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Weed interference periods in lettuce crop

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ABSTRACT

The knowledge of the adequate period for the beginning of weed management in lettuce crop can increase the efficiency of production, reducing the costs with management. The aim of this study was to determine the pre-interference period (PIP), the critical time for weed removal (CTWR) and the critical period of weed control (CPWC) in three lettuce cultivars, Elisa, Lucy Brown and Solaris. Coexistence and the absence of weeds were evaluated for each cultivar. The design was in randomized blocks with seven treatments (0, 7, 14, 21, 28, 35 and 42 days after transplanting - DAT) of coexistence and the same seven periods of weed absence with four replicates in each experiment. The highest infestation densities were with the species *Oxalis latifolia*, *Coronopus didymus* and *Amaranthus hybridus*. The leaf area and number of leaves per plant were reduced by up to 50% and 66%, respectively, in relation to the longest period of coexistence with weeds and yield reduced by 48% (Elisa), 40% (Lucy Brown) and 33% (Solaris). The cultivar Solaris showed greater tolerance to weed interference. Based on yield, PIP was 1, 3 and 3 DAT and CTWR was 37, 37 and 35 DAT, and CPWC was 2 to 37, 3 to 37 and 3 to 35 for the cultivars Elisa, Lucy Brown and Solaris, respectively.

Keywords: *Lactuca sativa,* weed competition, critical period, yield, weed management.

RESUMO

Períodos de interferência de plantas daninhas na cultura da alface

O conhecimento do período adequado para início do manejo de plantas daninhas na cultura da alface pode aumentar a eficiência de produção reduzindo os custos com o manejo. Objetivou-se neste trabalho determinar o período anterior à interferência (PAI), o período total de prevenção da interferência (PTPI) e o período crítico de prevenção da interferência (PCPI) em três cultivares de alface, Elisa, Lucy Brown e Solaris. Foram avaliadas a convivência e a ausência de plantas daninhas para cada cultivar. O delineamento foi em blocos casualizados com sete tratamentos [0, 7, 14, 21, 28, 35 e 42 dias após transplantio (DAT)] de convivência e os mesmos sete períodos de ausência de plantas daninhas com quatro repetições em cada experimento. As maiores densidades de infestação foram com as espécies *Oxalis latifolia*, *Coronopus didymus* e *Amaranthus hybridus*. A área foliar e número de folhas por planta foram reduzidas em até 50% e 66% respectivamente em função do maior período de convivência com as plantas daninhas e produtividade foi reduzida em 48% (Elisa), 40% (Lucy Brown) e 33% (Solaris). A cultivar Solaris apresentou maior tolerância à interferência das plantas daninhas. Com base nos dados de produtividade o PAI foi de 1, 3 e 3 DAT e o PTPI foi de 37, 37 e 35 DAT, sendo o PCPI de 2 a 37, 3 a 37 e 3 a 35 para as cultivares Elisa, Lucy Brown e Solaris, respectivamente.

Palavras-chave: *Lactuca sativa*, matocompetição, período crítico, produtividade, manejo de plantas daninhas.

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Lettuce (*Lactuca sativa*) is grown in the south-central region of Brazil, which stands out as the greatest leaf producer, surpassing 1.5 million tons per year (Pessoa & Machado Júnior, 2021). Being part of the meal of large part of the Brazilian population, lettuce is considered the most consumed vegetable in the country (ABCSEM, 2016). São Paulo state is the greatest lettuce producer, covering an area of 11,800 ha and an average yield of 19.7 t/ha (CEAGESP, 2019; IEA, 2019). The low cost in relation to other vegetables, as well as its pleasant taste and easy cultivation (several varieties adapted to different climates of several Brazilian regions throughout the year), contribute to large consumption.

Productivity can be negatively affected by the interference of weeds competing for water, light, nutrients and release of allelopathic compounds (Casadei *et al*., 2020; Riva *et al*., 2021). Moreover, weeds affect the leaf firmness and the content of nitrate and carotene (Giannopolitis *et al.*, 1989). Due to the fact that lettuce is commercialized for fresh salad consumption, the visual quality (head size, sanity and color of the leaves) is fundamental for the consumer; phytosanitary and weed managements are always a recurring farmers' concern (Fennimore *et al*., 2014). Due to the low availability of herbicides registered for lettuce, weed control still depends intensively on labor. Knowing the period when the weeds significantly reduce productivity is essential for directing efforts and resources available for the most important growing cycle.

Among the factors influencing on the degree of weed interference, the period and time of coexistence and the main crop show special importance. The critical period of competition is defined as the shortest possible period in the life cycle of a crop in which weed control has the highest economic return (Safdar *et al*., 2016). The different coexistence periods are called 'critical time for weed removal' (CTWR); 'pre-interference period' (PIP) and 'critical period of weed control' (CPWC) (Pitelli, 1985; Knezevic *et al.*, 2002). CTWR is the period when the crop shall be kept clean so that no interference occurs resulting in significant losses; PIP describes the period when the main crop and the weed can live together without yield loss; and CPWC occurs when CTWR is longer than PIP, corresponding to the phase in which management shall be carried out to avoid economic losses (Knezevic *et al*., 2002; Galon *et al*., 2018).

