Original Research Article

Plant –plant Interaction Strategy for Managing *Parthenium hysterophorus* L

.

ABSTRACT

Aims. *Parthenium hysterophorus* is an invasive plant species which can cause significant decline in agricultural production and pasture land. Variety of herbicides have been used to control its spread in different areas of the world. However, the use of herbicides have led to an increase of human health problems and biodiversity losses, necessitating the need of alternative management technique such as interspecific competition from allelopathic plants. The study aims to establish the effects of sorghum species, *Amaranthus spinous, Tagetes erictus* and *Cassia tora* on the Parthenium growth and development.

Study design: All experimental design (laboratory and greenhouse) were established using a randomized design. At each sites, there were five test species and *P. hysterophorus* (control) each with four replications.

Place and Duration of Study: The trials were run monthly and repeated three times from March to June 2018. The germination of each plants in both sites was recorded soon after germination for 14 days in the interval of two days.

Methodology: Germination tests were done for the selected seeds of *T. erictus*, *A. spinosus*, *C. tora*, *S. bicolor, S. arundinaceum* and *P. hysterophorous* where by 20 seeds for each species were planted separately and 40 seeds for each selected seeds were planted with the alien

Results: Results shows that *Sorghum bicolor, Tagetes erictus, Amaranthas spinous* and *Sorghum arundinaceum* showed strong inhibition effects on *Parthenium* biomass, height and root length of *P.hysterophorus*. However, *Cassia tora* exhibited weak suppression effects on both laboratory and greenhouse experiments

Conclusion: These findings suggest that these plant species could be recommended as alternative management method of invasive parthenium. Our finding provides bases towards developing an effective alternative to manage *P.hysterophorus.*

*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 (Evans, 1997). In Africa, the weed is recently reported to invade different countries such as Ethiopia, Somalia, Kenya, Madagascar, Mozambique, South Africa, Swaziland, Zimbabwe and Tanzania (Medhin 1992& Clark *et al* 2011; Kilewa 2014). *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 (Evans, 1997; Levine *et al.,* 2000; Zavaleta, 2000; Belnap and Philips, 2001; Maharjan, 2007; Tamado and Milberg, 2000; Mahadevappa *et al.,* 2000; APFISN 2007). *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 (Navie et al., 1996: Nguyen et al., 2010). Different control methods for the weed has been reported so far. One of the mostly reported method 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 for 30 years ago (McFadyen, 1992; Dhileepan and McFadyen 2012). It has been shown that, the use of Epiblema *stenuana* Walker and *Zygogramma bicolorata* Pallister in the war against carrot-weed has shown success, though with some limitations. The organisms do not induce full suppression of the weed (Dhileepan, 2003). 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. Despite of all the efforts applied in the management of *P.hysterophorus*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 allelochemicals 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) (Yaduraju et al.2005), Ethiopia using; Sorghum (*Sorghum bicolor* L, Moench); Tamado and Milberg, (2004) and in South Africa using African Lovegrass (*Eragrostis curvula Nox*; Van der Laan et al., 2008) *.*

The use of other plants such as Sorghum *species, Amaranthus spinous, Tagetes erictus* and *Cassi tora* with known allelophatic potential which are locally available in Tanzania remain not well reported. This study aims at establishing allelopathic effect of selected plants species on Parthenium seed germination and seedling growth and development.]

2.0. MATERIAL AND METHODS

2.1 Study Area

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

2.2 Plant material used in the study

Five 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 in Arusha. For each plant, 0.25 kg of seeds was collected and properly labeled and stored at -4ºC at Nelson Mandela laboratory until used.

2.3 Seed germination test

Germination was performed based on international seed test in which subsamples of 100 seeds were placed on blotters in petri dish (20 seeds per petri dish). Percentage germination was rated as normal, subnormal and dead seeds. In this experiment, only percentage of normal seeds were considered.

