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# Potential Suppression Effects of Aqueous Extracts of Selected Plants on Growth of Carrot Weed (*Parthenium hysterophorus* L.) in Arusha, Tanzania

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author NCM designed the study, performed the statistical analysis, and wrote the protocol and the first draft of the manuscript. Authors PN and EM design the study, wrote the protocol, and managed the analysis of the study. Author TM designed the study and managed the literature searches. All the authors read and approved the final manuscript*

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## ABSTRACT

This study investigates the potential suppression effects of aqueous extracts derived from selected plants on the growth of carrot weed (*Parthenium hysterophorus* L.) in Arusha, Tanzania. The research aimed to explore natural and sustainable methods for managing the proliferation of this invasive weed species. Through a series of laboratory experiments, aqueous extracts were prepared from specific plants namely amaranth (*Amaranthus spinous* L.), neem (*Azadiratchta indica* L.) wheat millet (*Sorghum bicolor*), and marigold flower (*Tagetes erictus* L.). The extracts were tested against carrot weed in the laboratory and pot experiment for their effectiveness in inhibiting the germination and growth of carrot weed seeds under controlled conditions. Leaf

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extracts at 25, 50, and 100% concentrations were sprayed on four and eight-week seedlings *of P. hysterophorus*. Distilled water was used as a control. The highest germination percentages were 95.5% and 93.33% in the control treatment for *T. erictus* flower extract and the leaf extracts respectively. Results showed that all plant extracts tested indicated high inhibition of growth and germination rate of *P. hysterophorus*. Due to increasing concentrations, from 25 to 100%. However, 100% concentration was more effective in all plant extracts used. Four weeks seedlings were more susceptible to foliar sprays compared with eight weeks seedlings. These findings highlight the potential of using locally available plants to develop eco-friendly strategies for managing carrot weed infestations in the region. Further research is warranted to identify and isolate the active compounds responsible for the observed suppression effects. This study contributes to the knowledge of sustainable weed management practices and underscores the importance of exploring nature-based solutions for agricultural challenges in Tanzania and beyond.

*Keywords: Parthenium; allelopathic; inhibition effects; allelochemicals; suppression.*

## 1. INTRODUCTION

*Parthenium hysterophorous* L., commonly known as carrot weed is an herbaceous annual weed native to America but was introduced to Africa, Asia, and Australia and established itself. This weed can reach a height of 2m, and produce thousands of seeds that remain viable for about six years in the soil seed bank [1]. Generally, the weed has the habit to invade disturbed areas and its incidence is high in flooded areas (McFadyen 1992). Also, this weed invades farm and grazing lands and affects biodiversity, animal and human health, agricultural productivity, and food security. This invasive plant species has been reported to originate from the hybrid of *P. confertum* and *P. bipinnatifidium* [2]. Since its invasion in the country*, P. hysterophorus* has become a serious threat to biodiversity through the degradation of natural ecosystems [2]. The weed is currently spreading to many habitats including agricultural lands, protected areas as well as pasture land [3]. *P. hysterophorus* L. has strong allelopathic effects hence able to establish itself rapidly in new environments and suppress the growth of other native species. Due to its allelopathic properties, the plant has the ability to colonize soils and inhibits the growth of most plant/crop species, and cause injuries to humans and animals [4-7] (Levine et al*.,* 2000). High reproductive potential, fast growth rate, adaptation to new environments, and interference by allelopathy are the major contributing factors for the rapid spread and successful establishment of this weed in any ecosystem [8].

Several management approaches such as mechanical, chemical, competitive replacement, and biological control have been used to control this weed where only herbicides application is the common practice [9]. Nevertheless, chemical herbicides such as polyphosphate, atrazine, 4-D, and Metribuzin are no longer reliable due to the cost and increasing weed resistance [10]. Therefore, the use of bio-pesticides seems to be a vital strategy of weed control in recent years. Many plants are known to have herbicidal effects on other plant species [11-13]. Plants such as *Amaranthas spinous*, *Azadiratchta indica*, and *Tagetes erictus* are reported to have allelochemicals which, when released to the environment, have effects on the seed germination, growth, and development of other plants.

The present research work aimed to investigate the effect of aqueous extract of leaves and flowers of *Azadiratchta indica, Amaranthus spinous*, *Sorghum bicolor,* and *Tagetes erectus (*leaf and flower*)* on germination, growth, and development of *P. hysterophorus*. Such information is critically important for the development of biological weed control methods.

## 2. METHODS

### 2.1 Experimental Site

The study was conducted at the Nelson Mandela African Institution of Science and Technology (NM- AIST) and at Tanzania Pesticides Research Institution (TPRI) in Arusha, Tanzania from May to November 2018. Experiments were conducted to determine the herbicidal effects of leaf and flower aqueous extracts of *A. indica, T. erictus S.bicolor, and A. spinous* on seed germination, fresh biomass, dry biomass, shoot and root elongation of *Parthenium hysterophorus*. Extract preparation was conducted at NM-AIST while screen house

experiments and part of laboratory work were conducted at Tanzania Pesticide Research Institution. (TPRI). The experiments were conducted in two different seasons, the first in May-August 2018 and the second in September-November 2018 following a complete randomized block design (CRBD).

