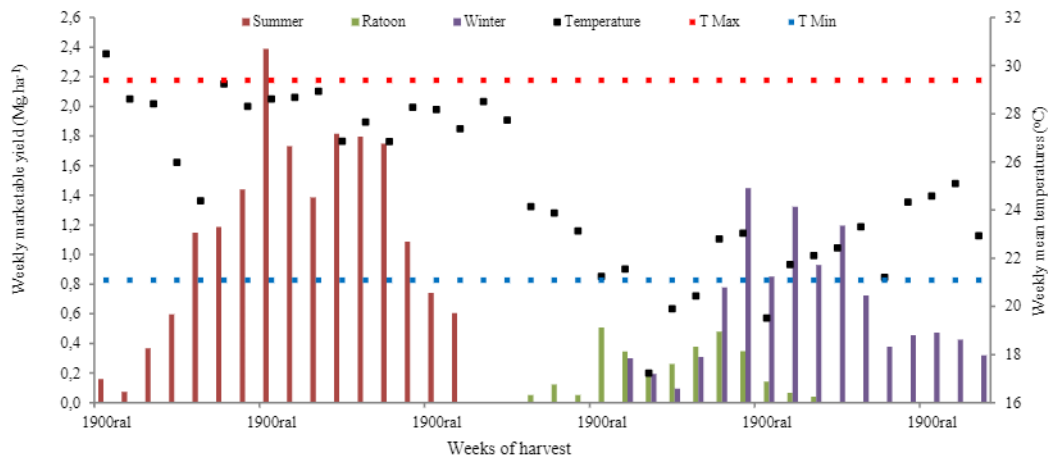
	Extra	I	II	III	Total
Un	285	125	279	57	746
%	37.60b	15.69a	38.99a	7.73b	100

Means followed by the same letter in the column do not differ significantly by Tukey test at 0.05 probability level.

Source: Authors.

Chart 1 presents the weekly marketable yields and weekly mean temperatures in the three growing periods, as well as the maximum and minimum limits of the most suitable temperature range for the crop.

Chart 1 – Weekly marketable yield of okra ( $\text{Mg ha}^{-1}$ ) and weekly mean temperatures in summer, ratoon and winter crops.



Source: Authors.

The most suitable mean temperature for okra development ranges from 21.1 to 29.4 °C (Sediyama et al., 2009). In the summer crop there were no mean temperatures below 24 °C, and temperatures above 29.4 °C occurred only in the first week of production (30.5 °C), which may have caused flower abortion and consequent decline of yield in the following week. The highest temperatures within the production peak occurred from the 6<sup>th</sup> to the 10<sup>th</sup> weeks, and maximum yield was observed in the 8<sup>th</sup> week. Thus, probably, only temperatures higher than the recommended optimal range will occur in this period of the year in the region, which can influence okra yield.



In the winter crop, temperatures were lower than 21.0 °C in the 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> and 7<sup>th</sup> weeks, and the lowest yields were found in the 7<sup>th</sup> and 11<sup>th</sup> weeks. In the 6<sup>th</sup> week of production, when the highest yield was found, the highest temperature (23 °C) within the peak of production occurred. In the ratoon from the summer crop, temperatures below 21 °C occurred in the 6<sup>th</sup>, 7<sup>th</sup> and 8<sup>th</sup> weeks, period with the lowest yields within the peak of production. Therefore, in this period of the year, mean temperatures below the optimal range for the crop led to reduction in yield.

#### **4. Conclusions**

1. In the three growing periods, the irrigation depths tested did not cause significant differences in total, marketable and unmarketable yields because of the high availability of water due to the rainfalls occurred along the entire experimental period.
2. Total yield, marketable yield, major and minor defects, curvature, fruit size and number of boxes per category were influenced by the growing periods and methods of conduction.
3. Marketable yield in the winter crop was up to three times higher than that in the ratoon crop; therefore, the producer should opt for a new planting during the winter instead of growing the ratoon from the summer crop.

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## References

Abd El-Kader, A. A., Shaaban, S. M., & Abd El-Fattah, M. S. (2010). Effect of irrigation levels and organic compost on okra plants (*Abelmoschus esculentus* L.) grown in sandy calcareous soil. *Agriculture and Biology Journal of North America*, 1(3), 225-231. DOI: 10.5251/abjna.2010.1.3.225.231.

