

# Original Article: Allelopathic effect of crude plant extract on *Ipomoea purpurea* L.



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## ABSTRACT

Weeds are among the main phytosanitary problems and are responsible for numerous losses in agriculture. Integrated management has become increasingly important in weed control. Therefore, the present study aimed to investigate the allelopathic effect of 24 plants on morning glory (*Ipomoea purpurea* L.). The tests were performed in a completely randomized design, both in *in vitro* and *in vivo* experiments. The *in vitro* germination data were used to calculate the time and germination index, and in the *in vivo* experiment, the length and fresh weight of the aerial part and root of the seedlings were evaluated, with subsequent comparison of averages by ANOVA. The plant extracts used exerted allelopathy, delaying (negative) and advancing (positive) the germination of this species. The extracts of banana, black plum, carqueja, Mexican sunflower, rosemary, guaco, lavender, lemongrass and garden mint resulted in high germination delays of up to +5 days. Rosemary, garden mint, Mexican sunflower and guaco extracts also reduced the germination rate by up to -10.5%. None of the tested extracts reduced the length of the aerial part of morning glory. In all treatments, shorter root length was observed. The extracts of lemongrass, rosemary and guaco reduced the dry weight of the aerial part, and in all treatments a lower fresh weight of roots was observed, except for the treatment with guaco. It can be concluded that the germination or growth of some problematic weeds such as *I. purpurea* may be affected by allelochemical extracts from different plants such as bananas, black plum, boldo, Mexican sunflower, rosemary, guaco, lavender, lemongrass, and garden mint.

## Introduction

Among the weeds, morning glory (*Ipomoea purpurea* L.) is one of the most common invasive species in agricultural areas since it is widespread in almost all Brazilian territory. Belonging to the Convolvulaceae family, which includes approximately 58 genera, the genus *Ipomoea* has about 650 known species (Mabberley, 1997). These are climbing and herbaceous plants, which occur more frequently in moist and well-prepared soils. Its propagation is exclusively by seed (Moreira and Bragança, 2011). It is extremely harmful to many annual crops because

it has a longer life cycle than cultivated species and also because it hinders mechanized harvesting, since it becomes intertwined with plants. Another important characteristic is the production of a considerable number of seeds per season, about 50 to 300, which have asynchronous germinations over time (Kissmann and Groth, 1999). According to Azania et al. (2003) and Pazuch et al. (2015), *Ipomoea* species have different germination flows during spring and summer, due to dormancy. In the soybean crop, losses of 27 to 45% have already been reported due to infestation by this invasive plant (Piccinini et al., 2018). In addition to what was mentioned, this vegetable can also host the

bacterium *Pseudomonas syringae* pv. *syringae* and mites of the genus *Brevipalpus* (Moreira and Bragança, 2011).

In agriculture, there is an increasing number of plant species that are resistant or tolerant to different herbicidal molecules (Travlos et al., 2020). For Vargas and Roman (2006), the level of tolerance of plants against herbicides can be classified as susceptible, tolerant and resistant, which will depend on how the species of weeds will react after the action of the herbicides. According to Monquero et al. (2004), *Ipomoea* species are among the most tolerant to glyphosate. Monquero and Silva (2007) also reported that glyphosate did not efficiently control *I. purpurea*. Later, Pazuch et al. (2017) reported tolerance in *Ipomoea* spp. in the southern region of Brazil, which raises concern about the future of the management of this invasive species.

Integrated management uses several techniques to combat weeds, for example: cultural, preventive, mechanical, physical, chemical and biological (Oliveira and Brighenti, 2018). This is a strategy that makes it possible to reduce the use of synthetic agricultural pesticides; in addition, the approach not only decreases the possibility of weeds becoming resistant, but it is also a way for farmers to save on the purchase of phytosanitary products and causes less environmental impacts. Allelopathy can be cited as a management measure, which consists of any positive or negative interaction that a plant can exert over another, through chemical compounds released by them (Mehdizadeh and Mushtaq, 2020). Allelopathic compounds released by a plant can affect several intrinsic factors, for example inhibiting or delaying the germination of seeds of other plant species (Miller, 1996). Through allelopathic indications, species can be selected for use in consortium, as a source of new herbicide molecules (Oliveira and Brighenti, 2009), and by using extracts for the alternative management of pests, diseases and weeds.

Some studies have already been carried out to investigate plant allelopathy regarding *Ipomoea* spp., for example, Steinsiek et al. (1982) who studied the potential allelopathic effect of wheat on *I. hederacea* (L.) Jacq. and *I. lacunosa* L.

