Revista Ensaios e Ciência
ISSN 1415-6938 e ISSN 2178-695X

DOI: https://doi.org/10.17921/1415-6938.2026v30n2p244-257

Performance of Quizalofop-p-ethyl on Goosegrass Control in Soybean Crop

Desempenho de Quizalofop-p-etíl Sobre o Controle de Capim Pé-de-Galinha na Cultura da Soja

Received on: February 2026
Accepted on: June 2026

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Abstract

The goosegrass (*Eleusine indica*) management represents a significant yield constraint for soybean, particularly in the Matopiba region, where are scarce studies addressing alternatives to glyphosate, such as quizalofop-p-ethyl. Thus, the objective of this study was to evaluate the control and selectivity of quizalofop-p-ethyl doses on goosegrass, applied alone and combined to glyphosate in the soybean post-emergence. The study was conducted in Mata Roma, Maranhão, Brazil, from January to April 2024, using a randomized block design in factorial arrangement 5×2, and four replications. The first factor consisted in quizalofop-p-ethyl doses (0, 25, 50, 75, and 100 g a.i. ha^{-1}), while the second factor included the absence and presence of glyphosate (864 g e.a. ha^{-1}). The spraying was carried out at the V_5 stage of soybean. We evaluated to goosegrass control, as well as soybean population, height, total chlorophyll index, vegetation index (NDVI), and soybean yield. The results of this study support the hypothesis of the existence of glyphosate-resistant goosegrass (EPSPS-inhibiting herbicide), with estimated soybean yield losses of up to 48%. The use of the herbicide quizalofop-p-ethyl demonstrated high selectivity for soybean, causing no phytotoxicity symptoms across different doses and combinations. The use of 50 to 75 g a.i. ha^{-1} of quizalofop-p-ethyl, applied alone or in combination with glyphosate (864 g e.a. ha^{-1}), is recommended as a safe option for post-emergence chemical control of goosegrass.

Keywords: *Eleusine indica* (L.) Gaertn. *Glycine max* (L.) Merril. Glyphosate. Herbicide Resistance. Selectivity.

Resumo

O controle de capim-pé-de-galinha (*Eleusine indica*) é uma relevante lacuna de produtividade da soja, em virtude da ótima adaptação às condições edafoclimáticas brasileiras e do histórico de resistência a herbicidas, como o glifosato. Porém, são escassos estudos que abordam o uso de quizalofop-p-etil para o controle desta espécie em solos arenosos, na fronteira agrícola do Matopiba. Objetivou-se avaliar o controle e seletividade de doses crescentes de quizalofop-p-etil, isolado e combinado com glifosato, sobre o capim pé-de-galinha, em pós-emergência da soja. O estudo foi realizado numa lavoura comercial, situada em Mata Roma, Maranhão, Brasil, entre os meses de janeiro e abril de 2024. O experimento foi delineado em blocos casualizados, sob arranjo fatorial 5x2 e quatro repetições. O primeiro fator consistiu em doses de quizalofop-p-etil (0, 25, 50, 75 e 100 g i.a. ha^{-1}), ao passo que o segundo, abrangeu a ausência e presença de glifosato (864 g e.a. ha^{-1}), ambos aplicados no estádio V_4 da soja. Avaliaram-se o controle de capim pé-de-galinha, bem como, a população, altura, índice de clorofila total, índice de vegetação (NDVI) e produtividade da soja. Os resultados desta pesquisa indicam a presença de populações de capim pé-de-galinha resistentes ao glifosato no estado do Maranhão, as quais apresentam níveis de controle escasso e ocasionam relevantes perdas de produtividade, estimadas em até 48%. O uso do herbicida quizalofop-p-etíl foi altamente seletivo à soja (cv. BMX Dominio IPRO), isolado ou combinado com glifosato. Recomenda-se o uso de 50 a 75 g i.a. ha^{-1} de quizalofop-p-etíl, isolado ou combinado com glifosato (864 g e.a. ha^{-1}), para o eficiente controle de capim pé-de-galinha, em pós-emergência da soja.

Palavras-chave: *Eleusine indica* (L.) Gaertn. *Glycine Max* (L.) Merril. Glifosato. Resistência a Herbicida. Seletividade.

1 Introduction

Soybeans are one of the world's most important agricultural crops. Currently, Bra-zil is the largest soybean producer, with an estimated production of 171 million metric tons, corresponding to approximately 40% of global production (USDA, 2026). The Brazilian ter-ritorial area under soybean cultivation increased from 10 million ha in 1990 to 47 million ha in 2025 (CONAB, 2026); its greatest geographic expansion occurred in transition areas with the Cerrado biome, particularly along the agricultural -frontier of MATOPIBA, which com-prises the states of Maranhão, Tocantins, Piauí, and Bahia (Santos *et al.,* 2025).

The management of glyphosate-resistant weeds is one of the main constraints on soybean yield in this region. Competition with these species affects grain and seed yield and quality and may even compromise soybean be harvesting. Chemical control has been the main strategy adopted for weed management owing to its practicality and short-term effec-tiveness (Silva *et al.,* 2025). However, the indiscriminate use of herbicides may lead to the selection of resistant biotypes and cause serious environmental problems (Adegas *et al.,* 2022).

The literature shows that over the last decade, approximately ten species have de-veloped resistance to glyphosate in soybean production systems, particularly in genetically modified Roundup Ready® varieties, in which this herbicide is generally used exclusively (Procópio *et al.,* 2024; Silva *et al.,* 2024). In this context, goosegrass is considered one of the main glyphosate-resistant weed species in Brazil, causing significant yield losses in differ-ent regions (Alcàntara-de la Cruz *et al.,* 2025; Braz *et al.,* 2025).

Numerous studies suggest that the replacement and/or combination of glyphosate with herbicides that inhibit the enzyme acetyl-CoA carboxylase (ACCase) enhances the con-trol of weed species belonging to the family Poaceae (Jhala *et al.,* 2025), such as goosegrass, and is a key component for its effective management (Santos *et al.,* 2024). In this regard, studies evaluating the performance of quizalofop-p-ethyl, applied alone or in combination with glyphosate, for the post-emergence control of goosegrass in soybean crops are scarce, particularly in the MATOPIBA region.

