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Article

SUGARCANE SEEDLINGS INFLUENCED BY THE MANAGEMENT WITH HERBICIDES

Mudas de Cana-de-Açúcar Influenciadas pelo Manejo com Herbicidas

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ABSTRACT - This research aimed at studying herbicides selectivity on individuals from three sugarcane families after different chemical managements in primary selection fields (F1). On the field, a randomized block design with five replications in a split plot scheme was used. Twelve herbicide treatments were allocated in the plots and the three seedlings families were allocated in the sub-plots. The herbicides treatments were T1– tebuthiuron POST$_{-i}$ + ametryn POST$_{-t}$; T2– (diuron + hexazinone) POST$_{-i}$ + ametryn POST$_{-t}$; T3– sulfentrazone POST$_{-i}$ + ametryn POST$_{-t}$; T4– (diuron + hexazinone) POST$_{-i}$ + metribuzin POST$_{-t}$; T5– sulfentrazone POST$_{-i}$ + metribuzin POST$_{-t}$; T6– imazapyr IPP; T7– imazapyr IPP + ametryn POST$_{-t}$; T8– imazapyr IPP + metribuzin POST$_{-t}$; T9– imazapyr IPP + tebuthiuron POST$_{-i}$; T10– imazapyr PPI + (diuron + hexazinone) POST$_{-i}$; T11– imazapyr IPP + sulfentrazone POST$_{-i}$ and T12- weeded control. Families were F400 (♀IAC086155 x ♂?), F43 (♀IACBIO264 x ♂IAC911099) and F14 (♀IACSP991305 x ♂GlagaH). For each individual, the intoxication symptoms and the chlorophyll content on the leaves (40 and 120 DAA$_{pós-i}$), the percentage of live seedlings and selected seedlings (240 DAA$_{pós-i}$) were evauated. The chemical management with alternative treatments (T2 to T11) was selective to the three seedlings families because it caused slight intoxication symptoms and interference in the chlorophyll content, in addition to the high percentage of survival that allowed the plants selection for the later stage (F2). The management with herbicide applied in incorporated pre-planting (IPP) was highlighted as selective even when supplemented after the establishment phase of seedlings (POST-t).

Keyword: *Saccharum* spp., breeding, phytotoxicity, selectivity.

RESUMO - Esta pesquisa objetivou estudar a seletividade de herbicidas a indivíduos de três famílias de cana-de-açúcar, após diferentes manejos químicos em campos primários de seleção massal (F1). No campo, utilizou-se o delineamento em blocos casualizados com cinco repetições, em esquema de parcelas subdivididas. Nas parcelas, foram alocados 12 tratamentos herbicidas e, nas subparcelas, três famílias de seedlings. Os tratamentos herbicidas foram constituídos por T1 – tebuthiuron PÓS$_{-i}$ + ametryn PÓS$_{-t}$; T2 – (diuron + hexazinone) PÓS$_{-i}$ + ametryn PÓS$_{-t}$; T3 – sulfentrazone PÓS$_{-i}$ + ametryn PÓS$_{-t}$; T4 – (diuron + hexazinone) PÓS$_{-i}$ + metribuzin PÓS$_{-t}$; T5 – sulfentrazone PÓS$_{-i}$ + metribuzin PÓS$_{-t}$; T6 – imazapyr PPI; T7 – imazapyr PPI + ametryn PÓS$_{-t}$; T8 –imazapyr PPI + metribuzin PÓS$_{-t}$; T9 – imazapyr PPI + tebuthiuron PÓS$_{-i}$; T10 – imazapyr PPI + (diuron + hexazinone) PÓS$_{-i}$; T11 – imazapyr PPI + sulfentrazone PÓS$_{-i}$; e T12 – testemunha capinada. As famílias foram F400 (♀IAC086155 x ?), F43 (♀IACBIO264 x ♂IAC911099) e F14 (IACSP991305 x GlagaH). Foram avaliados, em cada indivíduo, os sintomas de intoxicação e o conteúdo de clorofila na parte aérea (40 e 120 DAA$_{pós-i}$), percentual de seedlings vivas e seedlings selecionadas

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(240 DAA$_{pós-i}$). O manejo químico com os tratamentos alternativos (T2 ao T11) foram seletivos às três famílias de seedlings porque causaram leves sintomas de intoxicação, pouca interferência no conteúdo de clorofila, elevado percentual de sobrevivência e também possibilitou a seleção de plantas para a fase posterior (F2). Evidenciou-se como seletivo o manejo com herbicida em pré-plantio incorporado (PPI) mesmo quando complementado após a fase de estabelecimento das seedlings (Pós$_{-i}$).

Palavras-chave: *Saccharum* spp., melhoramento genético, fitotoxicidade, seletividade.

