

Selectivity of fomesafen and clomazone associated with other herbicides applied in preemergence of cotton plant¹

Seletividade dos herbicidas fomesafen e clomazone associados com outros herbicidas aplicados em pré-emergência do algodoeiro

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Abstract - A field experiment was conducted in Santa Helena de Goiás to evaluate the selectivity of herbicides fomesafen and clomazone and other combinations to cotton plants when applied in preemergence. The experiment was conducted in a randomized block design in a split plot design with four replications. The assessed herbicide treatments were: clomazone, clomazone + fomesafen (0.45 kg ha⁻¹ of a.i.), clomazone + fomesafen (0.625 kg ha⁻¹ of a.i.), clomazone + fomesafen + diuron, clomazone + fomesafen + prometryn, clomazone + fomesafen + trifluralin and clomazone + fomesafen + s-metolachlor. The visual symptoms of phytotoxicity were seen up to the evaluation of 19 days after emergence, and generally the injuries were higher where it was associated with three herbicides in the application. The treatments with clomazone alone and the associations clomazone + fomesafen (1.0 + 0.45 kg ha⁻¹ of a.i.), clomazone + fomesafen + diuron, clomazone + fomesafen + prometryn, clomazone + fomesafen + trifluralin and clomazone + fomesafen + s-metolachlor were selective to cotton plant. The highest dose of fomesafen (0.625 kg ha⁻¹ of a.i.) in associations with clomazone (1.0 kg ha⁻¹ of a.i.) was not selective to cotton plant (cultivar DP 555 BG RR and in a clayey textured soil, with 3.1% of OM and pH of 6.0).

Keywords: chemical control; *Gossypium hirsutum* r. Latifolia; tank mix

Resumo - Um experimento de campo foi realizado em Santa Helena de Goiás para avaliar a seletividade dos herbicidas fomesafen e clomazone e outras associações ao algodoeiro, quando aplicados em pré-emergência. O experimento foi conduzido em delineamento de blocos casualizados em esquema de parcelas subdivididas, com quatro repetições. Os tratamentos herbicidas avaliados foram: clomazone, clomazone + fomesafen (0,45 kg ha⁻¹ de i.a.), clomazone + fomesafen (0,625 kg ha⁻¹ de i.a.), clomazone + fomesafen + diuron, clomazone + fomesafen + prometryn, clomazone + fomesafen + trifluralin e clomazone + fomesafen + s-metolachlor. Os sintomas visuais de fitointoxicação foram visualizados até a avaliação de 19 dias após a emergência, e de modo geral, as injúrias foram maiores onde foi associado três herbicidas na aplicação. Os tratamentos com clomazone isolado e as associações clomazone + fomesafen (1,0 +

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0,45 kg ha⁻¹ de i.a.), clomazone + fomesafen + diuron, clomazone + fomesafen + prometryn, clomazone + fomesafen + trifluralin e clomazone + fomesafen + s-metolachlor foram seletivas ao algodoeiro. A maior dose de fomesafen (0,625 kg ha⁻¹ de i.a.) em associações com clomazone (1,0 kg ha⁻¹ de i.a.) não foi seletiva ao algodoeiro (cultivar DP 555 BG RR e em solo de textura argilosa, com 3,1% de MO e pH de 6,0).

Palavras-chaves: controle químico; *Gossypium hirsutum* r. Latifolia; mistura em tanque

Introduction

Clomazone is an herbicide of the oxazolidinone chemical group, whose mechanism of action is the inhibition of carotenoid biosynthesis. Its absorption occurs mainly by plant roots, and is translocated via the xylem, following the acropetal flow of perspiration (Senseman, 2007). Visual symptoms of phytotoxicity are bleaching and depigmentation according to inhibition of carotenoid biosynthesis, with subsequent plant death (Ferhatoglu and Barrett, 2006; Plese et al., 2009). Its selectivity to cotton plant crop is due to the use of safeners disulfoton or dietholate in seed treatment (Yazbek Júnior and Foloni, 2004; Dan et al., 2011).

Fomesafen herbicide is an option for weed community tillage infesting cotton plants because it has a mechanism of action still little used commercially (inhibitor of Protox) in the culture and effective for control of important weeds (Bond et al., 2006). This alternative becomes even more important after the identification of *Amaranthus palmeri* biotypes with multiple resistance to inhibitors of EPSPs (5-enolpyruvylshikimate-3-phosphate synthase) and ALS (acetolactate synthase) in cotton plants crops in the Brazilian state of Mato Grosso (Andrade Jr. et al., 2015;).