The weed interference in lettuce can promote reductions between 30 and 45% in yield depending on the coexistence period and the crop stage (Giancotti *et al*., 2010; Casadei *et al*., 2020). Studies on critical time for weed removal (CTWR) in lettuce crop show the value of 21 days (Cardona *et al*., 1977; Roberts *et al*., 1977; Appezato *et al*., 1983). For cultivar Elisa, CTWR was of 14 days (Silva *et al*., 1999) and for the crispy head lettuce Solaris CTWR of 21 days (Giancotti *et al*., 2010). Evaluating the interference and coexistence periods in organic cultivation of romaine lettuce cultivar Salvius, the authors found CTWR of 21 days, and when the weeds were not managed the yield losses were 45% (Parry & Shrestha, 2018). Studies on the evaluation of the interference of *Amaranthus retroflexus* for different lettuce cultivars identified higher tolerance to the interference by cultivar Lucy Brown with 28% reduction in yield in relation to the other evaluated cultivars (Casadei *et al*., 2020). Despite the importance of knowing the CTWR, few studies in the literature with information on the PIP and CPWC of different lettuce cultivars in relation to the flora and weed infestation (density) can be found.

Knowing the different coexistence periods may contribute to decide the ideal moment for weed management (Galon *et al*., 2018). However, determining CPWC is even more important for crops demanding a substantial quantity of hand hoeing, such as lettuce (Parry & Shrestha, 2018). In this context, the authors presented the following hypotheses: 1) the coexistence of weeds reduces the yield of the lettuce crop; 2) the crop tolerance to weed interference is low and 3) some differences among cultivars in relation to yield reduction were noticed. The aim of this study was to investigate the effect of different periods of weed coexistence and absence on cultivars Lucy Brown, Solaris and Elisa in order to determine PIP, CTWR and CPWC.

MATERIAL AND METHODS

The experiments were conducted in the vegetable garden at Setor de Olericultura at Universidade Estadual de Maringá, in Centro de Treinamento de Irrigação, municipality of Maringá (PR) (23º25'00''S, 51º57'05''W, altitude 542 m). The soil at the experimental area presented the following chemical properties: pH = 7.1; C = 19.6 g/dm^3; V = 83.71%; CTC = 22.30 cmol$_c$/dm^3; clay = 75.68%; sand = 12.26% and silt = 12.06%, classified as very clayey texture. During the experiment (June to July, 2016) the daily temperature, maximum, minimum and average were 37ºC, 11ºC and 24ºC respectively, whereas the maximum rainfall value was 26 mm and the minimum 0.2 mm.

Six treatments were carried out to determine PIP, CTWR and CPWC using three different lettuce cultivars: Elisa, Lucy Brown and Solaris, respectively. These are important commercial cultivars used in the region, representing consumer marketing preferences: cultivar Elisa is a looseleaf type, Solaris is a crispy head lettuce and Lucy Brown is a head lettuce. For each cultivar, the authors conducted two experiments, being one treatment for different coexistence periods (PIP), whereas the other with different periods of weed absence (CTWR). The experimental design used was randomized block, with seven treatments, and four replicates. For the experiments related to PIP, we used different coexistence periods with weeds (0, 7, 14, 21, 28, 35 and 42 days). Whereas for the experiments related to CTWR, we evaluated different periods of weed absence (0, 7, 14, 21, 28, 35 and 42 days). The coexistence and absence periods began on day 1 of the lettuce seedling transplant date. The experiments were conducted simultaneously and harvest was carried out at 42 DAT. After determining PIP and CTWR, the authors identified CPWC.

Lettuce seeds were sown in flexible plastic trays, and when the plants were 10 cm high, presenting a stable clod, they were transplanted into a seedbed, 37.8 m long x 1.2 m wide, 20 cm spacing. The experimental units measured 2.7 m long and 1.2 m wide, totalizing 3.24 m^2, with 36 lettuce plants put in four lines spaced 0.30 m. The useful plot area for the evaluations were the two central lines, ignoring the ends.

The seedbeds were previously built with the aid of a microtractor equipped with rotary hoes (10 cm) before seedling transplant. Urea fertilizer was applied as top-dressing (50% N) (200 kg/ha) using foliar fertilizer solution with Yogen® nº 2 (28% N; 10.0% P_2O_5; 1.0% Mg; 1.0% S; 0.03% B; 0.05% Cu; 0.10% Mn; 0.02% Mo; 0.10% Zn) (12 kg/ha), splitted into five weekly applications, beginning on the first week after seedling transplant.

Urea was broadcast applied and the fertilizer Yogen® nº 2 was diluted with water being manually watered. Plants were daily irrigated, sprinklers JET8020, 2 nozzles spaced 12 x 12 m, pressure of 30 mca and flow rate 0.90 m^3/h. Three 15-minute watering shifts were performed at 9 a.m., at noon and at 3 p.m., totalizing a 4.68 mm/day water depth. Weed management in the different periods of coexistence and absence was carried out with manual weeding throughout the experiment.