## 2.2 Preparation of Extracts

Leaves of *A. indica, A. spinous*, *T. erictus,* and flowers from *T. erictus* plants were collected from the fields in Kikwe village, Arusha (3º426345N 36º827934E) and air-dried at room temperature (25ºC) for 20 days. The dried leaves and flowers were ground separately to powder using a laboratory blender. Distilled water was used as extraction solvent whereby 100 g of powdered flowers/leaves were prepared and soaked in 1000 mL of distilled water. The mixture was kept in a conical flask with its top closed and stored in a dark room for 72 hours at room temperature and, thereafter, filtered using muslin cloth to obtain a stock solution of 0.1 g $mL^{-1}$ concentration. The stock solution was diluted in three different concentrations of 25, 50, and 100% and named as T2, T3, and T4, respectively. Distilled water was used as a control (T1).

### 2.2.1 Laboratory bioassays

Extracts were evaluated on *Parthenium* seeds germination using concentrations of 25%, 50%, and 100%. Twenty seeds of *Parthenium* were placed in a 7 cm diameter Petri dish plate lined with Whatman No. 1 filter papers moistened with 3 mL of separate concentration of each extract. The control treatments received the same quantities of distilled water. Each treatment was replicated three times. Plates were incubated in the growth chamber at room temperature (20◦in 12-hour light periods daily. Germinated seeds were counted manually for 14 days every 2 days intervals and the experiment last for 21 days.

### 2.2.2 Foliar spray bioassays

Seeds of *P. hysterophorus* were sown in pots of 10 cm diameter and 30 cm deep each containing 400 g of soil. Initially, 20 seeds were sown in each pot which was thinned to 5 uniform seedlings at the time of harvest. The freshly prepared extracts of *A. spinous, A. indica, S. bicolor, and T. erictus* (leaf and flower) were sprayed on the surface of 4 and 8 weeks old *P. hysterophorus* plants. Two consecutive sprays were carried out at 5 days intervals each. Control plants were similarly sprayed with distilled water. Plants were harvested 20 days after spraying.

## 2.3 Determination of Shoot Length, Root Length, Fresh Biomass, and Dry Biomass

Measurements of parameters were taken during the tenth week of growth of *P. hysterophorus* species in the pot experiment. Roots and shoots for *Parthenium* in each replicate were measured using a ruler. Fresh biomass was measured using a weighing balance thereafter the plants were placed in a labeled envelope and oven dried at 70°C for 3 days. The dry biomass of plants was recorded and the data obtained were analyzed using statistica Software.

**Fig. 1. Pot experiment in the screen house**

## 2.4 Germination Inhibition/Stimulation

The percentage inhibition/stimulation effect on seed germination was calculated using the formula proposed by Singh & Chaudhary [14]. Inhibition (-) or stimulation (+) = [(Germinated seeds in extracts - Germinated seed in control)/Geminated seeds in control] x 100.

## 2.5 Statistical Analysis

The significance of the differences in germination percentage, root and shoot length, and fresh and dry biomass of seedlings under different treatments were tested and compared using one-way Analysis of Variance (ANOVA). The analyses were done using a statistical package Statistica version 8. Computed at p=0.05 according to Fischer's least significant different test.

## 3. RESULTS

**T**he results show that plant extracts from different plant species used in this study significantly ($p \leq 0.001$) inhibited the germination and seedling growth of *P. hysterophorus*. Root and shoot length, fresh and dry biomass as well as percentage germination of *P. hysterophorus* in control were significantly higher than in the plant extracts treatments.

Results presented in Fig. 1 indicate that seed germination of *P. hysterophorus* was significantly inhibited by the aqueous extracts of *A. spinous, A.indica, T.erictus* (leaf and flower) and *S.bicolor*. The inhibitory effect on seed germination trends of *P. hysterophorus* was concentration dependent as increased plant aqueous extracts concentration led to an increased inhibitory effect on the germination of *P. hysterophorus*. The highest germination percentages were 95.5% and 93.33% in the control treatment for T. *erictus* flower extracts and the leaf extracts respectively. Inhibition percentage increased significantly ($p \leq 0.001$) from -30.00%, -38.00%, -40.00%, -95.00% at 100% concentration for *A. indica, T. erictus* leaves, *T. erictus* flower, *A. spinous*, and *S. bicol*or extracts respectively (Fig. 1). Among the plant extracts used, maximum inhibition was observed with *S. bicolor* where 5.00% seeds germinated followed by *A. spinous* (16.67%). Comparatively, *T. erictus* (flower), *T. erictus,* and *A. indica* leaves also reduced significantly the germination percentage by 20%, 30%, and 33.33%, respectively, compared with the control treatment (Fig. 1).