Phytotoxicity is the result of a complex interaction among the herbicide, the plant and environmental conditions (Weller, 2000) and its effects can be very variable. A complicating factor is the interaction that has been observed between the herbicides, whose effects are manifested by increased phytotoxicity in some cases and reduction in others (Snipes and Seifert, 2003).

An example of this interaction with the cotton plant crop has occurred in research conducted in the Brazilian state of Paraná with cultivars FMT 701 and Delta Opal, where the association of clomazone + s-metolachlor (0.9 + 0.672 kg ha⁻¹ of a.i.) was not selective only for cultivar Delta Opal (Brambilla, 2007). As for a similar research conducted in the tropical savanna ecoregion cerrado region in the Brazilian state of Goiás, it was described that the mixtures of clomazone + oxyfluorfen (1.00 + 0.19 kg ha⁻¹ of a.i.), clomazone + trifluralin + diuron (1.25 + 1.8 + 1.5 kg ha⁻¹ of a.i.) and clomazone + trifluralin + prometryn (1.25 + 1.8 + 1.5 kg ha⁻¹ of a.i.) were not selective to cotton plant, cultivar Nu Opal (Dan et al., 2011). These results show that the selectivity of herbicide mixtures are dependent on environmental conditions and evaluated genotype.

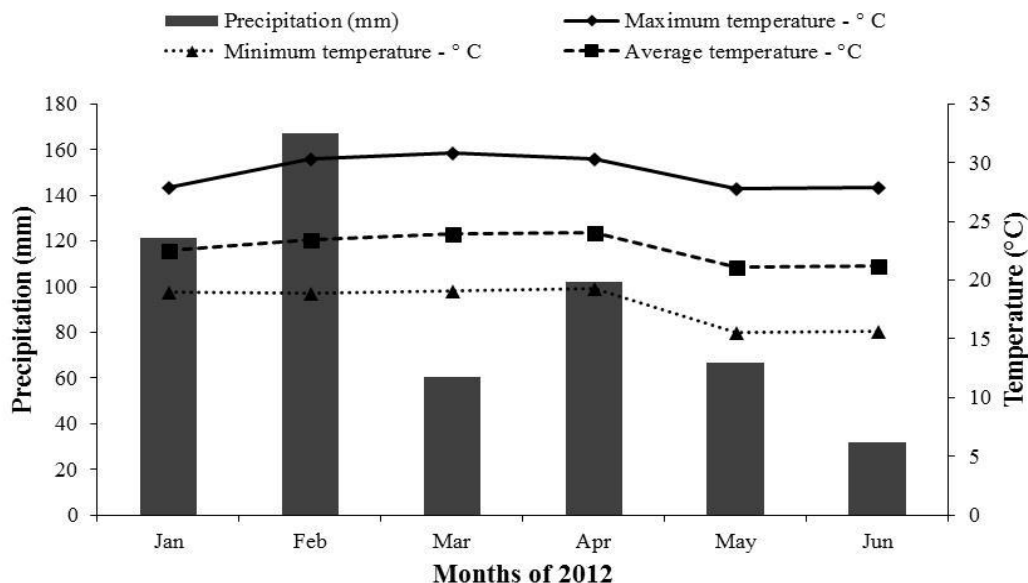
Experiments aimed to evaluate the selectivity of the mixture in tank of clomazone with fomesafen to cotton plant are still scarce. Experiments that address this issue are of paramount importance for weed management in cotton because the combination of clomazone and fomesafen is very interesting due to providing a treatment with a broad-spectrum of control, covering the major weed species infesting the cotton plants crops (Troxler et al., 2002).

Thus, the hypothesis that the combination of clomazone and fomesafen could be selective to cotton plants in appropriate dosages was formulated. Therefore, this work was developed to evaluate the selectivity of herbicides fomesafen and clomazone and other associations to cotton plants when applied in preemergence.

Material and Methods

The experiment was conducted during the 2012 harvest, from February to July, in the experimental area belonging to Fundação Goiás (Goiás Foundation), located in the Brazilian municipality of Santa Helena de Goiás, GO (17°50'18,7" south latitude, 50°35'58,6" west longitude and 547 m altitude).