Quizalofop-p-ethyl is a herbicide belonging to the aryloxyphenoxypropionic acid chemical group that acts as an inhibitor of fatty acid and lipid synthesis. It is applied post-emergence to control perennial and annual weed species of the Poaceae family and is an im-portant tool for the selective post-planting control of grasses in soybean crops (Azlan; Kam-Arudin; Chuah, 2025).

Therefore, we hypothesized that populations of goosegrass resistant to glyphosate, which is an inhibitor of the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS), were present in commercial soybean fields in the eastern mesoregion of Maranhão. The con-tinuous and often exclusive use of glyphosate, applications performed at advanced develop-mental stages of the weed, and lack of herbicide mixtures may have contributed to the selec-tion of these biotypes. However, the use of quizalofop-p-ethyl at appropriate rates is likely to be effective in controlling these resistant populations.

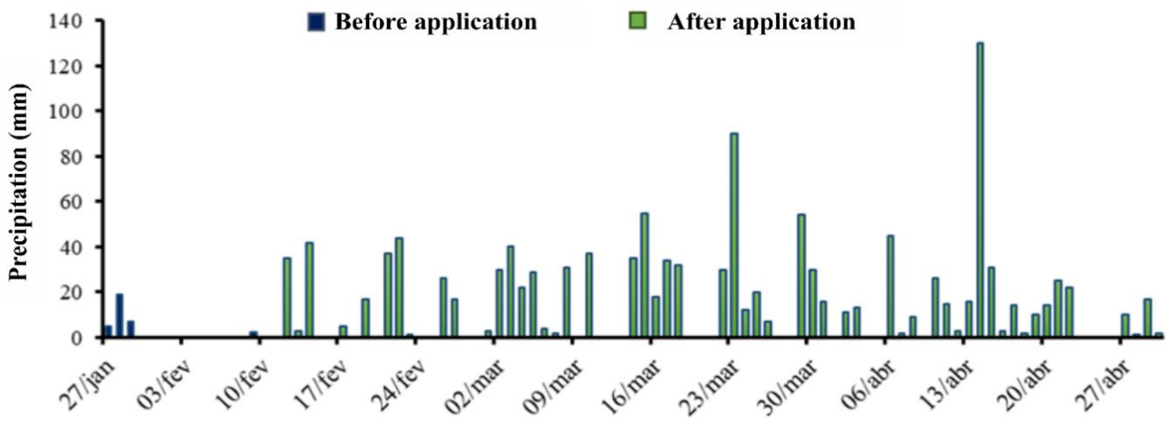
Given the above, we aimed to evaluate the control efficacy and selectivity of increas-ing rates of quizalofop-p-ethyl, applied alone or in combination with glyphosate, for the management of goosegrass in post-emergence soybean crops.

2 Material and Methods

2.1 Location of the experimental area

The experiment was conducted in a commercial soybean field in the municipality of Mata Roma (3°14′50″ S, 43°11′13″ W), Maranhão, Brazil between January and April 2024. The climate in the municipality is classified as tropical hot and humid (Aw), with an average annual temperature above 27 °C and mean annual precipitation of 1,800 mm, concentrated between January and June (Alvares *et al.,* 2013). Precipitation during the experimental period was recorded using a rain gauge installed in the experimental plot. These data are presented in Figure 1.

Figure 1 - Rainfall data recorded by a rain gauge positioned in the experimental plot, Mata Roma, Maranhão, Brazil, 2024



Source: research data.

The experimental area was selected based on its history of successive glyphosate use for at least 10 years and suspected occurrences of glyphosate-resistant populations of goose-grass. The soil in the experimental area was classified as a typical dystrocohesive Yellow Ultisol (Santos *et al.,* 2018). Its chemical properties are described in Table 1.

Table 1 - Soil chemical analysis of the experimental plot at depths of 0–10 cm and 10–20 cm. Mata Roma, Maranhão, Brazil, 2024

Depth	pH	M.O	P	K	Ca	Mg	Al	H+Al	SB	CTC	V
(cm)	($CaCl_2$)	(%)	(mg dm^{-3})				(cmolc dm^{-3})				%
0 - 10	5,2	1,3	1,9	0,06	1,4	0,5	0,0	1,6	2,0	3,6	54,0
10 - 20	4,9	0,9	1,8	0,03	1,2	0,4	0,0	1,9	1,6	3,5	47,0

Source: research data.

During the off-season, between May and December 2023, the plot was cultivated with millet (cv. ADR 300) at a seeding density of 20 kg of seeds per ha; sowing was per-formed by broadcasting. Seven days before planting, desiccation was performed using glyphosate (1,152 g a.e. ha^{-1} – Templo). At planting, pyroxasulfone + flumioxazin were ap-plied (90 g a.e. ha^{-1} + 60 g a.i. ha^{-1} – Kyojin). The soybean cultivar used was BMX Dominio IPRO, with an estimated plant population of 320,000 plants ha^{-1}.

2.2 Treatments and experimental design

The experiment was conducted in a randomized complete block design under a 5 × 2 factorial arrangement with four replications (Figure 2). The first factor consisted of increasing rates of quizalofop-p-ethyl (Targa Max): 0, 25, 50, 75, and 100 g a.i. ha^{-1}. The second factor consisted of the absence or presence of glyphosate (Templo) at a rate of 864 g a.e. ha^{-1}. Each experimental unit occupied an area of 18 m² (6 m × 3 m).

Figure 2 - Layout of the experimental area. Image acquired using a remotely piloted aircraft (DJI Phantom 4). Mata Roma, Maranhão, Brazil, 2024

Source: research data.

