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PHYTOSOCIOLOGICAL SURVEY AND WEED INTERFERENCE IN EGGPLANTS CULTIVATION[1]

Levantamento Fitossociológico e Interferência das Plantas Daninhas na Cultura da Berinjela

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ABSTRACT - Eggplants are vegetables of great importance in the South and Southeast regions of Brazil, which are subject to interference from weeds. In order to collaborate with weed management in this vegetable, this study was carried out to determine the periods of weed interference in growing eggplants. The study was conducted in the Brazilian municipality of Jaboticabal, SP, at the Faculty of Agricultural and Veterinary Sciences, UNESP [Universidade Estadual Paulista "Júlio de Mesquita Filho" (São Paulo State University)], in the period from February to July 2013. The experiment was arranged in a randomized block design with 22 treatments, three replications divided in 11 periods of coexistence and weed control with eggplants: 14, 28, 42, 56, 70, 84, 98, 112, 126, 140 and 154 days after transplanting (DAT). In each treatment, a phytosociological study was carried out to identify the important species of weeds in eggplant crops. The main weeds were Eleusine indica, Nicandra physaloides, Portulaca oleracea and *Cyperus rotundus* due to their high relative importance. The interference of these weeds caused losses of up to 96% to the standard commercial fruit yield. The period before interference was 6 DAT and the total period of interference was 102 DAT. Therefore, it is concluded that after the initial six days after transplanting eggplants, the crop should be free of weeds within the next 96 days.

Keywords: *Solanum melongena*, competition, productivity, weed community.

RESUMO - A berinjela é uma hortaliça de grande importância nas regiões Sul e Sudeste e, que está sujeita a interferências das plantas daninhas. Com o intuito de colaborar com o manejo das plantas daninhas nessa hortaliça, objetivou-se determinar os períodos de interferência das plantas daninhas no cultivo de berinjela Nápoli. O estudo foi realizado no município de Jaboticabal, SP, na Faculdade de Ciências Agrárias e Veterinárias da UNESP, no período de fevereiro a julho de 2013, no delineamento em blocos ao acaso com 22 tratamentos e três repetições, divididos em 11 períodos de convivência e de controle das plantas daninhas com a berinjela Nápoli: 14, 28, 42, 56, 70, 84, 98, 112, 126, 140 e 154 dias após transplantio (DAT). Em cada tratamento, foi realizado estudo fitossociológico para identificar as espécies importantes da comunidade infestante na cultura da berinjela. As principais plantas daninhas foram Eleusine indica, Nicandra physaloides, Portulaca oleracea e Cyperus rotundus, por apresentarem maior importância relativa. A interferência dessas plantas daninhas provocou perdas de até 96% na produtividade de frutos. O período anterior à interferência foi de 6 DAT, e o período total de prevenção à interferência de 102 DAT. Portanto, conclui-se que decorrido seis dias do transplantio da berinjela Nápoli, a cultura deve permanecer livre das plantas daninhas nos próximos 96 dias, para que não haja perdas na produtividade dos frutos de padrão comercial.

Palavras-chave: *Solanum melongena*, competição, produtividade, comunidade infestante.

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INTRODUCTION

Eggplant is a functional food with a wide range of medicinal uses (Meyer et al., 2014). This crop is produced in all regions of Brazil, especially the Southeast and South. In the Southeast, the largest producers are the Brazilian states of São Paulo, Minas Gerais and Rio de Janeiro. The sales volume of eggplant fruits in CEAGESP (Companhia de Entrepostos e Armazéns Gerais de São Paulo (Company of General Trading Posts and Warehouses of the city of São Paulo)] in 2012 reached 27,068 tons and by mid-2013, 17,436 tons (Agrianual, 2014).

Weeds are among the major obstacles in agricultural production, causing losses in crops and resulting in serious economic losses for people and their interests in many countries (Adkins & Shabbir, 2014). In vegetable crops such as okra and carrots, yield losses caused by weeds can be up to 94% and 95% (Coelho et al., 2009; Bachega et al., 2013), respectively. In carrots, if there is no weed control, losses can reach 94% (Coelho et al., 2009), while beets can reach 70% (Carvalho et al., 2008a) to 90% (Carvalho et al., 2008b) in crops for transplanting seedlings and direct seeding, respectively.

