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COMPETITION OF WILD POINSETTIA BIOTYPES, WITH A LOW-LEVEL RESISTANCE AND SUSCEPTIBLE TO GLYPHOSATE, WITH SOYBEAN

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ABSTRACT

The competition of soybean (*Glycine max* L.) with wild poinsettia (*Euphorbia heterophylla* L.) may alter crop growth and crop yield. The objective of this study was to analyze the competitive ability of wild poinsettia biotypes, with a low-level resistance and susceptible to glyphosate, with soybeans. Experiments were conducted in soybean replacement series with the susceptible biotype (11.4, from Panambi) (first experiment) or a low-level resistant biotype (21.1, from Condor) (second experiment) in 2013/14 and 2014/15. The population of plants in the experiments was 20 plants pot^{-1} (481 plants m^{-2}), whose tested proportions were 100:0 (soybean monoculture), 50:50 and 0:100% (wild poinsettia monoculture). The variables were height, leaf area and shoot dry matter. Soybeans are more competitive than wild poinsettia regardless of the competitive biotype. The most harmful intraspecific competition was related to the culture and the interspecific competition was related to the weed. Thus, susceptible wild poinsettia or with a low-level resistance to glyphosate have a lower competitive ability per individual than soybeans when they occur at the same rate.

Keywords: replacement series; intraespecific competition; competitiveness; *Euphorbia heterophylla*; competitiveness indexes

1. INTRODUCTION

Soybean (*Glycine max* L.) stands out among the main oil plants produced in the world. Brazil is the second largest producer and exporter of soybeans, and its production is around 86 million

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tons of grains (FAO 2016). Among the factors that affect crop productivity, the negative interference of weeds by competition stands out. Competition between plants occurs when at least one of the essential resources for the plant's development and growth is below the quantity necessary to meet the needs of all individuals in the environment (Radosevich et al., 2007).

Among important weeds for soybean culture, wild poinsettia (*Euphorbia heterophylla* L.) are relevant mainly to transgenic crops as there are reports of tolerance of this species to glyphosate (Vargas et al., 2011). Were observed a decrease in height (Carvalho et al., 2010), dry matter of soybean plants (Rizzardi et al., 2004) and number of trefoils (Carvalho et al., 2010) when in competition with wild poinsettia, highlighting the importance of this species.

To determine the competitive interactions between weeds and crops, several methods were developed. Such methods take into account population of plants, proportion of species and spatial arrangement (Radosevich 1987). Overall, the methods used to study the interference between crops and weeds consider at varying degrees the proximity factor by the adjustment of the plant population, spatial arrangement and/or ratio (Rizzardi et al., 2004).

Experiments with replacement series include analyses of monocultures and mixtures of tested species, in which the proportions of species vary while the total plant population is kept constant in all treatments (Cousens 1991; Radosevich et al., 2007). Such models allow studying inter and intraspecific competition with the assumption that the yield of the associations can be determined by comparing them to the monocrop yield.

Studies on the competitive ability of soybeans with wild poinsettia in replacement series showed that both species, when mixed, produced more than the respective monocultures. There was an increase in relative yield as the proportion of wild poinsettia increases (Rizzardi et al., 2004). However, little is known about the competitive ability of wild poinsettia biotypes with a low-level resistance to glyphosate. Further studies should analyze them considering the damage potential to soy in relation to susceptible biotypes. Thus, the objective of this study was to analyze the competitive ability of wild poinsettia biotypes, with a low-level resistance and susceptible to glyphosate, with soybeans.

2. MATERIALS AND METHODS

2.1. Study design

The study consisted of two replacement series from December 2013 to January 2014, repeated during November and December 2014, considering the 2013/14 and 2014/15 growing seasons, respectively. The experiments were conducted in a greenhouse in a completely randomized

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design with three replications. The experimental units were 8-liter pots with a diameter of 23 cm filled with Red-Yellow Argisol with a sandy loam texture and fertility corrected according to soil analysis.

The treatments were proportions of soybean and wild poinsettia plants: 100:0 (soybean monoculture), 50:50 (mixture), and 0:100% (wild poinsettia monoculture). The soybean cultivar used was the BMX Potência RR®. For wild poinsettia, different biotypes were used, namely: 11.4, from Panambi (28°26'02" S, 53°29'60" W), considered susceptible (first experiment) to glyphosate; and 21.1, from Condor (28°14'005" S, 53°36'582" W), considered as low-level resistant to the herbicide (second experiment). The seeds were sown in polyethylene trays and plants were transplanted to pots at 15 and 11 DAE for wild poinsettia and soy plants, respectively.

