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Herbicide selectivity in pre-sprouted seedlings of 'CTC14' sugarcane

Seletividade de herbicidas em mudas pré-brotadas de cana-de-açúcar 'CTC14'

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ABSTRACT: A new sugarcane planting system, using pre-sprouted seedlings (PSS) to replace sugarcane stem fragments, substantiates the hypothesis of this study that there might be seedling toxicity by herbicides that are sprayed at pre-emergence in traditional systems. Therefore, the aim of this paper was to study the selectivity of herbicides applied at pre-planting in PSS. A field experiment was conducted in a randomized block design, using seven treatments and four replications. Herbicides were sprayed and, 24 hours later, the seedlings were planted. At the beggining of seedling development, all herbicide treatments showed phytotoxicity, but the symptoms decreased with the growth and development of seedlings, with no difference in height, stem diameter, number of leaves, quantum efficiency of PSII (Fv/Fm) and dry matter of plants between treatments. There was also no significant difference in the yield and technological characteristics of stems. All herbicides used were selective to sugarcane seedlings when applied at pre-planting in the PSS system.

KEYWORDS: *Saccharum* spp.; phytotoxicity; chemical control.

RESUMO: Um novo sistema de plantio de cana-de-açúcar, utilizando mudas pré-brotadas (MPB) em substituição aos fragmentos de colmos de cana, fundamenta a hipótese deste trabalho de que poderá haver intoxicação nas mudas pelos herbicidas aplicados na pré-emergência em sistemas tradicionais. Portanto, objetivou-se neste estudo verificar a seletividade de tratamentos herbicidas aplicados em pré-plantio de MPB. O experimento foi realizado a campo, em blocos randomizados, utilizando sete tratamentos em quatro amostras replicadas. Foi realizada a pulverização dos herbicidas e, após 24 horas, o plantio das mudas. No início do desenvolvimento das mudas, todos os tratamentos com herbicida causaram fitotoxicidade, mas com o crescimento e desenvolvimento das mudas, os sintomas foram diminuindo, não havendo diferença entre os tratamentos quanto à altura, o diâmetro de colmos, o número de folhas, a eficiência quântica do FII (Fv/Fm) e a matéria seca das plantas. Também não houve diferença significativa na produtividade e nas características tecnológicas dos colmos. Todos os herbicidas utilizados foram seletivos às mudas de cana-de-açúcar no sistema MPB quando aplicados no pré-plantio.

PALAVRAS-CHAVE: *Saccharum* spp.; fitotoxicidade; controle químico.

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INTRODUCTION

Worldwide, Brazil stands out as the largest producer of sugarcane. The sector has the challenge of meeting the growing domestic demand for ethanol, with the need for excellent productivity in sugarcane plantations. For this reason, since the beginning of sugarcane cultivation, new management technologies are emerging so that high yields can be achieved, generating profitability to the sector. Among technologies, the sector is dedicated to the planting system, replacing the use of stems in the furrow by planting sugarcane seedlings.

This is a new concept in sugarcane multiplication, which previously consists of chemical treatment (generally, by using fungicides and insecticides) of "mini-cuttings", i.e., sugarcane stem pieces. These mini-cuttings are planted in tubes containing substrate, and their development takes place in greenhouses and seedling acclimatization sites, so that these can be taken to the field after approximately 60 days of development (LANDELL, 2014).

Due to these changes in the sugarcane planting system, other operations in the crop will undergo changes and adjustments, just like it is the case of weed management. The presence of these plants might interfere in the sugarcane production process, competing for environmental resources, releasing allelopathic substances, acting as hosts of pests and diseases common to the crop, and interfering in harvesting practices (BRESSANIN et al., 2016; PIZA et al., 2016; PITELLI, 1985), with chemical control being the most commonly used method to minimize such weeds (MONQUERO et al., 2011).

Considering the negative interference of weeds in the sugarcane crop, its control is unquestionable, but the product to be used should be selective (GALON et al., 2009). Selective herbicides are those capable of eliminating weeds that are present in the crop without reducing the yield and quality of cane fields (VELINI et al., 2000). Notwithstanding, the toxicity of sugarcane cultivars, due to the use of herbicides, causes, in most cases, a reduction in sugarcane yield (BRESSANIN et al., 2015; FERREIRA et al., 2005).