Species and infestation density of the weeds were evaluated in the experimental area using a sampling frame of 0.5 m^2, which was randomly placed within the useful area of the plots of the experiment of coexistence and absence of weeds at 7, 14, 21, 28, 35 and 42 days after transplant (DAT). The average infestation in the experiments with the same cultivar was used to represent both experiments (coexistence and absence), considering that it is the same experimental area with a history of infestation by the same weeds. The authors also identified and counted the weeds inside the same frame.

Number of leaves, leaf area and yield were evaluated. For the number of leaves and leaf area, two plants of the useful area were randomly collected, discarding senescent and dead leaves, as well as the leaves smaller than 3-cm long. Leaves were counted and the leaf area was measured using Delta T. Devices®. For yield, 5 lettuce plants of the useful area were harvested at 42 DAT, cutting the stem close to the ground and then weighed using a scale with 1 g sensitivity. The average weight of 5 lettuce plants was expressed in grams and afterwards converted into kg/ha.

To determine the different periods mentioned, the authors used yield. Considering the operational costs of hand weeding and also the lack of selected products for the crop, 5% was considered the minimum loss accepted for yield as a parameter to determine PIP in lettuce crop (Odero & Wright, 2013). Studies on critical interference prevention period (CPWC), 5% is the minimum loss accepted to determine PIP and CTWR (Knezevic *et al*., 2002; Kozlowski *et al*., 2009; Giancotti *et al*., 2010; Smitchger *et al*., 2012).

Data were submitted to tests of homogeneity of variance (Bartlett) and residue normality (Lilliefors), and the assumptions of analysis of variance were met ($p<0.05$) (Banzato & Kronka 2015). The analysis of variance was performed with the aid of GENES statistical software, and first and second degree polynomial models were adjusted in order to explain the data related to leaf area and number of leaves. To determine CTWR, yield results in the experiments concerning different periods of absence of weeds were submitted to the analysis of variance ($p<0.05$), and then adjusted to first degree polynomial models to assess data mentioned. To determine PIP, the experiments of coexistence with weeds were adjusted to three-parameter exponential decay nonlinear regression model, using SigmaPlot version 14.0. The model is expressed by the following equation:

$$y = y0 + a \times \exp(-b \times x)$$

Where "y" is the variable, "y0" is the minimum value of the variable, "a" is the difference between the minimum and maximum value of the variable, "b" is the total of losses per day and "x" is the coexistence day of the lettuce cultivars and the weeds (Prudente, 2012). To meet answers for our hypothesis, *Ho* (3) yield data were evaluated together, including three cultivars in both experiments (absence and coexistence), provided that the quotient between the largest and smallest residual average square of the individual variance analyses was lower than seven (Pimentel Gomes & Garcia, 2002). Treatments and experiments (different cultivars) were considered fixed factors, and the interaction was subdivided into treatments within experiments and experiments within treatments ($p<0.05$). Afterwards, the averages were compared using Tukey test ($p<0.05$), using GENES statistical software.

RESULTS AND DISCUSSION

Weed community

The experiment was installed in a weed-free area. During the crop development, nine species were identified, mostly dicots. The main family identified in the area was *Asteraceae,* with four species. *Asteraceae* and *Poaceae* families are the two main weed families in Brazil. They are found in most traditional growing areas and in differentiated systems, such as vegetable crops, sugarcane fields (Tuffi Santos *et al*., 2004) and even in pasture areas (Maciel *et al*., 2008).

The highest densities of weed species found were *Oxalis latifolia, Coronopus didymus* and *Amaranthus hybridus* (Figure 1). Garden pink-sorrel (*Oxalis latifolia*) is a slow-growing perennial plant. Since it propagates through resistant bulbs and fast-germinated seeds, this plant is able to live under different temperature and soil conditions, ensuring the reinfestation of the crops for several harvests (Arianoutsou *et al*., 2010; Everard *et al*., 2018). Native in South America and widely spread in temperate and subtropical climate regions, peppergrass (*Coronopus didymus*), in Brazil, occurs widely in the southern part of the country, infesting vegetable gardens and seedbeds. This weed species with prostrate growth habit, and large populations, spreads in areas widely (Kismann & Groth, 2000). The genus *Amaranthus* spp is an important weed species found in lettuce growing areas, always interfering with the early growth of the crop due to light interception by the highest canopy (Santos *et al*., 2003).

Evaluations of number of leaves and leaf area

For number of leaves and leaf area, the authors noticed significant effect of the different periods of coexistence and absence between weeds and the crop ($p<0.05$). First and second degree polynomial models were adjusted for all the lettuce cultivars, for both experiments, different coexistence period (PIP) and different absence period (CTWR).

For cultivar Elisa, when the crop was kept weed-free throughout the experiments (0 day of weed coexistence), we noticed 60 cm^2/plant of leaf area. As the coexistence days increased gradually, the leaf area of the lettuce plants decreased, resulting in values 30 cm^2/plant after 42 days of weed coexistence (Figure 2a). The presence of weeds reduced to almost 50% the leaf area of the plants. Evaluating the period of weed absence, in the first period (no weed at all) and the leaf area observed was also close to 30 cm^2/plant, confirming the results found in the experiment with weed-infested plants. On the other hand, when the crop was kept weed-free for 42 days, the authors observed leaf area of 50 cm^2/plant.

