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Article

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HALAUXIFEN-METHYL+DICLOSULAM: NEW OPTION TO CONTROL *Conyza* spp. PRIOR SOYBEAN SOWING

*Halauxifen-Methyl+Diclosulam: Nova Opção para o Controle de **Conyza** spp. em Pré-Semeadura da Soja*

ABSTRACT - Control of *Conyza* spp. prior to soybean sowing has faced difficulties because of the resistance cases in Brazil, hence new herbicides as halauxifen-methyl + diclosulam are important to manage this specie. The objective of this research was to evaluate the effectiveness of the herbicide halauxifen-methyl + diclosulam applied at pre-planting of soybean. The experiments were set up in three locations in Paraná State, Brazil, in the 2015/2016 season. The herbicide halauxifen-methyl + diclosulam was associated with glyphosate and compared to other commercial herbicide to *Conyza* spp. control. The application occurred 15 days before soybean sowing, in plants of *Conyza* spp. with an average height of 20-35 cm in the three areas. None of the treatments promoted *Conyza* spp. control above 90%, when soybean was at the V1 stage; however, the findings showed that halauxifen-methyl + diclosulam promoted better control in comparison to the other treatments. The control reached >90% at V3 soybean development stage, in which treatments containing glyphosate + halauxifen-methyl + diclosulam were more effective than the other treatments. In addition, treatments with glyphosate + halauxifen-methyl + diclosulam decreased dry matter content of *Conyza* spp. between 87 and 93%, depending on the location, when compared to the control. The burndown treatment to *Conyza* spp. with glyphosate + halauxifen-methyl + diclosulam did not decrease soybean yield, and it was always higher than the untreated check.

Keywords: burn down, *Conyza* spp. control., Arylpicolinate herbicide, auxin mimic herbicide, *Glycine max*.

*RESUMO - O controle de **Conyza** spp. antecedendo a semeadura da soja tem apresentado dificuldades no Brasil devido à presença de casos de resistência. Assim, novos herbicidas, como halauxifen-methyl + diclosulam, são importantes no manejo dessa espécie. O objetivo desta pesquisa foi avaliar a eficácia do herbicida halauxifen-methyl + diclosulam aplicado em dessecação pré-plantio da soja. Os experimentos foram instalados em três localidades no Estado do Paraná, Brasil, na safra de 2015/2016. O herbicida halauxifen-methyl + diclosulam foi associado ao glyphosate e comparado com outros herbicidas encontrados no mercado para o controle de buva; a aplicação ocorreu 15 dias antes da semeadura da soja, em plantas de **Conyza** spp. com altura média de 20-35 cm, nas três áreas. Nenhum dos tratamentos promoveu controle de **Conyza** spp., superior a 90%, quando a soja se encontrava no estádio V1; entretanto, os resultados demonstraram que halauxifen-methyl + diclosulam promoveu melhor controle em relação aos demais tratamentos. O controle melhorou (>90%) no estádio de desenvolvimento V3 da soja, no qual os tratamentos contendo glyphosate + halauxifen-methyl + diclosulam se mostraram superiores aos demais; além disso, os tratamentos com*

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glyphosate + halauxifen-methyl + diclosulam diminuíram a matéria da massa seca de ***Conyza*** *spp. entre 87 e 93%, dependendo da localização, quando comparados com o controle. A dessecação da buva com glyphosate + halauxifen-methyl + diclosulam não diminuiu a produtividade da soja, tendo sido esta sempre maior que a da testemunha não capinada.*

Palavras-chave: dessecação, controle de *Conyza* spp., herbicidas arylpicolinato, herbicidas mimetizadores de auxina, *Glycine max*.

INTRODUCTION

Conyza spp. is a weed found worldwide that are difficult to control (Owen et al., 2009). In Brazil, there are three main species: *C. bonariensis*, *C. canadensis* and *C. sumatrensis*, occurring across the southern and central regions of the country in orchards, wheat, corn, soybeans, cotton, forages, pastures and non-crop areas. Hybridization between these species sometimes occurs, hindering a clear distinction in the field (Santos et al., 2014).

It is a winter annual dicotyledonous plant that interferes in both winter and summer crops in Brazil (Vargas et al., 2007; Owen et al., 2009). Seed production ranges from 150-200 thousand seeds per plant, and the seeds are easily dispersed by wind and can remain viable in soil for up to 3 years (Kissmann and Groth, 1992; Wu et al., 2007). Glyphosate-resistant biotypes of *Conyza bonariensis*, *C. canadensis* and *C. sumatrensis* as well as multiple-resistant (glyphosate and ALS) biotypes to *Conyza sumatrensis* have been identified in Brazil (Heap, 2017).