Selectivity depends on several interrelated factors, which are not always attributed only to the herbicide (ALTERMAN; JONES, 2003). This selectivity may be linked to species-specific factors (morphological, anatomical, physiological, and metabolic), external factors (climate, edaphic and physical conditions, and product positioning), or both (DEUBER, 2003; SILVA et al., 2014).

There is little information on the selectivity of pre-emergence herbicides when planting pre-sprouted seedlings (PSS) of sugarcane, with a sole article published and being carried out in pots, and not under field conditions (DIAS et al., 2017). For proper management, it is essential to know the potential damage that each herbicide can cause to the crop. Due to these adjustments in the new planting system of sugarcane, using PSS to replace stems, there may be seedling poisoning by pre-emergence herbicides usually employed in the crop. Based on this, the objective was to study herbicide selectivity in PSS of sugarcane when applied at pre-emergence of weeds and pre-planting of seedlings.

MATERIAL AND METHODS

The experiment was carried out in the field, from December 2014 to June 2016, in an experimental farm of a plant in Ribeirão Preto City, São Paulo state, and whose geographical location is 21º21'34"S and 48º03'56"WGr; the area's mean altitude is 538 m above sea level. The preparation of the area was realized out according to the procedures of the plant, consisting of eliminating the previous ratoon, correcting soil acidity, and managing subsoiling and fertilization.

After the soil preparation procedures, the experimental area was furrowed and, on the occasion, a composite sample of the soil (0 – 20 cm) was removed, which was submitted to both routine chemical and physical analyses. The soil of the experimental area was classified as Red Yellow Latosol (RYL), containing 53% of clay, with the following results for chemical analysis: 5.13 pH ($CaCl_2$); 26.57 g dm^{-3} organic matter; 51.29 V(%); 21.57 mg dm^{-3} P (resin), and 1.94; 23.17; 7.71; 30.29 mmol$_c$dm^{-3}, respectively, of K, Ca, Mg and H+Al.

The region's climate, according to Köppen classification, is Cwa type, that is, mesothermic with a dry winter, with an average temperature for the hottest month exceeding 22°C; and an average temperature for the coldest month around 18°C (CEPAGRI, 2016). The monthly precipitation values recorded in the experiment are described in Figure 1.

Each experimental plot was constituted by five 10.0 m long rows spaced 1.5 m apart, totaling 75.0 m^2. For the evaluations, the first and fifth rows were discarded in each plot, as well as 1.0 m of each of the borders of the three central rows, totaling 36.0 m^2 useful area.

The experimental design was a randomized block design, with seven treatments and four replications, described in Table 1.

The herbicides were applied using a costal sprayer at constant pressure (maintained by compressed CO_2), equipped with a spray boom containing 6 flat-jet-type spraying nozzles (XR110015), spaced 0.5 m, with spray consumption equivalent to 150 L ha^{-1}. The edaphoclimatic conditions at the time of herbicide application are shown in Table 2.

Sugarcane seedlings came from the plant nursery. Twenty-four hours after applying herbicides, the seedlings were transplanted into the area using manual seed planters, spaced 0.5 m apart within the row. The CTC14 cultivar was used.

During the experimental period, all needed measures were taken to provide the adequate growth of plants and to maintain crop health, according to the procedures adopted by the plant. As a recommended procedure for the evaluation of product selectivity, the plots were kept free from weed interference through periodic hand weeding.

At 8, 15, 29, 49, and 78 days after application (DAA) of herbicides, visual evaluations of sugarcane seedling phytotoxicity were carried out, using 0 – 100% scales, in which zero represents the absence of visual damage and 100 represents plant death (EWRC, 1964). In addition, it was assessed the height of the main tiller in each clump, between the plant base and the last ligule. At 78 DAA, two plants per plot were sampled with destructive evaluations to determine the leaf area (LiCor, LI 3100 A), and dry mass of leaves and stems. Dry mass was obtained after drying the materials in a forced air circulation oven at 70°C until constant mass was achieved.

At the end of the experimental period, during the harvest period, yield was determined at 3 m within the useful area, representing six clumps of PSS, excluding new shoots, pointer and green and dry leaves. The yield in each plot was determined in two ways: by weighing samples of clumps harvested in the useful areas and extrapolating the values to tons per hectare (Method 1), and by using biometric parameters (Method 2).

