Agrária - Revista Brasileira de Ciências Agrárias
ISSN (on line) 1981-0997
v.9, n.3, p.359-364, 2014
Recife, PE, UFRPE. www.agraria.ufrpe.br
DOI:10.5039/agraria.v9i3a3658
Protocolo 3658 - 03/07/2013 • Aprovado em 12/03/2014

Growth and cotton yield over row spacing and growth regulator

João V. Ferrari[1], Enes Furlani Júnior[1], Samuel Ferrari[2], Ana P. P. G. Luques[1], Danilo M. A. dos Santos[1], Fabiano de M. Benke[3]

[1] Universidade Estadual Paulista Júlio de Mesquita Filho, Faculdade de Engenharia de Ilha Solteira, Departamento de Fitotecnia, Av. Brasil, 56, Centro, CEP 15385-000, Ilha Solteira, São Paulo, Brasil. E-mail: jao_unesp@hotmail.com; enes@agr.feis.unesp.br; apluques@hotmail.com; dmaires@hotmail.com

[2] Universidade Estadual Paulista Júlio de Mesquita Filho, Campus Experimental de Registro, Rua Nelson Brihi Badur, 430, Centro, CEP 11900-000, Registro-SP, Brasil. E-mail: ferrari@registro.unesp.br

[3] Instituto Nacional de Colonização e Reforma Agrária SR-16 MS, Avenida Afonso Pena, 2403, Centro, CEP 79002-207, Campo Grande-MS, Brasil. E-mail: fabiano.benke@cpe.incra.gov.br

ABSTRACT

Growth regulators and row spacing are an alternative to be considered and planned together and it consists in an effective technology in the establishment most profitable cotton crop. The main objective of this work was to evaluate the influence of row spacing in cotton crops and applications forms of growth regulator on components of cotton growth, production and yield for two growing seasons, 2007/08 and 2008/09 in Selvíria, state of Mato Grosso do Sul, Brazil. The experimental design was the completely randomized blocks arranged in bands and consisted in the following row spacing: 0.45, 0.70 and 0.90 m long. The management of growth regulator (mepiquat chloride - MC) was splitting in four applications (35, 45, 55, and 65 days after emergence - D.A.E.); single application at 70 D.A.E.; and there was no application. The use of growth regulator in a single application, as well in a split application, decreases plant height and stem diameter. Lower values for stem diameter, number of bolls and weight of 20 bolls were observed with the use of 0.45 m row spacing. Highest seed cotton yields were observed by splitting MC application and the use of sowing denser row spacing.

Key words: agronomic characteristics, *Gossypium hirsutum*, mepiquat chloride, yield components

Crescimento e produtividade do algodoeiro em função de espaçamentos e aplicação de regulador de crescimento

RESUMO

A utilização de reguladores de crescimento aliada ao espaçamento entrelinhas é uma das alternativas que se constitui em uma tecnologia eficaz no estabelecimento de lavouras algodoeiras mais lucrativas. O objetivo deste trabalho foi avaliar a influência de diferentes espaçamentos de semeadura do algodoeiro submetidos às formas de aplicação de regulador de crescimento nos componentes de crescimento, da produção e produtividade. O delineamento experimental empregado foi o de blocos ao acaso, disposto em faixas, composto por espaçamentos entrelinhas na semeadura: 0,45, 0,70 e 0,90 m; manejo de regulador de crescimento (cloreto de mepiquat - CM) parcelado em quatro aplicações aos 35, 45, 55 e 65 dias após a emergência (D.A.E.), única aos 70 D.A.E. e sem aplicação. A aplicação de regulador de crescimento, seja na forma única ou parcelada, diminui o desenvolvimento em altura das plantas e de diâmetro do caule. Menores valores para diâmetro do caule, número de capulhos e massa de 20 capulhos, foram encontrados com a utilização de espaçamento adensado de 0,45 m e maiores produtividades de algodão em caroço foram encontradas com aplicação parcelada de CM e pelo uso de espaçamento entrelinhas adensado na semeadura.

