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Control of *Alternanthera tenella, Amaranthus hybridus, Commelina benghalensis* and *Ipomoea grandifolia* depending on the application of halauxifene alone or in mixture with PROTOX and EPSPS inhibitors.

Control of Alternanthera tenella, Amaranthus hybridus, Commelina benghalensis, and Ipomoea grandifolia as a function of the application of halauxifen alone or in mixture with PROTOX inhibitors and EPSPS

Control of Alternanthera tenella, Amaranthus hybridus, Commelina benghalensis, and Ipomoea grandifolia as a function of the application of halauxifen alone or in mixture with PROTOX inhibitors and EPSPS

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Abstract: Weeds cause considerable economic damage to agronomic systems by competing for resources essential to cultivated plants, such as water, light, nutrients, and space, in addition to being hosts for insects and phytopathogens that can negatively impact agricultural productivity. When desiccating weeds before sowing major crops, it is necessary to know the weed community and plan the application of the most efficient herbicides for each management situation. With the relatively recent introduction of halauxifene into Brazilian agriculture, much research is needed to determine how this herbicide acts, alone or in tank mixtures, on some weed species. Therefore, the objective of this study was to evaluate the percentage of control of *Alternanthera tenella,* Amaranth *(Amaranthus hybridus),* Commelina benghalensis, and *Ipomoea grandifolia* as a function of the isolated application of halauxifene or in tank mixture with PROTOX and EPSPS inhibitor herbicides. The experiment was conducted at the Sobradinho Farm of IFTM Campus Uberlândia, in a randomized block design, with 12 treatments and 3 replications. The treatments consisted of: halauxifene (6.426 g ai ha-1); halauxifene (6.426 g ai ha-) + sulfentrazone (250 g ai ha-1); halauxifene (6.426 g ai ha-1) + sulfentrazone (400 g ai ha-); halauxifene (6.426 g ai ha-1) + glyphosate (1440 g ae ha-1); halauxifen (6.426 g ai ha-1) + saflufenacil (35 g ai ha-1); halauxifen (6.426 g ia ha-1) + saflufenacil (49 g ia ha-1); halauxifen (6.426 g ai ha-1) + flumioxazine (60 g ai ha-1); halauxifen (6.426 g ai ha-1) + flumioxazine (40 g ai ha-1); halauxifen (6.426 g ai ha-1) + thiafenacil (67.8 g ai ha-1); halauxifene (6.426 g ai ha-1) + thiafenacil (67.8 g ai ha-1) + sulfentrazone (250 g ai ha-1); halauxifene (6.426 g ai ha-1) + thiafenacil (84.75 g ai ha-1) and control (no weed control). All herbicides were applied on March 4, 2026, using a sprayer equipped with a CO2 cylinder and a boom with 6 110 015 spray nozzles, using a spray volume of 150 L haÿ[1]. The weeds were predominantly at the 6-leaf stage. Fourteen days after application, the percentage of control of each species was evaluated. The isolated application of halauxifene was not efficient in controlling the evaluated weed species. For example, morning glory showed a control percentage of 56.7% with this auxin mimic. However, tank mixing this herbicide with PROTOX inhibitors (saflufenacil, thiafenacil, and sulfentrazone) and with glyphosate increased the