The populations of plants were determined by previous experiment, when were find population of 32 plants pot^{-1} for wild poisettia, according to "law of constant final yield" (Radosevich et al., 2007), and 8 plants pot^{-1} for soybean (Agostinetto et al., 2009) (data not shown). The population per experimental unit were found by calculating the arithmetic mean of the populations, resulting in 20 plants pot^{-1}, equivalent to 481 plants m^{-2}.

2.2. Variables analysis

The variables evaluated at 45 days after transplanting (DAT) were height (HE), leaf area (LA) and shoot dry matter (SDM) for both species. HE was measured on five plants per replication with a millimeter ruler considering the length from the soil to the apex of the plant with the leaf blade distended. LA was determined with a leaf area meter, LI 3200 C. The value was obtained in cm^2 and converted into cm^2 $plant^{-1}$. The SDM was measured in an oven at 60°C and expressed in g $plant^{-1}$.

2.3. Data analysis

2.3.1. Relative and total yield

For data analysis, graphical analyses of relative productivity were used (Cousens 1991; Radosevich 1987). The procedure consists in designing diagrams based on the relative (RY) and total (RYT) yield in the plant proportions tested for the culture and the competitor biotype (equations 1 and 2, respectively).

$$RY = \frac{y_{mixture}}{y_{monoculture}} \quad (1)$$

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where $y_{mixture}$ is the average for the mixture and $y_{monoculture}$ is the average for the monoculture using in the calculation the average for each plant species in each experimental unit.

$$RYT = RY_{soybean} + RY_{biotype} \quad (2)$$

where $RY_{soybean}$ and $RY_{biotype}$ are the relative yield of the crop and the competitor wild poinsettia biotype, respectively, for each ratio of plants.

In the diagrams, the results are compared to the values of a hypothetical line joining the points zero and representing the absence of interference between genotypes. If RY results in a concave line, this means that there is a loss in the growth of one or both species; if the line is convex, there is benefit in the growth of one or both species. When the RYT is equal to the unity (one) (line), it means that there is competition for the same resources; if higher than one (convex line), the competition is avoided because the supply of resources exceeds the demand or because species have different demands for environmental resources; and, if less than one (concave), there is a mutual impairment on the growth of species (Cousens 1991; Radosevich et al., 2007).

2.3.2. Competitiveness indexes

In addition to RY and RYT, the relative competitive index (RC) (equation 3), the relative clustering coefficient (K) (equation 4) and the competitive index (C) (equation 5) were calculated (Cousens & O"Neill 1993). RC means comparative culture growth in relation to wild poinsettia biotype competitors (11.4 or 21.1), K indicates the relative dominance of one species over another, and C indicates which species is more competitive (Cousens 1991; Cousens & O'Neill 1993). The soybean crop is more competitive than the competitor biotype when RC > 1, $K_{soybean} > K_{biotype}$ and C > 0 (Hoffman & Buhler 2002). On the other hand, the competitor biotype is more competitive than soybean when RC < 1, $K_{soybean} < K_{biotype}$ and C < 0.

$$RC = \frac{RY_{soybean}}{PR_{biotype}} \quad (3)$$

$$K_{soybean} = \frac{RY_{soybean}}{1 - RY_{soybean}} \qquad K_{biotype} = \frac{RY_{biotipe}}{1 - RY_{biotype}} \quad (4)$$

$$C = RY_{soybean} - RY_{biotype} \quad (5)$$

2.3.3. Statistical analysis

The differences for RY values (DRY), obtained from a proportion of 50% of plants, was first calculated in relation to the values of hypothetical lines (Bianchi et al., 2006). Then, the t test (p

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= 0.05) was used to test the differences in DRY, RYT, RC, K and C indexes (Hoffman & Buhler 2002). The null hypotheses to test the differences in DRY and C are the following: averages are equal to zero ($H_0 = 0$); for RYT and RC, means are equal to one ($H_0 = 1$); for K, the mean of differences between $K_{soybean}$ and $K_{biotype}$ is zero [$H_0=(K_{soybean}-K_{biotype})=0$]. The criterion to consider the existence of differences in the competitiveness for the indexes RC, K and C was that at least two indexes differed according to t test (Bianchi et al., 2006). The results for HE, LA and SDM, expressed as average values per plant, were subjected to analysis of variance ($p\leq0.05$). When a significance was found, the averages were compared by t test ($p\leq0.05$).

3. RESULTS AND DISCUSSION

3.1. Competitive interaction between soybean and wild poinsettia biotypes

The graphical analysis of the combinations of soybean and wild poinsettia biotypes 11.4 (susceptible) or 21.1 (low-level resistant) for the variable HE in both experiments showed that the observed deviations of RY lines are represented by lines close to the hypothetical line for the culture and concave lines for the biotypes 11.4 and 21.1 (Figure 1). Similarly, soybean RYs competing with *Eleusine indica* (L.) Gaertn. show values close to the hypothetical values, indicating an absence of interference of a plant over another for this variable (Wandscheer et al., 2013).

