Planting density and arrangement for the mechanized spraying of vertically staked tomatoes

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ABSTRACT

We aimed to determine an adequate planting density and arrangement for the mechanized spraying of vertically staked tomatoes. Two experiments were carried out in the 2013/14 and 2014/15 harvests in the city of Calmon, state of Santa Catarina, Brazil, both in randomized block design. In 2013/14, treatments were arranged in a 4x2 factorial, corresponding to four planting densities (10,753, 12,903, 16,129 and 21,505 plants/ha) and two planting arrangements (single and double rows). In 2014/15, treatments were arranged in a 5x2 factorial, corresponding to five plant densities (the same planting densities of the previous harvest beyond 32,258 plants/ha) and the same planting arrangements. Total, marketable (considering extra AA and extra A fruits as marketable) and unmarketable yield, the average mass of marketable fruits and severity of leaf diseases were evaluated. Economic analysis was also performed. For tomatoes grown under mechanized spraying, double row plantings resulted in higher yield of marketable fruits and a higher percentage of top grade fruits compared to single row plantings. Maximum fruit yield was reached at approximately 34,000 plants/ha, although maximum revenue was estimated for 23,000 plants/ha. Bacterial spot and Septoria leaf spot severity were higher in double rows than in single rows. Increases in planting density resulted also in increases in bacterial spot and early blight severity.

Keywords: *Solanum lycopersicon*, cropping system, mechanization, disease severity, economic analysis.

RESUMO

Densidade e arranjo de plantas para pulverização mecanizada do tomateiro tutorado verticalmente

O objetivo do presente estudo foi determinar a melhor densidade e arranjo do tomateiro tutorado verticalmente para a pulverização mecanizada. Foram realizados dois experimentos nas safras 2013/14 e 2014/15 em Calmon-SC. Na safra 2013/14, o delineamento experimental foi em blocos ao acaso com arranjo fatorial 4x2, sendo combinados quatro densidades de plantas (10.753, 12.903, 16.129 e 21.505 plantas/ha) e dois arranjos de plantas tutoradas verticalmente (fila simples e fila dupla). Na safra 2014/15, o delineamento experimental foi em blocos ao acaso com arranjo fatorial 5x2, representado pela combinação de cinco densidades de plantas (10.753, 12.903, 16.129, 21.505 e 32.258 plantas/ha) e de dois arranjos de plantas tutoradas verticalmente (fila simples e fila dupla). Avaliou-se a produtividade total, comercial (extra AA e extra A) e descarte, a massa média de frutos comerciais (extra AA e extra A), a severidade de doenças folia-res e procedeu-se a análise econômica dos tratamentos. O arranjo de plantas em fila dupla, para a pulverização mecanizada do tomateiro, proporcionou maior produtividade de frutos comerciais e com maior porcentagem de frutos de melhor classificação, em comparação ao arranjo de plantas em fila simples. A máxima produtividade de frutos foi obtida na densidade de aproximadamente 34.000 plantas/ha, embora a densidade em que se obtém o maior retorno econômico é estimada em 23.000 plantas/ha. As maiores severidades de mancha bacteriana e septoriose foram observadas no arranjo de plantas em fila dupla, em relação ao arranjo de plantas em fila simples. O aumento da densidade de plantas aumentou a severidade de mancha bacteriana e de pinta preta.

Palavras-chave: *Solanum lycopersicon*, sistema de cultivo, mecanização, severidade de doença, análise econômica.

The city of Caçador and surrounding region (Lebon Régis, Rio das Antas, Macieira and Calmon) are the main tomato producer zone in the state of Santa Catarina and the second largest national table tomato producing area in summer (Carazzato *et al.*, 2015). In harvest 2012/13, 1,122 ha were estimated to be used to grow tomatoes, with an average yield estimated at 79.6 t/ha (Anater, 2015). Sharecroppers and contracted employees are the predominant labor force in the region (Wamser *et al.*, 2015) and labor represents approximately 30% of production costs (Deleo *et al.*, 2015). Tomato demands intensive labor due to the several and repeated cultural practices required during the cycle as, for example, phytosanitary sprayings (Mueller *et al.*, 2008).