Results presented in Figs. 5 and 6 revealed that aqueous leaf extract of *A. spinous* significantly ($p \leq 0.001$) reduced dry and fresh biomass of the *P. hysterophorus.* The highest values of fresh and dry biomass were 19.17,9.50,87.33and24.67 g for measurements taken at four and eight weeks of growth, respectively. In the control treatment, the lowest values of fresh and dry biomass of *P. hysterophorus* were 0.83, 0.01, 20.33, and 0.43 g for four and eight weeks respectively recorded at the 100% concentration. These results suggest that the fresh biomass of *P. hysterophorus* decreases significantly ($p \leq 0.001$) as the concentration level increases (Figs. 4 and 5). Furthermore, the results revealed that the control (0% concentration) was observed to have a high root and shoot length (9.67,10.73,8.36 and 8.82 cm, respectively) when compared with a high concentration 100% (Figs. 2 and 3). Moreover, high inhibition rate was observed on *A. indica* extracts on root and shoot length, fresh biomass, and dry biomass with values of 2.64, 3.48, 2.94, 2.95 cm, 1.33, 28.00 and 0.25 and 2.50 g, respectively and eight weeks respectively, as compared with control which had the values 9.68,11.40,19.679. 50 and 7.93,8.32,84.6,24g and 93.33% for root, shoot, fresh biomass, and dry biomass, respectively (Figs. 2,.3,4,5 and 6).

Results presented in Figs. 2 and 3 show significant ($p \leq 0.001$) bio-herbicidal effects of *T. erictus* leaf aqueous extract on roots and shoot length of *P. hysterophorus.* The effect on root and shoot length reduction was observed for both four and eight weeks for *Parthenium* treated with plant extracts, where the highest values were recorded in the control, which were 9.67and6.68 cm in roots and 11.00 and 8.71cm in shoots, respectively. The lowest root and shoot length were 2.03 and 2.94 cm and 2.17 and 2.38 cm, respectively (Figs. 3 and 4). Additionally, results also showed a significant reduction in both fresh and dry biomass (Figs. 5 and 6). Furthermore, the effects of aqueous flower extracts of *T. erictus* on the root, shoot length, and fresh and dry biomass of *P. hysterophorus were* also studied and the results are as presented in (Figs. 5 and 6). Both fresh and dry biomass of *P. hysterophorus* were reduced compared with the control treatment. The highest fresh biomass values observed in control treatments were 19.67 and 74.67 g for the four and eight weeks respectively, while the lowest values were 2.17 and 18.67 g observed

for four and eight weeks, respectively, recorded at 100% concentration. Similar inhibition effects were observed in dry biomass where the highest biomass values were 9.50 and 27.67 g in control treatment while the lowest values were 0.27 and 0.37g recorded in treatment with 100% concentration of aqueous flower extracts of *T. erictus* (Figs. 3 and 4). The lowest root length (1.63 and 3.50 cm) and shoot length (1.80 and 3.40 cm) of *P. hysterophorus* were found in pots treated with 100% (Figs. 3 and 4).

Results on Figs. 2, 3, 4, and 5 also showed that *Sorghum bicolor* extracts exhibited strong inhibition on root length, shoot length, fresh biomass, and dry biomass of *Parthenium*. The highest root and shoot length values observed in the control treatments were 7.93 and 11.00 cm respectively while the lowest values were observed at the concentration of 100%. The observed in the control treatments and the lowest in 100% concentration.

## 4. DISCUSSION

All plant extracts applied showed significance suppression of *P. hysterophorus* seedling growth in pot trials. Four weeks of seedlings were found to be more susceptible compared with eight weeks of seedlings. Results showed that the aqueous leaf extracts of *A. indica, T. erictus, S. bicolor, A. spinous* and *T. erictus* as well as flower extracts of *T. erictus* showed significant effects on seeds germination, reduction in shoot and root length as well as reduced dry and fresh biomass production. Findings obtained in our study are similar to those of Ngodya et al. [15] who reported that germination inhibition, root and shoot length reduction, and fresh and dry biomass were decreased with increasing concentration of *Desmodium* species extracts. Furthermore, Gholami [16] reports that inhibitory effects in roots and shoots were contributed by a reduction in cell division. This suggests that bioactive (bio-herbicidal) obtained from aqueous extracts of the investigated plants has a negative effect on cell division of *P. hysterophorus.*

Plant extracts have been reported to have inhibitory effects on the growth and development of other plants. For example, Siddiqui et al. (2009) reported that the aqueous leaf extract of mesquite (*Prosiposis julifora*) at different concentrations causes pronounced inhibitory effects on seed germination and root length on wheat (*Triticum aestivum*). Similarly, *Elisante* et al. [17] reported the inhibitory effects of *Datura stramonium* extracts on *Cenchrus ciliaris* and *Neonotania wightii* with their increasing concentration. Generally, germination is the result of the continuation of metabolic activities and growth of seed tissues which start with absorption of water through diffusion and osmosis hence causing activation of enzymes and increase metabolic activities.