For the variables LA and SDM, the RY of the culture showed convex and concave lines for wild poinsettia biotypes in both years (Figures 2 and 3). These results show that, in general, the presence of a competitor did not represent losses for soybeans, indicating that the weed was less competitive.

Considering the mixture of wild poinsettia with soybeans, there was a higher increase in the RY of the culture when the proportion of wild poinsettia increased, resulting in convex lines (Rizzardi et al., 2004) and confirming the results observed in this study. Similarly, the soybean crop was considered more competitive than *Digitaria ciliaris* (Retz.) Koel. based on the LA and SDM. The RY of soybean was represented by convex lines and the concave lines represented the weed (Agostinetto et al., 2013).

Differences in the competitive ability of weed biotypes with and without resistance to glyphosate may exist. This was observed for *Lolium multiflorum* L., where soybeans had a competitiveness equivalent to the susceptible biotype and lower than the resistant biotype (Oliveira et al., 2014). However, the RYs of soybean in competition with biotypes of *Conyza bonariensis* (L.) Cronq. resistant or susceptible to glyphosate, regarding HE, LA and SDM, were represented by concave lines and indicated that the culture's loss due to competition with the weed is independent of the

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biotype (Silva et al., 2014). For the experiments with wild poinsettia biotypes susceptible to glyphosate and with a low level of resistance, the behavior of the culture in relation to the presence of either one or the other competitor biotype was not affected. In all situations, the culture overcame the weed (Figures 1, 2 and 3).

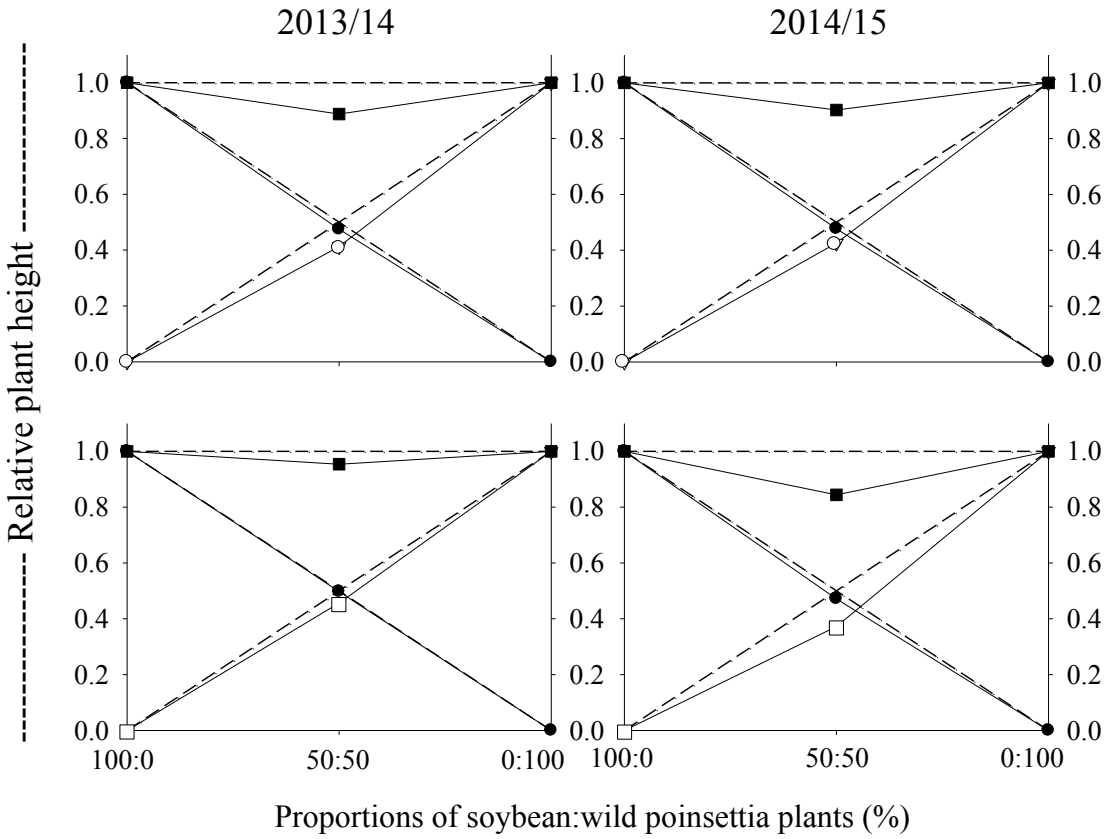

Figure 1. Relative yield of soybean (*Glycine max* (L.) Merr.) (□), wild poinsettia biotypes (*Euphorbia heterophylla* L.) 11.4 (□) (susceptible) or 21.1 (□) (low-level resistant), and relative yield total (□) for plant height in function of the ratio between species regarding plant population conducted during two growing seasons (2013/14 and 2014/15). Dashed lines refer to the hypothetical relative yield.

