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RESEARCH PAPER

Chloris polydactyla (L.) Sw., a perennial Poaceae weed: Emergence, seed production, and its management in Brazil

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Experiments were conducted to evaluate the plant emergence and seed production of *Chloris polydactyla* and the efficacy of herbicides for its control. The plants emerged mainly when the seeds were placed on the soil surface at ≤ 3 cm depth. Isolated plants produced a great amount of seeds. The pre-emergence herbicides, acetochlor, atrazine + simazine, s-metolachlor, alachlor, and trifluralin, were effective for *C. polydactyla* control. The postemergence herbicides, clodinafop-propargil, haloxyfop-methyl, clethodim, fluazifop-*p*-butil, tepraloxydim, sethoxydim, and quizalofop-*p*-tefuril showed satisfactory control of the plants at a 20 cm height with six leaves. During the flowering stage (85 cm plant height), only glyphosate was effective in controlling *C. polydactyla*.

Keywords: chemical control, soybean weed, tall windmillgrass, weed biology.

INTRODUCTION

Tall windmillgrass (*Chloris polydactyla*: Poaceae) is a native of the American Continent, occurring from the southern USA to Argentina. It is very common in Brazil, especially in the northern and midwestern regions, and also occurs in Bolivia and Paraguay (Kissmann & Groth 1997). It is a perennial plant, reaching a 50–110 cm height. The means of reproduction are seeds and short rhizomes (Lorenzi 2000). In general, *C. polydactyla* grows in clusters (cespitose plant), but also in a stoloniferous form. This species presents an increased and more efficient photosynthesis (C4 pathway) during strong light intensities and is adapted to poor soils, as found in the Brazilian Cerrados. It is similar to *Chloris gayana*; however, *C. polydactyla* has a larger raceme and is more flexuous with a smaller spicule. It is a weed that occurs in perennial crops and unoccupied areas. The amount of seed produced is large and the seeds are easily carried by the wind. The importance of *C. polydactyla* as a weed is increasing due to its efficient reproductive capacity. Sugarcane areas in São Paulo State (Carvalho *et al.* 2005b) and soybean areas in Paraná State (Brighenti *et al.* 2005a, b), Brazil, are infested with this weed, demanding special management to reduce competition. Furthermore, the plant is tolerant to several herbicides when applied at a more advanced plant growth stage. Therefore, the plant emergence, seed production, and chemical control of *C. polydactyla* were evaluated in this work.

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MATERIALS AND METHODS

Emergence

The experiment was carried out under greenhouse conditions from May to June 2005. The treatments were sorted in a completely randomized design, with four replicates, and consisted of different sowing depths: 0 (seeds on the soil surface), 1, 2, 3, 4, 5, 8, and 12 cm. The seeds were collected in February and sowed on 4 May 2005, without employing any method to break the seed dormancy. Three-hundred seeds were sowed in ceramic cylinders and placed in greenhouse conditions. The cylinders (20 cm diameter by 30 cm height) were filled with a Rhodic Hapludox soil, collected in the experimental area of Embrapa Soybean, Londrina, PR, Brazil. The emerged plants were counted at regular intervals of 7 days, for 28 days. The number of emerged

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plants was submitted to the Burr and Foster test (Burr & Foster 1972) to verify the homoscedasticity of variances and simple linear regression was applied using SAS statistical procedures (SAS Institute 1999–2001).

Seed production

Twelve plants of *C. polydactyla*, growing isolated in the field, were collected in Londrina, PR, during the reproductive stage. The plant dry matter weight, number of sprouts per plant, number of inflorescences per plant, number of racemes per inflorescence, number of seeds per raceme, number of seeds per inflorescence, and number of seeds per plant were evaluated.

Chemical control (pre-emergence herbicides)

The experiment was carried out under greenhouse conditions at Embrapa Soybean, Londrina, PR. Rhodic Hapludox soil was used to fill 10 L pots and 300 seeds of *C. polydactyla* were sowed per pot. The treatments were arranged in a completely randomized design, with four replicates, and consisted of: (i) acetochlor (2304 g ai ha^{-1}); (ii) atrazine + simazine (1500 + 1500 g ai ha^{-1}); (iii) s-metolachlor (1440 g ai ha^{-1}); (iv) alachlor (2880 g ai ha^{-1}); (v) trifluralin (1800 g ai ha^{-1}); and (vi) a check (without herbicide). The herbicide application was performed on 14 March 2005, with the treatments applied using a carbon dioxide (CO_2)-pressurized backpack sprayer (Herbicat, Catanduva, Brazil), calibrated to deliver 250 L ha^{-1} at 207 kPa and using flat-fan nozzles (110 015 BD; Spraying Systems of Brazil, São Bernardo do Campo, Brazil). The visual control of the plants was evaluated at 14, 22, and 30 days after treatment (DAT) using a scale from 0% (no control) to 100% (total death of the plants). At 30 DAT, the plants were collected from each pot and placed in a dryer at 70°C for 72 h to estimate the plant dry matter weight. The dry biomass data were subjected to the analysis of variance (ANOVA) and the Tukey test ($P \leq 0.05$), using SAS statistical procedures (SAS Institute 1999–2001).