Conyza spp. has a high growth rate and competitive potential (Moreira et al., 2010); it causes serious damage to soybean crops (Trezzi et al., 2013). Trezzi et al., (2013) evaluated seven soybean cultivars and noted that an average population of 13.3 plants m^{-2} reduced the average yields by 25%, and as much as 35% for some varieties.

The period before interference of glyphosate-resistant hairy fleabane (*Conyza bonariensis)* in the soybean crop is 24 days after soybean emergence for plants established before crop sowing (Silva et al., 2014). Thus, a burndown application before soybean planting allows the crop to germinate without weed competition, providing a proper and uniform distribution of the seeds during seeding and preventing weed competition during crop emergence (Minozzi et al., 2014).

The most common change adopted by farmers in fields with the presence of herbicide resistant weeds is the use of alternative herbicides applied alone or in combination with their current herbicides to improve control of resistant biotypes (Vieira Júnior et al., 2015).

Halauxifen-methyl is the first active ingredient of the new arylpicolinate group (Epp et al., 2016) and belongs to the synthetic auxin mechanism of action. It is absorbed and translocated by the xylem and phloem, and accumulates in the meristematic tissue. Some tests have shown that the molecule is rapidly degraded in soil and straw and provides effective control of several important broadleaf weeds (EFSA, 2015). Symptoms are similar to those caused by the herbicide 2,4-D, i.e., epinasty, deformation, necrosis and subsequent death.

The objective of this work was to evaluate the efficacy of halauxifen-methyl + diclosulam with other herbicide weed managements with respect to *Conyza* spp. in soybean. We hypothesize that the herbicide halauxifen-methyl plus diclosulam is a new tool for control of *C. sumatrensis* in soybean pre-seeding.

MATERIAL AND METHODS

The experiments were set up in three field areas in the 2015/2016 summer season. The areas were located in the west of Paraná state, Brazil. The climate, according to Köppen's classification, is CFA – mesothermal humid subtropical, with hot summers and infrequent frosts, with a tendency of more concentrated rainfall during summer months, and no dry season. Average temperatures in warmer months are higher than 22°C but not lower than 13 °C the in coolest months. Average annual rainfall ranges between 1,600-1,800 mm (IAPAR, 2014).

The first experiment (E1) was located in Assis Chateaubriand-PR (24°27'18.3"S and 53°27'36.4"W; 377 m of altitude), the second (E2) in Iporã-PR (24°04'39,01"S and 53°66'84,95"W; 365 m of altitude) and the third (E3) in Francisco Alves-PR (24°05'44.5"S and 53°54'30.9"W; 298 m of altitude). In all experiments, farmers carried burned down the areas with the application of glyphosate plus 2,4-D, and paraquat was applied after 7 days. All three experiments were conducted from September 2015 to February 2016.

Prior to conducting the experiments, soil samples at 0-15 cm were collected from both locations and main physical and soil chemistry characteristics were as follows: E1: pH 5.1; M.O. 18.00 g dm^{-3}; Ca 6.03; Mg 2.11; K 0.44 and CTC 13.19 $cmol_c$ dm^{-3}; P 6.94 mg dm^{-3}; clay 630 g kg^{-1}, 200 g kg^{-1} sand 170 g kg^{-1} silt, and classified as Eutrophic Red Latosol, clay textured. E2: pH 5.4; M.O. 8.00 g dm^{-3}; Ca 4.14; Mg 1.59; K 0.37 and CTC 9.72 $cmol_c$ dm^{-3}; P 4.51 mg dm^{-3}; clay 240 g kg^{-1}; sand 680 g kg^{-1} and 80 g kg^{-1} silt, and classified as Rhodic Paleudult soil, sandy textured. E3: pH 5.8; M.O. 6.45 g dm^{-3}; Ca 5.15; Mg 2.76; K 0.33 and CTC 10.21 $cmol_c$ dm^{-3}; P 3.81 mg dm^{-3}; clay 380 g kg^{-1}, sand 510 g kg^{-1} and 110 g kg^{-1} silt, and classified as Rhodic Paleudult soil, sandy textured.