Sprays in Caçador region are numerous due to the high incidence of insect pests (Santos *et al.*, 2008) and to the mild temperature and frequent rain observed between December and February, which favors the occurrence of the main tomato diseases (Becker, 2005). Sprays are predominantly manual, using stationary sprayers and spray rods, which constantly expose operators to drift, increasing intoxication risks (Santos, 2010). In addition, operator fatigue may reduce application efficiency along the work, which is also compromised by the shortage of qualified labor in the region (Wamser *et al.*, 2015). Producers say high labor costs, risks of operator intoxication, deficiency in application and shortage of qualified labor justify the adoption of mechanized spraying systems in tomato. Systems in use consist of turbo atomizers coupled in the power take-off of narrow tractors, with an approximate width of 1.30 m.

The use of mechanized sprayings affected crop management in tomatoes, especially in fields with vertical plant staking. Corridor spacing, between single rows, increased from 1.3-1.6 m (Mueller *et al.*, 2008) to 2.0-2.2 m and arrangements in double vertical rows were adopted, using 0.8 to 1.0 m spacing within the double row. Double row plantings, for example in cross-over or inverted "V", can result in losing many advantages of vertical single-row staking, among them spraying both sides of plants (Picanço *et al.*, 1995). Spraying both sides increases plant phytosanitary coverage and the efficiency in controlling diseases and pest insects (Wamser *et al.*, 2008; Becker *et al.* 2011). In addition, vertical plant staking in single rows increases the incidence of solar radiation and ventilation of plant canopies and, by reducing leaf wetness, reduces also disease severity (Santos *et al.*, 1999).

Planting arrangements using single rows with reduced spacing between plants, keeping the same plant density currently used by producers in double rows, are alternatives to overcome problems inherent to double row plantings. It is also possible to broaden the spacing between plants in double rows, improving the efficiency of phytosanitary sprayings, with positive consequences on crop production. Any changes in the planting staking system have economic impacts and can increase or decrease production costs. This aspect should also be considered when choosing the best staking system for tomato.

The correct management of tomato fields for mechanized spraying needs studies, aiming to improve the control of diseases and insect pests and to allow also for high productivity, good fruit quality and economic return to producers. The objective of this work was to determine the best planting density and arrangement for mechanized spraying of vertically staked tomatoes.

MATERIAL AND METHODS

Two on-farm experiments were carried out during harvests 2013/14 and 2014/15 in the city of Calmon, state of Santa Catarina, Brazil (26°37'43"S, 50°57'24"W, 1,208 m altitude). The climate in the region is constant humid subtropical, with mild summers, Cfb type according to the Köppen classification. Soil at the experimental areas was classified as humic Cambisol (FAO, 1994) with the following attributes: pH (water)= 6.1 and 6.4, P= 19.8 and 20.1 mg/dm^3, K= 90 and 246 mg/dm^3, OM= 38 and 38 g/dm^3, Al= 0.0 and 0.0 cmolc/dm^3, Ca= 8.8 and 18.1 cmolc/dm^3, Mg= 7 and 4.8 cmolc/dm^3, V%= 79 and 72, in 2013/14 and 2014/15 seasons, respectively.

In 2013/14, treatments consisted of four planting densities (10,753, 12,903, 16,129 and 21,505 plants/ha) and two planting arrangements (single or double rows), with vertically staked plants, in a 4x2 factorial design. In 2014/15, treatments and plant staking were as in the previous harvest, but with one additional planting density (32,258 plants/ha), in a 5x2 factorial. In both years, experiments were set in randomized blocks, with four replications.

Experimental plots were 6.0 m long in all treatments. In double rows, internal spacing was 0.9 m, with 2.1 m between double rows, while in-row spacings were 0.6, 0.5, 0.4, 0.3 and 0.2 m, corresponding to 10,753, 12,903, 16,129, 21,505 and 32,258 plants/ha, respectively. In single rows, the spacing between rows was 2.1 m and, between plants, 0.42, 0.35, 0.28, 0.21 and 0.14 m, corresponding to the same densities as in double rows. Sampling areas of experimental plots were 9.0 and 12.6 m^2 for arrangements in double and single rows, respectively.

