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Research Article

Effect of shading screens on the production and quality of 'Smooth Cayenne' pineapple[1]

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ABSTRACT

In pineapple cultivation, it is common to cover the fruit with newspaper, in order to avoid scalding caused by sunburn. However, the scarcity of material and the large labor force required have led to the search of control alternatives. This study aimed to evaluate the use of shading screens in the production and quality of 'Smooth Cayenne' pineapple. A randomized blocks experimental design was used, with five treatments (fruits covered with newspaper and plants covered with screens with 35, 40, 50 and 80 % of shading), four replicates and two seasons (summer and winter). In the summer, the use of screens with 50 % of shading provided average gains of 22 and 39 % of total and commercial mass of crowned fruits per plant and gains of 22 and 40 % of total and commercial yield per hectare, respectively. The gradual increase in shading intensity resulted in a decrease in the qualitative attributes of the fruits, when compared to covering the fruits with newspaper. Screens with up to 50 % of shading can replace newspaper when covering the fruits to avoid scalding.

KEYWORDS: *Ananas comosus* (L.) Merril, protected cultivation, artificial shading.

RESUMO

Efeito de telas de sombreamento na produção e qualidade de abacaxi 'Smooth Cayenne'

No cultivo de abacaxi, é comum a prática de cobertura dos frutos com jornal, a fim de evitar a escaldadura causada pela queima solar. Contudo, a escassez de material e o aumento de mão de obra têm levado à busca por alternativas de controle. Objetivou-se avaliar o uso de telas de sombreamento na produção e qualidade de abacaxi 'Smooth Cayenne'. O delineamento experimental foi o de blocos ao caso, com cinco tratamentos (frutos cobertos com jornal e cobertura das plantas com telas de 35; 40; 50; e 80 % de sombreamento), quatro repetições e duas épocas (verão e inverno). No verão, a utilização de telas com 50 % de sombreamento determinou ganhos médios de 22 e 39 % de massa total e comercial dos frutos com coroa por planta e 22 e 40 % de produtividade total e comercial por hectare, respectivamente. O aumento gradativo da intensidade de sombreamento resultou em decréscimo dos atributos qualitativos dos frutos, em comparação à cobertura com jornal. Telas com até 50 % de sombreamento podem substituir a cobertura de frutos com jornal para evitar a escaldadura dos frutos.

PALAVRAS-CHAVE: *Ananas comosus* (L.) Merril., cultivo protegido, sombreamento artificial.

INTRODUCTION

Brazil is the world's second largest producer of pineapple [*Ananas comosus* (L.) Merril], with an estimated production of 1.8 million tons, which corresponds to a share of 7.9 % of the total amount produced in the world scenario (FAO 2016). The São Paulo state, with a production of 93,637 t, is the fifth Brazilian state with the largest pineapple production (IBGE 2017), being 73 % of it concentrated in the northwest area (IEA 2017).

The climate directly influences the cultivation cycle (Carvalho et al. 2005), with fruit scalding resulting from solar burning being one of the biggest problems faced by producers, causing losses of up to 70 % (Lopes et al. 2014). Sunburn causes physiological effects on the fruits, such as peel discoloration in the affected region and spongy consistency in the pulp, resulting in financial losses for the producer and requiring the fruits to be physically protected, especially in periods and times of high solar radiation (Santos et al. 2020).

Conventionally, in producing areas of the northwest São Paulo state, fruits are wrapped with newspaper or paper bags (Teixeira et al. 2014). However, due to the scarcity of raw material and

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the large labor force required, many producers are seeking for new alternatives to control fruit scalding, such as using shading screens during fructification. There are few studies in this line of research. Lopes et al. (2014), for example, evaluated the effect of ways to protect pineapple fruits of the 'Pérola' cultivar (unprotected, newspaper, brown paper bag, nonwoven fabric and hydrated lime solution) and concluded that fruits protected with nonwoven fabric showed a reduction of 47 % for sunburn.