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Desiccation performance was high, reaching percentage values close to 100%. Regarding other weed species, the control percentages varied according to the type of molecule added to the tank mixture, highlighting the importance of determining the effect of herbicide mixtures on the species that make up the weed community.
Keywords: Synthetic auxin; Glyphosate; Saflufenacil; Sulfentrazone; Thiafenacil.
Abstract: Weeds cause considerable economic damage to agronomic systems by competing for resources essential to cultivated plants, such as water, light, nutrients, and space, in addition to being hosts for insects and phytopathogens that can negatively impact agricultural productivity. When desiccating weeds before sowing large crops, it is necessary to know the weed community and program the most efficient herbicides for each management situation.
With the relatively recent introduction of halauxifene into Brazilian agriculture, much research is needed to determine how this herbicide acts alone or in tank mixtures on some weed species. Therefore, the objective of this work was to evaluate the percentage of control of *Alternanthera tenella, Amaranthus hybridus, Commelina benghalensis,* and *Ipomoea grandifolia* as a function of the isolated application of halauxifene or in tank mixtures with PROTOX and EPSPS inhibitor herbicides. The experiment was conducted at the Sobradinho Farm of IFTM Campus Uberlândia in a randomized block design with 12 treatments and 3 replications. The treatments consisted of: halauxifen (6,426 g ai ha-1); halauxifen (6.426 g ai ha-1) + sulfentrazone (250 g ai ha-1); halauxifen (6,426 g ai ha-) + sulfentrazone (^{1}(400 g ai ha-1); halauxifen (6,426 g ai ha-1) + glyphosate (1440 g ai ha-1); halauxifen (6.426 g ai ha-1) + saflufenacil (35 g ai ha-1); halauxifen (6,426 g ai ha-1) + saflufenacil (49 g ai ha-1); halauxifen (6,426 g ai ha-^{1}) + flumioxazine (60 g ai ha-1); halauxifen (6,426 g ai ha-1) + flumioxazine (40 g ai ha-1); halauxifen (6.426 g ai ha-1) + thiafenacil (67.8 g ai ha-1); halauxifen (6.426 g ai ha-1) + thiafenacil (67.8 g ai ha-1) + sulfentrazone (250 g ai ha-1); Halauxifene (6.426 g ai ha-1) + thiafenacil (84.75 g ai ha-1) and a control (no weed control) were used. All herbicides were applied on March 4, 2026, using a sprayer equipped with a CO2 cylinder and a boom containing 6 110 015 spray nozzles, up to a spray volume of 150 L ha-1. The weeds were predominantly at the 6-leaf stage. Fourteen days after application, the control percentages for each species were evaluated. The isolated application of halauxifene was not efficient in controlling the evaluated weed species. Morning glory, for example, showed a control percentage of 56.7% with this auxin mimic. However, tank-mixing this herbicide with PROTOX inhibitors (saflufenacil, thiafenacil, and sulfentrazone) and glyphosate increased desiccation performance, reaching values close to 100%. Regarding other weed species, control percentages varied with the type of molecule added to the tank mix, highlighting the importance of assessing the effects of herbicide mixtures on the constituent species of the weed community.
Keywords: Synthetic auxin; Glyphosate; Saflufenacil; Sulfentrazone; Thiafenacil.

1. INTRODUCTION

Weeds are one of the main limiting factors for productivity.
agricultural, since they compete with economically important crops for water, light,
nutrients and space. In addition, they can act as hosts for insect pests and
Phytopathogens, making phytosanitary management difficult and increasing production costs. In
In intensive agricultural systems, the presence of these species can cause yield losses.
significant, especially when control is not carried out properly and in

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right moment (Balbinot Júnior; Vogt; Trezzi, 2011).

In the Brazilian grain production system, pre-sowing desiccation is a common practice. essential to ensure the initial establishment of crops, reducing interference from Weeds in the early stages of development. However, the high diversity of Weed species and the occurrence of herbicide-tolerant or resistant biotypes make it difficult. Chemical handling, which requires the use of mixtures of molecules with different mechanisms of action (Oliveira Júnior, 2011).

Among the species of greatest agricultural importance, *Alternanthera tenella* stands out. (fire extinguisher), *Amaranthus hybridus* (purple amaranth), *Commelina benghalensis* (dayflower) and *Ipomoea grandifolia* (morning glory). These plants exhibit a high capacity competitive, rapid spread, and difficulty of control under certain conditions of management. Species such as the wandering Jew and the morning glory exhibit natural tolerance to some herbicides are widely used, which compromises the efficiency of desiccation (Ronchi *et* al., 2002).

In this context, halauxifene-methyl has stood out as an alternative. Promising in the management of broadleaf weeds. This herbicide belongs to the group of auxin mimics, promoting physiological disorders that result in growth uncontrolled spread and death of susceptible plants. However, due to the relatively recent introduction While this molecule has recently been used in Brazilian agriculture, further studies are needed to evaluate its... efficiency when applied alone or in mixture with different herbicides mechanisms of action, such as PROTOX and EPSPS inhibitors (Oliveira Júnior, 2011).

