Glyphosate alone and in association with herbicide for weed control and selectivity in cotton crop RF

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ABSTRACT

Cotton (Gossypium hirsutum L.) is a fiber-producing plant that demonstrates high cultivation aptitude in Brazil. However, crop performance is influenced by factors such as weed interference, mainly due to the few options of selective herbicides to be applied in post-emergence in cotton cultivars with RF technology. Thus, the objective of this study was to evaluate the use of glyphosate associated with latifolicides for weed management in cotton crops. For this, a field experiment was carried out, in a randomized block design with 13 tracts and four replications, using cv. Deltapine DP1857B3RF. The treatments were composed of pyrithiobac-sodium at doses (36.4, 42.0 and 50.4 g a.i. ha-1), trifloxysulfuron-sodium (2.25, 2.62 and 3.0 g a.i. ha-1), glyphosate isopropylamine salt and potassium (1,350 and 1,512 g a.i. ha-1) used separately and together, with two deposition formats, in total area and directed jet, and two controls, one without any control method and the other weeded control. The association between the herbicides and the joint application of the three herbicides provided efficiency above 95% of control for volunteer soybean plants. The mixture of pyrithiobac-sodium and trifloxysulfuron-sodium (42.0 + 3.0 g a.i. ha-1), followed by sequential applications of glyphosate (1,512 g a.i. ha-1), regardless of the form of deposition of the herbicide, provided control above 95%, at 45 days after the first application, for the goosegrass (Eleusine indica) and viola-string (Ipomoea sp) plants. Symptoms of injury were observed in cotton plants, with greater intensity until 15 days after application (DAA), when pyrithiobac-sodium, trifloxysulfuron-sodium and glyphosate (36.4 + 2.25 + 1,350 g a.i. ha-1) were associated, reaching 35.5 % of the affected plants. Plant height was initially affected by the triple association between the herbicides pyrithiobac-sodium, trifloxysulfuron-sodium and glyphosate (36.4 + 2.25 + 1,350 g a.i. ha-1), however, at 90 DAA, all treatments provided higher plant height than the control without herbicide intervention, which was 95.3 cm. For boll weight, no difference was observed between the treatments, other than fiber yield, being lower for the treatments in which glyphosate was associated

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with pyrithiobac-sodium and trifloxysulfuron-sodium, providing 38.8 and 39.1%, respectively. Cotton yield was influenced by treatments where trifloxysulfuron-sodium was applied associated with glyphosate (2.62 + 1,350 g a.i. ha-1) and pythiobac-sodium, trifloxysulfuron-sodium and glyphosate (36.4 + 2.25 + 1,350 g a.i. ha-1), followed by glyphosate application at 43 DAE, but all treatments were superior to the control without herbicide application. Glyphosate applied alone or in association was essential for weed management in cotton production systems with RF technology.

Keywords: Chemical Control, Injury Level, Productivity.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is a species of great economic importance, whose production, in addition to being used as raw material for the manufacture of animal feed and vegetable oil, its fiber is essential for the textile industry, being the product of greatest importance and added value (VASCONCELOS et al., 2016).

Cotton cultivation has excellent business prospects and increased production in Brazil, as it has been well adapted to several regions of the country. In the Brazilian Midwest region, cotton cultivation finds good edaphoclimatic conditions for its development and production, with sowing carried out between the months of December and February and harvesting from June to July (DANIEL et al., 2021). This cultivation is configured as sowing in the second crop or "off-season", a practice that occurs almost simultaneously with the harvest of soybeans, previously cultivated as the main crop, causing the intensification of the production system (BAIO et al., 2020).

Cotton has a competitive disadvantage during its establishment, as it has a slow initial development compared to weeds, which can reach the adult stage after the first 30 days of emergence (JOAQUIN JR. et al., 2021). C3 metabolism and high photorespiration rate also make cotton plants more sensitive to damage caused by weed interference (BALLAMINUT, 2009).

The long cycle of cotton is based on one of the challenges for management, combined with its low tolerance to herbicides (EMBRAPA, 2021). Thus, the development of herbicide-selective plants, through genetically modified crops, emerged as a necessity, in order to facilitate the chemical control of weeds in the production system (SILVA et al., 2016). In Mato Grosso, most cotton crops grown are genetically modified, with events approved by CTNBio, offering resistance to glyphosate, including the MON1445 event, Roundup Ready (RR) approved in 2008, GHB614 GlyTol (GLT) approved in 2010 and the MON88913, Roundup Ready Flex (RF) approved in 2011 (CARVALHO et al., 2020).

The scarcity of herbicides with control aspects for broad leaves available for cotton is also a limitation, so the integration between pre-emergent and post-emergent herbicides can result in improved management performance (TOLEDO et al., 2015). In Brazil, for cotton crops as an option for selective herbicides registered for post-emergence application, with an effect on latifolicidal species, pyrithiobac-sodium and trifloxysulfuron-sodium stand out, whose mechanism of action is the inhibition of the enzyme acetolactate synthase (BRAZ et al., 2013). For the control of plants of the graminicide species, the use of herbicides inhibiting acetyl-CoA carboxylase, alone or in association with glyphosate, has been a common practice adopted (NUNES et al., 2021).

The soybean-cotton succession participates in the largest sowing area of cotton crops in the state, which requires effective measures to control weeds, because with the advent of glyphosate-tolerant plant technology, its use has greatly intensified in these production systems (CARVALHO et al., 2020, MATTE et al., 2019). In this sense, transgenic events do not lead to the selection of resistant biotics, as long as they are used rationally, but to the simplification of management with the adoption of the same events and herbicides (ALBRECHT et al., 2021). By the year 2023, in Brazil, 57 herbicide-resistant weed species had been described, and for the herbicide glyphosate, the reported frequency is 20 species, with the last report in 2023, for the species *Bidens subalternans* (HEAP, 2024).

However, the use of genetically modified cotton cultivars, with resistance throughout their cycle to glyphosate and high yield potential, has been widely explored in the Cerrado cultivation (BELOT et al., 2020). With the reduced number of active ingredients used in post-emergence in this production system, the time of application and the dose of herbicides are key factors for effective weed control in these areas (CARVALHO et al., 2020).

Based on the above, the objective of this study was to evaluate the selectivity and efficiency of glyphosate in post-emergence, in the control of weeds and volunteer soybean plants, resistant to glyphosate, at different doses, times and application system, in cotton with RF technology.

METHODOLOGY

The experiment was carried out in the region of Deciolândia, in the municipality of Diamantino – MT, located on the Paiaguás farm, of the SLC Agrícola group (latitude 14º04'13" S, longitude 57º26'43" W and altitude of 618 m) (Figure 1). The study area has a history of more than 10 years with cotton production.

According to the Köppen system, this region has a climate classified as Aw, that is, a hot and humid climate, with a temperature of the coldest month above 18ºC and an average annual temperature of around 24ºC. The average annual rainfall in the region varies between 1600 and 1800 mm, concentrated in the months of October to March (SEPLAN, 2023). The climatic data during the research are presented in Figure 2.

Figure 1. Map with the location of the experimental area, municipality of Diamantino -MT, latitude 14º04'13" S, longitude 57º26'43" W.