Adekiya, A. O., Agbede, T. M., Aboyeji, C. M., Dunsin, O., & Ugbe, J. O. (2019). Green manures and NPK fertilizer effects on soil properties, growth, yield, mineral and vitamin C composition of okra (*Abelmoschus esculentus* L.). *Journal of the Saudi Society of Agricultural Sciences*, 18(2), 218-223. DOI: 10.1016/j.jssas.2017.05.005.

Bake, I. D., Singh, B. K., Singh, A. K., Moharana, D. P., & Maurya, A. K. (2017). Effect of sowing dates and planting distances on quantitative attributes of Okra [*Abelmoschus esculentus* (L.) Moench] cv. Kashi Pragati. *The Pharma Innovation Journal*, 6(12), 142-148.

Cardoso, M. O.; & Berni, R. F. (2012). Nitrogen applied in okra under non-tightness grown and residual fertilization. *Horticultura Brasileira*, 30(4), 645-652. DOI: 10.1590/S0102-05362012000400014.

CEAGESP - Companhia de Entrepósitos e Armazéns Gerais de São Paulo. (2015). Centro de Qualidade em Horticultura. *Normas de classificação de quiabo*. São Paulo: CEAGESP.

Cividanes, T. M. S., Cividanes, F. J., & Matos, B. A. (2007). Biologia de *Psyllobora confluens* alimentada com o fungo *Erysiphe cichoracearum*. *Pesquisa Agropecuária Brasileira*, 42(12), 1675-1679. DOI: 10.1590/S0100-204X2007001200002.

Farias, D. B. S, Silva, P. S. O., Lucas, A. A. T., Freitas, M. I., Santos, T. J., Fontes, P. T. N., & Oliveira Júnior, L. F. G. (2019). Physiological and productive parameters of the okra under irrigation levels. *Scientia Horticulturae*, 252(1), 1-6. DOI: 10.1016/j.scienta.2019.02.066.

Ferreira, D. F., (2014). Sisvar: a Guide for its Bootstrap procedures in multiple comparisons. *Ciência & Agrotecnologia*, 38(2), 109-112. DOI: 10.1590/S1413-70542014000200001.

Filgueira, F. A. R. (2008). *Novo manual de olericultura: Agrotecnologia Moderna na Produção e Comercialização de Hortaliças* (3th ed.). Viçosa-MG: UFV.

Galati, V. C. (2013). Crescimento e acúmulo de nutrientes na cultura do quiabeiro. *Semina: Ciências Agrárias*, 34(1), 191-200. DOI: 10.5433/1679-0359.2013v34n1p191.



Ghannad, M., Madani, H., & Darvishi, H. H. (2014). Responses of okra crop to sowing time, irrigation interval and sowing methods in Shahrood region. *International Journal of Agriculture and Crop Sciences*, 7(10), 676-682.

Gomes, D. P., Carvalho, D. F., Almeida, W. S., Medici, L. O., & Guerra, J. G. M. (2014). Organic carrot-lettuce intercropping using mulch and different irrigation levels. *Journal of Food, Agriculture & Environment*, 12(1), 323-328. DOI: 10.1234/4.2014.4231.

Gonçalves, F. V., Medici, L. O., Almeida, W. S., Carvalho, D. F., Santos, H. T., & Gomes, D.P. (2014). Irrigação no cultivo orgânico de alface utilizando Irrigás, tanque classe A e um sistema automático de baixo custo. *Ciência Rural*, 44(11), 1950-1955. DOI: 10.1590/0103-8478cr20131448.

Kumar, V., Saikia, J., & Barik, N. (2017). Influence of Organic, Inorganic and Biofertilizers on Growth, Yield, Quality, and Economics of Okra [*Abelmoschus esculentus* (L). Moench] under Assam Condition. *International Journal of Current Microbiology and Applied Sciences*, 6(12), 2565-2569. DOI: 10.20546/ijcmas.2017.612.297.