The treatments were applied at the V4 soybean growth stage (24 days after sowing) using a CO_2-pressurized backpack sprayer calibrated to deliver 150 L ha^{-1} at a pressure of 200 kPa. At the time of application, goosegrass plants were at the vegetative stage, with two to six leaves per plant. Applications were carried out between 08:00 and 09:00 a.m. under a temperature of 30 °C, relative humidity of 81%, and wind speed of 5.7 km h^{-1}, which were all measured using a thermo-hygro-anemometer and in accordance with ISO 5682-1:1996 standards.

2.3 Variables analyzed

Control of goosegrass was visually evaluated at 15, 30, 45, and 75 days after treatment (DAT) by comparison with the untreated control using a percentage scale ranging from 0% to 100%, following the standards established by the Brazilian Weed Science Society (SBCPD, 1995). The levels of control were classified as none or poor (0–40%), fair (41–60%), sufficient (61–70%), good (71–80%), very good (81–90%), and excellent (91–100%). Only treatments achieving control levels equal to or greater than 80% (C ≥ 80%) were considered effective.

The selectivity of the herbicides on the soybean crop was visually evaluated according to the scale proposed by the European Weed Research Community (EWRC, 1964), which uses phytotoxicity scores ranging from 1 (no injury) to 9 (plant death). Additionally, the Normalized Difference Vegetation Index (NDVI) and total chlorophyll content were measured in soybean plants at 15, 30, 45, and 75 DAT using the portable meters GreenSeeker and ClorofiLOG, respectively (Figure 3).

Figure 3 - Photographic record of the experimental evaluations. A) Visual control assessments. B) Measurement of the NDVI index using GreenSeeker. C) Measurement of total chlorophyll index using ClorofiLOG. Mata Roma, Maranhão, Brazil, 2024

Source: research data.

2.4 Statistical analysis

The data were subjected to residual normality testing (Shapiro–Wilk, $p \leq 0.05$) and analysis of variance (F-test); when significant effects were detected ($p \leq 0.05$), means were compared using the Scott–Knott test.

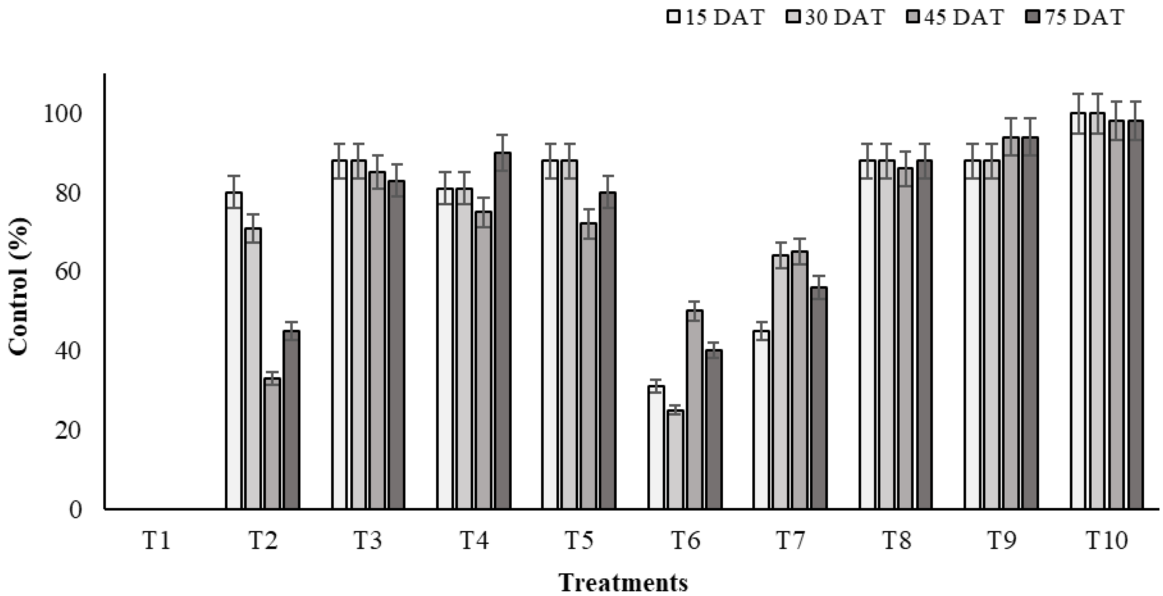
3 Results and Discussion

3.1 Weed control

Control of goosegrass was influenced by treatments across the different evaluation periods (Figure 4). Quizalofop-p-ethyl applied alone showed consistent performance at rates of 50, 75, and 100 g a.i. ha^{-1}, with control levels above 70% across all evaluation periods, reaching 90% control at 75 DAT with 75 g a.i. ha^{-1}. In contrast, the rate of 25 g a.i. ha^{-1} provided only 35% control at 75 DAT. Glyphosate applied alone showed low control levels (25–50%) throughout the evaluation periods. Its mixture with quizalofop-p-ethyl increased control efficiency for most treatment combinations. When combined with 50, 75, and 100 g a.i. ha^{-1} of quizalofop-p-ethyl, control percentages remained above

80% throughout the evaluation period. Conversely, the mixture with 25 g a.i. ha^{-1} showed intermediate performance (45–65%).

Figure 4 - Percentage control of Goosegrass at 15, 30, 45, and 75 days after treatment application in post-emergence soybean. Mata Roma, Maranhão, Brazil, 2024



Abbreviations: T1 = control (no herbicide); T2 = quizalofop-p-ethyl (25 g a.i. ha^{-1}); T3 = quizalofop-p-ethyl (50 g a.i. ha^{-1}); T4 = quizalofop-p-ethyl (75 g a.i. ha^{-1}); T5 = quizalofop-p-ethyl (100 g a.i. ha^{-1}); T6 = glyphosate (864 g a.e. ha^{-1}); T7 = glyphosate (864 g a.e. ha^{-1}) + quizalofop-p-ethyl (25 g a.i. ha^{-1}); T8 = glyphosate (864 g a.e. ha^{-1}) + quizalofop-p-ethyl (50 g a.i. ha^{-1}); T9 = glyphosate (864 g a.e. ha^{-1}) + quizalofop-p-ethyl (75 g a.i. ha^{-1}); T10 = glyphosate (864 g a.e. ha^{-1}) + quizalofop-p-ethyl (100 g a.i. ha^{-1}); DAT = days after treatment application.
Source: research data.