In our experiments, seeds of P. *hysterophorus* supplied with aqueous extracts of *A. indica, T.erictus, A. spinous*, and *S. bicolor* affected their germination compared with those supplied with water. This might be the reason that plant extracts had metabolic compounds with inhibition effects. These findings are similar to the recent study conducted by Ramachandran (2018) who reported that the germination of *P. hysterophorus* was inhibited due to an imbalance of enzymes due to the application of aqueous extracts of *Datural metel*, *Mangifera indica*, *A. indica, T. erictus* and *S. bicolor* and *Heliantus annuus* which all showed inhibitory effects on the germination. On the other hand, this study also is in line with the study by Javaid et al. [13] showed a reduction in the Germination of *P. hysterophorus* by aqueous extracts of allelopathic grass *Desmostachya bipinnata..* Similarly, germination inhibition of *P.hysterophorus* due to aqueous extracts of three allelopathic grasses namely *Dicanthium annulatum, Cenchrus pennisiformis,* and *Sorghum helepense* have been reported by Javaid and Anjum (2005).

In this study, we found a strong reduction of *P. hysterophorus* biomass by 33.33% using extracts from *A. indica*. This reduction is due to the bioactive compounds found in *A. indica* which has bio-herbicides that suppress the growth of *P. hysterophorus*. Behl et al. [18] reported the presence of bioactive compounds such as Nimbin, Azadirone, Azadirachtins, and Salanin in *A. indica*. These bioactive compounds have strong bio-herbicidal properties and might have caused suppressive effects in the *Parthenium* growth parameters. These findings suggest that aqueous extracts of *A. indica* could be effective in controlling and managing *P. hysterophorus*.