Mauli et al. (2009) evaluated the effect of aqueous extract of leucena (*Leucaena leucocephala* (Lam.), R. de Wit.) on the germination of *I. grandifolia* (Dammer) O'Donnell. Lima et al. (2009) also investigated lemon grass (*Cymbopogon citratus* Stapf.) and elderberry (*Sambucus australis* Cham. & Schltdl.) allelopathy in the germination and initial development of *I. grandifolia*. The hydroalcoholic extract of araticum-do-cerrado (*Annona crassiflora* Mart.) was also evaluated in the germination of *I. grandifolia*, by Inoue et al. (2010). According to Araújo et al. (2010), sunn hemp (*Crotalaria juncea* L.) extracts reduced the germination of *I. grandifolia*. Grisi et al. (2013) tested the influence of the aqueous extract of the soapberry root (*Sapindus saponaria* L.) on the germination of *I. grandifolia*. Silva et al. (2015a) evaluated the allelopathic potential of papaya seed extract (*Carica papaya* L.) on the germination of *I. purpurea*. Studies have shown that the aqueous extract of the leaves of *Eucalyptus grandis* W. Hill ex Maiden promote the inhibition and reduction of the germination of *I. purpurea* seeds (Silva et al., 2015b). Silva et al. (2016) described the antagonism of leachate from *Asemeia extraaxillaris* (Chodat) J.F.B. Pastore & J.R. Abbott on the growth of *I. cordifolia*.

Therefore, the objective of the present work was to evaluate the allelopathic effect of the aqueous crude extract of 24 plants on *Ipomoea purpurea* L.

## Materials and Methods

The study was conducted in the Federal District, central Brazil (15.58 °S, 47.73 °W), consisting of the Cerrado biome, during the months of August 2019, March 2020 and September 2020. According to the Köppen classification, the location has a Tropical seasonal climate of megathermic savannah, with an average annual precipitation of 1,400 mm (Cardoso et al. 2014).

The seed lots of *Ipomoea purpurea* were purchased from a commercial supplier, already chemically treated and within the expiry date.

The plants, source of plant extracts, were collected in the medicinal and toxicology garden or in the afforestation of the college's own

campus, in the morning period, and are described according to the table below (Table 1).  
**Table 1.** Description of the plants used in this study.

No.	Common Name	Scientific Name	Botanical Family
1	Lemongrass	<i>Cymbopogon citratus</i> (DC) Stapf.	Poaceae
2	Garden mint	<i>Mentha spicata</i> L.	Lamiaceae
3	Pomegranate	<i>Punica granatum</i> L.	Lythraceae
4	Citronella	<i>Cymbopogon winterianus</i> Jowitt	Poacea
5	Mexican sunflower	<i>Tithonia diversifolia</i> (Hemsl.) A. Gray.	Asteraceae
6	Rue	<i>Ruta graveolens</i> L.	Rutaceae
7	Rosemary	<i>Rosmarinus officinalis</i> L.	Lamiaceae
8	Basil	<i>Ocimum grantissium</i> L.	Lamiaceae
9	Brazilian joyweed	<i>Alternanthera brasiliensis</i> (L.) Kuntze	Amaranthaceae
10	Indian coleus	<i>Plectranthus amboinicus</i> Lour.	Lamiaceae
11	Castor bean	<i>Ricinus communis</i> L.	Euphorbiaceae
12	Aloe vera	<i>Aloe vera</i> L.	Xanthorrhoeaceae
13	Lavender	<i>Lavandula dentata</i> L.	Lamiaceae
14	Guaco	<i>Mikania glomerata</i> Spreng.	Asteraceae
15	Boldo	<i>Peumus boldus</i> Mol.	Monimiaceae
16	Indian-tree spurge	<i>Euphorbia tirucalli</i> L.	Euphorbiaceae
17	Bitter cassava	<i>Manihot esculenta</i> Crantz	Euphorbiaceae
18	Kalanchoe	<i>Kalanchoe</i> sp.	Crassulaceae
19	Black plum	<i>Syzygium cumini</i> L.	Myrtaceae
20	Banana	<i>Musa</i> sp.	Musaceae
21	Fennel	<i>Foeniculum vulgare</i> Mill.	Lamiaceae
22	Carqueja	<i>Baccharis trimera</i> (Less.) DC.	Asteraceae
23	Horseradish	<i>Moringa oleifera</i> Lam.	Horseradishceae
24	Myrrh	<i>Commiphora myrrha</i> (Nees) Engl.	Burseraceae

Six independent experiments were carried out (1-5 *in vitro*):

1. 1-9 plants (4 mL of 35% extracts) (Table 1);
2. 10-18 plants (4 mL of 35% extracts);
3. 19-24 plants (4 mL of 35% extracts);
4. Plants selected from previous experiments (8 mL of 35% extracts);
5. Plants selected from previous experiments (4 mL of 50% extracts);
6. Plants selected from previous experiments for *in vivo* tests.

To prepare the aqueous crude extract, 35 g or 50 g of young leaves and branches of the mentioned

plants were used, which were crushed in 100 ml of distilled water.

In the *in vitro* experiment, a gerbox (11 x 11 x 3.5 cm) containing three sheets of autoclaved germitest paper was used, where 50 seeds were deposited and 4 ml or 8 ml of the extract of each plant (treatments) were added. The gerboxes were sealed with plastic wrap to prevent drying, and then they were kept at room temperature and in light. As moisture was lost, the seeds were moistened. The readings of the experiment were daily, where the number of seeds germinated each day was recorded.

