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The Suppressive Effects of Selected Plants Species for the Management of *P. hysterophorus*

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The present study investigated the suppressive effects of *Sorghum bicolor, Sorghum arundinaceum*, *Amaranthus spinous, Tagetes erictus* and *Cassia tora* on the management of *Parthenium hysterophorus*.
Study Design: A randomized block design was used to assess the suppressive effects of Sorghum *bicolor, Tagetes erictus, Amaranthas spinous*, *Sorghum arundinaceum and C. tora* in laboratory and pot experiments. The treatments were replicated four times.
Place and Duration of Study: Experiments were conducted at the Tropical Pesticides Research Institute (TPRI) and Nelson Mandela Institution of Science and Technology (NM-AIST) for three months from March to June, 2018.
Methodology: Plant to plant and seed to seed interactions were used to study the growth parameters behavior of tested plants both in pots and in laboratory settings. The germination of each plants in both laboratory and screen house was recorded soon after germination for 14 days at the interval of two days. Additionally, for pot studies, plant height, root length and biomass yield were assessed after a period of 3 months during the termination of the study.
Results: Results showed that *Sorghum bicolor, Tagetes erictus, Amaranthus spinous* and

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Sorghum arundinaceum demonstrated strong suppression on germination inhibition and plant height and root length as well as reduced biomass of *P. hysterophorus*. However, *Cassia tora* exhibited weak suppression effects in both laboratory and pot experiments.

Conclusion: Findings from this study suggest that *Sorghum bicolor, Tagetes erictus, Amaranthus spinous*, *Sorghum arundinaceum* were effective in affecting *P. hysterophorus*. Our finding provides bases towards developing an effective alternative to manage *P. hysterophorous.*

Keywords: Parthenium; management; suppression; allelloapathic.

1. INTRODUCTION

Parthenium hysterophorus L. (Carrot-weed) is a noxious herbaceous plant originating from the subtropical region of North and South America [1]. In Africa, the weed is recently reported to invade different countries such as Ethiopia, Somalia, Kenya, Madagascar, Mozambique, South Africa, Swaziland, Zimbabwe and Tanzania [2,3,4]. *Parthenium* is considered as a weed of global significance because of its negative impacts including skin dermatitis, asthma, and bronchitis to human and animals and, effect on agricultural crops incited by its allelopathic dominance [1,5,6,7,8,9,10,11]. *P. hysterophorus* is characterized by strong tolerance to a wide range of soil and environmental conditions, high seed production and seed persistence in soil banks, rapid germination, seedling growth and short life cycle [12,13]. Furthermore this weed produces phytotoxic substance/chemicals which inhibit germination of other plant species around it [14]: [15]. Different control methods for the weed have been reported so far. One of the mostly reported methods is the use of other organisms (biological management) to control the weed. Biological management of *P. hysterophorus* has been practiced in different countries in the world. For example, in Australia the use of insects and rust pathogen to control the weed have been practiced [16,17]. It has been shown that, the use of Epiblema *stenuana* Walker and *Zygogramma bicolorata* Pallister in the war against *P. hysterophorus* has shown success, though with some limitations. The organisms do not induce full suppression of the weed [18]. Similar observation on *Parthenium* control using the same organisms was recently reported in Tanzania. *Zygogramma* has emerged as an alternative biological control of the weed, the approach deals only with parts of the plant such as leaves. Moreover, number of chemical methods have been used in the management of this weed but the results shows that the chemicals kill only the existing *P. hysterophorus* weed population found in the area, but cannot prevent the entry of new seeds that are brought in by wind, water or other dissemination agents [19].

Despite of all the efforts applied in the management of *P. hysterophorus*in in Tanzania, the weed is still spreading rapidly. Due to its harmful effects, there is a need to investigate other management strategies such as suppressive potential from different plants. The use of suppressive plants have been done in countries such as India using guinea grass (*Panicum maximum* Jacq.) tanner's cassia (*Cassia auriculata* L.) and Fedogoso (*Cassia occidentalis* L) [20], Ethiopia using; Sorghum (*Sorghum bicolor* L, Moench); [21] and in South Africa using African Lovegrass (*Eragrostis curvula Nox*; [22]).

Although several reports have shown suppressive effect from plants such as *A. spinous*, *T. erictus* and *C. tora* on the management of *P. hysterophorus* in different parts of the world, the suppressive effects of the same plants in the management of *P. hysterophorus* in Tanzania is not documented. Therefore, this study aimed at investigating the suppressive effects of the selected plants species on the management of *P. hysterophorus.* Seed to seed and plant to plant interaction approaches were used in the management of weed.

2. MATERIALS AND METHODS

2.1 Experimental Sites

The experiments were conducted at The Nelson Mandela African Institution of Science and Technology (NM-AIST) Laboratory and at the Tanzania Pesticides Research Institute (TPRI) Arusha-Tanzania.