The statistical design used in all three experiments was a randomized complete block, with eleven treatments and four repetitions. The treatments followed the application of different herbicides in a fallow burndown application, fifteen days prior to soybean sowing (Table 1). For each treatment performed, adjuvants were added according to the manufacturer's recommendation. Plot size was 4 x 6 m and the effective area consisted of six internal rows of 45 cm between them and 6 m length (24 m^2).

Table 1 - Herbicides used, respective rates, and source information for field experiments before soybean sowing

Treatment	Active ingredient	Rates g a.e. or a.i. ha^{-1}
T1	Untreated	-
T2	Hand-weeded	-
T3	Glyphosate(1) + saflufenacil(2)	1440 + 24.5
T4	glyphosate + diclosulam(3)	1440 + 29
T5	glyphosate + chlorimuron-ethyl(4)	1440 + 20
T6	glyphosate + 2,4-D(5)	1440 + 1005
T7	glyphosate + 2,4-D + saflufenacil	1440 + 1005 + 24.5
T8	glyphosate + 2,4-D + diclosulam	1440 + 1005 + 29
T9	glyphosate + 2,4-D + chlorimuron-ethyl	1440 + 1005 + 20
T10	glyphosate + (halauxifen-methyl + diclosulam)(6)	1440 + 30.6 (25.52 + 5.06)
T11	glyphosate + (halauxifen-methyl + diclosulam)(3)	1440 + 38.2 (31.90 + 6.32)

(1) Glizmax®Prime (Glyphosate dimethylamine salt, 480 g L^{-1}); (2) Heat®. Added Dash (Mix of methyl esters, aromatic hydrocarbons, unsaturated fatty acid and surfactant) at 500 mL ha^{-1}. (3) Spider®. (4) Classic®. (5) DMA® 806 BR. (6) Product under registration - Added MSO (methylated seed oil) at 1 L ha^{-1} (720 g a.i. ha^{-1}).

Conyza spp. plants were at the following growth stages and densities: E1: 30-35 cm, with 36 leaves and 12 plants m^{-2}; E2: 20-25 cm, with 25 leaves and 26 plants m^{-2} and E3: 25-30 cm, with 30 leaves and 21 plants m^{-2}. Herbicide applications were performed using a CO_2-pressurized backpack sprayer under constant pressure (2.46 kgf cm^{-2}) fitted with four AIXR 110015 flat-fan nozzles, providing a spraying volume of 150 L ha^{-1}. Table 2 shows the weather conditions during the applications.

The efficacy experiments were conducted in no-tillage areas. Soybean crop cultivars (Nideira 5959 RR2 Ipro®, BMX Ponta® and Monsoy 6210 RR2 Ipro®) were sown in 25/09/2015, 14/10/2015 and 15/10/2015, respectively for E1, E2 and E3. The three experimental areas consisted at 0.45 width row crop spacing, 16 seeds per meter and 5 cm planting depth with a population density of 310,000 seeds ha^{-1}. Prior to sowing, seeds were treated with a standard seed treatment of thiamethoxam + fipronil + pyraclostrobin + thiophanate-methyl. For all experiments, pesticide applications for control of insects and diseases were performed by following the recommendations proposed by Embrapa Soja (2010).

Weed control assessments were taken at the V_1 and V_3 soybean growth stages, using the *Conyza* spp. infestation observed in the untreated check as reference. These evaluations used a visual scale ranging between 0 and 100%, in which 0% means no herbicide symptoms and 100% means complete plant death (SBCPD, 1995). In addition, at V_3 crop stage, *Conyza* spp. plants were collected (1.0 m^2 area) and dried at 60 °C for 72 hours to constant weight to determine biomass, using a precision balance, and weight was compared with the untreated *Conyza* spp. infestation. When the soybean crop reached the V_4 growth stage, it was sprayed with glyphosate at 1,440 g a.e. ha^{-1} over the entire experimental area, except for the untreated and hand-weeded plots. Visual evaluations of *Conyza* spp. control were taken at V_6 and R_1, 14 and 28 days after post-emergence application of glyphosate. At the R_8 soybean growth stage, ten randomly-selected plants from each plot were assessed for soybean agronomic parameters (height insertion of first pod, number of pods, and 100 seed-weight). Height insertion of first pod was assessed with a milimeter ruler, measuring from the soil to the insertion of the last pod. Number of pods was counted manually. Crop yield was determined by manually harvesting all soybean plants present in the two central rows by four meters long (3.6 m^2) in the effective area of each plot. The grains were weighed and total yield corrected to 13% for all plots.