In Criollo lila eggplants in Colombia, the effect of competition from weeds on fruit yield has reduced productivity and the formation of quality fruit in 67% and 96%, respectively (Aramendiz-Tatis et al., 2010).

The interference occurs because the weeds are hosts for pests, diseases, nematodes, which, in addition to releasing allelopathic substances in the environment, can compete for growth components such as nutrients, light and water, and space (Pitelli, 1987). To minimize the negative effects of weed interference, it is necessary to know the important species in the weed community and the period in which their control should be done. This information can be obtained from phytosociological studies and interference periods. According to Freitas et al. (2004), knowledge of the critical period of weed interference is important to establish the number of weeding to be done, or to plan the application of herbicides in preemergence and/ or postemergence.

In Brazil there are no records of information about the interference periods in eggplant cultivation. This study was carried out to determine the periods of weed interference in cultivar Nápoli eggplants crops in order to generate information to increase productivity levels with the rationalization of weed control in eggplant crops.

MATERIAL AND METHODS

The experiment was conducted in the Brazilian municipality of Jaboticabal, SP, latitude 21º5'22" S, longitude 48º18'58" W and altitude 575 m, in the period from February to July 2013. The climate is Cwa, according to Köppen classification, with predominant summer rains and relatively dry winters. During the experiment, the average maximum temperature was 25 ºC and the minimum was 19.4 ºC. Maximum precipitation was 139.2 mm and minimum was 30.9 mm (Estação Agroclimatológica, FCAV/UNESP, 2013).

The soil of the experimental area, classified as typical clayey-textured Oxisol Eutrudox, moderate A, kaolinitic-oxidic, presented the following characteristics: pH ($CaCl_2$) = 5.6; MO = 26 g dm^{-3}; P (resin) = 83 mg dm^{-3}; V = 65%; and K, Ca, Mg, H+Al, CTC and SB = 2.6; 28; 10; 22; 63; and 42 $mmol_c$ dm^{-3}, respectively.

The soil preparation was carried out in a conventional manner, with plowing and harrowing. Planting fertilization was done in furrows, based on soil analysis and recommendation by Trani et al. (1997), with the application of 150 g m^{-1} of the formula 4-14-8 (1,500 kg ha^{-1}). Topdressing was performed every 15 days after transplanting the seedlings, applying 7 g per plant (46 kg ha^{-1}) of urea (45% of N) and 3.5 g per plant (23 kg ha^{-1}) of potassium chloride (60% of K_2O). A sprinkler irrigation system was used in the area, and pests and diseases were controlled with chemicals recommended for the crop.

Eggplant seedlings, cultivar Nápoli, were produced in trays and transplanted with four fully expanded leaves on February 2, spaced 1.5 m between rows and 1.0 m between plants. The experimental plots consisted of three 5 m long rows of cultivation. The center line, consisting of three plants, was used to evaluate crop productivity.

The experiment was conducted in an experimental design of randomized blocks with 22 treatments and three repetitions, divided into two experiments of 11 treatments. In the first one, the crop remained in coexistence with the weeds from transplanting to 14, 28, 42, 56, 70, 84, 98, 112, 126, 140 and 154 days after transplanting (DAT). After each period, the plots were kept free from weeds through weeding with hoes. In the second experiment, the crop remained free of weeds through hand weeding, from transplanting to the end of the same periods described above. After each period, the weeds emerged freely.

Evaluations of the weed community were carried out in treatments in conditions of coexistence with the infestation at the end of each period, while in treatments in conditions of infestation control the evaluation took place at 154 DAT. The survey of the infestation was done with the aid of a cut out metal frame laterally measuring 0.5 m, thrown three times in each plot. In each sample, the weeds shoots were reaped. The species were separated, quantified and stored in paper bags, properly identified, to dry in a forced-air circulation oven at 65 ^{o}C to constant weight when the dry matter was weighed on a precision scale to two decimal places.

The phytosociological indexes evaluated followed the criteria described by Mueller-Dombois & Ellenberg (1974), where the relative frequency (frequency of occurrence of the species), the relative density due to the number of individuals of the species and the relative dominance due to the dry matter of the species were calculated. These indices were used to calculate the relative importance (sum of constancy, relative density and dominance of each weed species in relation to the sum of the weeds community) of the species, according to the formula proposed by the authors above mentioned.

