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Flumioxazin and S-metolachlor efficiency and selectivity in preemergence application of cassava 'Baianinha'[1]

Eficiência e seletividade do flumioxazin e do S-metolachlor na aplicação em pré emergência da mandioca 'Baianinha'

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Abstract - This study has aimed to evaluate selectivity and efficiency in weed control of flumioxazin and S-metolachlor in 'Baianinha' cassava crops. The experimental design was randomized blocks with four replications. Treatments consisted in doses of flumioxazin of 50, 75, 100 and 125 g ha^{-1} a.i. and doses of S-metolachlor of 960, 1920, 2880 and 3840 g ha^{-1} a.i., besides weeded and unweeded controls. Treatments application was carried on 10/11/2013, 13 days after planting (DAP) and cassava cuttings presented underground sprouts measuring 3.0 to 4.5 cm. Flumioxazin at the highest dose provided 61.5% reduction of weeds biomass while S-metolachlor at the highest dose reduced 63.7% in the weeds biomass. Both herbicides have not promoted phytointoxication and have not altered roots yield and starch content of cassava plants. In conclusion, the herbicides were selective for 'Baianinha' cassava and efficient in weed control. However, control level increased with increments of doses assessed.
Keywords: herbicides; *Manihot esculenta*; weeds; selectivity

Resumo - Objetivou-se avaliar a seletividade e a eficiência no controle de plantas daninhas do flumioxazin e do S-metolachlor na cultura da mandioca 'Baianinha'. O delineamento experimental utilizado foi de blocos casualizados com quatro repetições. Os tratamentos consistiram nas seguintes doses do flumioxazin 50, 75, 100 e 125 g ha^{-1} i.a. e as doses do S-metolachlor foram 960, 1920, 2880 e 3840 g ha^{-1} i.a., além de uma testemunha sem capina e outra capinada. A aplicação dos tratamentos foi realizada em 11/10/2013, 13 dias após o plantio (DAP) e a maniva apresentava brotos subterrâneos com 3,0 a 4,5 cm. O flumioxazin na maior dose proporcionou 61,5% de redução da biomassa das plantas daninhas, enquanto que o S-metolachlor na maior dose reduziu 63,7% na biomassa de plantas daninhas. Ambos os herbicidas não promoveram fitointoxicação e não alteraram a produtividade de raízes e teor de amido das plantas de mandioca. Concluiu-se que, os herbicidas foram seletivos para a mandioca 'Baianinha' e eficientes no controle das plantas daninhas. Entretanto, o nível de controle aumentou de acordo com incrementos das doses avaliadas.
Palavras-chaves: herbicidas; *Manihot esculenta*; plantas daninhas; seletividade

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Introduction

Cassava plants have adaptability throughout the Brazilian territory and good productivity even when grown in soils of low fertility and subjected to water stress (Doretto, 1993; Sagrilo et al., 2002). Furthermore, to achieve maximum crop productivity, weeds interference must be avoided (Mezzete et al., 2009).

Interference caused by weeds can result in cassava roots yield reductions ranging from 70 to 100% (Johanns and Contiero, 2006; Biffe et al., 2010; Silva et al., 2012). These results highlight the importance of weed management to ensure high economic returns (Silva et al., 2014).

Among weed management methods available, chemical control stands out and has been the most widely used to reduce reliance on labor and promote an effective low-cost control (Silva, et al., 2009). However, for weed control in cassava there are few products registered (MAPA, 2011; Rodrigues and Almeida, 2011; Silveira et al., 2012). Thus, it is necessary to study the potential of new molecules that may be efficient and selective for cassava crops.

