

Research Application Summary

Competitiveness of selected pasture plant species with parthenium weed

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Abstract

A study was conducted to investigate competitiveness of pasture species grown in combination with parthenium weed (*Parthenium hysterophorus* L.) at varying density levels at Tony farm, Haramaya University in Ethiopia using a factorial Randomized Complete Block Design. The treatments consisted of 10, 20 and 30 plants of either *Cenchrus ciliaris*, *Chloris gayana*, *Desmodium intortum*, *Lablab purpureus* or *Panicum coloratum* grown together with 30, 20 or 10 parthenium plants other than pure plots of each. The test species showed a significant ($P < 0.05$) inhibition efficiency (IE) on the dry matter biomass (DMB), height, number of tillers, and or branches and leaf area of parthenium. Among the species, *C. ciliaris*, *C. gayana* and *P. coloratum* were strongly suppressive ($>50\%$ IE) whereas *D. intortum* and *L. purpureus* were ranked as moderately suppressive ($<50\%$ IE). The species had 59, 68, 73, 36 and 47% IE at heavier density, 39, 52 47, 21 and 25% at medium, and 11, 19 18, 9 and 13% at lower density levels, respectively. Similarly, at heavier densities, a reduction of 39, 44 and 52% on height, 30, 41 and 40% on number of tillers and/or branches and 24, 30 and 36% on the leaf area was recorded, respectively. At this density, the species had a higher value of 2.57, 1.69 and 2.33 relative crowding coefficient (RCC) and a positive numerical value of 0.61, 0.52 and 0.68 aggressivity index (AI), respectively. Moreover, the species produced good DMB from 255 to 348 g/plot at pure culture. There was a strong association between IE and morphological attributes with a correlation coefficient value $r = 0.848, 0.795, 0.549$ and 0.413 between DMB, height, number of tiller and/or branch and leaf area, respectively. The results suggest that successful management of parthenium can be achieved through a biological approach using competitive pastures species in infested rangelands and/or other locations.

Key words: Biological control, invasive alien species, parthenium weed, pasture, relative crowding coefficient, species composition

Résumé

Une étude a été menée pour évaluer la compétitivité des espèces fourragères plantées en combinaison avec l'adventice parthenium (*Parthenium hysterophorus* L.) à différents

niveaux de densité sur la ferme Tony, Université de Haramaya en Ethiopie, en utilisant un dispositif factoriel de block aléatoire complet. Les traitements comprenaient 10, 20 et 30 plantes de *Cenchrus ciliaris*, *Chloris gayana*, *Desmodium intortum*, *Lablab purpureus* ou *Panicum coloratum* plantées ensembles avec 30, 20 ou 10 plantes de parthenium. Parmi les espèces, *C. ciliaris*, *C. gayana* et *P. coloratum* ont eu un pouvoir supprimeur élevé tandis que *D. intortum* et *L. purpureus* ont eu un pouvoir supprimeur modéré. Les espèces ont eu un pouvoir supprimeur de 59, 68, 73, 36 et 74% pour une densité élevée, 39, 52, 47, 21 et 25% pour une densité moyenne et 11, 19, 18, 9, et 13% pour une faible densité, respectivement. De même, pour des densités élevées, il était observé une réduction de 39, 44, 52% sur la hauteur, 30, 41, et 40% sur le nombre de talles et/ou branches, et 24, 30 et 36% sur la surface foliaire, respectivement. Pour cette même densité, les espèces ont eu une valeur plus élevée de coefficient d'encombrement relatif de 2,57, 1,69 et 2,33 et une valeur numérique positive de 0,61, 0,52 et 0,68 pour l'indice d'agressivité. Par ailleurs, les espèces ont produit une biomasse sèche allant de 255 à 348g/parcelle sur culture pure. Il y avait une forte association entre le pouvoir supprimeur et les traits morphologiques ($r = 0,848, 0,795, 0,549$ et $0,413$ respectivement entre biomasse sèche, hauteur, nombre de talles et/ou, surface foliaire et de branche). Les résultats suggèrent que le contrôle de parthenium peut être réussi à travers une approche biologique en utilisant des espèces fourragères compétitives dans les parcours naturels et/ou autres locations infestés.