The first fruit harvest was done 62 days after transplanting (DAT) and continued weekly until 154 DAT, when the experiment ended. Em each harvest, only fruit with a commercial standard were manually collected: measuring 13 to 17 cm long, uniform and bright purple-black color, soft and firm flesh, green receptacle, with weight ranging between 180 and 250 g (Reis et al., 2007). The fruits from each treatment were weighed at every harvest and the yield was estimated in kilograms per hectare.

The total productivity data of the estimated standard commercial fruit (sum of crops) of fruit fresh matter were submitted to a sigmoid regression analysis, according to the model by Boltzmann: $Y = A_2+[(A_1-A_2)/(1+e^{((X-Xo)/DX)}]$, where Y is the estimated productivity of Nápoli eggplants, expressed in kg ha^{-1}, due to the periods of coexistence; X is the upper limit of the coexistence period or control (days); A_1 is the maximum yield obtained in the plots kept free from weeds throughout the entire cycle; A_2 is the minimal productivity resulting from plots held in the bush throughout the entire cycle; X_0 is the upper limit of the coexistence period, which corresponds to the intermediate value between maximum and minimum production; and DX is the parameter that indicates the speed of yield loss or gain.

Based on the regression equations, the PBI (period before interference), TPIP (total period of interference prevention) and CPIP (critical period of interference prevention) of weeds in eggplant crops were estimated, considering 5% reduction in productivity acceptable in relation to the treatment where the crop remained free from weeds throughout the entire cycle.

RESULTS AND DISCUSSION

The weeds in the experimental area were identified: *Achyrocline satureioides*, *Alternanthera tenella*, *Amaranthus retroflexus*, *Amaranthus spinosus*, *Amaranthus viridis*, *Bidens pilosa*, *Commelina benghalensis*, *Conyza canadensis*, *Cynodon dactylon*, *Cyperus rotundus*, *Digitaria insularis*, *Digitaria nuda*, *Eleusine indica*, *Emilia fosbergii*, *Marsypianthes chamaedrys*, *Sida* sp., *Nicandra physaloides*, *Parthenium hysterophorus*, *Portulaca oleracea*, *Richardia brasiliensis* and *Solanum americanum*.

In the treatments in the condition of coexistence with the infestation, 11 species were identified, 36% belonging to monocotyledons and 64% to eudicotyledons. In this experiment, the weeds density decreased over time (Figure 1). The largest density of the community occurred at 28 DAT (163.55 plants m^{-2}). The species with the highest density in the initial periods of coexistence were *E. indica*, *P. oleracea* and *C. rotundus*. They were hulled at the beginning of cultivation because they took advantage more efficiently of the environmental factors available: high temperature and luminosity in a freshly prepared soil. These weeds have a C_4 photosynthetic cycle (Christin et al., 2014; Venâncio et al., 2014), which gives them higher photosynthetic rates compared to C_3 plants in those environmental conditions. The lowest densities occurred from 56 DAT (18.2 plants m^{-2}) due to the weeds intraspecific and interspecific competition (Silva & Durigan, 2009).

The largest dry matter accumulation occurred at the end of the cycle (1.200 g m^{-2})

