Initial interference of *Cyperus rotundus* L. in pre-sprouted seedlings of sugarcane cultivars RB985476 and IACSP95-5000

Interferencia inicial de *Cyperus rotundus* L. en plántulas pre-brotadas de caña de azúcar cultivares RB985476 e IACSP95-5000

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ABSTRACT

Weeds compete with plants for water, light, nutrients and space. In sugarcane, planting pre-sprouted sugarcane seedlings (PSS) may mean a change in weed interference and management. The aim of this study was to generate information on the interference of *Cyperus rotundus* L. in PSS. Two experiments were carried out in a completely randomized design, one with cultivar RB985476, with seven densities of *C. rotundus* (0, 17, 35, 70, 140, 280 and 560 plants m^{-2}), and the second with cultivar IACSP95-5000, with four densities of *C. rotundus* (0, 70, 140 and 280 plants m^{-2}). For this weed, a 2x6 factorial design was used for the experiment with RB985476 and a 2x3 design was used for IACSP95-5000, the first factor being absence and presence of the crop, and the second factor the densities of the species. Biometric evaluations of height, diameter, number of tillers and leaves, leaf area and dry mass were carried out. The PSS had a reduction in height, number of leaves and leaf area in the main till at 60 d after planting (DAP) in RB985476. For the IACSP95-5000 cultivar, there was no reduction in the analyzed variables. The average dry mass per plant of *C. rotundus* decreased as the density of the species increased in the absence of PSS.

Key words: competition, Cyperaceae, densities, *Saccharum* spp.

RESUMEN

Las malezas compiten con las plantas cultivadas por el agua, la luz, los nutrientes y el espacio. En la caña de azúcar, la siembra con plántulas pre brotadas de caña de azúcar (PPB) puede significar un cambio en la interferencia y el manejo de las malezas. El objetivo de este trabajo fue evaluar la interferencia de *Cyperus rotundus* L. en plántulas pre-brotadas (PPB) de caña de azúcar. Se realizaron dos experimentos en invernadero, en diseño completamente al azar, uno con el cultivar RB985476, con siete densidades de *C. rotundus* (0, 17, 35, 70, 140, 280 y 560 plantas m^{-2}). El segundo con el cultivar IACSP95-5000, con cuatro densidades de *C. rotundus* (0, 70, 140 y 280 plantas m^{-2}). Para la maleza se adoptó un arreglo factorial de 2x6 para el experimento con RB985476 y 2x3 para IACSP95-5000, con el primer factor siendo la ausencia y presencia de caña de azúcar y el segundo factor las densidades de la especie. Se realizaron evaluaciones de altura, diámetro, número de perfiles y hojas, área foliar y masa seca de la parte aérea. Las PPB tuvieron reducción en altura, número de hojas y área foliar del perfil principal a los 60 días después del plantío en la RB985476. Para la variedad IACSP95-5000, no hubo reducción en las variables analizadas. La masa seca media por planta de *C. rotundus* se redujo con el aumento de la densidad de la especie en ausencia de PPB.

Palabras clave: competencia, Cyperaceae, densidades, *Saccharum* spp.

Introduction

A weed is any plant species that grows where it is not desired, interfering with cultivated plants, which can cause losses in production of around 20 to 30% (Lorenzi, 2014). Weeds interfere directly with crops through competition for water, light, nutrients and space. Additionally, they can interfere through allelopathic compounds capable of harming the development of crops or reducing the quality of products. They may also interfere indirectly since they are hosts of pests, diseases and nematodes, as well as harming culture and harvest practices (Pitelli, 1987).

According to Oliveira and Freitas (2008), 95 weed species have been identified in sugarcane (*Saccharum officinarum* L.), which are distributed in 74 genera and 30 families. The most representative in number of species are Poaceae, Asteraceae, Euphorbiaceae, Malvaceae, Papilionoideae and Amaranthaceae. Among these species, *Cyperus rotundus* L. (Purple Nutsedge) has obtained the Highest Value of Importance (HVI = 230.08) in relation to the infesting community.

The species *C. rotundus* is among the world's major weeds because of its high competition capacity and control

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difficulty (Kissmann and Groth, 2000) and its reproduction almost exclusively through tubers (Lorenzi, 2014). This species can have distinct levels of dormancy, which makes the management of this weed with herbicides difficult (Baloch *et al*., 2015). In sugarcane, Durigan *et al*. (2006) observed a reduction of 43.3% in yield in the presence of this species.