Mots clés: Control biologique, espèces invasives, herbe sauvage parthenium, pâturage, coefficient relatif d'encombrement, composition d'espèces

Introduction

Poor management of rangelands as extensive grazing along with increasing deforestation for agriculture, fuel wood and recurrent drought results in biodiversity reduction and reduces the nutritive value of indigenous species and gradual replacement of indigenous species by low palatable and/or unpalatable species (Alemayehu, 2004). Besides, invasion of undesirable herbaceous and woody plant species have been threatening the pastoral production system in the Horn of Africa particularly in eastern Ethiopia (Amaha, 2003). Hence, invasive alien species (IAS) are the major challenges for countries like Ethiopia, through significant reduction in production potential of rangelands (SERP, 1995). They spread fast, are highly competitive, and can colonize new areas within a short period of time. One of these IAS in Ethiopia is parthenium (*Parthenium hysterophorus* L.) an annual broadleaf invasive weed from Asteraceae family (Tamado and Milberg, 2000; Lisanework *et al.* 2010). It reduces the yield of crops and pastures and when consumed by animals it taints their milk and meat, reducing their value. Parthenium also causes human health problems such as severe contact dermatitis, hay fever and respiratory stress. Several approaches have been used to manage the weed but most have a limited effect. The use of herbicides provides faster control but needs to be reapplied on annual basis when the weed re-emerges from soil seed bank (Tamado and Milberg, 2004). Chemical control has also a number of negative impacts including its high cost, negative impacts upon human health and repeated use lead to herbicide resistance development (Martin *et al.*, 2008). Thus, an integrated weed management approach through competitive pasture species has shown potential in several parts of the world. The

present study aimed to quantify the effects of selected competitive pasture plant species as a biological control agent on parthenium growth attributes under field condition in Ethiopia.

Materials and methods

The experiment was conducted in Tony farm, Haramaya University in the 2013/14 cropping seasons. The site is located at an altitude of 980 m a.s.l and experiences annual maximum and minimum temperatures of 32.4°C and 18.2, respectively, and annual average rainfall of 604 mm. Three pasture grass species (*Cenchrus ciliaris*, *Panicum coloratum* and *Chloris gayana*) and two legumes (*Desmodium intortum* and *Lablab purpureus*) were used in the study. *C. ciliaris* and *P. coloratum* were obtained from Somali Region Pastoral and Agro-Pastoral Research Institute (SoRPARI) while *C. gayana* was obtained from the International Livestock Research Institute (ILRI). Legumes were on the other hand supplied by the Ethiopian Institute of Agricultural Research (EIAR). Mature Parthenium seeds were collected from plants growing within the experimental site. Upon collection, these were hand threshed and air-dried to minimize dormancy and to retain seed viability. Before use, parthenium seeds were subjected to a germination test (Wardle *et al.*, 1991).

A uniform, well-drained location with a relatively level surface (8.40×19.60 m) was selected for the study. The area was cultivated using a hoe to a depth of 30 cm and left for a week to get other plant species killed. The site was levelled and divided into four blocks (3.70×9.30 m). Blocks were rectangular and perpendicular to the direction of expected gradient. Blocks were further partitioned into three columns by seven rows having a total of 21 plots (0.90×0.90 m) per block using a measuring tape, string and wooden pegs. A spacing of 1/2 and 1 m wide pathway was maintained between each plot and block, respectively. Likewise, a spacing of 10 and 30 cm was maintained between plants and planting row, respectively. The pasture seeds were sown in each plot with slightly excess of the required proportion at five different levels of test species-to-parthenium. Ten days after emergence, seedlings were thinned to the required population and kept growing for four months. All emerged weeds other than parthenium were removed manually from the entire plots.

Treatments were established from a pure stand of one pasture plant with progressive replacement with pasture plant species up to the pure stands of the later. Besides, the pure stand of each species at the same density levels, treatments with the proportion of 75:25, 50:50 and 25:75 for the pasture and weed were used. Total density of plants in each plot was held constant (40 plants per plot) while the proportion between test species and parthenium were varied. The treatments were replicated four times. The treatments were arranged in a replacement approach with an addition series experiment (Rejmanek *et al.*, 1989) in a Randomized Complete Block Design (RCBD). Data were collected for plant height, number of tiller and/or branch, leaf area, dry matter biomass, and relative crowding coefficient and aggressivity index.

Data on growth attributes were subjected to two-way ANOVA (SAS 2008 version 8). The Duncan Multiple Range test (DMR) was used to determine the difference between treatments

means. Lastly, correlation analysis (CA) was done to determine any association between inhibition efficiency of pasture species and growth attributes.

