Universidade Federal Rural do Semi-Árido
Pró-Reitoria de Pesquisa e Pós-Graduação
https://periodicos.ufersa.edu.br/index.php/caatinga

ISSN 0100-316X (impresso)
ISSN 1983-2125 (online)
http://dx.doi.org/10.1590/1983-21252022v35n204rc

INTERCROPPING OF EGGPLANT AND TOMATO AS FUNCTION OF TIMES OF TRANSPLANT AND CROPPING SEASON[1]

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ABSTRACT - The use of intercropping system allows crops to better utilize inputs supplied and the productive capacity of the area, which can be advantageous to the farmer. Thus, the aim of this study was to evaluate the production performance of eggplant and industrial tomato intercropped as a function of the date of eggplant transplantation compared with tomato transplantation, in two seasons. Ten dates of eggplant transplantation were evaluated (-30, -25, -20, -15, -10, -5, 0, + 5, +10 and +15 days compared with tomato transplantation), with the first season from February to September 2009 and the second from August 2009 to February 2010. The number of commercial fruits per plant, commercial yield per plant and commercial yield of eggplant and tomato were influenced by the date of transplanting of eggplant. Highest eggplant yields were obtained in the second season, due to the more favorable weather conditions for the development of this crop. Late eggplant transplants resulted in yield losses due to tomato interference. For tomatoes, the later the eggplant was transplanted, the higher the yield. Therefore, it is concluded that the species have a high degree of interference with each other and the variation in the time of eggplant transplantation influenced the production characters of both crops. In terms of production, the intercropping of these species may not be economically viable for the farmer due to negative influences on the growth, development and production of these crops.

Keywords: Cropping systems. *Solanum lycopersicum. Solanum melongena.* Commercial Yield.

CONSÓRCIO DE BERINJELEIRA E TOMATEIRO EM FUNÇÃO DA DATA DE TRANSPLANTIO E ÉPOCA DE CULTIVO

RESUMO - A utilização do sistema consorciado permite às culturas explorar melhor os insumos utilizados e a capacidade produtiva da área, podendo ser vantajoso ao produtor. Assim, o objetivo deste estudo foi avaliar o desempenho produtivo da berinjela e do tomate indústria consorciados em função da data de transplante da berinjela em relação ao tomate, em duas épocas. Foram avaliadas 10 datas de transplante de berinjela (-30, -25, -20, -15, -10, -5, 0, + 5, +10 e +15 dias em relação ao transplante de tomate), sendo a primeira época de fevereiro a setembro de 2009, e a segunda de agosto de 2009 a fevereiro de 2010. O número de frutos comerciais por planta, a produtividade comercial por planta e a produtividade comercial de berinjela e tomate foram influenciadas pela data de transplante da berinjela. As maiores produtividades de berinjela foram obtidas na segunda safra, devido às condições climáticas mais favoráveis para o desenvolvimento dessa cultura. Os transplantes tardios de berinjela acarretaram em perdas na produtividade devido a interferência do tomate. Para o tomate, quanto mais tardio o transplante da berinjeleira, maior foi a produtividade. Portanto, conclui-se que as espécies apresentam alto grau de interferência umas nas outras e que a variação na época do transplante da berinjela influenciou nos caracteres produtivos de ambas culturas. Em termos produtivos, o consórcio dessas espécies pode não ser economicamente viável ao produtor devido as influências negativas no crescimento, desenvolvimento e produção dessas culturas.

Palavras-chave: Associação de culturas. *Solanum lycopersicum. Solanum melongena.* Rendimento comercial.

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[1]Received for publication in 12/07/2020; accepted in 09/17/2021.
Paper extracted from the doctoral thesis of the second author.
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INTRODUCTION

In Brazil, more than 70% of vegetable production comes from family farming (FAO, 2014), for which crop diversification is a strategy for an economic sustainability of the property. Thus, intercropping has proved to be a viable option for these producers, since the use of this cultivation system can provide savings on inputs and increase food production per unit area, consequently, increasing the profitability of the activity, with less environmental impact (NASCIMENTO et al., 2018).

The efficiency of the intercropping depends directly on the management of the cropping system adopted (CECÍLIO FILHO et al., 2011; BEZERRA NETO et al., 2012; RIBAS et al., 2020). Among the management factors, the moment of establishment of the intercropping is one of the main (CECÍLIO FILHO; MAY, 2002), as it affects both the period of species coexistence and the time of the cycles in which this occurs. Studying the moment of the establishment of the intercropping aims to minimize competition between species and maximize the temporal and/or spatial complementarity between crops (CECÍLIO FILHO et al., 2015; SANDHU et al., 2020). Cecílio Filho, Rezende and Dutra (2019) observed that the later the transplanting of lettuce compared with cucumber transplanting, the lower the degree of complementarity, since lettuces transplanted later received lower levels of solar radiation, which reduced yield. Efficiency losses in the vegetable intercropping have also been observed by Cecílio Filho et al. (2011, 2015) and Rezende et al. (2011), due to the high competition (low complementarity) between the intercropped vegetables with late sowing or transplanting from one crop to another.