The use of shading screens in crops aims to reduce the intensity of radiant energy and improve the distribution of light in the environment, in order to meet the plants needs and contribute to a better crop performance. Shading with black polypropylene screens reduces the light inside protected environments and attenuates high temperatures. This technique presents the problems of decreasing solar radiation to the detriment of photosynthesis, as well as increasing radiation in the infrared range, which would reach the plants in excess.

In horticulture, the use of shading screens is increasingly recurrent, such as for pepper (Araquam 2013), tomato (Santiago et al. 2017) and lisianthus (Almeida & Calaboni 2016).

Plastic screens are used for shading as a technique suggested for solving the issue of weather conditions action, such as the sunburn of pineapple fruits. However, the recommendation of the proper screen shading for a certain plant species may vary according to the meteorological conditions of the growing season. Thus, this study aimed to evaluate the use of shading screens during fruiting in the production and quality of pineapple.

MATERIAL AND METHODS

Two independent experiments evaluating the use of shading screens during the fruiting of the 'Smooth Cayenne' pineapple cultivar were carried out. In the summer, planting was carried out on February 01, 2017; the cover was placed on February 17, 2018; and the harvest started on April 08, 2018. In the winter, planting was carried out on June 01, 2017; the cover was placed in July 10, 2018; and the harvest started on August 29, 2018.

The experiments were conducted in two commercial pineapple-growing areas of the São Paulo state [Pereira Barreto (summer) and Muritinga do Sul (winter)], using seedlings of the 'Smooth Cayenne' cultivar. The climate of the region, according to the Köppen classification, is tropical, being hot and humid, with dry winters. The average annual rainfall is 1,150 mm and the average annual temperature 23 ºC. The weather data were obtained during the conduction of the experiments from a weather station of the Universidade Estadual Paulista, located in Pereira Barreto (20º67'12"S, 51º03'35"W and altitude of 357 m).

A randomized blocks experimental design was used, with four replicates and 56 plants plot^{-1}. The treatments consisted of fruit covering with newspaper, in which each individual fruit was covered and stapled with newspaper; and plant covering with black plastic screens with 35, 40, 50 and 80 % of shading, with the total area of each plot covered with black plastic screens, tied with strings (every 2.0 m) directly to the plants.

The areas were prepared with plowing and harrowing. A bed shaper was used to erect seedbeds with an approximate height of 0.40 m, where the pineapple seedlings were planted. Weed and phytosanitary controls and crop management were carried out when necessary, in accordance with the technical recommendations for the crop. Prior to the setting up of the experiments, the soil chemical characteristics in the two experimental areas were determined from a simple sample collected at the depth of 0.00-0.20 m. Based on the soil chemical analysis and according to the recommendations by Spironello et al. (1997), corrections, fertilization at planting and topdressing were carried out in both experiments.

Planting was carried out in double rows with spacing of 0.80 m between double rows, 0.40 m between single rows and 0.40 m between plants. The usable plots of the treatments presented width of 2.4 m (two double rows of 0.8 m) and length of 5.6 m, comprising a total area of 13.44 m^2, with 56 plants.

The total and commercial mass of crowned fruits per plant were obtained by weighing all the fruits in the plot and dividing the result by the number of plants (kg plant^{-1}); the total and commercial fruit yield per ha (t ha^{-1}) were obtained by multiplying the weight of the fruits per plant by the number of plants ha^{-1} (41,666 plants ha^{-1}), the length of crowned and crownless fruits, and the diameter (m) of five commercial fruits per plot. Commercial fruits were considered as those presenting a mass heavier than 1 kg and without defects.

Postharvest evaluations were carried out at the harvest time in the laboratory. From each plot, three fruits presenting yellow (50 %) peel were harvested and evaluated for total titratable acidity (TTA) by titration with sodium hydroxide solution (0.1 N), expressed as percentage of citric acid. The total soluble solids (TSS) content was determined using a digital refractometer, being expressed in ºBrix. From the obtained results, the TSS/TTA ratio was calculated. The pH was measured after the fruits were titrated and their mass was properly homogenized using a potentiometer (Digital DMPH-2). Pulp firmness was determined using a manual penetrometer (Effegi) equipped with an 8-mm tip, by reading two opposite points in the equatorial region of the fruit, and the results expressed in N.

