

# Evaluation of pre-emergent herbicides for weed control in cotton (*Gossypium hirsutum* L.)

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## ABSTRACT

**Objective:** To assess the efficacy of various pre-emergence herbicides for weed control in conventional cotton crops under the environmental and agronomic conditions of Chihuahua State, Mexico, aiming to identify alternatives that minimize dependence on repeated applications and extend the duration of control.

**Design/Methodology/Approach:** The trial was conducted at the Delicias Experimental Station (INIFAP) using a randomized complete block design with four replications. Four pre-emergence herbicides Fomesafen, Trifluralin, S-Metolachlor, and Pendimethalin alongside three controls (glyphosate [regional standard], cultural control, and an untreated weedy check) were evaluated across seven conventional cotton varieties. Weed control was measured at 15, 21, 30, 40, and 50 days after application (DAA), employing the European Weed Research Society (EWRS) rating scale.

**Results:** Fomesafen, Trifluralin, and S-Metolachlor achieved over 96.5% control within the first 30 days, categorized as “very good control.” Although efficacy declined by 50 DAA, it remained above 85%. Pendimethalin exhibited strong initial control but its effectiveness diminished more rapidly. Glyphosate demonstrated moderate control, which significantly declined by 30 DAA. The untreated checks showed poor to negligible weed suppression.

**Limitations/Implications:** The study evaluated only a single herbicide application per cropping cycle, without incorporating post-emergence or sequential pre-emergence treatments, thereby limiting the scope for evaluating long-term integrated weed management strategies.

**Findings/Conclusions:** The tested pre-emergence herbicides provided effective weed control during cotton’s critical competition period. Their integration into broader weed management programs is recommended to delay the onset of herbicide resistance and enhance overall control efficacy.

**Keywords:** Cotton, Weeds, Control, Herbicides.



## INTRODUCTION

Mexico has a total of 133,691 hectares dedicated to cotton cultivation, resulting in an annual yield of approximately 604,128 tons of cotton (FAOSTAT, 2023). Among Mexican states, Chihuahua stands out as the leading producer, with 97,460 hectares under cultivation, generating around 454,703 tons annually accounting for an impressive 75.27% of the national production (SIAP, 2023). When weeds are not effectively controlled, they can cause substantial yield reductions due to direct competition for light, nutrients, space, and water (Gao & Su, 2024). In cotton cultivation, yield losses may range from 10% to 90%, depending on infestation severity (Pala & Mennan, 2016). Currently, genetically modified cotton varieties used by producers contain genes that confer tolerance to specific herbicides such as glyphosate, glufosinate-ammonium, and dicamba.

This allows for the application of these herbicides without damaging the crop while effectively eliminating weeds (Nida *et al.*, 1996; Santamarta, 2004). However, the widespread use of these technologies has led to increased reliance on herbicides, placing substantial selective pressure on weed populations, ultimately resulting in the evolution of herbicide-resistant biotypes (Owen & Zelaya, 2005). In this regard, Heap (2025) reports that some weed species have developed resistance to 21 of the 31 known herbicide modes of action, encompassing resistance to 168 different active ingredients. Therefore, it is essential to evaluate alternative herbicidal molecules capable of protecting cotton crops during their critical weed competition period typically between 30 and 60 days after germination while also reducing the number of required applications (Pala & Mennan, 2019).

## MATERIALS AND METHODS

To identify the most effective pre-emergence herbicides for weed control in conventional cotton, an experimental plot was established at the Delicias Experimental Station (INIFAP-CEDEL), located in Ciudad Delicias, Chihuahua. The study involved the evaluation of four commercial herbicides Fomesafen, Trifluralin, S-Metolachlor, and Pendimethalin —and three control treatments: a regional standard (glyphosate), a cultural control (manual hoeing), and an untreated weedy check. Each treatment was replicated four times. Seven conventional cotton varieties (Cian 95, Cian Precoz, Nazas, Laguna, Juárez 91, Fibermax<sup>®</sup>, and Deltapine<sup>®</sup>) were sown on May 9, 2024, at a row spacing of 76 cm and a plant density of 12 plants per m<sup>2</sup>. The experimental design followed a randomized complete block structure, with each experimental unit covering an area of 12.16 m<sup>2</sup> (4 m in length × 3.04 m in width). The predominant weed species were identified after the emergence of the first weed generation through sampling within the weedy check plots using fixed quadrants measuring 25 × 50 cm. Herbicide applications were performed using a constant-pressure backpack sprayer equipped with a TeeJet 8001 nozzle, operating at 2.7 bar and delivering a flow rate of 120 L ha<sup>-1</sup> at a speed of 4 km h<sup>-1</sup>.