PROTOX-inhibiting herbicides, such as saflufenacil, flumioxazin, thiafenacil and sulfentrazone acts by promoting the accumulation of reactive oxygen species, which causes rapid cell necrosis. Glyphosate, belonging to the EPSPS inhibitor group, exhibits... Systemic action widely used in the desiccation of agricultural areas. The combination of these molecules can enhance control efficiency and broaden the spectrum of action on different invasive species.

Given the need to improve chemical handling in desiccation operations, the The present study aimed to evaluate the percentage of control of *Alternanthera tenella. Amaranthus hybridus, Commelina benghalensis ,* and *Ipomoea grandifolia* as a function of application. isolated from halauxifene or from tank mixtures with PROTOX-inhibiting herbicides and EPSPS.

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2. MATERIALS AND METHODS

The experiment was conducted at the Sobradinho Farm of the Federal Institute of the Triângulo Mineiro. Mineiro, Uberlândia Campus, whose area is located at geographic coordinates 18°46'23" south latitude and 48°17'27" west longitude, with an altitude of 644 m and climate classification Aw, according to Köppen-Geiger (PEEL; FINLAYSON; MCMAHON, 2007).

The soil at the site was classified as eutrophic Red Latosol and was being used for pasture, which was predominantly composed of Urochloa *plantaginea.* In the last week of January 2026, the experimental area was desiccated with glyphosate + 2,4-D. After 20 days, the soil was plowed and harrowed, aiming at soil preparation and incorporation of the brachiaria straw. Then, the experimental plots were demarcated. Each plot It measured 5 m in length and 3 m in width.

With the aim of ensuring the uniformity of the distribution of *Ipomoea* species Seeds of **Amaranthus grandifolia** and **Amaranthus hybridus** were acquired from company X for sowing. in each experimental plot. Sowing was carried out in furrows opened with a hoe and, Subsequently, the seeds were covered with a shallow layer of soil. (approximately 2 cm thick). The other species, namely *Alternanthera tenella* and Commelina *benghalensis* showed a naturally homogeneous distribution in the area. experimental.

The herbicide desiccation trial was structured in a block design. A randomized experiment with 12 treatments and 3 replicates was conducted. The treatments consisted of: halauxifene (6.426 g ai ha-1); halauxifene (6.426 g ai ha-1) + sulfentrazone (250 g ai ha-1); halauxifene (6.426 g ai ha-1) + sulfentrazone (400 g ai ha-1); halauxifene (6.426 g ai ha-1) + glyphosate (1440 g ea ha-1); halauxifene (6.426 g ai ha-1) + saflufenacil (35 g ai ha-1); halauxifene (6.426 g ai ha-1) + saflufenacil (49 g ai ha-1); halauxifene (6.426 g ai ha-1) + flumioxazin (60 g ai ha-1); halauxifene (6.426 g ai ha-1) + flumioxazin (40 g ai ha-1); halauxifene (6.426 g ai ha-1) + thiafenacil (67.8 g ai ha-1); halauxifene (6.426 g ai ha-1) + thiafenacil (67.8 g ai ha-1) + sulfentrazone (250 g ai ha-1); halauxifene (6.426 g ai ha-1) + thiafenacil (84.75 g ai ha-1) and control (without weed control).

The herbicides were applied using a sprayer equipped with a cylinder. CO2 and a boom with 6 fan-type nozzles 110 015, spaced 0.5 m apart. The spray volume used was 150 L.ha-1 and was applied at a speed of 5 km.h-1 . The herbicides were sprayed in the early afternoon of March 4, 2026, with the following

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Weather conditions: temperature = 30 °C, relative humidity = 45%, and wind speed = 4 km hÿ¹.

Fourteen days after herbicide application, the percentage of... was evaluated. Weed control.

The data on the percentage of weed species controlled were submitted The treatments were compared using the F-test of Analysis of Variance at a 5% probability level. compared to each other using the Scott-Knott test at a 5% probability level. All tests were performed with support from the SISVAR statistical program (Ferreira, 2011).

