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Article

Competitive Interaction Between Sweet Sorghum with Weeds

Habilidade Competitiva de Cultivares de Sorgo Sacarino com Plantas Daninhas

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ABSTRACT - The objective of this work was to determine the competitive interaction of sweet sorghum cultivars BRS 506, BRS509, and BRS 511 with biotypes of Alexandergrass and wild poinsettia. The adopted experimental design was the randomized block one, with four replications. Treatments were arranged in a substitution series by proportions of 100:0, 75:25, 50:50, 25:75, and 0:100%, corresponding to 20:0, 15:5, 10:10, 5:15 and 0:20 plant per pot of sweet sorghum (cultivars BRS 506, BRS 509 and BRS 511) withweeds (Alexander grass/wild poinsettia). The leaf area (LA) and dry matter (DM) of sweet sorghum, Alexandergrass and wild poinsettia plants were determined 50 days after emergence. Data about competitive abilities were analysed through the graphical analysis method, constructing diagrams based on yield or relative and total variations. Indices of relative competitiveness, clustering coefficient and aggressiveness were also determined; all of them were relative indices. There was competition for the same environmental resources between sweet sorghum cultivars and weeds, with mutual injury to the species involved in the community. Wild poinsettia and Alexandergrass negatively modified the LA and DM of the crop, demonstrating a greater competitive ability for the resources that are available in the environment. Wild poinsettia was less competitive than sweet sorghum cultivars, while Alexandergrass showed higher competitive ability than them. The highest losses for the LA and DM variables were observed when species were in interspecies competition rather than intraspecies competition.

Keywords: *Sorghum bicolor*, *Euphorbia heterophylla*, *Urochloa plantaginea*.

RESUMO - Este trabalho teve como objetivo determinar a interação competitiva de cultivares de sorgo sacarino com biótipos de papuã e de leiteiro. Os ensaios foram instalados em delineamento completamente casualizado, replicados quatro vezes. Os tratamentos foram dispostos em série substitutiva nas proporções de 100:0, 75:25, 50:50, 25:75 e 0:100%, o que equivaleu a 20:0, 15:5, 10:10, 5:15 e 0:20 plantas vaso^{-1} de sorgo sacarino (cultivares BRS 506, BRS 509 e BRS 511) com as plantas daninhas (papuã ou leiteiro). A área foliar (AF) e a massa seca (MS) das plantas de sorgo sacarino, do papuã e do leiteiro foram determinadas aos 50 dias após emergência das espécies. Os dados relativos às habilidades competitivas foram analisadas através do método da análise gráfica, construindo-se diagramas baseados nas produtividades ou variações relativas e totais. Determinaram-se também os índices de competitividade, coeficiente de agrupamento e agressividade, todos eles relativos. Ocorreu competição pelos mesmos recursos do meio entre os cultivares de sorgo sacarino e as plantas daninhas, com prejuízo mútuo às espécies envolvidas na comunidade. O leiteiro e o papuã modificaram de forma negativa a AF e a MS da cultura, demonstrando habilidade competitiva superior pelos recursos do ambiente. O leiteiro foi menos competitivo que os cultivares de sorgo sacarino,

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enquanto o papuã apresentou maior competitividade do que eles. Os maiores prejuízos para as variáveis AF e MS foram observados quando as espécies estiveram em competição interespecífica, em relação à competição intraespecífica.

Palavras-chave: *Sorghum bicolor*, *Euphorbia heterophylla*, *Urochloa plantaginea.*

INTRODUCTION

Sweet sorghum is an option for the production of ethanol during the sugarcane off-season, especially in cane field renewal areas or in regions where the cultivation of sugarcane is not adapted. However, there is a need to generate information on the management and cultural treatment of sorghum, so that this crop will gain space and competitiveness in the Brazilian scenario. Weed control becomes one of the important factors in sweet sorghum management, due to the low herbicide diversity recorded for the use in chemical control and the slow initial growth of the crop (Silva et al. 2014a; Galon et al., 2016).

The inadequate control of the weed community may lead to quantitative and qualitative losses in sorghum production. The control lack of weeds that infested BRS 511 sorghum cultivars during the whole crop cycle showed a drop in the stem yield of approximately 50% (Silva et al., 2014b). However, the interference degree can be influenced by factors related to weed species, population and their distribution in the area where they appear, inter-row distance and population of sown plants, besides phase and stage of coexistence (Fleck et al., 2008; Agostinetto et al., 2013).

Thus, studies that evaluate the competitiveness of weed cultivars are very important, since they define characteristics that give greater competitive ability to the crop over weeds. Cultivars presenting greater leaf area accumulation rate, plant height, dry matter, inter-row closing and light interception by the canopy tend to demonstrate greater competitive when infested by weed species (Galon et al., 2015; Bastiani et al., 2016). Weed density becomes one of the important factors in plant communities, since the more associated plants there are, the greater the competition for available resources in the environment, such as water, light and nutrients.

The experiments conducted in the substitute series model stand out as the most used evaluation methods to compare the competitive ability between species (culture vs. weed) in a given community (Bianchi et al., 2006; Aminpanah and Javadi, 2011; Bastiani et al., 2016). Tests installed in the substitute series model allow evaluating the effect of the plant population and the proportion between crop and weeds when they live in a community (Aminpanah and Javadi 2011).