The association of glyphosate with 100 g a.i. ha^{-1} of quizalofop-p-ethyl was the most effective treatment, maintaining excellent control from the initial evaluations to near harvest. In contrast, the low efficiency of glyphosate applied alone supports the hypothesis of goosegrass populations resistant to EPSPS-inhibiting herbicides in the study region.

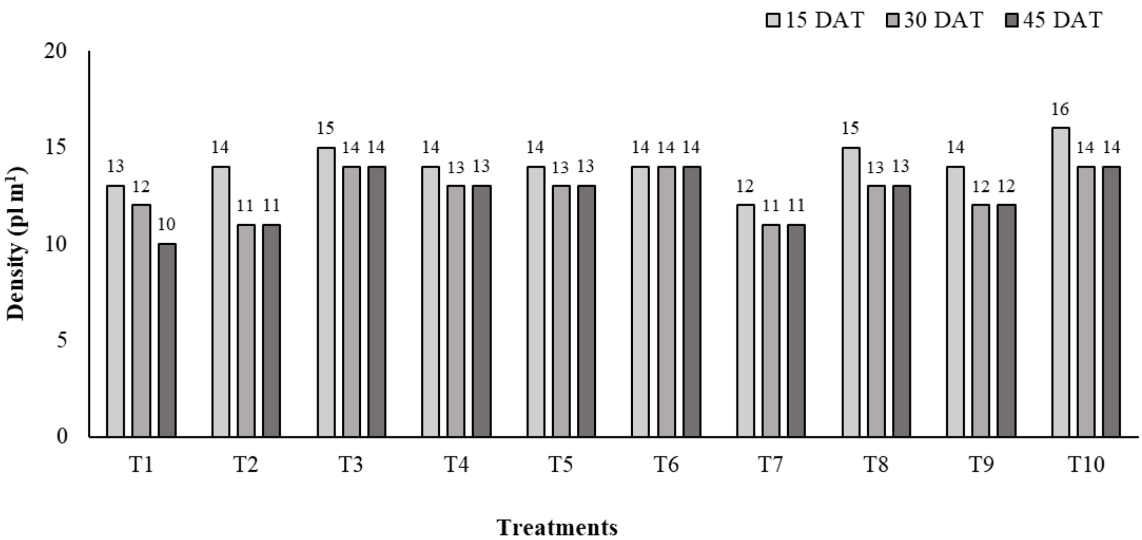
Regarding the low efficacy of the glyphosate mixture with 25 g a.i. ha^{-1}, evidence suggests that sublethal doses of ACCase-inhibiting herbicides do not ensure adequate control throughout the soybean growing cycle. There are reports of multiple resistance in goosegrass to EPSPS and ACCase inhibitors in Brazil. However, the evaluated population remained susceptible to quizalofop-p-ethyl, possibly owing to low selection pressure from this herbicide in the area, where the use of clethodim has been predominant over the years, according to the farmer.

Although both herbicides act by inhibiting ACCase, aryloxyphenoxypropionates and cyclohexanediones differ in their efficacy in controlling grass weeds (Chen *et al.,* 2021). Thus, the high control levels obtained with 75 and 100 g a.i. ha⁻¹ in combination with glyphosate corroborate the findings reported by Vilela et al. (2019), whereas the low efficacy of glyphosate applied alone reinforces regional reports of control failures and the empirical use of increased application rates. This practice intensifies selection pressure and increases the risk of resistance evolution, highlighting the importance of rotating modes of action and the judicious use of herbicide mixtures for the sustainable management of herbicide-resistant weeds.

3.2 Soybean growth and productivity

The final soybean stand was influenced by the periods of coexistence with and con-trol of goosegrass, with a 29% reduction in plant population in the untreated control (no herbicide application). The application of quizalofop-p-ethyl, either alone or in mixture with glyphosate, maintained a relatively stable soybean stand, which was higher than that of the untreated control, ranging from 160,000 plants ha^{-1} at 15 DAT to 110,000 plants ha^{-1} at 45 DAT (Figure 5).

Figure 5 - Soybean density (plant m^{-1}) at 15, 30, and 45 days after treatment application, Mata Roma, Maranhão, Brazil, 2024