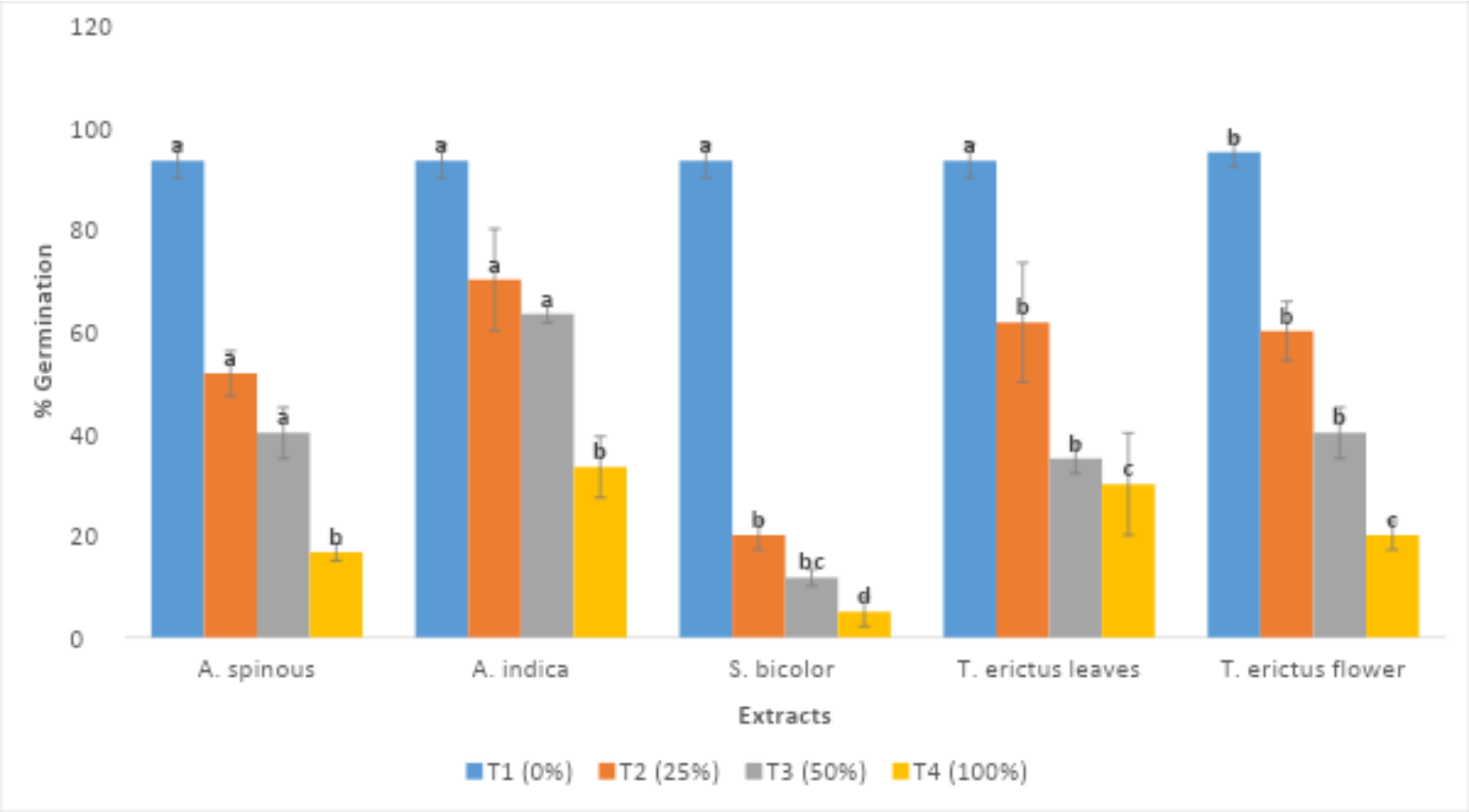


**Fig. 2. Inhibitory effects of aqueous extracts of *A. indica, T. erictus, A. spinous* and *S. bicolor* on seed germination**

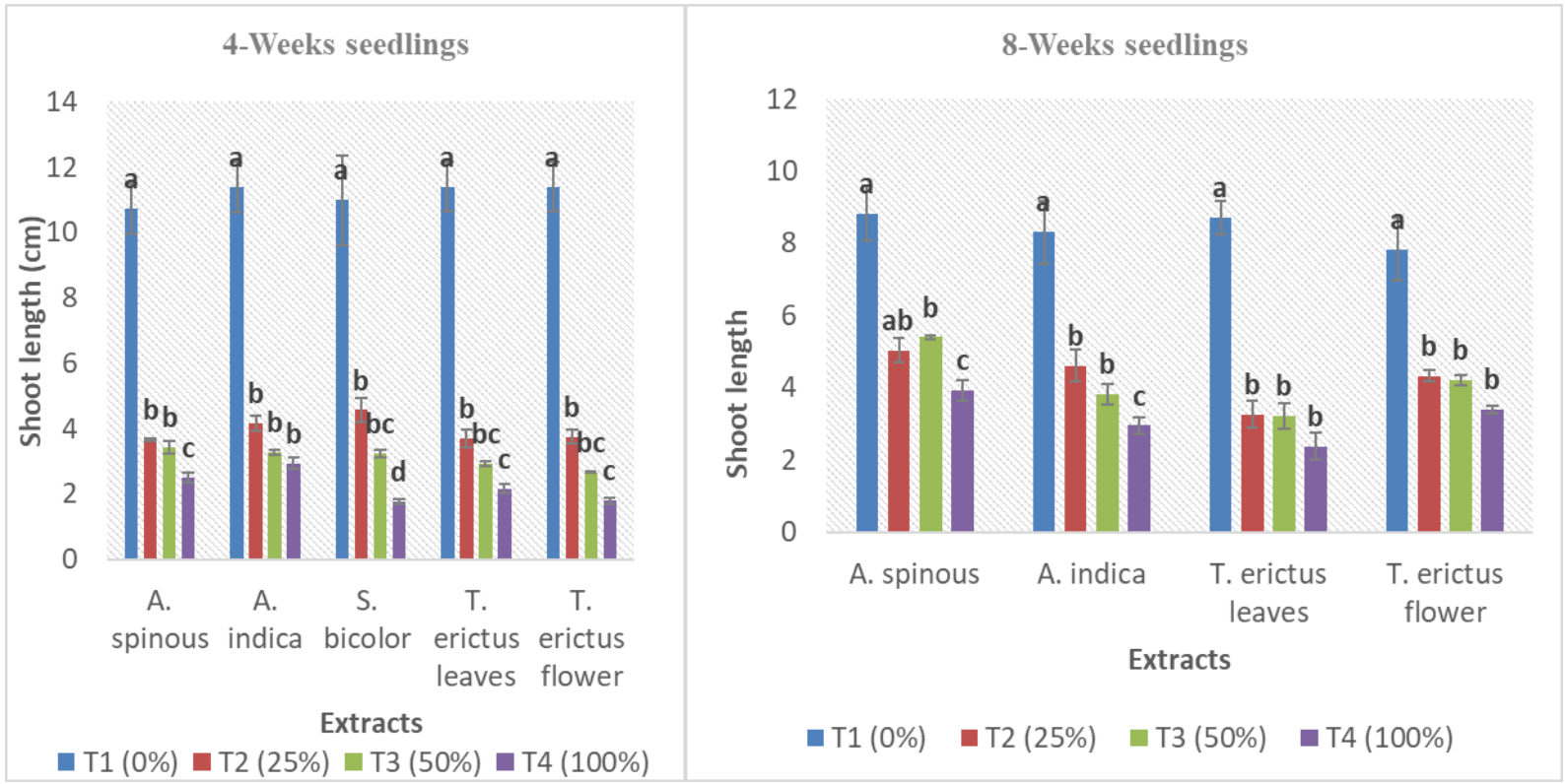


**Fig. 3. The effects of aqueous extracts on shoot length growth of *P. hysterophorus* sprayed at 4th week and 8th week of growth and harvested 20 days after spraying**