Similar behavior was observed in cultivars Lucy Brown and Solaris. In the experiment concerning weed absence, after 42 days, cultivar Lucy Brown presented 49.8 cm^2/plant of leaf area (34 cm^2/plant). Similar result was verified in the experiment 0 days of weed coexistence (49 cm^2/plant) whereas after 42 days of coexistence, the authors observed 34% of reduction

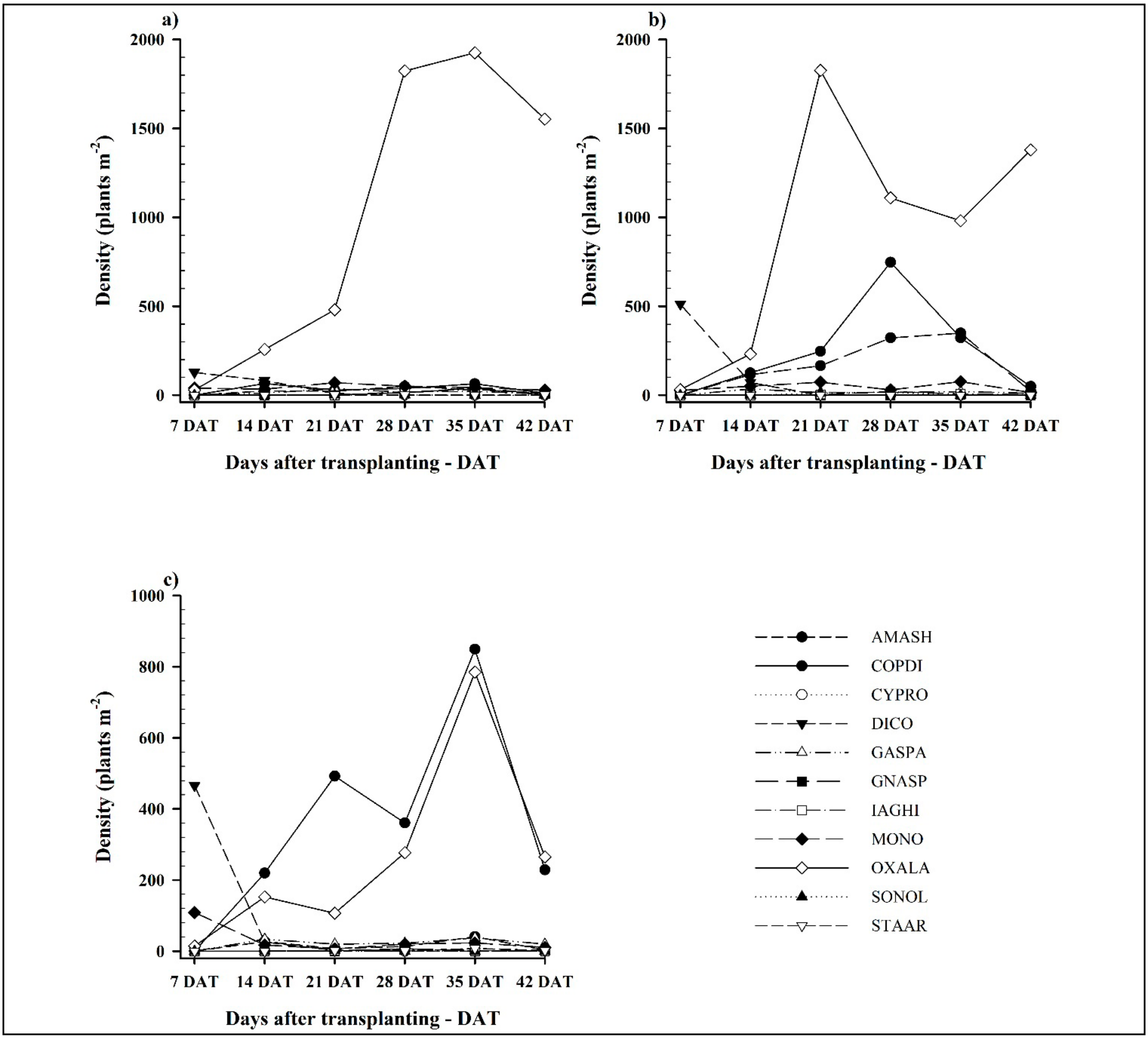

Figure 1. Average weed density by weed species in relation to different evaluation times in the experiments on coexistence and absence of weeds in cultivars Elisa (a), Lucy Brown (b) and Solaris (C). Maringá, UEM, 2016.

(32 cm^2/plant) (Figure 2c). As observed for Elisa and Lucy Brown, a reduction in the leaf area of cultivar Solaris related to an increase of the period of weed coexistence was verified. After 42 days of coexistence, the values were 36% lower (27.9 cm^2/plant) compared with the weed-free period (44 cm^2/plant). The authors noticed similar results in the experiment of weed absence. An increase in the weed-free period resulted in values 31.9% higher for lettuce leaf area (44.2 cm^2/plant) after 42 days with no weeds in the crop compared to 0 days of absence (30.1 cm^2/plant) (Figure 2e).