The indeterminate-growth tomato hybrid Paronset was used. Seedlings were produced in plastic trays, using a substrate of coconut-husk powder and vermiculite. Seedlings were transplanted to the field on November 22, 2013, and November 26, 2014. Furrow planting fertilization consisted of 50 kg/ha N as ammonium nitrate, 20 kg/ha of K$_2$O as potassium chloride, 300 kg/ha of P$_2$O$_5$ as triple superphosphate, 7 t/ha of poultry litter and 5 kg/ha of B as borax, in both years. Split fertilization was carried out weekly, starting 21 days after planting (DAP) and summing up 450 kg/ha of N and 475 kg/ha of K$_2$O using the same sources as for furrow fertilization, also in both seasons.

Plastic ribbons were used to vertically stake plants, which were conducted with two stems and periodic sprout pruning. Sprayings were carried out using a turbo atomizer model ARBO 480 (Montana, São José dos Pinhais, Brazil), coupled to the power take-off of a tractor model Montana 40 (Landini, Fabbrico, Italy), using volumes from 200 L/ha (from the beginning of the cycle to the beginning of harvest) to 550 L/ha (from the beginning to the end of harvest). Products used are registered to tomatoes and target pests and withholding periods were observed (Ministério da Agricultura, Pecuária e Abastecimento, 2016). Other cropping practices were carried out according to technical indications for staked tomatoes in the region of the Alto Vale do Rio do Peixe (Mueller *et al.*, 2008).

Tomatoes were harvested weekly as fruits reach the harvest point that is when apical ends turned reddish. Total, marketable (fruits extra AA, larger than

150 g; and extra A, between 100 and 150 g) and unmarketable yield were assessed, as well as average mass of marketable fruits (extra AA and extra A). Unmarketable yield corresponded to both small (less than 100 g) and damaged fruits, either physiological damages or injuries caused by diseases or insect pests. Disease severity, as function of the natural occurrence of late (*Phytophthora infestans*) and early (*Alternaria solani*) blight, bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) and *Septoria* leaf spot (*Septoria lycopersici*), was also assessed, 131 and 105 days after planting (DAP) in 2013/14 and 2014/15, respectively. Symptom severity was measured using diagrammatic scales for late (James, 1971) and early (Boff *et al.*, 1991) blights and bacterial spot (Mello *et al.*, 1997). For the *Septoria* leaf spot, the percentage of infected leaf area was evaluated by means of a diagrammatic scale previously developed (Walter Ferreira Becker, unpublished data).

For economic analysis, average prices for 23 kg-box of extra AA tomatoes paid to producers at Caçador from February to April in 2014 and in 2015 (Sabio *et al.*, 2014, 2015), corresponding to US$ 14.4 and US$ 11.6, respectively, were considered. Prices paid to extra A fruits were assumed as 65% of prices paid to extra AA fruits. Production costs in 2013/14 and 2014/15 were taken as described by Deleo *et al.* (2015), adjusting costs of seeds, nursery, seedling replanting and stakes (plastics or bamboo) according to planting densities and the need for temporary labor. Cost analysis considered an employee for each 5,500 plants, receiving the current minimum wage and a commission of US$ 0.56 and US$ 0.47 per harvested box in 2013/14 and 2014/15, respectively (Deleo *et al.*, 2015). Other production costs, such as inputs (fertilizers, lime, pesticides and adjuvants), infrastructure (maintenance and replacement), mechanical operations, irrigation, fixed labor, expenses with implements, general expenses, land leasing, working capital financing and the annual cost for asset renewal (ACAR) were assumed to be fixed in all treatments.

Data were submitted to analysis of variance (F test). Once significant differences were detected (p≤0.05), polynomial adjustments for plant density were applied. Statistical analysis was performed using the package ExpDes (v.1.1.2) of the software R (v.3.1.2).

RESULTS AND DISCUSSION

There was no significant interaction (p>0.05) between planting arrangement and density for none of the evaluated characteristics. Therefore, only simple effects of each factor were studied.