Chemical control (postemergence herbicides)

Two experiments were conducted in the field in Londrina, PR. The first one was installed on 22 February 2005. Three-hundred seeds of *C. polydactyla* were sowed in 10 L pots and maintained on supports in the field. The pots were filled with a mixture of three soil parts per one of humus. The treatments were arranged in a completely randomized design, with four replicates, and consisted of: (i) clodinafop-propargil (48 g ai ha^{-1}); (ii) haloxyfop-methyl (60 g ai ha^{-1}); (iii) clethodim (120 g ai ha^{-1}); (iv) fluazifop-*p*-butil (187.5 g ai ha^{-1}); (v) tepraloxydim (100 g ai ha^{-1}); (vi) sethoxydim (221 g ai ha^{-1}); (vii) quizalofop-*p*-tefuril (60 g ai ha^{-1}); and (viii) a check (without herbicide). To each herbicide treatment, 0.5% (v/v) mineral oil was added. The herbicides were applied on 19 March 2005, when the plants had an average of six leaves and a 20 cm height, using a CO_2-pressurized backpack sprayer, calibrated to deliver 160 L ha^{-1} at 220 kPa, using flat-fan nozzles, as above. The visual control ratings were obtained at 10 and 16 DAT, using the same visual scale as described previously. At 21 DAT, the plants were collected from each pot and placed in a dryer (70°C for 72 h) to estimate the mean values of the plant dry matter weight. The dry biomass data were subjected to the ANOVA and the Tukey test ($P \leq 0.05$), using SAS statistical procedures (SAS Institute 1999–2001).

The second experiment was started in March 2005 in a natural and homogenous *C. polydactyla* infestation in all the trial area. The treatments consisted of the application at the recommended and double doses of: (i) glyphosate (720 and 1440 g ai ha^{-1}); (ii) haloxyfop-methyl (60 and 120 g ai ha^{-1}); (iii) clethodim (120 and 240 g ai ha^{-1}); (iv) fluazifop-*p*-butil (188 and 376 g ai ha^{-1}); (v) tepraloxydim (100 and 200 g ai ha^{-1}); (vi) quizalofop-*p*-tefuril (60 and 120 kg ai ha^{-1}); and (vii) a check (without herbicide application). All the herbicides were added with mineral oil (0.5% v/v), except for fluazifop-*p*-butil. The plot area was 16 m^2 (2 m × 8 m). The herbicides were applied on 30 March 2005, when the plants were in the beginning of flowering, with an average of five sprouts and 85 cm height. The treatments were applied using a CO_2-pressurized backpack sprayer, calibrated to deliver 180 L ha^{-1} at 220 kPa, using flat-fan nozzles (110 015 AVI; Spraying Systems of Brazil, São Bernardo do Campo, Brazil). The visual estimate control was done at 12, 18, and 29 DAT, using the same scale previously described.

RESULTS AND DISCUSSION

Plant emergence occurred only in the first four depths (0–3 cm), reducing successively from the seeds on the soil surface to ≤ 4 cm depth (Fig. 1). Carvalho *et al.* (2005a) reported that more *C. polydactyla* plants emerge on the soil surface due to the oscilation of temperatures (20°C/30°C) and light availability.

The plants of *C. polydactyla* presented an average of 63 inflorescences, with 15 racemes per inflorescence and 99 seeds per raceme, and the total of the seeds per plant was 96 000 (Table 1). Besides being in great number, the seeds are light and easily transported by the wind.

Carvalho *et al.* (2005b) observed that only one sprout produced ≈ 3000 seeds and all the plant produced ≈ 30 000 seeds. However, those results were obtained under greenhouse conditions and mainly the reduced light and less soil available would have caused a reduction in seed production.

All the pre-emergence herbicides were efficient in controlling *C. polydactyla*, reaching 100% control in all evaluations (Table 2). Some products, such as acetochlor, s-metolachlor, and alachlor, are recommended for application in soybean and corn crops (Rodrigues & Almeida 1998) and trifluralin and the formulated mixture of atrazine plus simazine are recommended for soybean and corn, respectively (Rodrigues & Almeida 2005), representing options for *C. polydactyla* control. All the graminicides, when applied at the recommended doses and to plants at the initial growth stages, provided > 97% control at 10 DAT (Table 3). At 16 DAT, all the treatments presented ≥ 99% control. All the dry biomass values were statistically similar, except for the check.

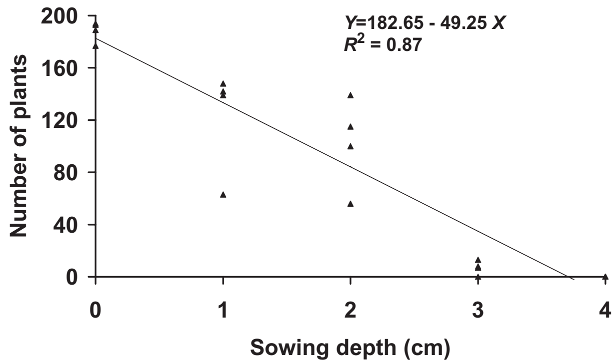

Fig. 1. Number of *Chloris polydactyla* plants that emerged, as a function of sowing depths.