Among weeds, Alexandergrass (*Urochloa plantaginea*) and wild pointsettia (*Euphorbia heterophylla*) are important species found in annual crops, also appearing in sweet sorghum. Alexandergrass is characterized by its C4 metabolism, which, under conditions of high temperature and luminosity, presents rapid initial growth, and may cause the shading of annual crops that have slower growth rates (Wandscheer et al., 2013). The wild pointsettia, however, is characterized by C3 metabolism and by better adapting to the environment with lower luminous intensity and temperature than a C4 plant. Wild pointsettia is a worrying species due to its short cycle; there might be two or three generations in less than a year, and it has great seed production and biotypes that resistant to acetolactate synthase inhibitors - ALS and protoporphyrinogen oxidase - PROTOX herbicides (Xavier et al., 2013).

In the agricultural environment, i.e. in crops, weed density may vary depending on the quantity of seeds in the soil bank or on the level of local infestation, while the density of the cultivated plants is generally constant. Thus, there may be a change in the proportion between weeds and crops (Agostinetto et al., 2013), which is why there is a need to verify, besides the influence of the plant population, the effect of the variation in the proportion of the species when in competition.

The hypothesis is that sorghum cultivars have a higher competitive ability than Alexandergrass or wild pointsettia biotypes when they occur in equal proportions and in adequate resource situations. Therefore, the objective of this study was to compare the competitive ability of sorghum cultivars with Alexandergrass or wild pointsettia biotypes.

MATERIAL AND METHODS

The experiments were conducted in a greenhouse at the Universidade Federal da Fronteira Sul (UFFS), Campus Erechim - Rio Grande do Sul state, from November 2014 to February 2015. The species were sown in plastic pots filled with 8 dm^3 of soil, classified as Humic aluminoferric Red Latosol (Embrapa, 2013); before sowing, fertility was corrected, following the technical recommendations for sorghum cultivation (ROLAS, 2014). The chemical and physical characteristics of the soil were: pH in water 4.8; MO = 3.5%; P = 4.0 mg dm^{-3}; K = 117.0 mg dm^{-3}; Al^{3+} = 0.6 $cmol_c$ dm^{-3}; Ca^{2+} = 4.7 $cmol_c$ dm^{-3}; Mg^{2+} = 1.8 $cmol_c$ dm^{-3}; CTC(t) = 7.4 $cmol_c$ dm^{-3}; CTC(TpH=7.0) = 16.5 $cmol_c$ dm^{-3}; H+Al = 9.7 $cmol_c$ dm^{-3}; SB = 6.8 $cmol_c$ dm^{-3}; V = 41%; and clay = 60%.

A completely randomized design, with four replications, was used in all tests. The tested species were sorghum cultivars BRS 506, BRS 509 and BRS 511, which competed with Alexandergrass (*Urochloa plantaginea*) or wild pointsettia (*Euphorbia heterophylla*) biotypes.

Preliminary experiments, in additive series (monocultures), were conducted for all the involved species, in order to identify the plant population of each species in which the biomass accumulation became constant. To meet the previously proposed objectives, 1, 2, 4, 8, 16, 24, 32, 40, 48, 56 and 64 pot per plants were used, which equals 25, 49, 98, 196, 392, 587, 784, 980, 1,176, 1,568 plants m^{-2}, respectively. Fifty days after the emergence of the species, the shoot of sorghum, Alexandergrass or wild pointsettia plants was harvested close to the soil, in order to measure its dry matter (DM), which was quantified by weighing, after being dried in a forced air circulation oven at a temperature of 72 °C. Through the mean DM values of the species, the constant DM production was obtained, with populations of 20 plants per pot for all sweet sorghum cultivars, Alexandergrass or wild pointsettia biotypes, representing 465 m^{-2} (data not demonstrated).

In order to test the competitive ability of sorghum cultivars (BRS 506, BRS 509 and BRS 511) with the competing plants (Alexandergrass or wild pointsettia), six substitution series tests were conducted, alternating the plant proportion in the association of weed biotypes with cultivars; the relative proportions of plant per pot were 20:0, 15:5, 10:10, 5:15 and 0:20, keeping the total population of plants: 20 plant per pot constant. Seeds from the species involved in the substitution tests were sown in plastic trays and later transplanted to the final experimental units (plastic pots) five days after emergence; thus, it was possible to establish the plant proportions defined for each treatment in an even manner.

The determination of leaf area (LA) and dry matter (DM) of sweet sorghum and weed plants (wild pointsettia or Alexandergrass) was carried out 50 days after the emergence of the species. This date was chosen because it is the stage at which both sorghum and weed cultivars were entering the reproductive stage. In the determination of the LA, a portable CI-203 BioScence leaf area meter was used. After LA was measured, the leaves from the studied species were placed in paper bags and dried in a forced air circulation oven at a temperature of 72 °C, until dry matter evenness.

Data were analyzed through graphical analysis about relative variation or productivity (Roush et al., 1989; Cousens, 1991; Bianchi et al., 2006); this procedure is also known as the conventional method for substitution experiments. This method allows the construction of a diagram, taking into account the relative (RP) and total (TRP) productivities or variations. If the RP result is a straight line, it means that the species' abilities are equivalent. However, if RP results in a concave line, it means that there is damage in the growth of one or both species. Conversely, if RP demonstrates a convex line, there is benefit in the growth of one or both species. If the TRP equals 1 (straight line), competition occurs for the same resources; if the TRP is greater than 1 (convex line), there will be no competition in the community. If the TRP is less than 1 (concave line), there is damage to the plants involved in the community, affecting growth and development (Cousens, 1991).