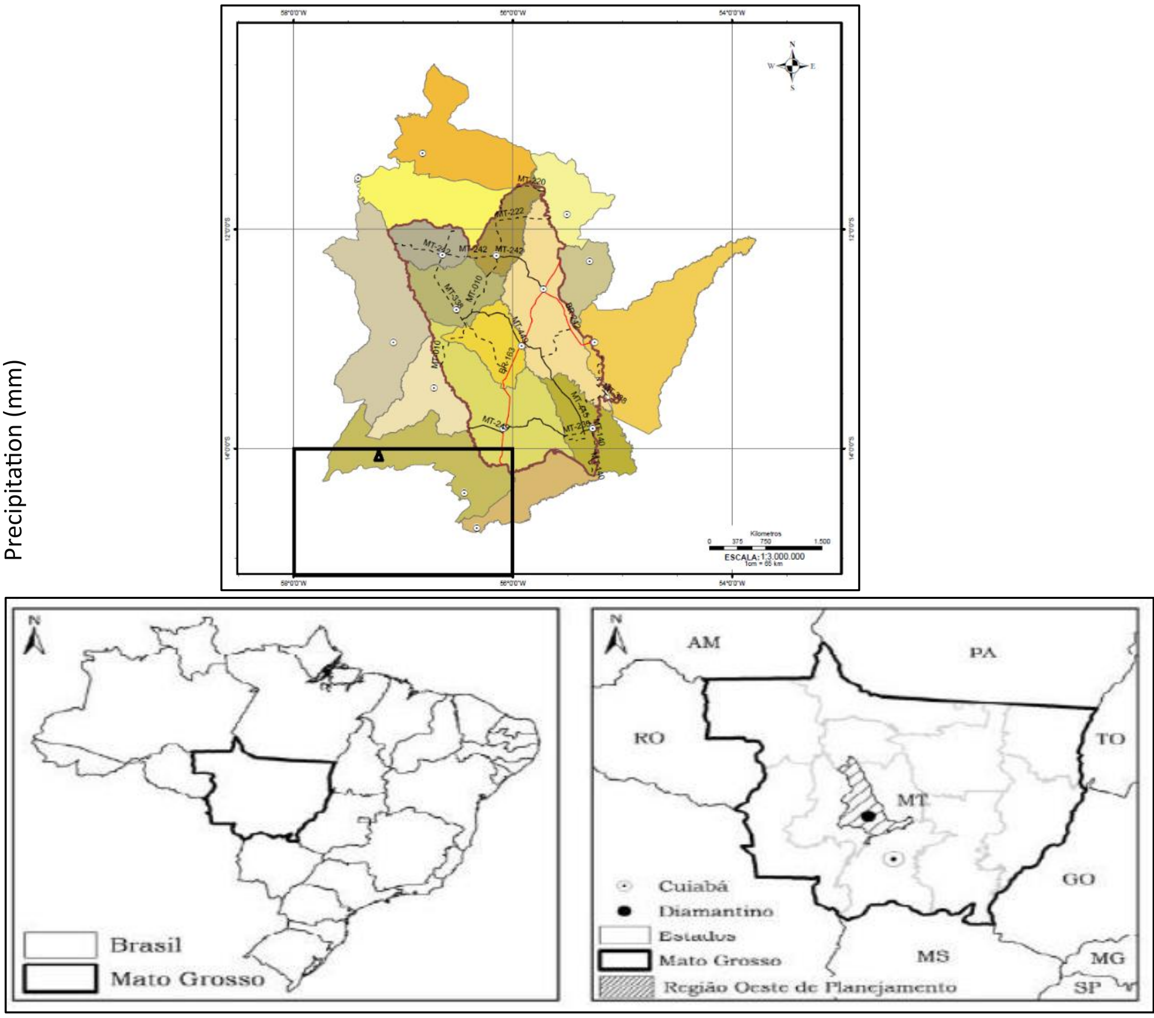
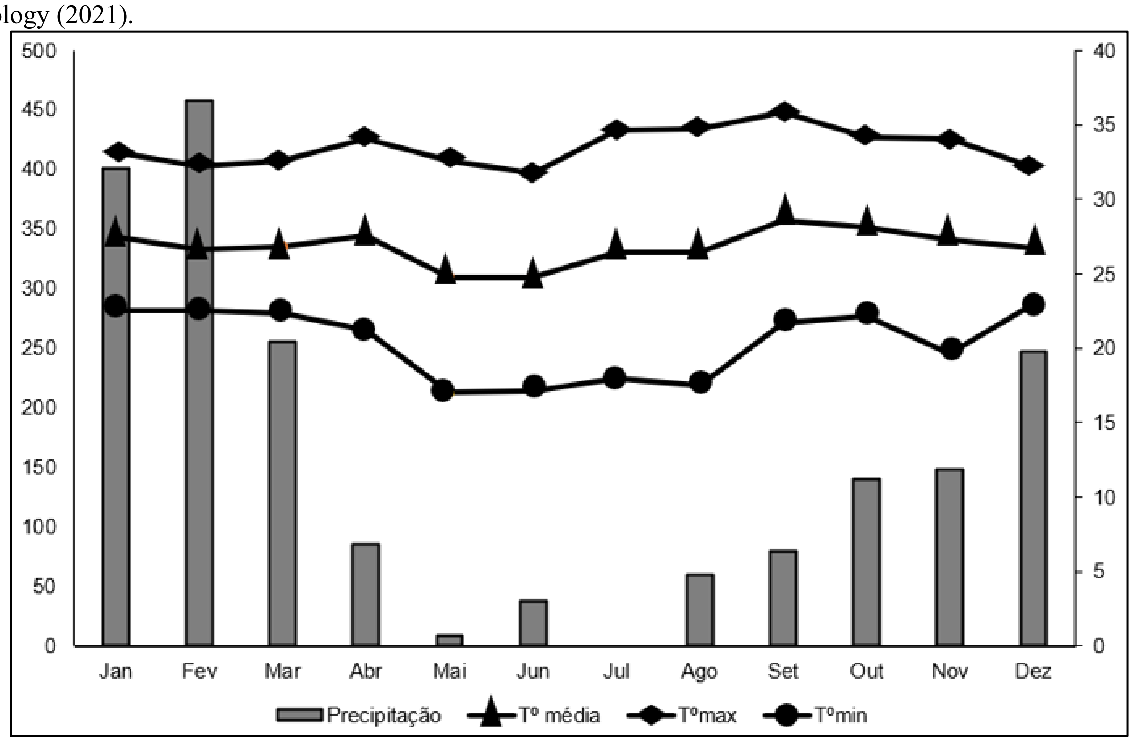


Figure 2 - Monthly averages of precipitation and air temperatures (average, maximum and minimum) for the municipality of Diamantino - MT, between January and December 2021. Source: Data from the National Institute of Meteorology (2021).



The climatic data during the period of the experiment were obtained through the CPTEC platform (Figure 2), since some climatic factors influence the dynamics of herbicides, weed control and crop yield potential.

Before the installation of the experiment, soil sampling was carried out at a depth of 0 to 20 cm. The soil of the region is characterized as a Red Latosol, according to the classification of the Brazilian Agricultural Research Corporation (2013), and its physicochemical characteristics are described in Table 1.

Table 1 - Chemical and physical characterization of the soil sample in the experimental area, from 0-20 cm. Paiaguás Farm, Diamantino – MT, 2021.

ph	Al3++ H+	Ca2++ Mg2+	K $^{+}$	P	MO	V	Sand	Silt	Clay
(H2O)	(CMOCC $^{DM-3}$)		DM-3 mg		g dm-3	(%)	g $^{kg-1}$		
5,9	5,17	4,31	62,6	18,3	34,6	46,37	350	69	581

Source: Agro Analysis Laboratory, Cuiabá MT.

The experimental design was randomized block with 13 treatments and four replications, using a cotton cultivar (11 chemical control methods and 2 controls, one without any control method and the other hoeded control). In the chemical treatments, the herbicides used were glyphosate applied alone and in association with pyrithiobac-sodium and trifloxysulfuron-sodium in different doses, management and application times (Table 2).

The experiment was arranged in plots of 5.4 x 6.5 m, totaling 1,825.2 m2 of floor area. The cotton cultivar used was DP1857B3RF, with a medium production cycle (160 to 170 days), which offers protection to lepidopterans with three Bt proteins (Cry1Ac, Cry2Ab2 and Vip3A) and MON88913, Roundup Ready Flex (RF), which contains copies of the CP4-EPSPS gene, effective for male reproductive structures, and glyphosate can be applied during their reproductive period. Sowing took place on February 9, 2021, in a mechanized way, with the help of a seeder with a vacuum distribution system, regulated to distribute approximately nine seeds per linear meter, and 0.9 m spacing between rows.

Table 2. Treatments evaluated in the experiment with cotton cultivar (cv) plants DP1857B3RF, submitted to post-emergence application with pyrithiobac-sodium (PYR), trifloxysulfuron-sodium (TRI) and glyphosate (GLY).