A study on the competition of wild poinsettia and soybeans in replacement series showed that the increase in the proportion of the weed by up to 75% in the mixture reduced the SDM of soybean by 28%, a value considered low when compared to the 60% decrease afforded by the presence of *Ipomoea ramosissima* (Poir.) Choisy. under the same conditions (Rizzardi et al., 2004). Thus, it is possible to estimate that a coexistence with wild poinsettia influences the soybean crop to a lesser extent. However, damage to the weed may occur.

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The coexistence of wild poinsettia in an equal proportion with soybean hindered the development of the weed, characterized by values below expectations shown in the graphical analysis of the combinations (Figures 1, 2 and 3). This result is different from that observed in a study using the same species, where both produced a biomass quantity above the expected, indicating a production higher in the mixture than in their respective monocultures (Rizzardi et al., 2004). *Digitaria ciliaris* plants coexisting with rice or soybeans had RYs lower than the values of the hypothetical line, confirming the damage caused by the weed due to competition as well as its low competitive ability (Agostinetto et al., 2013). However, the response of RY to LA and SDM of *Conyza bonariensis* in competition with soybean, evidenced by convex lines, demonstrated that the weed benefited from the presence of the culture (Silva et al., 2014).

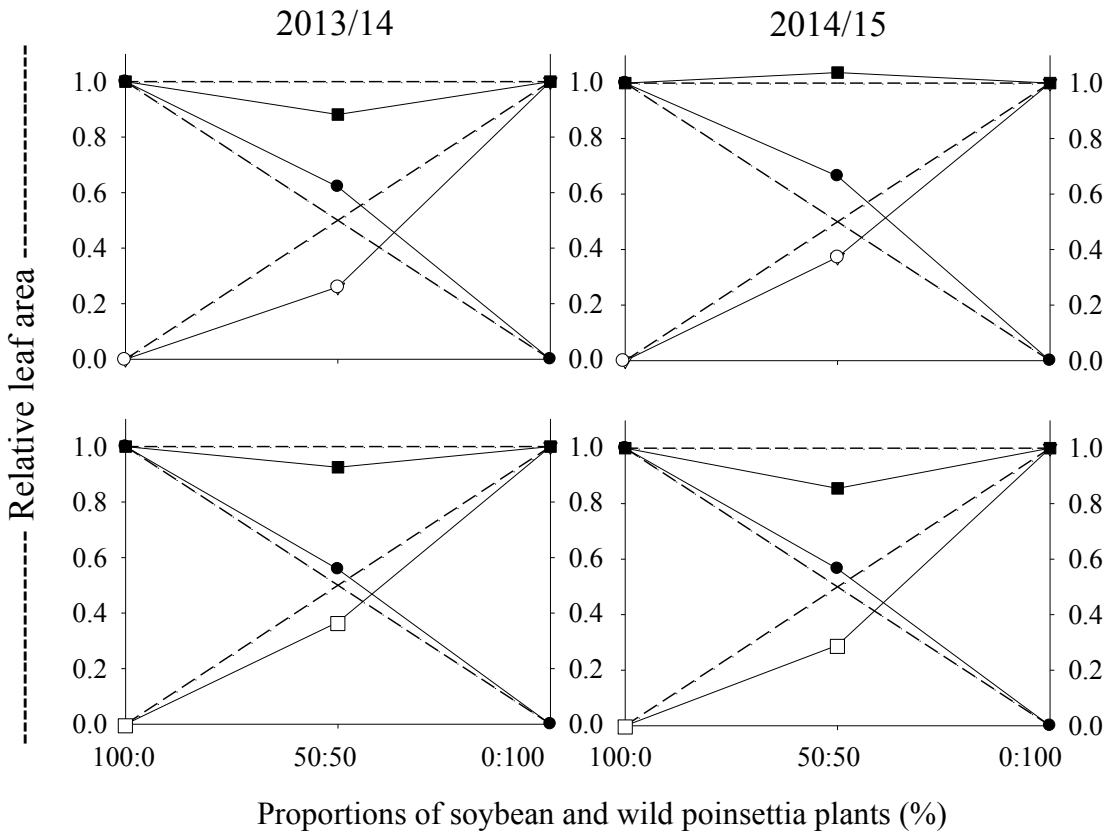

Figure 2. Relative yield of soybean (*Glycine max* (L.) Merr.) (□), wild poinsettia biotypes (*Euphorbia heterophylla* L.) 11.4 (□) (susceptible) or 21.1 (□) (low-level resistant), and relative yield total (□) for leaf area in function of the ratio between species regarding plant population conducted during two growing seasons (2013/14 and 2014/15). Dashed lines refer to the hypothetical relative yield.