Competitiveness indices (CR), cluster coefficient (K) and aggressiveness (A) were calculated; all were relative indices. Relative competitiveness expresses the comparative growth of sorghum cultivars (X) in relation to Alexandergrass or wild pointsettia competitors (Y); K determines the relative dominance of the crop in relation to weeds, and A indicates whether sorghum, Alexandergrass or wild pointsettia cultivars are more aggressive. Thus, CR, K and A indices indicate which species is most competitive, and the joint interpretation indicates more precisely the competitiveness of the species involved in the community (Cousens, 1991). Sweet sorghum cultivars X are more competitive than Alexandergrass or wild pointsettia Y when CR>1, Kx>Ky and A>0; on the other hand, Alexandergrass or wild pointsettia Y are more competitive than sorghum cultivars X when CR<1, Kx<Ky and A<0 (Hoffman and Buhler, 2002). Indices were calculated using the 50:50 proportions sweet sorghum vs. Alexandergrass or wild pointsettia plants, or the densities of 10:10 plants per pot, through the formulas: CR = PRx/RPy, Kx = RPx/(1-RPx), Ky = RPy/(1-RPy) and A = RPx – RPy, according to what was proposed by Cousens and O'Neill (1993).

For the statistical analyses of relative productivity or variations, the calculations of the differences for RP (DRP) values were included; they were obtained in the 25%, 50% and 75% proportions, in relation to the values belonging to the hypothetical line in the respective proportions, that is: 0.25, 0.50, and 0.75 for RP (Bianchi et al., 2006; Fleck et al., 2008). The t-test was used to test the relative differences for the DPR, TRP, CR, K, and A indices (Roush et al., 1989). It was considered as a null hypothesis to test the differences between DPR and A when the means were equal to zero (Ho = 0); for TRP and CR, when the means were equal to 1 (Ho = 1); and for K, when the means of the differences between Kx and Ky were zero [Ho = (Kx - Ky) = 0]. As a criterion to accept if the RP and TRP curves were different from the hypothetical lines, it was taken into account that at least in two proportions there were significant differences by the t test (Bianchi et al., 2006). A similar criterion was adopted for the CR, K and A indices, in which, in order to have competitiveness differences, it is necessary that at least two of them are significantly different by the t test.

AF and MS data were applied to the analysis of variance by F test; when significant, the means of the treatments were compared by Dunnett's test, taking into account the monocultures as control treatments in the comparisons.

RESULTS AND DISCUSSION

Through the analysis of variance, it was possible to observe a significant interaction in the associations between the proportions of sweet sorghum or wild pointsettia or Alexandergrass plants for the LA (leaf area) and DM (shoot dry matter) variables. Generally speaking, the graphical results indicate that the three sorghum cultivars showed a similarity in the competition with weeds. There was a reduction in the LA and MS variables of the cultivars in the different evaluated scenarios. The TRP of FA and DM of the cultivars was significantly influenced by at least two plant proportions, with concave lines and mean values lower than 1 (Figures 1 and 2; Table 1). However, the DM of cultivars BRS 509 and BRS 511, when competing with wild pointsettia, presented convex lines and mean values higher than 1 in the first three plant proportions (100:0, 75:25 and 50:50). Concave lines and values lower than 1 allow inferring the occurrence of competition, for similar resources, between sorghum and weeds. Researches have shown similar results to those found in this study when testing the competitive ability of rice cultivars with jointvetch (Galon et al., 2015) and of soybean cultivars in competition with gulf cockspur grass (Bastiani et al., 2016).

The LA of the cultivars, when infested by Alexandergrass or wild pointsettia, presented concave lines in all simulated situations (Figure 1). This fact indicates the occurrence of competition for the same resources of the environment, occurring mutual damages to the growth of sweet sorghum and competitors. The reduction of LA may be related to the allocation of resources to other drainage organs of the plant and not to the leaf. Competition for light may cause the plants to invest more in the development of stalks at the expense of the LA, in order to achieve greater height, as a strategy to increase the capture of luminosity. The light resource is one of the main limiters of the initial growth of the plant community, and can directly reflect on the productive potential of the crop (Page et al., 2010).

The effect of the coexistence of sorghum cultivars with weeds on DM varied according to the infesting species (Figure 2). In coexistence with wild pointsettia, sorghum cultivars presented convex lines, indicating that there is a benefit for the growth of the culture over weeds. On the other hand, when in coexistence with Alexandergrass, cultivars and weeds showed concave