3. RESULTS AND DISCUSSION

There was a significant difference between treatments for all plant species. The weeds were evaluated, which demonstrates that control efficiency varied depending on the mixtures. herbicides used (Tables 1, 2, 3 and 4). In general, the isolated application of halauxifen It showed inferior performance compared to combinations with PROTOX inhibitors and EPSPS, highlighting the importance of tank mixtures in the desiccation of difficult-to-clean species. control.

For the *Alternanthera tenella species,* treatments with halauxifene combined with Protox-inhibiting herbicides showed the highest control percentages. highlighting the halauxifene + thiafenacil + sulfentrazone mixture, with 91.7% efficiency. By On the other hand, the isolated application of halauxifen provided only 70.0% control (Table). 1) These results indicate that the association between distinct mechanisms of action potentiates Injury to weeds increases the efficiency of desiccation. According to Balbinot Júnior, According to Vogt and Trezzi (2011), the integration of chemical strategies is fundamental to maximizing the Weed management and reducing control failures.

Table 1. Percentage of control of *Alternanthera tenella* as a function of desiccation induced by halauxifene, applied alone or in mixture with PROTOX and EPSPS inhibitors.
Sobradinho Farm, Uberlândia-MG. Year: 2026.

Herbicides (g ia haÿ¹)	*Alternanthera tenella*
Halauxifene (6,426)	70.0 A
Halauxifene + sulfentrazone (250)	80.0 A
Halauxifene (6.426) + sulfentrazone (400)	70.0 A
Halauxifene (6,426) + glyphosate1 (1440)	76.7 A
Halauxifene (6,426) + saflufenacil (35)	86.3 A
Halauxifene (6,426) + saflufenacil (49)	80.0 A

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Halauxifene (6,426) + flumioxazine (60)	88.3 A
Halauxifene (6,426) + flumioxazine (40)	76.7 A
Halauxifene (6.426) + thiafenacil (67.8)	88.3 A
Halauxifene (6.426) + thiafenacil (67.8) + sulfentrazone (250)	91.7 A
Halauxifene (6.426) + thiafenacil (84.75)	75.0 A
Witness 1440	0.0 B

[1] g ea haÿ¹.
[*] Significant difference according to the F-test of the Analysis of Variance at a 5% significance level. CV = 21.99%. Treatments with different letters in the column differ from each other according to the Scott-Knott test at a 5% significance level.

Regarding *Amaranthus hybridus,* high sensitivity to mixtures was observed. containing glyphosate, flumioxazin, and thiafenacil, with control rates exceeding 83%. Treatment with halauxifene + glyphosate resulted in virtually complete control of the species, with 99.7% effectiveness. In contrast, the isolated application of halauxifene resulted in only 53.3% control (Table 2). The higher performance of the mixtures may be related to the action complementary to the herbicides used, mainly EPSPS inhibitors and PROTOX, which promote rapid tissue necrosis and metabolic impairment in plants. weeds.

Table 2. Percentage of control of purple amaranth *(Amaranthus hybridus)* as a function of desiccation induced by halauxifene, applied alone or in combination with PROTOX and EPSPS inhibitors. Sobradinho Farm, Uberlândia-MG. Year: 2026.

Herbicides (g ia haÿ¹)	*Amaranthus hybridus*
Halauxifene (6,426)	53.3 B
Halauxifene + sulfentrazone (250)	60.0 B
Halauxifene (6.426) + sulfentrazone (400)	74.7 B
Halauxifene (6,426) + glyphosate1 (1440)	99.7 A
Halauxifene (6,426) + saflufenacil (35)	73.3 B
Halauxifene (6,426) + saflufenacil (49)	81.7 A
Halauxifene (6,426) + flumioxazine (60)	93.3 A
Halauxifene (6,426) + flumioxazine (40)	83.3 A
Halauxifene (6.426) + thiafenacil (67.8)	85.0 A
Halauxifene (6.426) + thiafenacil (67.8) + sulfentrazone (250)	92.7 A
Halauxifene (6.426) + thiafenacil (84.75)	90.0 A
Witness	0.0 C

[1] 1440 g ea haÿ¹.
[*] Significant difference according to the F-test of the Analysis of Variance at a 5% significance level. CV = 17.38%. Treatments with different letters in the column differ from each other according to the Scott-Knott test at a 5% significance level.