Palavras-chave: características agronômicas, *Gossypium hirsutum*, cloreto de mepiquat, componentes de produção

Introduction

Cotton crop (*Gossypium hirsutum* L. r. *latifolium* Hutch*)* plays an important role in the Brazilian economy, represented by 1,090,200 hectares of cultivated area and a production of 1,641,600 tons cotton fiber. The Brazilians states of Mato Grosso, Mato Grosso do Sul, Bahia and Goiás represent the largest yield within the country (Conab, 2014).

The use of different row spacing is one of the phytotechnical factors aimed on seeking the ideal plant population and it can significantly contribute to the development of plants and increased productivity. The cotton plants growing in narrow row spacing potentially shortens the cycle compared to the conventional system, since the final number of bolls per plant is not more than five or six, which decreases the flowering period (Rosolem et al., 2012). In narrow row spacings fruit production per leaf area is larger (Best et al, 1997.), but the total dry matter production can be changed, depending on culture conditions (Silva et al., 2006). Research carried out with cotton plant, both outdoors and in Brazil are not consistent with regard to a better plant population, to be a cotton species with morphological plasticity when analyzed only the quantitative aspect of the yield.

The use of growth regulators is an alternative, which consists in an effective technology in the establishment of increasing profitable crops. When cotton grows with no limitations in moisture content and the adequate nutrient availability, produces excessive vegetation, which interferes negatively in the yield, thereby it turns inevitable the use of growth regulator (Ferrari et al., 2008, Oliveira et al., 2012).

The effects of mepiquat chloride (MC) on cotton plant are dependent on several factors, such as temperature, row spacing and plant density, sowing season, cultivar and fertilization (Bogiani & Rosolem, 2009). Cotton plants treated with MC are typically more compact, with fewer nodes (Reddy et al., 1990), shorter internodes and fewer reproductive branches. It also concentrates boll set on lower sympodia, increasing the synchrony of boll maturation and demand for photosynthate (Gwathmey & Clement, 2010).

Therefore, the objective of this work was to evaluate the influence of cotton row spacing and applications forms of growth regulator on cotton growth components, yield and yield components over a period of two years.

Material and Methods

The experiment was performed in Selvíria, city from Brazilian State of Mato Grosso do Sul (MS), in a region of Cerrado native vegetation (20º20'S latitude, 51º24'W longitude and altitude of 344 m). The region shows an Aw type climate according to the Köppen classification, defined as tropical-humid with rainy summer and dry winter; an annual average temperature of 24.5 ºC, an annual average precipitation of 1.232 mm and an annual average relative humidity of 64.8%. The soil was classified as an Oxisol (very clayed) with 500, 50 and 450 g kg^{-1} of clay, silt and sand, respectively.

In 2005, the area was cultivated with cotton crop in the conventional soil tillage system. Soil samples were collected on June 2006 for the characterization of chemical attributes. The analysis produced the following results: organic matter (OM) = 24 g dm^{-3}; pH($CaCl_2$) = 4.9; phosphorus (P resin) = 10 mg dm^{-3}; potassium (K), calcium (Ca), magnesium (Mg), potential acidity (H+Al), exchangeable acidity (Al) and cation exchange capacity (CEC) (mmol$_c$ dm^{-3}) = 4.6, 18, 10, 24, 0 and 57, respectively; and base saturation (V%) = 57%.

In the crop year 2006/07, it was held millet sowing, strain BN-2, previously to cotton sowing to supply biomass, with average of dry biomass of 6.5 t ha^{-1}. For the remaining crop years (2007/08 and 2008/09), the cotton crop was preceded by millet sowing in September of each year and produced 6.1 and 6.6 t ha^{-1} respectively.