Treatments	Post-emergence herbicide application		
	15 DAYS	28 DAYS	43 DAYS
	1st Application (g a.i. $^{ha-1}$)	2nd Application (g a.i. $^{ha-1}$)	3rd Application (g a.i. $^{ha-1}$)
T1	Control	Control	Control
T2	Weeding	Weeding	Weeding
T3	PYR (50,4)*	GLY (1.512)*	GLY (1.512)*
T4	PYR (50,4)*	GLY (1.512)**	GLY (1.512)**
T5	THREE (2.62)*	GLY (1.512)*	GLY (1.512)*
T6	THREE (2.62)*	GLY (1.512)**	GLY (1.512)**
T7	PYR + TRI (36,4 + 2,25)*	GLY (1.512)*	GLY (1.512)*
T8	PYR + TRI (36,4 + 2,25)*	GLY (1.512)**	GLY (1.512)**
T9	PYR + TRI (42,0 + 3,0)*	GLY (1.512)*	GLY (1.512)*

T10	PYR + TRI (42,0 + 3,0)*	GLY (1.512)**	GLY (1.512)**
T11	PYR + GLY (50,4 + 1.350)*	-	GLY (1.512)*
T12	TRI + GLY (2,62 + 1.350)*	-	GLY (1.512)*
T13	PYR + TRI + GLY (36,4 + 2,25+ 1.350)*	-	GLY (1.512)*

PYR = Pyrithiobac-sodium; TRI = Trifloxysulfuron-sodium; GLY = Glyphosate; DAE = Days after emergence. * Application in post-emergence, in total area; **Application in post-emergency, in jet directed between the lines. Note: 0.5% v/v mineral oil in all applications.

The sowing fertilization used was MAP (11-51-00), 200 kg $^{ha-1}$ and potassium chloride (00-00-60) 200 kg $^{ha-1}$, distributed near sowing and seedling emergence. On the other hand, the management of top dressing fertilization was carried out with the use of ammonium sulfate (21-00-00 + 23 S), 300 kg $^{ha-1}$ applied to the cast, at 10 and 25 days after emergence (DAE), and NPK (20-00-20 + 6 S) 200 kg ha-1 was also formulated in two applications at 40 and 60 DAE. As the predecessor crop was soybean (cv. Brasmax Foco IPRO), desiccation was performed two days before sowing with glyphosate + carfentrazone (1,440 + 30 g a.i. $^{ha-1}$) and applied with trifluralin + diuron (1,800 + 1,000 g a.i. $^{ha-1}$) in pre-emergence of cotton.

The first application was performed at 15 DAE, using pyrithiobac-sodium and trifloxysulfuron-sodium, applied alone and in association with each other and with glyphosate. At 28 DAE, glyphosate was applied, except for the treatments in which at 15 DAE received this a.i., differing by the form of application in post-emergence, being in the total area and in a jet directed to the between rows. At 43 DAE, the application was carried out in all treatments, except for the controls, differing only in the glyphosate deposition system, in order to evaluate its influence on cotton plants resistant to this herbicide. The other crop treatments followed the farm pattern according to the needs throughout the crop cycle, such as nutritional management, pests and diseases.

The herbicide application modality was post-emergence, using a CO2-based knapsack sprayer equipped with six XR 100.02 fan-type tips, with a flow rate of 120 L $^{ha-1}$ and a pressure of 200 kPa. At the time of the applications, the average temperature ranged from 25.7 to 26.5 ºC, with winds between 0.2 and 0.8 m $^{s-1}$ and relative humidity around 80 to 84%. In the directed jet treatments, the plants were covered by a non-permeable material, to avoid their contact with the herbicide.

The visual evaluations of weed control by herbicides were carried out at 3, 7, 10, 15, 21, 30, 37 and 45 days after the first application of the treatments (DAA), while the level of injuries at 3, 7, 10, 15 and 21 DAA, using a scale of scores from 0 (zero) to 100 (one hundred), in which 0 corresponds to no injury to the plants and 100 to the death of all plants, according to the recommendation of the Brazilian Society of Weed Science (SBCPD, 1995).

The predominant weed community was identified in the experimental area, according to specific knowledge and with the help of the manual of weed identification and control by Lorenzi (2014). The species found with the highest frequencies, totaling more than 95% of the population, were goosegrass (*Eleusine indica*), viola grass (*Ipomea* sp.), trapoeraba (*Commelina* ssp.) and soybean volunteer plants (*Glycine max*), with densities of 14.6, 7.2, 0.8 and 9.3 plants m2 respectively.

The height of cotton plants was measured from ground level to the last true leaf (greater than 2 cm in diameter), at 20, 30, 40, 50 and 90 DAA, in 30 plants properly marked, with the use of a tape measure. The average weight of bolls was acquired from 100 units of the entire plant, in grams, by weighing on a high-precision scale.

Yield was obtained after harvesting the entire useful area of all cotton treatments (421.2 m2) and extrapolated to arrobas of cotton seed per hectare. The fiber yield was obtained through 100 units of bolls, processed in a mini-mill of 12 saws, separating the fiber from the seed, which was weighed on a high-precision scale and extrapolated to fiber percentage. The result of production, in arrobas of lint per hectare, occurred through the productivity in arrobas of seed cotton by fiber yield. All variables had their values corrected to 12% humidity.

The climatic data during the period of the experiment were obtained through the CPTEC platform (Figure 2), since climatic factors influence the dynamics of herbicides in weed control. All data obtained were submitted to analysis of variance (ANOVA) analyzed by the F test and, when significant, the means were compared by the Scott Knott test ($p < 0.05$

RESULTS AND DISCUSSION

In the second crop cotton production system, in addition to weed control, the control of volunteer soybean plants resistant to glyphosate becomes a great challenge. According to Petter et al. (2016), one soybean plant per meter can reduce cotton productivity by 14%, making it necessary to adopt different managements related to active ingredients in the system. Raimondi et al. (2017) reported that the second crop cotton has a period before interference (PAI) of only 11 days after emergence (DAE).

The application of the herbicides in post-emergence to the 15 DAE had as its main objective, in addition to weed control, the control of volunteer soybean plants with Roundup Ready (RR) technology, from the sowing system that precedes cotton. The treatments that received the association of pyrithiobac-sodium and trifloxysulfuron-sodium, together with the association of glyphosate alone or in triple association, provided more than 95% control at 10 DAA-A, differing from the other treatments (Table 1). Pyrithiobac-sodium (50.4 g a.i. $^{ha-1}$) (T3 and T4) at 15 DAA-A provided a lower percentage of control in relation to trifloxysulfuron-sodium (2.62 g a.i. $^{ha-1}$) (T5 and T6) and, both a.i., in isolation, were less efficient in controlling soybean plants, compared to the other associated treatments. The association of pyrithiobac-sodium + trifloxysulfuron-sodium (36.4 + 2.25 g a.i. $^{ha-1}$) (T7 and T8) to 10 DAA-A, provided efficiency above 95% of control, not differing until 45 DAA-A. In this sense, it was evident that there is no need to increase the dose of associated herbicides.

The treatments that received the application of pyrithiobac-sodium + glyphosate (50.4 + 1,350 g a.i. $^{ha-1}$) (T11), trifloxysulfuron-sodium + glyphosate (2.62 + 1,350 g a.i. $^{ha-1}$) (T12) and pyrithiobac-sodium + trifloxysulfuron-sodium + glyphosate (36.4 + 2.25 + 1,350 g a.i. $^{ha-1}$) (T13) provided excellent control of volunteer soybean plants, with efficiency above 96% control, not differing from the 7 DAA-A of the control weeding, and, at 10 DAA-A, from (T9 and T10) to the final evaluation at 45 DAA-A, thus evidencing a synergistic effect between the association of glyphosate with pyrithiobac-sodium and trifloxysulfuron-sodium.

Table 3 Control of volunteer soybean plants in cotton cultivation cultivar DP1857B3RF, submitted to herbicide application in post-emergence.