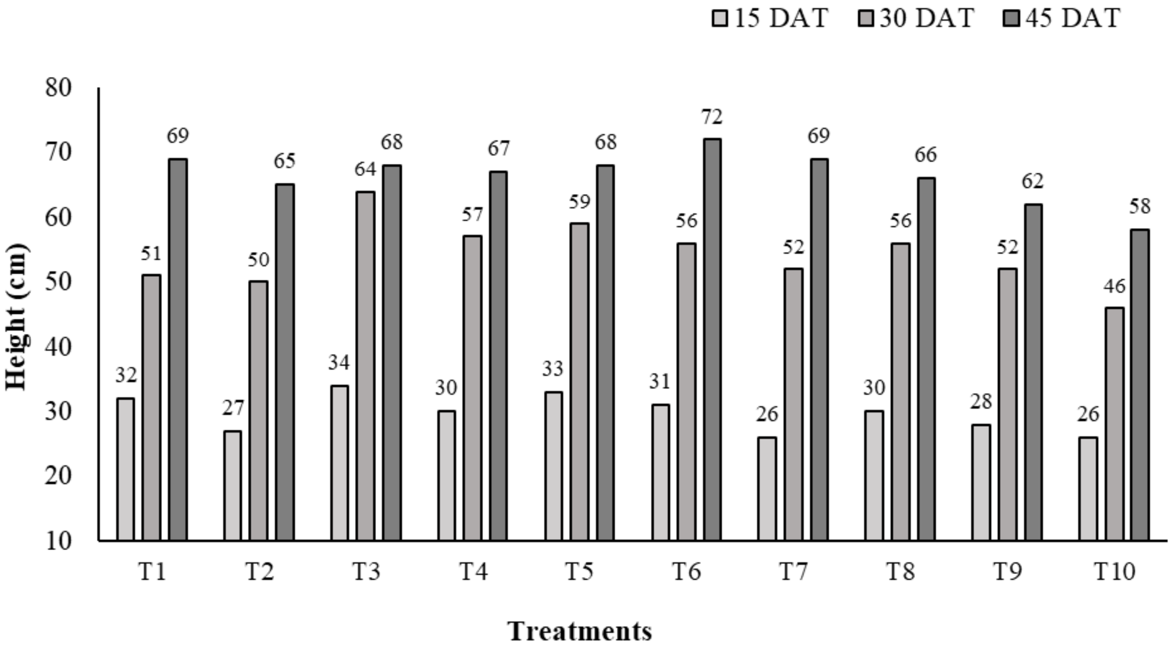
Abbreviations: T1 = control (no herbicide); T2 = quizalofop-p-ethyl (25 g a.i. ha^{-1}); T3 = quizalofop-p-ethyl (50 g a.i. ha^{-1}); T4 = quizalofop-p-ethyl (75 g a.i. ha^{-1}); T5 = quizalofop-p-ethyl (100 g a.i. ha^{-1}); T6 = glyphosate (864 g a.e. ha^{-1}); T7 = glyphosate (864 g a.e. ha^{-1}) + quizalofop-p-ethyl (25 g a.i. ha^{-1}); T8 = glyphosate (864 g a.e. ha^{-1}) + quizalofop-p-ethyl (50 g a.i. ha^{-1}); T9 = glyphosate (864 g a.e. ha^{-1}) + quizalofop-p-ethyl (75 g a.i. ha^{-1}); T10 = glyphosate (864 g a.e. ha^{-1}) + quizalofop-p-ethyl (100 g a.i. ha^{-1}); DAT = days after treatment application.
Source: research data.

The maintenance of soybean plant density in the chemically controlled treatments indicated that the reduction observed in the untreated control was associated with competition from goosegrass rather than with phytotoxic effects of the herbicides on the crop. Similar results were reported by

Furtado *et al.* (2025) and Ponte *et al.* (2024), who highlighted the importance of combining herbicides with different modes of action as an effective strategy for managing glyphosate-tolerant/resistant weed species.

Soybean plant height was influenced by the period of coexistence with and control of weeds. The most pronounced results were observed in the untreated control (69 cm) and treatment with glyphosate applied alone (72 cm) at 45 DAT (Figure 6).

Figure 6 - Soybean height (cm) at 15, 30, and 45 days after treatment application, Mata Roma, Maranhão, Brazil, 2024

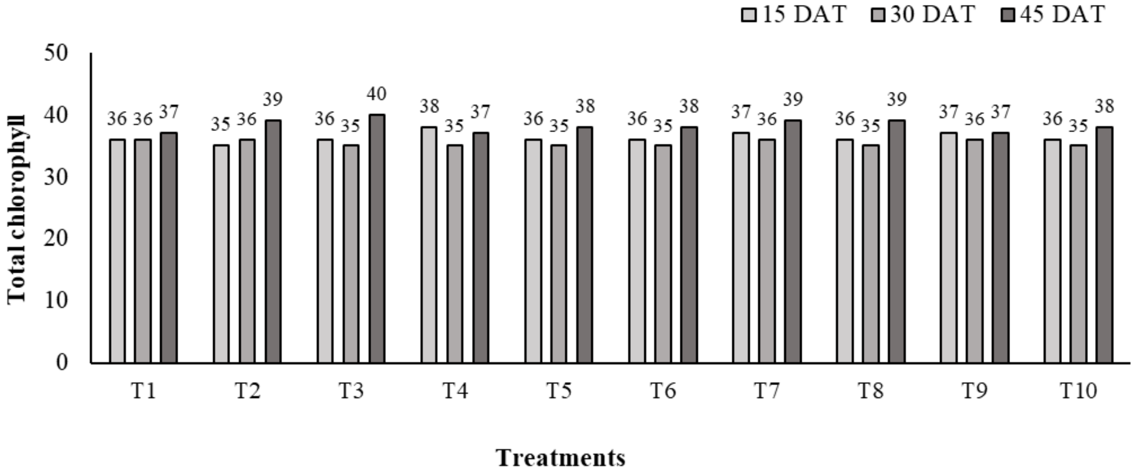


Abbreviations: T1 = Control (without herbicide); T2 = Quizalofop-p-ethyl (25 g a.i. ha⁻¹); T3 = Quizalofop-p-ethyl (50 g a.i. ha⁻¹); T4 = Quizalofop-p-ethyl (75 g a.i. ha⁻¹); T5 = Quizalofop-p-ethyl (100 g a.i. ha⁻¹); T6 = Glyphosate (864 g a.e. ha⁻¹); T7 = Glyphosate (864 g a.i. ha⁻¹) + Quizalofop-p-ethyl (25 g a.i. ha⁻¹); T8 = Glyphosate (864 g a.e. ha⁻¹) + Quizalofop-p-ethyl (50 g a.i. ha⁻¹); T9 = Glyphosate (864 g a.e. ha⁻¹) + Quizalofop-p-ethyl (75 g a.i. ha⁻¹); T10 = Glyphosate (864 g a.e. ha⁻¹) + Quizalofop-p-ethyl (100 g a.i. ha⁻¹); DAT – days after treatment application.
Source: research data.

The increase in plant height observed in the untreated control was not associated with superior vegetative vigor. Instead, it was caused by competition-induced etiolation in soy-bean plants. This behavior is characteristic of soybean plants under prolonged shading and occurs from the early growth stages, when the crop detects changes in the quality of incident light (Braz *et al.,* 2021).

In contrast, total chlorophyll values showed little variation among treatments, remaining between 35 and 40 units, with no significant effect of quizalofop-p-ethyl rates, alone or in mixture with glyphosate, throughout the evaluation period (Figure 7).