The soil of the experimental area was classified as dystrophic red latosol (Embrapa, 2013), presenting 490 g kg⁻¹ of clay, 60 g kg⁻¹ of silt, 450 g kg⁻¹ of sand, with a base saturation of 47%, 3.1% of OM and pH in water of 6.0. Weather conditions that occurred during the months of the experiment are shown in Figure 1.



Precipitation data collected in the experimental area and the temperature collected in Climatological Station located at Rio Verde University

Figure 1. Rainfall (mm), maximum, minimum and average temperature observed during the months of conducting the experiment. Santa Helena de Goiás, GO, 2012.

Weed management prior to cotton plants sowing was conducted by means of two paraquat applications at a dose of 600 g ha⁻¹ of a.i. (Gramoxone 200, 200 g L⁻¹ of a.i., SL, Syngenta) at seven and one days before sowing.

The cotton plant sowing, cultivar DP 555 BGR[®], was mechanically carried out on 02/02/2012. The seeds were treated with abamectin (Avicta 500 FS, 500 g L⁻¹ of a.i., FS, Syngenta) at the dose of 150 g for 100 seeds⁻¹ of a.i., thiamethoxam (Cruiser 350 FS, 350 g L⁻¹ of a.i., FS, Syngenta) at the dose of 210 g for 100 seeds⁻¹ of a.i. and dietholate (Permit, 500 g L⁻¹ of a.i., DS, FMC) at the dose of 375 g for 100 seeds⁻¹ of a.i. The spacing adopted between the rows was 0.76 m and the seeding rate was ten

seeds per linear meter, positioned at 3 cm deep. Simultaneously, basic fertilization with 400 kg ha⁻¹ of formulated 02-20-18 was held. Complementary topdressing with 100 kg ha⁻¹ of N as urea was used, 35 days after emergence, which was mechanically carried out using fertilizer discs.

The experiment was conducted in a randomized block design with four replications. Treatments were arranged in a split plot design consisting in seven plots (herbicide treatments) and two subplots (presence or absence of treatment). Plots were designed in an area of 30.4 m² (3.04 x 10.0 m) and subplots showed total area of 15.2 m² (3.04 x 5.0 m). The floor

area assessed was 6.08 m² (four linear meters of the two central rows of each subplot).

The plots consisted in seven herbicide treatments applied in preemergence of the cotton plant, and these consisted in: clomazone (1.0 kg ha⁻¹ of a.i.), clomazone + fomesafen (1.0 + 0.45 kg ha⁻¹ of a.i.), clomazone + fomesafen (1.0 + 0.625 kg ha⁻¹ of a.i.), clomazone + fomesafen + diuron (1.0 + 0.45 + 1.25 kg ha⁻¹ of a.i.), clomazone + fomesafen + prometryn (1.0 + 0.45 + 1.25 kg ha⁻¹ of a.i.), clomazone + fomesafen + trifluralin (1.0 + 0.45 + 1.8 kg ha⁻¹ of a.i.) and clomazone + fomesafen + s-metolachlor (1.0 + 0.45 + 0.77 kg ha⁻¹ of a.i.).

The herbicides used were: clomazone (Gamit, 500 g L⁻¹ of a.i., EC, FMC), fomesafen (Flex, 250 g L⁻¹ of a.i., SL, Syngenta), diuron (Herburon 500 BR, 500 g L⁻¹ of a.i., SC, Adama), prometryn (Gesagard 500 SC, 500 g L⁻¹ of a.i., SC, Syngenta), trifluralin (Trifluralina Nortox Gold, 450 g L⁻¹ of a.i., EC, Nortox) and s-metolachlor (Dual Gold, 960 g L⁻¹ of a.i., EC, Syngenta).

In the subplots two situations were assessed: one subplot that received herbicide application (treated) and another subplot that did not receive herbicide application (untreated). This arrangement allowed the positioning, on the same plot, of plants that were treated with the herbicide, and control plants that did not receive the application thereof. This design is an advantage in selectivity experiments because it effectively minimizes the variability of the experimental area, contributing to minimizing experimental error, which leads to more accurate results and recommendations on the selectivity of the products evaluated. The effectiveness of this methodology has been proven by Fagliari et al. (2001), Constantin et al. (2007), Dan et al. (2011) and Arantes et al. (2014).