The growing season is another important modifying factor in the interaction between the species involved in the intercropping. Nascimento et al. (2018) found that the growing season affected the viability of the lettuce and rocket intercropping because, regardless of the rocket sowing density, the fresh weight of the lettuce was greater in winter than in summer. Cecílio Filho et al. (2011), evaluating the intercropping of lettuce and tomatoes, observed that the yields of both crops were higher in the autumn/ winter. These authors point out that the difference in crop yields between harvests is a response to climatic conditions since the temperature has a high influence on the yield of horticultural crops.

The determination of intercropping efficiency may be based on factors such as fruit production and quality. Studying the intercropping of eggplant with beans, romaine lettuce, curly lettuce and taro, Güvenç and Yildirim (2005) and Brito et al. (2017) did not observe negative influence of intercropping on the number of fruits per plant, weight of fruits and final yield of eggplant. A similar response was obtained by Cecílio Filho et al. (2011), who evaluated the intercropping of tomato and lettuce and did not observe reductions in yield and classification of tomato fruit. Therefore, such results indicate that, since they do not suffer negative effects when intercropped, these crops are likely to be used in this cultivation system.

Despite the advantages of intercropping, studies evaluating the efficiency of the intercropping between tomato and eggplant have not been found in the literature. The aim of this work was to evaluate the production performance of eggplant and tomato in intercropping as a function of the eggplant transplant times compared with the tomato transplant and the growing seasons.

MATERIAL AND METHODS

Characteristics of experimental area

Two experiments were carried out in open field in two cropping seasons at UNESP, Jaboticabal, State of São Paulo, Brazil (21º15'22"S 48º18'58"W and altitude of 575 m). The first season was from February 12 to September 5, 2009, and the second season was from August 8, 2009, to February 20, 2010.

The soil in the area is classified as a Rhodic Eutrudox (SANTOS et al, 2018). Soil samples collected at 0.2 m depth in the first and second cropping seasons were analyzed and showed the following results, respectively: pH ($CaCl_2$) = 5.7 and 5.2; OM = 32.0 and 16.3 g dm^{-3}; P resin = 129 and 81 mg dm^{-3}, K = 2.6 and 5.3 $mmol_c$ dm^{-3}, Ca = 25.8 and 24.7 $mmol_c$ dm^{-3}, Mg = 16.8 and 12.3 $mmol_c$ dm^{-3} and BS = 72 and 55%. The climatic conditions during the period of the experiments are shown in Figure 1. (Data obtained from the UNESP meteorological station, municipality of Jaboticabal, São Paulo State, Brazil).

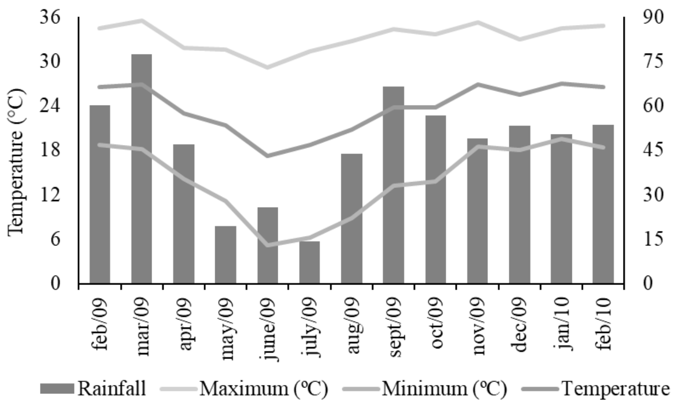

Figure 1. Monthly average of maximum (Tmax, ºC), minimum (Tmin, ºC) and average temperature (Tmed, ºC), and rainfall in the experimental area during the experiment.

Treatments and experimental design

In each experiment, 21 treatments were evaluated in a randomized complete block design in 2 x 10 + 1 factorial scheme, with four replications. The treatments corresponded to two cropping systems (intercropping and monoculture) and 10 eggplant transplanting times (-30, -25, -20, -15, -10, -5, 0, 5, 10 and 15 days after tomato transplanting). For each intercropping treatment, there was one corresponding monoculture of eggplant. The additional treatment corresponded to tomato monoculture.

The experimental plot in each experiment measured 9.10 m^2 in area (1.30 x 7.0 m) and contained seven plants of eggplant and 21 plants of tomato. The tomato and eggplant plants used for evaluating the characteristics under study were 15 and 5 plants taken from the central portion of the plant bed, respectively (Figure 2).