After the application of pre-emergence herbicides, irrigation was applied to activate the compounds. Post-emergence herbicides were applied once weeds emerged and reached a height of less than 10 cm. The cultural control consisted of manual hoeing along the crop rows. Weed control efficacy was assessed at 15, 21, 30, 40, and 50 days after application (DAA), using the European Weed Research Society (EWRS) rating scale, which ranges

from 0.0% (“no effect”) to 100.0% (“complete plant death”) (Table 1) (Champion, 2000). The collected data were subjected to analysis of variance (ANOVA), and treatment means were compared using Tukey’s test ( $p=0.05$ ) in the SAS statistical software, version 9.4 (SAS, 2011).

## RESULTS AND DISCUSSION

Initial sampling allowed for the identification of the predominant weed species in the study area, which included golden crownbeard (*Verbesina encelioides* Cav. A. Gray), puncturevine (*Tribulus terrestris* L.), Palmer amaranth (*Amaranthus palmeri* S. Watson), clustered flaveria (*Flaveria trinervia* Spreng. C. Mohr), jungle rice (*Echinochloa colona* L. Link), Russian thistle (*Salsola kali* L.), and morning glory (*Ipomoea* spp.). All evaluated pre-emergence herbicide treatments caused only mild phytotoxicity symptoms in cotton plants. Chlorosis symptoms did not exceed 3%, and no statistically significant differences were observed among treatments in terms of phytotoxicity, weed control efficacy, or yield across the seven cotton varieties (data not shown). However, significant differences were recorded among herbicide treatments, which maintained high control levels up to 40 days after application (DAA) (Table 2).

According to the European Weed Research Society (EWRS) rating scale, Fomesafen, Trifluralin, and S-Metolachlor provided “very good control” during the first 30 DAA, with efficacy rates exceeding 96.5%. Nevertheless, these values gradually declined over time, reaching “adequate control” by 50 DAA. Fomesafen maintained 87.5% control, consistent with Cahoon *et al.* (2015), who reported 89-93% control at 45 DAA. S-Metolachlor and Pendimethalin achieved control levels of 89.11% and 88.57%, respectively, and were consistently grouped into statistically distinct categories. Tariq *et al.* (2018) found that S-Metolachlor performed better in suppressing weed biomass compared to Pendimethalin. Notably, S-Metolachlor initially delivered “very good control” at 98.25%, aligning with Main *et al.* (2012), who reported an average of 98% control using this active ingredient alone. Regarding glyphosate, which was included as a regional control due to its widespread

**Table 1.** Scale proposed by the European Weed Research Society (EWRS) to evaluate weed control by herbicide.

Value	Weed control (%)	Effect on weeds	Phytotoxicity to the crop (%)	Effect on the crop
1	99.0-100.0	Death	0.0-1.0	No effect
2	96.5-99.0	Very good control	1.0-3.5	Very mild symptoms
3	93.0-96.5	Good control	3.5-7.0	Mild symptoms
4	87.5-93.0	Sufficient control	7.0-12.5	Obvious symptoms with no effect on performance
5	80.0-87.5	Average control	12.5-20.0	Medium damage
6	70.0-80.0	Fair control	20.0-30.0	High damage
7	50.0-70.0	Poor control	30.0-50.0	Very high damage
8	1.0-50.0	Very poor control	50.0-99.0	Severe damage
9	0.0-1.0	No effect	99.0-100.0	Death

