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Article

Weed Interference on Productivity of Bell Pepper Crops

Interferência de Plantas Daninhas na Produtividade do Pimentão

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ABSTRACT - The objective of this work was to determine the interference periods of weeds of the bell pepper cultivar 'Dahra'. Two experiments were conducted during the years 2014/15 (harvest with lower rainfall) and 2015/16 (harvest with higher rainfall). The treatments consisted of 11 growing periods of cohabitation and weed control with 'Dahra' bell peppers: 14, 28, 42, 56, 70, 84, 98, 112, 126, 140 and 154 days after transplanting (DAT). For the determination of the interference periods, the productivity data were analyze using the Boltzmann sigmoidal regression model. The main weeds were *Eleusine indica, Brachiaria plantaginea*, *Digitaria nuda* and *Nicandra physaloides* for presenting high biomass and relative density. The concomitance of these weeds caused losses of up to 85.22% (2014/15) and 86.2% (2015/16) in the fruit yield. It was found that, respectively, for the years 2014/15 and 2015/16, the period before the interference was 17 and 11 DAT, and the total interference prevention period of 71 and 89 DAT. Considering a tolerance of 5% in reducing bell pepper yield, it is recommended that weed control be performed from 11 to 89 DAT.

Keywords: *Capsicum annuum*, competition, coexistence.

RESUMO **-** *Objetivou-se com este trabalho determinar os períodos de interferência de plantas daninhas infestantes do pimentão cultivar Dahra. Dois experimentos foram conduzidos durante os anos 2014/15 (safra com menor precipitação pluviométrica) e 2015/16 (safra com maior precipitação pluviométrica). Os tratamentos consistiram de 11 períodos crescentes de convivência e controle das plantas daninhas com o pimentão Dahra: 14, 28, 42, 56, 70, 84, 98, 112, 126, 140 e 154 dias após o transplantio (DAT). Para a determinação dos períodos de interferência, os dados de produtividade foram analisados utilizando o modelo de regressão sigmoidal de Boltzmann. As principais plantas daninhas foram* ***Eleusine indica****,* ***Brachiaria plantaginea****,* ***Digitaria nuda*** *e* ***Nicandra physaloides****, por apresentarem alta biomassa e densidade relativa. A convivência com as plantas daninhas provocou perdas na produtividade de frutos de 85,22% (2014/15) e 86,2% (2015/16). Constatou-se que, respectivamente, para os anos 2014/15 e 2015/16, o período anterior à interferência foi dos 17 aos 11 DAT, e o período total de prevenção à interferência, dos 71 aos 89 DAT. Considerando uma tolerância de 5% na redução da produtividade do pimentão, recomenda-se que o controle das plantas daninhas seja realizado de 11 a 89 DAT.*

Palavras-chave: *Capsicum annuum*, competição, convivência.

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INTRODUCTION

Bell pepper (*Capsicum annuum*) is one of the ten most important potherbs in the Brazilian state of São Paulo, having reached an area of 2,364 hectares and yield of 6,827 ton in 2015 (IEA, 2015). Green bell peppers continue to be the most important in terms of volume marketed due to their strong presence in domestic and corporate cooking as well as the generation of jobs and income for many families, besides being an excellent source of vitamins A and C, calcium, phosphorus, iron, vitamin B complex and carotenoids (Reifschneider, 2000). 'Dahra' bell pepper is a new cultivar that is becoming increasingly successful in the region of São Paulo, as well as in other regions producing green bell pepper in Brazil, due to excellent post-harvest conservation and commercialization (Sakata, 2015).

Like any other crop, bell peppers are subject to biotic and abiotic factors effects that influence the yield. One of the main biotic factors that negatively affect yield is the presence of weeds. Bell pepper culture is extremely susceptible to the interference of these plants because it presents slow initial growth and low index of leaf area in relation to it (Coelho et al., 2013).

In olericulture environments, the problem of weed interference is accentuated by intensive cultivation and high frequency of soil mobilization, as well as high rates of fertilization and low water restriction (Pitelli, 1985). In this type of agroecosystem, there is a predominance of ruderal species characterized by rapid growth and large yield of diaspores (Carvalho et al., 2008). The degree of weed interference depends on factors related to the crop (species, cultivar and plants density), the weed community (specific composition, density and distribution), the management adopted (for both crop and weed) and the period of coexistence between the culture and the infesting community (time and duration), all of which are affected by edaphoclimatic conditions (Pitelli, 1985).

Weed interference studies aim to determine critical periods of interference between culture and infesting community. Such periods have been described by Pitelli and Durigan (1984) as: period prior to interference (PPI), total period of interference prevention (TPIP) and critical period of interference prevention (CPIP). PPI is the period after emergence in which weeds can coexist with crops without causing yield loss. TPIP is the period after emergence in which, when control is carried out, its end reflects the moment in which the crop is able to prevent weeds interference. CPIP is the period that extends from the end of the PPI to the end of the TPIP, where the presence of weeds causes yield loss in the crop and, therefore, control must be carried out. Knowledge of these periods is essential to establish weed control strategies, which is one of the determining factors for achieving potherbs high yield (Deuber, 2006).

There is little information on the periods of weed interference on bell pepper crops (Coelho et al., 2013). Thus, the goal was to determine the periods of weed community control and coexistence on 'Dahra' bell pepper yield.

MATERIALS AND METHODS

Experiments were conducted between October and March (2014/15) and September and February (2015/16), with geographic coordinates of latitude of 21°5'22" S, longitude of 48°18'58" W and altitude of 575 m. The region climate is Cwa-type, according to Köppen climate classification adapted for Brasil (Clayton et al., 2014), with predominant summer rains and relatively dry winter. Temperature, precipitation and insolation data during the experiments are shown in Table 1.

Experiments were conducted in a typical clayey textured red Oxisol Eutrudox (Embrapa, 2013). Soil was prepared in a similar way in the two harvests and harrowing operations were carried out followed by plowing and leveling harrowing. Liming was performed 30 days before transplanting with the application of 150 g m^{-2} in total area of the calcined limestone of RPTN (Relative Power of Total Neutralization) = 95%, CaO = 34% and MgO = 17%. The area was then grooved, with demarcation between rows to 1 m.