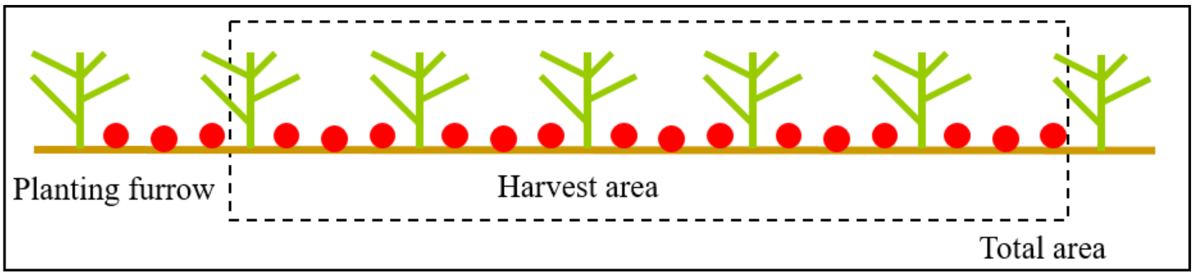

Figure 2. Representation of an experimental unit and arrangement of crops in intercropping system.

The hybrids 'Napoli F_1' of eggplant and AP 529 of industrial tomato were used because they are the most cultivated in the State of São Paulo. Based on chemical analysis of the soil, lime with RNV 126%, CaO 48% and MgO 16% was applied in the entire area, to raise soil base saturation to 80%, as recommended by Trani, Nagai and Passos (1997). Because of higher fertilizer doses recommended by these authors for eggplant than for tomato, doses of nutrients recommended for eggplant (TRANI et al., 1997) were applied in the plots of intercropping and eggplant in sole crop. In the plots of tomato in sole crop, the planting fertilization followed the recommendation of Trani, Nagai and Passos (1997). The fertilizers were applied in planting furrows in the layer of 0.2 m. Top-dressing fertilizations were performed in both cropping seasons, based on the recommendations of Trani et al. (1997) and Trani, Nagai and Passos (1997), for each species, applying the fertilizers about 5 cm away from the plants. In the intercropping systems, fertilization was performed for both species.

The eggplant and tomato were sown in 128-cell expanded polystyrene trays. The seedlings were transplanted when they had six leaves. In monoculture and intercropping, the eggplant was transplanted at the spacing of 1.30 x 1.00 m and tomato at 1.30 x 0.33 m.

During the experiment, weed control was carried out by hand weeding. Phytosanitary treatments with fungicides, insecticides and acaricides were also performed when necessary. Irrigation was applied by a sprinkler system.

Both species were evaluated for nutritional status, number of commercial fruits per plant, commercial yield per plant and commercial yield. Commercial eggplants were those with a characteristic shape of the cultivar, without deformations and defects that would hinder their commercialization. Fruits that were malformed, bruised and discolored were considered as non-commercial (MONTEIRO, 1975; NODA, 1980). Commercial tomato fruits were those with a transverse diameter greater than 33 mm and without defects (diseases, pests, physiological disorders and/ or physical damage) (MACHADO; ALVARENGA; FLORENTINO, 2007).

Statistical analysis

Combined analyses of variance of data of the experiments were performed using SAS software (CODY; SMITH, 2004). Tukey test was used to compare the cropping seasons and the cropping systems. Regression equations were fitted for the characteristics assessed as a function of times of eggplant transplant compared with tomato transplant using the software program Table Curve (JANDEL SCIENTIC, 1991). The averages for each characteristic obtained as a function of times of eggplant transplant compared with tomato transplant were compared individually to the average of monoculture by Dunnett's test at 5% probability level (BANZATTO; KRONKA, 2006).

RESULTS AND DISCUSSION

Eggplant

There was no significant interaction between cropping systems, times of eggplant transplanting and cropping season for the contents of macronutrients (N, P, K, Ca, Mg and S) and micronutrients (B, Cu, Fe, Mn and Zn) in the diagnostic leaf, which indicated the nutritional status of eggplant.

Significant effects of the cropping season were observed on the contents of K, Ca, Mg, Cu and Fe. The mean values observed for these nutrients in the first and second cropping seasons were 59.4 and 56.4 g kg^{-1}, 15.6 and 17.8 g kg^{-1}, 3.8 and 5.7 g kg^{-1}, 13.7 and 15.9 mg kg^{-1} and 139.6 and 144.8 mg kg^{-1}, respectively. For N, P, S, B, Mn and Zn, the mean contents observed were 52.4, 2.75 and 1.23 g kg^{-1}, 51.2, 49.4 and 108.9 mg kg^{-1}, respectively. According to the results, all nutrient values are within the appropriate levels for eggplant according to Trani et al. (2018).

Regarding the production aspects of eggplant, there was a triple interaction among crop season, cropping systems and times of transplanting on the number of commercial fruits per plant (NCFP), commercial yield per plant (CYP) commercial yield (CY) of eggplant.