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The interference effects of the two species, in a series replacement experiment, are manifested by the lack of interaction and the existence of effects on one or both species (Radosevich 1987). In the case of absence of interaction, it can be seen that the ability of each species to interfere with the other is equivalent and that the contribution of each species to total yield is directly proportional to its presence in the mixture, as the total population remains constant in this type of experiment (Rizzardi et al., 2004). In this study, the RYTs for the variables HE, LA and SDM for wild poinsettia biotypes generally presented concave lines, except for the RYTs of the biotype 11.4 in the experiment conducted during the 2014/15 growing season, which were represented by convex lines regarding LA and SDM, indicating values higher than one (Figures 1, 2 and 3).

The concave line of RYT represents a mutual impairment of growth, meaning that a competition for resources was established between the two species (Cousens 1991). However, it can be inferred that there is no mutual impairment of growth of the species in this study, because the RY of soybean was represented by convex lines, while the RY of wild poinsettia was represented by concave lines (Figures 1, 2 and 3). This result indicates that the reduction in RYT was due to the lower contribution of the weed caused by the increased competitiveness of soybeans and not exactly by the occurrence of a mutual damage between species (Agostinetto et al., 2013). A similar result was observed for rice culture or soybeans in competition with *Digitaria ciliaris* (Agostinetto et al., 2013) and different species of *Amaranthus* spp. coexisting with beans (Carvalho & Christoffoleti 2008).

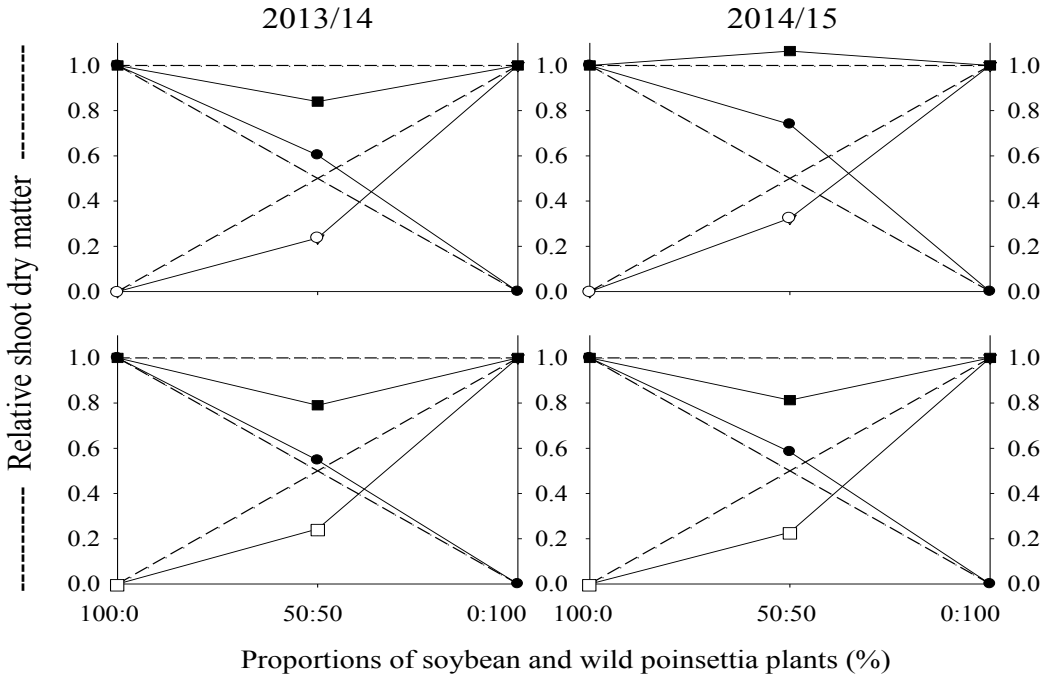

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Figure 3. Relative yield of soybean (*Glycine max* (L.) Merr.) (□), wild poinsettia biotypes (*Euphorbia heterophylla* L.) 11.4 (□) (susceptible) or 21.1 (□) (low-level resistant) and relative yield total (□) for shoot dry matter in function of the ratio between species regarding plant population conducted during two growing seasons (2013/14 and 2014/15). Dashed lines refer to the hypothetical relative yield.

Upon evaluating the RYT of the combination of soybean with *Conyza bonariensis* biotypes resistant or sensitive to glyphosate, it was observed that there was an antagonism for HE (Silva et al.,, 2014). The coexistence of soy and *Urochloa plantaginea* (Link) Webster. reduced the RYT in all plant ratios, with no competitive dominance of one over the other (Agostinetto et al.,, 2009). In a study that evaluated the competitive ability of wild poinsettia mixed with soybean, there was a synergism in the combination of both species (Rizzardi et al., 2004), a fact that may be related to the low plant population, about 60% lower than that determined for this study.