Fertilization of planting and cover for the two agricultural years, as well as soil correction, were carried out according to recommendations by Trani et al. (1997) based on results from soil

Table 1 - Average temperatures, rainfall and insolation. Jaboticabal, SP, 2014/15 and 2015/16

Period	Year 2014-15				
	MaxTemp (°C)	MinTemp (°C)	AveTemp (°C)	Precipitation (mm)	Insolation (H)
October	34.2	18.4	25.6	46.8	271.5
November	31.1	19.8	24.4	180.9	182.2
December	31.0	20.1	24.6	150.3	195.8
January	33.9	21.1	26.5	101.5	270.2
February	30.9	20.1	24.3	283.7	185.1
March	29.1	19.8	23.3	183.3	148.3
Average	31.84	19.86	24.78	157.75	208.83
	Year 2015-16				
September	34.1	19.9	25.8	249.7	231.6
October	31.1	20.3	24.8	255.8	189.2
November	31.0	20.9	24.8	372.3	155.8
December	29.9	20.6	24.4	449.4	163.5
January	31.9	21.1	25.2	201.2	180.3
February	31.4	20.2	24.6	132.9	209.1
Average	31.68	20.5	24.93	276.88	188.23

Source: Agroclimatological Station, FCAV/UNESP - Faculdade Agrária e Veterinária/Universidade Estadual Paulista "Júlio de Mesquita Filho" (2016).

chemical analysis and crop requirements. Before implementing the experiments, the soil presented the following characteristics: pH ($CaCl_2$) = 5.6; organic matter = 26 g dm^{-3}; P (resin) = 83 mg dm^{-3}; K = 2.6 $mmol_c$ dm^{-3}; Ca = 28 $mmol_c$ dm^{-3}; Mg = 10 $mmol_c$ dm^{-3}; H+Al = 22 $mmol_c$ dm^{3}; CTC = 63 $mmol_c$ dm^{-3}; SB = 42 $mmol_c$ dm^{-3}; and saturations by bases of the soil = 65% (2014/15); and: pH ($CaCl_2$) = 5.3; organic matter = 17 g dm^{-3}; P (resin) = 79 mg dm^{-3}; K = 4.6 $mmol_c$ dm^{-3}; Ca = 26 $mmol_c$ dm^{-3}; Mg = 12 $mmol_c$ dm^{-3}; H+Al = 28 $mmol_c$ dm^{-3}; CTC = 70.6 $mmol_c$ dm^{-3}; SB = 42.6 $mmol_c$ dm^{3}; and saturation by bases of the soil = 60% (2015/16).

Mineral fertilization was carried out 15 days before transplanting seedlings, manually in the planting row, with subsequent incorporation, using for the 2014-15 period, 10 g m^{-1} of urea, 200 g m^{-1} of superphosphate and 22 g m^{-1} of potassium chloride. Cover fertilization was carried out after transplanting seedlings every 15 days, using, for the 2014/15 period, 12 g m^{-1} of urea + 7.3 g m^{-1} of potassium chloride. For the 2015/16 period, 34 g m^{-1} of the formulation 20-0-20 were used and in the cover fertilization 4.8 m^{-1} of ammonium sulphate + 2.5 g m^{-1} of potassium chloride.

Throughout the development of the experiment, cultural practices inherent to the 'Dahra' bell pepper culture were carried out in relation to pests and diseases control, consisting of sprays with fungicides and insecticides as the presence of pests or disease symptoms was detected, through observations carried out in the experimental area. Irrigations were sprayed and plants were supported with polyethylene loops and wood stakes at 60 days after transplanting (DAT) the seedlings.

'Dahra' bell pepper seedlings were transplanted when they presented four leaves. Experimental units consisted of three rows measuring 3 m, spaced 1 m between rows and 0.5 m between plants. The central row was considered a floor area and one plant was discarded at each end.

Experiments were conducted in a randomized complete block design with 22 treatments and three replicates divided into two groups of 11 treatments. In the first group, the culture remained in contact with the weeds for 11 periods, from the transplant of the seedlings: 0 (control kept in a range of land with no vegetation), 0-14, 0-28, 0-42, 0-56, 0-70, 0-84, 0-91, 0-112, 0-126, 0-140 and 0-154. After each period, weeds were controlled by manual weeding. In the second group, the crop remained free from the presence of weeds from the transplant of the seedlings until the end of the same periods described previously. After each period, weeds emerged freely.

Infesting weed community evaluations were performed in the group with increasing coexistence treatment at the end of each period, while in the group with increasing control treatments the evaluation occurred at 154 DAT. Evaluation was carried out with the aid of a metallic frame (0.5 x 0.5 m) with an internal area of 0.25 m^2 on the side, launched three times within the floor area of each plot. At each sampling, the species were separated, individuals were identified and counted within each species and plants shoots were cut and stored in properly identified paper bags for forced air circulation at 65 ^oC until reaching constant mass. Subsequently, samples dry matter was obtained and weighed on a precision scale (0.01 g).

With the data obtained, phytosociological indices were determined: relative density (ReDe), relative frequency (ReFr) and relative dominance (ReDo). These indices were used to calculate the importance value index (IVI) (ReDe + ReFr + ReDo) of each weed species. The relative importance value index (RIVI) was calculated by means of the relation between the importance value index (IVI) of each species and the sum of the importance value indices (IVI) of all species, expressed as a percentage, as proposed by Mueller-Dombois and Ellenberg (1974).

Bell pepper yield was evaluated during five harvests, starting from 92 DAT, every 15 days until the end of the experiments. In each harvest, only fruits with intense green color and length between 12 and 18 cm were collected, corresponding to commercial classes “12”, “15” and “18”, according to classification rules for bell peppers (CEAGESP, 1998). After harvests, fruits were weighed and yield per treatment was estimated in kg ha^{-1} to determine interference periods.