Research application

Dry matter biomass of parthenium mixed with test species were significantly different ($P < 0.05$) from the dry matter production in pure plot at different levels of planting densities. The finding revealed that at higher densities, *C. ciliaris*, *C. gayana*, *L. purpureus* and *P. coloratum* had 27, 32, 11 and 37% more inhibition efficiency than the least competitive species, *D. intortum*. Furthermore, the species were still competitive at medium and lower densities compared to *D. intortum*.

There was a significant reduction ($P < 0.05$) in dry matter biomass of parthenium at different planting densities (Fig. 1). The pasture species planted at heavier planting density had greater inhibition efficiency compared to medium and lower level of density. Thus, increasing planting density from 10 to 20 plants resulted in the dry matter reduction of parthenium.

Under heavier planting density, parthenium dry weight biomass was reduced by greater than 50% when mixed with grasses as compared to its pure plot. The inhibition efficiency was greater than 40% at medium planting density with *C. gayana* and *P. coloratum* but less than 30% with legumes. However, dry matter biomass reduction was less than 20% at lower densities (Fig. 1). The finding was in line with those reported by O'Donnell and Adkins (2005) and Khan *et al.* (2011).

The mixture of test species had a significant impact ($P < 0.05$) on height, number of branches and leaf area of parthenium (Table 1). The height of parthenium was highly inhibited by mixtures of *C. ciliaris*, *C. gayana*, *D. intortum*, *L. purpureus* and *P. coloratum*. The result further revealed that the number of branches of parthenium reduced by 46, 37 and 15% at heavier, medium and lower levels of density, respectively. Similarly, the mean leaf area of parthenium decreased by 24, 30, 12, 31 and 36 when mixed with *C. ciliaris*, *C. gayana*, *D. intortum*, *L. purpureus* and *P. coloratum*, respectively at heavier density levels. The greater inhibition efficiency of the grasses might be due to rapid seedling establishment, greater plant height, more tillering ability, more leaf area and dry matter accumulation than legumes (Table 1). The finding was in agreement with Aerts *et al.* (1991) who reported that growth characteristics of plants such as larger leaf area, greater height and biomass attainment enabled plants to utilize environmental resources more efficiently. Furthermore, Bowen *et al.* (2007) reported that native grass species had a good suppressive ability over growth of parthenium despite the fact that their growth characteristics are not greater than those of introduced species. It is interesting to note that native species were generally more suppressive than introduced species. This is in line with the finding of Larger *et al.* (2010) and Shashe *et al.* (2013). Another possible explanation for this suppressive effect might be because of the species adaptation ability to a wide range of soil types and climatic condition, which assisted them to be more suppressive.

The relative crowding coefficient of grasses had higher value than parthenium at higher and medium densities. Legumes had higher value only at high density. Parthenium Aggressivity