The number of stems per meter, the length of five industrializable stems (measurement of the cut-off point at the break point of palm heart) per clump; and the diameter of five stems (using a pachymeter, measuring the lower middle third of five industrializable stemsper clump) were also evaluated. From such data, it was possible to estimate the yield, expressed in tons of cane per hectare (TCH), using the mathematical expression: $TCH = D^2 \times S \times H \times (0.007854/E)$, where D = diameter of stems (cm);

Table 2. Edaphoclimatic conditions at the time of herbicide application in the field.

Field conditions	Beginning of application	End of application
Time	10:30 a.m.	12:00 a.m.
Air temperature	24.0°C	26.0°C
Soil temperature	21.0°C	22.4°C
Air humidity	63.0	59.0
Wind speed	3.0 km/h	4.0 km/h

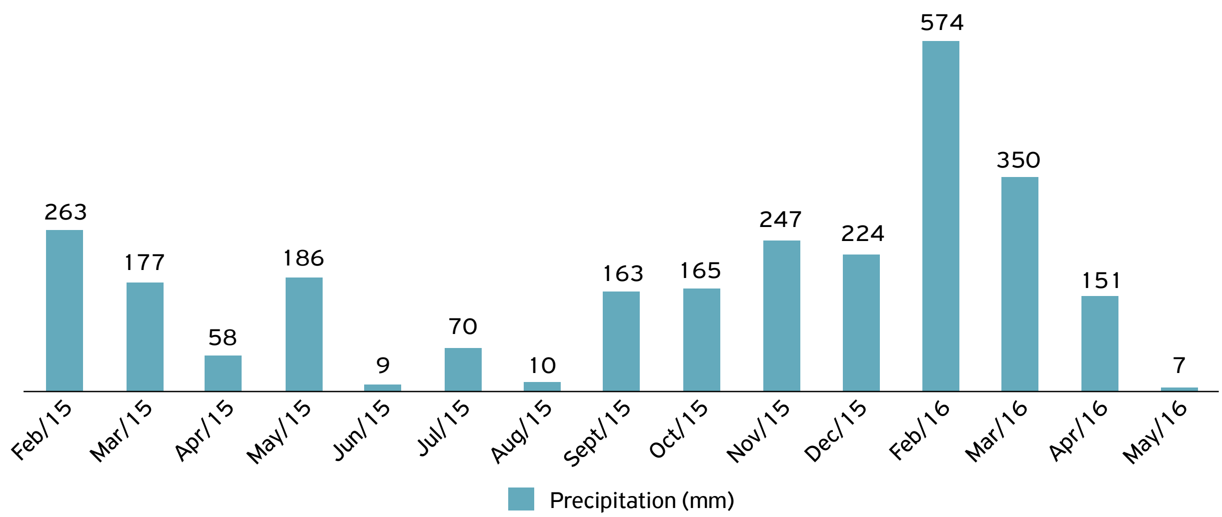


Figure 1. Monthly precipitation accumulated during the experimental period, between 2015 and 2016.

Table 1. Description of the experimental treatments.

Treat. No.	Commercial name	Active ingredient	Doses (g a.i ha^{-1})
1	Goal	Oxyfluorfen	600
	Boral 500SC	Sulfentrazone	750
2	Goal	Oxyfluorfen	720
	Atrazine	Atrazine	2500
3	Combine 500SC	Tebuthiuron	1100
	Boral 500SC	Sulfentrazone	750
4	Dual Gold	S-metolachlor	2112
	Boral 500SC	Sulfentrazone	750
5	Gamit 360CS	Clomazone	1008
	Atrazine	Atrazine	2500
6	Gamit 360CS	Clomazone	1080
	Boral 500SC	Sulfentrazone	750
7		Weed control	-
			-

S = number of stems per linear meter; H = mean length of stems (cm); and E = furrow spacing (m) (MARTINS; LANDELL, 1995). After biometry, a composite sample of ten stems was collected in each plot to determine the technological parameters of sugarcane using the method by CONSECANA (2014): Brix (°Brix), Pol (%), Purity (%), Fiber (kg t^{-1}) and TRS (kg t^{-1}).

Results were submitted to a variance analysis by the F test. The effects of treatments, when significant, were compared with the Tukey test at 5% of probability. The statistical program used was SISVAR (FERREIRA, 2011).