Yield results were submitted to regression analysis by the Boltzmann’s sigmoidal model (Microcal Origin 9.1). Based on the regression equations, the weed interference periods were determined for the arbitrary tolerance levels of 5% reduction in bell pepper crop yield in relation to the treatment maintained in the absence of weeds throughout the cycle. This model complies with the following equation:

$$Y = \frac{(A_1 - A_2)}{1 + e^{(x - x_0)/dx}} + A_2$$

where Y is the estimated bell pepper yield in kg ha^{-1}; x is the upper limit of coexistence or control periods considered; A_1 is the maximum estimated yield obtained in the plots kept in a range of land with no vegetation during the whole cycle; and A_2 is the minimum estimated yield obtained in the plots maintained with bush during the whole cycle; x_o is the upper limit of the control or coexistence periods, which corresponds to the intermediate value between maximum and minimum yield; and dx is the parameter indicating the yield loss or gain speed (tg α in point x_o).

RESULTS AND DISCUSSION

The infesting community present in the experimental area during the two years consisted of 14 species distributed in eight botanical families (Table 2). In the two experiments it was observed that 36% of the species found were monocotyledonous, while 64% were eudicotyledonous. These species present more rudimentary characteristics according to criteria by Grime (1982) due to rapid germination, short development cycle, rapid diaspores yield and high partitioning of resources in reproduction structures. These species are of common occurrence in areas of olericulture (Zanatta et al., 2006).

As for treatments with increasing periods of coexistence, in two years the highest density of community occurred at 28 DAT, obtaining for the first one 116 plants m^{-2} (Figure 1) while in the second year it was four times greater, i.e., 464 plants m^{-2} (Figure 2). In the first year, populations that presented the highest density in the initial periods of coexistence were *E. indica* and *D. nuda*. While in the second year, besides those mentioned, *C. rotundus* was found. The population that most contributed to density in the first year was of *E. indica* (74 plants m^{-2}) at 70 DAT (Figure 1). While in the second year it was *D. nuda* (198 plants m^{-2}) at 28 DAT (Figure 2). The lowest densities occurred from the 98 DAT for both experiments (19.38 and 111.75 plants m^{-2}, respectively, for the 2014/2015 and 2015/2016 periods) (Figures 1 and 2).

Table 2 - List of weeds by family, species, class, common name and international identification code found in the cultivation of 'Dahra' bell pepper. Jaboticabal, SP, 2014/15 and 2015/16

Family	Botanical name	Class	Common name	Code
Poaceae	*Digitaria nuda*	Monocotyledonous	Jamaican crabgrass	DIGNU
	Eleusine indica (L.) Gaertn.	Monocotyledonous	Indian goosegrass, wiregrass, or crowfootgrass	ELEIN
	Brachiaria plantaginea (Link) Hitchc.	Monocotyledonous	Alexandergrass, plantain signalgrass	BRAPL
	Echinochloa colona (L.) Link	Monocotyledonous	Jungle rice, awnless barnyard grass	ECHCO
Cyperaceae	*Cyperus rotundus* L.	Monocotyledonous	Coco-grass, Java grass, nut grass, purple nut sedge or purple nutsedge, red nut sedge, Khmer kravanh chruk	CYPRO
Commelinaceae	*Commelina benghalensis* L.	Monocotyledonous	Benghal dayflower	COMBE
Portulacaceae	*Portulaca oleraceae* L.	Eudicotyledonous	Purslane, verdolaga, pigweed, little hogweed, red root, pursley	POROL
Amaranthaceae	*Amaranthus viridis* L.	Eudicotyledonous	Slender amaranth, green amaranth	AMAVI
	Alternanthera tenella Colla	Eudicotyledonous	Joyweeds	ALRTE
Asteraceae	*Parthenium hysterophorus* L.	Eudicotyledonous	Santa-Maria, Santa Maria feverfew, whitetop weed, famine weed, congress weed	PTNHY
	Galinsoga parviflora Cav.	Eudicotyledonous	Gallant soldier, potato weed	GASPA
Solanaceae	*Nicandra physaloides* (L.) Gaertn.	Eudicotyledonous	Apple-of-Peru, shoo-fly plant	NICPH
	Solanum americanum Mill.	Eudicotyledonous	American nightshade, glossy nightshade	SOLAM
Brassicaceae	*Lepidium virginicum* L.	Eudicotyledonous	Least pepperwort, Virginia pepperweed, peppergrass	LEPVI

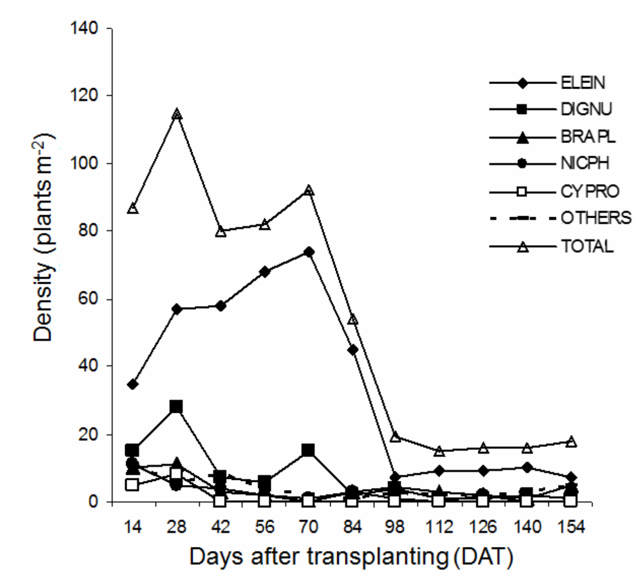

Figure 1 - Weed populational density of the infesting community due to coexistence periods in 'Dahra' bell pepper for the 2014/15 period, Jaboticabal, SP.

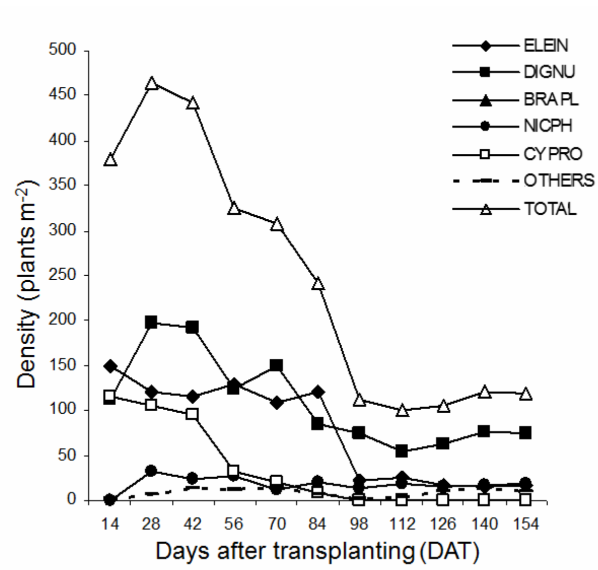

Figure 2 - Weed populational density of the infesting community due to coexistence periods in 'Dahra' bell pepper for the 2015/16 period, Jaboticabal, SP.

