HOW IS FECUNDITY AFFECTED BY MOWING IN THE TROPICAL WEED *STACHYTARPHETA CAYENNENSIS* (VERBENACEAE)?[1]

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ABSTRACT - The effect of mowing on the fecundity of the tropical weed *Stachytarpheta cayennensis* (Rich) Vahl. "gervão" was evaluated by simulating conventional mowing on plants grown individually in pots, in a greenhouse. Mowing was simulated by clipping plants at 12 cm from the soil surface at the beginning of the reproductive stage. Mowed plants were compared to unmowed ones grown under identical conditions. Starting 50 days after mowing, data on the number of flower-bearing spikes and branches per plant were collected every 20 days for 110 days. Mean spike length and the number of seeds per spike and plant were assessed 110 days after mowing. The number of branches per plant was negatively affected by mowing; however, the number of spikes per branch and the number of seeds per spike and per branch were higher in mowed plants. No significant differences between treatments could be detected on the final number of seeds per plant and on the mean spike length per plant. These results are discussed in relation to their practical significance.

Index terms: seed production, defoliation, Amazonia, weed control, pasture.

COMO A FECUNDIDADE É AFETADA PELA ROÇAGEM EM *STACHYTARPHETA CAYENNENSIS* (VERBENACEAE) ?

RESUMO - O efeito da roçagem na fecundidade da planta invasora tropical gervão, *Stachytarpheta cayennensis* (Rich) Vahl., foi avaliado em plantas cultivadas individualmente em vasos, em casa de vegetação. A roçagem foi simulada através de um corte, a 12 cm da superfície do solo, em plantas no início da fase reprodutiva. Plantas roçadas foram comparadas com plantas não roçadas, cultivadas em condições idênticas às plantas roçadas. A partir de 50 dias após a roçagem, foi medido a cada 20 dias, durante 110 dias, o número de espigas e ramos por planta. O tamanho médio das espigas e o número de sementes por espiga e por planta foram medidos 110 dias após a roçagem. O número de ramos por planta foi negativamente afetado pela roçagem, mas o número de espigas por ramo e o número de sementes por espiga e por ramo foram maiores nas plantas roçadas. Não foi detectada diferença estatisticamente significativa entre tratamentos no número de sementes por planta e no comprimento médio das espigas. Os resultados obtidos são discutidos com relação ao seu significado prático.

Termos para indexação: produção de sementes, desfolhamento, controle de ervas daninhas, Amazônia, pastagem, planta invasora.

INTRODUCTION

In tropical agricultural areas, recruitment of weed species through the establishment of seedlings is important (e.g., Staver, 1991). The process of recruitment of new individuals from seed requires a sequence of steps in order to be successful. These steps include seed production, dispersal, germination, seedling establishment and growth. In this context, production of seeds is a critical phase that, especially for a species lacking vegetative reproduction, will determine to a great extent how successful the recruitment of new individuals will be.

Stachytarpheta cayennensis (Rich) Vahl. ("gervão") is an erect Verbenaceae shrub recognized as an important perennial weedy species of pastures and crop areas in Brazil and, in particular, in the Brazilian Amazonia (Dias Filho, 1990; Lorenzi, 1991). Reproduction in *Stachytarpheta*

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occurs only sexually through seeds that are produced generally in pairs inside a dry fruit that develops in cavities along erect spikes (Fig. 1). Although native to tropical America, this species also occurs as a weed in Australia (McFadyen, 1984; Kleinschmidt & Johnson, 1987), Hawaii (Haselwood & Motter, 1983) and India (Nair et al., 1982).

A common weed management practice usually conducted in pastures invaded by *Stachytarpheta* and related weed species in the Brazilian Amazonia is the mechanical or manual mowing of the area by the beginning of the rainy season, when most weed species have just started their reproductive phase. This initial mowing is usually complemented by another by the end of the rainy season (i.e., three to five months later) (see Dias Filho, 1990). Even though most perennial weed species are known to withstand this mowing management (Dias Filho, 1990), it is believed that, compared to unmowed plants, the fecundity of mowed weeds can be decreased due to a reduced production of reproductive structures (e.g., inflorescence and seeds).