When considering the times of transplanting within cropping systems in the first crop season, it was observed that there were reductions of 21.63 and 26.90 in the number of commercial fruits per plant , of 5.95 and 6.88 kg plant^{-1} in the commercial yield per plant and 52451.15 and 43069.46 kg ha^{-1} in the commercial yield of eggplant, in the intercropped system and sole crop, respectively, when the transplant of eggplant changed from -30 to +15 days after tomato transplant - DATT (Figures 3A, 3C and 3E). In the second crop season, there were also decreases in these characteristics as a function of times of eggplant transplantation, but only for intercropping (Figures 3B, 3D and 3F).

In the monoculture, the differences in the response of eggplant for each crop season are explained by the thermal characteristics of each season. The number of harvests of eggplants was smaller when these plants were transplanted later than tomato due to low temperatures that occurred during the experiment, which did not happen with eggplant in the second cropping season, characterized by temperatures suitable for the development of these plants (Figure 1).

Low temperatures undermine the development of eggplant, being one of the major climatic factors that affect flowering and fruiting (FILGUEIRA, 2013). Temperatures below 14 ºC inhibit growth, flowering and fruiting, and the ideal range for fruit set occurs between 28 and 34 °C (REIS et al, 2007). In the first crop season, there were temperatures below 14 °C, especially during June and July, with means of minimum temperatures ranging from 5.4 to 18.4 ºC. In the second crop season, the mean minimum temperatures ranged between 17.5 and 22.1 °C, which are adequate temperatures for the development and proper production of eggplant.

Low temperatures bring about several changes in plant metabolism, such as changes in cell cycle, accumulation of sugars and changes in the composition of photosynthetic pigments (TAIZ; ZEIGER, 2006), reducing the operational efficiency of leaf photosynthesis. Therewith, the plant accumulates reactive oxygen species (ROS), which can damage the photosynthetic apparatus and indirectly reduce photosynthetic efficiency (YANG et al., 2018). In low temperature scenarios, although plants continue to carry out photosynthesis, the photoassimilates are not converted into growth, reducing the growth and production characters of the crop (ZHAO et al., 2019).

