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RESEARCH ARTICLE

Herbicide selectivity to cassava crop in post-emergence application

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Weed chemical control in cassava crop is an alternative that contributes to increase productivity and costs reduction. However, there are few registered products, becoming a trouble for this crop exploration. Therefore, the present research had the objective evaluate selectivity of post-emergent herbicides applied in cassava in two plant development stages. The experiment was carried out in greenhouse at Federal University of Tocantins - UFT, Campus Gurupi, TO Brazil. The experiment design was completely randomized, arranged in factorial 6x2, combination of 5 herbicide molecules with different mechanisms of action (mesotrione, carfentrazone-ethyl, Chlorimuron-ethyl, nicosulfuron and imazethapyr) and a control with no application, applied in two stages, 30 and 45 days after plant emergence, with four replications. The results were submitted to analysis of variance by F test, and means were statistically analyzed by LSD test, at 5% probability. Mesotrione, and chlorimuron herbicides were not toxic for the crop, promoting results similar to those observed for control. Differences in tolerance level of herbicides studied was founded between application stages.

Highlighted Conclusions

1. The herbicides mesotrione, chlorimuron and carfentrazone-ethyl applied in post-emergence are highly selective to cassava.
2. The herbicides nicosulfuron and imazethapyr show differences in the level of toxicity to cassava, depending on the growth stage, being less selective at 30 days after emergence.

Cassava (*Manihot esculenta* Crantz) is an important crop for world food security because its wide adaptability to marginal soils and irregular rainfall conditions, conditions that are limiting for most conventional crops (Adjebeng-Danquah and Safo-Kantanka 2013). Although cassava is a rustic specie and has high diversity, the crop yield is far below its real potential. Inadequate weed management is one of main causes that contribute to low crop yield (Albuquerque et al. 2008). In effect, weeds compromises crop growth, development, as well as photosynthetic characteristics, leading to reduction of size, weight and number of roots (Aspiazu et al. 2010).

In general, the two main methods used to control weeds are mechanical control, through weeding, and chemical control through herbicide application. However, the knowledge about selectivity and efficacy of alternatives of chemical weed control in cassava is not enough. One of the main problems for efficient weed control in cassava cultivation with low cost is the restricted number of herbicides registered and few available mechanisms of action, especially for post-emergence spraying (Biffe et al. 2010, Silva et al. 2012). According to studies, is necessary to keep weed-free crop at least up to 75 days after planting (DAP) in order to allow normal development of roots. Weed control should be started with first weeding near 25 DAP and the last one, close to 75 DAP (Albuquerque 2008; Albuquerque et al. 2012).

Although chemical control has advantages over other methods of weed control, it should be emphasized that it can only be practiced with the use of selective herbicides for the crop. Scariot et al. (2013) define selectivity as ability of an herbicide to eliminate weeds found in a cultivated area without reducing yield crop. In studies on herbicide selectivity, it is fundamental to evaluate the plant intoxication caused by herbicides, as well as effects on growth and yield (Galon et al. 2009). Under those circumstances, the present research aimed to evaluate selectivity of herbicides applied in post-emergence on cassava crop at two times of application.

MATERIAL AND METHODS

The study was carried out in a greenhouse at Federal University of Tocantins (Universidade Federal do Tocantins – UFT), Campus Gurupi, located in southern Tocantins State, Brazil (geographic coordinates: 11º 43 'S and 49º 04' W) and 280 m altitude. The experiment design was completely randomized, arranged in factorial 6x2, combination of 5 herbicide molecules with different mechanisms of action (Table 1) and a control with no application, applied in two stages, 30 and 45 days after emergence (DAE), with four replications. The cultivar used was *Cacau Melhorada*.

Table 1. Classification of herbicides and dosages applied in cassava plants.

Commercial Name	Common name (a.i.)	Dose a.i. (g ha^{-1})	Mechanism of Action
Callisto	Mesotrione	144	Carotenoid Inhibitor
Aurora 400 EC	Carfentrazone-ethyl	30	PPO Inhibitor
Clorim	Chlorimuron	20	
Sanson 40 SC	Nicosulfuron	60	ALS Inhibitors
Vezir 100	Imazethapyr	106	

a.i. - active ingredient.

The experimental units were vases with volumetric capacity of 10 dm^{-3} filled with soil classified as Red-Yellow Latosol dystrophic (Embrapa 2018), previously fertilized according to recommendations for the Cassava crop. Daily, plants were irrigated by automatic micro sprinkler system, according to the crop needs. The plant stems were got from local cassava farmers, being sowed in January 5, 2018, emerging 8 days later. Herbicide applications were performed at 30 and 45 DAE, while plants were about 20 cm high and 15 fully expanded leaves. A CO_2 pressurized sprayer was used with constant pressure, working at 50 cm above the target, velocity of 1 m s^{-1} and volume of 200 L ha^{-1}.