Table 2 - Weather conditions and weed stage in the three experimental areas

	E1	E2	E3
	Assis Chateaubriand	Iporã	Francisco Alves
Application date	09/19/15	10/08/15	10/07/15
Relative humidity %	62.0	63.0	57.0
Temperature °C	33.0	29.0	28.7
Wind speed km h^{-1}	2.2	4.2	2.3
Conyza spp. growth stage (cm)	30-35	20-25	20-30
Density plants m^{-2}	12	26	21

The analyses of the three sets of experiments indicated that the effects of the experiments and the interaction of the treatment and experiments were significantly different, not allowing an analysis of all the experiments together (Table 3). Data from individual sites were analyzed by utilizing analysis of variance (ANOVA) according to Pimentel-Gomes and Garcia (2002) and when the F test was significant, Tukey's test (p<0.05) was performed to compare the means. For statistical analysis, the software Sisvar® (Ferreira, 2011) was used.

Table 3 - Anova test for percentage of *Conyza* spp. control at V_1 and V_3, dry weight of *Conyza* spp. (grams) V3, percentage of *Conyza* spp. control after glyphosate application at V_1 and R_3. Soybean agronomic parameters at R8. Experiment 1, 2 and 3 during the 2015-16 season

Sources of variation	% Control		Dry weight of Conyza	% control 14 DAA	% control at 28 days after glyphosate application
	V_1	V_3	V_3	V_6	R_1
P(3) treat.(1)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
P exp.(2)	<0.0001	<0.0001	<0.0001	<0.0001	0.0001
P treat. by exp.	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sources of variation	Height of 1st pods	Final height	Number of ods	100-seed weight	Yield
	R_8	R_8	R_8		
P(3) treat.(1)	0.0220	0.0483	<0.0001	0.0097	<0.0001
P exp.(2)	<0.0001	0.0010	<0.0001	<0.0001	<0.0001
P treat. by exp.	0.0328	0.0331	<0.0001	0.0002	0.0001

(1) Treatments; (2) Experiment, (3) P value for F tests. E1 - Assis Chateaubriand, E2 - Iporã and E3 - Francisco Alves, Paraná, Brazil.

RESULTS AND DISCUSSION

The results in the three evaluated locations showed that the interaction was significant and therefore the locations will be discussed separately (Table 3).

Conyza spp. control and dry weight before glyphosate application

The *Conyza* spp. growth stage in the experiments ranged from 20-35 cm; however, the results showed that even with the differential *Conyza* spp. height among the experiments, the control was similar, with no treatment providing acceptable (>90%) *Conyza* spp. control at the V_1 growth stage (Table 4, 5 and 6), because according to ALAM (1974), control is considered to be good when greater than 80%. However, although the results in Tables 4, 5 and 6 showed that treatments with pre-mix halauxifen-methyl + diclosulam at V_1 growth stage provided better control than the other standard treatments, similar results were found when using the pre-mix halauxifen-methyl + diclosulam in different doses, for *Conyza* spp. control (Braz et al., 2017; Zobiole et al., 2018a; Zobiole et al., 2018b). It was noticed that the treatments without 2,4-D were not as effective as those associated with 2,4-D, and such results agree with the studies of Chahal and Johnson (2012) and Eubank et al. (2008), in which there was a better performance of herbicides when 2,4-D was used in the burndown application. According to Constantin et al. (2013), the growth stage of *Conyza* spp. influences the performance of herbicides and the spectrum of control, which as much higher the *Conyza* spp., the control will be difficult and fewer products will be available.

Table 4 - Percentage of *Conyza* spp. control at V_1 and V_3, Dry weight of *Conyza* spp. (grams) V_3, percentage of *Conyza* spp. control after glyphosate application (CGA) at 14 DAA and 28 DAA. Experiment 1 (E1) - Assis Chateaubriand, Paraná, Brazil. 2015-16 Season

Treatment	% Control		Dry weight of Conyza	CGA 14 DAA*	CGA 28 DAA
	V_1	V_3	V_3	V_6	R_1
T1	0.00 G	0.00 G	145.50 A	0.00 H	0.00 G
T2	100.00 A	100.00 A	0.00 D	100.00 A	100.00 A
T3	55.00 DE	33.00 EF	38.50 BC	29.50 D	13.25 EF
T4	41.25 F	35.75 E	35.50 BC	27.25 D	17.50 D
T5	42.75 E	28.50 F	45.00 B	14.25 G	9.50 F
T6	63.50 D	43.50 D	40.40 BC	20.00 EF	12.00 EF
T7	70.75 C	39.50 DE	30.50 BC	22.75 E	13.75 DE
T8	62.75 D	55.25 C	18.50 CD	16.50 FG	10.50 EF
T9	68.25 C	54.00 C	26.50 BC	20.75 E	13.25 EF
T10	68.25 C	92.00 B	13.50 CD	70.50 C	62.00 C
T11	81.50 B	97.25 AB	16.50 CD	75.25 B	66.00 B
Average	59.56	52.61	16.67	36.06	23.47
CV%	6.01	5.42	29.28	4.48	5.81
LSD	8.47	6.53	25.64	2.62	3.89