The populations species mentioned above benefited from the cultivation at the beginning because they took advantage of available environmental factors, such as water, high temperature and lightness in bare soil, freshly prepared. Such weeds have a C_4 photosynthetic cycle (Christin et al., 2014), which gives them higher rates of photosynthesis compared to C_3 plants. Throughout the experiment, the *C. rotundus* population had its density reduced due to interspecific competition with *E. indica* and *D. nuda*. Increased density in the second year was probably due to the incidence of higher rainfall. According to Pitelli (1985), rainfall is an abiotic factor that plays an important role in the weed community dynamics.

In the group of treatments with increasing periods of control, weed density increased during the experimental phase in the two years (Figures 3 and 4). However, weed densities represented less than 85% of the density present in the treatments initial periods in coexistence with these plants for the two years. The *C. rotundus* species had higher population density in both experiments (45.25 and 198 plants m^{-2} for the 2014/15 and 2015/16 periods, respectively) probably due to its high regrowth capacity. Similar results were obtained by Marques et al. (2016) for eggplant culture.

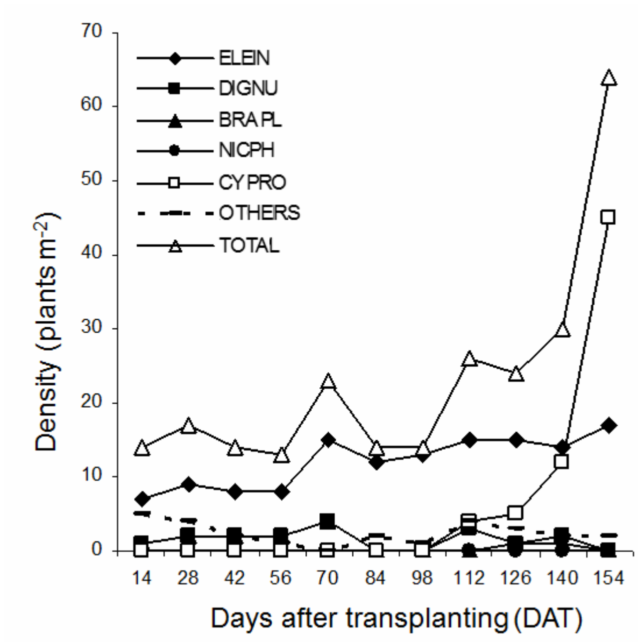

Figure 3 - Weed populational density of the infesting community due to control periods in 'Dahra' bell pepper for the 2014/15 period, Jaboticabal, SP.

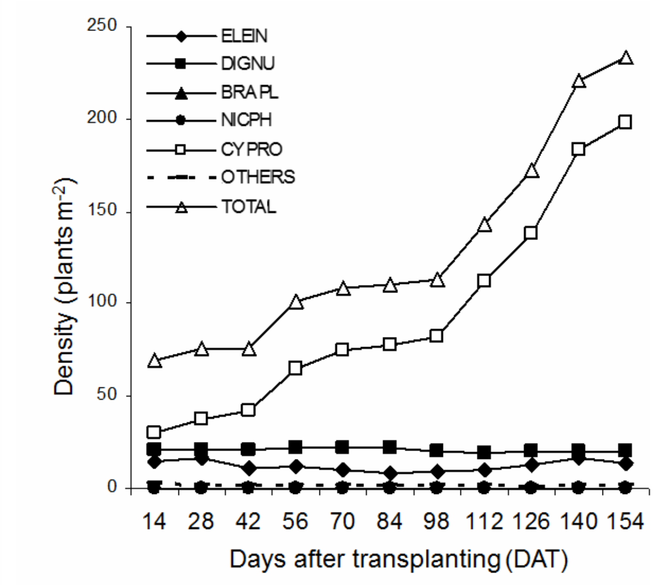

Figure 4 - Weed populational density of the infesting community due to control periods in 'Dahra' bell pepper for the 2015/16 period, Jaboticabal, SP.

For the growing coexistence periods during 2014/15 the accumulation of total dry matter presented an expressive increase from 28 DAT, after which two peaks of accumulation occurred at 70 and 140 DAT. The *E. indica* population was the largest contributor to such accumulation peaks, with 1,997.56 and 2,133.08 g m^{-2}, respectively (Figure 5). In the second experiment (2015/16), the dry matter accumulation behavior was similar to that obtained in the first experiment, in which the highest values were reached at 70 DAT. Populations that contributed to these values were of *D. nuda* (2,992.11 g m^{-2}), *E. indica* (522.63 m^{-2}) and *N. physaloides* (297.57 g m^{-2}) species. From 84 DAT, the *N. physaloides* population showed higher values of dry matter accumulation than the other populations present in the weed community until the end of the cycle (Figure 6).

In the growing control periods the accumulation of weed community total dry matter in the first experiment (2014/2015) increased up to 42 DAT, when there was a maximum accumulation of 1,671.3 g m^{-2} and from 70 to 84 DAT significantly decreased, going from 1,316.89 to 481.62 g m^{-2} (Figure 7). Populations that most contributed to the accumulation, in descending order, were of the *E. indica*, *B. plantaginea* and *D. nuda* species. From the 84 free days of weeds, dry matter

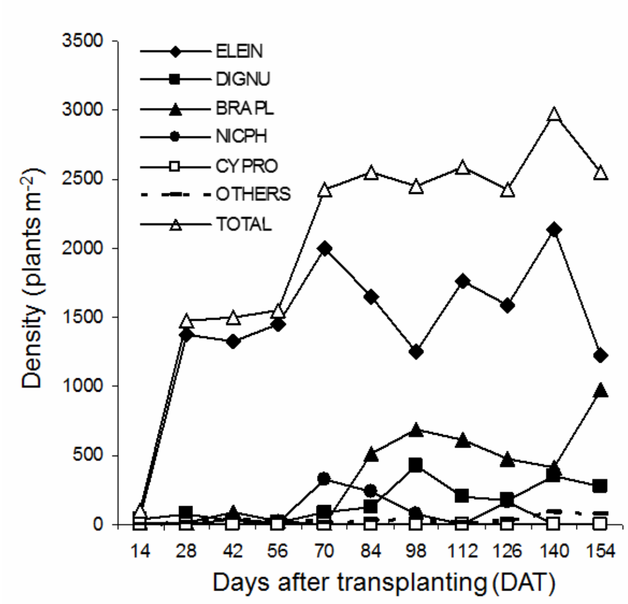

Figure 5 - Weed dry matter accumulation according to coexistence periods in 'Dahra' bell pepper for the 2014/15 period, Jaboticabal, SP.