At 30 days after application (DAA) we evaluated plant height (H) measuring between the soil and the apical gem, stem diameter (SD) using a caliper, and number of leaves (NL) counting plant leaves. In addition, all plants were harvested, separated into leaves, stems and roots, and dried in an oven with forced air circulation at 65 ºC until it reaches constant weight to determine dry matter. The results submitted to analysis of variance by F test, and means statistically analyzed by LSD test, at 5% probability, using the statistical software SISVAR (Ferreira 2011).

RESULTS AND DISCUSSION

Considering agronomic characteristics, the herbicide factor showed significant influence in all characteristics. Time of application was significant for most of the characteristics evaluated, except for stem diameter. However, herbicide interaction and herbicide application times presented significant effect only for plant height, number of leaves and shoot dry mass (Table 2).

The herbicides that inhibit the enzyme Acetolactate Synthase (ALS), nicosulfuron and imazethapyr, caused reductions of 39 and 44% in plant height, and 29 and 37% in number of leaves, respectively (Figure 1). This fact occurred because these herbicides have the ability that inhibit plant growth in a short time after application (Vidal and Winkler 2002). Other herbicides did not cause significant effects for these variables. Costa et al. (2013) noted that mesotrione also did not reduce the height of cassava plants. Carfentrazone-ethyl showed higher leaf number than control treatment, however did not differ significantly (Figure 1), indicating, even any damage occurred immediately after application, there was no interference in the development of the plant shoot.

Stem diameter was affected by nicosulfuron and imazethapyr (Figure 1). Silva et al. (2012) did not report reductions in plant height and stem diameter of four cassava cultivars after post-emergence application of the mesotrione herbicide, corroborating the results of this experiment study. Cassava propagates in a vegetative way, through segments removed from stem. Thus, any impact on stem growth at early development stage may reduce quality of planting material and altering production of subsequent cultivation.

For accumulation of shoot dry matter, was verified sensitivity in treatments with on nicosulfuron and imazethapyr, differing statistically from the control (Figure 2). The reduction of shoot growth contributes to reduction of photosynthetic tissue, which prejudice the carbohydrates accumulation into the roots, consequently affecting crop yield (Viana et al. 2001).

Concerning root dry matter, carfentrazone-ethyl, nicosulfuron, and imazethapyr caused higher reductions, respectively (Figure 2). Between 7 and 90 days after cassava planting start the formation of root system, mainly

fibrous roots, some which will turn into storage roots (Peressin and Carvalho 2002). Only mesotrione and chlorimuron did not cause significant reductions in total dry matter of cassava plants compared to control (Figure 2). Evaluating herbicide selectivity Agostinetto et al. (2002), verified relative values of phytomass at 28 DAA in relation to control (100%) of 84.2% and 97.8% for the herbicides Imazethapyr and Nicosulfuron, respectively.

Table 2. Values of F and significance level for Plant Height, Stem Diameter, Number of Leaves, Dry Mass of Shoot, Dry Mass of Roots and Total Dry Mass after application of herbicides on post-emergence of cassava.

SV	DF	Mean Square					
		H	SD	NL	DMS	DMR	TDM
Herbicide (H)	5	1371.450**	3.407*	163.783**	395.661**	1880.907**	3711.126**
Time (T)	1	420.083**	3.456^{ns}	140.083**	131.903*	1532.619*	2563.763**
H x T	5	240.033**	2.901^{ns}	42.933*	160.184**	138.021^{ns}	433.805^{ns}
Error	36	19.680	1.292	15.694	23.199	253.263	326.944
Average		53	10.65	21.16	32.41	49.36	81.78
CV %		8.37	10.67	18.72	14.86	32.24	22.11

Source of variation; DF: degrees of freedom; C.V.: coefficient of variation; H: plant height; SD: stem diameter; NL: number of leaves; DMS: dry mass of shoot; DMR: dry mass of roots; TDM: total dry mass; ** and * significant by 1 and 5% respectively; ns: no significant to F test.