Uppercase letters in the same column do not differ by Tukey's mean test ($p \leq 0.05$). * glyphosate application at V_4 soybean growth stage. CV: coefficient of variation; D LSD: low significant difference. T1 – untreated; T2 – hand-weeded; T3 - glyphosate + saflufenacil; T4 - glyphosate + diclosulam; T5 - glyphosate + chlorimuron-ethyl; T6 - glyphosate + 2,4-D; T7 - glyphosate + 2,4-D + saflufenacil; T8 - glyphosate + 2,4-D + diclosulam; T9 - glyphosate + 2,4-D + chlorimuron-ethyl; T10 - glyphosate + (halauxifen-methyl + diclosulam); T11 - glyphosate + (halauxifen-methyl + diclosulam).

The same results found at V_1 soybean growth stage were noted at V_3: treatments containing 2,4-D were slightly better than without it, although not acceptable yet. This low control in the treatments with the herbicide 2,4-D can be attributed to the stages of *Conyza* spp., since Takano et al. (2013) found that a height above 15 cm offered 50% less control compared to plants with a height of 6-15 cm with an association of glyphosate + 2,4-D (720 + 670 g a.e. ha^{-1}). In the areas in which the experiments were carried out, the heights of the plants of *Conyza* spp. were 30-35 cm, 20-25 cm and 25-30 cm for E1, E2 and E3, respectively. However, for *Conyza* spp. control at V_3 growth stage, T2 and T11 were effective in all experiments (Tables 4, 5 and 6), and only the treatments with glyphosate + halauxifen-methyl + diclosulam (T10 and T11) provided acceptable

control over 90% against death. According to Grey and Prostko (2015), diclosulam, when applied in a post-emergence period, has rapid absorption, about 67% in two hours, which may lead to increased control.

Table 5 - Percentage of *Conyza* spp. control at V_1 and V_3, Dry weight of *Conyza* spp. (grams) V_3, Percentage of *Conyza* spp. control after glyphosate application (CGA) at 14 DAA and 28 DAA. Experiment 2 (E2) - Iporã, Paraná, Brazil. 2015-16 Season

Treatment	% Control		Dry weight of Conyza	CGA 14 DAA*	CGA 28 DAA
	V_1	V_3	V_3	V_6	R_1
T1	0.00 H	0.00 H	84.51 A	0.00 H	0.00 D
T2	100.00 A	100.00 A	0.00 D	100.00 A	100.00 A
T3	72.75 C	50.75 E	32.50 B	13.25 DE	0.00 D
T4	36.00 G	36.50 F	28.50 B	14.00 D	0.00 D
T5	43.75 F	29.50 G	17.00 BC	8.75 G	0.00 D
T6	64.00 E	44.75 DE	23.50 BC	10.50 FG	0.00 D
T7	71.00 CD	42.00 E	21.50 BC	12.00 DEF	0.00 D
T8	65.50 DE	49.00 CD	17.50 BC	8.50 G	0.00 D
T9	64.75 DE	41.50 E	18.50 BC	11.75 EF	0.00 D
T10	69.00 CDE	92.75 B	11.00 CD	85.25 C	82.50 C
T11	79.50 B	92.00 B	9.00 CD	90.25 B	88.25 B
Average	60.56	52.88	23.95	32.20	24.25
CV%	4.65	3.75	27.58	2.74	1.58
LSD	6.66	4.72	15.97	2.05	0.90

Uppercase letters in the same column do not differ by Tukey mean test ($p \leq 0.05$).* glyphosate application at V_4 soybean growth stage. CV: coefficient of variation; LSD: low significant difference. T1 – Untreated; T2 – Hand-weeded; T3 - glyphosate + saflufenacil; T4 - glyphosate + diclosulam; T5 - glyphosate + chlorimuron-ethyl; T6 - glyphosate + 2,4-D; T7 - glyphosate + 2,4-D + saflufenacil; T8 - glyphosate + 2,4-D + diclosulam; T9 - glyphosate + 2,4-D + chlorimuron-ethyl; T10 - glyphosate + (halauxifen-methyl + diclosulam); T11 - glyphosate + (halauxifen-methyl + diclosulam).