Treatments	Control of Volunteer Soybean Plants (*Glycine max*) (%) 3 DAA-A		7 DAA-A		1 0 DAA-A	2 DAA-B / 15 DAA-A	8 DAA-B / 21 DAA-A	2 DAA-C / 17 DAA-B / 30 DAA-A	7 DAA-C / 22 DAA-B / 37 DAA-A	1 5 DAA-C / 9 DAA-B / 5 DAA-A
1	,00	nd	,00	nd	,00	,00	,00	,00	,00	,00
2	00,00		00,00		00,00	00,00	00,00	00,00	00,00	00,00
3	2,50		4,75		5,50	6,50	7,25	9,25	1,25	1,75
4	2,50		1,75		9,50	7,75	4,50	3,25	1,25	8,75
5	7,50		4,75		4,50	4,25	3,75	3,75	4,25	4,25
6	0,00		3,75		8,00	4,75	3,00	4,25	7,00	5,75
7	3,00		2,50		6,00	00,00	00,00	9,00	9,00	8,70
8	4,00		4,00		5,00	9,50	8,75	00,00	6,75	8,50
9	2,00		3,75		8,50	00,00	9,50	00,00	00,00	9,50
10	0,00		6,75		9,00	00,00	00,00	00,00	00,00	9,00
11	6,00		7,25		00,00	00,00	00,00	00,00	00,00	00,00
12	1,75		6,00		6,50	8,75	7,50	00,00	9,50	00,00
13	4,25		8,50		00,00	00,00	00,00	00,00	00,00	00,00
	185 ,50*		5 04,34*		2 91,15*	55 8,79*	19 5,98*	869 ,02*	446 ,63*	5 42,65*
V (%)	,73		,99		,70	,58	,34	,34	,86	,60

Averages followed by the same letter in the column do not differ by the Scott Knott test ($p < 0.05$); * = Differ by the F test ($p < 0.05$); DAA-A= Days after the first application; DAA-B= Days after the second application; DAA-C= Days after the third application;T1= Witness without any control method; T2 = Weeded witness; T3 = Pyr (50,4 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T4 = Pyr (50,4 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**; T5 = Tri (2,62 g i.a. ha^{-1})*+ Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*, T6 = Tri (2,62 g i.a. ha^{-1})*+ Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**, T7 = Pyr + Tri (36,4 + 2,25 g i.a ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T8 = Pyr + Tri (36,4 + 2,25 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**; T9 = Pyr + Tri (42,0 + 3,0 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T10 = Pyr + Tri (42,0 + 3,0 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})**+ Gly (1.512 g i.a. ha^{-1})**; T11 = Pyr + Gly (50,4 + 1.350 g i.a. ha^{-1})* + (-) + Gly* (1.512 g i.a. ha^{-1})*; T12 = Tri + Gly (2,62 +1350 g i.a. ha^{-1})* + (-)* + Gly* (1.512 g i.a. ha^{-1})*, T13 = Pyr + Tri + Gly* (36,4 + 2,25 + 1.350 g i.a. ha^{-1}) + (-) + Gly* (1.512 g i.a. ha^{-1}).

In a study conducted by Guerra et al. (2011), soybean showed sensitivity to trifloxysulfuron-sodium and pyrithiobac-sodium at doses of 4.3 and 22.8 g a.i. $^{ha-1}$, respectively, with plants showing phytotoxicity of 50%, with linear injury as herbicide doses increased. According to the authors, for each gram of trifloxysulfuron-sodium increase, phytotoxicity increased by 11%, while for pyrithiobac-sodium the rate of increase was 1.2%. On the other hand, Takahashi et al. (2020) observed excellent control results at 7 DAA, when trifloxysulfuron-sodium (3.0 g a.i. $^{ha-1}$) was applied alone to volunteer soybean plants.

According to Lima et al. (2011), an important issue to be observed in the control of volunteer soybean plants in post-emergence is the stage of development of these plants, because the more advanced it is, the more tolerant the plants become to the action of herbicides, often requiring increased doses to provide effective control. This fact may have corroborated the higher efficiency at lower doses observed in this study, as soybean was in the initial stage of development with two trefoils (V2). Carvalho et al. (2009) reported that the larger the plant, the larger the enzymatic apparatus, contributing to increased decomposition of herbicides, manifesting fewer symptoms. In this sense, Carvalho et al. (2020) obtained control of volunteer soybean plants with Intacta and Xtend technology at the two-trefoil stage, with efficiency above 90%, regardless of the soybean cultivar analyzed, for treatments with 2,4-D, paraquat and atrazine at doses of 670, 400 and 1500 g a.i. $^{ha-1}$, respectively.

Weed control in RF cotton, when associated with the herbicides pyrithiobac-sodium (50.4 g a.i. $^{ha-1}$) and trifloxysulfuron-sodium (2.62 g a.i. $^{ha-1}$) with glyphosate (1,350 g a.i. $^{ha-1}$) (T11 and 12), or even the triple association of this a.i., (36.4 + 2.25 + 1,350 g a.i. $^{ha-1}$) (T13), stood out for their rapid effectiveness in control, and at 7 DAA-A, these combinations did not differ from the treatment with weeding, presenting above 94.75% control (Table 4). According to Sousa et al. (2023), glyphosate provides an antagonism between tank mixtures. Similarly, Rezende et al. (2020) suggest that the association of glyphosate with other herbicides proves to be a favorable practice to improve efficiency in weed control, corroborating the results obtained in this study.

Table 4. Weed control, goosegrass (*Eleusine indica*), viola (*Ipomoea* sp.) and ragweed (*Commelina* ssp.), submitted to post-emergence applicationin cotton cultivation, cultivar DP1857B3RF.

Treat ments	Weed Control (%)															
											30 DAA-A		37 DAA-A		45 DAA-A	
							15 DAA-A		21 DAA-A		17 DAA-B		24 DAA-B		32 DAA-B	
	3 DAA-A		7 DAA-A		10 DAA-A		2 DAA-B		8 DAA-B		2 DAA-C		9 DAA-C		17 DAA-C	
1	,00		,00	nd	,00		,00		,00		,00		,00		,00	
2	00,00		00,00		00,00		00,00		00,00		00,00		00,00		00,00	
3	4,75		4,00		2,25		6,50		1,25		6,75		1,25		8,75	
4	4,00		3,00		5,25		0,25		2,00		2,50		1,25		7,50	
5	8,25		5,25		2,25		2,75	nd	9,25		2,50		5,25		0,00	
6	8,00		5,50		8,50	nd	3,00	nd	3,75		6,75		2,50		5,50	
7	2,50		4,00		6,75		4,25		6,25		8,75		5,75		0,00	
8	9,75		5,25		7,00		4,75		9,50		1,25		1,25		5,00	
9	9,25		8,25		7,75		6,75		9,50		3,75		8,25		5,25	
10	1,75		9,50		1,25		6,25		00,00		2,50		6,50		5,25	
11	4,25		6,50		00,00		9,50		5,25		6,25		3,75		5,00	
12	1,50		4,75		00,00		6,00		0,25	nd	3,75		1,25		1,25	
13	2,75		6,75		00,00		7,50		6,00		8,75		3,75		2,50	
	19 1,29*		386 ,43*		482 ,9*		534 ,48*		284 ,39*		16 0,37*		21 4,29*		17 0,32*	
V (%)	,69		,56		,03		,65		,67		,94		,13		,71	

Médias seguidas de mesma letra na coluna não diferem entre si pelo teste de Scott Knott ($p < 0,05$); * = Diferem pelo teste F ($p < 0,05$); DAA-A= Dias após a primeira aplicação; DAA-B= Dias após a segunda aplicação; DAA-C= Dias após a terceira aplicação; T1= Testemunha sem nenhum método de controle; T2 = Testemunha capinada; T3 = Pyr (50,4 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T4 = Pyr (50,4 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**; T5 = Tri (2,62 g i.a. ha^{-1})*+ Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*, T6 = Tri (2,62 g i.a. ha^{-1})*+ Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**, T7 = Pyr + Tri (36,4 + 2,25 g i.a ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T8 = Pyr + Tri (36,4 + 2,25 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**; T9 = Pyr + Tri (42,0 + 3,0 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T10 = Pyr + Tri (42,0 + 3,0 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})**+ Gly (1.512 g i.a. ha^{-1})**; T11 = Pyr + Gly (50,4 + 1.350 g i.a. ha^{-1})* + (-) + Gly* (1.512 g i.a. ha^{-1})*; T12 = Tri + Gly (2,62 +1350 g i.a. ha^{-1})* + (-)* + Gly* (1.512 g i.a. ha^{-1})*, T13 = Pyr + Tri + Gly* (36,4 + 2,25 + 1.350 g i.a. ha^{-1}) + (-) + Gly* (1.512 g i.a. ha^{-1}).