In search of options for weed chemical control, Scariot et al. (2013) have found efficiency in weed control and selectivity of herbicides flumioxazin (60 g ha^{-1} a.i.) and S-metolachlor (1920 g ha^{-1} a.i.) applied in preemergence in 'Cascuda' cassava. Biffe et al. (2010) have also observed that the application of S-metolachlor (1920 g ha^{-1} a.i.) has not caused symptoms of phytointoxication for 'Fécula Branca' and 'Fibra' cassavas. However, Oliveira Jr. et al. (1994) and Costa et al. (2013) have reported that herbicides selectivity for the culture of cassava can be influenced by applying different doses.

By presenting different infestation flows during the cycle, the adoption of weed management strategies in the culture of cassava such as the rotation of active ingredients is recommended to inhibit the resistance and increase the efficient and selective herbicide options (Silva et al., 2009).

The work hypotheses was based on the fact that selectivity for cassava cultivation and control efficiency of weeds and preemergent herbicides flumioxazin and S-metolachlor can be dependent on the dose applied. Thus, efficiency and selectivity of different doses of flumioxazin and S-metolachlor in the culture of 'Baianinha' cassava were evaluated.

Material and Methods

The experiment was conducted under field conditions in the experimental area belonging to *Universidade Estadual do Oeste do Paraná* (abbreviated UNIOESTE; State University of West Paraná; one of the public universities of the State of Paraná, Brazil). Climatic data during the experimental period were measured by means of an automatic meteorological station and are listed in Figure 1.

The soil was prepared with plowing, harrowing and ploughing. Chemical analysis of the soil had the following characteristics: pH ($CaCl_2$) = 4.52; organic matter (g dm^{-3}) = 21.87; P (mg dm^{-3}) = 5.84; H + Al, K, Ca, Mg, SB (sum of bases) and CEC (cation-exchange capacity) ($cmol_c$ dm^{-3}) = 3.82, 0.22, 3.99, 1.98, 6.19 and 10.01, respectively; and V% = 61.84 having in its textural composition 7.4% of sand; 39.0% of silt and 53.6% of clay. By interpretation of the soil analysis, liming and fertilization on the cassava crop were not performed (Takahashi, 2003).

The design was a randomized block with four replications. The treatments consisted of doses of herbicides flumioxazin (Flumyzin 500, 500 g L^{-1}, PM, Sumitomo Chemical) at doses of 50, 75, 100 and 125 g ha^{-1} a.i. and S-metolachlor (Dual Gold, 960 g L^{-1}, CE, Syngenta) at doses of 960, 1920, 2880 and 3840 g ha^{-1} a.i., besides two weeded and unweeded controls.

'Baianinha' cassava was planted on 09/28/2013 using a mechanized planter machine (Planti Center, model Bazuca) of two-row cassava cuttings. Each plot consisted of four

rows measuring 5 m long, spaced 0.90 m, totaling 18 m^2 of experimental area.

Herbicides application was carried out on 10/11/2013, i.e., 13 days after the planting (DAP), when the sprouts were submerged and measuring between 3 and 4.5 cm long. A knapsack sprayer pressurized at CO_2 with pressure of 333.4 kPa was used, equipped with a boom containing a fan-type nozzle (TT 11002), working at a height of 50 cm from the target, with a spray mix volume of 200 L ha^{-1}, temperature of 23.9 ºC, relative humidity of 61% and wind speed of 1.3 m s^{-1}.