In more advanced plant growth stages, no herbicides provided effective control at 12 DAT using the recommended or double the recommended dosages (Table 4). In the last two evaluations, only the double dose of glyphosate provided adequate control (>91%). In areas with high densities of *C. polydactyla* at the flowering stage, higher doses of glyphosate might be necessary to obtain effective control of this weed.

Chloris polydactyla emerged mainly when the seeds were on the soil surface and at ≤ 3 cm depth. The plants growing in isolated areas produced a great amount of seeds. Acetochlor (2304 g ai ha^{-1}), atrazine plus simazine (1500 + 1500 g ai ha^{-1}), s-metolachlor (1440 g ai ha^{-1}), alachlor (2880 g ai ha^{-1}), and trifluralin (1800 g ai ha^{-1}) were efficient in controlling *C. polydactyla* in pre-

Table 1. Plant dry matter (PDM) (g), the number of sprouts (NS), number of inflorescences per plant (NI), number of racemes per inflorescence (NRI), number of seeds per raceme (NSR), number of seeds per inflorescence (NSI), and number of seeds per plant (NSP) of *Chloris polydactyla* (mean of 12 plants)

Variable	PDM	NS	NI	NRI	NSR	NSI	NSP
Mean	285.6	136.0	63.0	15.4	99.2	1525.8	96 075
Standard error	44.2	15.5	12.3	0.7	2.9	67.3	24 450

Table 2. Percentage of *Chloris polydactyla* control at 14, 22, and 30 days after herbicide treatment (DAT) and the plant dry biomass per pot at 30 DAT, as a function of pre-emergence herbicides

Treatment	Dose (g ai ha^{-1})	Control (%)			Dry biomass (g pot^{-1})
		14 DAT	22 DAT	30 DAT	
Acetochlor	2304	100	100	100	0.00b†
Atrazine + simazine	1500 + 1500	100	100	100	0.00b
S-metolachlor	1440	100	100	100	0.00b
Alachlor	2880	100	100	100	0.00b
Trifluralin	1800	100	100	100	0.00b
Check	–	0	0	0	8.95a
Coefficient of variation (%)	–	–	–	–	90.00

† Means followed by the same letter in each column are not statistically different by the Tukey test ($P \leq 0.05$).

Table 3. Percentage of *Chloris polydactyla* control at 10 and 16 days after herbicide treatment (DAT) and the plant dry biomass per pot at 21 DAT, as a function of postemergence herbicides

Treatment	Dose (g ai ha^{-1})	Control (%)		Dry biomass (g pot^{-1})
		10 DAT	16 DAT	
Clodinafop-propargil	48	99.0	99.7	3.5b†
Haloxyfop-methyl	60	99.2	99.5	3.1b
Clethodim	120	99.2	100.0	3.4b
Fluazifop-*p*-butil	187.5	99.5	100.0	3.2b
Tepraloxydim	100	99.5	100.0	3.0b
Sethoxydim	221	97.5	99.0	4.5b
Quizalofop-*p*-tefuril	60	99.5	100.0	2.3b
Check	–	0.0	0.0	24.7a
Coefficient of variation (%)	–	–	–	26.4

† Means followed by the same letter in each column are not statistically different by the Tukey test ($P \leq 0.05$).

Table 4. Percentage of *Chloris polydactyla* control at 12, 18, and 29 days after herbicide treatment (DAT), as a function of postemergence herbicides

Treatment	Dose (g ai ha^{-1})	Control (%)		
		12 DAT	18 DAT	29 DAT
Glyphosate	720	63.3	80.0	80.0
	1440	76.6	91.6	93.3
Haloxyfop-methyl	60	13.3	23.3	43.3
	120	20.0	43.3	53.3
Clethodim	120	23.0	35.0	50.0
	240	30.0	55.0	63.3
Fluazifop-*p*-butil	188	13.3	30.0	46.6
	376	23.0	43.0	60.0
Tepraloxydim	100	16.6	30.0	43.3
	200	16.6	40.0	53.3
Quizalofop-*p*-tefuril	60	13.3	26.6	40.0
	120	16.6	40.0	50.0
Check	–	0.0	0.0	0.0

emergence conditions. Clodinafop-propargil (48 g ai ha^{-1}), haloxyfop-methyl (60 g ai ha^{-1}), clethodim (120 g ai ha^{-1}), fluazifop-*p*-butil (187.5 g ai ha^{-1}), tepraloxydim (100 g ai ha^{-1}), sethoxydim (221 g ai ha^{-1}), and quizalofop-*p*-tefuril (60 g ai ha^{-1}) were efficient in controlling the plants at a 20 cm height with six leaves. In the more advanced stages of growth (flowering and 85 cm plant height), only glyphosate at the double dose (1440 g ai ha^{-1}) provided satisfactory control.

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