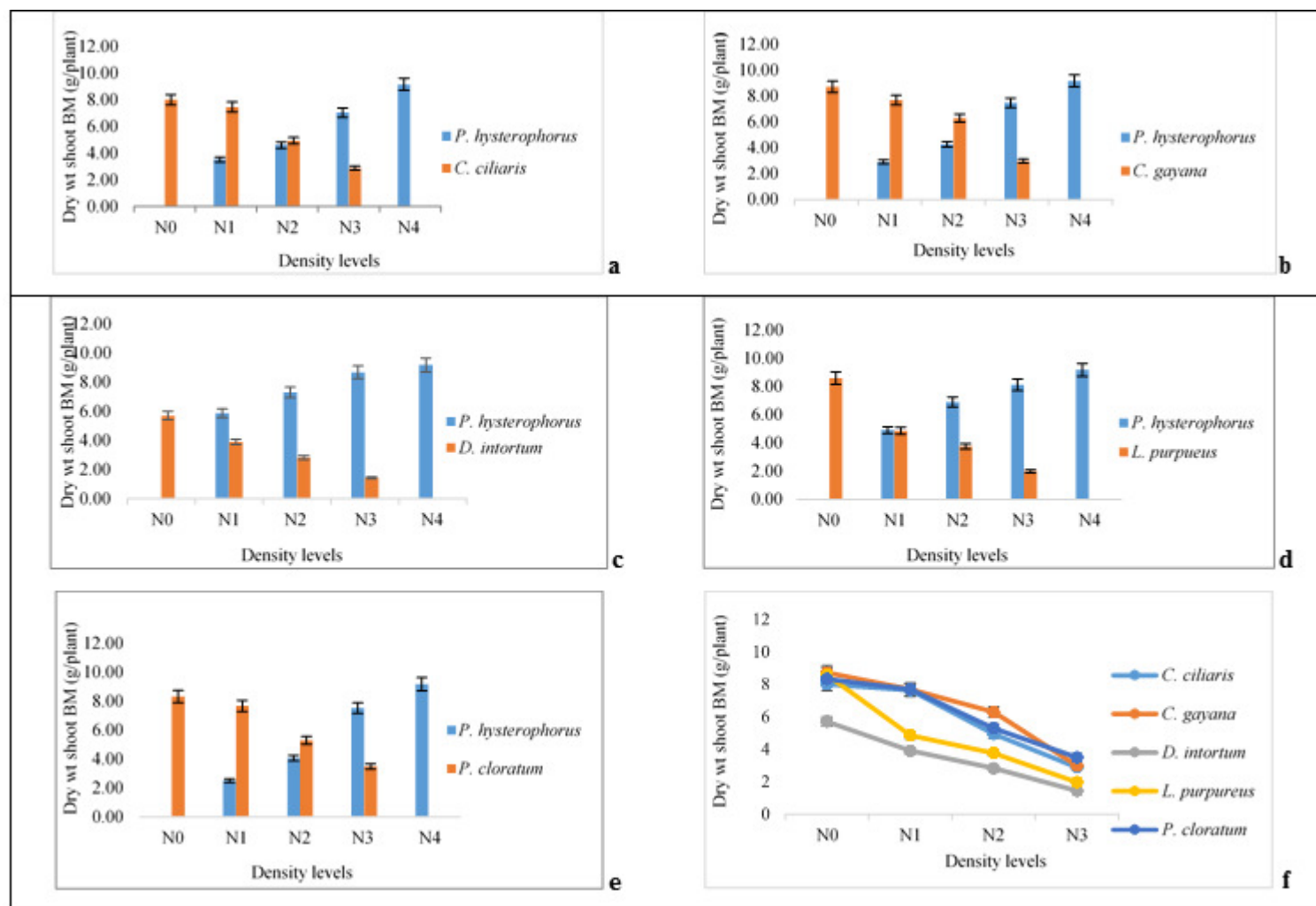


Figure 1. The mean dry weight shoot biomass of parthenium in combination with test species at five density levels

Table 1. Parthenium growth attributes when grown with pasture plant species with different combination levels

Species mixture	Growth attributes			
	Density (%)	Height (cm)	Tiller/Branch (no.)	Leaf area (cm ²)
<i>C. ciliaris</i> : <i>P. hysterophorus</i>	25:75	126.57±4.1 ^b	6.68±0.3 ^a	30.93±0.9 ^a
	50:50	89.67±2.1 ^c	5.94±0.4 ^b	25.93±1.6 ^b
	75:25	82.47±3.5 ^{cd}	5.15±0.5 ^{bc}	24.78±0.9 ^{bc}
	100:0	82.06±3.5 ^b	3.45±0.4 ^b	17.95±0.9 ^b
	25:75	115.38±7.9 ^{ab}	6.39±0.4 ^{ab}	30.62±1.2 ^a
<i>C. gayana</i> : <i>P. hysterophorus</i>	50:50	84.95±3.5 ^c	5.53±0.24 ^b	27.76±1.2 ^{ab}
	75:25	76.81±2.2 ^d	4.40±0.3 ^c	23.45±1.2 ^{bc}
	100:0	88.49±2.2 ^{ab}	3.75±0.3 ^{ab}	17.33±1.2 ^b
	25:75	122.96±3.5 ^{ab}	6.65±0.24 ^a	30.28±0.9 ^a
<i>D. intortum</i> : <i>P. hysterophorus</i>	50:50	107.82±2.2 ^{bc}	6.50±0.3 ^a	28.25±0.9 ^{ab}
	75:25	98.96±2.9 ^b	6.18±0.3 ^{ab}	27.75±0.9 ^{ab}
	100:0	37.6±2.9 ^d	1.9±0.3 ^c	11.15±0.9 ^{bc}
	25:75	118.59±2.2 ^{ab}	6.77±0.3 ^a	28.76±1.2 ^{ab}
<i>L. purpureus</i> : <i>P. hysterophorus</i>	50:50	97.52±2.9 ^{bc}	6.35±0.3 ^{ab}	27.83±1.2 ^{ab}
	75:25	97.07±2.1 ^{bc}	5.85±0.4 ^b	25.86±1.2 ^b
	100:0	73.42±2.1 ^{bc}	4.00±0.4 ^{ab}	23.93±1.2 ^{ab}
	25:75	107.64±2.9 ^{bc}	6.67±0.3 ^a	29.82±1.1 ^a
<i>P. coloratum</i> : <i>P. hysterophorus</i>	50:50	87.75±2.1 ^c	4.63±0.4 ^{bc}	25.35±1.1 ^b
	75:25	67.46±4.1 ^{de}	4.41±0.3 ^c	21.43±1.1 ^c
	100:0	87.18±4.1 ^{ab}	3.50±0.3 ^b	18.07±1.1 ^b
<i>P. hysterophorus</i>		135.14±7.9 ^a	7.35±0.4 ^a	31.55±0.9 ^a