The relative differences between the observed lines (DRY) and lines expected for soybean competing with wild poinsettia biotypes generally showed no significant differences, except for the variables LA and SDM of the culture competing with wild poinsettia biotypes in the experiment conducted during the 2014/15 growing season (Table 1). For the DRY of the wild poinsettia biotype 21.1, which has a low resistance to glyphosate, competing with soy, there were differences in the SDM variable in both years. For the variables HE and LA, there were differences during the second year of experiments (Table 1). For the biotype 11.4, there was a difference only during the growing season 2013/14 for all variables. For RYT, there was a difference only for the experiment with soy coexisting with the biotype 21.1 (Table 1).

Table 1. Relative yield differences (DRY) for the variables height, leaf area, shoot dry matter and relative yield total (RYT) at a 50:50 (%) proportion of soybeans (*Glycine max* (L.) Merr.) associated with wild poinsettia biotypes (*Euphorbia heterophylla* L.) 11.4 (susceptible) or 21.1 (low-level resistant to glyphosate) during two growing seasons (2013/14 and 2014/15 harvests)

	Height	Leaf area	Shoot dry matter
		2013/14	
$DRY_{soybean}$	-0.03 (±0.02)^{ns}	0.12 (±0.06)^{ns}	0.10 (±0.03)^{ns}
$DRY_{11.4}$	-0.09 (±0.02)*	-0.24 (±0.02)*	-0.26 (±0.01)*
RYT	0.89 (±0.04)^{ns}	0.88 (±0.08)^{ns}	0.84 (±0.04)^{ns}
$DRY_{soybean}$	0.00 (±0.02)^{ns}	0.06 (±0.06)^{ns}	0.05 (±0.04)^{ns}
$DRY_{21.1}$	-0.04 (±0.01)^{ns}	-0.13 (±0.07)^{ns}	-0.26 (±0.05)*
RYT	0.95 (±0.01)^{ns}	0.93 (±0.14)^{ns}	0.79 (±0.09)^{ns}
		2014/15	

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$DRY_{soybean}$	-0.02 (±0.01)^{ns}	0.16 (±0.04)*	0.24 (±0.04)*
$DRY_{11.4}$	-0.07 (±0.02)^{ns}	-0.13 (±0.07)^{ns}	-0.28 (±0.09)^{ns}
RYT	0.90 (±0.03)^{ns}	1.04 (±0.09)^{ns}	1.06 (±0.11)^{ns}
$DRY_{soybean}$	-0.03 (±0.01)^{ns}	0.07 (±0.01)*	0.08 (±0.01)*
$DRY_{21.1}$	-0.13 (±0.02)*	-0.21 (±0.01)*	-0.27 (±0.02)*
RYT	0.84 (±0.02)*	0.85 (±0.02)*	0.81 (±0.03)*

^{ns} Not significant, and * significant in relation to the hypothetical line by "t" test ($p \leq 0.05$). Figures in brackets represent the mean standard error.

Soybeans in competition with *Conyza bonariensis* biotypes susceptible and resistant to glyphosate generally presented significant DRYs for HE, LA and SDM, characterizing values lower than those expected (Silva et al., 2014). On the other hand, for the competitive situation with *Lolium multiflorum* biotypes susceptible and resistant to glyphosate, DRYs significant for LA and SDM were observed for the susceptible biotype. For the resistant biotype, there was no difference (Oliveira et al., 2014), indicating that there is a different competitive ability among biotypes resistant or not to the herbicide.

The analysis of the overall results for soybean experiments in coexistence with wild poinsettia susceptible biotypes (11.4) or low-level resistant (21.1) to glyphosate allows inferring that the weed has a lower competitiveness than the culture. This inference can be based on the fact that, considering the values of the six possible comparisons for each biotype, the biotype 11.4 showed a difference in three comparisons, while the biotype 21.1 showed differences in four comparisons. All values were below zero (Table 1).

3.2. Competitiveness indexes

In order to confirm the higher competitive ability of a species over the other, it is necessary to analyze RC, K and C. Their joint interpretation indicates a competitiveness of the species involved (Cousens 1991).

A genotype is more competitive than other when RC > 1, Kx > Ky, and C > 0 (Hoffman & Buhler 2002). The criterion to demonstrate competitive superiority is the occurrence of significant differences on at least two indexes (Bianchi et al., 2006). Thus, according to the results, it is possible to infer that, during the first year of experiments and for LA and SDM, regardless of the wild poinsettia competitive biotype, soybeans showed to be more competitive. This also happened concerning HE for the biotype 11.4 (Table 2). Still, results of the 2014/15 harvest showed that soybean was more competitive in relation to the biotype 21.1, while the

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biotype 11.4 showed generally no difference in competitiveness indexes, except for SDM (Table 2).