Based on the germination data, the average germination time (equation 1) and the germination index (equation 2) were calculated using the following equations (Santana and Ranal, 2004):

$$T = \frac{\sum(f_i \times x_i)}{\sum f_i} \quad (\text{days}), \quad \text{average germination time} \quad (\text{Eq 1})$$

$$\text{Germination index (\%)} = \frac{\text{germinated seeds}}{\text{total number of seeds}} \times 100 \quad (\text{Eq 2})$$

Where  $f_i$  = number of seeds germinated on the  $i^{\text{th}}$  day; and  $x_i$  = number of days counted from sowing to the day of reading.

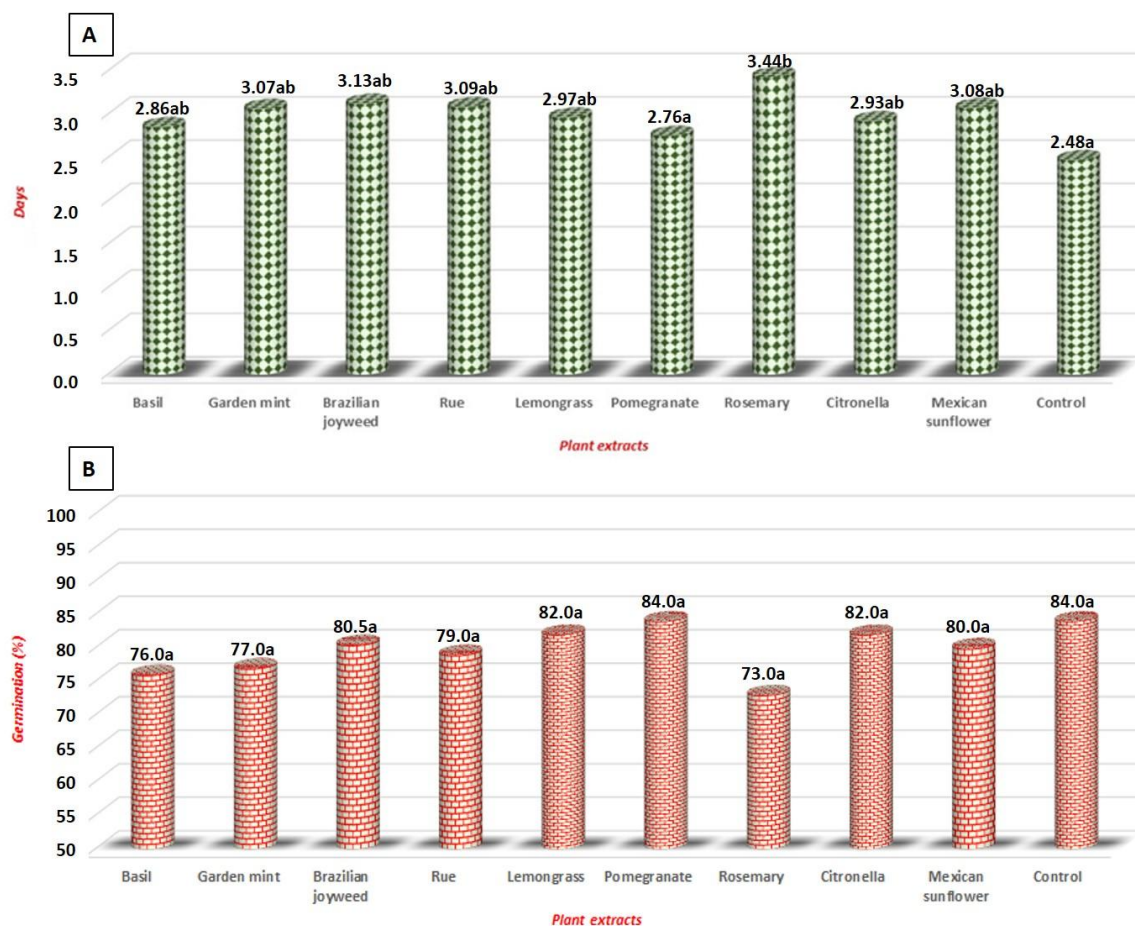
The experiment was conducted using a completely randomized design (CRD). The data were submitted to analysis of variance

(ANOVA), followed by the Tukey test, at 5% significance level, using the Sisvar 5.6 program (Ferreira, 2014).

## Results and Discussion

### Experiment 1

The results of this experiment showed a delay in the radicle emission of *Ipomoea purpurea* for all treatments (Figure 1A), varying between 0.28 and 0.96 days. The rosemary crude extract, which took 3.44 days to germinate, stood out when compared to the control treatment, which germinated in 2.48 days, causing a significant delay of almost one day.



**Figure 1.** Experiment 1: A) Average germination time in days (Axis y) of *Ipomoea purpurea* seeds treated with 4 mL of 35% plant extracts (Axis x). B) Germination index (Axis y) of seeds treated with 4 mL of 35% plant extracts (Axis x). Means followed by the same letter do not differ significantly by the Tukey test ( $P < 0.05$ ).