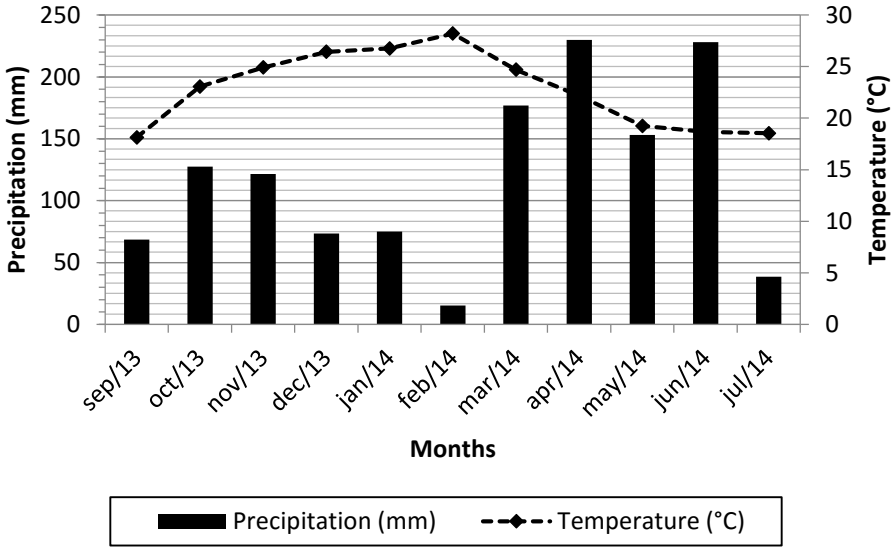

Figure 1. Precipitation and average monthly temperatures during the experiment. Marechal Cândido Rondon, PR. 2013.

The evaluations of cassava plant phytointoxication and weed control were carried out at 13, 39 and 52 days after application (DAA) of the herbicides. A range of grades percentage was used, where 0 (zero) corresponds to no injury, demonstrated by the cassava plant or weed control, and 100 (one hundred) to the cassava plant death or weed control (SBCPD [*Sociedade Brasileira da Ciência das Plantas Daninhas* (Brazilian Society of Weed Science)], 1995). The criteria used to establish the phytointoxication grades were: growth inhibition, amount and uniformity of injuries or control, plants regrowth capacity and quantity of dead plants.

The evaluations of heights (cm) of the cassava plants were carried out at 77, 139 and 187 DAA with the aid of a tape measure (or measuring tape) from the ground level to the upper edge of the plant.

At harvest, the weeds dry matter was evaluated (269 DAA). A metal frame (0.25 m^2) was used and the plants were identified, measured, collected and subsequently dried in a forced-air circulation oven at 60 °C for 72 h and weighed on a precision scale (0.001 g).

Roots yield determination (t ha^{-1}) was performed at 269 DAA, collecting six plants in the two central rows of the plots, excluding 50 cm from the ends. The roots were cleaned and weighed on a precision scale (0.1 g) and later starch content (%) was determined using the hydrostatic scale method (Grossman and Freitas, 1950).

The data obtained were submitted to analysis of variance (ANOVA) by the F-test ($p \geq 0.05$), and the means were adjusted to response surface regression models, and the equations were chosen based on significant

models ($p \geq 0.05$) with a biological logic and high R^2.

Results and Discussion

The application of herbicides flumioxazin and S-metolachlor has not provided visual symptoms of phytointoxication in the cassava plants at 13, 39 and 52 DAA (results not shown). In addition, the incidence of weeds in these periods was extremely low, and the control evaluation was done at the end of the experiment by estimating the dry matter of the species that formed the weed community (Table 1).

Table 1. Weed infesting community present in the cassava experimental area at 269 DAA. Marechal Cândido Rondon, PR. 2013.

Species			
Family	Scientific name	Common name	Frequency (%)
Poaceae	*Digitaria horizontalis* W.	Capim-colchão	0.3
	Digitaria insularis L	Capim – amargoso	25.2
	Cenchrus echinatus L.	Capim – carrapicho	0.8
	Rhynchelytrum repens W.	Capim – favorito	0.3
Asteraceae	*Sonchus oleraceus* L.	Serralha	2.0
	Gnaphalium pensylvanicum W.	Macela	65.0
	Bidens pilosa L.	Picão – preto	0.3
Commelinaceae	*Commelina benghalensis* L.	Trapoeraba	1.1
Malvaceae	*Sida rhombolia* L.	Guanxuma	4.1
Solanaceae	*Solanum sisymbrifolium* L.	Juá	0.3
Euphorbiaceae	*Euphorbia heterophylla* L.	Amendoim-bravo	0.6