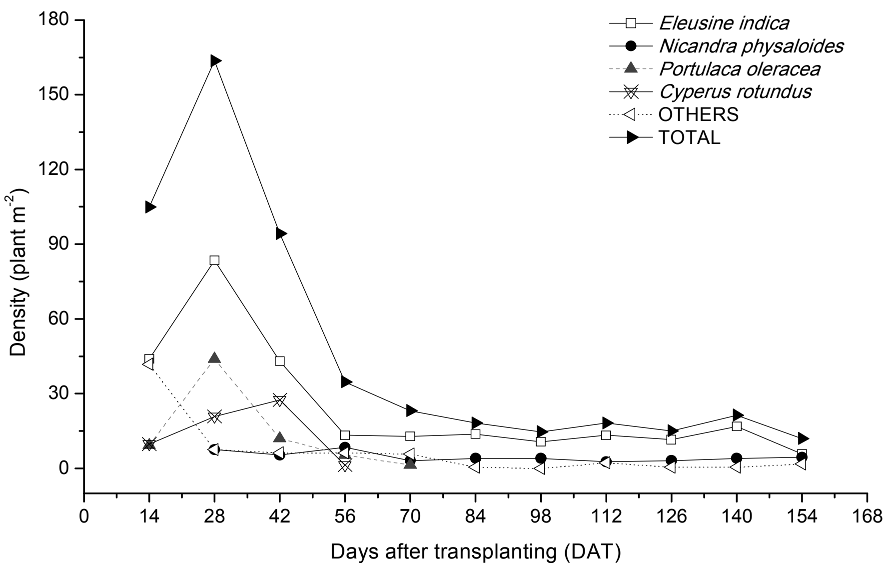

Figure 1 - Population density of the main weeds and total of the weed community in increasing periods of coexistence with Nápoli eggplant.

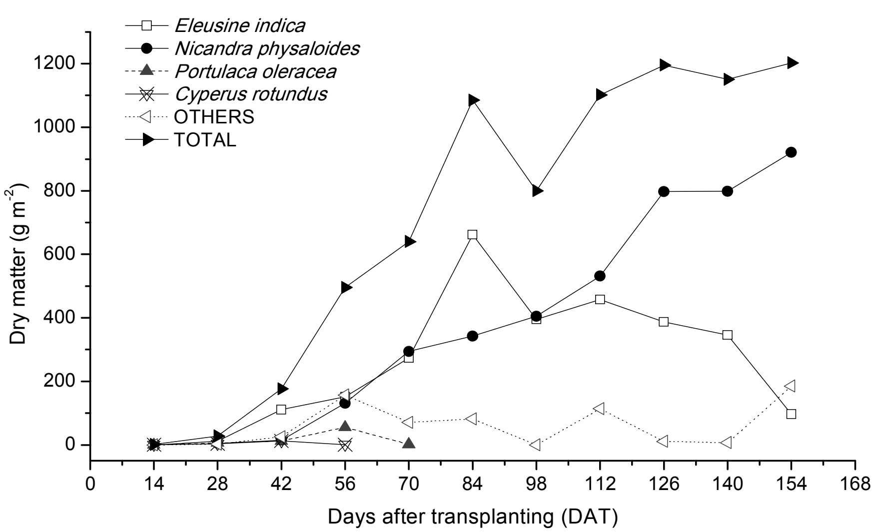

Figure 2 - Dry matter of the main weeds and total of the weed community in increasing periods of coexistence with Nápoli eggplant.

and the species that presented higher dry matter accumulation were *N. physaloides* and *E. indica*. The first one presented growing accumulation of dry matter, standing out from the 42 DAT from the other species present in the population. The second species presented maximum accumulation up to 84 DAT, and decreased in subsequent periods.

The most important weeds in treatments in conditions of coexistence with the infestation were *E. indica* in all periods and *N. physaloides* from 28 DAT (Figure 3). The relative importance of these species was due to the density of the parameters and mass accumulation (Figures 1 and 2). The species *C. rotundus* and *P. oleraceae* stood out due to the high density values only at the beginning of the cycle (Figure 1).

In the experiment, in which treatments showed increasing initial periods of control, 17 species were identified, 35% belonging to monocotyledons and 65% to eudicotyledons. In this group, the highest densities occurred in the periods with a higher occurrence of weeding, which consisted in the treatments with 98-140 DAT (Figure 4). However, the value of the weed density in that period represented less than half of what occurred in the early periods of the crop coexistence with weeds. In this period, the species with the highest density in the community was *C. rotundus* (49.25 plants m^{-2}), probably due to its high capacity for regrowth.

The largest dry matter accumulation of the weed community in treatments with increasing initial periods of control occurred in the 14 DAT treatment with weeding, when the accumulation was 1,548 g m^{-2} (Figure 5) and decreased, in treatments with longer periods of control, to 70 DAT (291.30 g m^{-2}) with weeding. The species that contributed most to the dry matter accumulation were *N. physaloides*, when weeding occurred up to 14 DAT and *E. indica*, when they were constant up to 28, 42, 56 and 70 DAT. At 84, 98, 112, 126 and 140 DAT with weeding, the dry matter accumulation was reduced in 94% (20.79 g m^{-2}). It was observed that weeding up to 84 DAT, associated with the crop shadowing, was sufficient to maintain the dry matter of the weed community at low levels.