The experimental design was done by using randomized blocks and the treatments consisted of the following row spacing at sowing operation: 0.90 m, 0.70 m and 0.45 m. The use of the growth regulator MC, with a rate of 1.0 L ha^{-1}, concentration of 50 g L^{-1} has been applied only to 70 days after emergence (D.A.E.); The applications methods consisted in split application (35, 45, 55 and 65 D.A.E.) and the treatment without application of growth regulator. Applications were performed in the morning over the leaves of cotton crop.

It was used cotton (*Gossypium hirsutum*, Delta Opal cultivar) for sowing, which occurred in November 21, 2007 and in November 27, 2008. For the seeds treatment it was used carbofuran and carboxin+thiram (100 g a.i. for 100 kg of seeds). Each experimental unit was consisted of four rows (5 m long, spaced 0.9 m apart). Seedling emergence occurred five days after sowing, in which eight seedlings per linear meter was remained, resulting in a total population about 88,900, 114,300 and 178,000 plants per hectare for the row spacing 0.90 m, 0.70 m and 0.45 m respectively. This cotton cultivar was chosen due to its high productivity under the local field conditions (Ferrari et al., 2008).

In both years a tractor-drawn seeder-fertilizer applicator was used, with 200 kg ha^{-1} of NPK at a 08-28-16 proportion in the sowing furrow. For covered fertilization was used 60 kg ha^{-1} of N divided in two doses at 35 and 55 D.A.E. In the first application it was used urea source and for the second one it was used ammonium sulfate source.

Weeds, pests and diseases were monitored and controlled to guarantee homogeneous cotton growth and development in all experimental plots. The area was irrigated whenever needed during seedling emergence and crop establishment. In one month was applied in both years 120 mm of water. The accumulated in the crop year 2007/08 was 1280 mm and 1158 mm in the crop year 2008/09.

Measurements were performed in 10 cotton plants, in which plant height at 2007/08 in 32, 46, 66, 102 and 116 D.A.E and 2008/09 in 30, 60, 90 and 130 D.A.E. was measured with tape measure, ranging from the topsoil to the apex of the plant. The stem diameter, in the same dates of measurements, was died with a caliper rule in a height of 0.02 m above the soil. The number of bolls per plant was carried out by counting during the harvest, and the weight of 20 bolls, picked randomly in the middle third of the plants and it was weighted with a digital weighter and, the seed cotton yield was obtained by hand harvesting two central rows of each plot, which occurred in

April 2008 and April 2009, at 150 and 152 D.A.E. respectively. After harvesting the crop debris were destroyed using a rotary shredder coupled to a tractor mower.

The results were submitted to variance analysis by F test at 5 and 1% probability and the averages compared by Tukey test at 5% probability, using the program Sisvar version 5.3 (Ferreira, 2011).

Results and Discussion

The mean did not have significant differences for row spacing (Tables 1 and 2) through the comparison between the plants height of two years study (2007/08 and 2008/09).

It was found that the cotton crop cycle beginning 32 and 30 D.A.E. (Table 1 and 2 respectively) have no significant difference for plant height, and it can be explained by the treatment without application of growth regulator in their plots. After 46 D.A.E., considering the effect of the first split application of MC, it was found smaller plants in the plots that received the product. At 66 D.A.E. only application had a average height higher in 0.19 m (Table 1).

For the assessments performed at 102 and 116 D.A.E. (Table 1) the split application of MC resulted in lower cotton plant height compared with the control treatment and only application. The results of this work confirm those found by Teixeira et al. (2008) who found significant differences among single and split application of growth regulator, and the further development of plants in a single application.

In Table 2, at 60 D.A.E., with three applications of MC, plants had lower height compared to the other treatments. At 90 D.A.E., the plants which had received split application were shorter in height than a only application and they differ from plants without application. By analyzing 110 and 130 D.A.E. it was found that the method of split application from MC provides reducing of plant height, resulting in up to 0.37m difference among treatments. These results highlight the efficiency of the use of MC as growth regulator and a systemic product, mainly absorbed by the green parts of the plan and also included in the group of inhibitors of gibberellic acid biosynthesis (cell elongation inhibitor) (Taiz & Zeiger, 2009, Nagashima et al., 2010, Rosolem et al., 2013). Zanon (2002) said that even using or not growth regulator, the differences range in the order of 0.19 m between the treatments. Athayde & Lamas (1999) studied several times the rates of growth regulator and they found height differences of up to 0.34 m between plants with or without the application. These results were similar to those found by Ferrari et al. (2008).