The data were subjected to analysis of variance and the differences between means were compared by the Tukey test at 5 % of probability, using the Sisvar statistical software.

RESULTS AND DISCUSSION

The global radiation was, on average, 22 % higher in the summer, when compared to the average global radiation in the winter. In the summer, the average daily global radiation was 17.2 MJ m^{-2} day^{-1}, while, in the winter, it was 13.5 MJ m^{-2} day^{-1} (Figure 1).

The solar radiation has a high potential for interfering in agriculture and can cause variations in yield and fruit quality. Its incidence on the Earth's surface is attenuated by the interaction of the atmospheric constituents (Li et al. 2015).

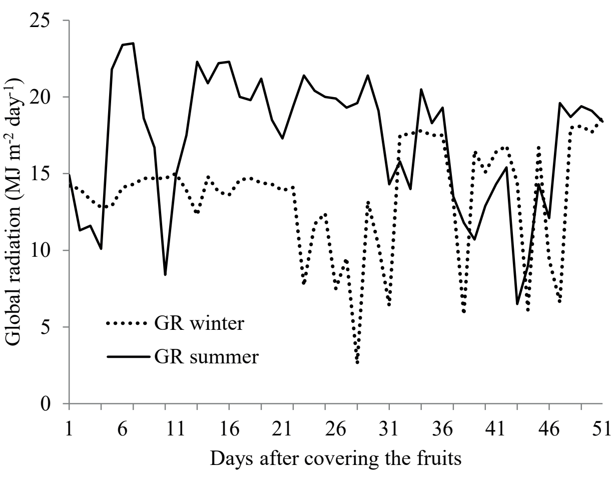

Figure 1. Average global radiation (GR) in the two periods (winter and summer) of the experiment.

Santos et al. (2020), based on climatological data, verified that, for the conditions of the Roraima state, the critical period for the appearance of scalding in pineapple occurs between August and October, coinciding with the period of less cloudiness and, consequently, greater global radiation. The climatic variations that are typical of the western region of the São Paulo state indicate that the appearance of scalding in pineapple may occur throughout the year, making the fruit protection an essential practice in any growing season. The treatments and the variation in global radiation in the present study resulted in quantitative and qualitative differences in the two experimental periods.

There was a significant effect of the treatments on the total and commercial mass of crowned fruits per plant and total and commercial fruit yield for the two evaluation periods.

In the summer, screens with 50 % of shading represented greater mass and yield gains, when compared to covering the fruit with newspaper. On average, the screen with 50 % of shading in the summer represented gains of 22 and 39 % of total and commercial mass of fruits per plant and 22 and 40 % of total and commercial yield per hectare, respectively, when compared to covering the fruits with newspaper (Table 1). In the winter (Table 1), screens with 80 % of shading presented lower gains for total fruit mass per plant and total fruit yield, with averages of 1.71 kg $plant^{-1}$ and 71.10 t ha^{-1}, when compared to the screen with 50 % of shading (1.96 kg $plant^{-1}$ and 81.72 t ha^{-1}) and covering the fruit with newspaper (1.96 kg $plant^{-1}$ and 81.58 t ha^{-1}), respectively. In addition, the screens with 80 % of shading presented lower gains for commercial fruit mass and yield, with averages of 1.66 kg $plant^{-1}$ and 69.30 t ha^{-1}, when compared to the screens with 50 and 40 % of shading and covering the fruits with newspaper, obtaining average commercial fruit masses of 1.94, 1.91 and 1.91 kg $plant^{-1}$ and average commercial fruit yields of 80.82, 79.55 and 79.67 t ha^{-1}, respectively.