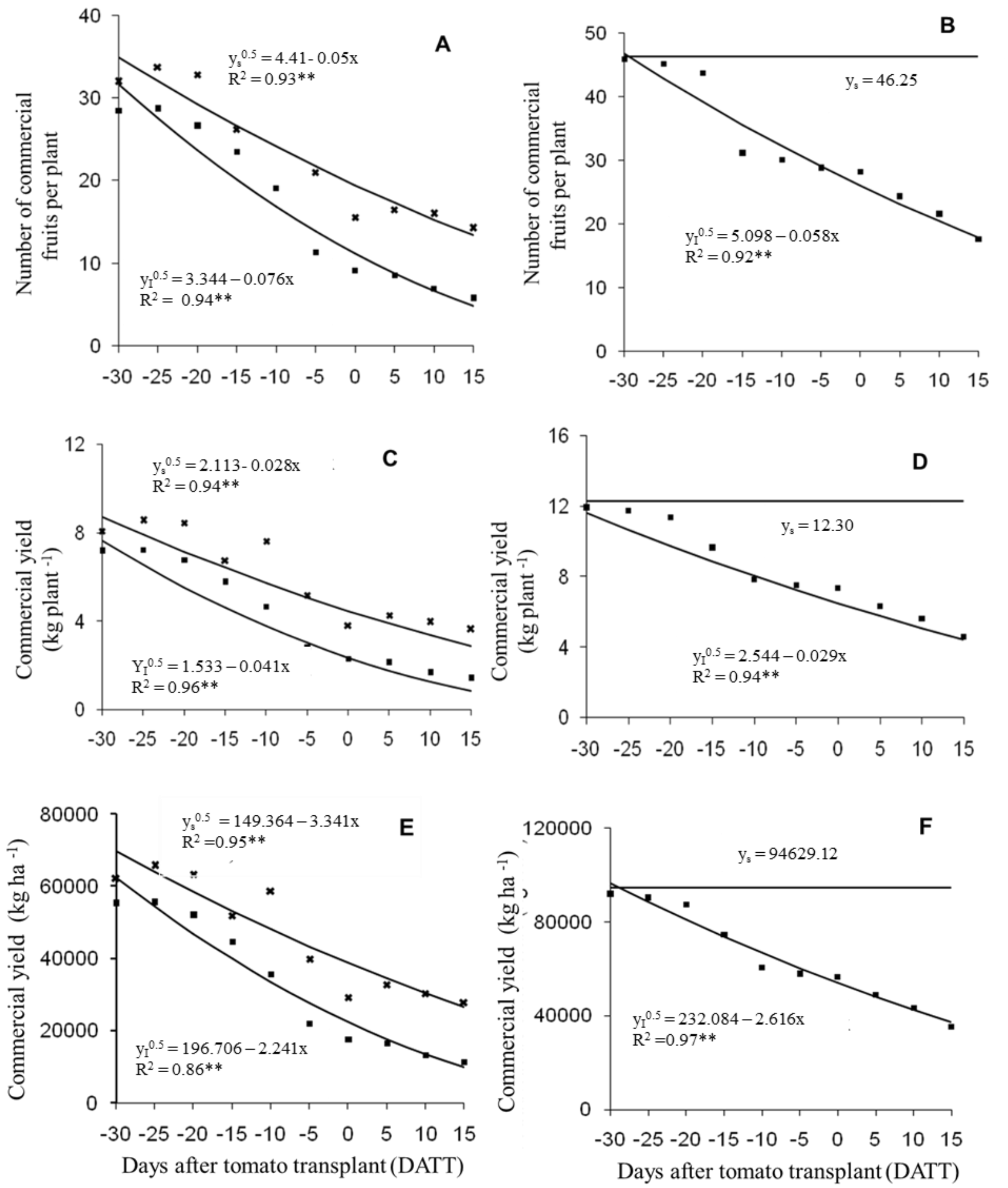

Figure 3. Number of commercial fruits per plant, commercial yield per plant and commercial yield of eggplant in monoculture (Y_S) and intercropping (Y_I) in the first time of planting (A, C and E) and in the second planting time (B, D and F), as a function of times of eggplant transplants in relation to the tomato.

The effect of cropping season on the feasibility of intercropping of lettuce and rocket was observed by Barbosa et al. (2015), who found that higher values of fresh mass of lettuce and rocket were obtained in the first cropping season (April to June). According to these authors, the second cropping season (August to September) had higher temperatures, which negatively influenced the production of fresh mass. Cecílio Filho, Rezende and Dutra (2019) also observed better performance of cucumber intercropped with lettuce in one of the evaluated growing seasons, which had temperatures within the ideal range for the development of the cucumber crop.

In the intercropping system, besides the temperature, the interspecific competition also adversely affected the traits evaluated in the eggplant transplanted later than tomato. This caused large reductions in the number of commercial fruits per plant, commercial yield per plant and commercial yield of eggplant.

The later the transplantation of eggplant, the greater the interference of tomato over eggplant, and the larger the loss in the yield components (Figure 3). This occurred because, at the time of transplanting of eggplants, the tomato plants had greater height and leaf area (Table 1).

Table 1. Plant height and leaf area of eggplant and tomato at the times of transplant tomato.

Treatments	Plant height (cm)		Leaf Area (cm^2 plant^{-1})	
	Eggplant	Tomato	Eggplant	Tomato
-30 DATT[1]	9.3	12.1	598.9	97.8
-25 DATT	8.9	12.1	496.4	97.8
-20 DATT	8.7	12.1	459.5	97.8
-15 DATT	8.1	12.1	322.8	97.8
-10 DATT	7.9	12.1	214.9	97.8
-5 DATT	7.5	12.1	119.5	97.8
0 DATT	7.2	12.1	102.6	97.8
+5 DATT	7.2	18.7	102.6	439.0
+10 DATT	7.2	21.6	102.6	685.4
+15 DATT	7.2	24.8	102.6	1,201.9
Tomate in monoculture	-	21.1	-	97.8

[1]DATT: Days after tomato transplant.

The change in the date of transplant of one of the species in relation another and, consequently, in the establishment of the intercropping, modifies the competition period and so the complementarity between them, with consequences on yield. In addition, the species in intercropping usually differ in height and distribution of leaves in space, among other morphological characteristics, which can cause the plants to compete for light, water and nutrients (CECÍLIO FILHO; REZENDE; DUTRA, 2019). These authors observed that the intercropping of cucumber and lettuce, which was transplanted later (10, 20 and 30 DAT of cucumber), showed twisted leaves and no head, i.e. noncommercial characteristics. Additionally, lettuce plants were only considered commercial when they were transplanted simultaneously with cucumber from August to November.

In the first cropping season, differences were observed in all characteristics of eggplant, with the monoculture standing out from the intercropping. In the second cropping season, there was no difference in the commercial yield of eggplant between the intercropping and monoculture only at the time of -30 DATT. For the number of commercial fruits per plant and commercial yield of eggplant, in the second cropping season, there were differences between the systems of monoculture and intercropping at all times of transplanting. In the intercropping, for both seasons, reductions were observed in all evaluated characteristics of eggplant (Tables 2 and 3) as its transplant was later than that of tomato.

For the NCFP, CYP and CY at most transplant times, the intercropping was superior to the monoculture. These results agree with those of Nwofia et al. (2017), who observed a reduction in the number of fruits per eggplant plant greater than 20% in intercropping with cowpea. On the other hand, Brito et al. (2017) found no differences in the number of fruits per plant, fruit weight and eggplant yield in intercropping with taro.

In the intercropping, for both crop season, reductions were observe in NCFP, CYP and CY of eggplant when its transplant was later than that of tomato (Tables 2 and 3). Therefore, the reductions in yield components of eggplant intercropped with tomato were the result of interspecific competition. According to Horwith (1985), it is common to observe a greater reduction in the development and production of intercrops, particularly when the second crop has been planted later.