RESULTS AND DISCUSSION

The treatments with oxyfluorfen + sulfentrazone (1), and oxyfluorfen + atrazine (2) showed the highest phytotoxicity at 8, 15, and 29 DAA, causing chlorotic and necrotic spots on the leaves of seedlings. Possibly, this high toxicity observed is related to the herbicide oxyfluorfen, which has a positioning selectivity and almost zero solubility, less than 0.1 ppm (RODRIGUES; ALMEIDA, 2011). Considering that the planting system used was of PSS, which is shallower and has seedlings with roots, these roots may be closer to the herbicide-treated range. In addition, given the immobility of the product, which is positioned on the surface of the treated soil by the planting system with manual seed planters, the product could have been carried into the furrow (micro-erosion), and placed near the roots of the seedlings.

With the crop's development, new leaves emitted presented little or no sign of toxicity (Table 3). Similar results were also found by VELINI et al. (2000), who studied ten sugarcane cultivars and applied the oxyfluorfen + ametryn mixture, before and after crop emergence, leading to initial phytotoxicity (reddening and necrosis), and recovery after crop development, not affecting the characteristics evaluated such as yield, height and technological analysis. A similar effect occurred with treatment 4 (s-metolachlor + sulfentrazone), which caused no sign of phytotoxicity at 78 DAA (Table 3).

The treatment with tebuthiuron + sulfentrazone (3) showed the lowest toxicity at 8 DAA. However, between 29 DAA and 49 DAA, toxicity in sugarcane plants were already observed, as well as the treatment with clomazone + atrazine (5), differing from the grassed control; subsequently, toxicity decreased again at 78 DAA. The explanation for this event may be due to the high volume of precipitation recorded in the days after the experiment was installed (Fig. 1). The herbicide sulfentrazone present in treatment 3 and the clomazone in treatment 5 have from medium to high solubility, respectively (RODRIGUES; ALMEIDA, 2011). This characteristic increases the availability of the herbicide in the soil solution, increasing its absorption by the roots of the seedling sand, therefore, phytotoxicity.

The results obtained for leaf area, dry mass of leaves, and sheathed stems at 78 DAA did not present significant difference for any of the characteristics evaluated (Table 4). These results confirm the recovery of seedlings, which initially presented visual symptoms of toxicity due to herbicide application.

Table 4. Leaf area (cm^2), dry mass (g) of sheathed stems (DM s + s) and dry mass (g) of leaves per clump of treatments 78 days after application of herbicides.

	Treat.	LA	DM s + s	DML
1	oxyf + sulf	4992.50 a[(1)]	40.75 a	52.00 a
2	oxyf + atraz	5247.00 a	58.50 a	65.50 a
3	tebu + sulf	5417.83 a	44.00 a	54.50 a
4	s-met + sulf	4467.33 a	52.00 a	58.50 a
5	clom + atraz	6844.67 a	62.50 a	68.00 a
6	clom + sulf	5214.17 a	45.25 a	53.25 a
7	grass. cont.	5914.00 a	49.25 a	58.25 a
	F	1.34^{NS}	1.95^{NS}	1.41^{NS}
	CV (%)	20.77	22.54	17.60
	MSD	3152.11	26.08	23.70

LA: leaf area; DM: dry mass; DML: dry mass of leaves; ^{NS}: non-significant by F test at $p < 0.01$; [(1)]means followed by the same letter in the column do not differ significantly from each other by Tukey test at $p < 0.05$.

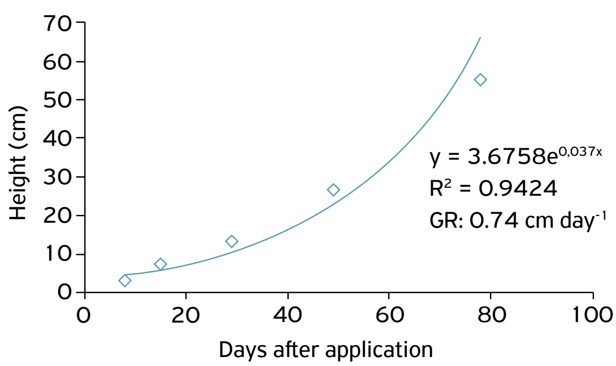
Table 3. Percentage of phytotoxicity of herbicide treatments at 8, 15, 29, 49, and 78 days after application, besides the control without application.