At 7 DAA-A, the highest dose used in association of pyritobac-sodium + trifloxysulfuron-sodium (42.0 + 3.0 g a.i. $^{ha-1}$) (T9 and T10) provided greater efficiency in weed control compared to treatments in the same association with lower dose. However, at 15 DAA-A there was no difference between them. The application of trifloxysulfuron-sodium (2.62 g a.i. $^{ha-1}$) (T5 and T6) alone provided lower efficiency than pyrithiobac-sodium (50.4 g a.i. $^{ha-1}$) (T3 and T4), at 15 DAA-A, but both with control above 82% (Table 4). Raimondi et al. (2012) observed the good efficiency of pyrithiobac-sodium in weed control at doses of 42 and 56 g a.i. $^{ha-1}$ for the species of *Commelina benghalensis, Amaranthus retroflexus, Ipomoea grandifolia* and *Euphorbia heterophylla*. In a study conducted by Silva et al. (2013), both trifloxysulfuron-sodium and pyrithiobac-sodium provided good viola string control efficiency (*Ipomoea* sp) up to 15 DAA, exceeding 85% efficiency.

The application of glyphosate at a dose of 1,512 g a.i. $^{ha-1}$ (T3 to T10), both in total area and in directed jet application, provided high control efficiency (>85% to 45 DAA). However, in the treatments that did not receive the application of the same (T11, T12 and T13), at 28 DAE, there was the emergence of new weed emergence flows and, because they did not receive the application of glyphosate, they resulted in lower control efficiency in the evaluation at 45 DAA-A, probably due to the higher stage of development of the plants of the species Corda de viola (*Ipomoea* sp.) and pé-de-galinha grass (*Eleusine indica*).

According to Carneiro et al. (2020), glyphosate at a dose of 1,920 g a.i. $^{ha-1}$ is not recommended to control viola-de-viola, due to its low efficiency on this weed, not exceeding 25.5% control after 21 DAA. These data are in line with those of Rocha et al. (2021), in which, on the same evaluation date, glyphosate applied alone controlled only 31.25% of the viola rope plants. Takano et al. (2018) found that glyphosate applied alone provided a maximum of 70% control over small goosegrass plants with up to three tillers and 55% control over plants in full vegetative development stage. Different results were found by Calegarim et al. (2019), working with goosegrass biotypes in soybean crops, and glyphosate had no effect on different populations, probably due to the resistance of these plants, causing an 88.8% reduction in production.

The late application of glyphosate, according to Fipke and Vidal (2019), requires an increase in doses to obtain the same effect, when the application is carried out early in the early stages of the plants. The longer interval between applications and development of cotton plants may also have contributed to the result of the last glyphosate application. According to Falsarelli et al. (2021), the crop development stage, with an increase in leaf area index, interferes with the penetration of droplets into the plant canopy, causing a decrease in herbicide control. This fact may have contributed to the lower control efficiency in the treatments that received glyphosate via protected application.

According to Cavalieri et al. (2014), the association of glyphosate with pyrithiobac-sodium and trifloxysulfuron-sodium, applied at 15 days after sowing (DAS), followed by an application at 55 DAS of glyphosate, provided excellent control of the species *Euphorbia heterophylla, Richardia brasiliensis, Eleusine indica* and *Alternanthera tenella*, but the same did not occur for the triple mixture at the same times for the species *A. tenella.* In this sense, the results are similar to those found in this study, since the triple association between pyrithiobac-sodium, trifloxysulfuron-sodium and glyphosate (36.4 + 2.25 + 1,350 g a.i. $^{ha-1}$) (T13) provided 97.50% control at 15 DAA-A.

However, with the application of only 43 DAE of glyphosate, the effect was lower than the best treatments and manual weeding, and may be associated with the long period of re-entry (28 days) and the most advanced stage of the new weed flow.

In a study carried out by Mendes et al. (2020), for the control of *Digitaria insularis*, with sequential applications of glyphosate in association with another herbicide, there was better efficiency, ranging from 17 to 24 days. This result may explain the better efficiency of the association of pyrithiobac-sodium + trifloxysulfuron (42.0 + 3.0 g a.i. $^{ha-1}$) (T9 and T10), at 15 DAE, followed by the sequential application of glyphosate at 28 and 43 DAE, with control above 95% at 45 DAA-A.

Braz et al. (2014), evaluating the residual of pyrithiobac-sodium in cotton weed control, observed residual activity of this herbicide in the soil for some species, with doses higher than 28.0 g a.i. $^{ha-1}$, including *A. tenella, A. lividus, A. hybridus, E. heterophylla* and *Tridax procumbens*, suggesting a residual effect for the species found most frequently in this study, which may help to reduce the emergence of new flows and contribute to better control of T9 and T10. According to Takano et al. (2018), the association between active ingredients is necessary to control goosegrass and the use of waste products is determinant, as products applied in post-emergence are more efficient in small plants.

Table 5 shows the difference in the levels of injuries caused by the treatments to the cotton plants in all the evaluated periods, in relation to the results found in the controls (no injury). Symptoms started mild at 3 DAA-A, with yellowish spots accentuating at the end of the first week.

The treatments that received pyrithiobac-sodium (50.4 g a.i. $^{ha-1}$) (T3 and T4) and trifloxysulfuron-sodium (2.62 g a.i. $^{ha-1}$) (T5 and T6), in isolated applications, provided lower phytotoxicity in the plants up to 15 DAA-A. The association of pyrithiobac-sodium + trifloxysulfuron-sodium, at different doses, provided greater initial injury up to 15 DAA, not differing from each other, however, with the increase in doses at 7 and 10 DAA-A, the symptoms of injury were accentuated, not differing from the treatment that received pyrithiobac-sodium + glyphosate (50.4 + 1,350 g a.i. $^{ha-1}$) (T11) after 3 DAA-A. In a study conducted by Paula et al. (2020), at two concentrations of pyrithiobac-sodium (22.4 and 42.0 g a.i. $^{ha-1}$), low levels of injury were observed in the crop during its cycle, providing excellent selectivity for the cotton crop.

The herbicides trifloxysulfuron-sodium + glyphosate (2.62 + 1,350 g a.i. $^{ha-1}$) (T12) caused a rate of 15% of plants with injuries at 20 DAA-A, significantly differentiating from T11 in all DAA-A studied (Table 5). Even at lower concentrations of a.i., the addition of glyphosate to pyrithiobac-sodium and trifloxysulfuron-sodium (1,350 + 36.40 + 2.25 g a.i. $^{ha-1}$) (T13) resulted in greater plant injury, differing from all other treatments, and injury was observed in 20% of the treated plants even at 20 DAA-A (Table 5). Trifloxysulfuron-sodium in application alone or in association with pyrithiobac-sodium and glyphosate provided a greater phytotoxic effect compared to pyrithiobac-sodium under the same conditions evaluated (Table 5).

In a study conducted by Ferreira et al. (2009), trifloxysulfuron-sodium caused greater injury, regardless of the stage of the crop studied, even at the lowest dose used, which was 5.0 g a.i. $^{ha-1}$. Freitas et al. (2006), using conventional cotton cultivar for herbicide (cv. Fabrika), observed a slight yellowing in the seedlings caused by the application of 7.8 g. a.i. $^{ha-1}$ of trifloxysulfuron-sodium, causing 12.5% of injuries to the plants, affecting the initial development in the first weeks after application.

Table 5. Injuries in cotton plants, cultivar DP1857B3RF, submitted to herbicide application in post-emergence.

Treatments	Injuries (%)									
							15 DAA-A		20 DAA-A	
	3 DAA-A		7 DAA-A		10 DAA-A		2 DAA-B		7 DAA-B	
T1	0,00	a	0,00	a	0,00	a	0,00	a	0,00	a
T2	0,00	a	0,00	a	0,00	a	0,00	a	0,00	a
T3	2,00	a	2,00	b	2,00	a	2,00	a	0,00	a
T4	2,00	a	2,00	b	2,00	a	2,00	a	0,00	a
T5	5,00	b	4,	b	3,50	b	2,75	a	0,00	a
T6	5,25	b	4,00	b	5,00	b	2,75	a	0,00	a
T7	4,50	b	5,25	c	5,00	b	5,00	b	0,50	a
T8	4,25	b	5,00	c	8,75	c	6,25	b	0,50	a
T9	6,26	b	7,75	d	10,00	c	6,25	b	1,00	a
T10	7,50	b	7,75	d	8,75	c	6,25	b	2,25	a
T11	11,25	c	10,00	d	10,00	c	7,50	b	2,75	a
T12	27,50	d	25,00	and	22,50	d	23,87	c	15,00	b
T13	27,50	d	27,50	f	27,50	and	32,50	d	20,00	c
F	41,72*		106,44*		114,59*		85,98*		49,72*	
CV (%)	35,98		22,02		19,33		27,9		56,86	