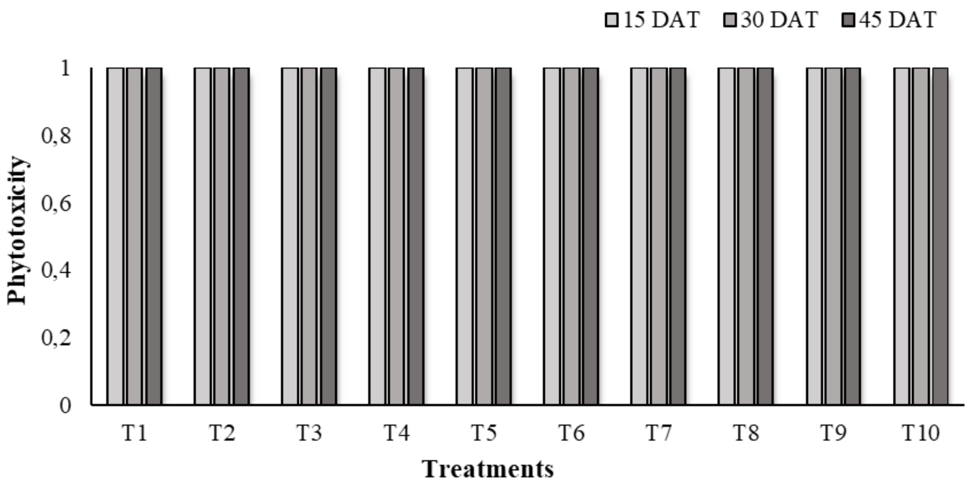
Figure 7 - Total chlorophyll index of soybeans, at 15, 30 and 45 days after treatment application, Mata Roma, Maranhão, Brazil, 2024



Abbreviations: T1 = Control (without herbicide); T2 = Quizalofop-p-ethyl (25 g a.i. ha^{-1}); T3 = Quizalofop-p-ethyl (50 g a.i. ha^{-1}); T4 = Quizalofop-p-ethyl (75 g a.i. ha^{-1}); T5 = Quizalofop-p-ethyl (100 g a.i. ha^{-1}); T6 = Glyphosate (864 g a.e. ha^{-1}); T7 = Glyphosate (864 g a.i. ha^{-1}) + Quizalofop-p-ethyl (25 g a.i. ha^{-1}); T8 = Glyphosate (864 g a.e. ha^{-1}) + Quizalofop-p-ethyl (50 g a.i. ha^{-1}); T9 = Glyphosate (864 g a.e. ha^{-1}) + Quizalofop-p-ethyl (75 g a.i. ha^{-1}); T10 = Glyphosate (864 g a.e. ha^{-1}) + Quizalofop-p-ethyl (100 g a.i. ha^{-1}); DAT – days after treatment application.
Source: research data.

The stability of chlorophyll indices indicates the absence of physiological injury to soybeans caused by the applied herbicides, reinforcing the high selectivity of quizalofop-p-ethyl, alone or in mixture, to the soybean crop. In this regard, all treatments received an av-erage score of 1.0 in the visual phytotoxicity assessment, indicating the absence of herbicide injury symptoms in the soybean crop (Figure 8).

Figure 8 - Visual phytotoxicity scores in soybean crops at 15, 30, and 45 days after treatment application. Mata Roma, Maranhão, Brazil, 2024



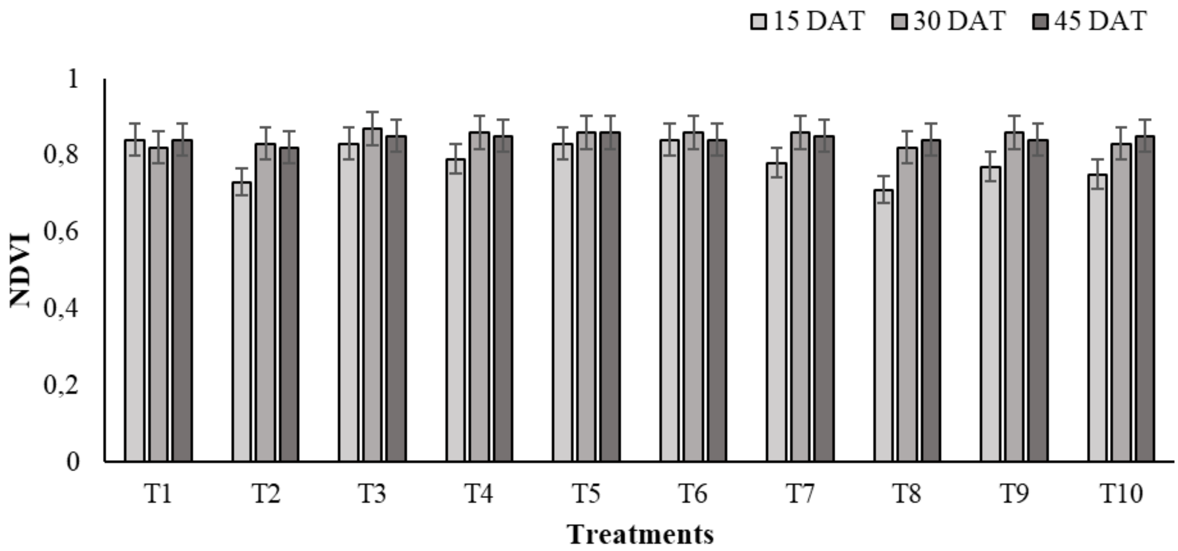
Abbreviations: T1 = Control (without herbicide); T2 = Quizalofop-p-ethyl (25 g a.i. ha^{-1}); T3 = Quiza-lofop-p-ethyl (50 g a.i. ha^{-1}); T4 = Quizalofop-p-ethyl (75 g a.i. ha^{-1}); T5 = Quizalofop-p-ethyl (100 g a.i. ha^{-1}); T6 = Glyphosate (864 g a.e. ha^{-1}); T7 = Glyphosate (864 g a.i. ha^{-1}) + Quizalofop-p-ethyl (25 g a.i. ha^{-1}); T8 = Glyphosate (864 g a.e. ha^{-1}) + Quizalofop-p-ethyl (50 g a.i. ha^{-1}); T9 = Glyphosate (864 g a.e. ha^{-1}) + Quizalofop-p-ethyl (75 g a.i. ha^{-1}); T10 = Glyphosate (864 g a.e. ha^{-1}) + Quizalofop-p-ethyl (100 g a.i. ha^{-1}); DAT – days after treatment application.