INTRODUCTION

Programs for the genetic improvement of sugarcane may take up to 15 years to present a new promising cultivar (Cesnik and Miocque, 2004). In Brazil, there are three improvement programs: the pioneer Instituto Agronômico de Campinas (IAC), the Rede Interuniversitária para o Desenvolvimento do Setor Sucroalcooleiro (RIDESA) and the Centro de Tecnologia Canavieira (CTC).

As an example of the commercial areas that had their productivity reduced up to 80% due to the interference of weeds (Victoria Filho and Christoffoleti, 2004), the initial fields of the selection (F1) may have the total discard of the individuals from the first mass selection. Since F1 fields are wide enough for the transplantation of up to 1,500,000 individual per year^{-1} (RIDESA, 2013), the chemical management in controlling weeds is also necessary.

The consequence is that intoxication symptoms caused by herbicides, particularly the ones jeopardizing the anatomorphological structure of plants (Carvalho et al., 2009), interfere in the selection of F1 individuals. Since mass selection is grounded on the visual aspect of plants (Skinner et al., 1982), damages caused by herbicides on the height or the tillers of the plants affect the selection process.

Symptoms provided by herbicides, such as chlorosis, necrosis or albinism on the foliar limb, are similar to the symptoms of scald (*Xanthomonas albilineans*) and leaf rust (*Puccinia melanocephala*), and they confuse the improvers during selection. Lower diameter, height and tiller reduction are also symptoms caused by herbicides and may be confused with symptoms of ratoon stunting disease (*Leifsonia xyli*), as well as damaging the selection of individuals.

In the fields of sugarcane improvement in Brazil, it is possible to observe the use of tebuthiuron, because it provides a slight chlorosis on the culture leaves. The absence or fewer symptoms of intoxication on the leaves help the selection; this justifies the use of herbicides.

Tebuthiuron applied in pre-emergence controls infestations of *Panicum maximum*, *Urochloa decumbens*, *Urochloa plantaginea, Ipomoea* spp. and *Amaranthus* spp., which are frequent in cane fields. The herbicide is also selective to the sugarcane, as an example of its use in cultivars RB835089 (Azania et al., 2001) and RB855113 (Negrisoli et al., 2004). However, its use is ineffective on fields infested by species like *Cynodon dactylon* and *Cyperus rotundus* (Brasil, 2015), which are also predominant in cane fields.

In temperate regions, such as in the United States, pendimethalin (508 g ha^{-1}) is applied on experimental selection fields (Bischoff and Gravois, 2004), but the herbicide is not effective in controlling *Cyperus* spp. *Cynodon dactylon* and *Ipomoea* spp., which are frequent in cane fields in Brazil.

Managements providing less intense visual symptoms on F1 individuals need to be more elucidated. In this case, the use of imazapyr applied on day 60 before planting is common and effective in controlling *C. rotundus*, *C. dactylon* and *Ipomoea* spp. (Brazil, 2016); since it is applied before planting, it may result into less intense symptoms on the culture. Azania et al. (2001) tested imazapyr (125.0 g ha^{-1}) and observed selectivity in the ratoon of cultivar RB83-5089.

Slight intoxication symptoms (less than 20%) in cane fields were observed when diuron+hexazinone (Negrisoli et al., 2004) and sulfentrazone (Blanco and Velini, 2005) were applied in the initial post-emergence (POST$_i$) of the culture. However, there is no selectivity record of these herbicides over sugarcane seedlings.

Slight intoxication symptoms were also observed when using ametryn and metribuzin on sugarcane (Carvalho et al., 2009). These herbicides are inhibitors of the photo-system II and leave plants chlorotic (Monquero et al., 2011); however, after 30 days from the application, they did not cause intoxication symptoms on the cultivar RB 85-5113 (Negrisoli et al., 2004).

Based on the ways of applying herbicides on sugarcane, it is possible to propose as an hypothesis that the chemical management to control weeds is selective to sugarcane seedlings cultivated in mass selection fields (F1), particularly when the herbicide application in incorporated pre-planting (IPP) was used, complemented with the application in post-emergence after the plant establishment stage (POST-t). In order to confirm the hypothesis, the goal was to study the selectivity of herbicides to individuals from three sugarcane families, after different chemical management in primary fields of mass selection (F1).

MATERIAL AND METHODS

Hybridization. Sugarcane seeds were obtained by bi-parental hybridization and poly-crossing between May and June 2013 at the IAC station in Uruçuca, Bahia state, Brazil. The region has a tropical coastal climate, classified according to Köppen as Af (tropical humid). For the bi-parental hybridization, the families F43 (IACBIO264 x ♂IAC911099) and F14 (♀IACSP991305 x ♂GlagaH) were constituted, and, for poly-crossing, the family F400 (♀IAC086155 x ♂?).