Cecílio Filho, Rezende and Dutra (2019) found that for lettuce transplanted 30 days after cucumber there was a 29% reduction in the total fresh weight of lettuce compared to that obtained when the crops were transplanted the same day. Ohse et al. (2012), who evaluated intercropping systems of broccoli with lettuces, observed similar results. They found that the delay in transplantation compared with broccoli transplantation caused reductions in the fresh weight of lettuce, and that the greater the delay, the greater the intensity of the reduction in the growth of lettuce.

Table 2. Mean values of the number of commercial fruit per plant (NCFP) and commercial yield per plant (CYP) of eggplant in the first and second time of planting, as a function of cropping systems and times of eggplant transplants in relation to the tomato.

Times of transplant	First season		Second season		First season		Second season	
	Number of commercial fruit per plant				Commercial yield per plant			
	Inter	Mono	Inter	Mono	Inter	Mono	Inter	Mono
-30	28.48bB	31.92aD	45.90aA	47.25aC	7.20bB	8.08aD	11.95bA	12.30aC
-25	28.75bB	33.70aD	45.10bA	46.78aC	7.22bB	8.55aD	11.74bA	12.18aC
-20	26.68bB	32.78aD	43.68bA	46.80aC	6.77bB	8.45aD	11.36bA	12.19aC
-15	23.52bB	26.22aD	37.15bA	46.58aC	5.80bB	6.75aD	9.67bA	12.12aC
-10	19.08bB	29.18aD	30.12bA	46.85aC	4.65bB	7.63aD	7.85bA	12.20aC
-5	11.38bB	21.02aD	28.85bA	46.40aC	2.85bB	5.18aD	7.52bA	12.09aC
0	9.10bB	15.55aD	28.15bA	46.78aC	2.30bB	3.83aD	7.34bA	12.19aC
5	8.52bB	16.48aD	24.35bA	46.50aC	2.15bB	4.25aD	6.35bA	12.10aC
10	6.90bB	15.95aD	21.57bA	46.45aC	1.70bB	3.95aD	5.62bA	12.10aC
15	5.85bB	14.22aD	17.65bA	47.28aC	1.45bB	3.63aD	4.60bA	12.32aC

For a same characteristic and crop season, means with different small letters in the same row implies in significant differences between cropping systems, by Tukey at 5% probability.
For a same characteristic and cropping system, means with different capital letters in the same row implies in significant differences between crop seasons, by Tukey at 5% probability.

Table 3. Mean values of commercial yield (CY) of eggplant in the first and second time of planting, as a function of cropping systems and times of eggplant transplants in relation to the tomato.

Times of transplant	First season		Second season	
	Inter	Mono	Inter	Mono
-30	55,340.66bB	62,148.35aD	91,906.59bA	94,629.12aC
-25	55,608.79bB	65,573.08aD	90,339.29bA	93,699.18aC
-20	52,054.12bB	63,281.04aD	87,410.17bA	93,771.98aC
-15	44,594.23bB	51,865.11aD	74,453.30bA	93,254.12aC
-10	35,501.65bB	58,605.77aB	60,402.47bA	93,867.31aC
-5	21,900.27bB	39,792.58aD	57,854.40bA	93,026.10aC
0	17,529.40bB	29,246.43aD	56,448.08bA	93,760.99aC
5	16,492.86bB	32,697.80aD	48,866.76bA	93,090.66aC
10	13,078.30bB	30,163.46aD	43,230.77bA	93,065.94aC
15	11,169.51bB	27,831.04aD	35,412.09bA	94,803.57aC

*For a same crop season, means with different small letters in the same row implies in significant differences between cropping systems, by Tukey at 5% probability.
†For a same cropping system, means with different capital letters in the same row implies in significant differences between crop seasons, by Tukey at 5% probability.

When studying the crop season, cropping system and each time of tomato transplant, a significant difference was observed between the two cropping seasons. The second crop season stood out from the first one in the number of commercial fruits per plant, commercial yield per plant and commercial yield (Tables 2 and 3). Evaluating the intercropping of lettuce and tomato, Cecílio Filho et al. (2011) observed that, regardless of the lettuce transplant date compared with tomato transplant, the yields of both crops were higher in the autumn/ winter growing season (January to July). Nascimento et al. (2018), studying the intercropping of lettuce and rocket, also found that lettuce plants had 22.5% more leaves in summer than in winter.

Tomato

There was no interaction between the crop season and the eggplant transplant date compared with the tomato transplant for the contents of macronutrients and of B, Cu, Fe, Mn and Zn in tomato leaf analysis. The observed mean values for N, P, K, Ca, Mg, S, Cu, Fe, Mn, Zn and B were 51.4, 4.3, 28.5, 41.4, 9.7 and 1.67 g kg^{-1}, 27.1, 250.0, 140.6, 32.5 and 75.2 mg kg^{-1}, respectively. Except for K, Ca, Mg, S, Cu and Zn, all other values are within the appropriate levels for tomato plants, according to Trani et al. (2018).