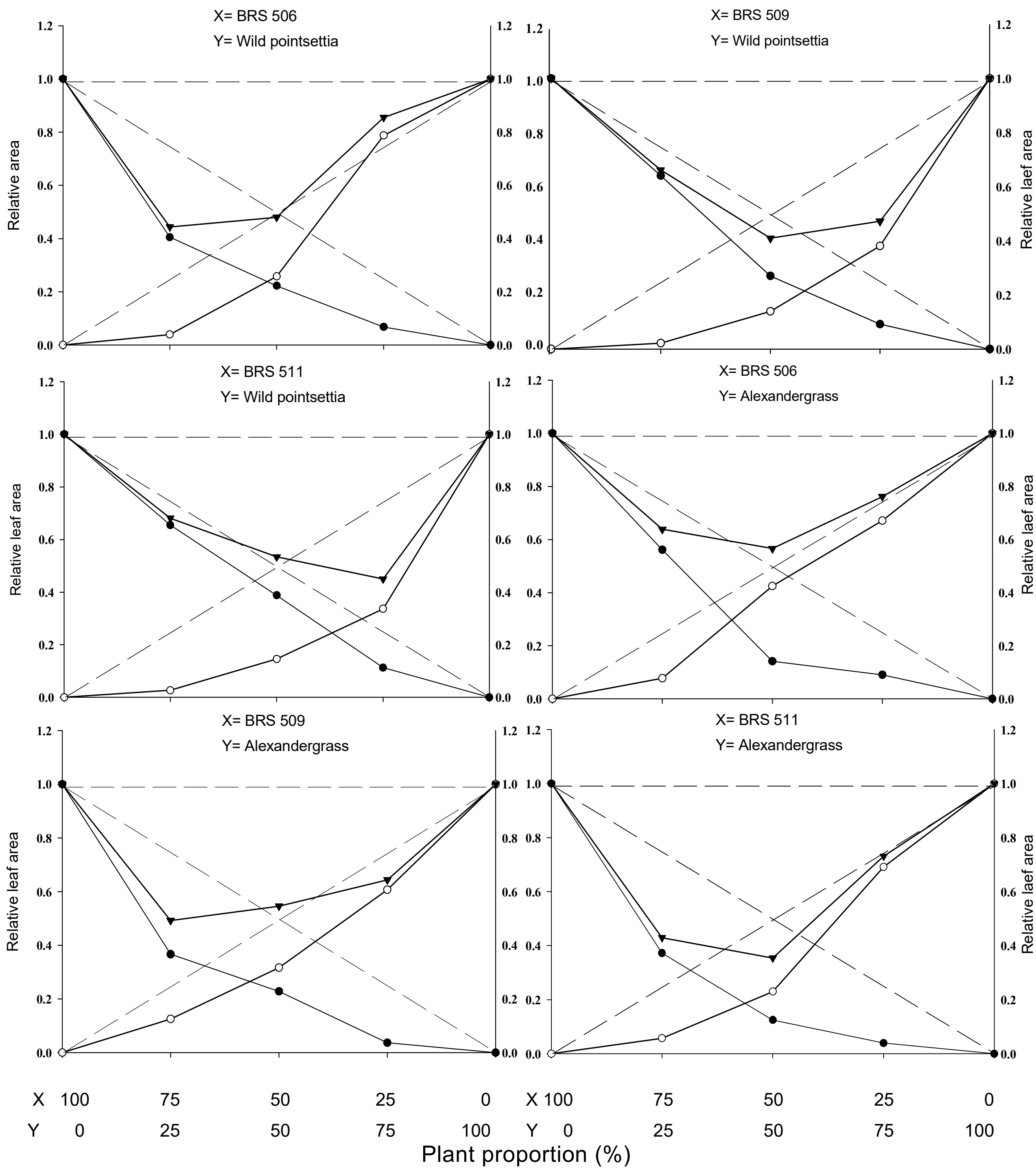

Figure 1 - Relative productivity (RP) for relative leaf area of sweet sorghum (•), wild pointsettia or Alexandergrass (o) and total relative productivity (TRP) of the community (▼), depending on the proportion of associated plants (sweet sorghum: wild pointsettia or sweet sorghum: Alexandergrass). UFFS, Erechim - Rio Grande do Sul state, 2014/15.

lines, indicating mutual injury to the species involved in the competition. The differentiated competition of weeds on the crop can be explained by the characteristics of the weed species. The high interference degree of wild pointsettia on the crops is more related to the density and the distribution that occurs in crops than to their individual ability to compete with them (Tanveer et al., 2015). On the other hand, Alexandergrass is characterized by being more adapted to conditions of high temperature and luminosity, through the emission of tillers and the high competitive capacity with the cultures due to its fast growth rate (Velho et al., 2012).