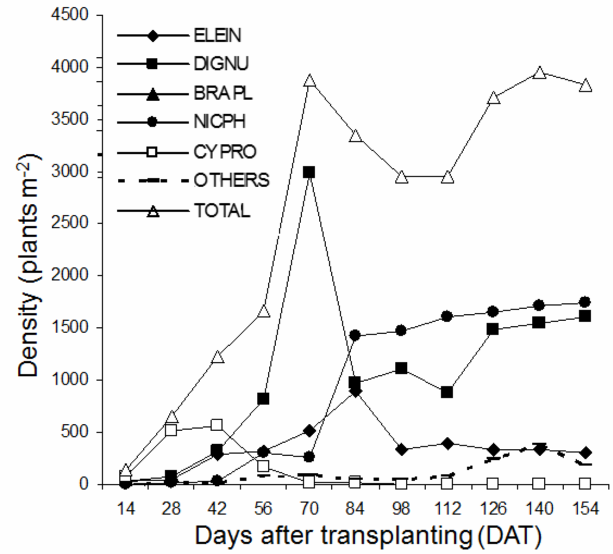

Figure 6 - Weed dry matter accumulation according to coexistence periods in 'Dahra' bell pepper for the 2015/16 period, Jaboticabal, SP.

accumulation was reduced in 89% (186.2 g m^{-2}), a fact that confirms that the control associated to shading the crop was enough to significantly reduce the infesting community biomass.

In treatments with increasing periods of control conducted during 2015/16, the dry matter accumulation gradually decreased as weeding was carried out. Populations that most contributed to obtain the highest total accumulation at 14 DAT (1,800.3 g m^{-2}) were of *C. rotundus*, *D. nuda* and *E. indica* species. At the end of the cycle, total dry matter accumulation was reduced 76% (431.6 g m^{-2}) (Figure 8).

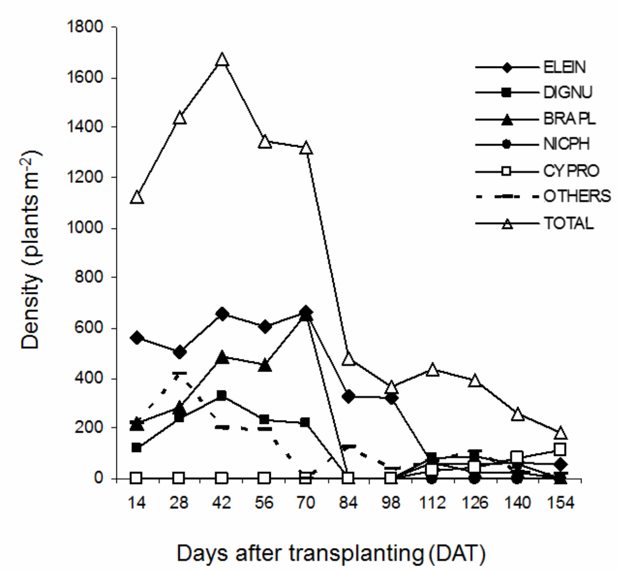

Figure 7 - Weed dry matter accumulation according to control periods in 'Dahra' bell pepper for the 2014/15 period, Jaboticabal, SP.

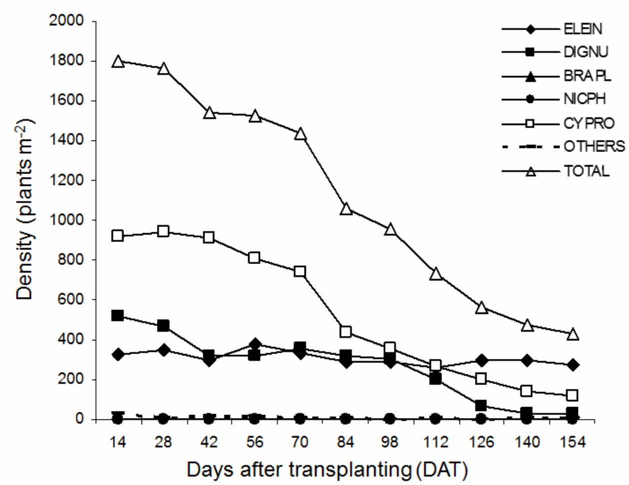

Figure 8 - Weed dry matter accumulation according to control periods in 'Dahra' bell pepper for the 2015/16 period, Jaboticabal, SP.

Analyzing the infesting community populations RIVI index behavior in the group of treatments with increasing coexistence periods for the experiment conducted in 2014/15, the ones with higher RIVI were *E. indica*, *D. nuda*, *B. plantaginea*, *N. physaloides* and *C. rotundus* (Figure 9).