The average commercial fruit mass (0.73 kg $plant^{-1}$) and yield (30.61 t ha^{-1}) using the screen with 80 % of shading did not show significant differences, when compared to covering the fruits with newspaper. In the summer, the shading screens resulted in higher yields, when compared to covering

Table 1. Total and commercial mass of crowned fruits per plant, and total and commercial yield of pineapple fruits ('Smooth Cayenne' cultivar), as a function of covering the fruits with newspaper and covering the plants with screens with different shading rates.

Treatment	Total mass		Commercial mass		Total yield		Commercial yield	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
	kg plant^{-1}				t ha^{-1}			
Newspaper	1.04 b[1]	1.96 a	0.63 c	1.91 a	43.23 b	81.58 a	26.21 c	79.67 a
35 %	1.25 ab	1.91 ab	0.89 ab	1.82 ab	52.02 ab	79.34 ab	37.19 ab	75.87 ab
40 %	1.20 ab	1.93 ab	0.94 a	1.91 a	49.91 ab	80.43 ab	39.27 a	79.55 a
50 %	1.33 a	1.96 a	1.05 a	1.94 a	55.25 a	81.72 a	43.56 a	80.82 a
80 %	1.08 ab	1.71 b	0.73 bc	1.66 b	45.18 ab	71.10 b	30.61 bc	69.30 b
F	4.80**	3.76*	17.64**	4.68*	4.79*	3.76*	17.64**	4.54*
CV (%)	9.14	5.76	9.33	5.67	9.15	5.79	9.34	5.74

[1] Distinct letters in the column indicate significant differences for α < 0.5, according to the Tukey test. * and ** Significant at 5 and 1 % of probability, respectively.

the fruits with newspaper. In the winter, the use of screens with 80 % of shading resulted in lower yields, probably due to the difference in the global radiation incidence in the two periods. Costa et al. (2011a) analyzed different types of shading screens for the strawberry production and observed that the use of screens during the summer (November and December) reduced the number of fruits per plant, when compared to the control. However, until that period (October), no differences were observed for the number of fruits, in relation to the presence or absence of cover. There was a significant effect of the treatments on crowned fruit length in the two evaluation periods and on fruit diameter in the summer. As the shading rate of the screens increased, there was a tendency to increase the crown size.

Solar radiation is essential for plant growth, not only for providing energy for photosynthesis, but also for regulating its development through light receptors, which are sensitive to different light intensities and spectral quality (Taiz & Zeiger 2016). In the present study, when the shading increased to 80 %, the photosynthesis rate was probably reduced, also reducing the fruits productive and qualitative characteristics. On average, the crowned fruit length, when covered with screens with 80 % of shading, was 0.11 and 0.03 m longer, when compared to the fruits covered with newspaper in the two seasons, respectively (Table 2).

The pineapple crown emerges from the apical meristem after flowering and develops during the fruit formation, paralyzing its growth with its maturation (Ddungu 1973, Giacomelli 1982). The use of shading screens causes changes in the environment, which can directly influence the growth and development of plants and fruits. The lower light incidence caused by the screens with 80 % of shading resulted in a greater etiolation of the pineapple crown, producing fruits with a greater length. Etiolation is a response to shading, as a way to avoid low sunlight irradiance. Auxins (AIA) are responsible for cell elongation and are photosensitive substances (Taiz & Zeiger

Table 2. Crowned and crownless fruit length and diameter of pineapple fruits ('Smooth Cayenne' cultivar), as a function of covering the fruits with newspaper and covering the plants with screens presenting different shading rates.