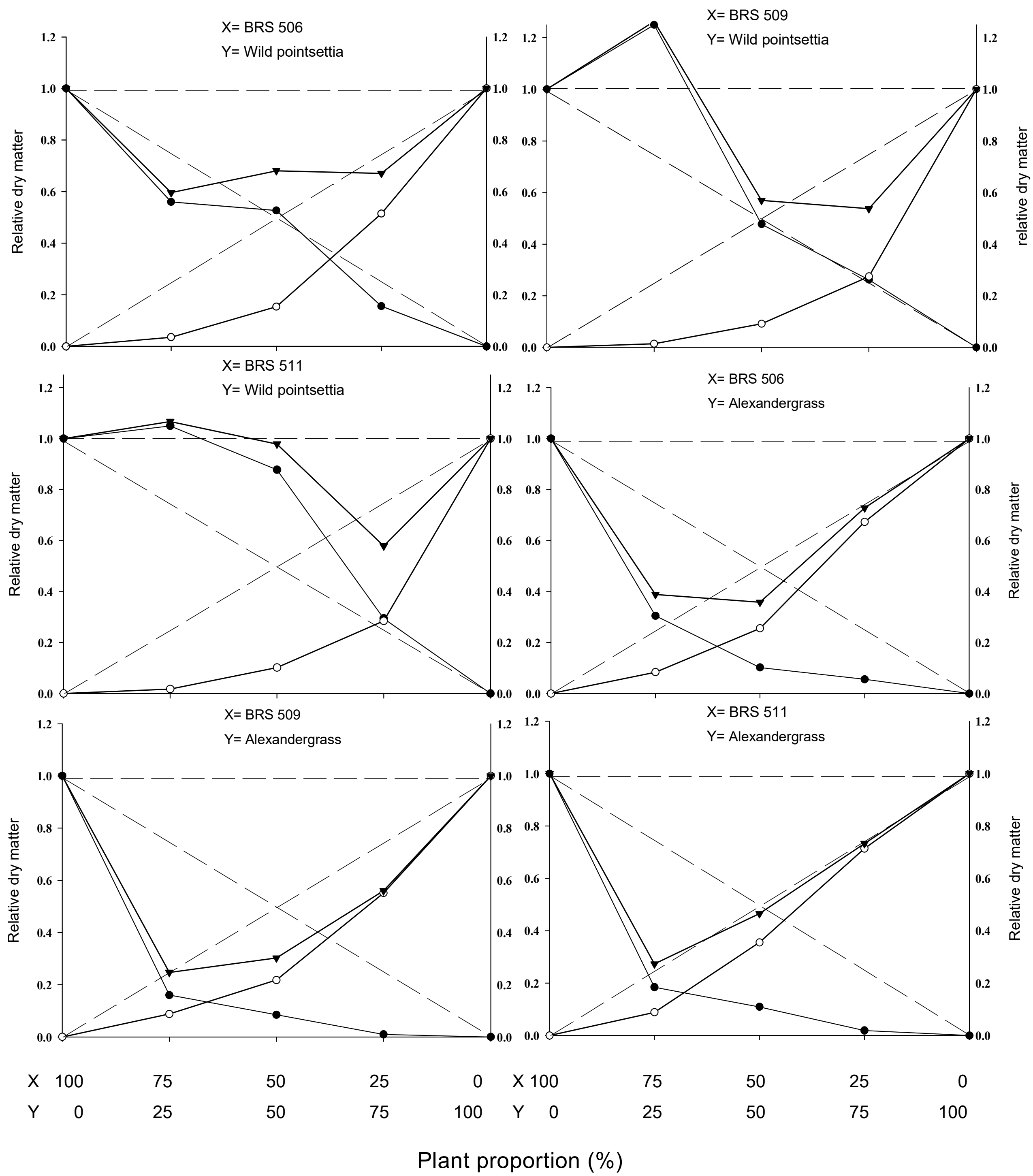

Figure 2 **-** Relative productivity (RP) for the relative dry mass of sweet sorghum (●), wild pointsettia or Alexandergrass (O) and total relative productivity (TRP) of the community (▼), according to the proportion of associated plants (sweet sorghum: wild pointsettia or sweet sorghum: Alexandergrass).UFFS, Erechim - Rio Grande do Sul, 2014/15.

The RF of LA and DM of cultivars and weeds showed concave lines, except for BRS 509 and BRS 511, which, with wild pointsettia in the proportions of 100:0, 75:25, and 50:50 showed convex lines for the DM (Figures 1 and 2). The RP values of sorghum cultivars (BRS 509 and BRS 511) were higher than 1 when the culture competed with wild pointsettia. This fact demonstrates the different competitive ability among cultivars. Galon et al. (2011), when studying the effect of ryegrass on the development of barley, found similar results to those in the present study. These authors verified the occurrence of concave lines for the crop and competitor for the characteristics

Table 1 **-** Differences for relative leaf area and shoot dry matter of sorghum cultivars BRS 506, BRS 509 and BRS 511 or wild pointsettia or Alexandergrass. UFFS, Erechim - Rio Grande do Sul, 2014/15

Variables	Plant proportions (sweet sorghum: weed)		
	75:25	50:50	25:75
	Leaf area		
BRS 506	-0.32 (±0.03)*	-0.26 (±0.01)*	-0.18 (±0.01)*
wild pointsettia	-0.21 (±0.01)*	-0.24 (±0.04)*	0.04 (±0.07)
Total	*0.47 (±0.03)**	*0.49 (±0.05)**	*0.86 (±0.07)*
BRS 509	-0.11 (±0.001)*	-0.23 (±0.02)*	-0.16 (±0.001)*
wild pointsettia	-0.23 (±0.001)*	-0.36 (±0.001)*	-0.37 (±0.02)*
Total	*0.66 (±0.001)**	*0.41 (±0.02)**	*0.47 (±0.02)**
BRS 511	-0.10 (±0.03)*	-0.11 (±0.01)*	-0.14 (±0.001)*
wild pointsettia	-0.22 (±0.001)*	-0.35 (±0.02)*	-0.41 (±0.02)*
Total	*0.68 (±0.04)**	*0.53 (±0.02)**	*0.45 (±0.02)**
	Shoot dry matter		
BRS 506	-0.19 (±0.01)*	0.03 (±0.03)	-0.09 (±0.001)*
wild pointsettia	-0.09 (±0.001)*	-0.35 (±0.04)*	-0.24 (±0.04)*
Total	*0.60 (±0.01)**	*0.68 (±0.04)**	*0.67 (±0.04)**
BRS 509	0.50 (±0.08)*	-0.02 (±0.04)	0.01 (±0.02)
wild pointsettia	-0.24 (±0.01)*	-0.41 (±0.01)*	-0.48 (±0.01)*
Total	*1.26 (±0.08)**	*0.57 (±0.04)**	*0.54 (±0.02)**
BRS 511	0.30 (±0.08)*	0.38 (±0.09)*	0.04 (±0.03)
wild pointsettia	-0.23 (±0.001)*	-0.40 (±0.01)*	-0.47 (±0.01)*
Total	*1.07 (±0.08)*	*0.98 (±0.09)*	*0.58 (±0.03)**
	Leaf area		
BRS 506	0.22 (±0.02)*	-0.36 (±0.01)*	-0.16 (±0.001)*
Alexandergrass	-0.17 (±0.001)*	-0.08 (±0.04)*	-0.08 (±0.02)*
Total	*0.64 (±0.03)**	*0.57 (±0.04)**	*0.76 (±0.02)**
BRS 509	-0.38 (±0.01)*	-0.27 (±0.02)*	-0.21 (±0.001)*
Alexandergrass	-0.12 (±0.01)*	-0.18 (±0.01)*	-0.14 (±0.001)*
Total	*0.49 (±0.02)**	*0.55 (±0.02)**	*0.64 (±0.001)**
BRS 511	-0.38 (±0.03)*	-0.38 (±0.001)*	-0.21 (±0.001)*
Alexandergrass	-0.19 (±0.01)*	-0.27 (±0.01)*	-0.06 (±0.01)*
Total	*0.43 (±0.03)**	*0.35 (±0.01)**	*0.73 (±0.01)**
	Shoot dry matter		
BRS 506	-0.45 (±0.03)*	-0.40 (±0.001)*	-0.19 (±0.01)*
Alexandergrass	-0.17 (±0.01)*	-0.24 (±0.01)*	-0.08 (±0.04)*
Total	*0.39 (±0.03)**	*0.36 (±0.02)**	*0.73 (±0.05)**
BRS 509	-0.59 (±0.01)*	-0.42 (±0.01)*	-0.24 (±0.001)*
Alexandergrass	-0.16 (±0.01)*	-0.28 (±0.02)*	-0.20 (±0.04)*
Total	*0.25 (±0.01)**	*0.30 (±0.01)**	*0.56 (±0.04)**
BRS 511	-0.57 (±0.04)*	-0.39 (±0.01)*	-0.23 (±0.001)*
Alexandergrass	-0.16 (±0.001)*	-0.14 (±0.03)*	-0.04 (±0.05)
Total	*0.27 (±0.04)**	*0.43 (±0.03)**	*0.73 (±0.05)**