Planting arrangement in double rows resulted in higher total and marketable yield in both harvests, as well as in higher yield of extra AA fruits in 2013/14 and higher yield of extra A fruits in 2014/15, compared to single rows (Figures 1 and 2). In 2013/14, marketable and extra AA fruits produced in double rows had higher average mass and therefore extra AA fruits had a significantly higher contribution to total marketable yield than when plants were arranged in single rows (Table 1). On the other hand, in 2014/15, the average mass of extra A fruits was higher in plants in single than in double rows (Table 1).
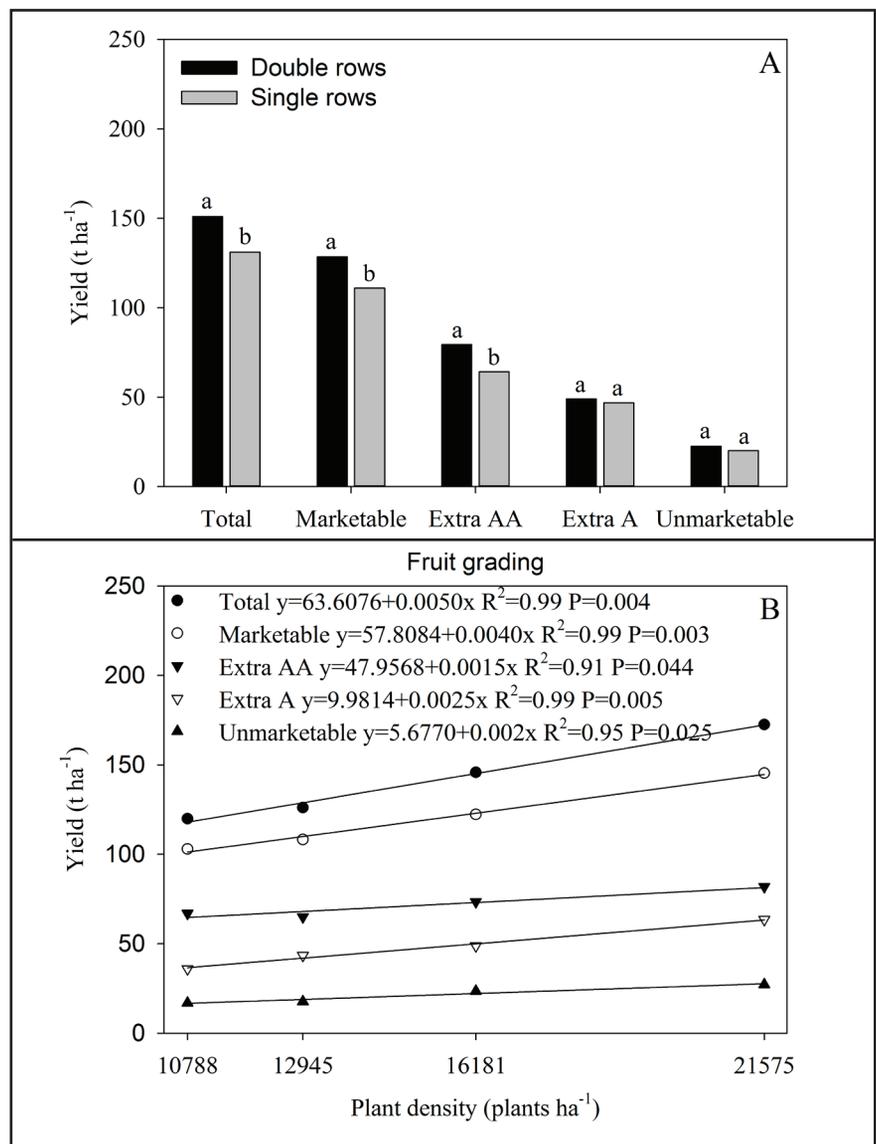
These results indicate that, for

Figure 1. Total, marketable, extra AA, extra A, and unmarketable fruit yield of tomatoes grown under mechanized spraying as function of planting arrangement (A) and density (B), 2013/14 harvest. Means followed by the same letter in each fruit class do not differ from each other, F test, p>0.05. Caçador, Epagri, 2015.

tomato mechanized spraying, planting arrangements in double rows significantly increase yield and fruit quality in relation to plantings in single rows, which is likely to be due to the larger in-row spacing in double rows in relation to single rows. Broadening in-row spacing increases fruit production per plant up to a threshold (Azevedo *et al.*, 2010). Thus, for a given plant density, arrangements with larger spacing between plants result in higher yields, as we observed.