Seedling formation. Seeds from the three families were brought to Ribeirão Preto, São Paulo state, Brazil, and were placed to germinate in plastic boxes, filled with substrate formulated with pine bark and coconut fiber, fertilized with ammonium sulphate (300 g), potassium chlorate (200 g) termophosphate (200 g) and osmocote (300 g, 15-9-12 formulation) for every 100 L. After that, they were kept in a greenhouse with controlled environment (32 °C, 80% air relative humidity and irrigation of 1 mm day^{-1}).

After germination, each seedling was individually transplanted to a cell filled with the same substrate used in germination. After transplanting, the trays with the cells were kept in greenhouse with irrigation (8 mm day)♀ for 20 days. In the following 40 days, seedlings were allocated on benches exposed to the sun and irrigated (4 mm day^{-1}), pruning was performed frequently in the aerial part - a necessary process to minimize water loss by transpiration.

Experiment on the field. In the period between November 2013 and November 2014, an experiment was conducted in the city of Ribeirão Preto, (21°12'28.29" LS and 47°52'23.30" LW), at 621 m from the sea level, classified according to Köppen as high altitude tropical climate (Cwa). During the experimental period, 935 mm of rain and 16.9 and 29.8 °C as an average of the minimum and maximum temperatures were recorded.

The soil was classified as Distroferric Red Latosol with clayey texture (582, 126 and 292 g kg^{-1} of clay, sand and silt), respectively. As for the chemical characteristics, it presented 4.6 $pH_{(water)}$, 42 g dm^{-3} of organic matter (OM), 108.4 $mmol_c$ dm^{-3} of cation exchange capacity (CEC), 9 mg dm^{-3} de P_{resin} and 2.96, 30.58 and 15.86 $mmol_c$ dm^{-3} of K, Ca and Mg, respectively.

In preparing the soil, two subsoilings were used (0.8 m depth), one harrowing with a heavy disc harrow and two with a light one. Subsequently, on December 13th, 2013, imazapyr (500 g ha^{-1}) was applied in incorporated pre-planting on part of the experimental area. After 40 days of fallow, glyphosate (2,160 g ha^{-1}) was applied on the total area, in order to eliminate the weeds that were not contemplated by the IPP treatment. A tractor sprayer was used, with TT110/02 fan nozzles and 200 L ha^{-1} spray volume.

After 18 days from the application of glyphosate, the desiccated weeds in the area without IPP use were incorporated into the soil with the use of a leveling disc harrow. The delimitation of the experimental area in randomized block design with 12 treatments in five replications was performed, in a split-plot scheme. The herbicide managements were allocated in the plots (3 lines x 6 m x 1.5 m) (Table 1) and the seedling families were allocated in the subplots (1 line x 6 m x 1.5 m). For each subplot, 12 individuals from the same family were transplanted.

Seven hundred and twenty seedlings from each family were transplanted (02/12/2014), spaced 1.5 m between the lines and 0.5 m between plants, with a mechanic planter. After transplanting,

Table 1 - Herbicide treatments proposed for primary fields (F1) of seedling selection in sugarcane. 2016

Treatment	IPP	$POST_{-i}$	$POST_{-t}$ *
T1	--	tebuthiuron (1,200 g ha^{-1})	ametryn (3,000 g ha^{-1})
T2	--	ametryn (1,404 g ha^{-1}) hexazinone (396 g ha^{-1})	ametryn (3,000 g ha^{-1})
T3	--	sulfentrazone (800 g ha^{-1})	ametryn (3,000 g ha^{-1})
T4	--	diuron (1,404 g ha^{-1}) hexazinone (396 g ha^{-1})	metribuzin (1,920 g ha^{-1})
T5	--	sulfentrazone (800 g ha^{-1})	metribuzin (1,920 g ha^{-1})
T6	imazapyr (1,000 g ha^{-1})	--	--
T7	imazapyr (1,000 g ha^{-1})	--	ametryn (3,000 g ha^{-1})
T8	imazapyr (1,000 g ha^{-1})	--	metribuzin (1,920 g ha^{-1})
T9	imazapyr (1,000 g ha^{-1})	tebuthiuron (1,200 g ha^{-1})	--
T10	imazapyr (1,000 g ha^{-1})	diuron (1,404 g ha^{-1}) hexazinone (396 g ha^{-1})	--
T11	imazapyr (1,000 g ha^{-1})	sulfentrazone (800 g ha^{-1})	--
T12	--	weeding	weeding

Incorporated pre-planting (IPP); initial post-emergence ($POST_{-i}$); late post-emergence ($POST_{-t}$) - herbicide absence; * 0.5% of adjuvant over the total spray volume.

the experiment was irrigated to guarantee the establishment of plants. The herbicides in initial post-emergence ($POST_{-i}$) were applied on the plots on February 20, 2014 (Table 1).