At 32 D.A.E. (Table 3) the cotton plants presented no statistical difference between treatments for stem diameter.

Table 1. Cotton plants height to Delta Opal cultivar according to the respective treatments. Selvíria, state of Mato Grosso do Sul, Brazil, 2007/08

	Height (m)				
	32 D.A.E.	**46 D.A.E.**	**66 D.A.E.**	**102 D.A.E.**	**116 D.A.E.**
			F test		
Row Spacing (R)	1.74	2.23	0.28	1.55	2.94
Grow Regulator (G)	0.78	23.58**	5.56**	30.53**	44.41**
R*G	2.25	1.57	0.39	0.28	0.52
Row Spacing			Tukey test		
0.90	0.350	0.684	1.160	1.298	1.341
0.70	0.358	0.707	1.127	1.257	1.306
0.45	0.361	0.676	1.119	1.246	1.283
Grow Regulator					
Without	0.359	0.732 a	1.163 ab	1.372 a	1.411 a
Only	0.359	0.704 a	1.215 a	1.295 b	1.333 b
Split	0.352	0.631 b	1.027 b	1.135 c	1.186 c
C.V. (%)	4.47	5.41	12.46	5.99	4.53
D.M.S.	0.016	0.038	0.144	0.077	0.060

**, * Significant F test, at p<0.05 and p<0.01, respectively, by the analysis of variance.
Means followed by the same letters in the columns do not differ by Tukey test (p<0.05).
D.A.E. - Days after emergency.

Table 2. Cotton plants height to Delta Opal cultivar according to the respective treatments. Selvíria, state of Mato Grosso do Sul, Brazil, 2008/09

	Height (m)				
	30 D.A.E.	**60 D.A.E.**	**90 D.A.E.**	**110 D.A.E.**	**130 D.A.E.**
			F test		
Row Spacing (R)	1.22	2.62	1.17	2.82	3.21
Grow Regulator (G)	0.11	35.22**	39.98**	65.47**	81.57**
R*G	0.09	0.74	0.33	0.44	0.73
Row Spacing			Tukey test		
0.90	0.390	0.858	1.329	1.366	1.407
0.70	0.403	0.835	1.278	1.303	1.342
0.45	0.390	0.872	1.323	1.378	1.412
Grow Regulator					
Without	0.392	0.885 a	1.489 a	1.568 a	1.610 a
Only	0.395	0.903 a	1.268 b	1.280 b	1.313 b
Split	0.397	0.777 b	1.173 c	1.200 b	1.239 b
C.V. (%)	6.12	4.66	6.78	6.14	5.42
D.M.S.	0.024	0.040	0.090	0.084	0.076

**, * Significant F test, at p<0.05 and p<0.01, respectively, by the analysis of variance.
Means followed by the same letters in the columns do not differ by Tukey test (p<0.05).

Table 3. Cotton plant stem diameter to Delta Opal cultivar according to the respective treatments. Selvíria, state of Mato Grosso do Sul, Brazil, 2007/08

	Diameter (mm)				
	32 D.A.E.	46 D.A.E.	66 D.A.E.	102 D.A.E.	116 D.A.E.
			F test		
Row Spacing (R)	1.63	10.67**	37.50**	27.71**	32.81**
Grow Regulator (G)	0.91	2.08	3.59*	4.19*	5.80**
R*G	2.71	0.75	2.60	2.27	2.90*
Row Spacing			Tukey test		
0.90	5.69	10.55 ab	13.98 a	14.53 a	14.91
0.70	6.03	11.01 a	14.50 a	15.29 a	15.58
0.45	5.81	10.01 b	11.98 b	12.98 b	13.42
Grow Regulator					
Without	5.74	10.75	13.81 a	14.63 a	15.01
Only	5.98	10.34	13.63 ab	14.41 ab	14.77
Split	5.80	10.55	13.03 b	13.75 b	14.12
C.V. (%)	7.85	4.65	5.57	5.44	4.57
D.M.S.	0.47	0.50	0.77	0.79	0.68

**, * Significant F test, at p<0.05 and p<0.01, respectively, by the analysis of variance.
Means followed by the same letters in the columns do not differ by Tukey test (p<0.05).