* Significant difference by t test ($p \leq 0.05$). Values in parenthesis represent the standard error of the mean.

of tillering, LA and DM, thus corroborating the results found in this research. There are several reports in literature that show that there is a differentiated competitive ability among cultivars, such as rice, wheat, barley and soybean, when coexisting with several weed species (Fleck et al., 2008; Rigoli et al., 2008; Galon et al., 2011; Bastiani et al., 2016).

Generally speaking, sorghum cultivars showed higher relative growth than wild pointsettia and smaller relative growth than the Alexandergrass. The LA and DM variables presented higher

RP for the crop and were lower for wild pointsettia; this behavior is different from what was observed for sorghum when in competition with Alexandergrass (Figures 1 and 2, Table 1). It can be reported that the probable cause for sorghum to have a higher relative growth than wild pointsettia is related to the height of plants, making the crop more suitable and efficient in the search for light, thus occurring weed shading (Almeida and Mundstock, 2001). On the other hand, the greater relative growth of Alexandergrass in relation to sorghum can be related to the fact that both belong to the same family (Poaceae), and, since weeds show greater aggressiveness, they take advantage in the competition.

Generally speaking, when one species is more competitive than another, it indicates that it is more capable of assimilating the resources that are available in the environment. Thus, there will be increased growth and development, causing greater damage to the competitor, since smaller amounts of resources will be available to plants (Agostinetto et al., 2013). It is worth mentioning that in substitution series experiments, there is little evidence of qualitative changes according to population increases, that is, the dominance of one species over the other rarely changes with a change in plant density (Cousens and O'Neill, 1993).

There were increases in the TRP of the combinations as the proportions of plants competing with each other increased - a significant situation for all evaluated variables (Table 1). This demonstrates that sweet sorghum and weeds are competitive, and that one species does not contribute more than expected to the total productivity of the other. In this work, there was no differentiation in the competition of the crop belonging to the grass family when there was a Euphorbiaceae (wild pointsettia) or another Gamineae (Alexandergrass) weed, that is, both species explored the same ecological niche and competed among themselves for the same resources of the environment, regardless of the botanical family involved. Thus, they did not present a distinction in terms of competitiveness, since these differences were verified in many other studies that used related species, such as barley x ryegrass (Galon et al., 2011), wheat x ryegrass (Rigoli et al., 2008), rice x weed rice (Fleck et al., 2008) and cultivated sorghum vs. *Sorghum halepense* (Hoffman and Buhler, 2002). However, some studies report the occurrence of plant differentiation in differentiated families, such as wheat x turnip (Rigoli et al., 2008), southern crabgrass x soybean (Agostinetto et al., 2013), rice x jointvetch (Galon et al., 2015) and soybean x gulf cockspur grass (Bastiani et al., 2016).

Generally speaking, the relative growth of sweet sorghum (cultivars BRS 506, BRS 509, and BRS 511) presented equivalent values in the same proportion as plants when competing for LA and DM (Figures 1 and 2; Table 1). Thus, even if cultivars differ in terms of characteristics related to height and development cycle (Brasil, 2016), no differences were observed in their competition with weeds. These results demonstrate that there was no marked effect of the differential characteristics of cultivars on weeds, and that the abilities of sorghum genotypes to interfere with wild pointsettia or Alexandergrass are equivalent. The results of this study disagree with those reported by Fleck et al. (2008) and Galon et al. (2015), in which the authors verified the existence of competitive variability according to the development cycle of each cultivar. However, this is due to the fact that in works developed on the field, there is the influence of several biotic and abiotic factors, which can alter the cultivars in a differentiated way; thus, it is possible to have greater importance of the existing genetic differentiations in each cultivar, which is not observed in greenhouses, because the environment is controlled and there is less pressure by external agents.

There was a reduction in the morphological variables, LA and DM, of cultivars BRS 506, BRS 509, and BRS 511 when competing with wild pointsettia or Alexandergrass in all analyzed associations, regardless of the plant proportion (Tables 2 and 3). It was observed that the higher the proportion of the competitor in association with sorghum cultivars, the greater the damage to the culture variables. However, it is worth mentioning that there was no significant difference between BRS 509 and BRS 511 when competing with wild pointsettia, since, to be significant, it is necessary to have at least two differing plant proportions (Bianchi et al., 2006). In weeds, wild pointsettia or Alexandergrass, the same reduction tendency of LA and DM was observed as the one observed for the culture, with no differentiation in the competition for the LA of Alexandergrass in the presence of the cultivar BRS 506 sorghum. Studies report that there may be damages to the growth of crops and weeds when they are in competition in a given community (Feck et al., 2008; Rigoli et al., 2008; Galon et al., 2011; Bastiani et al., 2016).