Table 2. Competitiveness indexes between soybeans (*Glycine max* (L.) Merr.) and wild poinsettia biotypes (*Euphorbia heterophylla* L.) 11.4 (susceptible) or 21.1 (low-level resistant to glyphosate) during two growing seasons (2013/14 and 2014/15) expressed as relative competitiveness (RC), and relative clustering (K) and competitiveness (C) coefficients

	2013/14			
	RC	$K_{soybean}$	$K_{11.4}$	C
Height	1.15 (±0.01)*	0.91 (±0.07)*	0.70 (±0.05)	0.06 (±0.01)*
Leaf area	2.40 (±0.17)*	1.80 (±0.51)^{ns}	0.35 (±0.04)	0.36 (±0.05)*
Shoot dry matter	2.26 (±0.16)*	1.55 (±0.22)*	0.31 (±0.02)	0.37 (±0.03)*
	RC	$K_{soybean}$	$K_{21.1}$	C
Height	1.09 (±0.06)^{ns}	0.99 (±0.06)*	0.84 (±0.04)	0.04 (±0.03)^{ns}
Leaf area	1.57 (±0.13)*	1.37 (±0.38)*	0.63 (±0.21)	0.19 (±0.01)*
Shoot dry matter	2.39 (±0.34)*	1.24 (±0.20)*	0.33 (±0.09)	0.30 (±0.01)*
	2014/15			
	RC	$K_{soybean}$	$K_{11.4}$	C
Height	1.13 (±0.05)^{ns}	0.92 (±0.05)^{ns}	0.75 (±0.07)	0.05 (±0.02)^{ns}
Leaf area	1.89 (±0.30)^{ns}	2.05 (±0.31)^{ns}	0.64 (±0.21)	0.29 (±0.07)*
Shoot dry matter	2.61 (±0.58)^{ns}	2.98 (±0.24)*	0.55 (±0.24)	0.42 (±0.09)*
	RC	$K_{soybean}$	$K_{21.1}$	C
Height	1.27 (±0.04)*	0.89 (±0.04)*	0.59 (±0.04)	0.10 (±0.01)*
Leaf area	1.98 (±0.06)*	1.30 (±0.06)*	0.41 (±0.03)	0.28 (±0.01)*
Shoot dry matter	2.58 (±0.16)*	1.40 (±0.05)*	0.30 (±0.03)	0.36 (±0.01)*

^{ns} Not significant, and * significant by "t" test ($p \leq 0.05$). Figures in brackets represent the mean standard error.

For soybeans in competition with *Eleusine indica*, RC and C competitiveness indexes showed no significant differences for SDM. However, a K value higher for the culture than for the weed was observed, meaning that soybean was dominant (Wandscheer et al., 2013). Thus, it is possible to infer that eventually crops have a higher competitive ability than weeds, confirming the results observed in this study.

The greater competitive ability of the culture in relation to the weed observed in experiments conducted in replacement series may happen because the damage caused by weeds is due not only to individual competitive ability, but also to degree of infestation. Thus, in production areas,

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the culture population is kept constant, while the population of weeds varies according to the soil seed bank and the environmental conditions that influence the infestation (Agostinetto et al., 2013; Galon et al., 2011). However, there are cases in which the weed is more competitive than the culture, as is the case of *Conyza bonariensis* competing with soybean (Silva et al., 2014).

3.3. Competition's impact on plant's growth

Plant growth characteristics may be related to the competitive ability due to the ability to provide the capture of resources of the environment more quickly. In soybeans, some of the important characteristics that confer a greater competitive ability are height and leaf area (Bianchi et al., 2006). Larger plants tend to dominate the canopy and optimize the use of photosynthetic active radiation. In this study, differences in soybean culture were observed only when it coexisted with weeds or in monocrop during the first year of experiment (Table 3). However, except for HE, it was found that the intraspecific competition was more detrimental to the culture due to the decrease in the absolute values of LA and SDM for the soybean monoculture (Table 3).