On evaluating 46 D.A.E. it was noted that the intermediate row spacing had higher stem diameter compared to the closer spacing. For other ratings (66 and 102 D.A.E.) it was found that plants that have grown in larger spacing (0.90 and 0.70 m) presented higher values of stem diameter. Zanon (2002) conduced studies with cultivars Delta Opal, IAC 23 and CD 401 observed an increasing stem diameter in larger spacing.

In evaluations at 32 and 46 D.A.E. (Table 3), it was not found significant differences in stem diameter by using MC. Sobrinho et al. (2007) that using cotton cultivar BRS-200, at 20 and 40 D.A.E., and testing different rates of mepiquat chloride, found no difference between treatments. Significant differences were found at 66 and 102 D.A.E., having smaller stem diameter plants that had the split application of growth regulator (Table 3). This information coupled with the decrease in plant height (Table 1 and 2) indicates that it is an important strategy on the control of cotton plants vegetative development; these results also found by Zanon (2002).

Analyzing of Table 4, it was observed an interaction effect between the treatments, noticing that only the row spacing of 0.90 m plants that received only or split applications had lower stem diameter. However, when assessing the different methods of growth regulator application, it was found that in the absence of the product, sowing denser row spacing resulted in smaller stem diameter. Nonetheless, for a single rate application, it was found that the intermediate spacing had lower diameter.

At 30 and 60 D.A.E. (Table 5), cotton plants presented similar stem diameter for different row spacing, confirming that the beginning of cotton crop cycle the interrelationships plant/competition offered did not significantly influence by the treatments. At 90 and 110 D.A.E., denser row spacing (0.45 m) promoted smaller stem diameter when compared to wider row spacing, and 130 D.A.E. both denser as intermediate row spacing differ significantly with row spacing at 0.90 m. These results demonstrate that over one cycle cotton plants cv. Delta Opal become sensitive mainly by competition for nutrients and light (Jost & Cothren, 2000; Silva et al., 2006), the 0.45 m row spacing, where the competition is greater, presented the smaller stem diameter. For the second growing season (2008/09, Table 5), the methods of growth regulator application did not affect the values of stem diameter.

Table 4. Row spacing and growth regulator interaction of cotton plant stem diameter. Selvíria, state of Mato Grosso do Sul, Brazil, 2007/08

Row spacing	Diameter (mm)		
	116 D.A.E.		
	Without	Only	Split
0.90	16.03 aA	14.63 bB	14.08 abB
0.70	15.75 a	15.83 a	15.15 a
0.45	13.28 b	13.85 b	13.13 b
F		2.90*	
C.V. (%)		4.57	
D.M.S.		1.18	

* Significant F test, at p<0.05 by the analysis of variance.
Means followed by the same capital letters horizontally, minuscule in vertically do not differ by Tukey test (p<0.05).

For agricultural years of studies, the smallest number of bolls per plant were observed in the denser spacing (0.45 m), it means that as the distance between sowing lines increases, the competition between plants for light, water and nutrients also increase. Similarly, Zanon (2002) on studying cotton plants cv. Delta Opal, IAC 23 and CD 401, and and Boquet (2005) on studying cotton plants cv. Suregrow 125RR and Suregrow 501BR in three years verified the highest number of bolls per plant cultivation in wider row spacing.