Machado *et al*. (2009) also verified prejudicial effect on the leaf area of lettuce plants concerning competition with weeds. Different results were found in other studies, when in competition with weeds; the cultivar Lucy Brown presented an increase in leaf area at 7 DAT (Melhorança Filho *et al*., 2008). The authors argue that the crop minimizes the effects of competition for light with plant shading. However, the evaluation of species and growth habit of the weeds have to be evaluated. Melhorança Filho *et al*. (2008) did not present the infesting flora diversity in this study, besides the *Cyperus rotundus* species. In this study, the highest infestation densities are related to *Oxalis latifolia* and *Coronopus didymus* plants. The experiments with cultivar Lucy Brown presented density, for *Coronopus didymus,* of 246 and 747 plants/m^2 at 28 and 35 DAT; the experiments with the cultivar Solaris showed weed density of 492 and 360 plants/m^2 at 28 and 35 DAT, respectively. For *Oxalis latifolia* infestation, the values were greater than 750 plants/m^2, in at least one of the evaluations in the experiments using the three cultivars (Figure 1). As they are small size plants, no severe competition with the main crop for light interception could be noticed, these weeds significantly increase their population, though. *Coronopus didymus* presents prostrate growth habit, spreading rapidly in the areas (Kismann & Groth, 2000).

For number of leaves per plant, at 0 days of weed coexistence, the cultivar Elisa showed 36% more commercially viable leaves/plant, when compared to 42-day coexistence (23 leaves/plant). The opposite was observed in the experiment concerning weed-free days, considering 0 days of weed absence (presence of weeds throughout the period) the number of leaves per plant were 33% lower (22 leaves/plant), whereas at 42 days of weed absence the value observed was 33 leaves/plant