In order to apply the herbicides, a constant pressure (CO_2) manual backpack sprayer was used, equipped with a four fan nozzle bar (TT110/02) and 240 L ha^{-1} flow. The application was performed between 7h6min and 8h17min and, at the time, there were air temperature from 24.3 to 28.1 °C, air relative humidity from 61.2 to 57.7%, wind speed from 5 to 3.5 km h^{-1} and 0% cloudiness.

After 50 days, on April 11th 2014, herbicides in late post-emergence (POST-t) were applied, completing the 12 proposed managements (Table 1). In the applications, a constant pressure (CO_2) manual sprayer with 240 L ha^{-1} flow was also used. The applications were performed between 9h15min and 9h57min and, at the time, there were air temperature from 23.5 to 26.1 °C, air relative humidity from 75 to 70.3%, wind speed from 5 to 3.8 km h^{-1} and 10% cloudiness.

Evaluated characteristics. For a practical effect in counting time, the date 02/20/2014-RP was considered, referring to the application of herbicides in initial post emergence ($POST-_{i}$). Starting from this date, counting began in days after application (DAA), to designate each evaluation.

For each individual, injuries and chlorophyll content in the aerial part were evaluated (40 and 120 DAA_{post-i}), as well as the percentage of selected and living seedlings (240 DAA_{post-i}). Injuries were obtained according to the percentage and visual scale, starting at 0% (absence of injuries) and ending at 100% (plant death), according to ALAM (1974). The chlorophyll content was determined by the indication (given in unit spad - us) on the total chlorophyll gauge and on two random points on the leaf + 3. A Konica Minolta SPAD-502 Plus equipment was used.

For each subplot, the percentage of living seedlings (*(“grades/12)*100*) and the percentage of selected seedlings *(“selected plants/12)*100* were evaluated, where 12 is the total number of planted individuals per subplot. In order to calculate the living seedlings (%), grade 1 was assigned to living plants and grade 0 to the dead ones. In order to calculate the selected seedlings (%), the number of plants that were suitable for further selection (F2) was calculated. Selected plants with height, stalk diameter and tillering that were proper for commercial harvesting were considered, and so was the absence of diseases and of Brix%syrup higher than 10%.

Statistical analysis. The evaluated variables were submitted to F test for analysis of variance, according to the proposed design, and the averages of the treatments were compared by LSD test ($p<0.05$), using the statistical program SAS.

RESULTS AND DISCUSSION

The intoxication symptoms observed on seedlings (Table 2) in each treatment were slight and acceptable in practice (lower than 30%) up to 40 40 DAA_{post-i} (04/02/14). Symptoms varied from 4.58 (T3 – sulfentrazone $POST_{-i}$ + ametryn POST-t) to 10.11% (T7 – imazapyr IPP + ametryn $POST_{-t}$) on F400 plants; from 7.33 (T1 – tebuthiuron $POST_{-i}$ + ametryn POST-t) to 15.66% (T5 – sulfentrazone $POST_{-i}$ + metribuzin POST-t) on F14; and from 10.99 (T9 – imazapyr IPP + tebuthiuron $POST_{-i}$) to 21.83% (T5 – sulfentrazone $POST_{-i}$ + metribuzin $POST_{-t}$) on F43, all characterized by yellow discoloration on the leaves.

In the later evaluation, on day 120 DAA_{post-i} (06/27/2014), the evolution of symptoms was observed, but they were still considered as slight (lower than 30%). The most intense symptoms did not exceed 10.83% (T5 – sulfentrazone $POST_{-i}$ + metribuzin $POST_{-t}$), 28.16% (T7 – imazapyr PPI + ametryn $POST_{-t}$ on F14) and 30.49% (T7-imazapyr PPI + ametryn $POST_{-t}$ on F43).

In commercial cane fields, similar injuries were also observed after the application in pre-emergence of different herbicides on different cultivars. Injuries in the aerial part not exceeding 24% were also observed in treatments with imazapyr (125 g ha^{-1}) and tebuthiuron (1,100 g ha^{-1})

Table 2 - Intoxication percentage (%) in three seedling sugarcane families cultivated in primary mass selection fields (F1), 2016