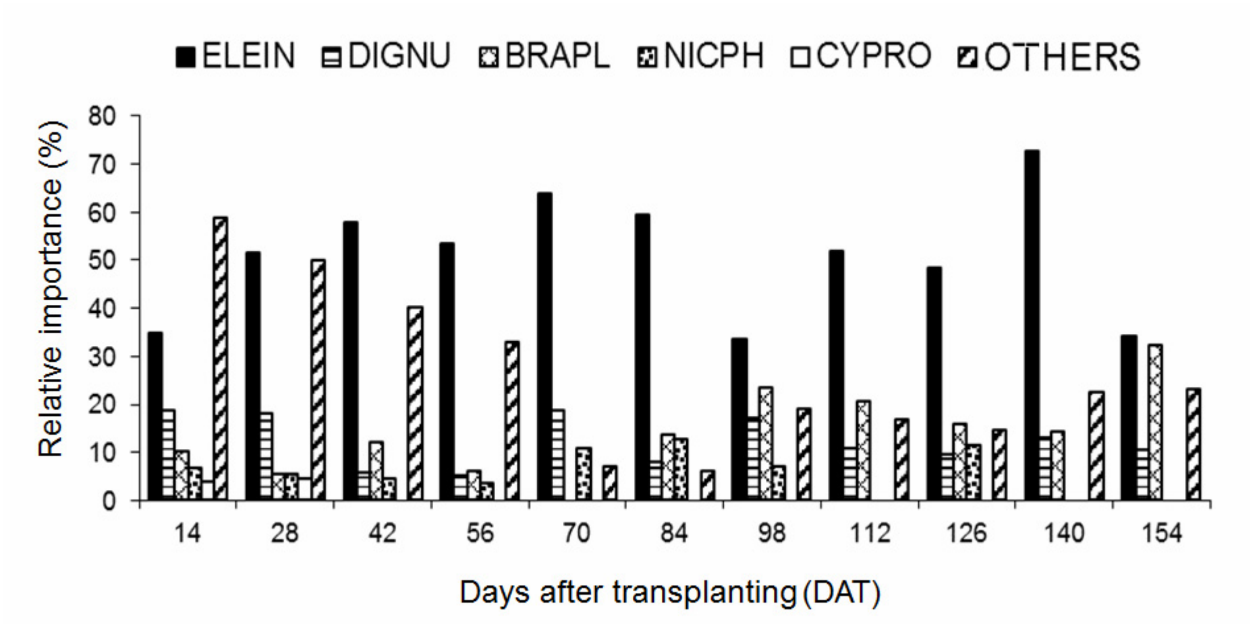

Figure 9 - Relative importance of weed community species according to coexistence periods for the 2014/15 period for 'Dahra' bell pepper, Jaboticabal, SP.

E. indica stood out from the rest of the populations during the whole experiment, presenting the highest values of RIVI at 70 and 140 DAT, with 63.72 and 72.65%, respectively, due to the higher accumulations of density and dry matter obtained. *D. nuda* presented the second largest RIVI of the community in the first half of the cycle (18.77%) while *B. plantaginea* was the second most important in the final periods, reaching an RIVI of 32.24%. The *N. physaloides* population was the fourth one in the order of RIVI in the initial periods, gaining importance in the intermediate periods of 70, 84 and 126 DAT, occupying the third highest RIVI value. *C. rotundus* was important only at 14 and 28 DAT, being the fifth most important species within the community for these periods (Figure 9).

For the experiment conducted in the 2015/16 period, the species with the highest RIVI values were, in descending order, *N. physaloides*, *D. nuda*, *E. indica* and *C. rotundus* (Figure 10). After 84 DAT, the *N. physaloides* population surpassed the other community populations, with RIVI values above 50% in all subsequent periods due to their large accumulation of dry matter (Figure 10). Similar results were found in beet, okra and eggplant crops (Carvalho et al., 2008; Bachega et al., 2013; Marques et al., 2016) under similar edaphoclimatic conditions, where there was an expressive accumulation of dry matter of this species at 91, 77 and 84 days after emergence, respectively, allowing a higher RIVI for these crops.

For the group of treatments with increasing control periods in 2014/15, the RIVI analyses revealed a highlight of *E. indica*, *D. nuda*, *B. plantaginea* and *C. rotundus* populations (Figure 11). It was observed that the *E. indica* population presented higher RIVI in the period from 14 to 126 DAT. In subsequent periods the highest percentages of RIVI were for the *C. rotundus* population due to the density.

In the 2015/16 experiment, the most important populations in the group of treatments with increasing periods of control were *C. rotundus*, *E. indica* and *D. nuda*, persisting throughout the cycle (Figure 12). The *C. rotundus* population had the greatest prominence, with RIVI values that remain in the range from 39.14 to 45.21% due to the density. The *E. indica* species had an increase in its RIVI values in the periods of 126, 140 and 154 DAT due to the accumulated dry matter in these stages. *D. nuda* was the second most important species up to 98 DAT due to its density and accumulation of dry matter, being surpassed by *E. indica* in subsequent periods, thus being in third place in order of importance (Figure 12).

According to Radosevich et al. (2007), usually in the initial periods of coexistence of an infesting community with agricultural crops there is a higher density of infestation than in the final periods. This can be explained because, due to the increase in population density and the

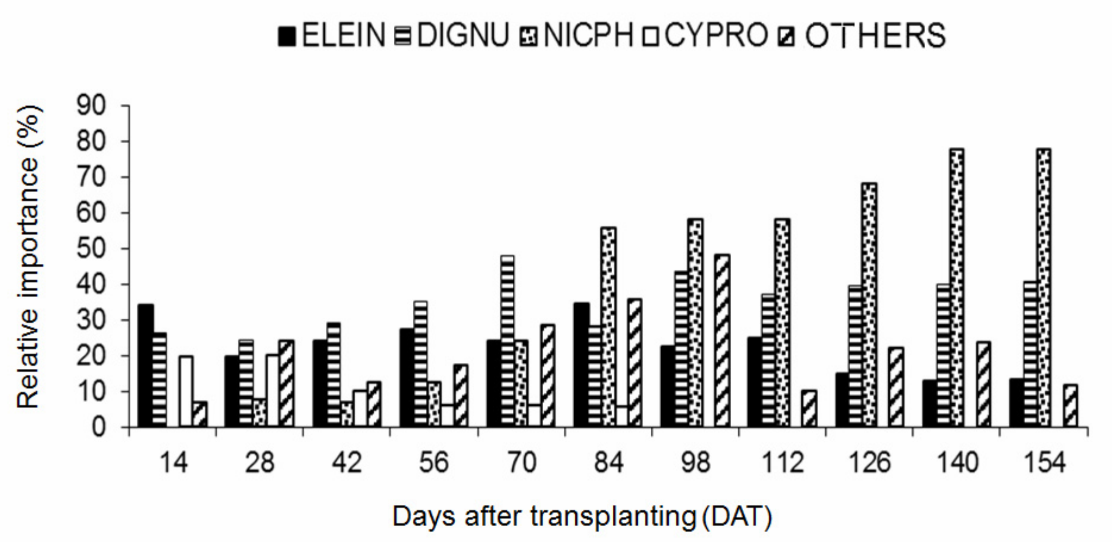

Figure 10 - Relative importance of weed community species according to coexistence periods for the 2015/16 period for 'Dahra' bell pepper, Jaboticabal, SP.