Table 2 - Differences between plants associated or not with BRS 506, BRS 509 and BRS 511 sweet sorghum cultivars and wild pointsettia as for leaf area and shoot dry matter. UFFS, Erechim - Rio Grande do Sul, 2014/15

Plant proportion Sorghum:wild pointsettia	Sweet sorghum cultivars		
	BRS 506	BRS 509	BRS 511
Leaf Area (cm^2 pot^{-1})			
100:0 (T)	4580.50	2876.00	2544.73
75:25	2473.00*	2455.50*	2221.35*
50:50	2038.43*	1554.25*	1975.47*
25:75	1234.75*	1048.50*	1150.33*
VC (%)	11.63	9.14	7.88
Wild pointsettia competitor			
0:100 (T)	285.60	448.67	425.67
25:75	299.95	228.10*	190.90*
50:50	147.00*	125.03*	123.93*
75:25	44.67*	38.75*	44.83*
VC (%)	18.45	14.10	17.13
Shoot dry matter (g pot^{-1})			
100:0 (T)	75.68	63.65	40.32
75:25	56.55*	106.02*	56.43
50:50	79.73	60.81	70.76*
25:75	47.13*	66.75	47.47
VC (%)	12.02	16.35	19.59
Wild pointsettia competitor			
0:100 (T)	17.54	39.16	51.34
25:75	12.04*	14.34*	19.48*
50:50	5.41*	7.16*	10.42*
75:25	2.50*	2.21*	3.57*
VC (%)	20.08	26.34	11.49

* The mean differs from the control treatment (T) by Dunnett's test ($p \leq 0.05$).

It was generally observed for LA and DM that the highest means for sorghum or even wild pointsettia or Alexandergrass plants occurred when they were found in smaller populations in the association (Tables 2 and 3). Thus, it was noted that interspecies competition is less harmful, both for sweet sorghum and for wild pointsettia or Alexandergrass, than for intraspecies competition. This support the results obtained by other researchers, when studying the competition between crops of agronomic interest and weed species (Rigoli et al., 2008; Agostinetto et al., 2013; Galon et al., 2015; Bastiani et al., 2016).

Sorghum cultivars appeared to be more competitive than weeds, compared to the coefficients developed by Hoffman and Buhler (2000), CR>1, Kx>Ky and A>0. It is worth pointing out that the occurrence of a significant difference in at least two indices was adopted as a criterion to prove competitive superiority (Bianchi et al., 2006). Sweet sorghum (BRS 506, BRS 509, and BRS 511) showed higher growth, for the variables LA and DM, when in competition with wild pointsettia, as indicated by the CR index (greater than 1), K (higher than the one of the weed) and A (positive), except for the LA of cultivar BRS 506, which showed no differentiation in at least two indices in the presence of the weed. The growth of Alexandergrass exceeded that of the three cultivars, according to the CR index (less than 1), with the relative dominance (K) of the competitor being higher than that of the crop and of A (negative), indicating that Alexandergrass was more competitive than the culture (Table 4).

Differences in the competitive ability among sorghum cultivars were observed when competing with wild pointsettia and Alexandergrass. Sorghum was more competitive than wild pointsettia and less competitive than Alexandergrass (Table 3). This can be explained by the difference in the photosynthetic metabolism between wild pointsettia (C3) and Alexandergrass

Table 3 - Differences between plants associated or not with BRS 506, BRS 509 and BRS 511 sweet sorghum cultivars and Alexandergrass as for leaf area and shoot dry matter. UFFS, Erechim - Rio Grande do Sul state, 2014/15

Plant proportion Sorghum: Alexandergrass	Sweet sorghum cultivars		
	BRS 506	BRS 509	BRS 511
Leaf area (cm^2 pot^{-1})			
100:0 (T)	2514.47	4101.60	3674.13
75:25	1881.68*	2005.85*	1823.29*
50:50	711.23*	1876.90*	915.75*
25:75	912.13*	604.91*	581.26*
VC (%)	7.65	7.51	13.54
Alexandergrass competitor			
0:100 (T)	8690.27	7221.65	10715.93
25:75	7774.60	5844.33*	9880.21
50:50	7373.73	4578.64*	4931.14*
75:25	2682.08*	3631.52*	2449.75*
VC (%)	13.94	6.37	11.35
Shoot dry matter (g per plant)			
100:0 (T)	47.25	100.21	63.33
75:25	19.21*	21.37*	15.02*
50:50	9.65*	16.95*	11.68*
25:75	9.50*	3.75*	4.05*
VC (%)	25.80	9.71	20.63
Alexandergrass competitor			
0:100 (T)	69.85	42.31	100.69
25:75	62.69	31.08	95.88
50:50	35.71*	18.44*	71.60*
75:25	23.31*	14.78*	35.79*
VC (%)	14.48	25.56	13.07

* The mean differs from the control treatment (T) by Dunnett's test ($p \leq 0.05$).