The severity of both bacterial spot, in 2013/14, and *Septoria* leaf spot, in 2014/15, were higher in double row than in single row plantings (Table 2), strengthening the hypothesis that, for plant vertical staking, double row planting favors disease occurrence when compared to single row. Possibly, sprayings on only the plant side facing the row reduce fungicide coverage and, thus, fungicide efficiency. It is also possible that the internal row in the double row is less ventilated and consequently more humid, enhancing the pro-disease microenvironment. Wamser *et al.* (2008) and Becker *et al.* (2011) observed similar results when comparing vertical and cross staking systems, in which plants are also sprayed only on the side facing the row.

The highest productivity in double rows resulted in higher net revenue in double rows than in single rows in both years (Table 3). In 2013/14, net revenue from double row plantings was US$ 9,866.10 higher than those obtained in single rows. In 2014/15, the increase in net revenue in double rows was US$ 2,403.74 in relation to single rows. These increases represented gains of 35.7 and 9.7%, respectively, in double row plantings in relation to single row arrangements. The highest increase in 2013/14 was mainly due to the higher yield of extra AA fruits observed in this harvest in double rows when compared to single rows (Figure 1). In 2014/15, there were no significant differences between planting arrangements for yield of extra AA fruits. In addition, yield of extra A fruit was significantly higher in single rows than in double rows in this harvest (Figure 2). Emphasis must be given to the great impact extra AA fruits

have in revenues, since extra AA fruits have higher commercial value than extra A fruits (CEAGESP, 2016).

Increases in planting density raised the productivity for all fruit classes in 2013/14 (Figure 1). Data adjustments resulted in linear models and, therefore, no maximum technical efficiency was reached within the planting density range studied. Effects of planting density on increasing tomato yield are well described in literature (Azevedo *et al.*, 2010; Wamser *et al.*, 2009, 2012). Nevertheless, determination of the optimum density, in which maximum

marketable fruit yield would be reached, has been receiving little attention.