The different management of growth regulator did not alter significantly the number of bolls per plant in both years of cultivation (Table 6). These results show that the MC has no function to change the number of reproductive structures in plants, but with regard to their vegetative growth (Tables 1, 2 and 3). Similar results were found by Athayde & Lamas (1999) and Zanon (2002), where no significant difference results in the number of bolls per plant by using different rates, times and methods to use growth regulator.

Note that the different row spacing promoted significant influence at mass of 20 bolls in the agricultural year 2008/2009, and sowing denser row spacing promote lower values when compared to conventional sowing (0.90 and 0.70 m), indicating that the cultivar Delta Opal has further development of bolls in larger spacing. According Bednarz et al. (2000), the row spacing have the potential to affect the distribution of bolls on flowering plants and this may influence the individual boll weight, since the weight thereof can vary with cotton boll position on the branch node and to the main stem.

For both years studied, application of growth regulator did not influence significantly the weight of 20 bolls (Table

Table 5. Cotton plant stem diameter to Delta Opal cultivar according to the respective treatments. Selvíria, state of Mato Grosso do Sul, Brazil, 2008/09

	Diameter (mm)				
	30 D.A.E.	**60 D.A.E.**	**90 D.A.E.**	**110 D.A.E.**	**130 D.A.E.**
			F test		
Row Spacing (R)	3.10	2.43	5.13*	4.13*	4.44*
Grow Regulator (G)	0.33	0.28	0.15	0.06	0.15
R*G	0.65	0.12	0.73	0.61	0.49
Row Spacing			Tukey test		
0.90	8.21	14.78	18.11 a	19.71 a	20.14 a
0.70	7.73	15.11	16.79 ab	18.02 ab	17.64 b
0.45	7.56	13.30	16.06 b	17.01 b	17.53 b
Grow Regulator					
Without	7.92	14.75	17.19	18.08	18.31
Only	7.71	14.34	16.86	18.25	18.75
Split	7.88	14.10	16.91	18.40	18.25
C.V. (%)	8.44	14.90	9.35	12.75	13.15
D.M.S.	0.67	2.19	1.62	2.37	2.47

**, * Significant F test, at p<0.05 and p<0.01, respectively, by the analysis of variance.
Means followed by the same letters in the columns do not differ by Tukey test (p<0.05).

Table 6. Bolls per plant, weight of 20 bolls and yield of seed cotton Delta Opal cultivar due to row spacing and growth regulator. Selvíria, state of Mato Grosso do Sul, Brazil

	Bolls per plant (nº)		Weight of 20 bolls (g)		Yield (kg ha^{-1})	
	2007/2008	**2008/2009**	**2007/2008**	**2008/2009**	**2007/2008**	**2008/2009**
			F test			
Row Spacing (R)	12.20**	4.48*	1.90	9.66**	0.50	3.89*
Grow Regulator (G)	1.69	0.23	1.17	0.75	3.58*	0.65
R*G	0.29	0.10	0.28	2.45	0.19	1.13
Row Spacing			Tukey test			
0.90	17.00 a	17.64 a	102.09	98.11 a	1941.75	2900.49 ab
0.70	16.40 a	17.17 ab	100.89	97.15 a	1859.33	2446.98 b
0.45	13.48 b	14.03 b	97.33	92.27 b	1905.33	3163.04 a
Grow Regulator						
Without	14.94	15.94	97.91	95.13	1778.00 b	2447.32
Only	15.61	16.78	100.82	95.58	1924.25 ab	3008.34
Split	16.34	16.11	101.59	96.82	2004.17 a	2754.85
C.V.(%)	11.96	19.73	6.22	3.64	10.61	22.43
D.M.S.	1.91	3.28	6.35	3.56	205.79	648.84

**, * Significant F test, at p<0.05 and p<0.01, respectively, by the analysis of variance.
Means followed by the same letters in the columns do not differ by Tukey test (p<0.05).

6). Likewise, Athayde & Lamas (1999), conclude finding no difference between treatments with different rates of the growth regulator, neither when compared to control.

