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THE COMBINED EFFECT OF BIOLOGICAL CONTROL WITH PLANT COMPETITION ON THE MANAGEMENT OF PARTHENIUM WEED (*PARTHENIUM HYSTEROPHORUS* L.)

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Abstract

Parthenium hysterophorus L., (Asteraceae) commonly known as parthenium weed, is a highly invasive plant that has become a problematic weed of pasture lands in Australia and many other countries around the world. For the management of this weed, an integrated approach comprising biological control and plant competition strategies was tested in southern central Queensland. Two competitive pasture plant species (butterfly pea and buffel grass), selected for their high competitive ability, worked successfully with the biological control agent (*Epiblema strenuana* Walker) to synergistically reduce the biomass of parthenium weed, by between 62 and 69%. In the presence of biological control agent, the corresponding biomass of competitive plants, butterfly pea and buffel grass increased in comparison to when the biological control agent had been excluded, by 15 and 35%, respectively. This suggests that biological control and competitive plants can complement one another to bring about improved management of parthenium weed in Australia. Further, this approach may be adopted in countries where some of the biological control agents are already present including South Africa, Ethiopia, India, Pakistan and Nepal.

Keywords: Biocontrol, Asteraceae, Plant Suppression, Integrated Weed Management

Introduction

The combined effect of both competitive plants and specialist herbivores released as classical biological control agents would be expected to be greater than either approach alone (Crawley 1983; Shabbir *et al.*, 2013). The invasive potential of a weed should be significantly compromised by the biological control agents as well as by the neighbouring vegetation (Doyle *et al.,* 2007; Sheppard 1996). It is known that growth interference caused by competitive plants and by biological control agents can have a synergistic (Lee & Bazzaz 1980; Sheppard 1996; Ferrero-Serrano *et al.,* 2008) or no effect (Suwa *et al.,* 2010) on the growth of a weed species.

Parthenium hysterophorus L., is a highly invasive weed species, native to the Gulf of Mexico, the southern United States of America (USA) and possibly within Argentina and Brazil, has now developed a worldwide distribution and is currently present in more than 30 countries (Adkins & Shabbir. 2014). Around the world this invasive plant has become a significant problem of rangelands, crops, a threat to natural ecosystems and a human and animal health hazard (Adkins & Navie 2006). Parthenium weed is considered as one of the most problematic pest plant species in central Queensland where it is reducing the pasture productivity and thus inducing losses of up to AUD 109 million per year (Adamson & Bray 1999). The weed can directly affect livestock health, milk and meat quality (Tudor *et al.,* 1982) and indirectly it can prevent marketing of pasture seed (Chippendale & Panetta 1994).

In Australia, the classical biological control is the main strategy used to manage parthenium weed and to date, 11 bioconrol agents (9 insects and 2 rust pathogens) have been released into the field (Dhileepan & McFadyen 2012). Some of the released agents (*Zygogramma bicolorata* Pallister; *Epiblema strenuana* Walker and *Listronotus setosipennis* Hustache) have provided a good control of parthenium weed populations but not all agents established throughout the range of parthenium weed in Queensland (McFadyen 1992; Dhileepan 2003).

In this study the combined effects of biocontrol control agents with competitive plants on the growth of parthenium weed is ascertained under field environments. This study will determine how competitive plants and selected biological control agents can interact to give better management than either approach alone.

Materials and Methods

Field site and its preparation: A field site (S 24° 88' E 151° 27' 19") near the town of Monto in south central Queensland was selected for this study. Once the site had been selected it was cultivated and 15 treatment plots each (6 × 4 m) were created. A 1 m wide path was maintained between each replicated plot to distinguish the plots from each other and for later use in site husbandry practices. The seed of the suppressive plants (butterfly pea and buffel grass) was obtained from seed merchant. The seed for each plot was mixed well with dry sawdust (*ca*. 3kg) and then broadcast onto the individual plots using the standard seeding rate for both selected species. However, this rate was adjusted following seed viability tests carried out under lab conditions. After sowing, the seed was tapped into the soil surface using a hand driven water tank roller (*ca.* 100kg). A fence of barbed wire was set up around the site to exclude large wild or domestic animals from the experimental site. A plastic irrigation pipe connected to sprinklers was laid out over the filed site and irrigation was applied only once, 1 week after sowing to help establish the pasture species.

Exclusion of biocontrol agents and weeds: Biological control agents that were present at this site were removed from certain plots by the application of pesticides. The fungicide Mancozeb (15g $10L^{-1}$) and the insecticide mixture of Dimethoate (7.5mL $10L^{-1}$) and Bifenthrin (6.0mL $10L^{-1}$) and a commercial surfactant (Activator, Nufarm Australia Ltd.) were applied using a back pack spray rig directly onto the parthenium weed plants and using a plastic shield to prevent application to other neighbouring plants. All weeds (other than parthenium weed) present in plots were controlled using spot-spray applications of glyphosate (500mL $ha^{-}1$).