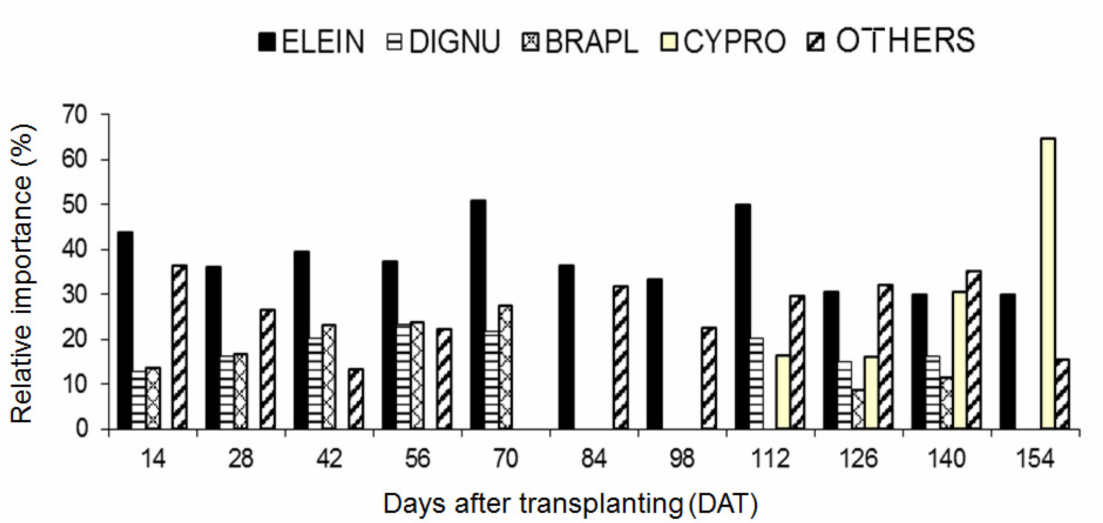

Figure 11 - Relative importance of weed community species according to control periods for the 2014/15 period for 'Dahra' bell pepper, Jaboticabal, SP.

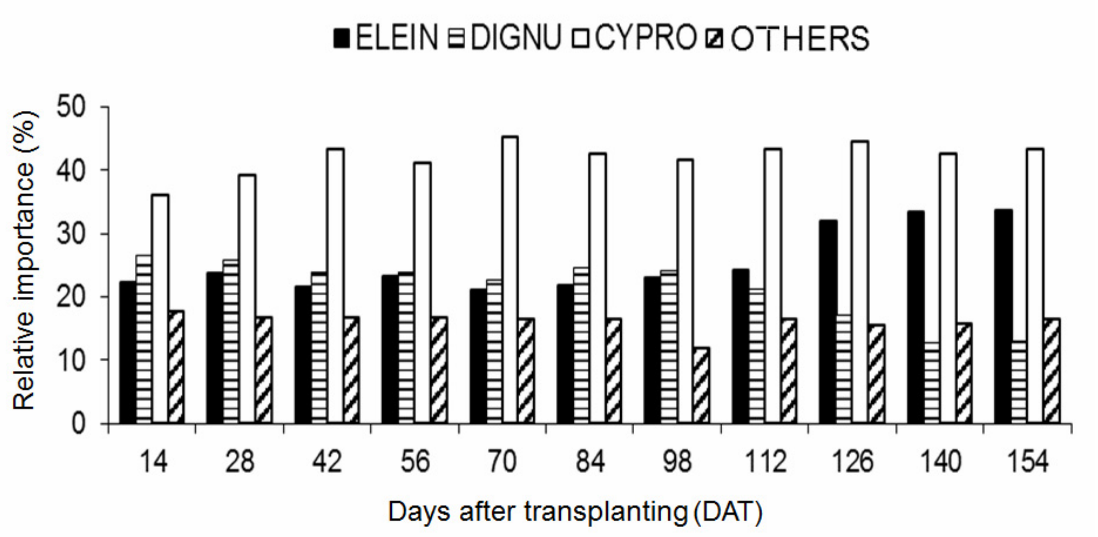

Figure 12 - Relative importance of weed community species according to control periods for the 2015/16 period (b) for 'Dahra' bell pepper, Jaboticabal, SP.

development of species, especially those that germinated and emerged at the beginning of a crop cycle, intraspecific and interspecific competitions are intensified by resources of the environment, mainly by light. In this sense, weeds with higher vegetative canopies become dominant and those with lower vegetative canopies are suppressed or die. This behavior justifies the weed community plants density reduction with increase of the dry matter during the period evaluated.

'Dahra' bell pepper yield for the groups of treatments with increasing periods of weed coexistence and control was respectively 22,874.81 and 9,379.25 kg ha^{-1} (2014/15) (Figure 13) and 21,735 and 4,997.5 kg ha^{-1} (2015/16) (Figure 14). It was observed that weed interference reduced yield of first and second experiments at 85.22 and 86.2%, respectively. Reductions above 80% are common in areas of olericulture, as verified by Zanatta et al. (2006) in a review of weed interference in potherbs.