Table 6 - Percentage of *Conyza* spp. control at V_1 and V_3, Dry weight of *Conyza* spp. (grams) V_3, Percentage of *Conyza* spp. control after glyphosate application (CGA) at 14 DAA and 28 DAA. Experiment 3 (E3)- Francisco Alves, Paraná, Brazil. 2015-16 Season

Treatment	% Control		Dry weight of Conyza	CGA 14 DAA*	CGA 28 DAA
	V_1	V_3	V_3	V_6	R_1
T1	0.00 F	0.00 H	53.00 A	0.00 G	0.00 D
T2	100.00 A	100.00 A	0.00 F	100.00 A	100.00 A
T3	72.25 CD	32.00 G	29.00 B	10.75 F	0.00 D
T4	54.50 E	44.50 F	18.50 C	13.50 EF	0.00 D
T5	56.00 E	34.75 G	20.00 BC	17.50 D	0.00 D
T6	59.50 E	41.00 F	16.50 CD	11.00 EF	0.00 D
T7	84.75 BC	50.25 E	10.50 CDE	11.75 EF	0.00 D
T8	69.75 D	62.50 C	12.50 CDE	14.75 DE	0.00 D
T9	72.50 C	57.00 D	16.50 CD	12.75 EF	0.00 D
T10	71.50 D	92.50 B	7.00 DEF	89.25 C	83.75 C
T11	81.25 BC	97.50 A	3.50 EF	94.75 B	86.75 B
Average	65.63	55.63	17.00	34.18	24.59
CV%	5.99	3.55	26.79	4.69	2.21
LSD	9.04	4.44	10.18	3.75	1.28

Uppercase letters in the same column do not differ by Tukey's mean test ($p \leq 0.05$). ^{ns} not significant. * glyphosate application at V_4 soybean growth stage. CV: coefficient of variation; LSD: low significant difference. T1 – untreated; T2 – hand-weeded; T3 - glyphosate + saflufenacil; T4 - glyphosate + diclosulam; T5 - glyphosate + chlorimuron-ethyl; T6 - glyphosate + 2,4-D; T7 - glyphosate + 2,4-D + saflufenacil; T8 - glyphosate + 2,4-D + diclosulam; T9 - glyphosate + 2,4-D + chlorimuron-ethyl; T10 - glyphosate + (halauxifen-methyl + diclosulam); T11 - glyphosate + (halauxifen-methyl + diclosulam).

In addition, low dry weight of *Conyza* spp. was found for T10 and T11, which decreased biomass between 91 to 89 % for E1, 87 to 89% (E2) and 87 to 93% (E3), compared to the untreated plot. Such results corroborate others, in which there was a reduction of *Conyza* spp. dry weight caused by the application of other auxinic herbicides such as halauxifen-methyl + diclosulam, dicamba, 2,4-D amine and 2,4-D ester and (Chahal and Johnson, 2012; Braz et al., 2017; Zobiole et al., 2018a).

When the herbicides 2,4-D and halauxifen-methyl are compared, they both have the same auxin mode of action; however, in different chemical groups: phenoxycaboxylic acid (2,4-D) and arylpicolinates (halauxifen-methyl) (EFSA, 2015). Nevertheless, there was better *Conyza* spp. control in those treatments with halauxifen-methyl (T10 and T11) than with the herbicide 2,4-D (T6, T7, T8 and T9). Therefore, these results may be due to different bind protein receptors, once halauxifen-methyl has more interaction with the electrostatic AFB5 protein (Auxin F-Box) (Bell et al., 2014), while 2,4-D, with the TIR1 protein (Transport Inhibitor Response 1) (Grossmann, 2009; Lee et al., 2014).

Conyza spp. control after glyphosate application

The results at V_6, after glyphosate application at V_4, showed that the percentage of control decreased in all treatments because of plant regrowth (Tables 4, 5 and 6). However, the treatments which showed highest control were the hand-weeded treatment and those treatments with halauxifen-methyl + diclosulam (T10 and T11), mainly because of glyphosate resistant biotypes in the several fields in the Parana state. Importantly, the herbicide treatments T10 and T11 were those that promoted the best burndown control to *Conyza* spp.