There was interaction between the times of transplanting and crop season of tomatoes for the number of commercial fruits per plant (NCFP), commercial yield per plant (CYP) and commercial yield (CY). When evaluating the times of transplanting within each cropping season, it was possible to observe increases in NCFP, CYP and CY of 25.00 and 20.34, 1.89 and 2.07 kg plant^{-1} and 46775.37 and 48213.54 kg ha^{-1} in the first and the second crop seasons, respectively, when the transplant of eggplant changed from -30 to 15 DATT (Figure 4).

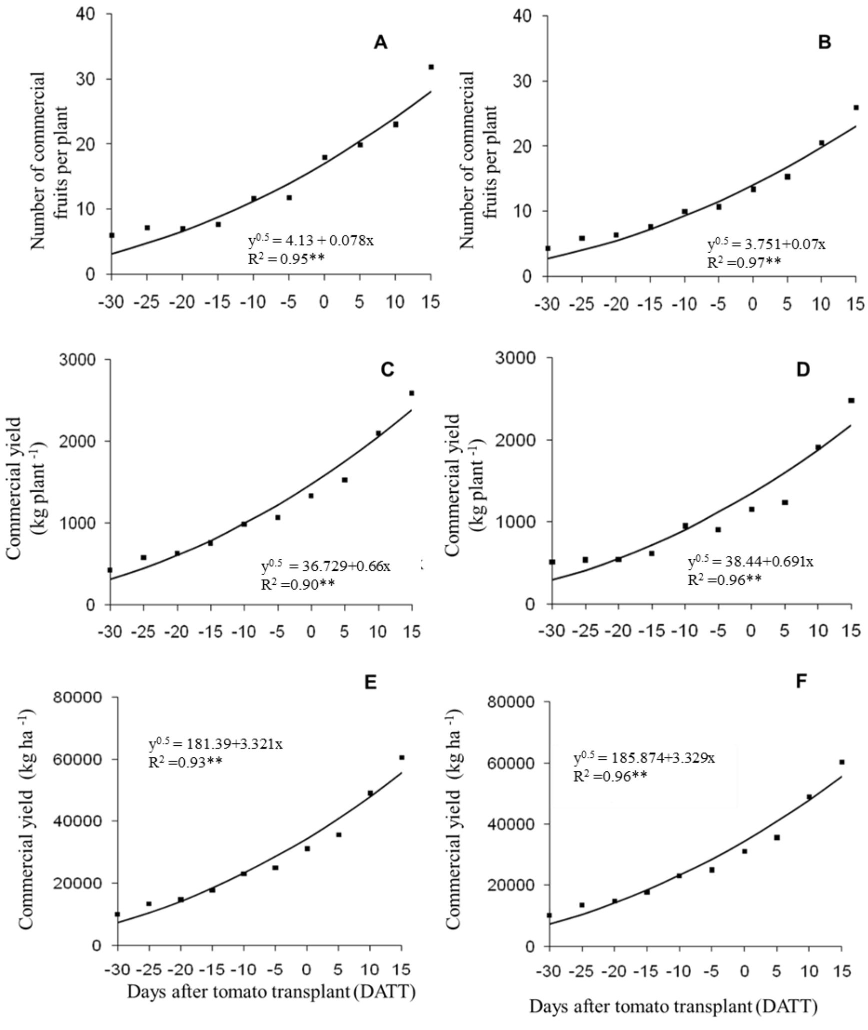

Figure 4. Number of commercial fruit per plant, commercial yield per plant and commercial yield of tomato in the first (A, C and E) and in the second crop season (B, D and F), as a function of times of eggplant transplants in relation to the tomato.

The rapid growth of eggplant and hence the rapid formation of leaf area and solar radiation interception caused different intensities of shading on tomato from different times of establishment of the intercropping, with the interference in the temporal complementarity of the intercropped species. In this context, the earlier the transplanting of eggplant compared with that of tomato, the lower the degree of temporal complementarity, because the tomato had, from the beginning of its development, low availability of solar radiation, and growth of these plants. This fact can be attributed to the increased competition that eggplant exerted on tomato when it was transplanted earlier than tomato.

In intercropping systems, light can be a limiting factor for plant growth, due to the shading of one species over another. Under low light, the energy processes of plant metabolism will be reduced, such as the synthesis of ATP and carbohydrates, causing less biomass production and decreased yield (GONG et al., 2015). Cunha-Chiamolera et al. (2017) observed a 74% reduction in lettuce yield due to the shading caused by tomato plants. These same authors point out that the lettuce plants in monoculture were not restricted by luminosity and achieved higher yield.

The advantage in favor of tomato, for land occupation and lower shading by the eggplant, was expanded when eggplant was transplanted at the same day or after the tomato, and the later the best for tomato because the greater is its ability to compete with eggplant, obtaining, therefore, increases in production.