Kuva *et al*. (2007) evaluated the weed community in sugarcane mechanically harvested at 120 d after cutting, and the importance of the *C. rotundus* species, which was found in 20 areas, was notable; in 13 of these areas, it was the most important species, presenting a Relative Importance index (RI%) above 90%. In another study, Kuva *et al*. (2008) observed the presence of *Cyperus* sp. in 11 of 29 studied plots in a seed bank, ranging from 9.09% to 80% in relation to the RI%.

In a conventional green cane system, difficulties controlling species such as *C. rotundus*, *Commelina benghalensis* L. (Bengal Dayflower), *Sida rhombifolia* L. (Arrowleaf Sida), *Digitaria nuda* (Crabgrass) and *Urochloa plantaginea* (Link) R.D. Webster (Alexandergrass) were identified. Of these species, *C. rotundus* presented an HVI of 54%, a relative frequency (RF) of 33.3%, a relative density (RD) of 76.3% and a relative dominance (RD) of 51.9%. In fallow, this species also obtained high values of HVI (51.1%), RD (66.7%) and RD (45.5%) (Soares *et al*., 2016).

In relation to the influence of weed density on sugarcane, Durigan *et al.* (2005) observed that low (58-246 epigeal manifestations m^{-2}), average (318-773 epigeal manifestations m^{-2}) and high (675-1,198 epigeal manifestations m^{-2}) weed densities reduced sugarcane yield by 13.5, 29.3 and 45.2%, respectively, as compared to the control (free of interference).

The interference of *C. rotundus* in sugarcane is already recognized, but further studies are needed for pre-sprouted sugarcane seedlings (PSS). In this planting method, seedlings arrive at the field with the aerial part and roots already developed, which can guarantee a greater competitive advantage for sugarcane, to the detriment of weeds, since it can allow faster closing between lines, reducing the period of interference (Oliveira, 2016; Dias *et al*., 2017; Silva *et al*., 2018). According to Landell *et al.* (2012), PSS help maintain a cane field with greater vigor and quality, reduce mixtures of cultivars and maintain high phytosanity.

The aim of this study was to evaluate the initial interference of *C. rotundus* in pre-sprouted sugarcane seedlings (PSS) cultivars RB985476 and IACSP95-5000.

Materials and methods

Two experiments were carried out, the first from June to August, 2017, with cultivar RB985476, and the second from February to April, 2018, with cultivar IACSP95-5000. Both experiments were carried out in a greenhouse in Piracicaba, São Paulo, Brazil (22°42'31.2" S and 47°37'44.5" W, 547 m a.s.l.). Irrigation was maintained simulating the regional precipitation of the month of October, with an average of three mm per day (average of the last ten years) according to data collected by the meteorological station (22°42'30" S, and 47°38'30" W, 546 m a.s.l.).

The experimental design was completely randomized, with four replicates. A seedling was planted in a 10 L plastic pot, with a planting area of 572 cm^2. For cultivar RB985476, the treatments were composed of seven densities of *C. rotundus:* 0, 1, 2, 4, 8, 16 and 32 plants/pot, equivalent to 0, 17, 35, 70, 140, 280 and 560 plants m^{-2}, respectively. For the IACSP95-5000 cultivar, the treatments corresponded to four densities of *C. rotundus*: 0, 4, 8, and 16 plants/pot, equivalent to 0, 70, 140 and 280 plants m^{-2}, respectively.

For the *C. rotundus* weed, in both experiments, the treatments were composed of the densities in the absence and presence of the crop, with the treatments arranged in 2x7 (experiment with cultivar RB985476) and 2x4 factorial schemes (experiment with the cultivar IACSP95-5000), that is, two conditions of coexistence in seven and four densities, respectively. The plants were planted at a depth of three cm at the corresponding densities of each treatment. The tubers were radially allocated in relation to the sugarcane that was planted in the center of the pot.