The species with higher values of relative importance in the treatments with increasing initial periods of control were *E. indica* and *N. physaloides*, in the period from 14 to 84 DAT (Figure 6), due to the higher accumulation of dry matter (Figure 5). For the periods from 98 to 140 DAT with weeding, the species that showed higher relative importance were *C. rotundus* and *E. indica* (Figure 6), due to the higher density (Figure 4).

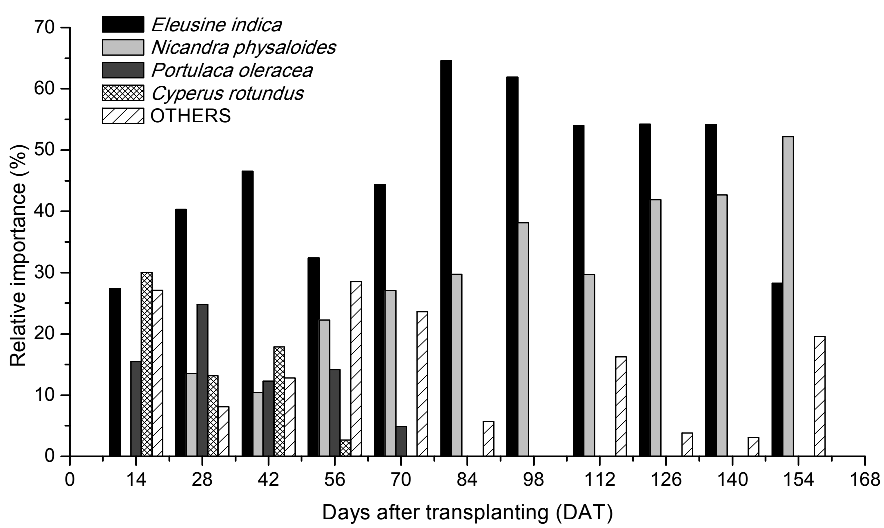

Figure 3 - Relative importance of *E. indica*, *N. physaloides*, *P. oleracea*, *C. rotundus* and other species of the weed community in increasing periods of coexistence with Nápoli eggplant.

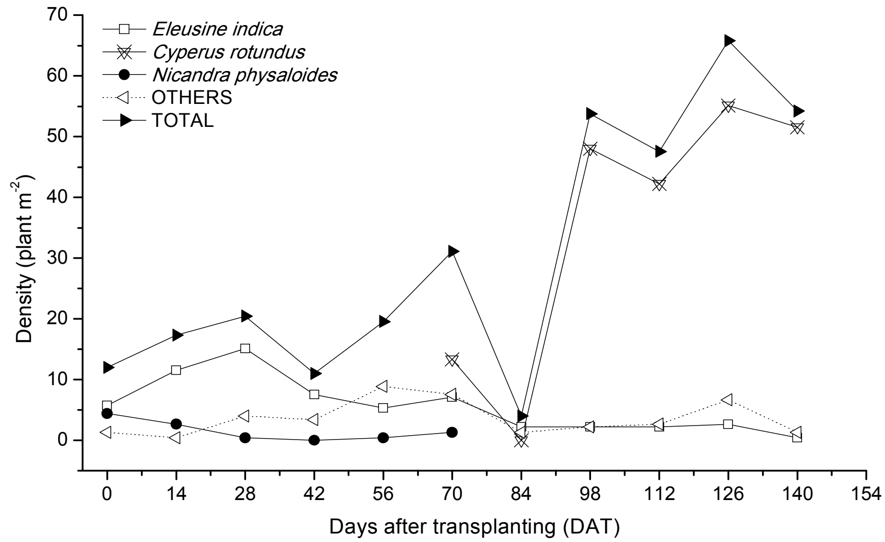

Figure 4 - Population density of the main weeds and total of the weed community in increasing periods of control with Nápoli eggplant.