Treatment	Crowned fruit length		Crownless fruit length		Diameter	
	Summer	Winter	Summer	Winter	Summer	Winter
	m					
Newspaper	0.32 c[1]	0.34 b	0.15	0.21	0.37 ab	0.40
35 %	0.36 bc	0.34 b	0.16	0.20	0.39 a	0.40
40 %	0.36 bc	0.35 ab	0.15	0.21	0.39 a	0.41
50 %	0.39 ab	0.36 ab	0.16	0.21	0.38 ab	0.41
80 %	0.43 a	0.37 a	0.15	0.19	0.37 b	0.40
F	13.77**	5.02*	1.24^{ns}	2.62^{ns}	3.56*	2.31^{ns}
CV (%)	5.70	3.41	6.28	5.44	1.75	2.09

[1] Distinct letters in the column indicate significant differences for α < 0.5, according to the Tukey test. ^{ns}, * and ** Not significant and significant at 5 and 1 % of probability, respectively, by the F test.

2016). The solar radiation reduction caused by the use of shading screens results in increased auxin and, consequently, etiolation.

Amarante et al. (2009) evaluated the effect of screens on photosynthesis in apple trees and concluded that black shading screens similar to those used in this study reduced the solar radiation and, consequently, sunburn and the potential photosynthetic rate. There are few studies that relate the effect of shading screens and the etiolation of plants in fruit farming, but many studies on vegetables relate the use of shading screens with higher plant length (Costa et al. 2011b, Hirata & Hirata 2015, Hirata et al. 2017). Screens with 35 and 40 % of shading provided fruits with larger diameter, when compared to the screen with 80 % of shading, in the summer. However, although the increase was significant, it was not very representative, varying only 0.02 m. There was a significant difference for all quality characteristics analyzed, except for firmness in the two evaluation periods and pH in the summer (Table 3). There was a tendency for decreasing the qualitative attributes of the fruits with the gradual increase of the shading rate in the plants, especially when compared to the covering of fruits only with newspaper. Fruits subjected to the treatment with 80 % of shading presented increases of 25 and 27 % for the TTA in the summer and winter, respectively, a 30 % decrease for the TTS in the winter, and decreases of 36 and 67 % of the ratio in the summer and winter, respectively, when compared to covering the fruits with newspaper. Screens with 35, 40 and 50 % of shading resulted in more acidic fruits in the winter, in relation to covering the fruits with newspaper. The screens with shading rates of 35 and 40 % also resulted in fruits with a lower pH in the winter, when compared to covering the fruits with newspaper. The pineapple TTA is highly related to climatic variables such as temperature, humidity and maturity stage.

The classification standards establish that pineapple, in order to be considered mature, should present a TSS content of at least 12 ºBrix (CEAGESP 2003), which is the index used to determine the moment of harvest (Gonçalves 2000). The TSS contents in the two seasons remained within the standard commercial limits, except for the treatment using the screen with 80 % of shading, in which the contents obtained were below 12 ºBrix. The gradual increase in shading reduced luminosity, decreasing the solar radiation and, consequently, the photosynthesis and sugar content. Similar results were observed for apple, where the TSS content was also reduced with the use of shading screens (Amarante et al. 2011).

Screens with 80 % of shading provided fruits with ratio of 10.84 and 11.54 in the summer and winter, respectively, being inferior to the treatment in which the fruits were covered with newspaper, with averages of 14.78 and 19.31. Ratio values must be greater than 20. Ratio is the measure that best reflects the consumer's perception of taste (Abílio et al. 2009). Although acidity has a greater impact on the ratio, low sugar contents may also indicate less flavorful fruits. Usually, the ratio may be influenced by cultivar, maturity stage, sampled position in the fruit and fruit development conditions, and may range from 8 to 40 (Bartholomew et al. 2003). Although being very important, there are few studies that relate the influence of the use of shading screens on fruit quality.

Table 3. Total titratable acidity (TTA), total soluble solids (TSS), firmness, pH and TSS/TTA ratio of pineapple fruits ('Smooth Cayenne' cultivar), as a function of covering the fruits with newspaper and covering the plants with screens with different shading rates.