In 2014/15, increases in planting density also increased productivity in all fruit classes, except for extra AA fruits (Figure 2). As one more level in the planting density factor was included in this harvest (32,258 plants/ha), quadratic adjustments for total and marketable fruit yield, as well as for yield of extra A fruits, were obtained. Yet, models indicate maximum technical efficiencies to be reached above the maximum plant densities evaluated, that is, 38,189, 33,892 and 34,465 plants/ha,
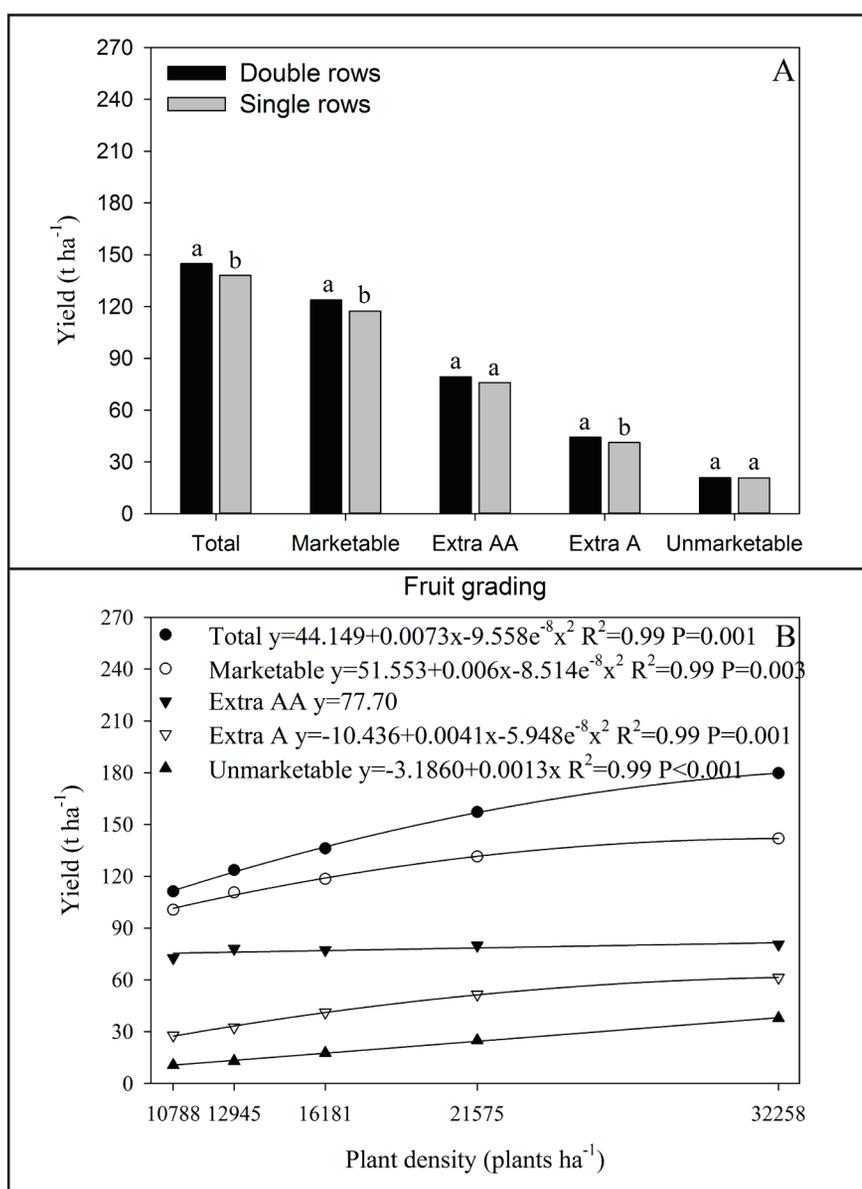

Figure 2. Total, marketable, extra AA, extra A, and unmarketable fruit yield of tomatoes grown under mechanized spraying as function of planting arrangement (A) and density (B), 2014/15 harvest. Means followed by the same letter in each fruit class do not differ from each other, F test, p>p0.05. Caçador, Epagri, 2015.

Table 1. Mass of marketable, extra AA and extra A tomatoes, percentage of marketable fruits in total production and percentage of extra AA fruits in marketable production, for plants grown under mechanized spraying as function of planting arrangement and density, 2013/14 and 2014/15 harvests. Caçador, Epagri, 2015.

Factor levels	Harvest 2013/14, fruit average mass (g)			Harvest 2014/15, fruit average mass (g)		
	Marketable	Extra AA	Extra A	Marketable	Extra AA	Extra A
Planting arrangement						
Double-rows	156.4**	184.1**	120.9ns	152.9ns	174.8ns	123.7**
Single-rows	152.1	175.6	122.4	154.0	174.9	125.3
Planting density (plants/ha)						
10,788	156.4**	183.3**	123.0ns	161.5**	180.6**	126.6**
12,945	152.1	181.8	122.2	159.5	178.6	126.8
16,181	149.3	177.0	121.0	153.0	173.6	125.0
21,575	147.2	177.2	120.6	149.0	172.9	122.7
32,258	-	-	-	144.3	168.6	121.3
Regression	$y=163.4777-0.0008x$	$y=188.9187-0.0006x$	$y=121.7$	$y=184.1871-0.0025x+3.895e^{-8}x^2$	$y=184.6939-0.0005x$	$y=129.5582-0.0003x$
R²	0.88	0.75	-	0.99	0.88	0.92

Factor levels	Marketable/ total fruit production (%)	Extra AA/marketable fruit production (%)	Marketable/total fruit production (%)	Extra AA/marketable fruit production (%)
Planting arrangement				
Double-rows	85.2ns	62.2**	86.1ns	64.8ns
Single-rows	84.7	57.9	85.7	65.4
Planting density (plants/ha)				
10,788	85.8ns	64.4**	90.4**	72.2**
12,945	85.8	59.8	89.5	70.7
16,181	83.8	59.9	87.0	65.3
21,575	84.5	56.3	83.6	60.7
32,258	-	-	78.9	56.7
Regression	$y=85.0$	$y=70.0439-0.0006x$	$y=96.1176-0.0005x$	$y=92.7444-0.0022x+3.425e^{-8}x^2$
R²	-	0.84	0.99	0.99

** =significant, F test, p>0.01; ns =non-significant.

respectively for total, marketable and extra A fruit yield. Streck *et al*. (1998) observed maximum yield of marketable tomatoes with 43,862 plants/ha, in protected cultivation.