	Treat.	8 DAA	15 DAA	29 DAA	49 DAA	78 DAA
1	oxyf + sulf	32.50 a[(1)]	27.50 ab	12.50 a	11.25 a	5.00 a
2	oxyf + atraz	27.50 ab	31.25 a	8.75 ab	11.25 a	3.75 ab
3	tebu + sulf	11.25 cd	13.75 cd	5.00 bc	10.00 ab	6.25 a
4	s-met + sulf	18.75 bc	11.25 d	7.50 ab	1.25 bc	0.00 b
5	clom + atraz	16.25 bc	22.50 abc	5.00 bc	8.75 abc	2.50 ab
6	clom + sulf	15.00 bc	18.75 bcd	3.75 bc	3.75 abc	0.00 b
7	control.	0.00 d	0.00 e	0.00 c	0.00 c	0.00 b
	F	14.50**	19.87**	7.10**	5.69**	9.10**
	CV (%)	32.27	26.63	49.22	61.23	69.01
	MSD	12.85	10.94	6.87	9.30	3.97

DAA: days after application; **significant by F test at $p < 0.01$; [(1)]means followed by the same letter in the column do not differ significantly from each other by Tukey test at $p < 0.05$.

Among the herbicides studied, s-metolachlor (treatment 4) acts by inhibiting cell division, reaching growth points (RODRIGUES; ALMEIDA, 2011). Thus, it would affect plant height, which was not found in this study, since all means did not differ significantly from each other. The mean daily growth rate of the seedlings evaluated was 0.74 cm day^{-1} up to 78 DAA (Fig. 2).

In a study with PSS in pots and pre-planting application of herbicides, DIAS et al. (2017) used the s-metolachlor + sulfentrazone mixture, which showed to be selective to the CTC14 cultivar, up to 63 DAA and also did not affect height in the periods evaluated. However, for these authors, sulfentrazone was the second most toxic herbicide, after diclosulam, and the period in which the symptoms were more clearly visible was that between 21 and 42 DAA, though the toxicity symptoms of sulfentrazone started to dissipate 49 DAA and were almost completely gone 63 DAA. The association of S-metolachlor and sulfentrazone was the third most toxic treatment obtained by DIAS et al. (2017). Probably, the intoxication symptoms of that mixture were less severe than those of isolated sulfentrazone, due to a possible antagonic effect between those products, considering that sulfentrazone doses were the same in both treatments.



GR: daily growth rate.

Figure 2. Height (cm) of the main tiller at 8, 15, 29, 49, and 78 days after application. Each symbol (◊) represents the mean value of the seven treatments in each evaluation.

Selective herbicides with pre-emergence application, applied to the soil after planting stems, do not cause damage to the sugarcane crop, because for approximately 30 days after bud sprouting the plant lives on nutrient reserves contained in the stem, and partially on water supply and nutrients provided by fixation radicles (CASTRO; KLUGE, 2001; SILVA et al., 2014).

The roots of PSS of sugarcane, when in contact with the soil solution after planting, will already be at full absorption rate and will be able to absorb larger amounts of pre-emergent herbicides applied previously, resulting in different sensitivity responses to the products, which may lead to phytotoxicity.

Although all treatments caused severe symptoms of toxicity in the PSS of sugarcane at early development, there was no significant difference between treatments in relation to yield in tons per hectare, in both methods of estimation evaluated (Table 5).

In studies on sugarcane by NEGRISOLI et al. (2004) using some herbicides, among them oxyfluorfen, sulfentrazone, clomazone and tebuthiuron, products also used in this work, the authors indicated that sugarcane can tolerate up to 14% of toxicity without reductions in stem yield. In this study, all treatments initially had signs of toxicity greater than 14% from 8 to 15 days, except for tebuthiuron + sulfentrazone; nonetheless, at 29 DAA, toxicity decreased, and no differences were detected between treatments with or without the use of herbicides during harvest, not affecting stem yield.

Analyzing the technological qualitative characteristics of sugarcane, there was no significant difference between the effects of treatments for Brix, Pol, purity, fiber, and TRS, considering that the recommended values are 18% for Brix, 14% for Pol, and 85% or more for purity (RIPOLI; RIPOLI, 2004).

Table 5. Effects of treatments on yield (M. 1: Method 1; M. 2: Method 2, for yield estimation) and technological analysis of sugarcane 15 months after the application.