Evaluating the first crop year (2007/08, Table 6) it was found that the different row spacing did not significantly alter the seed cotton yield. These results match with those found by Clawson et al. (2006) while studying three and four row spacing (0.19, 0.38, 0.76 m) found no significant differences in the fiber yield. Already analyzing the second growing season (2008/09), it was observed that higher seed cotton yields were found for the smallest row spacing (0.45 m) compared to the intermediate row spacing, demonstrating that the cultivar has proper capacity to adapt to different spacing, since, although the number of bolls per plant was lower when compared to the conventional row spacing (Table 6), the greater number of cotton plants in the same area that can effectively in supply cotton bolls (Boquet, 2005; Ferrari et al., 2008) there is since that each plant needs to produce only 5 to 6 bolls (Rosolem et al., 2012). In denser row spacing fruit yield by unit leaf area is larger (Best et al., 1997). The first year (2007/08, Table 6), had higher seed cotton yield with applied split growth regulator application compared to plants that did not receive the MC. The highest yield found to relate to the efficiency that the growth regulator has to promote a more uniform opening of cotton bolls at harvest.

Conclusions

The use of growth regulator in a single application, as well in a split application, decreases the development in plant height and stem diameter.

Lower values for stem diameter, number of bolls and weight of 20 bolls were found with the use of 0.45 m row spacing.

Highest seed cotton yields were found by splitting MC application and the use of sowing denser row spacing.

Acknowledgements

To Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) for supporting this work.

Literature Cited

Athayde, M. L. F.; Lamas, M. F. Aplicação seqüencial de cloreto de mepiquat em algodoeiro. Pesquisa Agropecuária Brasileira, v.34, n.3, p.369-375, 1999. <http://seer.sct.embrapa.br/index.php/pab/article/view/5192/2384>. 15 Mai. 2013.

Bednarz, C. W.; Bridges, D. C.; Brown, S. M. Analysis of cotton yield stability across population densities. Agronomy Journal, v.92, n.1, p.128-135, 2000. <http://dx.doi:10.2134/agronj2000.921128x>.

Best, E. C.; Riney, J. B.; Krieg, D. R. Factors affecting source-sink relations in cotton. In: Beltwide Cotton Conferences, 1997, Memphis. Proceedings… Memphis: National Cotton Council of America, 1997. v.2, p.1387-1389.

Bogiani, J. C.; Rosolem, C. A. Sensibilidade de cultivares de algodoeiro ao cloreto de mepiquat. Pesquisa Agropecuária Brasileira, v.44, n.10, p.1246-1253, 2009. <http://dx.doi.org/10.1590/S0100-204X2009001000006>.

Boquet, D. J. Cotton in ultra-narrow row spacing: Plant density and nitrogen fertilizer rates. Agronomy Journal, v.97, n.1, p.279-287, 2005. <http://dx.doi.org/10.2134/agronj2005.0279>.

Clawson, E. L.; Cothren, J. T.; Blouin, D. C. Nitrogen fertilization and yield of cotton in ultra-narrow and conventional row spacings. Agronomy Journal, v.98, n.1, p.230-245, 2006. <http://dx.doi.org/10.2134/agronj2005.0033>.

Companhia Nacional de Abastecimento - CONAB. Acompanhamento de safra brasileira: algodão, quinto levantamento, fevereiro 2014. Brasília: Conab, 2014. 31p.

Cordão Sobrinho, F. P.; Fernandes, P. D.; Beltrão, N. E. M.; Soares, F. A. L.; Terceiro Neto, C. P. C. Crescimento e rendimento do algodoeiro BRS-200 com aplicações de cloreto de mepiquat e lâminas de irrigação. Revista Brasileira de Engenharia Agrícola e Ambiental, v.11, n.3, p.284-292, 2007. <http://dx.doi.org/10.1590/S1415-43662007000300007>.