In 2013/14, there were increases of 43.9, 41.2, 22.2, 76.6 and 60.7% in total, marketable, extra AA, extra A and unmarketable fruit yield, respectively, from the lowest to the highest planting density. The increase in productivity of extra A fruit, whose commercial value is lower than extra AA fruits, had stronger influence on the increase in marketable yield as function of the rising planting densities than the increase of extra AA fruits, whose commercial value is higher than that of extra A fruits. Participation of extra AA fruits in marketable production fell (Table 1), although not enough to have significantly reduced the marketable yield contribution to total yield (Table 1).

In 2014/15, increases in total, marketable, extra A and unmarketable fruit yield were 61.6, 41.1, 119.9 and 256.2%, respectively, from the lowest to the highest density. The increase in productivity of extra A fruits, with lower commercial value than extra AA fruits, was the only factor increasing marketable productivity as function of the mounting plant densities. As consequence, the proportion of extra AA fruits in marketable production declined (Table 1). In this harvest, as there was no increase in yield of extra AA fruits as function of increases in density, marketable fruit participation in total yield fell (Table 1).

Marketable, extra AA and extra A fruit mass decreased with the increase in planting density in both years, except for extra A fruit mass in 2013/14, when there were no significant differences in extra A fruit mass as function of variation in planting density (Table 1). Decreases in fruit quality (fruit grading and mass) related to increases in planting density are well described in literature for tomatoes (Azevedo *et al*., 2010; Wamser *et al*., 2009, 2012) and are due to competition between plants (Papadopoulos & Pararajasingham,

Table 2. Leaf disease severity in tomato grown under mechanized spraying as function of planting arrangement and density, 2013/14 and 2014/15 harvests. Caçador, Epagri, 2015.

Factor level	Bacterial spot	Early blight[1]	Late blight[1]	Septoria leaf spot[1]
	Harvest 2013/14			
Planting arrangement				
Double-rows	37.44*	-	-	-
Single-rows	28.81	-	-	-
Planting density (plants/ha)				
10,788	27.75ns	-	-	-
12,945	35.13	-	-	-
16,181	32.88	-	-	-
21,575	36.75	-	-	-
	Harvest 2014/15			
Planting arrangement				
Double-rows	35.23ns	0.44ns	0.01ns	2.07**
Single-rows	33.50	0.49	0.01	0.74
Planting density (plants/ha)				
10,788	29.13*	0.28*	0.01ns	1.46ns
12,945	30.00	0.31	0.00	0.74
16,181	35.31	0.31	0.01	0.92
21,575	35.00	0.66	0.03	1.79
32,258	42.38	0.75	0.01	2.09
Regression	$y=23.2310+0.0006x$	$y=0.0049+2.4382e^{-5}x$	-	-
R^2	0.93	0.87	-	-

[1]/ Early and late blight and Septoria leaf spot did not occurr in 2013/14. * Factor levels differed significantly from each other, F test, $P > 0.05$; **Factor levels differed significantly from each other, F test, $P > 0.01$. ns/ There were no significant differences between factor levels, F test, $P > 0,05$.

1997).

Increases in planting density resulted in higher severity of bacterial spot and early blight (Table 2). Wamser *et al.* (2012) observed related results for early blight and emphasize increments on plant density favor disease occurrence in tomatoes.