Data collecting and harvesting: This trial was run for one growing season (September 2008 to March 2009) and the field site was monitored on monthly basis to see if irrigation was necessary, to apply pesticides and herbicides, and to check the fence line. On the fifth visit (*ca*. 145 days after sowing), the biomass of parthenium weed and test plant in each plot were harvested. To do this, a quadrate (1 m^2) was thrown randomly into each plot five times and plants cut at soil level with the help of grass shears and placed individually, for each plot, into brown paper bags for later dehydration (at 80°C for 3 days) and dry weight determination.

Experimental design: In total 30 treatment plots (each $24m^2$) were created with five replicates for each treatment and the experiment was laid out in a randomized design fashion. For the comparison of biomasses for both the competitive plants and parthenium weed, a two way analysis of variance was performed using Minitab 16 statistical analysis software.

Results and Discussion

The only biological control insect observed at the Monto field was the stem galling moth (*E. strenuana*). Both the competitive plants (butterfly pea and buffel grass) when growing alone, without biological control agent were able to reduce the growth of parthenium weed by as much as 33 and 50%, or by 62 and 69%, respectively when the biological control agent was present (Fig. 1, Table 1). In the presence of the biological control agent, the corresponding biomasses of the competitive plants (butterfly pea and buffel grass) increased in comparison to that seen in the exclusion plots by 15 and 33 %, respectively (Fig. 1, Table 1). Buffel grass suppressed parthenium weed growth to a greater degree and produced more biomass as compared to butterfly pea, under both in the presence and in the absence of the agent (Fig. 1, Table 1).

The gross suppressive effect of the competitive plants resulted in 42% reduction in the above ground biomass of parthenium weed, and this was similar to that seen at the Injune, another field site already studied in south central Queensland (Shabbir *et al.,* 2013). In the presence of the biological control agents, the suppressive effect of test plants was increased to 66 % which was comparatively less than that seen at the Injune (Shabbir *et al.,* 2013). These differences in weed growth suppression across the two sites, involving both biological control agents and competitive plants, may have been due to the diversity of the agents present at the two different sites. At Injune, four biological control agents (*E. Strenuana, Z. bicolorata, L. setosipennis and P. abrupta*) were recorded while at Monto, the only one insect biological control agent (*E. strenuana*) was observed throughout the growing season the field.

When comparing competitive plants, in the absence of biological control agents, buffel grass was able to suppress parthenium weed growth more than butterfly pea. Buffel grass has already been reported to be a highly competitive species against parthenium weed in Australia (O’Donnell & Adkins 2005; Khan *et al*., 2010; Khan 2011). Furthermore, Navie *et al*., (2005) reported that buffel grass can to synergistically interact with a biological control agent, (*E. strenuana*) to bring about high levels of vegetative and reproductive growth suppression of parthenium weed under shadehouse conditions.

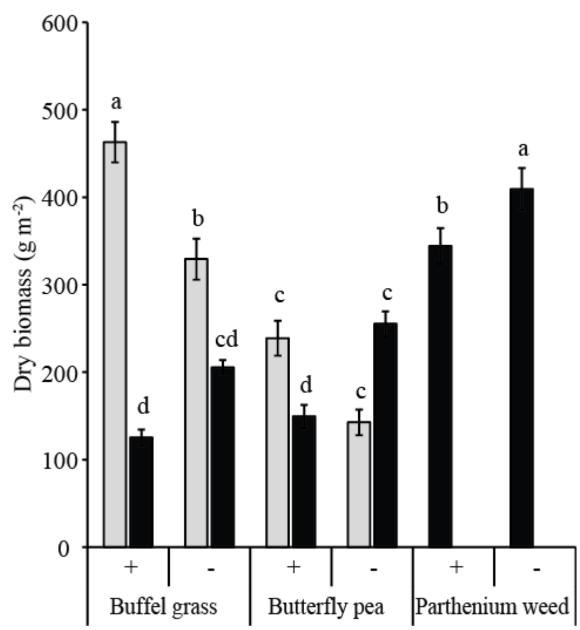

Fig. 1. The effect of biological control agent (+ is biological control agent present; – is biological control agent eliminated) on dry biomass production by competitive plant species (■) and parthenium weed (■). Error bars indicate standared error of the mean and different letters indicate significant differences ($p < 0.05$).

Table 1. The dry biomass change (%) of two test pasture species and parthenium weed, in presence or absence biological control (BC) agents.

Plant species	Dry biomass change (%)Test species		Dry biomass change (%) Parthenium weed
	BC present	BC excluded	BC present
Butterfly pea	+15	- 33	- 62
Buffel grass	+ 33	- 50	- 69
Parthenium weed	-		-21

Conclusions

It is concluded from this study that competitive pasture plants and biological control agents can work successfully together in the field to provide improved management of parthenium weed and these plants can also produce good levels of biomass (fodder). However these results were obtained under non-grazing conditions and undertaken using just a single species in a plot. It is anticipated that to gain the best parthenium weed growth suppression, mixes of suppressive plants should be used and, hence future work should focus on the use of sowing mixes under grazing pressure.

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