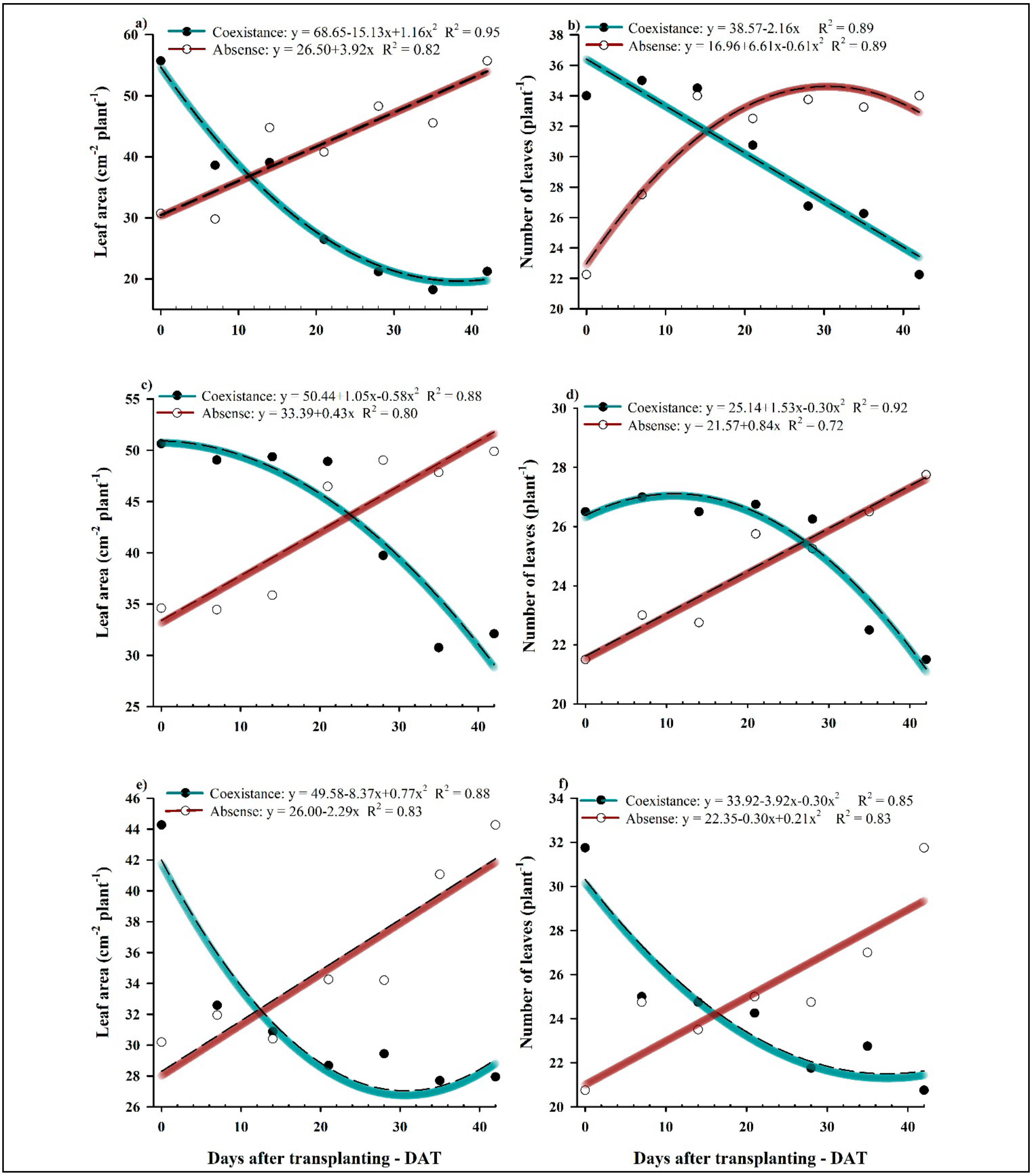

Figure 2. Evaluation of leaf area and number of leaves for cultivar Elisa (a; b); Lucy Brown (c; d) and Solaris (e; f) in relation to different periods of coexistence and absence of weeds. Maringá, UEM, 2016.

(Figure 2b).

Cultivars Lucy Brown and Solaris also showed decreasing behavior for number of leaves as the coexistence periods were longer. Cultivar Lucy Brown accumulated a reduction of 18% (21.5 leaves/plant) after 42 days of weed coexistence compared to the days of weed free period (26.5 leaves/plant) (Figure 2d). After 42 days of weed coexistence, the cultivar Solaris reduced the number of leaves 35% (20 leaves/plant) when compared with weed-free period (31 leaves/plant). The experiment concerning the weed-free period also showed similar behavior, increasing the number of leaves/plant in relation to an increase in weed-coexistence period (Figure 2f).

Studies on the evaluation of the influence of different periods of weed coexistence also verified negative effect on lettuce traits, such as plant height, fresh matter and leaf area in different cultivars (Silva *et al*., 1999; Machado *et al*., 2009; Giancotti *et al*., 2010; Odero & Wright, 2013; Casadei *et al*., 2020).

Determination of the pre-interference period (PIP), critical time for weed removal (CTWR) and critical period of weed control (CPWC)

Yield data were used to determine different weed coexistence periods. Weed coexistence and absence influenced yield ($p<0.05$). For the experiments concerning the effect of different weed coexistence periods, three-parameter exponential decay model was adjusted, whereas for experiments with different absence periods with the main crop, first degree polynomial model was adjusted.

Cultivar Elisa showed maximum yield (21.90 t/ha) when the crop showed to be free from weeds throughout the entire growing season, and after 42 days of coexistence, the authors verified a reduction of 48.3% in yield, resulting in 11.33 t/ha. In the experiment on 42-day weed absence, the authors verified similar values (21.67 t/ha), showing