Treatment	Intoxication (%)					
	40 DAA			120 DAA		
	F400	F14	F43	F400	F14	F43
T1 – tebuthiuron (1,200 g ha)(2) ametryn (3,000 g ha)(3)	6.51 a	7.33 b	11.66 b	11.66 ab	15.33 bc	17.16 bc
T2 – diuron (104 g ha)(2) hexazinone (396 g ha)(2) ametryn (3,000 g ha)(3)	9.49 a	15.16 ab	14.66 ab	12.00 ab	19.00	21.16
T3 – sulfentrazone (800 g ha)(2) ametryn (3,000 g ha)(3)	4.58 a	11.50 ab	14.58 ab	11.00 ab	15.83 bc	21.66
T4 – diuron (104 g ha)(2) hexazinone (396 g ha)(2) metribuzin (1,920 g ha)(3)	6.33 a	8.85 ab	13.76 ab	7.50 b	10.49 c	24.68 abc
T5 – sulfentrazone (800 g ha)(2) metribuzin (1,920 g ha)(3)	5.50 a	15.66 a	21.83 a	10.83 ab	19.50 ab	30.83 ab
T6 – imazapyr (500g ha)(1)	9.50 a	13.50 aB	16.16 aB	14.01 a	24.33 aB	23.66 abc
T7 – imazapyr (500g ha)(1) ametryn (3,000 g ha)(3)	10.11a	12.00 ab	14.16 ab	13.79 a	28.16 a	30.49 a
T8 – imazapyr (500 g ha)(1) metribuzin (1,920 g ha)(3)	5.03 a	10.16 ab	12.83 b	10.54 ab	17.66 bc	23.37 abc
T9 – imazapyr (500 g ha)(1) tebuthiuron (1,200 g ha)(2)	6.50 a	9.00 ab	10.99 b	12.33 ab	16.66 bc	16.58 c
T10 – imazapyr (500 g ha)(1) diuron (1,404 g ha)(2) hexazinone (396 g ha)(2)	6.83 a	11.83 ab	17.33 ab	10.16 ab	18.83 abc	27.33 ab
T11 – imazapyr (500 g ha)(1) sulfentrazone (800 g ha)(2)	7.66 a	14.41 a	16.66 ab	10.99 ab	25.33 ab	26.16 abc
T12 – weeded control sample	0.00 b	0.00 c	0.00 c	0.00 c	0.00 d	0.00 d
MSD	5.19	7.39	8.16	6.55	9.88	11.46
VC (%)	12.92	11.31	10.93	11.88	10.79	9.56
p>F	0.0007 *	0.0001**	0.0001**	0.0001**	0.0001**	0.0001**

F43 - family with seedlings obtained by biparental hybridization (♀IACBIO264 x ♂IAC911099); F14 - family with seedlings obtained by biparental hybridization (♀IACSP991305 x ♂GlagaH); F400 - family with seedlings obtained by poly-crossing hybridization (♀IAC086155 x ♂ ?); (1) incorporated pre-planting (IPP) -12/12/2013; (2) initial post-emergence (DAA_{POST-i}) – 02/20/2014; (3) late post-emergence (DAA_{POST-i}) – 04/11/2014; 40 DAA_{POST-i} – 02/04/2014; and 120 DAA_{POST-i} – 06/21/2014.

in the RB 83-5089 cultivar (Azania et al., 2001); with diuron (1,865 g ha^{-1}) + hexazinona (234 g ha^{-1}) in the IACSP94-2094, IACSP94-2101 and IACSP93-3046 cultivars (Souza et al., 2009); and with sulfentrazone (800 g ha^{-1}) in the SP80-3280 cultivar (Ferreira et al., 2010). Post-emergence applications of trifloxysulfuron-sodium + ametryn (37+1,463 g ha^{-1}) and metribuzin (1,920 g ha^{-1}) in the RB 92-8064 cultivar (Monquero et al., 2009) also provided similar injuries to the ones observed on Table 2.

As well as the injuries, the chlorophyll content on plant leaves (Table 3) was also not damaged by herbicides. In the three studied families, treatments (T2 – diuron + hexazinone POST$_{-i}$ + ametryn POST$_{-t}$ and T11 – imazapyr IPP + sulfentrazone POST$_{-i}$) provided contents that were close to the ones obtained in the standard treatment (T1 – tebuthiuron POST$_{-i}$ + ametryn POST-t) and in the weeded control sample (T12 – weeded control sample). The chlorophyll content found in the seedlings varied from 44.02 (T7 – imazapyr PPI + ametryn POST$_{-t}$) to 48.46 us (T3 – sulfentrazone POST$_{-i}$ + ametryn POST$_{-t}$) on F400; from 42.73 (T2- (diuron + hexazinone) POST$_{-i}$ + ametryn POST$_{-t}$) to 48.01 us (T4 – diuron + hexazinone POST$_{-i}$ + metribuzin POST$_{-t}$) on F14, and from 41.17 (T2 – diuron + hexazinone POST$_{-i}$ + ametryn POST$_{-t}$) to 49.48 us (T9 – imazapyr PPI + tebuthiuron POST$_{-i}$) on F43, on day 40 DAA$_{post-i}$.