2.4 Experimental layout for Pot/greenhouse experiment

Before starting germination test, seeds were sterilized using sodium hypochlorite (5%) to remove any possible contaminations and then the seeds were washed thoroughly 4 times with distilled water. Germination tests were done for the selected seeds of *T. erictus*, *A. spinosus*, *C. tora*, *S. bicolor, S. arundinaceum* and *P. hysterophorous* where by 20 seeds for each species were planted separately and 40 seeds for each selected seeds were planted with the *Parthenium*. Germination testing was done by planting the test seeds in 44 pots measured 30cm deep and 10 cm wide containing six kg of sterile soils with a ratio of 1:3 sand and forest soils. Eleven treatments replicated 4 times were used for each test species. 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 trials were run monthly and repeated three times from March to June 2018.

2.5 Experimental layout for laboratory

The procedures for the seeds germination were the same as for the pot experiment. Germination tests were done for the selected seeds of, *T.erictus A. spinosus*, *C. tora*, S. *bicolor*, S. *arundinaceum* and *P. hysterophorus* where by 20 seeds for each species were planted separately and 40 seeds for each selected seeds were planted with the alien species in the Petri dishes with double layer towel paper. The experiment involved total of 44 Petri dishes. For each test plant, there were eleven treatments and was replicated four times. Then each treatment in petri dishes were irrigated with distilled water 3 mLs equally in the interval of four days to maintain moisture. The experiment/trial lasted for 21 days.

2.6 Experimental design and data collection

All experimental design for both (laboratory and greenhouse) were established using a randomized block design. At each places, there were five test species and *P. hysterophorus* (control) each with four replications. Germination of each plants in both laboratory and screen house was recorded soon after germination for 14 days in the interval of two days. To determine dry plant biomass, height and root length at the screen house sites, sample of five plants were randomly uprooted from each of the replicated pots. All samples were separated from *P. hysterophorus* or test species, then dried for 72 h at 70 ºC, and weighed. Other measured parameters included: root length, biomass and plant height.

2.7 Germination inhibition

Percentages of inhibition/stimulation effect on seed germination over control (T1) were calculated using the formula proposed by Singh & Chaudhary (2011).

Inhibition (-) or stimulation (+) = [(Germinated seeds in association - Germinated seed in control)/Geminated seeds in control] x 100.

2.8 Statistical Analysis

The effects of treatments on different parameters such as 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.

3.0 RESULTS AND DISCUSSION

3.1 The effects of seed-seed interaction on germination

The germination rate and inhibition percentage in pot (screen house) experiment indicated that the growth of *P. hysterophorus* was strongly inhibited by *S. bicolor* with -87.5 % when compared with the control (*P.hysterophorus* alone) which had the germination rate of 91.3%. Other plants showed moderate germination inhibition percentage of -83.6, -82.4, -81.3 and -

37.5% for *A.spinous, T.erictus, S.arundinaceum and C.tora*, respectively, on *P. hysterophorus* as indicated in Table 1. The growth inhibition was also investigated. We found that tested plants showed different inhibition rates. For instance, sorghum showed stronger inhibition effect on the germination of *P. hysterophorus* in both pot and petri dish experiment with germination rate of 12.5% and 10.0%, respectively. *S. bicolor* showed highest inhibition -87.5% (equivalent to 12.5% germination) compared with the lowest inhibition percentage value of -37.5% (equivalent to 62.5% germination) when grown with *C. tora*. Laboratory experiment for 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*. Findings from this study suggests 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 allelochemicals in plants parts have strong inhibition property which compete with the *P. hysterophorus* for nutrition and growth.

3.2 Effects of selected plant species on the growth of *Parthenium* Parameters

The study showed that *P. hysterophorus* attained a height of 4.25 ± 0.26 cm when grown alone compared with when in interaction with the test species. The heights were 1.09 ± 0.51 cm, 1.1 ± 0.34 cm, 1.05 ± 0.19 cm, 1.42 ± 0.31 cm and 3.63 ± 0.70 cm when grown with *A. spinous, T.erictus, S. bicolor, S. arundinaceum* and *C. tora,* respectively, (Table 1). These findings suggests that, *S. arundinaceum* and *C. tora* are not effective in inhibiting the growth of *P. hysterophorus*. On the other hand, the effectiveness of other plants could be attributed to by the presence of their 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* affected the growth of other plants (Thapar 2005; Gommers & Bakker, 1988), and hence the depressive effects on *P. hysterophorus* as observed in our study (Table 1). In this study, the metabolites/ allelochemicals produced by *C. tora* showed no-significant competition or growth inhibition on *P. hysterophorus* (Table 1).