The chemical characteristics according to the soil analysis were: pH ($CaCl_2$) = 4.9, P = 7 mg dm^{-3}, K = 1.69 $mmol_c\,dm^{-3}$, Ca = 48.49 $mmol_c\,dm^{-3}$, Mg = 14.65 $mmol_c\,dm^{-3}$, H + Al = 22 $mmol_c\,dm^{-3}$, organic matter = 42 g kg^{-1}, base saturation = 74.6 %, saturation by Al = 0.4%, and cation exchange capacity (CEC) = 86.8 $mmol_c\,dm^{-3}$.

Evaluations of cultivar RB985476 were performed at 30 and 60 d after planting (DAP) and up to 90 DAP for IACSP95-5000. Plant height was measured from the soil surface to the last fully developed leaf with a visible auricle, the diameter of the stem was measured with a digital caliper at 5 cm from the soil, and the number of leaves and tillers was also estimated.

In the last evaluation of each experiment, the leaf area was measured with a LiCor, LI 3000A (Nebraska, USA). The dry mass of the sugarcane plants and the Purple Nutsedge were estimated by cutting samples close to the soil surface, placing them in properly identified paper bags and oven drying them with forced air circulation at a temperature of 65°C to obtain the dry mass. The data were submitted to analysis of variance by the F test, and the means of the treatments were compared with Tukey's test ($P \leq 0.05$) (Pimentel-Gomes and Garcia, 2002).

Results and discussion

Experiment I: RB985476

According to the analysis of variance, no statistical differences were observed for the parameters: diameter (Tab. 1), number of tillers and dry mass of the sugarcane plants (Tab. 2).

Differences were observed only at 60 DAP for the variable height between the treatments, with 16 (17.75 cm) and 32 (26.62 cm) plants/pot (Tab. 1); however, neither differed from the control in the absence of the weed. The lowest values of leaf area were verified for the treatments with 1 and 16 plants of *C. rotundus*/pot when compared with the highest density of competition (Tab. 2). The number of sugarcane leaves was lower for the treatment with 16 plants/pot (3.50) as compared to the zero density (7.50) at 60 DAP (Tab. 2).

In relation to the total dry mass of the aerial part of the plants of *C. rotundus*, the analysis of variance showed an

TABLE 1. Height (cm) and diameter (mm) at 30 and 60 DAP in the PSS of sugarcane cultivar RB985476 in competition with *C. rotundus*.

Densities (plants/pot)	Height		Diameter	
	30	60	30	60
0	18.50	24.62 ab	5.50	8.00
1	16.00	19.50 ab	4.30	7.60
2	16.50	22.62 ab	5.00	8.30
4	17.50	22.62 ab	4.70	7.20
8	16.50	19.50 ab	4.70	5.80
16	17.00	17.75 b	4.60	7.30
32	15.75	26.62 a	5.20	7.60
Mean	16.82 ns	21.89 *	4.80 ns	7.40 ns
LSD	3.12	8.74	2.90	4.90
C.V. (%)	8.08	17.38	26.24	29.19

ns: non-significant; *followed by equal letters in a column means they do not differ according to the Tukey test at 5% probability; C.V.: coefficient of variation; LSD: less significant difference; DAP: days after planting.

TABLE 2. Number of leaves and tillers at 30 and 60 DAP, leaf area (cm^2) and dry mass (g) at 60 DAP of PSS of sugarcane cultivar RB985476 in competition with *C. rotundus*.

Densities (plants/pot)	Number of leaves		Number of tillers		Leaf area	Dry mass
	30	60	30	60		
0	5.75	7.50 a	0.00	0.00	490.075 ab	7.71
1	5.00	6.25 ab	0.25	0.50	270.912 b	5.14
2	5.25	6.00 ab	0.00	0.25	459.752 ab	6.93
4	5.50	7.00 a	0.00	0.50	470.567 ab	7.66
8	4.50	5.75 ab	0.25	0.75	287.920 ab	6.05
16	4.00	3.50 b	0.00	0.00	147.662 b	4.48
32	5.50	8.00 a	0.25	0.50	658.612 a	8.87
Mean	5.07 ns	6.28 *	0.10 ns	0.35 ns	397.928 *	6.69 ns
LSD	2.58	2.81	0.75	1.46	372.341	5.47
C.V. (%)	22.15	19.48	12.98	21.41	21.55	14.88

ns: non-significant; *means followed by the same letters in a column do not differ according to the Tukey test at 5% probability; C.V.: coefficient of variation; LSD: less significant difference; DAP: days after planting.