Table 3 - Chlorophyll content (spad) in three seedling sugarcane families cultivated in primary mass selection fields (F1), 2016

Treatment	Chlorophyll content (spad)					
	40 DAA			120 DAA		
	F400	F14	F43	F400	F14	F43
T1 – tebuthiuron (1,200 g ha) [2] ametryn (3,000 g ha) [3]	45.98 a	45.70 a	45.35 ab	40.81 b	42.75 abc	40.75 a
T2 – diuron (104 g ha) [2] hexazinone (396 g ha) [2] ametryn (3,000 g ha) [3]	45.20 a	42.73 a	41.17 b	40.91 b	39.64 bcd	38.74 a
T3 – sulfentrazone (800 g ha) [2] ametryn (3,000 g ha)[3]	48.46 a	47.04 a	45.07 ab	41.94 ab	40.97 abcd	39.00 a
T4 – diuron (104 g ha) [2] hexazinone (396 g ha) [2] metribuzin (1,920 g ha)[3]	46.33 a	48.01 a	45.90 ab	46.00 a	44.93 a	36.49 a
T5 – sulfentrazone (800 g ha) [2] metribuzin (1,920 g ha)[3]	46.71 a	43.88 a	42.52 b	41.81 b	37.36 cd	34.04 a
T6 – imazapyr (500g ha) [1]	45.24 a	42.83 a	44.16 ab	40.86 b	38.91 bcd	38.67 a
T7 – imazapyr (500g ha) [1] ametryn (3,000 g ha)[3]	44.02 a	45.24 a	43.64 ab	42.36 ab	37.15 d	37.56 a
T8 – imazapyr (500 g ha) [1] metribuzin (1,920 g ha)[3]	44.94 a	45.25 a	46.70 ab	42.59 ab	42.27 abcd	40.27 a
T9 – imazapyr (500 g ha) [1] tebuthiuron (1,200 g ha) [2]	45.13 a	46.28 a	49.48 a	44.00 ab	43.28 ab	40.92 a
T10 – imazapyr (500 g ha) [1] diuron (1,404 g ha) [2] hexazinone (396 g ha) [2]	46.11 a	46.67 a	44.65 ab	42.32 ab	42.60 ab	36.25 a
T11 – imazapyr (500g ha) [1] sulfentrazone (800 g ha) [2]	44.31 a	42.61 a	42.56 b	43.79 ab	40.32 abcd	39.88 a
T12 – weeded control sample	44.65 a	47.82 a	42.72 b	40.27 b	42.62 ab	38.31 a
DMS	5.32	6.32	5.75	3.99	5.13	7.63
VC (%)	2.03	2.71	2.57	1.70	2.37	3.92
p>F	0.9527^{ns}	0.6454^{ns}	0.3712*	0.2743*	0.0896*	0.8160^{ns}

F43 - family with seedlings obtained by biparental hybridization (♀IACBIO264 x ♂IAC911099); F14 - family with seedlings obtained by biparental hybridization (♀IACSP991305 x ♂GlagaH); F400 - family with seedlings obtained by poly-crossing hybridization (♀IAC086155 x ♂ ?); [1] incorporated pre-planting (IPP) -12/12/2013; [2] initial post-emergence (DAA$_{POST-i}$) – 02/20/2014; [3] late post-emergence (DAA$_{POST-i}$) – 04/11/2014; 40 DAA$_{POST-i}$ – 04/02/2014; and 120 DAA$_{POST-i}$ – 06/21/2014.

In the following evaluation (120 DAA_{post-i}) values were not subjected to drastic changes: on F400 they varied from 40.27 (T12 – weeded control sample) to 46.00 us (T4 – diuron + hexazinone $POST_{-i}$ + metribuzin $POST_{-t}$); on F14, from 37.15 (T7 – imazapyr IPP + ametryn $POST_{-t}$) to 44.93 us (T4 – diuron + hexazinone $POST_{-i}$ + metribuzin $POST_{-t}$); and on F43, from 40.92 (T9 – imazapyr IPP + tebuthiuron $POST_{-i}$) to 34.04 us (T5 – sulfentrazone $POST_{-i}$ + metribuzin $POST_{-t}$).

Surely, the effect of the herbicides on the metabolism of seedlings little impacted on the chlorophyll pigment, because the values observed on the plants from different treatments were similar to the ones on the plants from the control sample treatment. However, opposite effects to the ones obtained in this work were observed in commercial cane fields after the application of ametryn (2,500 g ha^{-1}), diuron + hexazinone (1,170+330 g ha^{-1}), imazapic (147 g ha^{-1}), 2,4-D (1,000 g ha^{-1}), tebuthiuron (1,200 g ha^{-1}) and sulfentrazone (800 g ha^{-1}) in pre-emergence of the SP80-3280 cultivar (Ferreira et al., 2010).