Net revenue increased with planting densities in both harvests (Table 3). In 2013/14, increases in net revenue followed a linear adjustment [net revenue (NR), in US$/ha, NR= 13,906.9846 + 1.1966 x density], resulting in US$ 12,234.98 or 43.5% increase in net revenue in the highest density in relation to the lowest. In 2014/15, increases in net revenue followed a quadratic adjustment [Net revenue (NR), in US$/ha, NR= 11,742.1358 + 1.4105 x density - 3.0631e^{-5} x density^2]. In 2014/15, maximum economic efficiency

was estimated with 23,033 plants/ha, a density 2.1 times greater than what is commonly used by producers of Caçador region, in general, 11,000 plants/ha (Deleo *et al.*, 2015). Net revenue increase observed in the highest in relation to the lowest planting densities evaluated was US$ 5,111.60 or 22.4%.

Increases in planting density lead to increases also in labor cost. Nevertheless, labor cost can be compensated for by increasing efficiency, namely the number of plants each worker handles. According to Oliveira (2006), in high-density tomato fields, the number of plants managed per unit of labor is larger than in fields with lower planting densities. For example, in production systems with 44,000 stems per hectare, it is possible for each worker to handle about 13,000 stems per cycle (Oliveira, 2006), while in the traditional

systems, with 22,000 stems per hectare, each worker handles not more than 11,000 stems per cycle (Deleo *et al.*, 2015). Thus, the high number of plants managed by each worker may, in fact, contribute to improving revenues at higher planting densities.

In crops with mechanized spraying, planting arrangements in double rows resulted in higher marketable fruit yield and higher percentage of fruits with good grading than arrangements in single rows, in the studied region. The highest yield was estimated with approximately 34,000 plants per hectare. Nevertheless, the highest economic return (net revenue) was estimated to take place with 23,000 plants per hectare. Bacterial spot and *Septoria* leaf spot severity were higher in double row than in single rows plantings. Increases in plant density led to increases in both

Table 3. Net revenue of tomatoes grown under mechanized spraying as function of planting arrangement and density, harvests 2013/14 and 2014/15. Caçador, Epagri, 2015.

Factor level	Gross revenue	Cost (US$/ha)				Net revenue
		Seeds and seedlings	Staking material[1]	Labor[2]	Total[3]	
Harvest 2013/14						
Planting arrangement						
Double-rows	69,677.33	2,211.09	1,183.97	10,726.27	32,207.12	37,470.21
Single-rows	59,219.40	2,211.09	1,010.12	10,308.30	31,615.29	27,604.11
Planting density (plants/ha)						
10,788	56,559.06	1,551.70	951.59	7,833.01	28,422.10	28,136.96
12,945	58,338.47	1,861.96	1,020.03	9,037.68	30,005.46	28,333.00
16,181	65,818.61	2,327.41	1,122.70	10,979.79	32,515.70	33,302.91
21,575	77,073.26	3,103.27	1,293.84	14,218.41	36,701.32	40,371.94
Harvest 2014/15						
Planting arrangement						
Double-rows	54,407.74	1,762.87	915.07	8,819.88	26,662.37	27,745.38
Single-rows	51,748.28	1,762.87	787.70	8,691.52	26,406.64	25,341.64
Planting density (plants/ha)						
10,788	45,651.80	1,237.16	730.61	5,668.18	22,800.49	22,851.31
12,945	49,883.71	1,484.52	787.44	6,597.62	24,034.12	25,849.59
16,181	52,314.66	1,855.62	872.69	7,847.41	25,740.27	26,574.39
21,575	56,999.33	2,474.20	1,014.80	9,926.72	28,580.26	28,419.06
32,258	60,545.44	3,699.31	1,296.24	13,738.87	33,898.97	26,646.47

[1]/ Wires and anchor and regular stakes – polythene strips and bamboo; [2]/ Monthly wages, labor charges and commission per harvested box; [3]/ Refer to variable costs, dependent of evaluated factors – seeds and seedlings, material for staking and labor – and fixed costs, independent of evaluated factors, namely US$ 18,085.80 and US$ 14,426.22 per hectare in 2013/14 and 2014/15 harvests, respectively (Deleo *et al.*, 2015). Reference exchange rates: R$ 1,00 = US$ 0,42, in March 15, 2014; R$ 1,00 = US$ 0,31, in March 15, 2015.

bacterial spot and early blight severity.

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