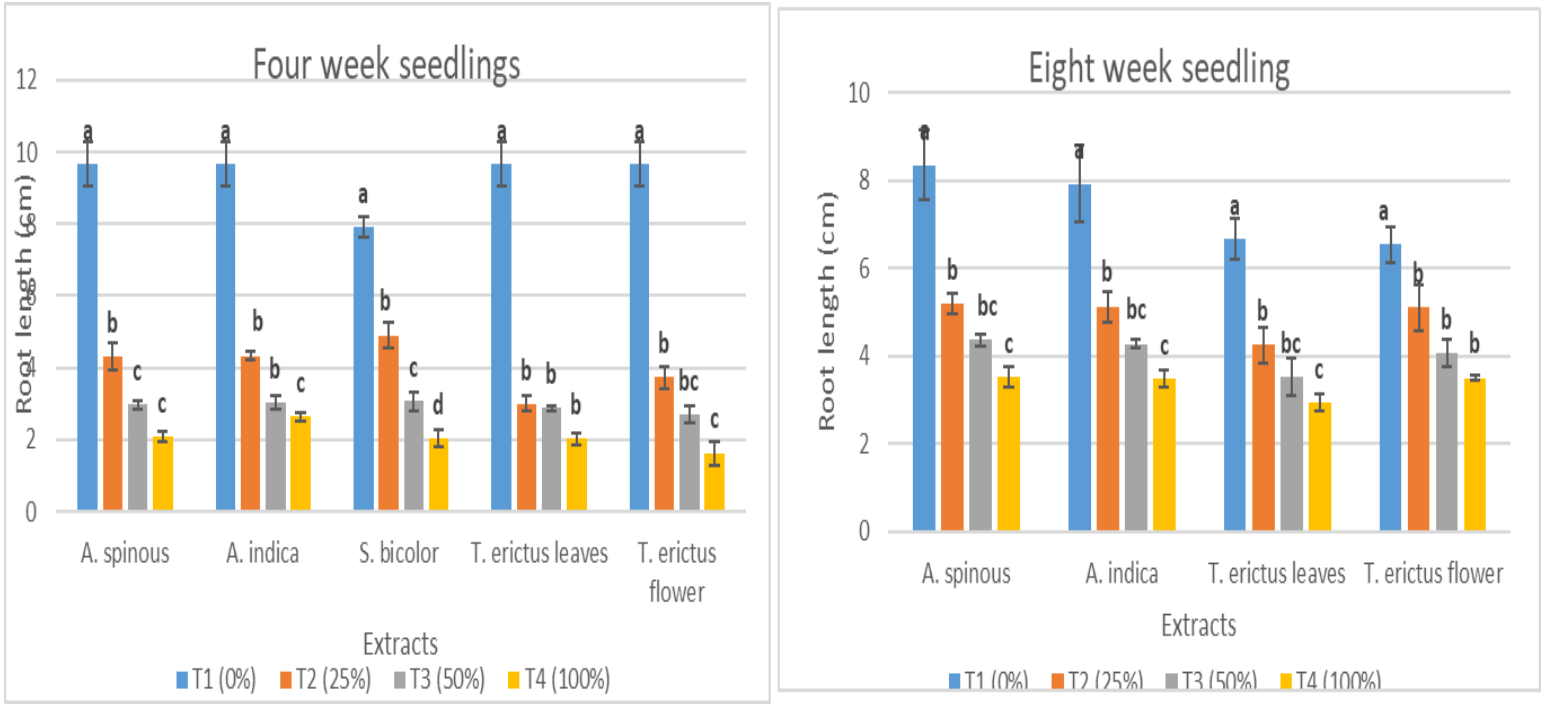


**Fig. 4. The effects of aqueous extracts on root length growth of *P. hysterophorus* sprayed at the 4th week and 8th week of growth and harvested 20 days after spraying**