Source: research data.

The absence of visual phytotoxicity is consistent with the total chlorophyll results and confirms the selectivity of the evaluated herbicides. These results are consistent with those of Yu et al. (2021), who also reported high selectivity of quizalofop-p-ethyl when applied post-emergence in soybeans.

NDVI readings at 15 DAT indicated similar values between the untreated control and certain less effective weed control treatments, whereas the most effective treatments showed relatively high vegetation cover indices (Figure 9).

Figure 9 - NDVI index in the soybean canopy at 15, 30, and 45 days after treatment application. Mata Roma, Maranhão, Brazil, 2024

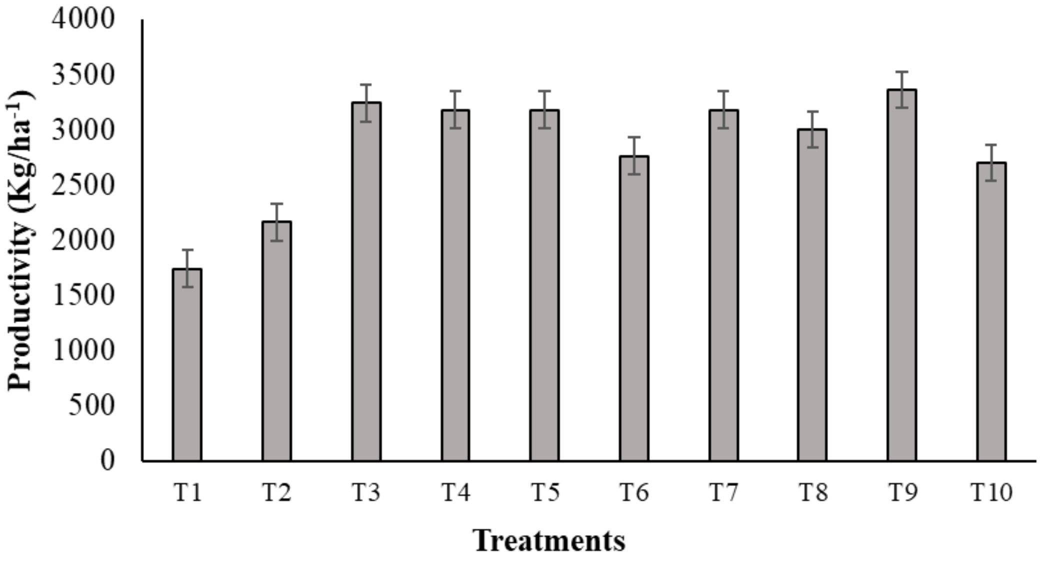


Abreviações: T1 = Testemunha (sem herbicida); T2 = Quizalofop-p-etíl (25 g i.a. ha^{-1}); T3 = Quizalofop-p-etíl (50 g i.a. ha^{-1}); T4 = Quizalofop-p-etíl (75 g i.a. ha^{-1}); T5 = Quizalofop-p-etíl (100 g i.a. ha^{-1}); T6 = Glifosato (864 g e.a. ha^{-1}); T7 = Glifosato (864 g e.a. ha^{-1}) + Quizalofop-p-etíl (25 g i.a. ha^{-1}); T8 = Glifosato (864 g e.a. ha^{-1}) + Quizalofop-p-etíl (50 g i.a. ha^{-1}); T9 = Glifosato (864 g e.a. ha^{-1}) + Quizalofop-p-etíl (75 g i.a. ha^{-1}); T10 = Glifosato (864 g e.a. ha^{-1})+ Quizalofop-p-etíl (100 g i.a. ha^{-1}); DAT – dias após a aplicação dos tratamentos.
Source: research data.

In the less effective treatments, NDVI variations reflect the vegetation cover resulting from competition with goosegrass. In contrast, in the most effective treatments, elevated NDVI values are associated with increased soybean biomass, which results from effective weed control.

Soybean yield was affected by interference from goosegrass. In the absence of chemical control, the yield was estimated at 1,740 kg ha^{-1}. The application of quizalofop-p-ethyl increased yields to values ranging from 3,180 to 3,240 kg ha^{-1} at rates of 50, 75, and 100 g a.i. ha^{-1}. When combined with glyphosate and 75 g a.i. ha^{-1} of quizalofop-p-ethyl, the highest yield of 3,360 kg ha^{-1} was obtained (Figure 10).

Figure 10 - Soybean yield under different post-emergence herbicide treatments for the control of Goosegrass. Mata Roma, Maranhão, Brazil, 2024



Abreviações: T1 = Testemunha (sem herbicida); T2 = Quizalofop-p-etíl (25 g i.a. ha^{-1}); T3 = Quizalofop-p-etíl (50 g i.a. ha^{-1}); T4 = Quizalofop-p-etíl (75 g i.a. ha^{-1}); T5 = Quizalofop-p-etíl (100 g i.a. ha^{-1}); T6 = Glifosato (864 g e.a. ha^{-1}); T7 = Glifosato (864 g e.a. ha^{-1}) + Quizalofop-p-etíl (25 g i.a. ha^{-1}); T8 = Glifosato (864 g e.a. ha^{-1}) + Quizalofop-p-etíl (50 g i.a. ha^{-1}); T9 = Glifosato (864 g e.a. ha^{-1}) + Quizalofop-p-etíl (75 g i.a. ha^{-1}); T10 = Glifosato (864 g e.a. ha^{-1})+ Quizalofop-p-etíl (100 g i.a. ha^{-1}); DAT – dias após a aplicação dos tratamentos.
Source: research data.