When soybean reached R_1, at 28 days after glyphosate application, only the hand-weeded (T2) treatment and the treatments with halauxifen-methyl + diclosulam (T10 and T11) showed better control (Tables 4, 5 and 6) in the experiments. The performances of the ALS herbicides associated with glyphosate were not acceptable probably because of the ALS resistant and glyphosate biotypes in the region of the current study (Santos et al., 2014).

Soybean agronomic parameters

In general, most of the soybean attributes evaluated as height insertion of first pod, number of pods, and 100 seed-weight were not statically affected by the treatments applied (Tables 7, 8 and 9). Yield per hectare to highlight the effectiveness and importance of herbicides in integrated weed management (Oliveira Neto et al., 2010); thus, in E2 and E3, all management treatments with herbicides were higher than the untreated check, mainly because of population density in these areas, where populations above 13.3 plants m^{-2} can reduce the average yields by 25% and as much as 35% (Trezzi et al., 2013). Therefore, the herbicides were selective and caused *Conyza* spp. control, while in other herbicides such as chlorimuron-ethyl, diclosulam and halauxifen-methyl + diclosulam herbicides, there were no reductions in yield and dry weight of soybean (Osipe et al., 2013; Gazola et al., 2016; Braz et al., 2017). Other authors have reported that when *Conyza* spp. is controlled by post-emergent herbicides such as glyphosate + 2,4-D associated with residual herbicides e.g., diclosulam, they provided excellent burndown and residual control in soybean crops with significantly higher yield than the untreated check (Oliveira Neto et al., 2010).

However, in E1 (Assis Chateaubriand - PR) only treatments, the hand-weeded treatment and glyphosate + (halauxifen-methyl + diclosulam), in both doses, are statistically greater than the untreated check (Table 7), possibly because of lower plant density of *Conyza* spp. According to Braz et al. (2017) the application of halauxifen-methyl + diclosulam does not interfere in soybean yield even when it is applied three days before sowing, thus showing the selectivity of this auxinic herbicide in soybean, similarly to the herbicide 2,4-D (ester and amine) and dicamba (Thompson et al., 2007). Thus, this herbicide becomes a great alternative for control of *Conyza* spp., and when it is applied 15 days before sowing, it does not interfere in soybean yield.

Table 7 - Soybean agronomic parameters at R8: Height of 1st Pods (cm), Final height (cm), Number of pods, 100-seed weight (grams) and Soybean yield (kg ha^{-1}). Experiment 1 (E1) - Assis Chateaubriand, Paraná, Brazil. 2015-16 Season

Treatment	Height of 1st Pods^{ns}	Final height^{ns}	Number of pods^{ns}	100 seed weight^{ns}	Yield
	R_8	R_8	R_8		
T1	18.00	75.41	37.83	17.25	2898.73 B
T2	16.80	79.62	34.08	16.39	4031.12 A
T3	20.12	84.45	35.45	16.71	3871.27 AB
T4	19.04	83.91	43.08	16.70	3714.81 AB
T5	18.24	87.33	38.04	17.25	3745.13 AB
T6	18.16	86.54	36.08	16.70	3753.63 AB
T7	18.04	81.42	38.13	16.18	3732.38 AB
T8	16.96	89.62	34.70	17.02	3815.20 AB
T9	19.25	83.54	39.12	17.21	3797.73 AB
T10	18.54	85.75	39.25	16.19	4009.83 A
T11	17.25	79.62	38.25	16.76	3952.58 A
Average	18.15	83.38	37.64	16.67	3753.15
CV%	10.71	9.18	16.37	5.54	11.14
LSD	4.54	17.96	14.43	2.16	973.40

Uppercase letters in the same column do not differ by Tukey's mean test ($p \leq 0.05$). ^{ns} not significant. CV: coefficient of variation; LSD: low significant difference. T1 – untreated; T2 – hand-weeded; T3 - glyphosate + saflufenacil; T4 - glyphosate + diclosulam; T5 - glyphosate + chlorimuron-ethyl; T6 - glyphosate + 2,4-D; T7 - glyphosate + 2,4-D + saflufenacil; T8 - glyphosate + 2,4-D + diclosulam; T9 - glyphosate + 2,4-D + chlorimuron-ethyl; T10 - glyphosate + (halauxifen-methyl + diclosulam); T11 - glyphosate + (halauxifen-methyl + diclosulam).

Table 8 - Soybean agronomic parameters at R8: Height of 1st Pods (cm), Final height (cm), Number of pods, 100-seed weight (grams) and Soybean yield (kg ha^{-1}). Experiment 2 (E2) - Iporã, Paraná, Brazil. 2015-16 Season.