2.2 Plant Material Used in the Study

Five plants species namely *Tagetes erictus, Amaranthus* spinous, *Cassia tora*, *Sorghum* *bicolor* and *Sorghum arundinaceum* were used as suppressive plants. Seeds from mature plants were collected from different fields at Nambala village in Arusha, region, Tanzania. For each plant, 0.25 kg of seeds was collected and properly labeled and stored at -4ºC at NM-AIST, laboratory until used.

2.3 Seed-seed and Plant–plant Interaction Experiments

The experimental design for both laboratory and pot were established using a randomized block design. The treatments included seeds of 1) *P. hysterophorous* grown alone; 2) *T. erictus + P; hysterophorous*; 3) *A. spinosus + P. hysterophorous*; 4) *C. tora + P. hysterophorous*; 5) *S. bicolor + P. hysterophorous,* and 6) *S. arundinaceum + P. hysterophorous*. In petri dish experiment, germination was performed based on international seed testing standards (IST2014) in which seed subsamples were placed on blotters in petri dish. For *P. hysterophorous* grown alone, 200 seeds were planted in the petri dishes (20 seeds/petri dish). For treatments including a combination of species (*A. spinosus*, *C. tora*, *S. bicolor,* and *S. arundinaceum*) with *P. hysterophorous*, each petri dish was planted with 20 seeds of each species and 20 seeds of *P. hysterophorous*. These treatments were replicated four times. Before starting germination test all seeds were sterilized using sodium hypochlorite (5%) to remove any possible contaminations and then the seeds were washed thoroughly 4 times with distilled water. After planting, each treatment in petri dishes were irrigated with 3 mL of distilled water equally in the interval of four days to maintain moisture. The same treatments above were also planted in plastic pots containing six kilograms of sterile soils with a ratio of 1:3 sand and forest soils. These were replicated eight times. The plots were exposed to direct rain, and no fertilizer neither watering was used. All plants that germinated other than those selected species sown and *P. hysterophorus* were removed manually. The petri dish (Laboratory experiment) and four replications of the pot experiments were kept for 21 days. Other four replications of the pot experiments were evaluated for three months to determine the suppressive effects between plants.

During the 21 one days of germination test, the percentage germination was rated as normal, subnormal and dead seeds. In this experiment, only percentage of normal seeds was considered. Percentages of inhibition/stimulation effect on seed germination over control (T1) were calculated using the formula proposed by [23] Inhibition (-) or stimulation (+) = [(Germinated seeds in association - Germinated seed in control) / Geminated seeds in control] x 100.

For pot experiments that were evaluated for three months to determine the suppressive effects between plants, the growth parameters such as plant height and root length were determined by selecting five plants randomly, uprooting them from each of the replicated pots. All samples were separated from *P. hysterophorus* or test species, then dried for 72 h at 70ºC, and weighed for dry plant biomass.

2.4 Statistical Analysis

The effects of treatments on different parameters such as percent germination, plant height, root length and dry biomass were assessed using one way Analysis of Variance (ANOVA). The analysis were done using STATISTICA package Version 8. The significant means were compared at p=0.05 according to Fischer's least significant different test.

3. RESULTS AND DISCUSSION

3.1 Laboratory Tests to Evaluate Effect of Seeds of *A. spinous*, *S. bicolor, S. arundinaceum*, *T. erictus* and *C. tora* on Germination of *Parthenium hysterophorus*

Laboratory germination results indicate *that P. hysterophorus* germination was significantly decreased when grown in association with *S. bicolor, T.erictus, S. arundinaceum* and *A. spinous* (Table 1). The highest germination percentage was 97.5% in the control treatment as compared with other treatments. The germination percentage was lowered from 97.5% to 22.8, 21.3, 17.5, 11.3 and 10 for *C. tora, S. arundinaceum, A. spinous, T. erictus* and *S. bicolor*, respectively (Table 1). Furthermore, numerically, *S. bicolor* showed highest inhibition effects on germination of *P. hysterophorus.* Seeds to seeds interaction showed highest inhibition percentage value -89.5%, (equivalent to 10.0% germination) for *S. bicolor* compared with lowest inhibition percentage of -74.9% (equivalent to 22.8% germination) for *C. tora.*

Plants are known to produce metabolites which can affect the growth and development of other plants [24]. The extracts of plants have been considered in the past for management of *P. hysterophorous* due to their inhibition potentials [25,26], the trend also observed in this experiment. Herein, we have assessed the seed to seed interaction of different plant to manage the growth of *P. hysterophorous.* We found that different seeds (*S. bicolor, T. erictus, S. arundinaceum* and *A. spinous*) showed suppressive effect on the measured growth parameters. Other studies have also reported the use of biological agents to manage weeds. For example, the use of phytopathogenic fungi extracts were reported to strongly suppress the growth of *P. hysterophorous* and hence manage its spread in Pakistan [25]. Furthermore, [26] reported that extracts of different parts of Sorghum showed significance reduction on the germination of *Amaranthus refroflexus* weed. In a similar way, our findings on the tested plants showed suppressive inhibition on *P. hysterophorus* seed germination. This suggests that allelochemicals present in *S. bicolor, T. erictus, S. arundinaceum* and *A.spinous* have suppression effects to the germination of other crops. Findings from this study suggest that both tested plants could be used in management of the weed as they exhibited growth and germination inhibition. From these results, we conclude that the suppressive effects contributed by allelochemicals present in the tested plant species which have strong inhibition property and competes with the *P. hysterophorus* for nutrition and growth.