The main families present in the experimental area were *Poaceae*, with four species, *Asteraceae*, with three species, and *Commelinaceae, Malvaceae, Solanaceae* and *Euphorbiaceae*, each presenting one species. The species with higher frequency were cudweeds (*Gnaphalium pensylvanicum* W.), sourgrass (*Digitaria insularis* L.) and arrowleaf sida (other common names include rhombus-leaved sida, Paddy's lucerne, jelly leaf, and also somewhat confusingly Cuban jute, Queensland hemp, and Indian hemp) (*Sida rhombifolia* L.) with 65.0, 25.2 and 4.1%, respectively.

Changes in plants heights were not observed after applications of flumioxazin and S-metolachlor, regardless of the doses evaluated (Figures 2A and 2B). Gomes et al. (2007) have shown that plant height is related to the production of shoots and roots and thus the results imply that the herbicides were not phytotoxic for the cassava plants.

The application of flumioxazin at doses of 50, 75, 100 and 125 g ha^{-1} a.i. reduced the weeds total dry matter in 10, 42, 49 and 61% (Figure 3A). As for the application of S-metolachlor at doses of 960, 1920, 2880 and 3840 g ha^{-1} a.i., reductions were of 48, 56, 59 and 64% (Figure 2B).

Yield data (t ha^{-1}) are shown in Figure 4. The application of flumioxazin at doses of 50, 75, 100 and 125 g ha^{-1} a.i. provided increases in relation to the control with total weeding of 25, 32, 31 and 19% (Figure 4A), respectively. As for the application of S-metolachlor, an average yield of 18.35 t ha^{-1} was observed, i.e., there were no adjustments of the data to any regression model (Figure 4B).

The data obtained by Scariot et al. (2013) have shown that after 105 DAA both flumioxazin (60 g ha^{-1} a.i.) as S-metolachlor (1920 g ha^{-1} a.i.) have not adversely affected crop yield due to not showing phytotoxic effects. This can be justified by the characteristics of the soil with high organic matter content and an effective CEC, which results in clayey soils, lesser absorption of the herbicide by the cassava plant without causing phytointoxication and reductions in

productivity. Or else there may be a distinct tolerance among the varieties of cassava to the herbicides (Rossi et al., 2005; Costa et al. (2014).