Similarly, *S.bicolor, S.arundinaceum T.erictus and A.spinous* showed reduction in root length and dry biomass of *P. hysterophorus*, except for *C. tora* which had long shoots (3.63 ± 0.70 cm) and high root length (2.69 ± 0.41 cm) (Table 1). *Sorghum almun* was previously reported to suppress *P. hysterophorus* by Khan et al. (2013) in Australia and Pakstani. In their study, they found that *S. almun* reduced the height of *P. hysterophorus* up to 73%. Such findings are similar to our present study where *S. bicolor*, reduced the height of *P. hysterophorus* by 4-folds (Table1). Our finding suggests that different species of sorghum can be used to reduce infestation of *P. hysterophorus* in the ecosystems. In a study by Ali and Khan (2017), they reported that sorghum species reduced biomass of *P. hysterophorus* up to 84%. , Like wise, in our present study we observed that *S. bicolor* reduce *P. hysterophorus* biomass by nearly 4-folds. Furthermore, in our study we have found that *A. spinous* inhibited shoot height of *P. hysterophorous*. Our findings are similar to those reported by Thapar and Singh (2005) who found that leaves of *A. spinous* produces metabolites such as amino acids and organic acids which accumulates in the leaves of *P. hysterophorus and* hence affects its respiration. Similarly, it is possible that inhibition of *A. spinous* in our study could have resulted from the accumulation of the amino and organic acid metabolites which eventually affected the respiration system of the plant and impaired its growth. It has also been reported that, *Tagetes erictus* extracts inhibited growth of *P. hysterophorus,* reduced shoots, root length and biomass (Shafique 2011). Aerial leaf extracts of *T. erictus* are known to reduce the growth of shoot and root length and biomass of *P. hysterophorous*. Our present findings on plant to plant interaction are in agreement to the findings by Shafique (2011).

Table 1 Suppressive effects of different plants on growth of *Parthenium hysterophorus*

Plant Name	**Height (cm)**	**Germination (%)**	**Inhibition %**	**Root Length (cm)**	**Biomass (g)**
P.hysterophorus	4.25 ±0.51b	91.3± 8.75c	-	2.50 ± 0.11b	4.05 ± 0.21b
P.hysreophorus + A.spinous	1.09 ± 0.26a	16.3 ± 6.88a	-83.8 ± 6.88	1.02 ± 0.49a	1.50 ± 0.29a
P.hysterophorus+ T.erictus	1.10 ± 0.34a	16.3 ± 4.73a	-82.4 ± 4.31	0.86 ± 0.15a	1.50 ±0.29a
P.hysterophorus + S.bicolar	1.05 ± 0.19a	12.5 ± 1.44a	-87.5 ± 1.44	0.89 ± 0.09a	1.03± 0.39a
P.hysterophorus + S.	1.42 ±0.031a	18.8 ± 54.27a	-81.3 ± 4.27	1.24 ± 0.34a	1.13 ± 0.13a

arundinaceum					
P.hysterophorus + C. tora	3.63 ± 0.70b	62.5 ± 13.62b	-37.5 ± 13.62	2.69 ± 0.41b	3.45± 0.33b
F-Statistic	11.95***	18.35***		7.38***	16.56***

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

Table 2 Seed-seeds competition

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

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 effects of plant to plant interaction for the management of p*. hysterophorus.* Tested plant species showed significant effects on seed germination, growth, root length, and dry biomass on parthenium. Degree of suppression differed in the respective plant species investigated. *S bicolor* was more effective on suppressing parthenium germination, plant height, root length and dry biomass compared with other tested species. 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**.]**

COMPETING INTERESTS

Authors declare that they have no competing interests

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