For *Commelina benghalensis,* a species recognized for its tolerance to various

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In systemic herbicides, it was observed that treatments with combinations of molecules were significantly superior to halauxifene applied alone. The halauxifene + mixture Glyphosate provided 93.3% control, while the halauxifene + thiafenacil + combination sulfentrazone reached 86.7% efficiency. Halauxifene alone, however, showed only 46.7% efficiency. (Table 3). These results demonstrate that the isolated use of the auxin mimic is not sufficient for the proper management of dayflower, requiring the addition of herbicides. contact or herbicides with different mechanisms of action to increase the effectiveness of control.

Table 3. Percentage of control of dayflower *(Commelina benghalensis)* as a function of desiccation induced by halauxifene, applied alone or in mixture with PROTOX and EPSPS inhibitors.
Sobradinho Farm, Uberlândia-MG. Year: 2026.

Herbicides (g iaha-1)	*Commelina benghalensis*
Halauxifene (6,426)	46.7 C
Halauxifene + sulfentrazone (250)	76.7 A
Halauxifene (6.426) + sulfentrazone (400)	66.7 B
Halauxifene (6,426) + glyphosate1 (1440)	93.3 A
Halauxifene (6,426) + saflufenacil (35)	66.7 B
Halauxifene (6,426) + saflufenacil (49)	73.3 A
Halauxifene (6,426) + flumioxazine (60)	83.3 A
Halauxifene (6,426) + flumioxazine (40)	76.7 A
Halauxifene (6.426) + thiafenacil (67.8)	78.3 A
Halauxifene (6.426) + thiafenacil (67.8) + sulfentrazone (250)	86.7 A
Halauxifene (6.426) + thiafenacil (84.75)	70.0 B
Witness	0.0 D

1 * 1440 g ea haÿ¹.
Significant difference according to the F-test of the Analysis of Variance at a 5% significance level. C = 14.77%. Treatments with different letters in the column differ from each other according to the Scott-Knott test at a 5% significance level.

The species *Ipomoea grandifolia* showed high susceptibility to mixtures. herbicides evaluated, with control percentages close to or equal to 100% in the treatments. containing saflufenacil, flumioxazin, and thiafenacil. The isolated application of halauxifene achieved... Only 56.7% control was achieved, reinforcing the limitations of using this herbicide alone in pest control programs. desiccation (Table 4). Associations with PROTOX inhibitors resulted in rapid Desiccation and intense oxidative damage to leaf tissues, which justifies the high rates observed efficiency levels.

Table 4. Percentage of morning glory *(Ipomoea grandifolia)* control as a function of desiccation induced by halauxifene, applied alone or in mixture with PROTOX and EPSPS inhibitors. Sobradinho Farm, Uberlândia-MG. Year: 2026.

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Herbicides (g ia haÿ¹)	*Ipomoea grandifolia*
Halauxifene (6,426)	56.7 B
Halauxifene + sulfentrazone (250)	88.7 A
Halauxifene (6.426) + sulfentrazone (400)	96.0 A
Halauxifene (6,426) + glyphosate1 (1440)	90.0 A
Halauxifene (6,426) + saflufenacil (35)	99.7 A
Halauxifene (6,426) + saflufenacil (49)	100.0 A
Halauxifene (6,426) + flumioxazine (60)	99.0 A
Halauxifene (6,426) + flumioxazine (40)	97.7 A
Halauxifene (6.426) + thiafenacil (67.8)	99.3 A
Halauxifene (6.426) + thiafenacil (67.8) + sulfentrazone (250)	99.3 A
Halauxifene (6.426) + thiafenacil (84.75)	93.0 A
Witness	0.0 C

[1] 1440 g ea haÿ¹.
* Significant difference according to the F-test of the Analysis of Variance at a 5% significance level. C = 9.02%. Treatments with different letters in the column differ from each other according to the Scott-Knott test at a 5% significance level.