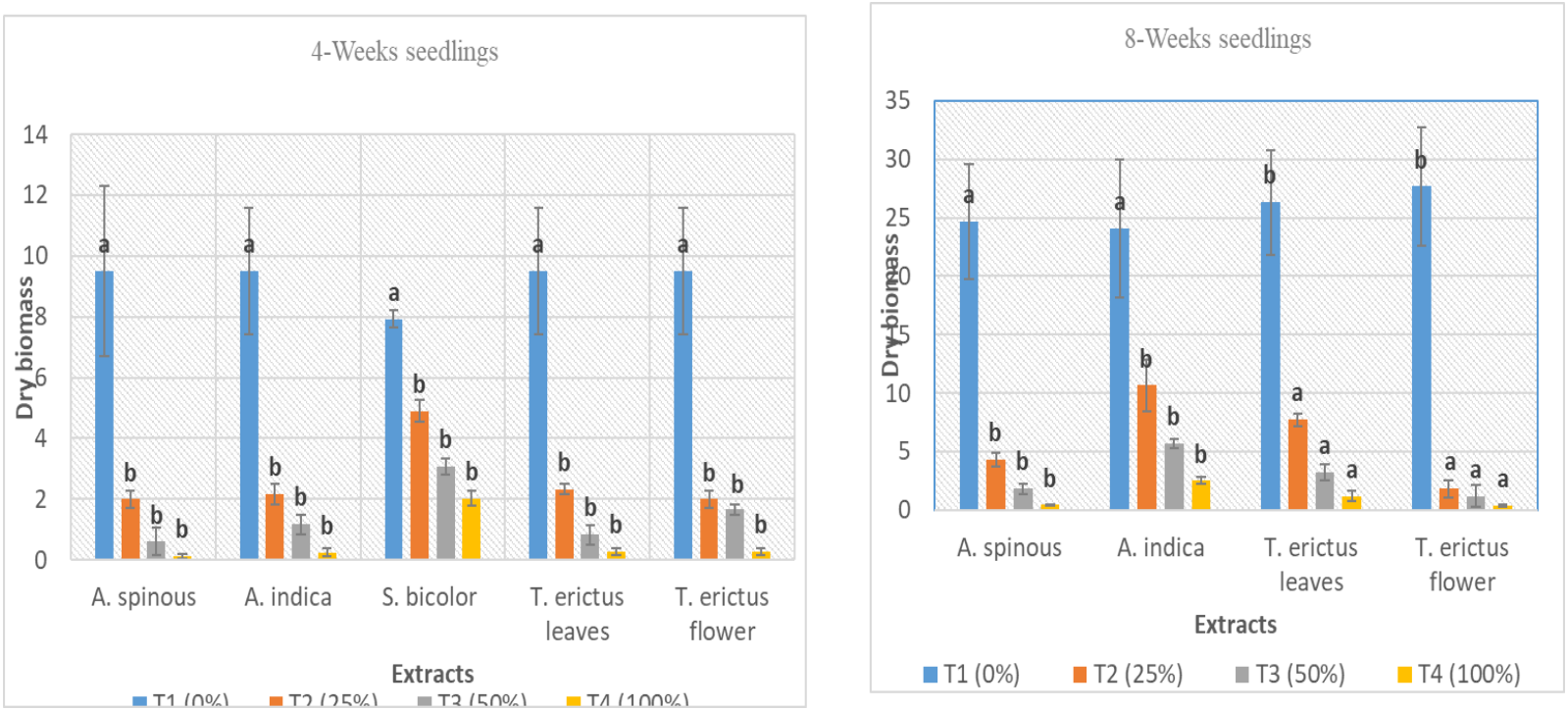


**Fig. 5. The effects of aqueous extracts on dry biomass of P. hysterophorous sprayed at 4th week and 8th week of growth and harvested**