index of the entire species was positive at higher densities indicating that the dry matter biomass of parthenium was inhibited in presence of other species.

Results further showed that the legumes at medium densities and the entire test species at lower densities had negative values indicating that they were inhibited by parthenium (Table 2). The finding was contrary to the finding of Shashie (2007) and Shashe *et al.* (2013) that *C. ciliaris* was dominant at three density levels, *P. coloratum* at two (50:50 and 75:25) and *C. gayana* out-competed only at (75:25) level of density in greenhouse.

Production performance of the test species and parthenium were significantly different ($P < 0.05$) when grown under weed-free plots. Among the species, *C. ciliaris*, *L. purpureus* and *P. coloratum* produced higher dry matter biomass while *C. gayana* had the highest dry

Table 2. The value of aggressivity index and relative crowding coefficient of pasture plant species and parthenium

Species mixture	Density (%)	AI _t	AI _p	RCC _t	RCC _p
<i>C. ciliaris</i> : <i>P. hysterophorus</i>	25:75	-0.41	0.41	0.10	1.37
	50:50	0.08	-0.08	0.20	0.15
	75:25	0.61	-0.61	2.57	0.10
	25:75	-0.48	0.48	0.09	1.61
<i>C. gayana</i> : <i>P. hysterophorus</i>	50:50	0.25	-0.25	0.22	0.14
	75:25	0.52	-0.52	1.69	0.09
	25:75	-0.71	0.71	0.07	2.55
<i>D. intortum</i> : <i>P. hysterophorus</i>	50:50	-0.19	0.19	0.15	0.26
	75:25	0.04	-0.04	0.92	0.19
	25:75	-0.63	0.63	0.08	2.01
<i>L. purpureus</i> : <i>P. hysterophorus</i>	50:50	-0.32	0.32	0.16	0.24
	75:25	0.05	-0.05	0.81	0.16
	25:75	-0.44	0.44	0.12	1.78
<i>P. coloratum</i> : <i>P. hysterophorus</i>	50:50	0.11	-0.11	0.19	0.16
	75:25	0.68	-0.68	2.33	0.07

matter production (Table 2). The greater fodder production of test species indicated that they might have more adaptation abilities to soil and climatic condition of the test area. Another possible reason might be due to rapid seedling establishment, greater plant height, tillering abilities, leaf area and rapid biomass accumulation. These characteristics might assist them to grow more rapidly and develop a dense plant canopy that consequently shade the weed, deprives its light and most likely soil water and nutrients.

Correlation analysis indicated that good predictors of species suppressive ability upon parthenium were dry matter biomass accumulation, height attainment and number of tiller and/or branch ($r=0.848$, 0.795 and 0.549 , respectively). This was in line with findings of Lemerle *et al.* (2001) and Davis *et al.* (2004) who reported that rapid attainment of shoot biomass and plant height were good predictors of suppressive ability.

Conclusion and recommendations

Among the tested species, grasses were ranked as strongly suppressive through rapid biomass accumulation, higher plant height, more tillering and/branching ability and leaf area production. The pasture species having attributes of rapid establishment, faster growth, high biomass production and canopy development played a major role in competitiveness and as a result they were able to shade and suppress weed growth. The result showed that parthenium was a weak competitor. It failed to establish in an areas where there were pasture plants with a close and compact canopy.

The findings of the study revealed that a number of pasture plant species can suppress growth of parthenium and are able to produce sufficient amount of fodder for livestock. The study showed that native species in presence of tall, relatively branched biotype with more leaf area and biomass are endowed with a potential capacity to compete with parthenium. Another feature noticed was that under normal circumstances as long as the pastures are not severely overgrazed parthenium cannot cause serious damage.

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