TABLE 3. *C. rotundus* dry mass of the aerial part (g) and dry mass per plant (g) at 60 DAP in the presence and absence of PSS of sugarcane cultivar RB985476.

Densities (plants/pot)	Dry mass of the aerial part			Dry mass per plant		
	Presence	Absence	Mean	Presence	Absence	Mean
1	1.67 cA	1.64 bA	1.65	1.67 aA	1.64 aA	1.65
2	3.01 cA	2.44 abA	2.72	1.50 aA	1.22 abA	1.36
4	5.38 bcA	4.20 abA	4.79	1.34 abA	1.05 abA	1.19
8	7.08 bA	1.03 bB	4.05	0.88 abA	0.12 bA	0.50
16	3.89 bcA	3.28 abA	3.58	0.24 bA	0.20 bA	0.22
32	14.01 aA	6.17 aB	10.09	0.43 abA	0.19 bA	0.31
Mean	5.84	3.13	4.48	1.01	0.74	0.87
$F_{factor\ 1}$		24.55 *			2.58 ns	
$F_{factor\ 2}$		19.42 *			8.36 *	
$F_{factor1\ x\ factor2}$		6.23 *			0.39 ns	
C.V. (%)		17.91			13.68	

ns: non-significant; *means followed by the same lowercase letters in a column and capital letters in a row do not differ according to the Tukey test at 5% probability; DAP: days after planting.

interaction between the factors (Tab. 3). In the interaction within the factor of absence and presence of sugarcane, a difference was observed between the densities of 8 plants/pot, with 7.08 g in the presence of sugarcane and 1.03 g in the absence, and 32 plants/pot, with 14.01 g in the presence and 6.17 g in the absence. For the densities factor, in the presence of sugarcane, the highest total dry mass value of *C. rotundus* was reached with 32 plants/pot, and the lowest total dry mass with 1 plant/pot, as was expected.

For dry mass per plant in the presence of sugarcane, the highest values were seen with the densities of 1 plant/pot (1.67 g) and 2 plants/pot (1.50 g), differing from 16 plants/pot (0.24 g). For the variable average dry mass per plant, within the factor absence of sugarcane, lower values for the densities of 8 (0.12 g), 16 (0.20 g) and 32 (0.19 g) were verified, as compared to 1 plant/pot (1.64 g). These results may suggest the beginning of intraspecific competition. There was no difference for the factor presence and absence of sugarcane within the density factor (Tab. 3).

TABLE 4. Height (cm) and diameter (mm) at 30, 60 and 90 DAP of PSS of sugarcane cultivar IACSP95-5000 in competition with *C. rotundus*.

Densities (plants/pot)	Height			Diameter		
	30	60	90	30	60	90
0	14.75	33.75	63.00	4.37	11.75	18.85
1	11.75	28.50	46.00	5.50	9.85	14.42
4	13.50	30.00	48.50	4.75	10.62	14.75
8	14.75	31.62	53.00	6.50	11.42	15.32
Mean	13.68 ns	30.96 ns	52.62 ns	5.28 ns	10.91 ns	15.83 ns
LSD	4.23	10.54	19.97	3.08	4.49	4.62
C.V. (%)	14.73	16.21	18.07	27.84	19.60	13.90

ns: non-significant; C.V.: coefficient of variation; LSD: less significant difference; DAP: days after planting.

Experiment II: IACSP95-5000

The analysis of variance was not significant for the variables: height, diameter (Tab. 4), number of leaves, number of tillers, leaf area, aerial part dry mass of the sugarcane (Tab. 5) or dry mass of the aerial part of *C. rotundus* (Tab. 6).

TABLE 5. Number of leaves and tillers at 30, 60 and 90 DAP, leaf area (cm^2) and dry mass of the aerial part (g) at 90 DAP of PSS of sugarcane cultivar IACSP95-5000 in competition with *C. rotundus*. Piracicaba, São Paulo, Brazil (2018).