3.2 Suppressive Effects of Selected Plant Species on the Growth of *Parthenium*

The pot experiments from all the plant species showed a significant suppressive effects on germination of *P. hysterophorus* expect *Cassia tora* (Table 2). The highest germination percentage was 91.3% in the control as compared with other treatments. The germination was lowered from 91.3% to 62.5%, 18.8% 16.3%, 16.3% and 12.5% for *C. tora, S arundinaceum, T. erictus, A. spinous* and *S. bicolor* respectively .Numerically, *S. bicolor* showed stronger inhibition effect compared with other treatments. Inhibition percentage increased significantly ($p<0.005$) from -37.5%, -81.5%, -82.4%, -83.8% and -87.5% for *C. tora, S. arundinaceum, T. erictus, A. spinous* and *S. bicolor* respectively. Furthermore, this study showed that plant height, root length and dry biomass were significantly lowered when *P. hysterophorus* was grown in association with *S. bicolor, T. erictus, S. arundinaceum*, *A. spinous* (Table 2). However, sowing *P. hysterophorus* with *C. tora* had no significant effects on plant height, root length and dry biomass yield.

These findings suggest that, *S. bicolor, T. erictus, S. arundinaceum*, *A. spinous* had significant suppressive effects on the growth of *P. hysterophorus*, whereas *C. tora* was not effective in inhibiting the growth of *P. hysterophorus*. The effectiveness of *S. bicolor, T. erictus, S. arundinaceum* and A*. spinous* in reducing growth of *P. hysterophorus* could be attributed by the presence of active metabolites/allelochemicals which resulted in the suppression effects. For instance, it has been shown that, compounds such as organic and amino acids, phenolics, cyanogenic glycosite, sorgoleone, benzoquinone, alpha-terthienyl produced by *A. spinous*, *S. bicolor, S. arundinaceum*, and *T. erictus* affects the growth of other plants by suppressing growth [27, 28,29,30]. Such compounds could have contributed to the suppression effects on the growth *P. hysterophorous* observed in our study. This plants could be further tested in large scale and for other weeds.

Table 1. Effects of seed-seed interaction

Plant name	% Germination	% Inhibition
P. hysterophorous	97.5 ± 4.33a	
P. hysterophorus+ A. spinous	17.5 ± 2.50b	-81.8 ± 4.76a
P. hysterophorus+ T. erictus	11.3 ± 1.25b	-88.5 ± 2.37a
P. hysterophorus + S. bicolor	10.0 ± 2.04b	-89.5 ± 2.39a
P. hysterophorus + S. arundinaceum	21.3 ± 7.18b	- 78.2 ± 7.17a
P. hysterophorus+ C. tora	22.8 ± 8.98b	-74.9 ± 9.43a
F- statistics	41.8****	

Values presented are means± SE. Values with the same letter in the column are not statistical different (p=0.05)

Table 2. Suppressive effect of different plants on growth of *Parthenium hysterophorus* in pots

Plant name	Germination (%)	Inhibition %	Plant height (cm)	Root length (cm)	Biomass (g)
P. hysterophorus	91.3± 8.75c	-	4.25±0.51b	2.50 ± 0.11b	4.05 ± 0.21b
P. hysreophorus + A. spinous	16.3 ± 6.88a	-83.8 ± 6.88a	1.09 ±0.26a	1.02 ± 0.49a	1.50 ± 0.29a
P. hysterophorus+ T. erictus	16.3 ± 4.73a	-82.4 ± 4.31a	1.10 ±0.34a	0.86 ± 0.15a	1.50 ±0.29a
P. hysterophorus + S. bicolar	12.5 ± 1.44a	-87.5 ± 1.44a	1.05 ±0.19a	0.89 ± 0.09a	1.03± 0.39a
P. hysterophorus + S. arundinaceum	18.8 ± 54.27a	-81.3 ± 4.27a	1.42±0.03a	1.24 ± 0.34a	1.13 ± 0.13a
P. hysterophorus + C. tora	62.5 ± 13.62b	-37.5 ± 13.62b	3.63±0.70b	2.69 ± 0.41b	3.45± 0.33b
F-Statistic	18.35***		11.95***	7.38***	16.56***

Values presented are means ± SE. Values with the same letter in the column are not statistical different (p=0.05)

4. CONCLUSION

The motivation of the present study was to investigate the suppressive effects of *S. bicolor, T. erictus, S. arundinaceum, A. spinous* and *C. tora* in the management of germination and growth of *P. hysterophorus.* Tested plant species showed suppression effects on seed germination, growth, root length, and dry biomass on parthenium. Degree of suppression differed significantly with *C. tora* showing minimum suppressive effects. The study provide basis for parthenium management. 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

Authors have declared that no competing interests exist.

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