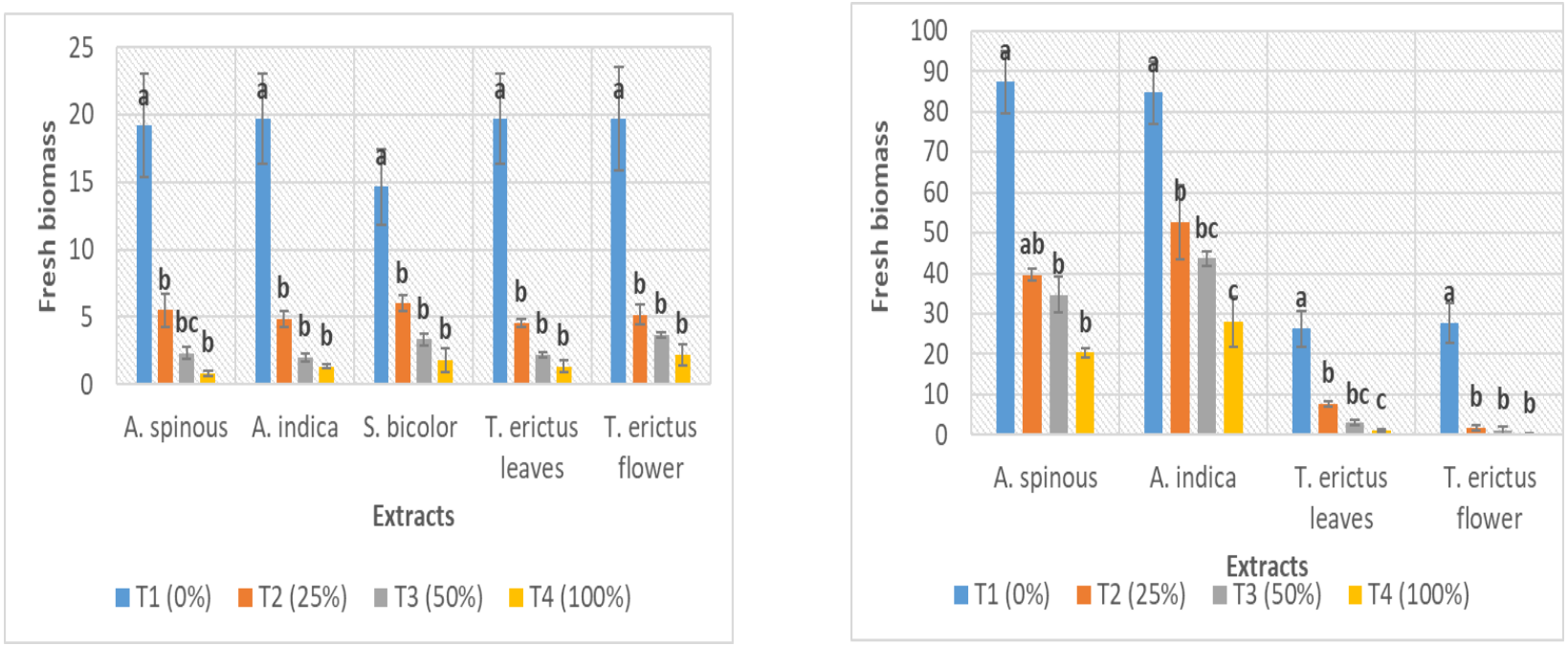


**Fig. 6. The effects of aqueous extracts on fresh biomass of *P. hysterophorus* sprayed at the 4th week and 8th week of growth and harvested 20 days after spraying**

Extracts from *A. spinous* showed significant effects on the growth of *P. hysterophorus* parameters. For example, at a 50 percent concentration of *A. spinous*, the root length was reduced by nearly 2-fold, while the dry biomass was reduced nearly 20-fold (Figs. 4 and 5). This could be contributed by the bio-herbicidal present in *A. spinous*. Our results are in agreement with a similar study by Thapar and Singh [19] who reported that the leaf extracts of *A. spinous* reduced the growth of *P. hysterophorus*. In their study, the suppressive effects of growth were associated with the presence of organic compounds such as amino acids. Another study [19] has reported that the bio-herbicidal present in the leaves of *A. spinous* stimulated lignin biosynthesis which increased the rigidity of the cell wall and limited the cell growth. The effects of aqueous leaf and flower extracts of *T. erictus* on seeds germination and growth of *P. hysterophorus* was investigated. Our findings showed that both extracts inhibited the growth of *P. hysterophorus* nearly by 3-folds at the 100% concentration. These findings are in agreement with the study conducted by Shafique [20] whose results revealed that the increase in the concentration of aqueous extracts of *T. erictus* reduced the root length, shoot length, and fresh and dry biomass of *P. hysterophorus,* and this was attributed to the concentration of the extract and presence of herbicidal properties found in *T. erictus*. Furthermore, Guzman [21] revealed that the intensity of inhibitory effects of different parts of plants may be due to the presence of different phytotoxic compounds such as phenolics, sesquiterpenes, and lactones from plant parts. In this study, more inhibition on roots, shoots, and germination, fresh and dry biomass was observed when the flower extracts were applied as compared with the leaf extracts. This suggests that flowers of *T. erictus* released stronger bioactive compounds which inhibited the growth parameters compared with leaves. *Sorghum bicolor* plant extracts also significantly inhibited the germination and the growth of *P. hysterophorus* root, shoot, fresh and dry biomass, and germination as a function of concentration increase. Our findings suggest that *S. bicolor* has great potential to control and manage *P. hysterophorus*. The present results are in agreement with the findings of Randhawa et al. [22] who reported that sorghum water extracts at high concentrations significantly reduced the germination, root, and shoot length of *Trianthema portulacastrum*.

## 5. CONCLUSION

It can be concluded that aqueous leaf and flower extracts of *S. bicolor A. spinous, T. erictus* (leafs and flower) and *A. indica* have bio-herbicidal effects on root and shoot length, fresh and dry weight, and germination of *P. hysterophorus* in the laboratory and pot experiments. The results show that all the applied plant extracts have potential in the management of *P. hysterophorus* when applied at higher concentrations. Further studies should be conducted under field conditions to ascertain the effectiveness of *S. bicolor A. spinous, T. erictus,* and *A. indica* in controlling *P. hysterophorus*. Further research on biological management by using other botanicals is needed to come up with a proper solution for this noxious weed. The promising plants are recommended for large-scale testing in areas where the weed is increasingly becoming a problem.

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## COMPETING INTERESTS

The authors have declared that no competing interests exist.

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