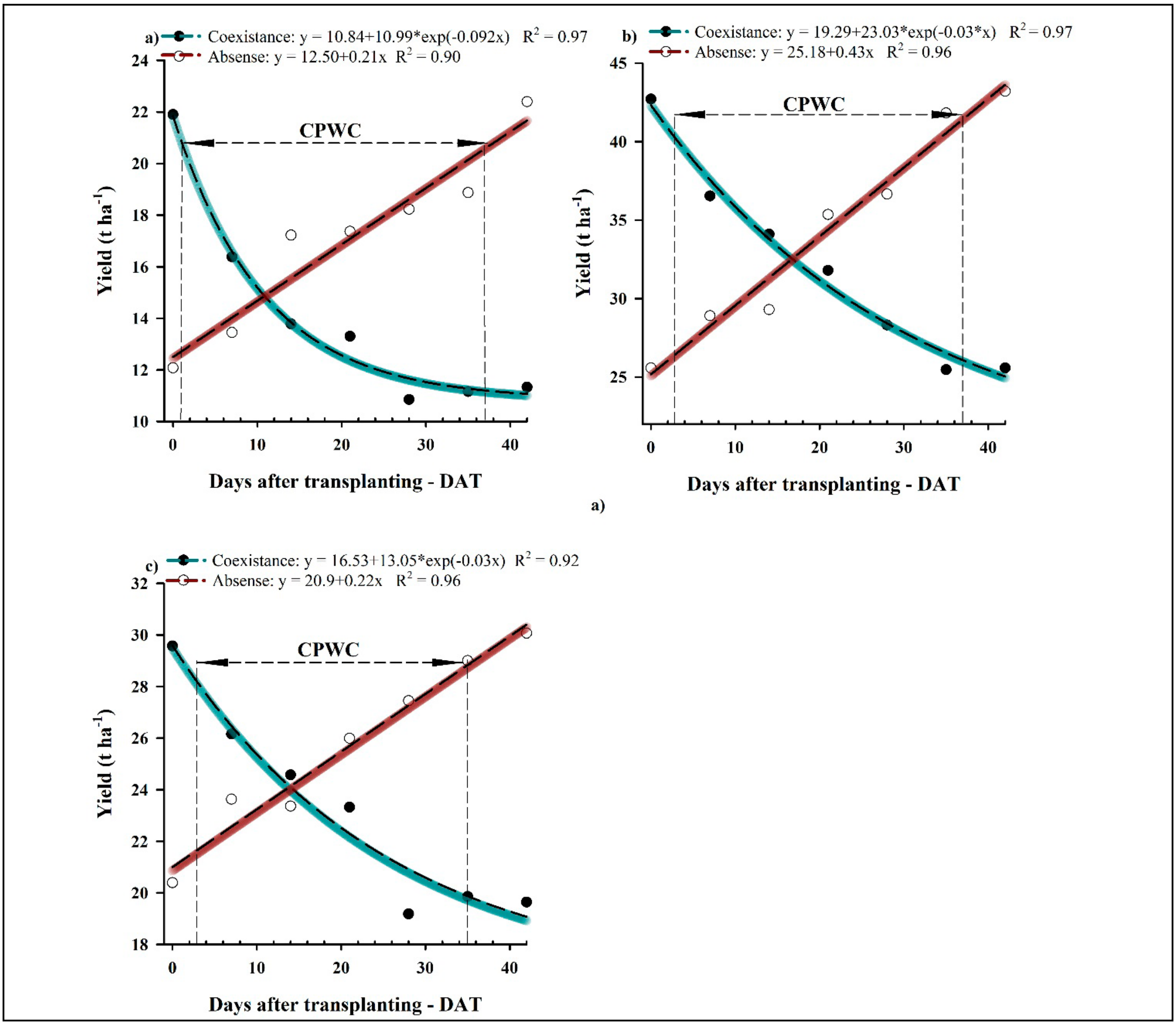

Figure 3. Yield evaluation as a function of different coexistence periods and absence of weeds for the cultivars Elisa (a), Lucy Brown (b) and Solaris (c). Maringá, UEM. 2016.

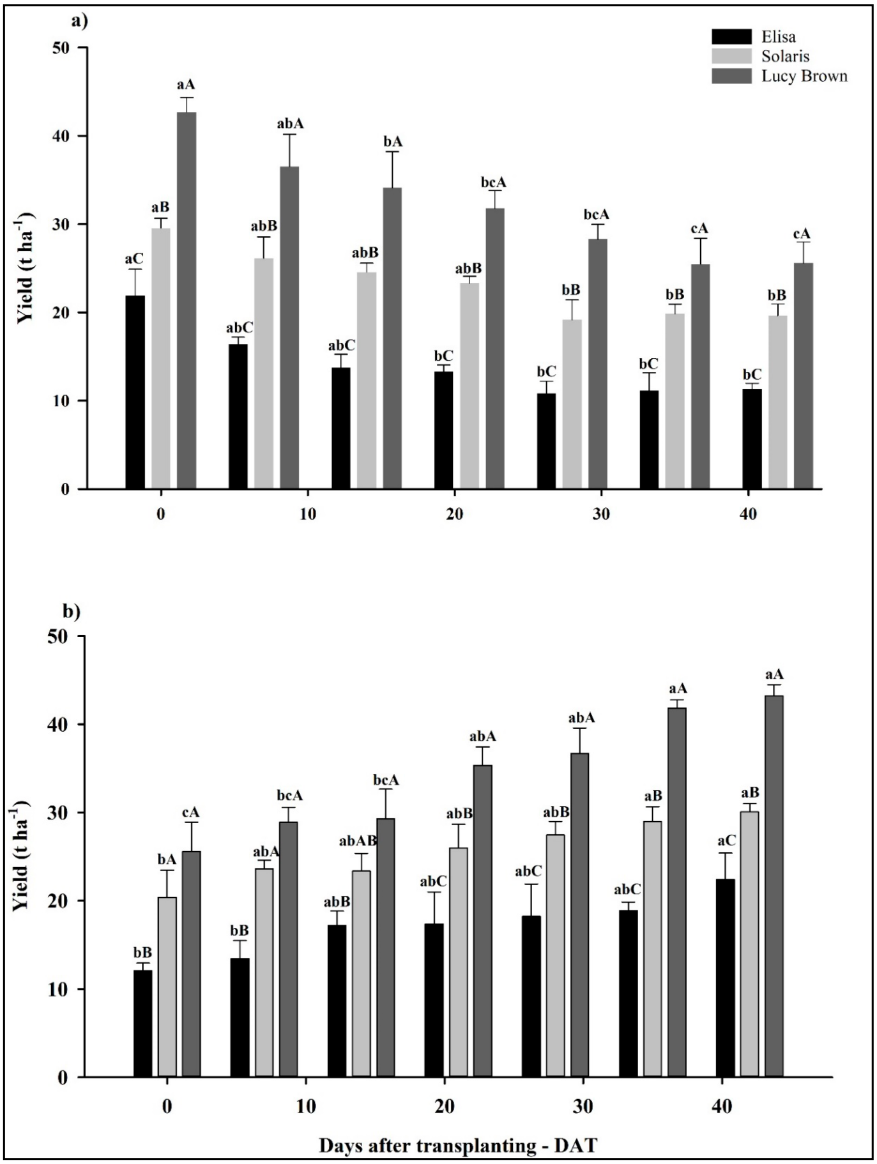

Figure 4. Yield of cultivars Elisa, Solaris and Lucy Brown, in the different periods of coexistence experiments (a) and absence (b) of weeds. Uppercase letters compare cultivars in the same treatment (interference period) and lowercase letters compare treatments [periods of coexistence (a) and absence (b) of weeds, by Tukey test ($p<0.05$)]. Maringá, UEM, 2016.

a negative impact when the plant coexist for a longer period of time with weeds (Figure 3a). The adjusted model estimated a reduction in 5% of yield for cultivar Elisa from day 1 coexisting with weeds, so that PIP was already determined for 1 day. In relation to the conditions of this experiment, CTWR of the cultivar was evaluated at 37 days and CPWC was 2 at 37 days.