Regarding the germination index, there was no significant difference between treatments

(Figure 1B), although all treatments showed a reduction in germination when compared to the

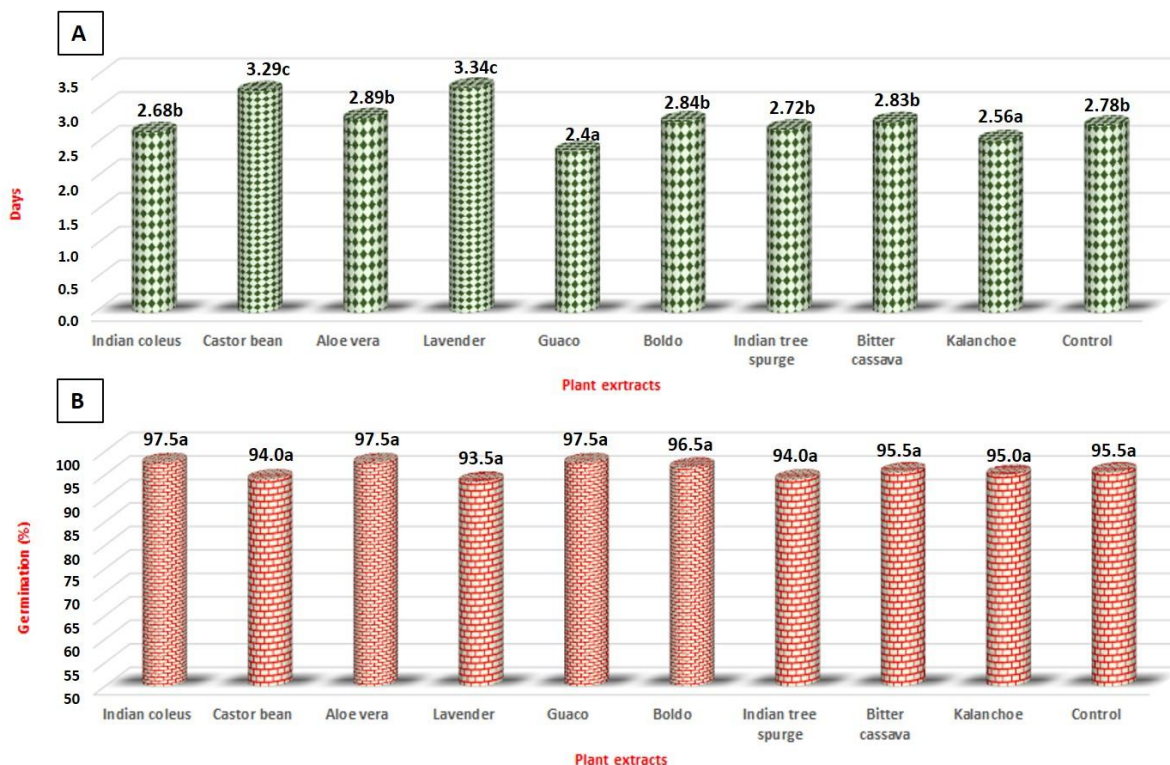


control, varying between -2 and -11%, except for the treatment with extract of pomegranate.

### Experiment 2

In this experiment, there was a delay and advance in the germination of the morning glory

seeds (Figure 2A). Castor bean and lavender extract delayed germination by 0.56 and 0.51 days, respectively. In contrast, the guaco and kalanchoe extracts advanced the germination by 0.38 and 0.22 days, respectively.



**Figure 2.** Experiment 2: A) Average germination time in days (Axis y) of *Ipomoea purpurea* seeds treated with 4 mL of 35% plant extracts (Axis x). B) Germination index (Axis y) of seeds treated with 4 mL of 35% plant extracts (Axis x). Means followed by the same letter do not differ significantly by the Tukey test ( $P < 0.05$ ).

The germination analysis of this experiment (Figure 2B) showed that there was no significant difference between the treatments, although the treatments with lavender, castor bean, Indian-tree spurge and kalanchoe had their germination reduced between -0.5 and -2%. The other treatments showed germination  $\geq$  the control.

### Experiment 3

Based on the data analysis, it was possible to observe that the crude leaf banana extract (Figure 3A) delayed the average time (+ 4.75 days) of germination of the morning glory seeds, although they did not differ significantly from the black plum extracts (+2.14 days), carqueja (+2.27 days) and myrrh (+0.89 days). On the other hand, only the fennel extract advanced the germination (-0.46 days), although it did not differ from the control.