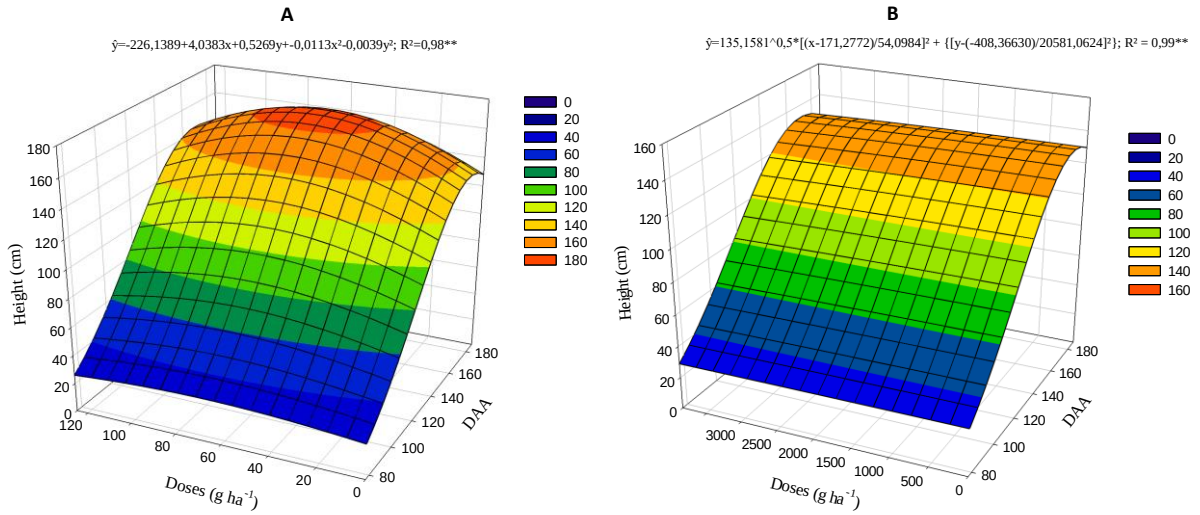

Figure 2. Cassava plants height up to 187 days after the application of flumioxazin (A) and S-metolachlor (B). Marechal Cândido Rondon, PR. 2013.

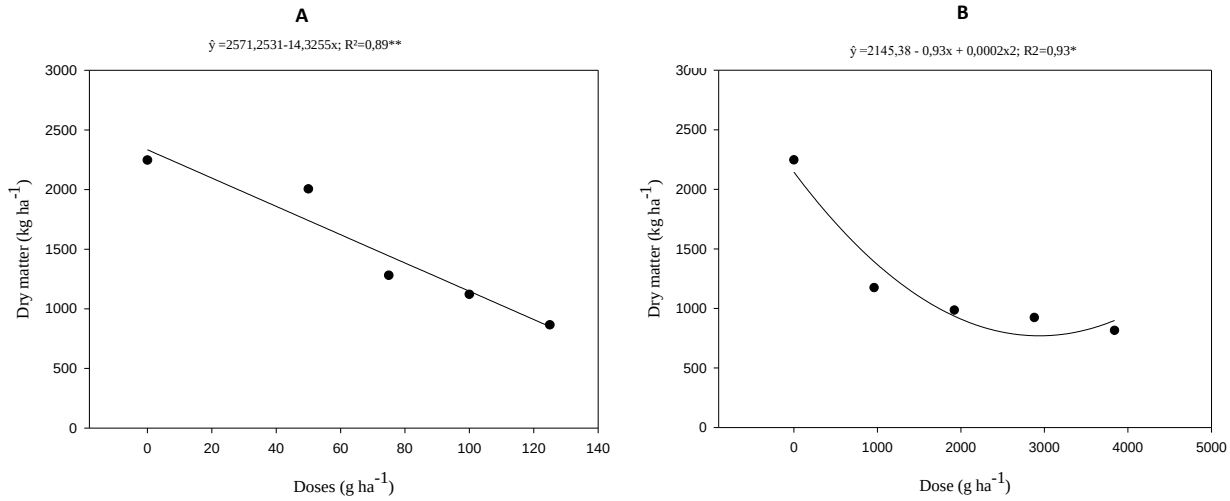

Figure 3. Weed dry matter during cassava plants harvest at 269 days after the application of flumioxazin (A) and S-metolachlor (B). Marechal Cândido Rondon, PR. 2013.

There were no adjustments for the starch content data (Figure 5A and 5B). However, both in the applications of increasing doses of flumioxazin (50, 75, 100 and 125 g ha^{-1} a.i.) as in the applications of S-metolachlor there were similar means around 27%. Costa et al. (2014) have reported that in the application of flumioxazin (80 g ha^{-1} a.i.) there were no reductions in starch content for 'Fécula Branca'. This fact applies to the present study due to starch content being directly connected to the cassava plant dry matter content, which was not affected by phytointoxication symptoms caused by the herbicides.

The results of this study confirm the hypothesis that the selectivity of flumioxazin and S-metolachlor may be dependent on the dose used, since increasing doses evaluated in both herbicides were extremely selective to 'Baianinha' cassava, as well as the level of weed control.