The yield of cultivars Lucy Brown and Solaris were also negatively affected by the weeds. For cultivar Lucy Brown, the maximum yield estimated concerning 0 coexistence days with weeds was 42.32 t/ha. Among the evaluated cultivars, Lucy Brown showed the highest yield potential. This cultivar belongs to the group of head or iceberg lettuce and, therefore, has greater capacity to hold water when comparing to the other cultivars. The model adjusted for the data showed an expressive reduction in yield right at the beginning of the periods of coexistence with weeds (Figure 3b). After 42 days of coexistence between the cultivar and weeds, the yield estimated was 25.04 t/ha (Figure 3b), 40.8% reduction.

In different periods of absence between weeds and cultivar Lucy Brown, the authors observed a fast response in relation to an increase of lettuce yield. At 0 days of weed absence, the yield was 25.18 t/ha, whereas after 7 days of weed absence, the estimated yield was 28.25 t/ha, providing an increase of 12.2% in crop yield. After 42 days of no weed interference, yield was 43.62 t/ha, accumulating an increase of 42.2% compared to the period when coexisted all the time with weeds. The period of greatest susceptibility of crops to competition with weeds is from the seedling planting to the beginning of development (Odero & Wright, 2013). So, the absence of weeds at the beginning of the crop development cycle can promote a greater yield response, contradicting Melhorança Filho *et al*. (2008) and in agreement with Machado *et al*. (2009). Moreover, studying the interference of mixed weed populations in lettuce crop, the authors identified 75% reduction in yield when the plants coexisted with weeds throughout the cycle (Odero & Wright, 2013). In the experiments using cultivar Lucy Brown, after 42 DAT, we identified a density of 19.4 plants/m^2 of *Amaranthus hybridus*. A 64.2% reduction in yield of lettuce, cultivar Lídia, was observed in an experiment using 16 plants/m^2 of *Amaranthus* spp. (Casadei *et al*., 2020). Considering the acceptable loss limit of 5% yield, the PIP for the Lucy Brown cultivar was at 3 days (2.8 days) and CTWR at 37 days. Thus, the CPWC consists of a period of 3 to 37 days of the crop cycle.

In relation to lettuce cultivar Solaris, after 42 days of weed coexistence, the authors estimated yield of 19.07 t/ha, whereas at 0 days of coexistence the yield was 29.58 t/ha, 35.5% reduction. Data related to weed absence corroborated the results observed in the experiment concerning coexistence. After 42 days of weed absence, we observed yield of 30.39 t/ha, whereas at 0 days of weed absence, yield was 20.99 t/ha (Figure 3c) a difference of 30.9%. Assuming a limit of 5% of acceptable losses, the PIP of the Solaris cultivar was at 2.9 days (3 days) and the CTWR at 35 days, so the CPWC consisted of 3 to 35 days.

The reduction of yield of the different cultivars in relation to a longer coexistence with weeds is due to competition for water, light and nutrients, which may have affected physiological traits of the lettuce, such as production of xanthophylls, β-carotene and chlorophyll, resulting in reduced growth and development (Parry & Shrestha, 2018). Within the same species, different cultivars have different levels of tolerance to weed interference (Pitelli & Durigan, 1992). Lettuce yield was significantly different among the cultivars in both experiments (absence and coexistence) ($p<0.05$). Cultivar Lucy Brown surpassed the yield of cultivar Solaris and Elisa regardless of the period of absence and coexistence with weeds (Figure 4). Data related to these different cultivars showed a proportional reduction of yield. Even in free-weed periods (0 days of coexistence and 42 days of absence) the yield of cultivars was different ($p<0.05$). However, differences between the amplitude of variation in yield between periods of 0 and 42 days of absence and coexistence between cultivars can be verified. The increase in yield related to the weed-free experiments were 40%, 32% and 46%, whereas the decreases of yield in the weed-infested experiments were 40%, 33% and 48% for Lucy Brown, Solaris and Elisa, respectively. Cultivars Elisa, Lucy Brown and Solaris presented CPWC of 2 to 37, 3 to 37 and 3 to 35 days, respectively.

These results showed that weed interference reduces the lettuce yield and that the crop has low tolerance to weed interference. Besides, cultivar Solaris showed higher tolerance to weed interference when compared with the other cultivars, Elisa and Lucy Brown. These data help out lettuce producers (cultivars Elisa, Solaris and Lucy Brown) choose the right time to start and end weed management. The information in this study highlights the periods when the crops are more sensitive to competition with weeds due to the density and diversity of the flora in the production area. Lettuce agriculturists can use these pieces of information to reduce yield losses related to weed interference, and also, costs with weed management after critical interference period.

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