Densities (plants/pot)	Number of leaves			Number of tillers			Leaf area	Dry mass
	30	60	90	30	60	90		
0	6.00	8.25	7.00	0.00	0.75	1.25	2117.55	65.78
1	6.25	6.25	6.00	1.25	1.25	1.00	1850.30	34.13
4	6.25	6.75	6.00	0.50	1.00	1.00	1761.09	32.41
8	5.75	6.50	6.25	0.25	0.25	0.25	1415.38	32.99
Mean	6.06 ns	6.93 ns	6.31 ns	0.50 ns	0.81 ns	0.87 ns	1786.08 ns	41.33 ns
LSD	2.12	2.20	1.05	2.14	2.28	2.53	985.93	41.59
C.V. (%)	16.67	15.15	7.58	28.08	27.34	29.47	26.29	19.83

ns: non-significant; C.V.: coefficient of variation; LSD: less significant difference; DAP: days after planting.

TABLE 6. Dry mass of aerial part (g) and dry mass per plant (g) of *C. rotundus* at 90 DAP in the presence and absence of PSS of sugarcane cultivar IACSP95-5000.

Densities (plants/pot)	Dry mass of aerial part			Dry mass per plant		
	Presence	Absence	Mean	Presence	Absence	Mean
4	1.28	4.12	2.70	0.32 B	1.03 aA	0.67
8	2.01	3.02	2.52	0.25 A	0.37 abA	0.31
16	3.65	4.84	4.25	0.22 A	0.30 bA	0.26
Mean	2.32	3.99	3.15	0.26	0.57	0.41
$F_{factor\ 1}$		4.091 ns			4.058 ns	
$F_{factor\ 2}$		1.752 ns			2.960 *	
$F_{factor\ 1\ x\ factor\ 2}$		0.491 ns			1.828 ns	
C.V. (%)		22.83			10.85	

ns: not significant; *means followed by the same lowercase letters in a column and capital letters in a row do not differ according to the Tukey test at 5% probability; C.V.: coefficient of variation; DAP: days after planting.

For the variable mean dry mass per plant of *C. rotundus*, the analysis showed a significant effect in the absence of sugarcane, with the highest value in the density of 4 plants/pot as compared to 16. However, differences were not found with the treatment with 8 plants/pot. A higher mean dry mass was also observed in the density of 4 plants/pot in the absence of sugarcane than in the treatment with presence of the crop (Tab. 6).

Hijano (2016) observed no differences in height, diameter, number of leaves of main stem, leaf area of main stem, dry mass of primary leaves and primary stem at 120 DAP of PSS of cultivars RB855156 and CTC14 when subjected to competition with *Rottboellia cochichinensis* (Lour.) Clayton (Itchgrass). Similar results were obtained in the present study, in which no reduction in height, diameter, or number of leaves and tillers at 30, 60 and 90 DAP of cultivar IACSP95-5000 was observed when subjected to competition with *C. rotundus*.

The height of PSS cultivar RB966928 was not reduced when they were in competition with *Panicum maximum* Jacq. (Guineagrass), at 60 and 90 d after emergence (DAE) of the weed at densities of 3.8, 7.7, 11.5 and 15.4 plants m^{-2}; however, at 45 DAE, a lower height was observed at the higher density (21 cm) as compared to the control (26.3 cm) (Paula, 2015). A height reduction also was observed in this study for cultivar RB985476 at 60 DAP at the density 16 plants/pot of *C. rotundus*, reducing the average height of the plants by 8.87 cm. In contrast to what was observed in this study, in which the IACSP95-5000 cultivar did not show a reduction in the height variable, Zera *et al.* (2016) verified a lower height of this cultivar at 30 DAP when subjected to competition with *U. plantaginea*, *S. rhombifolia*, *Digitaria horizontalis* Willd., *Amaranthus retroflexus* L. (Pigweed Redroot) and *P. maximum*, as compared to a control treatment (absence of weeds). In the present study, the lowest plant height at 60 DAP was found for cultivar RB985476 at the density 16 plants/pot (17.75 cm).

The mean number of tillers, height and dry mass of PSS cultivar RB966928 was not reduced at 30, 60 and 90 DAE when in competition with *Ipomoea hederifolia* L. (Morning Glory) at the densities 1, 2, 3 and 4 plants/pot, corresponding to 3.8, 7.7, 11.5 and 15.4 plants m^{-2}. The same was observed when the competition was established with *D. horizontalis* in the variables height and number of tillers; however, for dry mass, differences were observed between the control (absence of weed) (53.3 g) and treatment with a plant of *D. horizontalis*/pot (34.4 g) (Paula, 2015). This was not observed in the present study, in which there was no reduction in dry mass for the cultivars IACSP95-5000 and RB985476 when in competition with *C. rotundus* at 90 and 60 DAP.