The significant yield loss observed in the untreated control and glyphosate-only treatment corroborates the importance of a sustainable management strategy for goosegrass. Otherwise, this may negatively affect profitability and reduce the prospects for farmers to remain in agricultural production. Given this condition, the use of quizalofop-p-ethyl at rates of 50 to 100 g a.e. ha^{-1} represents an effective strategy for combination or rotation with glyphosate for the post-emergence control of goosegrass in soybean crops.

4 Conclusion

Quizalofop-p-ethyl is highly selective for soybeans (cv. BMX Dominio IPRO) when applied alone or in combination with glyphosate. For effective post-emergence control of goosegrass in soybeans, the use of 50–75 g a.i. ha^{-1} of quizalofop-p-ethyl is recommended, either alone or in combination with glyphosate (864 g a.e. ha^{-1}).0

References

ADEGAS, F.S. *et al.* Glyphosate-resistant (GR) soybean and corn in Brazil: past, present, and future.

Adv. Weed Sci., v.40, p.e0202200102, 2022. doi: doi.org/10.51694/AdvWeedSci/2022;40:seventy-five004

ALCÁNTARA-DE LA CRUZ, R. *et al.* The rise of *Eleusine indica* as Brazil's most troublesome weed. *Agronomy*, v.15, n.8, art. 1759, 2025. doi: doi.org/10.3390/agronomy15081759

ALVARES, C.A. *et al.* Köppen's climate classification map for Brazil. *Meteorol. Z.,* v.22, p.711-728, 2013. doi.org/10.1127/0941-2948/2013/0507

AZLAN, M.I.; KAMARUDIN, K.N.; CHUAH, T.-S. Preliminary investigation of multiple resistance in goosegrass (Eleusine indica) to premix of diuron and MSMA, glyphosate, clethodim, *quizalofop-p-etil* in Malaysia. *Adv. Weed Sci*., v.43, p.e020250119, 2025. doi: doi.org/10.51694/AdvWeedSci/2025;43:00016

BRAZ, G.B.P. *et al.* Sourgrass interference on soybean grown in Brazilian Cerrado. *Rev. Caatinga*, v. 34, n. 2, p. 350–358, 2021. doi: doi.org/10.1590/1983-21252021v34n211rc

CHEN, J. *et al*. Characterization of glyphosate and quizalofop-p-ethyl multiple resistance in Eleusine indica. Pestic. Biochem. *Physiol.*, v.176, p.104862, 2021. doi: doi.org/10.1016/j.pestbp.2021.104862

CONAB- Companhia Nacional de Abastecimento. *Safra – Série Histórica dos Grãos*. Brasília: CONAB, 2026.

EWRC - European Weed Research Council. Report of the 3rd and 4th meetings of EWRC. Committee of Methods in Weed Research. *Weed Res*., v.4, p.88, 1964.

FURTADO, J.A.L. *et al.* Uso de herbicidas residuais para o manejo de plantas daninhas tolerantes a glifosato no cerrado maranhense. *Rev Cient. Multidisc. Núcleo Conhec.*, v.2, p.24-40, 2025. doi: doi.org/10.32749/nucleodoconhecimento.com.br/agronomia/manejo-de-plantas

JHALA, A.J. *et al.* Acetyl-CoA carboxylase (ACCase)-inhibiting herbicides: Past, present, and future. *Weed Technol.*, v.40, p.1-45, 2025. doi: doi.org/10.1017/wet.2025.10073.

PONTE, I.S. *et al.* Aerial survey and glyphosate-resistant weeds control before soybean seeding. *Aust. J. Crop Sci.,* v.18, p.29-36, 2024. doi.org/ 10.21475/ajcs.24.18.01.p4019

PROCÓPIO, S.O. *et al*. Impacts of weed resistance to glyphosate on herbicide commercialization in Brazil. *Agriculture*, v.14, n.12, p.2315, 2024. doi: doi.org/10.3390/agriculture14122315

SANTOS, C.A.F. *et al.* Performance of lipophilic pre-emergence herbicides in no-till and conventional soybean cultivation systems. Ensaios Ciênc., v.29, p.978-994, 2025. doi: https://doi.org/10.17921/1415-6938.2025v29n4p978-994

SANTOS, H. G. *et al.* Sistema Brasileiro de Classificação de Solos. Rio de Janeiro: Embrapa Solos, 2018.

SANTOS, M.S. *et al.* Weed phytosociology survey in a Brazilian native pineapple, variety Turiaçu. *Aust. J. Crop Sci.,* p.460-465, 2024. doi: doi.org/10.21475/ajcs.24.18.08.p4083

SBCPD- Sociedade Brasileira da Ciência das Plantas Daninhas. Procedimentos para instalação, avaliação e análise de experimentos com herbicidas. Londrina: SBCPD, 1995.

SILVA, L.R.D *et al.* Glyphosate-Resistant Weeds Control with Double-Shooting in Soybean Pre-Planting. *Rev Ensaios e Ciênciae*, v.29, n.3, p.655-669, 2025. doi: doi.org/10.17921/1415-6938.2025v29n3p655-669

SILVA, M.M. *et al.* Pre-emergence herbicides effects in no-till soybean system with pani-cum maximum "BRS Tamani." *Aust. J. Crop Sci.,* v.18, p.21-28, 2024. doi: doi/10.3316/informit.T2024041400004200976814058

USDA- United States Department of AgriculturE. Foreign Agricultural Service. *Production – Soybeans*. Washington: USDA, 2025.

YU, X. *et al.* Effects of the herbicides quizalofop-p-ethyl and quizalofop-p-ethyl on the physiology, oxidative damage, synthesis, and release of microcystin-LR in Microcystis aeruginosa. *Sci. Total Environ*., v.776, p.146036, 2021. doi.org/10.1016/j.scitotenv.2021.146036