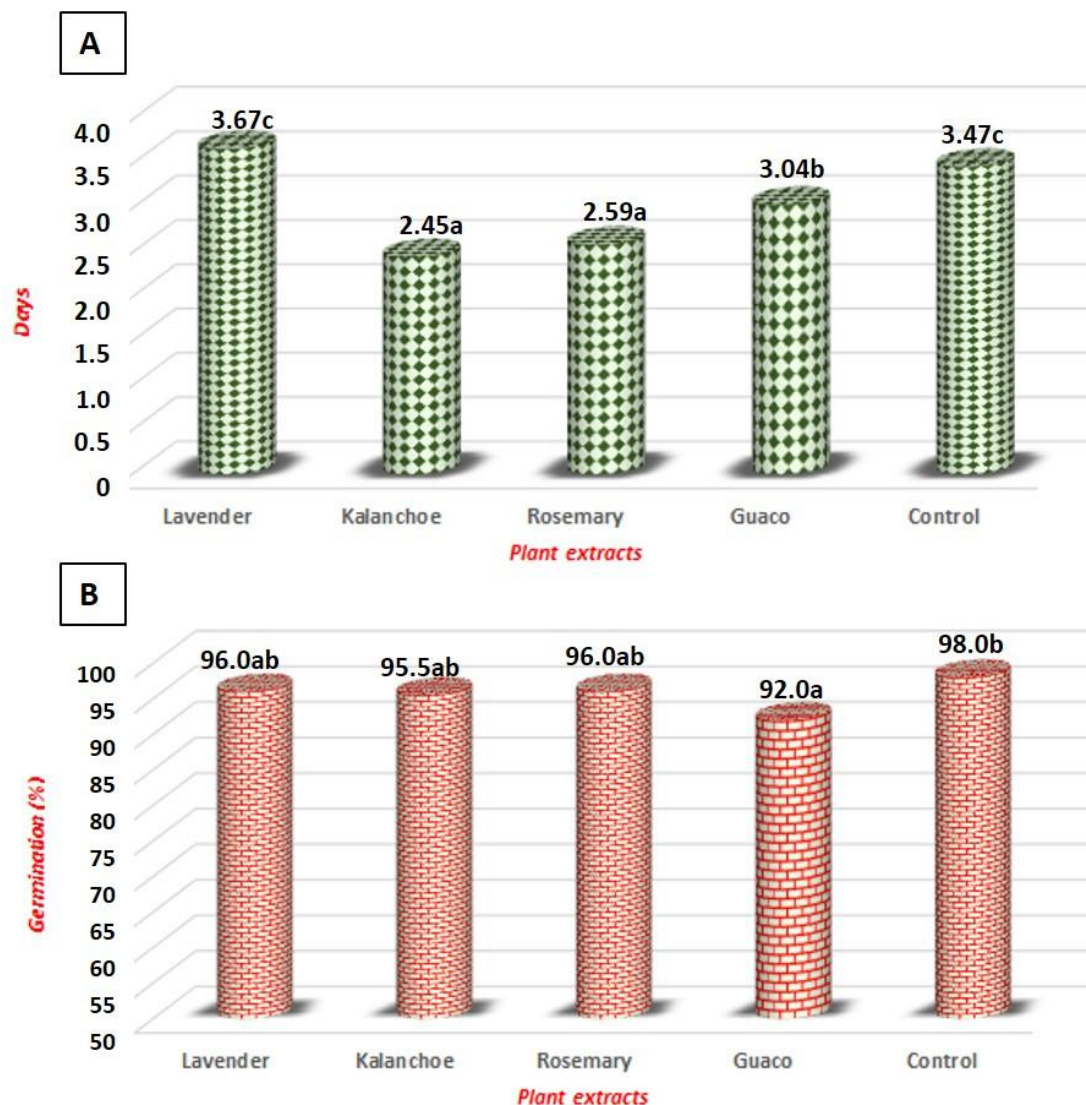


**Figure 3.** Experiment 3: A) Average germination time in days (Axis y) of *Ipomoea purpurea* seeds treated with 4 mL of 35% plant extracts (Axis x). B) Germination index (Axis y) of seeds treated with 4 mL of 35% plant extracts (Axis x). Means followed by the same letter do not differ significantly by the Tukey test ( $P < 0.05$ ).

As for germination, it was observed that three treatments had lower germination than the control, although they did not differ significantly. The reduction was: banana (-8%); horseradish (-5.4%) and gorse (-3.8%). The other treatments showed germination that was higher than the control.

#### Experiment 4

The use of double the extract (8 mL) showed a slight delay with the lavender extract (+0.2 days), with no significant difference from the control. In contrast, kalanchoe, rosemary and guaco extracts advanced germination by -1.02; -0.88 and -0.43 days, respectively (Figure 4A).



**Figure 4.** Experiment 4: A) Average germination time in days (Axis y) of *Ipomoea purpurea* seeds treated with 8 mL of 35% plant extracts (Axis x). B) Germination index (Axis y) of seeds treated with 8 mL of 35% plant extracts (Axis x). Means followed by the same letter do not differ significantly by the Tukey test ( $P < 0.05$ ).