The earlier the eggplant is transplanted compared with the tomato transplant, the greater was the damage on the tomato and, consequently, the lower their yield. Instead, the more delayed the eggplant transplanting compared with the tomato transplanting, the greater its yield (Table 4). This can be attributed to less competition that eggplant exerted on the tomato, when it was transplanted earlier than tomato. This advantage in favor of tomato was increased, when eggplant transplanting was performed later than the tomato. Under these conditions, there was ability of tomato in competing with eggplant, growing, occupying the ground and suffering less shading by eggplant, consequently obtaining increase in the production. When the eggplant was transplanted at 5, 10 and 15 days after the tomato, the leaf area of tomato was about 260%, 545% and 1260% higher than the leaf area of eggplant plants when the intercropping was established with the transplant of tomatoes and eggplant on the same day (Table 1).

Table 4. Mean values of the number of commercial fruit per plant (NCFP), commercial yield per plant (CYP) and commercial yield (CY) of tomato in the first and second crop season, as a function of times of tomato transplants and times of planting in relation to the eggplant transplant.

Times of transplant	First crop season	Second crop season	First crop season	Second crop season	First crop season	Second crop season
	Number of commercial fruts per plant		Commercial Yield Per plant		Commercial Yiel	
-30	5.97 a	4.30 a	0.51 a	0.43 a	11,909.83 a	10,144.71 b
-25	7.15 a	5.85 a	0.53 a	0.58 a	12,529.76 a	13,579.18 a
-20	6.97 a	6.35 a	0.54 b	0.63 a	12,556.86 b	14,829.13 a
-15	7.70 a	7.60 a	0.59 b	0.76 a	14,377.10 b	17,774.10 a
-10	11.65 a	9.95 a	0.95 a	0.99 a	22,185.95 a	23,218.11 a
-5	11.80 a	10.70 a	0.95 b	1.07 a	21,568.99 b	25,067.03 a
0	17.95a	13.37 b	1.09 b	1.34 a	25,923.36 b	31,235.96 a
5	19.87 a	15.30 b	1.64 b	1.53 a	40,053.91 a	35,676.44 b
10	23.00a	20.47 b	1.91 b	2.10 a	44,546.91 b	49,058.50 a
15	31.85 a	25.90 b	2.48 b^{ns}	2.59 a^{ns}	58,916.07 a	60,451.92 a
Monoculture	30.95†	26.82	2.32	2.69	55,233.91	62,594.63

*For a same characteristic, means with different small letters in the same row implies in significant differences between crop season, by Tukey at 5% probability;

†Means of tomato monoculture differ significantly of the times of eggplant transplant by Dunnett's test at 5% probability;

^{ns} Means of the times of transplant does not differ from the tomato monoculture by Dunnett test at 5% probability.

In treatments in which the eggplant was transplanted from -30 to -20 DATT, due to the intense shading that eggplant exerted on the tomato, this crop was etiolated, with plants disfigured morphologically, with low fruit fixation and even death of some plants that were heavily shaded. Consequently, there was a reduction in all evaluated characteristics of the tomato (Table 4). The physiological disorder observed in tomato plants when eggplant was transplanted earlier was because the partitioned incident light by different canopies can induce aboveground competition for the light between the component crops, as light is frequently the limiting resource in intercropping systems (GONG et al., 2015).

According to Andriolo (2000), high air temperatures combined with low levels of radiation are harmful to crops, because they decrease photosynthesis, maintaining high respiration and altering hormonal balance, favoring the etiolation of plants. Cunha-Chiamolera et al. (2017) observed that the shading conditions imposed by tomato-lettuce intercropping reduced gas exchange, chlorophyll pigment contents, and growth rate of the secondary crop (lettuce). When lettuce was transplanted later than tomato, the shading of tomato on lettuce plants was higher and caused harmful effects on physiological parameters and dry matter.

The study of crop season within each date of the tomato transplanting showed a significant effect of the cropping season on the number of commercial fruits per plant, when eggplant was transplanted at 0-15 DATT, and the highest values were obtained in the first cropping season (Figure 4 and Table 4). For commercial yield per plant, the two seasons differed when the transplant of eggplant was performed at -20, -15 and -5 to 15 DATT, with higher values in the second cropping season (Figure 4D and Table 4). For the commercial yield, the superiority of the second cropping season over the first season was observed when the eggplant transplant occurred at -30, -20, -15 and -5 DATT and between 0 and 10 DATT (Figures 4E and 4F and Table 4).

CONCLUSION

The study shows that the species have a high degree of interference with each other. Transplant of eggplants earlier than tomato was better for the eggplant and worse for the tomato. Varying the time of eggplant transplanting was not beneficial for the yield of both crops in both seasons. This negative influence on crop yields shows that the intercropping of eggplants and industrial tomato may not be an economically viable system when the plants are transplanted at the times evaluated.

ACKNOWLEDGMENTS

We would like to thank FAPESP for awarding the scholarship and for financing the research.

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