	Treat.	t/ha (M. 1)	t/ha (M. 2)	BRIX	POL (%)	PURITY	FIBER	TRS (kg/ton)
1	oxyf + sulf	107.98 a[(1)]	129.08 a	17.78 a	15.16 a	85.23 a	12.76 a	127.50 a
2	oxyf + atraz	100.91 a	134.52 a	17.28 a	14.67 a	85.00 a	12.92 a	123.39 a
3	tebu + sulf	101.29 a	118.44 a	17.23 a	14.55 a	84.42 a	12.48 a	123.41 a
4	s-met + sulf	106.28 a	132.70 a	17.36 a	14.73 a	84.83 a	12.84 a	123.92 a
5	clom + atraz	100.52 a	128.43 a	16.77 a	14.03 a	83.61 a	12.19 a	120.02 a
6	clom + sulf	116.01 a	150.68 a	17.28 a	14.59 a	84.37 a	12.72 a	123.20 a
7	grass.cont.	119.59 a	144.69 a	18.03 a	15.43 a	85.60 a	12.61 a	129.94 a
	F	0.90^{NS}	0.85^{NS}	1.17^{NS}	1.27^{NS}	1.06^{NS}	1.52^{NS}	1.24^{NS}
	CV (%)	14.99	17.41	4.17	5.42	1.50	3.20	4.67
	MSD	37.07	53.69	1.67	1.84	2.92	0.93	13.36

^{NS}: non-significant by F test at $p < 0.01$; CV: coefficient of variation; MSD: minimal significant difference; [(1)]means followed by the same letter in the column do not differ significantly from each other by Tukey test at $p < 0.05$.

CONCLUSIONS

In this study, all the herbicides tested, in their respective doses, applied at the moment of pre-planting PSS, were selective to sugarcane CTC14 cultivar, despite the initial symptoms of toxicity in the crop. No effects of herbicides were observed on the yield and technological characteristics of sugarcane stems.

REFERENCES

ALTERMAN, M.K.; JONES, A.P. *Herbicidas:* fundamentos fisiológicos y bioquímicos del modo de acción. Santiago: Universidad Católica de Chile, 2003. 333p.

BRESSANIN, F.N.; JAYME NETO, N.; NEPOMUCENO, M.P.; ALVES, P.L.C.A.; CARREGA, W.C. Interference periods of velvet bean in sugarcane. *Ciência Rural*, Santa Maria, v.46, n.8, p.1329-1337, 2016. http://dx.doi.org/10.1590/0103-8478cr20150630

BRESSANIN, F. N.; GIANCOTTI, P.R. F.; JAYME NETO, N.; AMARAL, C.L.; ALVES, P.L.C.A. Eficácia de herbicidas aplicados isolados em pré e pós-emergência no controle de mucuna-preta. *Agrária*, Recife, v.10, n.3, p.426-431, 2015. http://dx.doi.org/10.5039/agraria.v10i3a5337

CASTRO, P.R.C.; KLUGE, R.A. *Ecofisiologia de culturas extrativas:* cana-de-açúcar; seringueira; coqueiro; dendezeiro e oliveira. Cosmópolis: Stoller do Brasil, 2001. 138p.

CENTRO DE PESQUISAS METEOROLÓGICAS E CLIMÁTICAS APLICADAS À AGRICULTURA (CEPAGRI). Portal. Available from: <https://www.cpa.unicamp.br/outras-informacoes/clima-dos-municipios-paulistas>. Access on: Apr. 20 2016.

CONSELHO DOS PRODUTORES DE CANA DE AÇÚCAR, AÇÚCAR E ETANOL DO ESTADO DE SÃO PAULO (CONSECANA). *Manual de instruções*. Disponível em: <http://www.cana.com.br/biblioteca/manual_consecana_2013.pdf>. Access on: Jun. 15 2014.

DEUBER, R. *Ciência das plantas infestantes-fundamentos*. 2. ed. Jaboticabal: Funep, 2003. 452p.

DIAS, J.L.C.S.; SILVA JUNIOR, A.C.; QUEIROZ, J.R.G.; MARTINS, D. Herbicides selectivity in pre-budded seedlings of sugarcane. *Arquivos do Instituto Biológico*, Campinas, v.84, p.1-9, 2017. http://dx.doi.org/10.1590/1808-1657000112015

EUROPEAN WEED RESEARCH COUNCIL (EWRC). Methods in weeds research. *Weed Research*, Oxford, v.4, p.88, 1964.