Treatment	Height of 1st Pods^{ns}	Final height^{ns}	Number of pods^{ns}	100 seed weight^{ns}	Yield
T1	11.42	73.42	53.68	14.33	1240.71 B
T2	14.00	79.96	77.75	13.87	5457.14 A
T3	11.88	82.00	64.33	13.96	4486.32 A
T4	13.58	80.58	61.50	14.82	4944.32 A
T5	12.13	83.29	66.54	15.97	4579.40 A
T6	13.79	84.92	72.25	14.94	4743.45 A
T7	12.83	87.68	72.63	16.50	4918.54 A
T8	14.17	84.54	63.33	16.28	4783.19 A
T9	13.96	85.92	74.33	14.18	4251.42 A
T10	12.34	85.83	57.00	14.12	4790.07 A
T11	13.13	82.21	68.63	14.49	5445.12 A
Average	13.02	82.75	66.54	14.85	4512.69
CV%	13.42	18.28	23.65	9.28	20.11
LSD	4.08	35.35	37.69	3.27	2151.88

Uppercase letters in the same column do not differ by Tukey's mean test ($p \leq 0.05$). ^{ns} not significant. CV: coefficient of variation; LSD: low significant difference.T1 – Untreated; T2 – hand-weeded; T3 - glyphosate + saflufenacil; T4 - glyphosate + diclosulam; T5 - glyphosate + chlorimuron-ethyl; T6 - glyphosate + 2,4-D; T7 - glyphosate + 2,4-D + saflufenacil; T8 - glyphosate + 2,4-D + diclosulam; T9 - glyphosate + 2,4-D + chlorimuron-ethyl; T10 - glyphosate + (halauxifen-methyl + diclosulam); T11 - glyphosate + (halauxifen-methyl + diclosulam).

The use of this herbicide halauxifen-methyl + diclosulam associated with glyphosate should be a very good tool to manage *Conyza* spp. in the Brazilian soybean producing system, because it promoted efficient *Conyza* spp. control in different locations, with greater control in comparison to other herbicides which were tested and higher soybean yield compared with the hand-weeded treatment. When 2,4-D was added to the treatments, they showed more efficient controls;

Table 9 - Soybean agronomic parameters at R : Height of 1st Pods (cm), Final height (cm), Number of pods, 100 seed-weight (grams) and Soybean yield (kg ha^{-1})[8]. Experiment 3 (E3)- Francisco Alves, Paraná, Brazil. 2015-16 Season

Treatment	Height of 1st Pods^{ns}	Final height^{ns}	Number of pods	100 seed weight	Yield
T1	15.12	83.13	23.00B	8.29B	464.71 B
T2	13.38	97.58	40.92A	12.38A	4576.06 A
T3	13.21	87.33	42.79A	11.33A	3670.50 A
T4	12.71	88.58	47.79A	11.03A	3876.09 A
T5	13.08	84.21	44.92A	10.82A	3684.60 A
T6	13.25	84.50	40.75A	11.23A	3795.98 A
T7	13.62	89.25	43.17A	11.78A	3760.54 A
T8	13.62	85.38	46.58A	11.24A	3711.42 A
T9	14.29	90.67	36.88AB	11.59A	4397.60 A
T10	13.83	89.29	44.13A	10.97A	4247.39 A
T11	13.67	86.42	43.25A	11.46A	4233.02 A
Average	13.61	87.84	41.29	11.1 0	3674.35
CV%	11.11	7.27	15.14	7.21	13.06
LSD	3.54	14.89	15.08	1.91	1160.61

Uppercase letters in the same column do not differ by Tukey's mean test ($p \leq 0.05$). ^{ns} not significant. CV: coefficient of variation; LSD: low significant difference. T1 – untreated; T2 – hand-weeded; T3 - glyphosate + saflufenacil; T4 - glyphosate + diclosulam; T5 - glyphosate + chlorimuron-ethyl; T6 - glyphosate + 2,4-D; T7 - glyphosate + 2,4-D + saflufenacil; T8 - glyphosate + 2,4-D + diclosulam; T9 - glyphosate + 2,4-D + chlorimuron-ethyl; T10 - glyphosate + (halauxifen-methyl + diclosulam); T11 - glyphosate + (halauxifen-methyl + diclosulam).

however, when compared to the treatments containing halauxifen-methyl plus diclosulam, the latter showed to be more efficient.

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