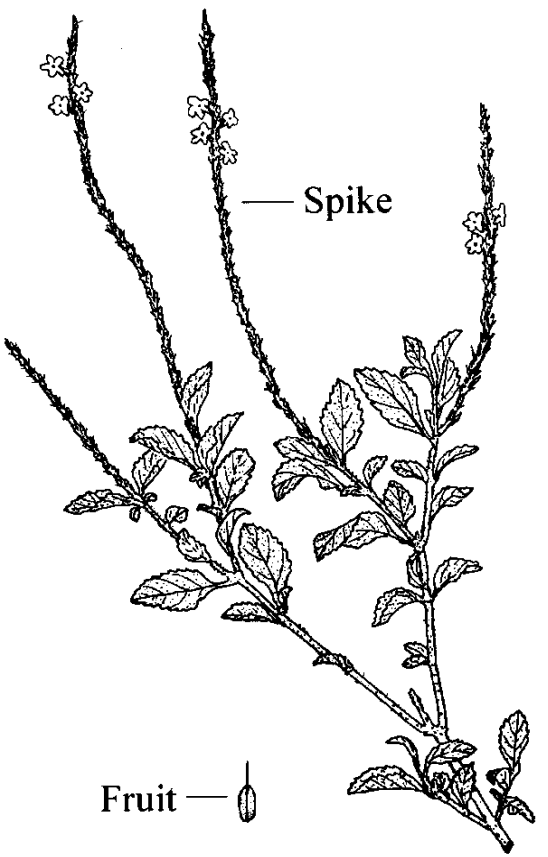

FIG. 1. Detail of a branch (with flowering spikes) and a fruit of *Stachytarpheta cayennensis*.

Although mowing is a common practice in the management systems of agricultural areas in Amazonia and other tropical areas, no published information is known to exist on the effects of defoliation on the fecundity of individual weed species. Such knowledge would help evaluating the biological and economic effectiveness of mowing in controlling these species and also determining how adapted they are to defoliation.

The objective of this study was to determine how a simulated mowing regime (a single defoliation at 12 cm from the soil surface, at the beginning of the species' reproductive phase) affects fecundity (i.e., the number and size of flowering spikes and the number of seeds) in the tropical weed *S. cayennensis*, grown under controlled environmental conditions.

MATERIALS AND METHODS

Plant material and growing conditions

Stachytarpheta cayennensis seeds were collected from plants growing in pasture areas 12 km from Paragominas, PA (3° 05' S - 47° 21' W) in the Eastern Brazilian Amazonia. Seeds were germinated on filter paper in petri dishes and then planted individually in 1750 ml plastic pots in a mixture of peat:vermiculite:perlite (1:1:1). Plants were grown in a greenhouse at temperatures of 24 ± 2.2°C (minimum) to 33 ± 2.1°C (maximum) and a maximum photosynthetic photon flux density (PPFD) of approximately 900 µmol m^{-2} s^{-1}. Pots were watered every other day to field capacity and fertilized every two weeks with 30 ml of a water soluble fertilizer solution (15 % N, 30 % P_2O_5, 15 % K_2O, 0.02 % B, 0.07 % Cu, 0.15 % Fe, 0.05 % Mn, 0.0005 % Mo and 0.06 % Zn; 3.5 g L^{-1}).

Treatments and sampling

Conventional mowing was simulated on *Stachytar-*

pheta plants by clipping the plants at 12 cm from the soil surface at the beginning of the reproductive stage, i.e., five to six weeks after germination. Mowed plants were compared to unmowed plants grown under the same conditions. Number of primary branches off the main stem and flowering spikes (Fig. 1) were assessed for each plant every 20 days for 60 days, starting at 50 days after mowing. At the last evaluation date (i.e., 110 days after mowing), the number of seeds per spike and spike length were also recorded for all plants.

Experimental design and statistical analysis

Pots were arranged in the greenhouse in a completely randomized design with seven replicates. Each replicate was an individual pot planted with a single plant and placed at a particular location inside the greenhouse.

Differences between treatments in the number of spikes per plant and per branch through time were analyzed by analysis of variance with repeated measures (Ende, 1993). The within-subject or repeated measures effect was Time, and the between-subject main effect was Mowing intensity. Homoscedastic residuals, assessed by Box M test, were confirmed both for logarithmically transformed values of number of spikes per branch (P= 0.1) and untransformed values of number of spikes per plant (P= 0.3). No severe departures from the normality assumption were identified by examining half-normal probability plots of z-transformed within-cell correlations for both data. Compound symmetry of the covariance matrix of each analysis of variance was tested by the Mauchly's sphericity test. The Huynh-Feldt correction (Ende, 1993) was considered for both analyses. Differences in the number of seeds and branches per plant were evaluated by Kruskal-Wallis ANOVA. Differences in the number of seeds per branch and per spike and in the mean spike length per plant were assessed by Mann-Whitney U test. The statistical package STATISTICA for Windows release 4.5 (STATISTICA for Windows, 1994) was used for all computations of the data.

RESULTS AND DISCUSSION

The indicators of *Stachytarpheta* fecundity were differentially affected by mowing. Mowing significantly increased the number of spikes per branch (Table 1, Fig. 2) and the number of seeds per branch and per spike (Mann-Whitney U Test, P= 0.001, for both variables) (data not shown).