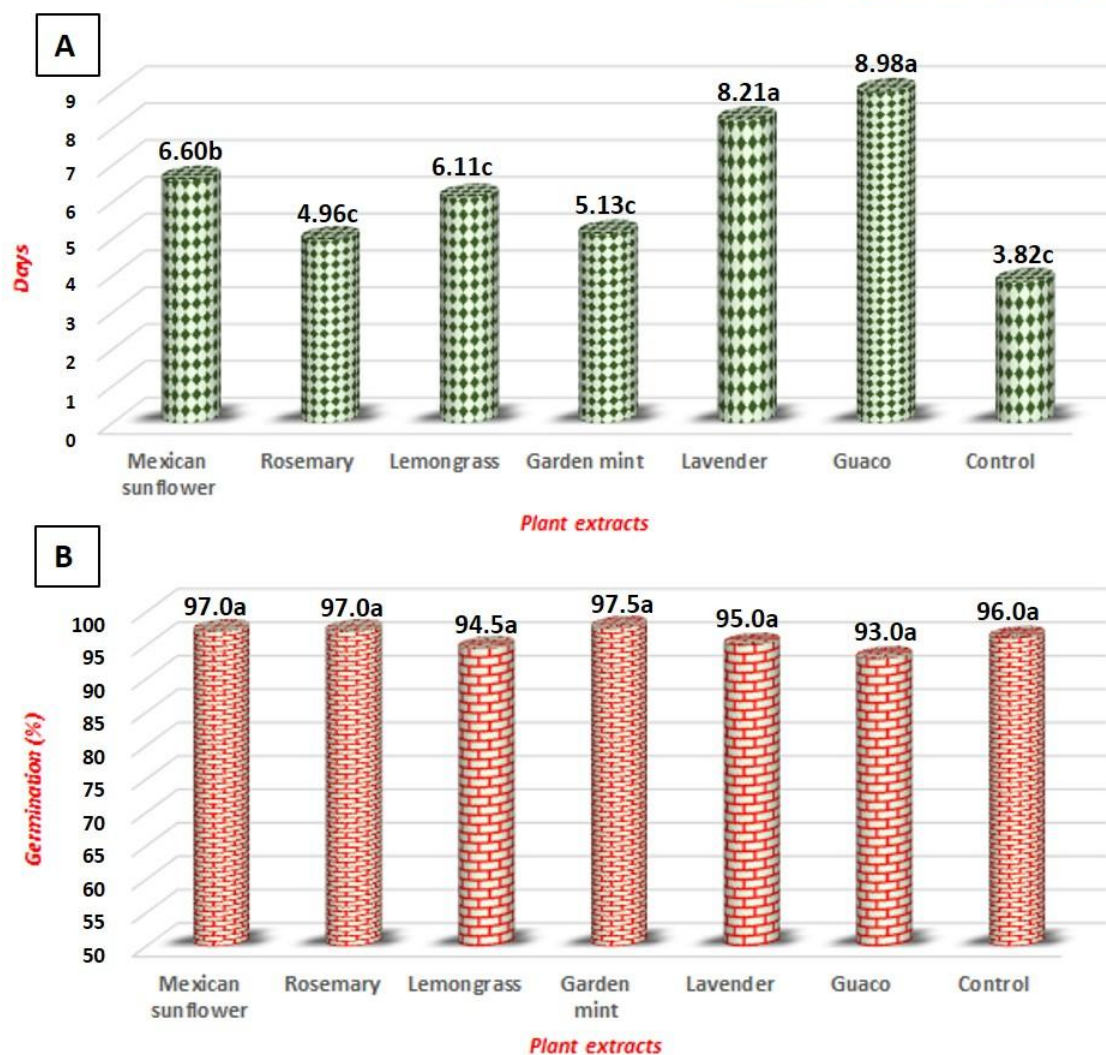
Regarding the germination index, a difference was observed between guaco and the control. All treatments showed lower germination than the control, varying between -2.5 and -6% (guaco).

#### Experiment 5

The use of extracts, now at 50%, showed that all treatments germinated faster than the control,

although rosemary (-1.14 days), garden mint (-1.32 days) and lemongrass (-2.29 days) did not differ significantly. The treatments with Mexican sunflower (+2.78 days), lavender (+4.39 days) and guaco (+5.16 days) stood out, with the highest values in the germination delay (Figure 5A).





**Figure 5.** Experiment 5: A) Average germination time in days (Axis y) of *Ipomoea purpurea* seeds treated with 4 mL of 50% plant extracts (Axis x). B) Germination index (Axis y) of seeds treated with 4 mL of 50% plant extracts (Axis x). Means followed by the same letter do not differ significantly by the Tukey test ( $P < 0.05$ ).

As regards the germination rates in this experiment, there was also no significant difference between them; however, the treatments with guaco, lemongrass and lavender showed lower germination than the control: -3, -1.5 and -1%, respectively. In contrast, treatments with extracts of garden mint, Mexican sunflower and rosemary showed germination higher than the control of +1.5; +1 and +1%, respectively (Figure 5B).