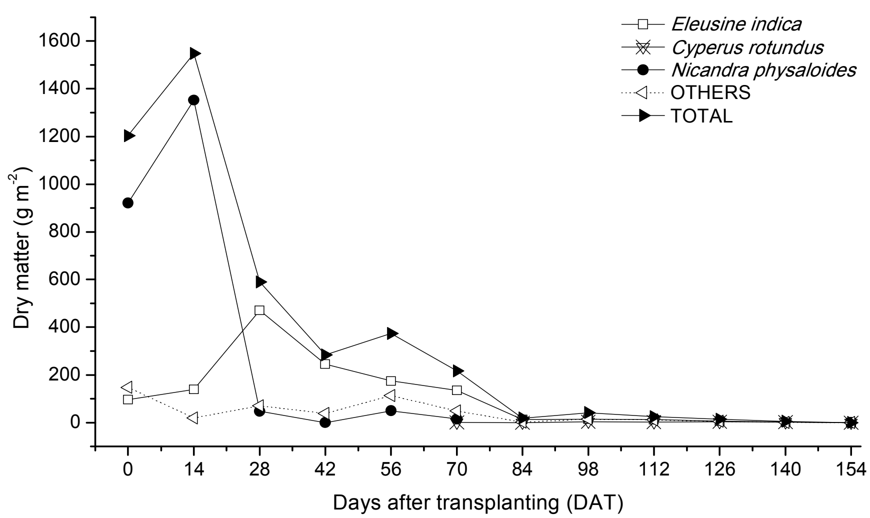

Figure 5 - Dry matter of the main weeds and total of the weed community in increasing periods of control with Nápoli eggplant.

Weeds *N. physaloides*, *E. indica* and *P. oleraceae* are common in vegetable crops. These species were also found in research on crops of okra, beets and tomatoes (Nascente et al., 2004; Carvalho et al., 2008a; Bachega et al., 2013). Furthermore, these researchers have mentioned that in the treatments with longer periods of coexistence some plants substantially grow, as *N. physaloides*, preventing the incidence of light and decreasing, as a result, the possibility of emergence of other species of the weed community.

The yield of commercial fruits of eggplant was 53,808 kg ha^{-1} and 1,973 kg ha^{-1}, respectively, for treatments in which the crop remained without coexistence and with coexistence with weeds throughout the entire cycle. It was observed that the weeds interference reduced productivity in 96.4%. In the cultivation of Criollo Lila eggplants in Colombia, reduction in productivity and formation of quality fruit around 67% and 96%, respectively, was also observed (Aramendiz-Tatis et al., 2010). In other vegetable crops, such as okra and potatoes, productivity losses caused by weeds can be up to 96% and 40%, respectively (Ahmadvand et al., 2009; Bachega et al., 2013). In carrots and beets, these losses may reach 90% (Carvalho et al., 2008a, b).

According to the commercial fruit yield curves for Nápoli eggplants, the period in which the crop can coexist with the weeds (PBI) was of 6 DAT and that in which it should be in the absence of coexistence (TPIP) was up to 102 DAT (Figure 7). In the meantime, weed control should be done so that the losses do not exceed 5% of the commercial productivity when the crop remains free from weeds during the entire cycle. After the period of 102 DAT, it is no longer necessary to control the weed community because the crop has a culture control through soil shading as to avoid the

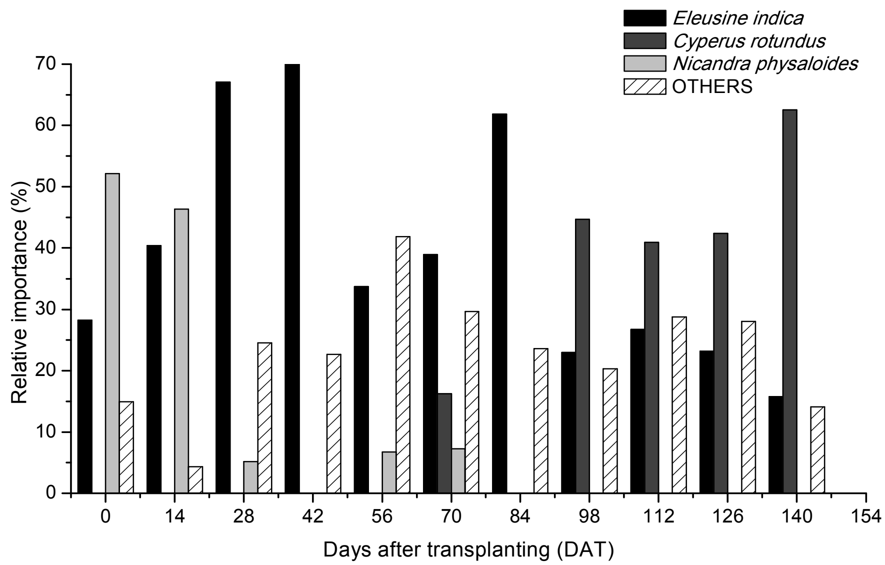

Figure 6 - Relative importance of *E. indica*, *C. rotundus*, *N. physaloides* and other species of the weed community in increasing periods of control with Nápoli eggplant.