The slight injuries and the small damage of the chlorophyll content in the seedling leaves did not affect the development of plants. On day 240 DAA_{post-i} (10/21/2014), the percentage of living seedlings from T2 - diuron + hexazinone $POST_{-i}$ + ametryn $POST_{-t}$ to T11 - imazapyr IPP + sulfentrazone $POST_{-i}$ was similar to the one from the control sample (T12 - weeded control sample) and the standard treatment (T1 tebuthiuron $POST_{-i}$ + ametryn $POST_{-t}$) in the three studied families (Table 4). In seedlings from F400, T2 - diuron + hexazinone $POST_{-i}$ + ametryn POST-t (96.60%), from F14, also T2 - diuron + hexazinone $POST_{-i}$ + ametryn POST-t (90.20%), and from F43, T5 - sulfentrazone $POST_{-i}$ + metribuzin POST-t (89.20%) presented the lowest percentage of living plants.

Naturally, the death of plants in mass selection fields, regardless of the herbicide treatment, is commonly observed. This observation may be verified by the percentage of living seedlings in the control sample treatment (T12 - weeded control sample) in plants from F400 (98.40%), F14 (95.20%) and F43 (90%). However, 89.20% (T5 sulfentrazone $POST_{-i}$ + metribuzin $POST_{-t}$ on F43) of plant survival in primary selection fields in perfectly acceptable in practice.

The high percentage of living seedlings indicates that treatments may be used in primary selection fields (F1) without significant damages on the seedling that will be evaluated. Treatments with sulfentrazone (T3 - sulfentrazone $POST_{-i}$ + ametryn $POST_{-t}$, T5 - sulfentrazone $POST_{-i}$ + metribuzin $POST_{-t}$ and T11 - imazapyr IPP + sulfentrazone $POST_{-i}$) indicated for the control of *Cyperus rotundus* and *Ipomoea* spp. and with imazapyr indicated for *Cynodon dactylon* (Brazil, 2015) were selected to the seedlings and stood out as an alternative to the standard treatment with tebuthiuron (T1 – tebuthiuron $POST_{-i}$ + ametryn $POST_{-t}$).

The selectivity of chemical treatments was observed because on day 240 DAA_{post-i} plants developed and it was possible to select them for the following stage of the improvement process. Surely, selectivity occurred in detriment of the interactions between environmental, herbicide and plant conditions.

In the soil, herbicide movement was favored by their physical-chemical characteristics, associated to the intensity of rainfalls occurred during the experimental period. According to Mancuso et al. (2011), the physical-chemical factors such as solubility (sw), lipophilicity (koc) and retention (koc) of the molecules determined the herbicide movement into the soil.

Water availability (935.3 mm of rain) helped the movement into soil if one considers the solubility values of herbicides, according to PPDB (2016) tebuthiuron (2,500 ppm), diuron (42 ppm)+hexazinone (33,000 ppm), sulfentrazone (780 ppm), ametryn (200 ppm), metribuzin (1,100 ppm) and imazapyr (11,272 ppm).

Also in the soil, the clayey texture may have helped the process of herbicide adsorption. According to Liu et al. (2008), clay helps the sorption process of herbicides to the organic matter and clay. The higher the sorption coefficient to organic carbon (koc) of the herbicide, the more intense the adsorption of molecules into the soil.

When considering the observed koc values, according to PPDB (2016), for tebuthiuron (80), ametryn (30), diuron (480), hexazinone (54), metribuzin (60), imazapyr (125) and sulfentrazone (85), it is possible to imply that the processes of sorption and desorption were favored. According to Azania et al. (2011), koc values may be classified as moderate, which according to Rigi et al. (2015) results into the gradual desorption of herbicides into solution of the soil.

Table 4 - Living plants (%) selected by the process of mass selection (%) in three seedling sugarcane families cultivated in primary mass selection fields (F1), 2016