The treatments application was performed on 02/03/2012 by means of a knapsack sprayer of accuracy with pressurization by CO₂, provided with a 2.5 m boom with six spray nozzles AI 110.02 plane spray-type (0.5 m between nozzles), pressurized

at 206.8 kPa and displacement speed of 1 m s⁻¹, which gave an application rate equivalent to 200 L ha⁻¹. The environmental conditions at the time of application were of average air temperature 29.1 °C, average RH of 52%, wind speed of 3.7 km h⁻¹ and wet soil.

Cultivation practices were conducted as needed by the culture by means of weekly monitoring. The culture was maintained continuously free from the interference of weeds by four manual hoeings conducted during the crop cycle.

Intoxication evaluations were performed at 7, 19 and 30 days after emergence (DAE) of seedlings, using the EWRC (European Weed Research Council) visual scale (where 1 represents no symptom and 9 represents death of all plants) (EWRC, 1964).

At 160 DAE, final stand, insertion height of the first sympodial branch, plant height, number of sympodial branches per plant, number of bolls per plant, weight of bolls (located on the top and bottom) and productivity were determined. The stand was assessed by counting plants in 4 linear meters in the two central rows of each plot. For the variables insertion height of the first sympodial branch, plant height, number of sympodial branches per plant and number of bolls per plant they were randomly taken in ten plants located in the floor area of each plot. For mass of bolls located in the upper and lower parts of the plants, 15 bolls were collected from each plant within the floor area of each experimental unit. Cotton seed productivity was quantified by manual harvesting and weighing all open bolls located in the two central rows of the plot (6.08 m²).

Variables were analyzed by comparing the areas treated with herbicides in relation to the untreated area, i.e., there was a partial unfolding of the dual interaction, comparing only the subplots averages (treated vs. untreated), according to the methodology described by Fagliari et al. (2001). Data were subjected to analysis of variance by F-test and when significant the averages were compared by Tukey's test at 10% probability. Analyses

were performed with the help of statistical program Sisvar (Ferreira, 2011).

Results and Discussion

During the period which included sowing the cotton plant crop there was an accumulated rainfall of 430 mm (Figure 1), and this fell far short of the volume required by cotton plant, which ranges between 600 and 800 mm per cycle. In addition, it is known that water demand in cotton plant is 2, 4 and 8 mm day⁻¹ for the emergence phases at the first flower bud, first flower bud at first flower, and first flower at opening boll, respectively. Thus, the volume of rain accumulated in the opening phase of the flowers at maturation was below the required by the crop (Beltrão et al., 1999, 2011).

Precipitation that occurs in the period between sowing and the emergence of cotton seedlings has a significant influence on phytointoxication levels promoted by fomesafen, and large rain volumes in this period favor the most of this herbicide injury (Main et al., 2012). In the experiment, the highest rainfalls in February occurred after seedling emergence; therefore, the condition was favorable to the selectivity of fomesafen.

The temperature was within the proper limits for cotton plant (Figure 1), while the minimum temperature was above 15 °C, the maximum temperature did not exceed 31 °C, and the average temperature ranged from 21 to 24 °C (Oosterhuis, 1999).

Variables number of bolls per sympodial branch and mass of bolls were assessed; however, no significant differences were observed between the treatments and the untreated control; therefore, it was decided to not present the results.

Treatments assessed caused visual symptoms of phytotoxicity at 7 and 19 DAE (Table 1). However, the intensity of injury depended on the herbicides used. In general, injuries were higher where triple mixtures were employed, with grades between 2.5 and 4.0. These results differ from those obtained by Troxler et al. (2002), who reported injuries minor than 5% in cotton plants treated with the mixture of clomazone + fomesafen. However, in these authors' work, the doses of clomazone and fomesafen were lower, and the experiments were conducted in a sandy and average textured soil, with pH in water ranging from 5.7 to 6.0 and OM (%) between 1.0 and 1.3.

Table 1. Notes of phytotoxicity at 7, 19 and 30 days after emergence (DAE) of the cotton after applying different herbicides treatments in preemergence. Santa Helena de Goiás, GO, 2012.