### Experiment 6

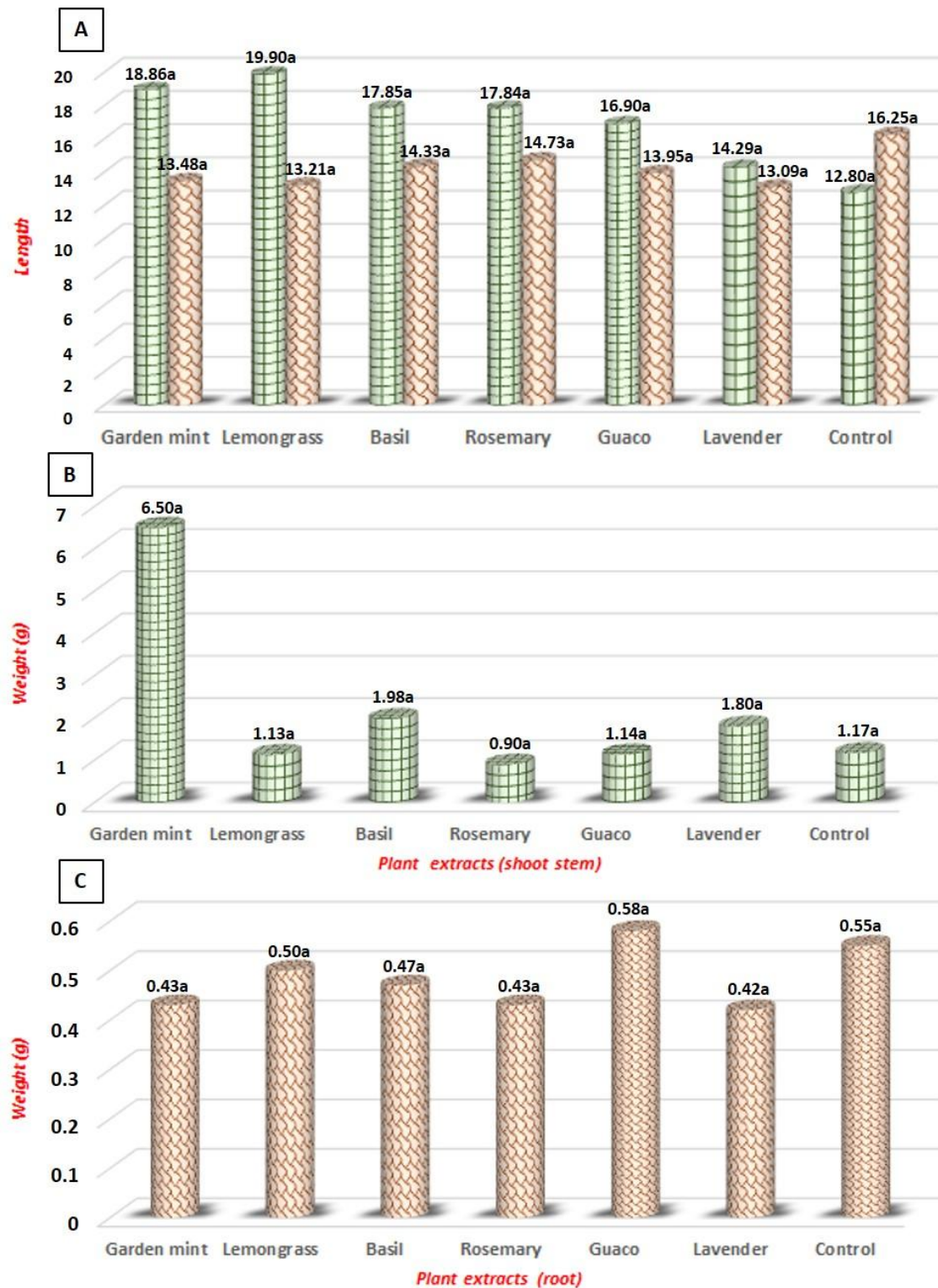
Based on the results of the *in vivo* experiment, all lengths of the aerial part were greater than that of the control, with increments between 11.6 and 55.4% (Figure 6A). On the other hand, all roots presented a shorter length than the control,

with decreases varying between -19.5 and -9.36%, although they did not differ significantly from each other (Figure 6A).

Regarding fresh weight (Figure 6B), it was observed that three treatments led to a greater weight of the aerial part, although without a significant difference from the control: Garden mint (+ 455.5%), basil (+ 69.2%) and lavender (+ 53.8%). The other treatments led to lower weight of the aerial part: rosemary (-23%), lemongrass (-3.4%) and guaco (-2.5%).

In the fresh weight of roots, it was observed that in all treatments they were lower than the control, without extract, varying between -9% and -23.6%; except for the treatment with guaco (Figure 6), which exhibited the highest average (+5.4%).





**Figure 6.** Effect of 4 mL of 50% plant extracts on the length of aerial parts and seedling roots (A). Effect of 4 mL of 50% plant extracts on the fresh weight of aerial parts of seedlings (B). Effect of 4 mL of 50% plant extracts on the fresh weight of *Ipomoea purpurea* root seedlings. Means followed by the same letter do not differ significantly by the Tukey test (P < 0.05).