In summary, the results obtained show that halauxifene presents better results. performance when used in mixtures with herbicides of different mechanisms of action, primarily inhibitors of PROTOX and EPSPS. In addition to increasing control efficiency. Of the species evaluated, these associations contribute to broadening the spectrum of action and may to help reduce the selection of resistant biotypes. Thus, the appropriate choice of mixtures When choosing herbicides, one must consider the species present in the area, as well as their characteristics. Tolerance and susceptibility to available mechanisms of action.

In the present study, regarding *Alternanthera tenella,* the highest percentages of Control issues were observed in treatments containing halauxifene in combination with thiafenacil. flumioxazin and sulfentrazone. According to Oliveira Júnior (2011), the herbicides that inhibit... PROTOX promotes the rapid formation of reactive oxygen species, destroying the cell membranes and accelerating necrosis of plant tissues. This characteristic contributes for greater effectiveness against broadleaf weeds, especially when combined systemic herbicides, such as halauxifen.

In the case of *Amaranthus hybridus,* high susceptibility to mixtures was observed. containing glyphosate, flumioxazin and thiafenacil, with control percentages greater than 85%. According to Heap (2024), species of the genus *Amaranthus* exhibit high capacity adaptation and development of herbicide resistance, which makes it necessary to The use of distinct mechanisms of action in management programs. Thus, the association between Halauxifene, EPSPS and PROTOX inhibitor herbicides, increases control efficiency and

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reduces the risk of selecting resistant biotypes.

Considering the species *Commelina benghalensis,* the results demonstrated that the halauxifene applied alone showed low control efficiency, while Tank mixing yielded better results. Studies by Ronchi *et al.* (2002) They report that species of spiderwort exhibit natural tolerance to glyphosate and high levels of tolerance to glyphosate. The ability to regenerate vegetatively makes managing these species difficult. Therefore, the use of contact herbicides, such as PROTOX inhibitors, in combination with Systemic herbicides contribute to greater leaf injury and increased efficiency of... desiccation.

Regarding *Ipomoea grandifolia,* treatments containing saflufenacil, flumioxazin and tiafenacil showed control rates close to 100%, demonstrating high efficacy. of these associations. According to Carvalho *et al.* (2013), species of the genus *Ipomoea* present vigorous growth and high competitiveness in agricultural areas, which requires the application of Herbicides with different mechanisms of action to achieve satisfactory control. The authors They also highlight that PROTOX inhibitors exhibit rapid action against broadleaf leaves. promoting the control of morning glory in desiccation applications.

The results of this study highlight the importance of integrated management and... Use of herbicide mixtures in pre-sowing desiccation. As highlighted by Balbinot. Júnior, Vogt and Trezzi (2011), the integration of different chemical strategies is fundamental for increase the efficiency of weed control, reduce management failures, and minimize... selection pressure on resistant biotypes. Thus, the association of halauxifene with Protox and EPSPS inhibitor herbicides have shown promise as an alternative for... management of the species evaluated in this study

CONCLUSION

The isolated application of halauxifene did not show satisfactory efficiency in controlling the disease. of the species *Alternanthera tenella, Amaranthus hybridus, Commelina benghalensis* and *Ipomoea grandifolia.*

Tank mixtures of halauxifene with PROTOX and EPSPS inhibitor herbicides They provided higher percentages of control of the evaluated weeds, with particular emphasis on... the associations with glyphosate, flumioxazin, saflufenacil and thiafenacil, which presented indices control levels close to or above 90%.

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Year VII, v.1 2026 | Submission: 05/23/2026 | Accepted: 05/26/2026 | Publication: 05/29/2026

The species *Commelina benghalensis* showed greater tolerance to the treatments. primarily due to halauxifene applied alone, while *Ipomoea grandifolia* It demonstrated high susceptibility to the herbicide mixtures evaluated.

Thus, the association of halauxifen with herbicides of different mechanisms The action method constitutes an efficient alternative for weed management in operations. pre-sowing desiccation, contributing to broadening the spectrum of control and reducing failures in chemical handling.

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