Treatments (kg a.i. ha ⁻¹)	Phytotoxicity (EWRC) ^{1/}		
	7 DAE	19 DAE	30 DAE
1. Clomazone (1.0)	1.8	3.3	1.0
2. Clomazone+fomesafen (1.0+0.45)	2.3	3.5	1.0
3. Clomazone+fomesafen (1.0+0.625)	2.3	3.3	1.0
4. Clomazone+fomesafen+diuron (1.0+0.45+1.25)	2.5	4.0	1.0
5. Clomazone+fomesafen+prometryn (1.0+0.45+1.25)	3.5	3.5	1.0
6. Clomazone+fomesafen+trifluralin (1.0+0.45+1.8)	3.5	3.8	1.0
7. Clomazone+fomesafen+s-metolachlor (1.0+0.45+0.77)	2.8	3.8	1.0

"+" indicates tank mix. ^{1/} Scale EWRC, 1.0 = without injury and 9.0 = plant dead

The symptom observed in plants treated with herbicide clomazone was bleaching on the leaves edges in some plants of the plot. These symptoms are similar to those presented by Brambilla (2007). The low level of phytointoxication promoted by clomazone can be attributed to the treatment of seeds with the

safener dietholate, which provides protection to phytotoxic effects caused by this herbicide (Yazbek Júnior and Foloni, 2004). Fomesafen herbicide promoted symptoms of necrotic scores scattered in the adaxial part of the leaf edge and, in severer cases, shriveling of the leaf

edge was observed. These symptoms were similar to those described by Main et al. (2012).

At the 30 DAE assessment, no visual symptom of phytotoxicity was observed in the plants treated with the herbicides, and grade 1.0 was assigned to all treatments. Dan et al. (2011) have found that the visual symptoms of phytotoxicity of clomazone + oxyfluorfen mixture remained for 28 days after treatment application, showing that a long persistence of

injuries caused by the herbicides applied in preemergence was common.

The application of clomazone alone or in tank mixtures with fomesafen + prometryn and fomesafen + trifluralin has not affected the insertion height of the first sympodial branch. The other treatments, clomazone + fomesafen (1.0 + 0.45 and 1.0 + 0.625 kg ha⁻¹ of a.i.) and clomazone + fomesafen + s-metolachlor, have significantly reduced the insertion height of the first sympodial branch (Table 2).

Table 2. Insertion height of the first sympodial branch (cm) in cotton preharvest (160 DAE). Santa Helena de Goiás, GO, 2012.

Treatments (kg a.i. ha ⁻¹)	Insertion Height (cm)	
	Treated	Non-treated
1. Clomazone (1.0)	23.9 a	25.4 a
2. Clomazone+fomesafen (1.0+0.45)	23.9 b	26.1 a
3. Clomazone+fomesafen (1.0+0.625)	21.2 b	24.7 a
4. Clomazone+fomesafen+diuron (1.0+0.45+1.25)	24.5 b	26.4 a
5. Clomazone+fomesafen+prometryn (1.0+0.45+1.25)	23.6 a	24.7 a
6. Clomazone+fomesafen+trifluralin (1.0+0.45+1.8)	24.9 a	24.2 a
7. Clomazone+fomesafen+s-metolachlor (1.0+0.45+0.77)	23.4 b	25.5 a
CV (%)	6.13	
DMS	1.82	

“+” indicates tank mix. Average followed by the same letter in the same line do not differ by Tukey test to 10% to probability ($p \leq 0.10$).

The insertion height of the first sympodial branch is a variable that directly influences the height adjustment of the cotton picker basket (Bélot and Vilela, 2006). Therefore, when the herbicide modifies this variable, it is necessary to adjust the basket height to avoid crop losses. The insertion of the first sympodial branch very close to the ground is also detrimental to the fiber quality because rain splashes containing mineral and organic particles easily reach the first bolls, depreciating the material produced.

Plants treated with the mixture of clomazone + fomesafen at the dose 1.0 + 0.45 kg ha⁻¹ of a.i. were significantly shorter than their respective controls (Table 3). The other herbicide treatments have not harmed the cotton plant growth. Dan et al. (2011) have observed that the mixture in tank of clomazone + oxyfluorfen (1.0 + 0.19 kg ha⁻¹ of a.i.) has significantly reduced the plants height (cultivar

Nu Opal and soil with 390 g kg⁻¹ of clay, pH in water of 5.45 and 1.98% of organic matter). Inoue et al. (2013), evaluating preemergence application of various treatments in two locations in Brazil (Diamantino and Campos de Júlio), have concluded that no treatment affected the plants height of cultivar FMT 701, at 150 DAA (Diamantino: soil with 601 g kg⁻¹ of clay, pH in water of 5.9 and 2.77% of OM and Campos de Júlio: soil with 740 g kg⁻¹ of clay, pH in water of 6.0 and 3.0% of OM).