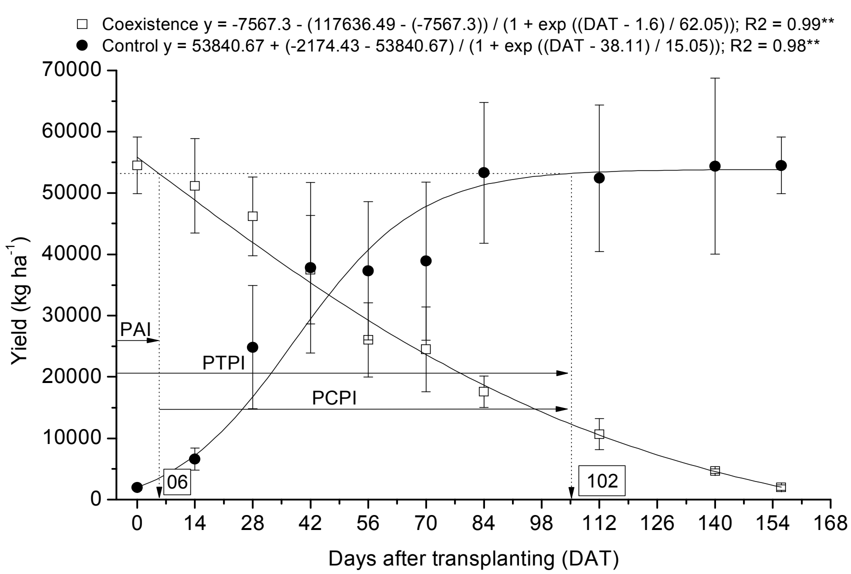

Figure 7 - Total yield of commercial fruits of Nápoli eggplant in response to periods of coexistence and weed control.

emergence of new weeds or limit the environment resources so that these species may perhaps emerge (Stagnari & Pisante, 2011).

PBI of only 6 DAT may be related to the high density values of *E. indica*, *P. oleraceae* and *C. rotundus*, which occurred at 14 and 28 DAT in the treatments in conditions of coexistence with the infestation (Figure 1). When the density of the community or of some weed species is greater, resources are limited, which brings negative impacts to agricultural crops. For example, in maize crops the interference of weeds gulf cockspur grass and spiny amaranth reduced the leaf area index of maize and consequently there was a decrease in the crop growth rate, as well as a reduction in the plants ability to capture light (Ghanizadeh et al., 2014).

The TPIP of 102 DAT may be related to the dry matter accumulation of *E. indica* up to 70 days of control (Figure 5). This weed negatively affects the development of agricultural crops. In okra, this species has severely affected the number of leaves and hence the shoots dry matter, not suffering negative changes from the culture (Santos et al., 2010). In addition, the dry matter accumulation of weeds in crops causes reduction in fruit yield, as demonstrated in tomato crops (Nascente et al., 2004).

In the CPIP, the species with the highest relative importance, taking into account the treatments with and without coexistence, were *E. indica*, *N. physaloides*, *P. oleraceae* and *C. rotundus*.

The interference periods of this study differed from those found by Aramendiz-Tatis et al. (2010) in crops of Criollo Lila eggplants in Colombia. These researchers found that the control should be performed from transplanting to 40 DAT. The extent of interference periods depends on the competition between the crop and the weeds due to the specific differences among species in morphology, physiology and development. From this evaluation, the CPIP may be unique to each crop and it varies according to the composition and density of the weed population, as well as the time of onset compared to the crop (Knezevic et al., 2002). The cropping system and management practices also influence the extent of the interference periods (Carvalho et al., 2008b; 2010), as well as edaphic climatic factors.

Thus, it is concluded that the period when Nápoli eggplants must remain free of weeds to maintain the commercial fruits yield has started six days after transplanting and ended 102 DAT, considering a weed community consisting mainly of *E. indica*, *N. physaloides*, *P. oleraceae* and *C. rotundus*.

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