For the cultivars of this study, differences in the number of tillers according to the density of *C. rotundus* were not observed. Hijano (2016) observed a reduction in the number of tillers when increasing the density of *R. cochichinensis* for the cultivars RB855156 (85 and 120 DAP) and CTC14 (55, 85 and 120 DAP). A reduction in the number of tillers was verified for cultivar RB966928 in coexistence with four plants of *U. decumbens*/pot at 60 and 90 DAE of the weed. In addition, a reduction in the dry mass of the sugarcane with 1 plant/pot was also observed; however, there was no reduction in height (Paula, 2015).

At 120 DAP, Zera *et al.* (2016) observed a reduction in the number of tillers in cultivar IACSP95-5000 with Plene Evolve, Plene PB and MPB-IACSP in competition with *P. maximum*. This was not observed in the present study, in which there was no reduction in the number of tillers for any of the studied cultivars in competition with *C. rotundus*. Paula (2015) observed a reduction in the number of tillers when PSS cultivar RB966928 was in competition with a density of 15.4 *P. maximum* plants m^{-2} at 60 DAE of the weed and a density of 7.7 plants m^{-2} at 90 DAE.

The competition of cultivar RB855536 with *I. hederifolia* during 229 DAP of sugarcane reduced the number of tillers by 34%, from 10.68 to 7.06 m^2. In addition, the authors observed a 33-d period prior to interference (PPI), yielding 71.65 t ha^{-1} when the crop remained free of weeds and 38.59 t ha^{-1} with competition for 229 DAP (Silva *et al.*, 2009).

The PPI, the critical period of preventing interference (CPPI), and the total period of preventing interference (TPPI) for sugarcane cultivar SP803280 (second cut) were 18, 18-137 and 137 DAP when subjected to competition with 12 weed species, with the highest importance for *P. maximum*, *Acanthospermum hispidum* DC. and *Alternanthera tenella* Colla (Joyweed). The yield in the absence of weeds was 126.8 t ha^{-1}, which was reduced to 84.4 t ha^{-1} when the crop competed for 270 DAP (Meirelles *et al.*, 2009).

For the dry mass of the aerial part of the PSS, no differences were found between the densities of *C. rotundus*. Zera *et al.* (2016) did not observe differences for cultivar IACSP95-5000 (Plene Evolve, Plene PB and MPB-IACSP technologies) in competition with *U. plantaginea*, *S. rhombifolia*, *D. horizontalis*, *A. retroflexus* and *P. maximum*.

Beyond sugarcane, other crops suffer from large interference caused by *C. rotundus*. Maize crops of the DKB 390 hybrid, in competition with *C. rotundus*, have presented reductions of approximately 10% for the variables dry mass, mass of 100 grains, grain mass and grain yield with increased weed densities in the presence of 10 plants m^{-2} (Silva *et al.*, 2015).

In this study, the stem diameter variable for both cultivars of sugarcane was not reduced. Kuva *et al.* (2003) estimated a reduction of stem yield of the cultivar RB835089 in competition with *U. decumbens* and *P. maximum* (most representative species in the area) as the weed dry mass increased.

The results demonstrate the importance of studies to better understand weed management in the PSS system since the behavior of sugarcane was different from that observed for conventional planting with parts of the stem.

In addition, sugarcane plants arrive in the field with developed aerial parts and roots, which makes it difficult to manage weeds from the Poaceae family with herbicides. Another important factor that should be considered is that, in seedling planting areas, there is no straw, which can be favorable for positive photoblasts and smaller seeds (Silva *et al.*, 2018).

Conclusions

It was concluded that *C. rotundus* interfered with the height, number of leaves and leaf area of the main tiller of cultivar RB985476 at 60 d after planting, mainly in the treatment with 16 plants/pot (280 plants m^{-2}).

There was no initial interference in the parameters evaluated for the IACSP95-5000 cultivar up to 90 d after planting.

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