Averages followed by the same letter in the column do not differ by the Scott Knott test ($p < 0.05$); * = Differ by the F test ($p < 0.05$); DAA-A = Days after the first application; DAA-B= Days after the second application; T1= Witness without any control method; T2 = Weeded witness; T3 = Pyr (50,4 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T4 = Pyr (50,4 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**; T5 = Tri (2,62 g i.a. ha^{-1})*+ Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*, T6 = Tri (2,62 g i.a. ha^{-1})*+ Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**, T7 = Pyr + Tri (36,4 + 2,25 g i.a ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T8 = Pyr + Tri (36,4 + 2,25 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**; T9 = Pyr + Tri (42,0 + 3,0 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T10 = Pyr + Tri (42,0 + 3,0 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})**+ Gly (1.512 g i.a. ha^{-1})**; T11 = Pyr + Gly (50,4 + 1.350 g i.a. ha^{-1})* + (-) + Gly* (1.512 g i.a. ha^{-1})*; T12 = Tri + Gly (2,62 +1350 g i.a. ha^{-1})* + (-)* + Gly* (1.512 g i.a. ha^{-1})*, T13 = Pyr + Tri + Gly* (36,4 + 2,25 + 1.350 g i.a. ha^{-1}) + (-) + Gly* (1.512 g i.a. ha^{-1}).

The effects of injury from selective herbicides for cotton crops, when applied in isolation, disappear between three and five weeks after application (THOMAS et al., 2006). These results support those found in this study, because even in association with the highest doses of pyrithiobac-sodium (42.0 g a.i. $^{ha-1}$) and trifloxysulfuron-sodium (3.0 g a.i. $^{ha-1}$), injuries after 20 DAA-A were close to zero, not differing from the controls without the use of herbicides.

In a study conducted by Braz et al. (2011), the association between the herbicides glyphosate and glufosinate-amonnium with pyrithiobac-sodium did not provide an antagonistic effect, which makes it possible to use these together and cultivars with GHB614 GlyTol (GLT) technology.

Probably, the greatest injury to cotton plants observed in this study is related to the potentiation between the association of trifloxysulfuron-sodium and glyphosate. According to Kelley et al. (2004), trifloxysulfuron-sodium, in addition to causing yellowing of the leaves, can cause symptoms of necrosis and death of the plant's growth points, due to the non-competitive inhibition of the enzyme acetolactate synthase in the synthesis route of the branched-chain amino acids valine, leucine and isoleucine.

The applications of glyphosate (1,512 g a.i. $^{ha-1}$), at 28 and 43 DAE, did not provide visual effects of phytotoxicity between the treatments. According to Huff et al. (2010), genetically improved plants, with the insertion of a new transformation event (MON 88913), show vegetative and reproductive tolerance to glyphosate. Reports by Arantes et al. (2015) showed initial injuries, but these are not observed throughout the development of the crop, indicating plant recovery.

Regarding plant height (Table 6), at 20 and 30 DAA-A, the highest value found was in the control without application (T1). This fact may be related to the condition of greater etiolation of the cotton plants due to the competition of the cotton plant for space and light. Pereira et al. (2021), studying the effect of the cotton plant population on the characteristics of height and stem diameter, observed that the greater the number of plants per unit of area, the higher the values of plant height, as plants tend to etiolate with greater density.

Contrary to what was observed in this study, Silva et al. (2013) report that the highest plant height was found in the treatments that showed greater efficiency in weed control. In the same sense, Lisboa et al. (2017) found a reduction in height and leaf area of cotton plants, as weed competition increased. However, Rocha et al. (2012), studying the intercropping of citronella grass (*Cymbopogon nordus* L.) with cotton cultivation, did not observe a difference in the height of the cultivated plants. In this context, the weed population present in the area can significantly influence the height of cotton plants.

Table 6. Height of cotton plants, cultivar DP1857B3RF, submitted to herbicide application in post-emergence.

Treatments	Plant Height (cm)									
					40 DAA-A		50 DAA-A		90 DAA-A	
	20 DAA-A		30 DAA-A		27 DAA-B		37 DAA-B		77 DAA-B	
	7 DAA-B		17 DAA-B		12 DAA-C		22 DAA-C		62 DAA-C	
T1	45,20	a	59,20	a	74,50	a	81,50	c	95,39	d
T2	40,30	b	50,92	b	70,25	a	94,35	a	122,39	a
T3	37,00	c	52,35	b	70,40	a	91,95	a	117,05	b
T4	37,25	c	51,65	b	67,60	a	91,85	a	116,52	b
T5	37,15	c	49,10	b	67,45	a	87,65	b	116,07	b
T6	37,25	c	50,40	b	66,90	a	90,50	a	120,95	a
T7	34,25	c	48,35	b	67,20	a	84,90	b	115,25	c
T8	36,05	c	49,00	b	66,15	a	86,50	b	117,60	b
T9	35,80	c	46,10	c	64,66	a	84,65	b	116,42	b
T10	34,35	c	48,20	b	66,00	a	87,70	b	16,77	b

T11	36,95	c	49,00	b	67,30	a	86,85	b	113,70	c
T12	29,00	d	40,10	d	61,25	a	78,25	c	115,62	b
T13	29,10	d	41,85	d	60,00	a	77,35	c	113,08	c
F	8,30		12,39		3,32		6,61		56,75	
CV (%)	8,09		5,48		6,15		4,66		12,67 ns	

Averages followed by the same letter in the column do not differ by the Scott Knott test ($p < 0.05$); * = Differ by the F test ($p < 0.05$); DAA = Days after the first application; DAA-B= Days after the second application; DAA-C= Days after the third application; T1= Witness without any control method; T2 = Weeded witness; T3 = Pyr (50,4 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T4 = Pyr (50,4 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**; T5 = Tri (2,62 g i.a. ha^{-1})*+ Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*, T6 = Tri (2,62 g i.a. ha^{-1})*+ Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**, T7 = Pyr + Tri (36,4 + 2,25 g i.a ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T8 = Pyr + Tri (36,4 + 2,25 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**; T9 = Pyr + Tri (42,0 + 3,0 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T10 = Pyr + Tri (42,0 + 3,0 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})**+ Gly (1.512 g i.a. ha^{-1})**; T11 = Pyr + Gly (50,4 + 1.350 g i.a. ha^{-1})* + (-) + Gly* (1.512 g i.a. ha^{-1})*; T12 = Tri + Gly (2,62 +1350 g i.a. ha^{-1})* + (-)* + Gly* (1.512 g i.a. ha^{-1})*, T13 = Pyr + Tri + Gly* (36,4 + 2,25 + 1.350 g i.a. ha^{-1}) + (-) + Gly* (1.512 g i.a. ha^{-1}).

In the plots that received weeding, a difference in plant height was identified at 20 DAA-A, compared to the others that received chemical intervention. This result corroborates the values found by Pellosi et al. (2019), in which the highest cotton plant height was found at 32 DAS, in the weed-free treatment. However, the plants that received the association of trifloxysulfuron-sodium + glyphosate (2.62 + 1,350 g a.i. $^{ha-1}$) (T12) and the triple mixture of pyrithiobac-sodium + trifloxysulfuron-sodium + glyphosate (36.4 + 2.25 + 1,350 g a.i. $^{ha-1}$) (T13), followed by the application of glyphosate (1.512 g a.i. $^{ha-1}$), showed lower plant height in the evaluations at 20 and 30 DAA-A, which may be related to greater initial injury caused by these associations (Table 5).

For Takahashi et al. (2020), the treatments that provided better control of voluntary RR soybeans were also the treatments that imposed a lower growth rate on cotton plants. This information can be important for the management of crops, regarding the management of the use of growth regulators in cotton.

Regarding post-emergence applications in total area and directed jet of glyphosate in cotton plants, no difference was observed regarding the deposition of the a.i., which may be related to the dose used and also to the transgenic technology provided by the MON88913 resistance (RF) gene (CP4).

During plant development, at 40 DAA-A, there were no differences in height between the treatments under study (Table 6). However, at 50 DAA-A, the treatments with trifloxysulfuron-sodium + glyphosate (2.62 + 1,350 g a.i. $^{ha-1}$) (T12) and the triple mixture of pyritiobac-sodium + trifloxysulfuron-sodium + glyphosate (36.4 + 2.25 + 1,350 g a.i. $^{ha-1}$) (T13), followed by the glyphosate application (1.512 g a.i. $^{ha-1}$), did not differ from the control without intervention (T1), being identified by the lower plant height (Table 6).