Ferrari, S.; Furlani Júnior, E.; Ferrari, J. V.; Santos, M. L.; Santos, D. M. A. dos. Desenvolvimento e produtividade do algodoeiro em função de espaçamentos e aplicação de regulador de crescimento. Acta Scientiarum. Agronomy, v.30, n.3, p.365-371, 2008. <http://dx.doi.org/10.4025/actasciagron.v30i3.3546>.

Ferreira, D. F. SISVAR: a computer statistical analysis system. Ciência e Agrotecnologia, v.35, n.6, p.1039-1042, 2011. <http://dx.doi.org/10.1590/S1413-70542011000600001>.

Gwathmey, C. O.; Clement, J. D. Alteration of cotton source-sink relations with plant population density and mepiquat chloride. Field Crops Research, v.116, n.1, p.101-107, 2010. <http://dx.doi.org/10.1016/j.fcr.2009.11.019>.

Jost, P.H.; Cothren, J.T. Growth and yield comparisons of cotton planted in conventional and ultra-narrow row spacings. Crop Science, v.40, n.3, p.430-435, 2000. <http://doi:10.2135/cropsci2000.402430x>.

Nagashima, G. T.; Miglioranza, E.; Maurur, C. J.; Yamaoka, S.; Silva, J. G. R. Desenvolvimento do algodoeiro em resposta a modo de aplicação e doses de cloreto de mepiquat via sementes. Ciência Rural, v.40, n.1, p.7-11, 2010. <http://dx.doi.org/10.1590/S0103-84782009005000236>.

Oliveira, F. de A. de; Medeiros, J. F. de; Oliveira, F. R. A. de; Freire, A. G.; Soares, L. C. da S. Produção do algodoeiro em função da salinidade e tratamento de sementes com regulador de crescimento. Revista Ciência Agronômica, v.43, n.2, p.279-287, 2012. <http://dx.doi.org/10.1590/S1806-66902012000200010>.

Reddy, V. R.; Baker, D. N.; Hodges, H. F. Temperature and mepiquat chloride on cotton canopy architecture. Agronomy Journal. v.82, n.2, p.190-195, 1990. <http://dx.doi.org/10.2134/agronj1990.00021962008200020004x>.

Rosolem, C. A.; Echer, F. R.; Lisboa, I. P.; Barosa, T. S. Acúmulo de Nitrogênio, fósforo e potássio pelo Algodoeiro Sob Irrigação Cultivado em Sistemas Convencional e Adensado. Revista Brasileira de Ciência do Solo. v.36, n.2, p.457-466, 2012. <http://dx.doi.org/10.1590/S0100-06832012000200015>.

Rosolem, C. A.; Oosterhuis, D. M.; Souza, F. S. de. Cotton response to mepiquat chloride and temperature. Scientia Agricola, v.70, n.2, p.82-87, 2013. <http://dx.doi.org/10.1590/S0103-90162013000200004>.

Silva, A. V.; Chiavegato, J. E. B.; Carvalho, L. H.; Kubiak, D. M. Crescimento e desenvolvimento do algodoeiro em diferentes configurações de semeadura. Bragantia, v.65, n.3, p. 407-411, 2006. <http://dx.doi.org/10.1590/S0006-87052006000300006>.

Taiz, L.; Zeiger, E. Fisiologia vegetal. Porto Alegre: Artmed, 2009. 719p.

Teixeira, I. R.; Kikuti, H.; Borém, A. Crescimento e produtividade de algodoeiro submetido a cloreto de mepiquat e doses de nitrogênio. Bragantia, v.67, n.4, p.891-897, 2008. <http://dx.doi.org/10.1590/S0006-87052008000400011>.

Zanon, G. D. Manejo de cultivares de algodoeiro em densidade populacional variável com o uso de regulador de crescimento. Piracicaba: Escola Superior de Agricultura “Luiz de Queiroz”, Universidade de São Paulo, 2002. 112p. Dissertação Mestrado. <http://www.teses.usp.br/teses/disponiveis/11/11136/tde-08012003-091325/publico/graciela.pdf>. 15 Mai. 2013.