**Table 2.** Effect of treatments at 15, 30, 40 and 50 days after application.

Active ingredient	15DDA	30DDA	40DDA	50DDA
Fomesafen	99.71 a	98.54 a	94.18 b	89.75 ab
Trifluralin	99.39 a	98.46 a	94.82 ab	92.18 a
S-Metolachlor	99.64 a	99.71 a	97.36 a	89.11 abc
Pendimethalin	99.32 a	98.25 a	95.00 ab	88.57 bc
Glyphosate	44.82 b	89.21 b	96.14 ab	86.14 c
Cultural Control	0 c	30.71 c	93.36 b	86.07 c
Weed Control	0 c	0 d	0 c	0 d

Different literals indicate differences between groups ( $P < 0.05$ ), Tukey's test. DDA: Days after application.

use, the herbicide was applied seven days after sowing, coinciding with the emergence of the first weed generation.

Glyphosate provided “moderate control,” with an initial efficacy of 89.21%, which declined by 30 DAA. These results are in agreement with Gower *et al.* (2003), who documented control rates ranging from 74% to 93% for both broadleaf and grass weeds. However, they also noted a marked decline in efficacy ( $>90\%$ ) when only a single application was made, due to subsequent weed flushes or delayed emergence. Thus, at least two applications are recommended for more effective weed suppression, and in the case of dense annual infestations, more than two may be necessary.

The cultural control treatment showed efficacy levels ranging from “moderate” to “adequate,” likely due to the difficulty in detecting or removing certain weed species during manual weeding. All treatments showed a decline in control efficacy toward the end of the evaluation period. In this regard, Everman *et al.* (2009) suggested that excellent weed control ( $>91\%$ ) can be sustained up to 74 days after pre-emergence application, provided that at least two post-emergence applications are also made during early weed growth stages. The effectiveness of pre-emergence herbicides typically lasts between 40 and 50 days, delivering acceptable control levels (Delchev, 2021). Therefore, incorporating herbicides with additional modes of action, whether residual or contact-based, in both pre- and post-emergence stages is a widely adopted and critical practice to prolong control efficacy (Alptekin *et al.*, 2023; Ramprakash *et al.*, 2024), and can be especially effective in managing secondary infestations (Isik *et al.*, 2015). However, in this study, all active ingredients were applied only once in order to determine the duration of protection provided by a single intervention. Beyond chemical control, it is essential to integrate additional agronomic practices that contribute to effective weed management. As noted earlier, only a single application of active ingredients was made. Nonetheless, row spacing played a significant role in weed suppression, as cotton plants began to close rows and shade the soil surface between 40 and 80 days after sowing, due to vegetative growth (Gaytán-Mascorro, 2004). This canopy development reduced light availability, thereby limiting weed emergence and growth (Hernández-Ríos *et al.*, 2022), which may have contributed to sustained control in the treatments. This phenomenon has been widely documented in crop-weed competition studies. For example, Iqbal *et al.* (2020) demonstrated that narrow row spacing reduced

weed growth by 55%, increased fiber yield by 26%, and shortened the critical weed competition period from 154 to 42 days. In this context, the need for integrated weed management (IWM) strategies becomes evident. Such strategies should combine rational herbicide use with complementary agronomic practices including optimal row spacing, timely seeding density, and cultural management to enhance weed control efficacy and sustainability.

## CONCLUSIONS

The results of this study demonstrate that S-Metolachlor, Fomesafen, and Trifluralin provide effective weed control during the early stages of cotton development. However, the decline in their efficacy beyond 50 days after application (DAA) indicates that a single application is insufficient to ensure prolonged control throughout the crop's critical weed competition period. In contrast, cultural control showed lower efficacy compared to chemical treatments and requires a high labor input, which can pose both operational and economic limitations. Nevertheless, it may serve as a valuable complementary strategy. In this context, the findings underscore the importance of adopting integrated weed management (IWM) strategies that combine herbicides with diverse modes of action alongside agronomic practices such as optimized row spacing to enhance crop competitiveness and support the sustainable management of weed populations.

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