Medici, L. O., Rocha, H. S., Carvalho, D. F., Pimentel, C., & Azevedo, R. A. (2010). Automatic controller to water plants. *Scientia Agricola*, 67(6), p.727-730. DOI:10.1590/S0103-90162010000600016.

Mello, G. A. B., Carvalho, D. F., Medici, L. O., Silva, A. C., Gomes, D. P., & Pinto, M. F. (2018). Organic cultivation of onion under castor cake fertilization and irrigation depths. *Acta Scientiarum. Agronomy*, 40(1), 1-8. DOI: 10.4025/actasciagron.v40i1.34993.

Mota, W. F., Finger, F. L., Silva, D. J. H., Corrêa, P. C., Firme, L. P., & Neves, L. L. M. (2005). Caracterização físico-química de frutos de quatro cultivares de quiabo. *Horticultura Brasileira*, 23(3), 722-725. DOI: 10.1590/S0102-05362005000300006.

Mota, W. F., Oliveira, G. B., Nobre, S. A. M., & Silva, H. R. (2017). Agronomic performance of okra under the effect of seed microbiolization with rhizobacteria. *Horticultura Brasileira*, 35(3), 410-414. DOI:/10.1590/S0102-053620170315.

Oliveira, A. P., Silva, O. P. R., Silva, J. A., Silva, D. F., Ferreira, D. T. A., & Pinheiro, S. M. G. (2014). Produtividade do quiabeiro adubado com esterco bovino e NPK. *Revista Brasileira de Engenharia Agrícola e Ambiental*, 18(10), 989-993. DOI: 10.1590/1807-1929/agriambi.v18n10p989-993.

Paes, H. M. F., Esteves, B. S., & Sousa, E. F. (2012). Determinação da demanda hídrica do quiabeiro em Campos dos Goytacazes, RJ. *Revista Ciência Agronômica*, 43(), 256-261. DOI: 10.1590/S1806-66902012000200007.



Pereira, L. S., Allen, R. G., Smith, M., & Raes, D. (2015). Crop evapotranspiration estimation with FAO56: Past and future. *Agricultural Water Management*, 147(1), 4-20. DOI: 10.1016/j.agwat.2014.07.031.

Premsekhar, M., & Rajashree, V. (2009). Influence of organic manures on growth, yield and quality of okra. *American Eurasian Journal of Sustainable Agriculture*, 3(1), 6-8.

Romero, R., Muriel, J. L., García, I., & Muñoz de la Peña, D. (2012). Research on automatic irrigation control: State of the art and recent results. *Agricultural Water Management*, 114, 59-66. DOI: 10.1016/j.agwat.2012.06.026.

Santos, H. C., Pereira, E. M., Medeiros, R. L. S., Costa, P. M. A., & Pereira, W. E. (2019). Production and quality of okra produced with mineral and organic fertilization. *Revista Brasileira de Engenharia Agrícola e Ambiental*, 23(2), 97-102. DOI: 10.1590/1807-1929/agriambi.v23n2p97-102.

Sediyama, M. A. N., Santos, M. R., Vidigal, S. M., Salgado, L. T., Pedrosa, M. W., & Jacob, L. L. (2009). Produtividade e estado nutricional do quiabeiro em função da densidade populacional e do biofertilizante suíno. *Bragantia*, 68(4), 913-920. DOI:10.1590/S0006-87052009000400011.

Silva, D. M. N., Oliveira, F. L., Graziotti, P. H., Favero, C., & Quaresma, M. A. L. (2013). Organic cultivation of okra under ground cover of perennial herbaceous legumes. *Horticultura Brasileira*, 31(3), 450-456. DOI: 10.1590/S0102-05362013000300017.

Silva, G. S., & Pereira, A. L. (2008). Efeito da Incorporação de Folhas de Nim ao Solo sobre o Complexo Fusarium x Meloidogyne em Quiabeiro. *Summa phytopathol*, 34(4), 368-370. DOI: 10.1590/S0100-54052008000400015.

Torres, S. B., Gomes, M. D. A., Silva, F. G., Benedito, C. P., & Pereira, F. E. C. B. (2013). Controlled deterioration to evaluate okra seed vigor. *Horticultura Brasileira*, 31(12), 317-321, 2013. DOI: 10.1590/S0102-05362013000200023.