FERREIRA, D.F. Sisvar: a computer statistical analysis system. *Ciência e Agrotecnologia*, Lavras, v.35, n.6, p.1039-1042, 2011. http://dx.doi.org/10.1590/S1413-70542011000600001

FERREIRA, E.A.; SANTOS, J.B.; SILVA, A.A.; VENTRELLA, M.C.; BARBOSA, M.H.P.; PROCÓPIO, S.O.; REBELLO, V.P.A. Sensibilidade de cultivares de cana-de-açúcar à mistura trifloxysulfuron-sodium + ametryn. *Planta Daninha*, Viçosa, v.23, n.1, p.93-99, 2005. http://dx.doi.org/10.1590/S0100-83582005000100012

GALON, L.; FERREIRA, E.A.; FERREIRA, F.A.; SILVA, A.A.; BARBOSA, M.H.P.; REIS, M.R.; SILVA, A.F.; CONCENÇO, G.; ASPIAZÚ, I.; FRANÇA, A.C.; TIRONE, S.P. Influência de herbicidas na qualidade da matéria-prima de genótipos de cana-de-açúcar. *Planta Daninha*, Viçosa, v.27, n.3, p.555-562, 2009. http://dx.doi.org/10.1590/S0100-83582009000300017

LANDELL, M.G.A. Cana para a indústria: os rumos da pesquisa. *AgroANALYSIS*, Rio de Janeiro, v.34, n.1, p.6-8, 2014.

MARTINS, A.L.M.; LANDELL, M.G.A. *Conceitos e critérios para avaliação experimental em cana-de-açúcar utilizados no programa Cana IAC*. Pindorama: Instituto Agronômico. 1995.

MONQUERO, P.A.; BINHA, D.P.; INÁCIO, E.M.; SILVA, P.V.; AMARAL, L.R. Seletividade de herbicidas em variedades de cana-de-açúcar. *Bragantia*, Campinas, v.70, n.2, p.286-293, 2011. http://dx.doi.org/10.1590/S0006-87052011000200006

NEGRISOLI, E.; VELINI, E.D.; TOFOLI, G.R.; CAVENAGHI, A.L.; MARTINS, D.; MORELLI, J.L.; COSTA, A.G.F. Seletividade de herbicidas aplicados em pré-emergência na cultura de cana-de-açúcar tratada com nematicidas. *Planta Daninha*, Viçosa, v.22, n.4, p.567-575, 2004. http://dx.doi.org/10.1590/S0100-83582004000400011

PITELLI, R.A. Interferências de plantas daninhas em culturas agrícolas. *Informe Agropecuário*, Belo Horizonte, v.11, n.129, p.16-27, 1985.

PIZA, C.S.T.; NEPOMUCENO, M.P.; ALVES, P.L.C.A. Period prior to interference of morning glory in sugarcane. *Científica*, Jaboticabal, v.44, n.4, p.543-548, 2016. http://dx.doi.org/10.15361/1984-5529.2016v44n4p543-548

RIPOLI, T.C.C.; RIPOLI, M.L.C. *Biomassa de cana-de-açúcar:* colheita, energia e ambiente. Piracicaba: Barros & Marques Ed. Eletrônica, 2004. 302p.

RODRIGUES, B.N.; ALMEIDA, F.S. *Guia de Herbicidas*. 6. ed. Londrina: Edição dos Autores, 2011. 697p.

SILVA, B.P.; ALMEIDA, R.O.; SALGADO, T.P.; ALVES, P.L.C.A. Efficacy of imazapic, halosulfuron and sulfentrazone for *Cyperus rotundus* L. control in response to weed tuber density. *African Journal of Agricultural Research*, v.9, n.47, p.3458-3464, 2014. https://doi.org/10.5897/AJAR2013.8411

VELINI, E.D.; MARTINS, D.; MANOEL, L.A.; MATSUOKA, S.; TRAVAIN, J.C.; CARVALHO, J.C. Avaliação da seletividade da mistura de oxyfluorfen e ametryne, aplicada em pré ou pós-emergência, a dez variedades de cana-de-açúcar (cana-planta). *Planta Daninha*, Viçosa, v.18, n.1, p.123-134, 2000. http://dx.doi.org/10.1590/S0100-83582000000100012