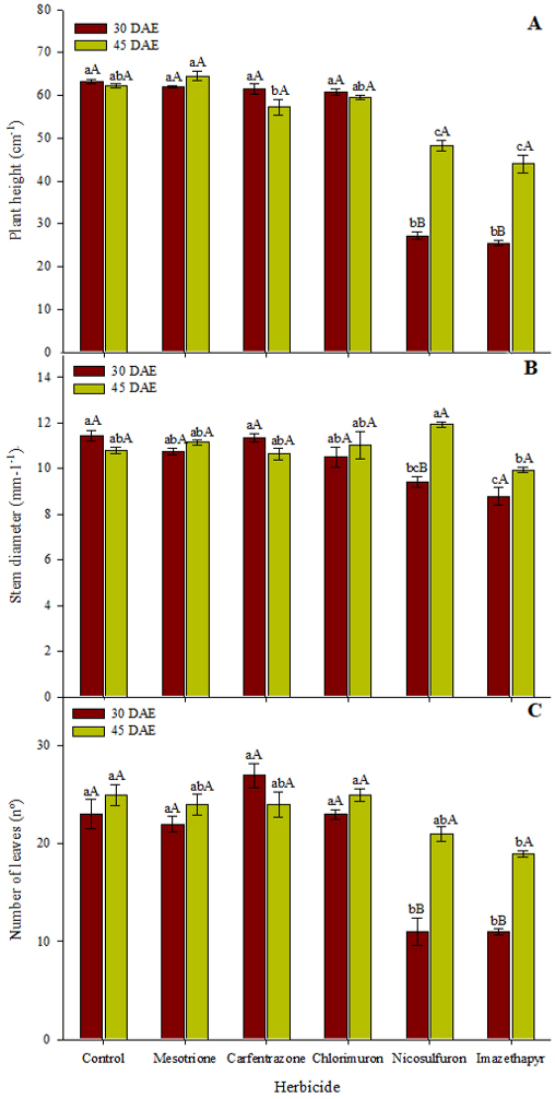

Figure 1. Effect of herbicides applied in post-emergence of cassava plants on plant height (A), stem diameter (B) and number of leaves (C) in two times of application after plant emergence. Bars followed by same lower-case letter between the herbicide treatments or the same upper-case letter, for 2 stages of application, are not significantly different by LSD test at 0.05 of significance (plant height DMS: 6.36; stem diameter. DMS: 1.63; number of leaves DMS: 5.68). Data refer to mean values (n=4)±standard error.

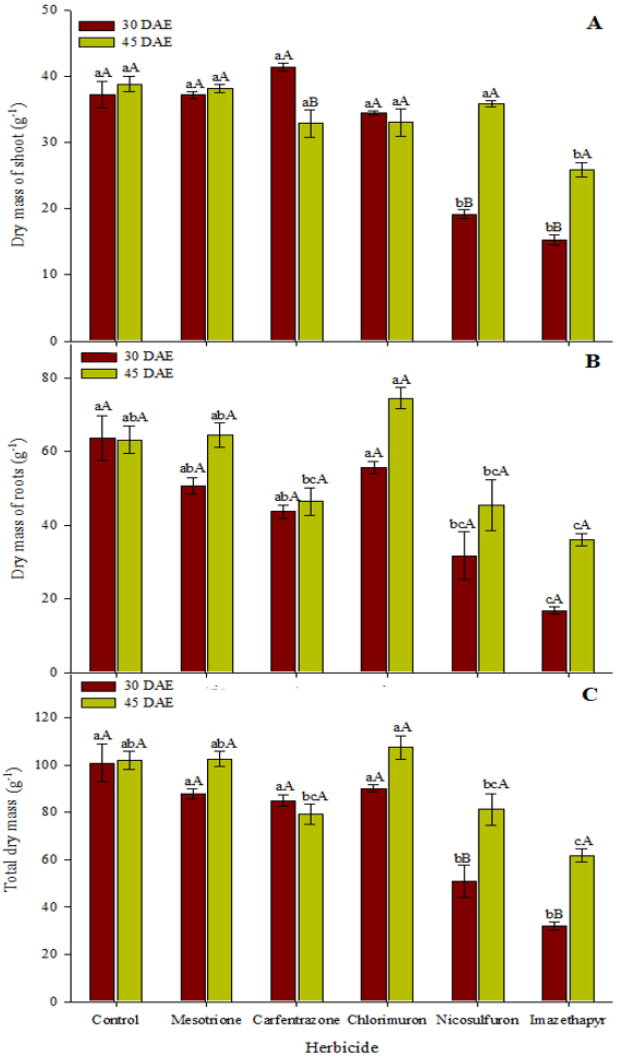

Figure 2. Effect of herbicides applied in post-emergence of cassava plants on dry mass of shoot (A), dry mass of roots (B) and total dry mass (C) in two times of application after plant emergence. Bars followed by same lower-case letter between the herbicide treatments or the same upper-case letter, for 2 stages of application, are not significantly different by LSD test at 0.05 of significance (dry mass of shoot DMS: 6.90; dry mass of roots DMS: 22.82; total dry mass. DMS: 25.93). Data refer to mean values (n=4)±standard error.

At the second stage of application (45 DAE) presents higher mean values for most treatments (Figure 2). The plant age affects herbicide absorption, its translocation and activity in plants (Oliveira Junior and Inoue 2011). Young plants are more susceptible to herbicides than older, mainly because young plant has more meristematic tissues.

As has been noted, the results indicate that both herbicides mesotrione and chlorimuron can be sprayed at 30 DAE and 45 DAE, without damage to characteristics analyzed. At the same time, the herbicide carfentrazone-ethyl only showed a significant difference between the time for shoot dry mass, with a lower average at 45 DAE, certainly because it had shorter recovery time until the final evaluation. In fact, studies in field are required to determine effects on crop yield.

In conclusion, the herbicides mesotrione, chlorimuron and carfentrazone-ethyl were highly selective to cassava until 30 DAA, at dosages used, independently if sprayed at 30 or 45 DAE. Differences in the level of tolerance were found between spraying stages to the herbicides nicosulfuron, and imazethapyr, being less selectivity at 30 DAE.

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