In the final evaluation, at 90 DAA-A, all treatments provided an increase in plant size, compared to the control (T1) (Table 6). According to Dias and Santos (2023), the initial development of cotton is quite slow and stress due to phytotoxicity and/or distinct competitions with the plant can affect its physiological characteristics during its cycle. According to Arantes et al. (2015), the damage to the plant caused by herbicide associations, in addition to reducing its growth, can lead to a decrease in productivity. Thus, the competition exerted by weeds, initially may not have interfered in the height, however, throughout the cycle associated with the herbicide applications carried out, it may have influenced the final height of the cotton plants (Table 6), even more so because it is a crop with a long cycle and indeterminate growth.

Regarding the cotton production variables cv DP1857B3RF, significant responses were evidenced for seed and plume yield, as well as fiber yield, however, for the weight of bolls, no significant response was observed (Table 7). According to Snider and Kawakami (2014), bollly weight is related to the intrinsic characteristics of the cultivar and can be affected by climatic conditions during the cultivation cycle. The reduction of boll mass can directly affect the productive potential of the cultivar (WANG et al., 2016).

For Arantes et al. (2015), the application of herbicide in pre-emergence and *over the top* did not influence the boll mass and plume mass per boll, corroborating the results found in this study, because even the treatments that provided greater injury and lower height of cotton plants (Tables 5 and 6), did not differ significantly in the average weight of bolls (Table 7). According to Zhao et al. (2012), if the water availability in the soil, luminosity and temperature are low, the weight of the plant can be reduced. For Echer (2017), the number of plant nodes, number of bolls and cotton yield were affected in low light conditions, although the average boll weight was not influenced, suggesting a greater effect of the abiotic and genetic factors of the cultivar in the definition of boll weight.

Table 7. Variables of cotton yield, cultivar DP1857B3RF, submitted to herbicide application in post-emergence.

Treatments	Weight.Boll			Productivity			Rend. Fibre			Productivity		
	(g)			@. car. ha^{-1}			(%)			@.fiber.ha-1		
T1	3,77	a		63,42	c		41,67	a		26,41	c	
T2	3,45	a		286,04	a		40,42	a		115,69	a	
T3	3,57	a		274,84	a		41,10	a		113,05	a	
T4	3,47	a		261,72	a		40,55	a		106,01	a	
T5	3,32	a		260,95	a		40,62	a		105,99	a	
T6	3,52	a		272,52	a		41,55	a		113,23	a	
T7	3,65	a		260,33	a		40,87	a		106,51	a	
T8	3,70	a		273,76	a		40,72	a		111,47	a	
T9	3,67	a		262,03	a		40,62	a		106,54	a	
T10	3,65	a		279,32	a		40,25	a		112,48	a	
T11	3,52	a		263,73	a		38,87	b		102,57	a	
T12	3,80	a		225,77	b		39,17	b		88,29	b	
T13	3,65	a		235,77	b		40,37	a		95,20	b	
F	2,00 ^{ns}			36,09*			2,3*			28,76*		

CV (%)	5,3			7,77			2,70			8,74		

Averages followed by the same letter in the column do not differ according to the Scott-Kcnott test ($p < 0.05$); @. car. ha = arrobas in stone hectare; @. fibra. ha = arroba in fiber hectare; T1= Control without any control method; T2 = Control with weeding; T3 = Pyr (50,4 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T4 = Pyr (50,4 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**; T5 = Tri (2,62 g i.a. ha^{-1})*+ Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*, T6 = Tri (2,62 g i.a. ha^{-1})*+ Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**, T7 = Pyr + Tri (36,4 + 2,25 g i.a ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T8 = Pyr + Tri (36,4 + 2,25 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**; T9 = Pyr + Tri (42,0 + 3,0 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T10 = Pyr + Tri (42,0 + 3,0 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})**+ Gly (1.512 g i.a. ha^{-1})**; T11 = Pyr + Gly (50,4 + 1.350 g i.a. ha^{-1})* + (-) + Gly* (1.512 g i.a. ha^{-1})*; T12 = Tri + Gly (2,62 +1350 g i.a. ha^{-1})* + (-)* + Gly* (1.512 g i.a. ha^{-1})*, T13 = Pyr + Tri + Gly* (36,4 + 2,25 + 1.350 g i.a. ha^{-1}) + (-) + Gly* (1.512 g i.a. ha^{-1}).

When analyzing the yield of the control without herbicide intervention, the potential for weed interference in cotton cultivation is evident, probably caused by the reduction in the number of structures per plant and not by their weight (Table 7). Studying the cultivation of dense cotton in the second harvest and assuming a maximum loss of 5% in production, Raimondi et al. (2014) observed that the coexistence of weeds with cotton began to affect the plant as early as four days after its emergence, establishing an early process of interference in crop production. Goosegrass has a slow initial development, however, at the density of five plants $^{m-2}$, in cotton crop, it can generate a 27% reduction in productivity (MA et al., 2015). This fact may be related to the low productivity obtained in the treatment without herbicide application, since the cotton crop cycle exceeded 155 DAE, of coexistence with weeds.

In a study carried out by Freitas et al. (2002), weed interference in cotton cultivation significantly reduced the average number of apples, with an increase in the weed coexistence period during the cycle, reaching productivity losses of up to 81.2%. Ben et al. (2012) reported productivity losses due to interference in the same way, greater than 66%. On the other hand, Carbonari et al. (2016) found that the presence of weeds, throughout the crop cycle, caused an 85% reduction in cotton productivity. In this context, the productivity losses resulting from competition with weeds found in this study were greater than 100% reduction when compared to the treatment without herbicide application, evidencing higher loss values than those found in the literature.

The treatments that received the first application of pyrithiobac-sodium and trifloxysulfuron-sodium, alone or in combination with each other, with different doses (T3 to T10), followed by applications of glyphosate (1,512 g a.i. $^{ha-1}$), at 28 and 43 DAE, did not show any difference between them (Table 7), resulting in yields close to the average of the state of Mato Grosso for the 21/22 harvest, which was 284.34 @ $^{ha-1}$ of seed cotton (IMEA, 2024).

The application of glyphosate in the treatments in the total area of the plants did not differ from the treatments applied in directed jet (Table 7). Huff et al. (2010) report that the yield of cotton with glyphosate resistance technology was not affected by the time and rate of glyphosate application. For Castro et al. (2019), the application of glyphosate doses of up to 4,800 g a.i. $^{ha-1}$ caused phytotoxicity in the RR soybean crop, but was not enough to reduce the yield potential. The same was observed in these data corroborate the results found in this study, since the doses of glyphosate (1,512 g a.i. $^{ha-1}$) at 28 and 43 DAE, in treatments T3, T5, T7 and T9, did not cause a significant reduction in the productive potential of cotton cv. DP1857B3RF, compared to the weeded control (Table 7), evidencing the resistance of RF technology to exposure to glyphosate at the doses and times used.

The application of pyrithiobac-sodium + glyphosate (50.4 + 1,350 g a.i. $^{ha-1}$) (T11) at 15 DAE, followed by glyphosate (1,512 g a.i. $^{ha-1}$) at 43 DAE, did not differ from the control with manual hoeing (T2), being among the most productive (Table 7). On the other hand, trifloxysulfuron-sodium + glyphosate (2.62 + 1,350 g a.i. $^{ha-1}$) (T12) and the triple association of pyrithiobac-sodium + trifloxysulfuron-sodium + glyphosate (36.4 + 2.25 + 1,350 g a.i. $^{ha-1}$) (T13) at 15 DAE, followed by the application of glyphosate at 43 DAE, did not differ from each other, but provided lower productivity than the other treatments, except for the control without intervention (T1) (Table 7). In this sense, the lower productivity of these treatments may be related to the greater injury caused by the first application at 15 DAE (Table 5), combined with the lower efficiency in weed control verified at 43 DAE (Table 4).

Dan et al. (2011) found a drop in cotton yield using herbicides oxyfluorfen + diuron and trifluralin + oxyfluorfem, with pre-emergence application, which showed greater injury to the plants at 15 DAE and negative effects were also noticeable regarding the number of apples per plant, thus affecting the final yield of cotton. Similar results were found by Santos et al. (2018), where the competition established by weeds and the phytotoxic effect of herbicides, outweighs the competition established in the control.