Treatment	living plants (%)			selected plants (%)		
	240 DAA			240 DAA		
	F400	F14	F43	F400	F14	F43
T1 – tebuthiuron (1,200 g ha) (2) ametryn (3,000 g ha) (3)	100.00 a	100.00 a	95.00 a	0.00 b	1.60 a	0.00 a
T2 – diuron (104 g ha) (2) hexazinone (396 g ha) (2) ametryn (3,000 g ha)(3)	96.60 a	90.20 c	96.80 a	5.00 ab	0.00 a	1.60 a
T3 – sulfentrazone (800 g ha) (2) ametryn (3,000 g ha)(3)	98.40 a	98.40 ab	93.40 a	1.60 ab	1.60 a	0.00 a
T4 – diuron (104 g ha) (2) hexazinone (396 g ha) (2) metribuzin (1,920 g ha)(3)	100.00 a	100.00 a	93.40 a	3.40 ab	1.60 a	0.00 a
T5 – sulfentrazone (800 g ha) (2) metribuzin (1,920 g ha)(3)	100.00 a	91.60 bc	88.20 a	1.60 ab	0.00 a	0.00 a
T6 – imazapyr (500g ha) (1)	98.40 a	95.00 abc	95.00 a	1.60 ab	0.00 a	1.60 a
T7 – imazapyr (500g ha) (1) ametryn (3,000 g ha)(3)	96.80 a	93.60 abc	95.00 a	1.60 ab	0.00 a	0.00 a
T8 – imazapyr (500 g ha) (1) metribuzin (1,920 g ha)(3)	98.40 a	98.40 ab	95.00 a	0.00 b	3.20 a	0.00 a
T9 – imazapyr (500 g ha) (1) tebuthiuron (1,200 g ha) (2)	100.00 a	98.40 ab	98.40 a	1.60 ab	0.00 a	1.60 a
T10 – imazapyr (500 g ha) (1) diuron (1,404 g ha) (2) hexazinone (396 g ha) (2)	100.00 a	100.00 a	98.40 a	0.00 b	1.60 a	0.00 a
T11 – imazapyr (500g ha) (1) sulfentrazone (800 g ha) (2)	100.00 a	91.80 bc	93.40 a	3.40 ab	1.60 a	0.00 a
T12 – weeded control sample	98.40 a	95.20 abc	90.00 a	0.00 b	1.60 a	0.00 a
DMS	3.97	7.11	12.73	5.04	3.34	2.24
VC (%)	0.67	1.31	2.55	21.44	18.04	12.69
p>F	0.6021^{ns}	0.0571*	0.9091^{ns}	0.6556^{ns}	0.6497^{ns}	0.5989^{ns}

F43 - family with seedlings obtained by biparental hybridization (♀IACBIO264 x ♂IAC911099); F14 - family with seedlings obtained by biparental hybridization (♀IACSP991305 x ♂GlagaH); F400 - family with seedlings obtained by poly-crossing hybridization (♀IAC086155 x ♂ ?); (1) incorporated pre-planting (IPP) -12/12/2013; (2) initial post-emergence (DAA_{POST-i}) – 02/20/2014; (3) late post-emergence (DAA_{POST-i}) – 4/11/2014; 240 DAA_{POST-i} – 10/21/2014.

In seedlings, kow values, according to PPDB (2016), for tebuthiuron (63), ametryn (427), diuron (480), hexazinone (589), metribuzin (44) and sulfentrazone (9.8), classified and lipophilic according to Azania et al. (2011), may have favored the penetration into plants. Even with the metabolism and the anatomorphological characteristics of each seedling, the lipophilic characteristic of the herbicides possibly favored the absorption and penetration into plant tissues.

Herbicides with kow close to 100 are easily translocated by the symplast (Silva et al., 2013), which is a slow transportation route (Concenço et al., 2007); this may provide due time to the metabolization of the herbicide by the plant metabolism. With this, the negative effects of herbicides on seedlings were possibly minimized.

The developed plants, by climate conditions, fertility or favorable dynamic of the herbicide in the soil, tolerated applications of ametryn and metribuzin in $POST_{-t}$. Both herbicides inhibit the passage of electrons between the photosystems in the photosynthesis process (Dayan and Zaccaro, 2012), but they did not cause injuries or damages on chlorophyll content and plant survival.

Still on day 240 DAA_{post-i} (10/21/2014), the development and satisfactory survival percentage (88.20 to 100%) of plants enabled the selection of seedlings (Table 4) for the following selection stage (F2) in all alternative treatments (T2 to T11). In F400, 5% (T2), 3.40% (T4 and T11) and

1.60% (T3, T5, T6, T7 and T9); in F14, 3.20% (T8) and 1.60% (T1, T3, T4, T10 to T12); and in F43, 1.60% (T2, T6 and T9) of the seedlings were selected. Thus, it was possible to observe that the alternative treatments (T2, T3, T4, T6, T8, T9 and T11) to the standard one tebuthiuron+ametryn (T1) were selective, because they did not affect the development of plants and allowed the final selection of the progenies by the improvers.

The chemical control with alternative treatments (T2 to T11) was selective to the three seedling families because they caused slight intoxication symptoms, little interference in the chlorophyll content, high survival percentage and they also enabled the selection of plants for the following stage (F2). Thus, it was possible to highlight as selective the management of herbicide during incorporated pre-planting (IPP9 even when they were complemented after the establishment stage of seedlings ($Post_{-t}$) in F1 fields. With the increase in control alternatives, the management in areas with hardly controllable plants, such as *C. rotundus*, *C. dactylon* and *Ipomoea* spp., may be performed with selectivity and effectiveness.

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