Regarding the plants final stand, it was observed that the number of plants in the treatments was similar or higher than those recorded in the respective controls (Table 4). These results differ from those described by Dan et al. (2011), who have observed a significant reduction in the cotton plant stand treated with the mixture in tank of clomazone with another inhibitor of PROTOX (oxyfluorfen) in an experiment conducted with cultivar Nu Opal.

Table 3. Plant height (cm) in cotton preharvest (160 DAE). Santa Helena de Goiás, GO, 2012.

Treatments (kg a.i. ha ⁻¹)	Height (cm)	
	Treated	Non-treated
1. Clomazone (1.0)	73.5 a	71.5 a
2. Clomazone+fomesafen (1.0+0.45)	73.2 b	79.4 a
3. Clomazone+fomesafen (1.0+0.625)	76.5 a	75.4 a
4. Clomazone+fomesafen+diuron (1.0+0.45+1.25)	74.1 a	72.0 a
5. Clomazone+fomesafen+prometryn (1.0+0.45+1.25)	76.3 a	75.0 a
6. Clomazone+fomesafen+trifluralin (1.0+0.45+1.8)	73.7 a	77.3 a
7. Clomazone+fomesafen+s-metolachlor (1.0+0.45+0.77)	76.2 a	77.4 a
CV (%)	5.34	
DMS	4.88	

“+” indicates tank mix. Average followed by the same letter in the same line do not differ by Tukey test to 10% to probability (p ≤0.10).

The number of bolls per plant was influenced by the different treatments applied in preemergence, and a reduction in the values of this variable using clomazone + fomesafen (1.0 + 0.625 g ha⁻¹ of a.i.) could be seen (Table 5). Different results were reported by Dan et al. (2011), who found no significant reduction in the number of apples per plant when using mixtures in tank involving clomazone (1.0 kg ha⁻¹ of a.i.) applied in preemergence.

Table 4. Final Stand (4 m⁻¹ plants) in cotton pre-harvest (160 DAE). Santa Helena de Goiás, GO, 2012.

Treatments (kg a.i. ha ⁻¹)	Standes (plantas 4 m ⁻¹)	
	Treated	Non-treated
1. Clomazone (1.0)	30.5 a	29.1 a
2. Clomazone+fomesafen (1.0+0.45)	30.3 a	27.9 a
3. Clomazone+fomesafen (1.0+0.625)	25.5 a	26.3 a
4. Clomazone+fomesafen+diuron (1.0+0.45+1.25)	30.4 a	30.4 a
5. Clomazone+fomesafen+prometryn (1.0+0.45+1.25)	29.9 a	25.6 b
6. Clomazone+fomesafen+trifluralin (1.0+0.45+1.8)	30.6 a	26.3 b
7. Clomazone+fomesafen+s-metolachlor (1.0+0.45+0.77)	28.0 a	29.9 a
CV (%)	10.26	
DMS	3.57	

“+” indicates tank mix. Average followed by the same letter in the same line do not differ by Tukey test to 10% to probability (p ≤0.10).

Table 5. Number of cotton bolls per plant. Santa Helena de Goiás, GO, 2012.

Treatments (kg a.i. ha ⁻¹)	Cotton bolls (n)	
	Treated	Non-treated
1. Clomazone (1.0)	7.6 a	6.6 b
2. Clomazone+fomesafen (1.0+0.45)	7.9 a	7.8 a
3. Clomazone+fomesafen (1.0+0.625)	6.9 b	7.7 a
4. Clomazone+fomesafen+diuron (1.0+0.45+1.25)	6.5 a	6.7 a
5. Clomazone+fomesafen+prometryn (1.0+0.45+1.25)	7.5 a	7.8 a
6. Clomazone+fomesafen+trifluralin (1.0+0.45+1.8)	6.9 a	7.6 a
7. Clomazone+fomesafen+s-metolachlor (1.0+0.45+0.77)	7.1 a	6.6 a
CV (%)	8.53	
DMS	0.75	

“+” indicates tank mix. Average followed by the same letter in the same line do not differ by Tukey test to 10% to probability (p ≤0.10).