Treatment	TTA		TSS (º Brix)		Firmness (N)		pH		TSS/TTA ratio	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Newspaper	0.84 b[1]	0.76 b	12.38 ab	14.55 a	32.83	32.09	3.85	3.98 a	14.78 a	19.31 a
35 %	0.88 ab	0.98 a	12.92 a	13.93 a	28.91	37.85	3.77	3.75 b	14.45 a	14.49 ab
40 %	0.90 ab	0.91 a	12.57 ab	13.20 a	29.77	41.47	3.79	3.75 b	14.26 a	14.69 ab
50 %	0.91 ab	0.88 a	12.20 ab	13.95 a	31.24	37.85	3.79	3.84 ab	13.44 ab	16.10 ab
80 %	1.05 a	0.97 a	11.22 b	11.20 b	32.83	38.03	3.72	3.86 ab	10.84 b	11.54 b
F	4.04*	3.28*	4.03*	9.79**	0.74^{ns}	1.49^{ns}	1.97^{ns}	6.01*	6.57**	6.61**
CV (%)	8.51	11.16	5.18	6.22	11.27	14.75	1.78	2.05	9.17	14.42

[1] Distinct letters in the column indicate significant differences for α < 0.5, according to the Tukey test. ^{ns}, * and ** Not significant and significant at 5 and 1 % of probability, respectively, by the F test.

Lopes et al. (2014) evaluated the influence of different protections for fruits of the 'Pérola' pineapple cultivar and observed that the physical protection of the fruit was able to provide a good protection against scalding. In the present study, regardless of the time, all the treatments controlled scalding.

CONCLUSIONS

1. The use of screens with 35-50 % of shading provides greater gains in mass and yield for the 'Smooth Cayenne' pineapple cultivar, when compared to covering the fruits with newspaper, especially in the summer;
2. Shading screens with 80 % of shading impair the fruit production and quality.

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REFERENCES

ABÍLIO, G. M. F.; HOLSCHUH, H. J.; BORA, P. S.; OLIVEIRA, E. F. Extração, atividade de bromelina e análise de alguns parâmetros químicos em cultivares de abacaxi. *Revista Brasileira de Fruticultura*, v. 31, n. 4, p. 1117-1121, 2009.

ALMEIDA, J. M.; CALABONI, C. Lisianthus cultivation using differentiated light transmission nets. *Ornamental Horticulture*, v. 22, n. 2, p. 143-146, 2016.

AMARANTE, C. V. T.; STEFFENS, C. A.; ARGENTA, L. C. Yield and fruit quality of 'Gala' and 'Fuji' apple trees protected by white anti-hail net. *Scientia Horticulturae*, v. 129, n. 1, p. 79-85, 2011.

AMARANTE, C. V. T.; STEFFENS, C. A.; MIQUELOTO, A.; ZANARDI, O. Z.; SANTOS, H. P. Disponibilidade de luz em macieiras 'Fuji' cobertas com telas antigranizo e seus efeitos sobre a fotossíntese, o rendimento e a qualidade dos frutos. *Revista Brasileira de Fruticultura*, v. 31, n. 3, p. 664-670, 2009.

ARAQUAM, W. W. C. *Condições microclimáticas em ambientes cobertos com tela de sombreamento cultivados com pimentão no Vale do Submédio do São Francisco*. Dissertação (Mestrado em Engenharia Agrícola) - Universidade Federal do Vale do São Francisco, Juazeiro, 2013.

BARTHOLOMEW, R. E.; PAULL, R. E.; ROHRBACH, K. G. *The pineapple*: botany, production, and uses. London: CABI, 2003.

CARVALHO, S. L. C.; SVJNEVES, C. C.; BÜRKLE, R.; MARUR, C. J. Épocas de indução floral e soma térmica do período do florescimento à colheita de abacaxi 'Smooth Cayenne'. *Revista Brasileira de Fruticultura*, v. 27, n. 3, p. 430-433, 2005.

COMPANHIA DE ENTREPOSTOS E ARMAZÉNS GERAIS DO ESTADO DE SÃO PAULO (CEAGESP). *Programa brasileiro para modernização da horticultura*: normas de classificação do abacaxi. São Paulo: CEAGESP, 2003. (Documentos, 24).