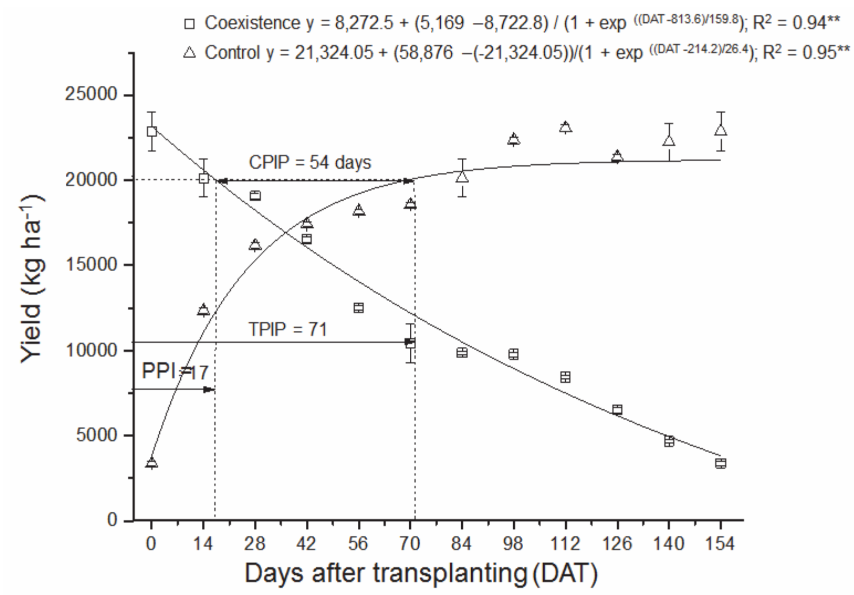

Figure 13 - Total 'Dahra' bell pepper yield, according to the periods of weed coexistence and control with the respective periods of interference, considering some loss of 5% for the 2014/15 period, Jaboticabal, SP.

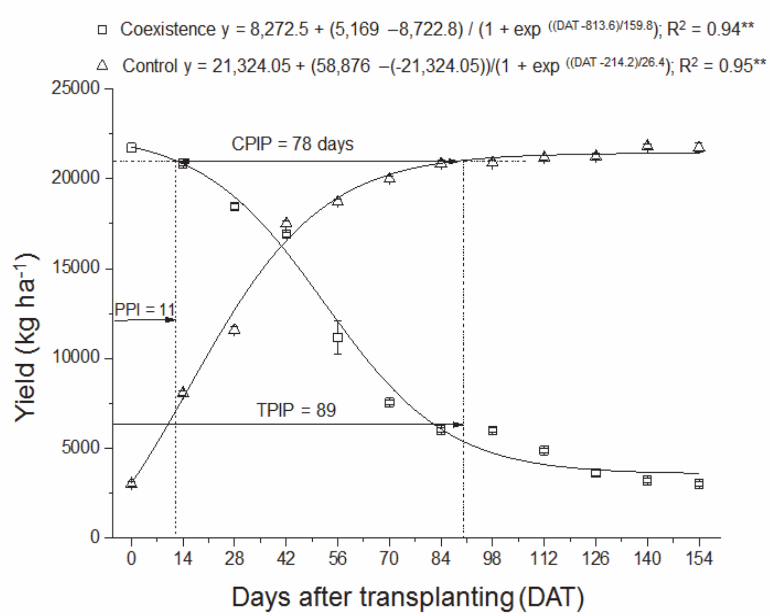

Figure 14 - Total 'Dahra' bell pepper yield, according to the periods of weed coexistence and control with the respective periods of interference, considering some loss of 5% for the 2015/16 period, Jaboticabal, SP.

Similar results were found by Cunha et al. (2015) in bell pepper plants under conventional planting and direct planting in the Brazilian region of Mossoró, RN, with yield reductions of 92.57 and 94.98%, respectively. In other olericultures such as beets, carrots, eggplants and okra, yield losses caused by weeds were up to 90, 94, 96 and 96.4%, respectively (Carvalho et al., 2008; Soares et al., 2010; Bachega et al., 2013; Marques et al., 2016).

In both experiments, the upper limit values of PPI and TPIP were estimated, with tolerance of 5% in yield reduction of 'Dahra' bell peppers. Therefore, PPI observed in first and second experiments, respectively, corresponds to 0-17 and 0-11 DAT. And TPIP to 0-71 and 0-89 DAT. Thus, CPIP for the experiment conducted in the 2014/15 period takes place from 17 to 71 DAT (Figure 13) and from 11 to 89 DAT for the 2015/16 period (Figure 14). Regarding the weed community, it was verified that weeds behavior in the second year was more aggressive than in the first year, since it presented lower PPI and higher CPIP. TPIP 18 day increase in the second year may be related to the expressive accumulation of dry matter of *E. indica* and *D. nuda* species from the beginning of the cycle, together with dry matter accumulation of *N. physaloides* species of the intermediate periods until the end of the bell pepper cycle. *E. indica* and *D. nuda* are ruderal species, according to criteria by Grime (1982), presenting characteristics of rapid germination, short cycle of development, rapid yield of diaspores and high partition of resources in the reproduction structures (Carneiro and Irgang, 2005). *N. physaloides* is a species with slower germination flow having longer cycle relative to *E. indica* and *D. nuda*. In addition, it is a more vigorous plant with higher vegetative canopy. Thus, even with low density at the beginning of the cycle, it has provided great accumulation of dry matter and has become the dominant species in the final periods of that year cycle. This fact was also verified by Carvalho et al. (2008) in eggplants and by Bachega et al. (2013) in okra in treatments with the longest coexistence period where the *N. physaloides* population substantially developed, preventing the incidence of light on the culture. In addition, it should be taken into account that in the 2015/16 period the accumulated rainfall was higher than the precipitation occurring during the 2014/15 period, a factor that in a significant way influenced dry matter accumulation rates of the dominant species.

In Mossoró (RN), Cunha et al. (2015), cultivating bell pepper in a conventional way, have verified the same PPI value but diverged in CPIP (89 days). Differences in PPI and TPIP time and extent occur due to composition and density of weed communities species in each yield area as well as the relative importance of each population and climate, soil and management conditions. These factors influence weed communities growth. Therefore, the interference imposed by the weeds present in them depends on the intrinsic growth potential of each species and the interference interactions between the individuals themselves in those communities (Pitelli, 1985).

Thus, it is essential that there be more studies on weed interference periods on bell pepper crops and, in addition, that these studies be developed in different producing regions in order to be aware of the competitive potential of the crop itself in view of the weeds of the region in question, the management strategies that can increase this competitive potential and the times when weed management is essential to reduce interference.

Under the experiments conduction conditions, it is concluded that *E. indica*, *N. physaloides*, *B. plantaginea* and *D. nuda* were the main weed species responsible for interference in the 'Dahra' bell pepper crop. Lack of weed control leads to reduction of more than 85% on bell pepper yield. Considering a tolerance of 5% in yield reduction, it is recommended that weed control be performed from 11 to 89 DAT.

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