The allelopathic effect of cultivated plants can be considered an important tool in the control of weeds (Mushtaq et al. 2020). It is known that a well-established crop is better able to compete with or resist pests. Thus, methods that provide an advantage for the crop at the beginning of its cycle will increase its competitive potential over invaders (Constantin, 2011). Regarding the germination time and based on study experiments, it was observed that different seed lots of *I. purpurea* have differences in the germination time, as the average time varied between 2.48 and 7.22 days, in the control treatments. These values coincide with the Seed Analysis Rule (Brasil, 2009), which says that evaluations with this species must be done within 21 days, and with Kissmann and Groth (1999), who reported asynchronous germination for this species. On the other hand, Pazuch et al. (2015) claim that the species begins to emit the radicle between the 3rd and 4th day.

The extracts that stood out in delaying germination, when compared to the control of the respective experiment, were rosemary, lavender, castor bean and banana (in the concentration of 35%) and lavender, guaco and Mexican sunflower (in the concentration of 50%). These results are similar to those of Steinsiek et al. (1982), who also observed a delay in the germination of *I. hederace* and *I. lacunosa* with wheat extract. Mauli et al. (2009) observed that aqueous leucena extracts significantly delayed the germination of *I. grandifolia*. Likewise, Araújo et al. (2010) reported that crotalaria extract also delayed the germination of *I. grandifolia*. Additionally, Silva et al. (2016) reported that leachate from *A. extraaxillaris* delayed the emergence of *I. cordifolia*.

In contrast, the extracts that stimulated germination were: kalanchoe and guaco (35% / 4 mL) and rosemary, kalanchoe and guaco (35% / 8 mL). No studies were found that reported increased germination of *I. purpurea*, although it is an interesting role, as they could awaken dormant seeds or those that are in the soil seed bank, allowing the adoption of management measures for these plants.

The 50% extracts were more efficient in delaying germination for the tested plants. In contrast, extracts tested at twice the volume, in general, exhibited average times lower than 35%, except for kalanchoe, in which the advance was greater. An important observation that must be emphasized is

that the extracts of kalanchoe, lavender and Mexican sunflower maintained the pattern in terms of germination time, delaying it both in concentrations of 35 and 50%. Rosemary extract at 35% and 50% delayed and at 35% (8 mL) it advanced the germination of morning glory seeds. Regarding guaco extract at 35% (4 and 8 mL), the germination advanced, and at 50% it showed the opposite result, delaying germination, indicating that the allelopathic effect may be involved with the dose or concentration. Lavender extract also maintained the pattern of delaying germination, although it was much greater at 50%.

Concerning the germination index, the present results agree with the reports by Ferreira and Áquila (2000), in which allelopathy had no (significant) effect on germination, being more efficient in delaying it. However, in most experiments, germination was less than the control, suggesting some effect, except for Indian coleus, aloe vera, guaco, boldo, fennel, ginger bush, black plum and Mexican sunflower, for which germination was greater than the control, although without a significant difference. Evaluating the extracts for which new volumes or concentrations were tested, the guaco extract also behaved in the opposite way with respect to germination, as it was higher in the concentration of 35% (4 mL) and lower in the concentration of 50% (4 mL) and 35% (8 mL). The treatment with mint extract germinated less than the control at 35% (4 mL) and higher in the 50% (4mL) treatment, showing that the volume and concentration can also affect individual germination, depending on the plant extract in question.

Reinforcing this idea, in the studies by Mauli et al. (2009), evaluating cold and hot aqueous extracts of leucena on the germination of *I. grandifolia*, there was no significant interference in the germination index. In contrast, studying the hydroalcoholic extract of araticum-do-cerrado on the germination of *I. grandifolia*, Inoue et al. (2010) observed a significant decrease in the germination of this plant.

Regarding the *in vivo* parameters evaluated, the length of the aerial part (aerial part) was greater than the control for all treatments, suggesting growth promotion or positive allelopathy, although without a significant difference. Plant extracts (called biofortifiers or biostimulants) have been investigated to promote plant growth. Lorensi et al. (2017) evaluated extracts of Aloe vera and boldo in tomato development, showing an increase in

germination, root length and aerial part length. As for the root length, the result was the opposite, as all were shorter than the control, suggesting an inhibition of the roots. Corroborating the results of the present study, Mauli et al. (2009) also observed that leucena plant extracts reduced the length of *I. grandifolia* roots. The fresh weight of the aerial part was lower, although with no significant difference between the treatment with lemongrass, rosemary and guaco. As for the dry weight of roots, the only one greater than the control was guaco, also without a statistical difference. However, studies by Nimbal et al. (1996) showed that for roots, sorgoleone, a sorghum substance with allelopathic effects, led to a greater accumulation of dry mass of *I. hederacea* roots.

## Conclusion

It can be concluded that the germination or growth of some problematic weeds such as *I. purpurea* may be affected by allelopathic methods and the use of allelochemical extracts from different plants such as bananas, black plum, boldo, Mexican sunflower, rosemary, guaco, lavender, lemongrass, and garden mint.

## Conflicts of Interest

No conflicts of interest have been declared by authors.

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