COSTA, C. M. F.; SEABRA JUNIOR, S.; ARRUDA, G. R.; SOUZA, S. B. S. Desempenho de cultivares de rúcula sob telas de sombreamento e campo aberto. *Semina: Ciências Agrárias*, v. 32, n. 1, p. 93-101, 2011b.

COSTA, R. C.; CALVETE, E. O.; REGINATTO, F. H.; RAMBO, A.; LOSS, J. T.; BORDIGNON JÚNIOR, C. Telas de sombreamento na produção de morangueiro em ambiente protegido. *Horticultura Brasileira*, v. 29, n. 1, p. 98-102, 2011a.

DDUNGU, J. C. M. Rooting-behaviour of different types of pineapple propagating material. *Acta Horticulturae*, v. 33, n. 1, p. 155-159, 1973.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO). *FAO global statistical yearbook*. Rome: FAO, 2016.

GIACOMELLI, E. J. *Expansão da abacaxicultura no Brasil*. Campinas: Fundação Cargill, 1982.

GONÇALVES, N. B. *Abacaxi*: pós-colheita. Brasília, DF: Embrapa-SCT, 2000. (Frutas do Brasil, 5).

HIRATA, A. C. S.; HIRATA, E. K. Desempenho produtivo do agrião d'água cultivado em solo sob telas de sombreamento. *Pesquisa Agropecuária Brasileira*, v. 50, n. 10, p. 895-901, 2015.

HIRATA, A. C. S.; HIRATA, E. K.; MONQUERO, P. A. Manejos do solo associados a telas de sombreamento no cultivo da cebolinha no verão. *Horticultura Brasileira*, v. 35, n. 2, p. 298-304, 2017.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). *Censo agropecuário*. 2017. Available at: http://www.sidra.ibge.gov.br. Access on: Sep. 03, 2019.

INSTITUTO DE ECONOMIA AGRÍCOLA (IEA). Agência Paulista de Tecnologia dos Agronegócios. *Quem somos*. São Paulo: IEA-APTA, 2017.

LI, D.; JU, W.; LU, D.; ZHOU, Y.; WANG, H. Impact of estimated solar radiation on gross primary productivity simulation in subtropical plantation in southeast China. *Solar Energy*, v. 120, n. 1, p. 175-186, 2015.

LOPES, O. P.; MAIA, V. M.; SANTOS, S. R.; MIZOBUTSI, G. P.; PEGORARO, R. F. Proteções contra queima solar de frutos de abacaxizeiro submetido a diferentes lâminas de irrigação. *Revista Brasileira de Fruticultura*, v. 36, n. 3, p. 748-754, 2014.

SANTIAGO, E. J. P.; OLIVEIRA, G. M.; RAMOS LEITÃO, M. M. V. B.; ROCHA, R. C.; SILVA, R. R. Condições microclimáticas proporcionadas por tela de sombreamento no cultivo do tomate cereja. *Agrometeoros*, v. 25, n. 1, p. 153-161, 2017.

SANTOS, N. S.; ALVES, J. M. A.; UCHÔA, S. C. P.; SILVA, D. C. O.; BARRETO, G. F.; CASTRO, T. S.; ANJOS, A. J. E. Damage levels of sunburn in pineapple fruits submitted to natural and artificial protection. *Revista Agro@mbiente*, v. 14, n. 1, p. 1-16, 2020.

SPIRONELLO, A.; FURLANI, P. R. Frutíferas: abacaxi. *In*: RAIJ, B. V. *Recomendações de adubação e calagem para o estado de São Paulo*. 2. ed. Campinas: Instituto Agronômico, 2017. p. 128.

TAIZ, L.; ZEIGER, E. *Fisiologia vegetal*. 6. ed. Porto Alegre: Artmed, 2016.

TEIXEIRA, L. A. J.; SPIRONELLO, A.; SIQUEIRA, W. J. *Abacaxi*. Campinas: Instituto Agronômico, 2014.