To evaluate the herbicide treatments effects on cotton seeds yield it is possible to notice that there was a significant decrease in this variable only with the application of the mixture between clomazone and fomesafen (1.0 + 0.625 kg ha⁻¹ of a.i.). The plants treated with

this mixture had a drop in productivity of 23 arrobas [345 kilograms (759 lb)] of cotton seed per hectare, compared to its respective control (Table 6). According to Troxler et al. (2002), the increase in the fomesafen herbicide dose affects its selectivity to cotton plant.

Table 6. Cotton seed yield (kg ha⁻¹). Santa Helena de Goiás, GO, 2012

Treatments (kg a.i. ha ⁻¹)	Productivity (kg ha ⁻¹)		Pr>F
	Treated	Non-treated	
1. Clomazone (1.0)	2125.7 a	1973.7 a	0.40
2. Clomazone+fomesafen (1.0+0.45)	2304.7 a	2168.0 a	0.45
3. Clomazone+fomesafen (1.0+0.625)	2012.7 b	2358.1 a	0.06
4. Clomazone+fomesafen+diuron (1.0+0.45+1.25)	2123.8 a	2055.9 a	0.70
5. Clomazone+fomesafen+prometryn (1.0+0.45+1.25)	2378.7 a	2329.4 a	0.78
6. Clomazone+fomesafen+trifluralin (1.0+0.45+1.8)	2354.0 a	2414.7 a	0.73
7. Clomazone+fomesafen+s-metolachlor (1.0+0.45+0.77)	2109.4 a	2115.5 a	0.97
CV (%)	11.34		
DMS	303.92		

“+” indicates tank mix. Average followed by the same letter in the same line do not differ by Tukey test to 10% to probability (p ≤0.10).

The other mixtures involving clomazone and fomesafen have not affected cotton plant yield and can therefore be considered selective to the crop. These results are similar to those described by Troxler et al. (2002), who have also observed no negative effects on productivity when fomesafen (0.28 or 0.42 kg ha⁻¹ of a.i.) was mixed to clomazone (0.84 kg ha⁻¹ of a.i.) (soils of sandy and average texture, pH in water ranging between 5.7 and 6.0 and percentage of OM between 1.0 and 1.3).

One reason for the high selectivity performed by herbicides evaluated may have been treating seeds with the safener dietholate, which is known to be used in protecting cotton seeds against clomazone (Yazbek Júnior and Foloni, 2004). It is known that dietholate inhibits cytochrome P-450 mono-oxygenase, responsible for the activation of clomazone, since this one has no herbicide activity and is considered a pre-herbicide as it needs to be activated for the 5-keto form of clomazone, which is the metabolite of clomazone with activity in weed control (Sanchotene et al., 2010).

In this experiment, none of triple mixtures affected the productivity of cotton

seed, unlike what was reported by Dan et al. (2011) and Arantes et al. (2015). Two factors may have contributed to these results: a) the dose of clomazone used in the triple mixtures were below those by Dan et al. (2011) and b) the application was done exclusively in preemergence, and it can be verified in the work by Arantes et al. (2015) that the applications were carried out in a chemical control system, covering applications in preemergence, over the top and in postemergence.

Therefore, the initial hypothesis was confirmed because the clomazone association with the lowest dose evaluated of fomesafen was selective to cotton plant and can be used without damage to the culture, in similar conditions to the ones of the experiment. However, there are still some points to be clarified in future research, such as whether this association will remain selective in a chemical control system involving pre and postemergence applications. This type of information is of paramount importance, since due to the low initial growth rate of shoots, it is common to integrate different procedures for application as a strategy for weed management in cotton plant

Conclusions

The treatments with clomazone alone and the associations clomazone + fomesafen (1.0 + 0.45 kg ha⁻¹ of a.i.), clomazone + fomesafen + diuron, clomazone + fomesafen + prometryn, clomazone + fomesafen + trifluralin and clomazone + fomesafen + s-metolachlor were selective to cotton plant (cultivar DP 555 BG RR and in a clayey textured soil, with 3.1% of OM and pH 6.0).

The highest dose of fomesafen (0.625 kg ha⁻¹ of a.i.) in associations with clomazone (1.0 kg ha⁻¹ of a.i.) was not selective to cotton plant (cultivar DP 555 BG RR and in a clayey textured soil, with 3.1% of OM (organic matter) and pH of 6.0).

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