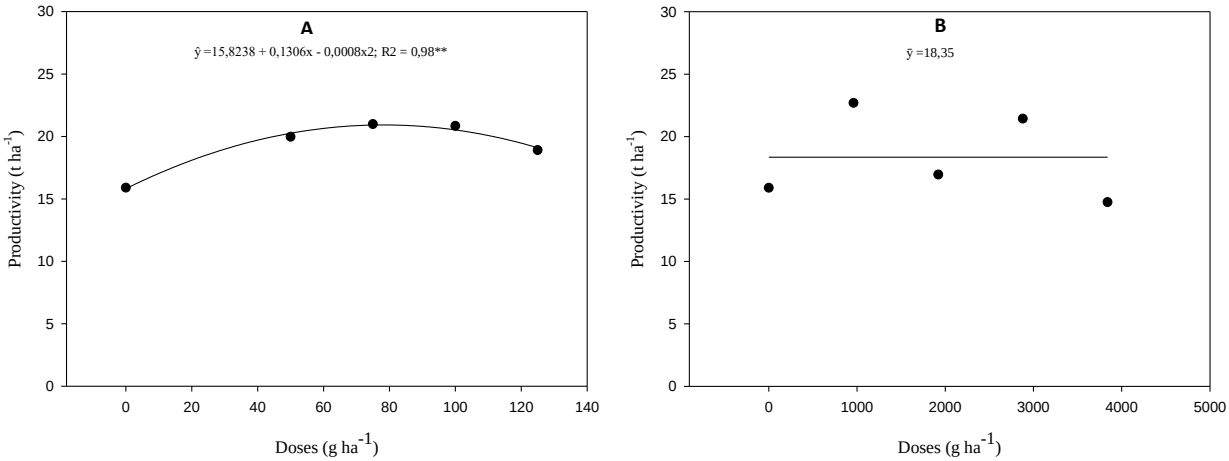

Figure 4. Cassava plants yield after the application of flumioxazin (A) and S-metolachlor (B). Marechal Cândido Rondon, PR. 2013.

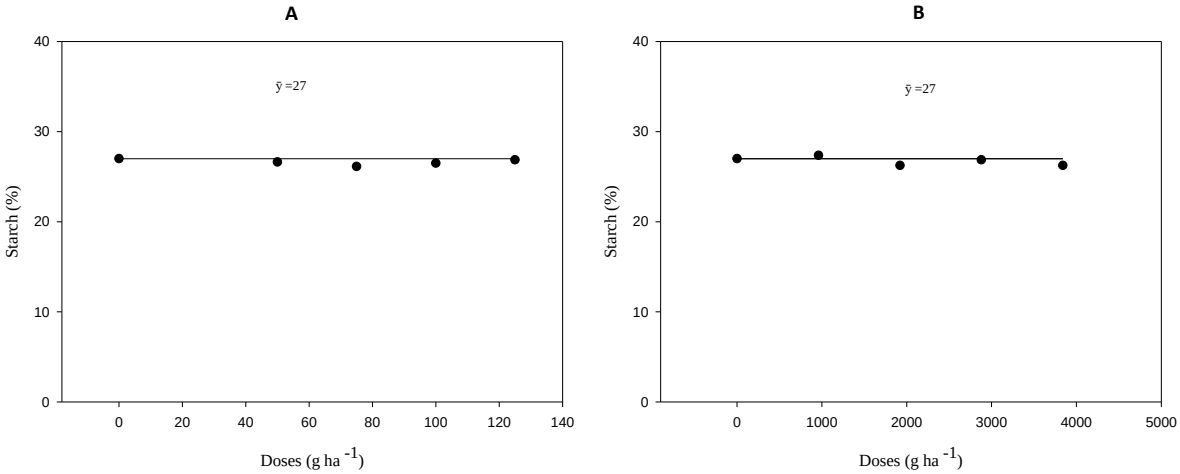

Figure 5. Starch content of cassava plants after the application of flumioxazin (A) and S-metolachlor (B). Marechal Cândido Rondon, PR. 2013.

Conclusions

The applications of doses of flumioxazin and S-metolachlor were selective for 'Baianinha' cassava plants, besides being efficient to control weeds. However, higher doses of herbicides caused more efficient control of plants.

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