Table 3. Response of soybean (*Glycine max* (L.) Merr.) to the interference of wild poinsettia biotypes (*Euphorbia heterophylla* L.) 11.4 (susceptible) or 21.1 (low-level resistant to glyphosate) during two growing seasons (2013/14 and 2014/15)

Plant proportion soybean:wild poinsettia	Height (cm)	Leaf area (cm^2 $planta^{-1}$)	Shoot dry matter (g $planta^{-1}$)	Height (cm)	Leaf area (cm^2 $planta^{-1}$)	Shoot dry matter (g $planta^{-1}$)
	2013/14			2014/15		
	Soybean:11.4					
100:0	72.93 ns	242.20 b	1.96 b	65,87 ns	273,17 ns	2,12 ns
50:50	69.62	321.89 a	2.90 a	62,53	339,48	2,55
CV (%)	2.28	3.99	4.80	6.11	13.89	5.89
0:**100**	71.59 ns	70.82 ns	1.20 ns	69,29 a	97,14 a	1,84 a
50:**50**	60.92	52.83	0.78	57,21 b	50,52 b	0,87 b
CV (%)	6.46	13.22	17.63	4.75	12.11	6.43
	Soybean:21.1					
100:0	62.63 a	227.72 ns	2.23 b	60,93 ns	235,71 ns	1,96 ns
50:50	59.09 b	257.40	2.61 a	60,60	263,01	2,14
CV (%)	1.65	4.93	4.09	0.66	10.30	6.09
0:**100**	61.04 ns	90.61 a	1.46 a	56,20 a	119,21 a	1,69 a
50:**50**	45.43	52.52 b	0.67 b	51,34 b	87,63 b	0,82 b
CV (%)	10.52	6.96	12.88	1.80	3.27	1.41

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ns: not significant by F test ($p \leq 0.05$). Means followed by the same letter in columns, comparing proportions of each type for each variable, do not differ significantly by t test ($p \leq 0.05$).

The higher HE observed for the soybean monoculture corroborates a study that noted such characteristic in the culture when coexisting with low populations of wild poinsettia in relation to wild poinsettia populations free of weeds (Carvalho et al., 2010). The variation in plant height in competitive situations is probably related to the plant's strategy to capture more light, promoting the etiolation of plants and consequently lower investment in growth. Light is considered the main limited resource in the community and plays an important role in the initial response of plants with more competitive potential (Galon et al., 2011; Page et al., 2010). For wild poinsettia biotypes, the coexistence with soybean (50:50) caused a decrease in growth variables in relation to the monoculture of the weed (0:100), indicating that the interspecific competition was predominant (Table 3).

3.4. Competitive ability of soybean and wild poinsettia biotypes

Considering that, in this study, the variable that best explained the results was SDM, it can be inferred that the soybean crop is more competitive than the wild poinsettia crop regardless of the competitive biotype and that the intraspecific competition is more damaging to the culture and the interspecific competition is more damaging to the weed. Based on the SDM, it was found that soybean was more competitive than *Eleusine indica* when both species coexisted in equal proportions. The intraspecific competition was more damaging to the culture (Wandscheer et al., 2013). Studies showed that, in species with a greater competitive ability, intraspecific competition is more harmful than interspecific competition because plants compete for the same resources in the ecological niche (Dal Magro et al., 2011). Moreover, it is often observed that intraspecific competition is more important for crop species than interspecific competition (Radosevich et al., 2007).

The intraspecific competition was more harmful to common beans (*Phaseolus vulgaris* L.), suggesting that the damage to this culture caused by weeds are more related to the high occurrence of populations than to the intrinsic competitive ability of the species (Carvalho & Christoffoleti 2008). However, the growth of *Conyza bonariensis* biotypes was benefited when coexisting with soybean and at a lesser proportion than the culture. This indicates that intraspecific competition is more relevant to weeds than interspecific competition (Silva et al., 2014).

It should be noted that no experiments were conducted to evaluate the competitiveness of wild poinsettia biotypes with a low resistance or susceptible to glyphosate. Thus, the difference in competitiveness between them cannot be confirmed. Similarly, there were no indications of a

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competitive advantage of susceptible wild poinsettia biotypes compared to biotypes resistant to ALS and PROTOX (protoporphyrinogen oxidase) inhibitors (Trezzi et al., 2009). Similarly, there was an equivalent competitive ability among *Cyperus difformis* L. biotypes resistant and susceptible to ALS-inhibiting herbicides (Dal Magro et al., 2011).

In case of no competitive advantage of plants susceptible to a particular herbicide compared to resistant plants, the suppression of the selector herbicide may not be sufficient to promote an increase in the frequency of susceptible individuals in the areas (Trezzi et al., 2009). It is therefore necessary that wild poinsettia integrated management measures be taken in order to reduce the infestation of such weed in soybean crops given the potential competitiveness of biotypes with a low-level resistance to glyphosate and the risk of increasing the proportion of such biotypes in relation to susceptible biotypes.

4. CONCLUSIONS

Susceptible wild poinsettia or with a low-level resistance to glyphosate have a lower competitive ability per individual than soybeans when they occur at the same proportion. The intraspecific competition in general is more harmful to the soybean crop when competing with wild poinsettia biotypes. The interspecific competition of weeds predominates.

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