In a study carried out by Inoue et al. (2013), studying the selectivity of herbicides in pre-emergence in cotton crops, even the treatments that provided greater initial phytotoxicity did not cause losses in yield. However, Raimondi et al. (2014) pointed out that the lower the initial competition of cotton with weeds, the greater its productive potential.

The fiber yield found in the treatments is below the average for the state of Mato Grosso, which was 41.73% yield for the 21/22 IMEA harvest (2024). According to Santos et al. (2016), cotton fiber yield can be influenced by the availability of nutrients, especially nitrogen, which can stimulate the flow of photoassimilates to plant growth structures, providing greater accumulation of these for seed reserves, in relation to the deposition of cellulose in the fibers.

The application of pyrithiobac-sodium + glyphosate (50.4 + 1,350 g a.i. $^{ha-1}$) (T11) and trifloxysulfuron-sodium + glyphosate (2.62 + 1,350 g a.i. $^{ha-1}$) (T12), together with the second application of glyphosate (1,512 g a.i. $^{ha-1}$), at 43 DAE, differed from the other treatments, as they presented lower values of this production variable (Table 7). However, even the treatment with pyrithiobac-sodium + glyphosate (50.4 + 1,350 g a.i. $^{ha-1}$) (T11), at 15 DAE, and glyphosate (1,512 g a.i. $^{ha-1}$), at 43 DAE, providing lower fiber yield value (38.87%), the final result of cotton lint yield was not affected, being among the treatments that provided the highest yield (Table 7). Alves et al. (2019) report that fiber yield can be affected by several factors, including genetic, climatic and management factors.

According to Wang et al. (2016), fiber yield directly influences production and the increase or decrease may be associated with climatic factors, such as water stress. In this sense, according to Bezerra et al. (2012), the cotton crop needs a water demand of around 4 to 8 mm $^{day-1}$, varying according to its development phase, and in the harvest in question, an accumulation of rain was evidenced between January and March close to 1100 mm (Figure 2), which is not a limit. In a study carried out in the northern region of Mato Grosso, with herbaceous cotton cultivars, Farias et al. (2015) found average values for fiber yield of 44.4 and 46.2% for the cultivars TMG 81WS and Fiber Max 944 GL, respectively, well above the values found in this work, for the cultivar DP1857B3RF. Such variation may be due to the climatic conditions of the year, management and especially the cultivar used in the study.

For Kazama et al. (2016), the lint harvesting system can significantly influence the cotton fiber yield, taking into account that this parameter is one of the components of lint production, however, the *stripper* system considerably decreases the fiber yield compared to the *picker system*, which in turn does not differ from the manual system, which was used in this study.

Regarding the intrinsic quality of the cotton fiber, no difference was observed between the treatments, which remained with results similar to those of the controls without interventions (Table 8). Souza et al. (2021), studying the fiber quality of two herbaceous cotton cultivars in the municipality of Ipiranga do Norte in Mato Grosso, reported a difference in quality between them, where the FM 944GL cultivar showed better standards of length, resistance, lower short fiber index, and more adjusted micronaire. According to Echer and Rosolem (2014), abiotic factors can dominate the genetic characteristics of cultivars, which can alter the fiber quality standards defined by the breeder.

Table 8. Cotton fiber quality variables, cultivar DP1857B3RF, submitted to herbicide application in post-emergence.

Treatments	Fiber Quality															
	UHML		UI		SFI		ST		ELK		MIC		FOOD		SCI	
	(mm)		(%)		(%)		g/tex^{-1}		(%)		$\mu g/pol^{-1}$		(%)		-	
T1	9,65	a	3,02	a	8,02	a	1,17	a	7,97	a	3,8	a	4	a	48,0	a
T2	9,52	a	2,80	a	8,67	a	0,15	a	8,57	a	3,45		2	a	47,0	a
T3	9,27	a	2,30	a	8,35	a	9,90	a	9,07	a	3,63		2	a	41,5	a
T4	9,08	a	1,80	a	8,80	a	9,50	a	8,77	a	3,57	a	3	a	38,5	a
T5	9,46	a	2,45	a	8,12	a	9,42	a	8,47	a	3,35	a	2	a	44,0	a

T6	8,70	a	2,27	a	8,65	a	9,80	a	8,85	a	3,77	a	3	a	38,8	a
T7	9,46	a	1,37	a	8,52	a	0,22	a	8,62	a	3,52	a	2	a	39,8	a
T8	9,46	a	2,47	a	8,40	a	0,00	a	8,60	a	3,58	a	2	a	43,3	a
T9	9,84	a	2,62	a	8,30	a	0,20	a	8,50	a	3,63	a	3	a	44,3	a
T10	0,22	a	3,82	a	7,97	a	0,02	a	8,60	a	3,47	a	2	a	52,5	a
T11	9,19	a	2,72	a	8,77	a	9,80	a	8,40		3,43	a	2	a	50,0	a
T12	8,72	a	1,30	a	8,60	a	9,10	a	8,47	a	3,89	a	5	a	46,5	a
T13	8,90	a	2,57	a	8,80	a	9,00	a	8,62	a	3,66	a	4	a	46,3	a
F	0,12ns		0,23ns		0,24ns		0,65ns		0,18ns		0,46ns		0,10ns		0,42ns	
CV (%)	2,32		1,41		5,95		4,2		4,94		6,09		1,4		5,81	

Averages followed by the same letter in the column do not differ by the Scott Knott test ($p < 0.05$); UHML = Fiber length; UI = Fiber uniformity; SFI = Short fiber index; STR = Fiber strength; ELG = Elongation; MIC = Maicroneer; MAT = Maturation; SCI = Reliability index; ns not significant $p < 0.05$; T1 = Control without any control method; T2 = Control with weeding.; T3 = Pyr (50,4 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T4 = Pyr (50,4 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**; T5 = Tri (2,62 g i.a. ha^{-1})*+ Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*, T6 = Tri (2,62 g i.a. ha^{-1})*+ Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**, T7 = Pyr + Tri (36,4 + 2,25 g i.a ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T8 = Pyr + Tri (36,4 + 2,25 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})** + Gly (1.512 g i.a. ha^{-1})**; T9 = Pyr + Tri (42,0 + 3,0 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})*; T10 = Pyr + Tri (42,0 + 3,0 g i.a. ha^{-1})* + Gly (1.512 g i.a. ha^{-1})**+ Gly (1.512 g i.a. ha^{-1})**; T11 = Pyr + Gly (50,4 + 1.350 g i.a. ha^{-1})* + (-) + Gly* (1.512 g i.a. ha^{-1})*; T12 = Tri + Gly (2,62 +1350 g i.a. ha^{-1})* + (-)* + Gly* (1.512 g i.a. ha^{-1})*, T13 = Pyr + Tri + Gly* (36,4 + 2,25 + 1.350 g i.a. ha^{-1}) + (-) + Gly* (1.512 g i.a. ha^{-1}).

However, in general, all fiber quality standards in the treatments evaluated were close to the universal standards for cotton classification (EMBRAPA, 2006). According to the same author, the main standards are the length of the fiber, from 28 to 31 millimeters, the uniformity of this length, which can vary from 83 to 85%, resistance from 28 to 32 gf/tex, and the micronaire, which varies from 3.5 to 4.9. Thus, the post-emergence herbicide managements applied in this study did not interfere with the final quality of cotton fiber, cultivar DP1857B3RF (Table 8).

FINAL CONSIDERATIONS

The herbicides glyphosate, pyrithiobac-sodium and trifloxysulfuron-sodium, applied in post-emergence, provided efficient weed control in cotton crops with RF technology. The joint use of trifloxysulfuron-sodium and glyphosate in the first application and the triple association between pyrithiobac-sodium, trifloxysulfuron-sodium and glyphosate, provided greater initial injury to the plants, compromising the productive potential of cotton. The combination of pyrithiobac-sodium and glyphosate provided good efficacy in the initial control of weeds without reducing the final plume yield. The application of associated pyrithiobac-sodium and trifloxysulfuron-sodium, followed by sequential application of glyphosate, provided the best weed control combined with the highest increases in cotton seed and fiber production, compared to the treatments in which trifloxysulfuron-sodium was associated with glyphosate and the triple association between the three herbicides, in the first application in post-emergence. Application of glyposate in total area did not present significant influences on production variables, compared to application in directed jet.

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