Table 4 - Competitiveness indices among cultivars of sorghum BRS 506, BRS 509, and BRS 511, wild pointsettia or Alexandergrass, competing in equal proportions as plants (50:50), expressed by relative competitiveness (CR), clustering coefficients (K) and aggressiveness (A). UFFS, Erechim - Rio Grande do Sul, 2014/15

Variable	CR	Kx (sorghum)	Ky (competitor)	A
Leaf area				
BRS 506 x wild pointsettia	0.97 (±0.12)	0.31 (±0.02)	0.36 (±0.06)	-0.02 (±0.03)
BRS 509 x wild pointsettia	1.94 (±0.13)*	0.37 (±0.03)*	0.16 (±0.002)	0.13 (±0.02)*
BRS 511 x wild pointsettia	2.78 (±0.35)*	0.64 (±0.04)*	0.17 (±0.02)*	0.24 (±0.03)*
Shoot dry matter				
BRS 506 x wild pointsettia	4.27 (±1.18)*	1.16 (±0.18)*	0.19 (±0.06)*	0.37 (±0.06)*
BRS 509 x wild pointsettia	5.27 (±0.48)*	0.95 (±0.14)*	0.10 (±0.01)*	0.39 (±0.01)*
BRS 511 x wild pointsettia	8.77 (±1.14)*	1.18 (±0.43)	0.11 (±0.009)	0.78 (±0.09)*
Leaf area				
BRS 506 x Alexandergrass	0.34 (±0.02)*	0.17 (±0.01)*	0.76 (±0.12)	-0.28 (±0.03)*
BRS 509 x Alexandergrass	0.72 (±0.04)*	0.30 (±0.03)*	0.46 (±0.01)*	-0.09 (±0.01)*
BRS 511 x Alexandergrass	0.55 (±0.04)*	0.14 (±0.006)*	0.30 (±0.02)*	-0.11 (±0.01)*
Shoot dry matter				
BRS 506 x Alexandergrass	0.40 (±0.02)*	0.11 (±0.005)*	0.35 (±0.03)*	-0.15 (±0.01)*
BRS 509 x Alexandergrass	0.41 (±0.08)*	0.09 (±0.01)*	0.28 (±0.03)*	-0.13 (±0.03)*
BRS 511 x Alexandergrass	0.31 (±0.01)*	0.12 (±0.008)*	0.56 (±0.06)*	-0.25 (±0.02)*

* Significant difference by t test ($p \leq 0.05$). Values in parentheses represent the standard error of the mean. Kx and Ky are the relative clustering coefficients of sorghum cultivar and competitor, respectively.

(C4). C4 plants are characterized by a better ability to use the resources that are available in the medium and, therefore, are usually more competitive than C3 plants.

In tests conducted in a substitute series, crops normally present a higher competitive ability compared to weeds. This may be due mainly to the fact that, on the field, the effect of weeds on the crop is due to the level of infestation and not to its individual competitive ability (Vilá et al., 2004). However, this type of behavior is not always observed. There are cases, like the one of the Alexandergrass, in which weeds show more competitive ability than the culture. This characteristic can be related to the high capacity of using the resources by the Alexandergrass, making them unavailable for sorghum. Although both species possess a C4 metabolism, sweet sorghum presents a slow initial development, which makes it susceptible to weed competition, mainly during its initial growth (Silva et al., 2014a).

Studies evaluating the three indices in order to define competitiveness have found that cultivated sorghum was more competitive than *Sorghum halepense* (Hoffman and Buhler, 2002); that forage turnip overcame soybean genotypes in the competition (Bianchi et al., 2006); that weed rice presented greater aggressiveness than irrigated rice (Fleck et al., 2008); and that irrigated rice and soybean crops stood out compared to southern crabgrass (Agostinetto et al., 2013).

Generally speaking, when analyzing the graphs related to the relative variables and their significance in relation to the equivalent values (Figures 1 and 2, Table 1), the morphological variables (Tables 2 and 3) and the competitiveness indices (Table 4) it was possible to observe competition effects of wild pointsettia or Alexandergrass over sweet sorghum cultivars (BRS 506, BRS 509 and BRS 511), showing that these weeds present a high competitive ability in relation to the crop. This work corroborates the results found by Galon et al. (2011), when they observed that ryegrass also showed greater competitiveness than BRS Greta, BRS Elis and BRS 225 barley cultivars. Because they compete for essentially the same resources, sorghum, wild pointsettia or Alexandergrass compete for similar resources in the community where they are living together. Thus, differences in competitiveness between sweet sorghum and weeds may be related to the fact that these species present similar demands on nutrients, light and water. Researches have reported that species belonging to botanical families with different morphophysiological characteristics, such as turnip x soybean (Bianchi et al., 2006), southern crabgrass x soybean (Agostinetto et al., 2013), rice x jointvetch (Galon et al., 2015), or similar ones such as barley x ryegrass (Galon et al., 2011), sorghum x Johnson grass (Rigoli et al., 2008), showed similarities in the demand for natural resources.

Thus, understanding the dynamics and the competitive ability when crops and weeds are living in the same community becomes important for the decision making on when to control the infesting population. In the case of sorghum, there are scarce works that have evaluated the competition with weeds, especially wild pointsettia and Alexandergrass, which produce a great number of seeds; these plants are resistant to ALS and PROTOX inhibiting herbicides - wild pointsettia (Xavier et al., 2013) and ACCase inhibiting herbicides - Alexandergrass (Gazziero et al., 2004); these products are currently used for the chemical control of these weed species in several cultures.

There was competition for the same environmental resources between sweet sorghum (BRS 506, BRS 509 and BRS 511) and wild pointsettia or Alexandergrass, with mutual injury to the species involved in the community. Wild pointsettia and Alexandergrass negatively affected the LA and DM of sorghum cultivars, demonstrating greater competitive ability for the resources available in the medium. Interspecies competition causes greater damage to LA and DM than the intraspecies one. Wild pointsettia was less competitive than sorghum cultivars, while Alexandergrass was more competitive than the culture. Thus, it is recommended to control of wild pointsettia or Alexandergrass even when they are found in low densities, due to the damages they cause to the growth of the sweet sorghum culture.

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