TABLE 1. **Analysis of variance of number of spikes per branch with repeated measurement on time. Treatment (mowed and unmowed) is the fixed main effect.**

Sources	df	MS	F	*P*	H-F
Between-subjects					
Treatment (Tr.)	1	48.1	5.7	0.03	----
Error	12	8.43			
Within subjects					
Time (T)	3	3.58	45.7	----	< 0.001
T × Tr.	3	0.36	4.6	----	0.008
Error	36	0.078			

H-F, Huynh-Feldt corrected significance level (see Materials and Methods)

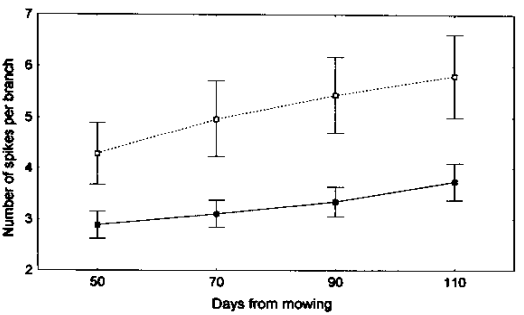

FIG. 2. Change over time in the number of flowering spikes per branch (mean ± S.E., n= 7) for two mowing intensities: mowed (open squares) and unmowed (closed squares).

The number of primary branches per plant was 45 % lower (Kruskal-Wallis ANOVA, H= 10.4, P= 0.001) in mowed plants, and did not change from day 50 to 110 after mowing (data not shown). Mean spike length per plant was slightly higher for mowed plants (17.3 cm vs. 16.6 cm); however, this difference was only marginally significant (Mann-Whitney U test, P= 0.06). No significant effect of mowing could be detected on the number of spikes per branch (ANOVA, $F_{1,12}$= 1.96, P= 0.19). However, a tendency for a lower number of spikes in mowed plants was observed throughout the evaluation period (Fig. 3).

The total number of seeds per plant was not affected significantly by mowing (Kruskal-Wallis ANOVA, H= 0.04, *P*= 0.85); however, seed number in mowed plants had a tendency to be higher than in unmowed ones (Fig. 4). So, although mowing significantly increased the number of spikes per plant and the number of seeds per branch and per spike, seed number per plant was not significantly affected. This response was a consequence of the negative effect mowing had on the number of branches per plant.

Other studies have reported inconsistent results on the effects of defoliation (i.e., mowing and grazing) on the reproductive output of plant species. In the legume shrub *Stylosanthes hamata*, a single heavy grazing followed by mowing (Wilaipin & Humphreys, 1976) or a defoliation to 13 cm (Fisher, 1973) significantly increased seed yield. Also, grazing increased seed yield in *Trifolium subterraneum* (Steiner & Grabe, 1986). Conversely, in the grasses *Bouteloua gracilis* (Coffin & Lauenroth, 1992) and *Panicum virgatum* (George et al., 1990) and in the legume *Aeschynomene americana* (Chaparro et al., 1991), grazing significantly reduced seed production.

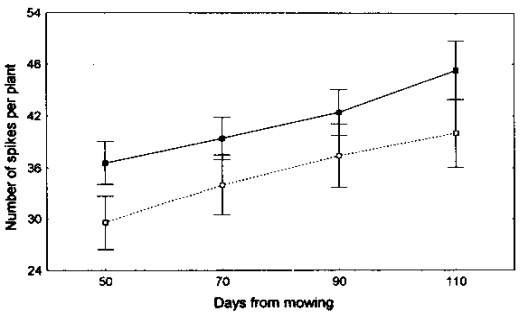

FIG. 3. Change over time in the number of flowering spikes per plant (mean ± S.E., n= 7) for two mowing intensities: mowed (open squares) and unmowed (closed squares).

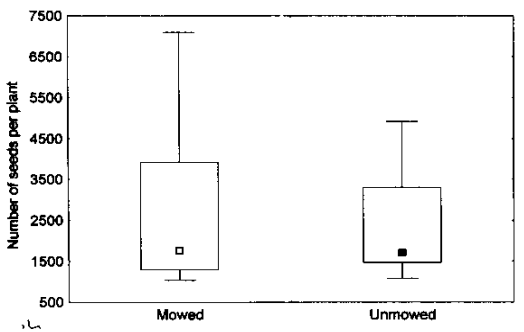

FIG. 4. Box plot of the number of seeds per plant for two mowing intensities. For, each box plot the middle point is the median, the box represents the quartiles (25th and 75th percentiles), and the whisker is the range (minimum and maximum values).

These contrasting results may be explained both by the distinctive response to defoliation of individual species and also by the particular intensity and frequency of defoliation used. So, although a single and not intense defoliation may increase reproductive output by removing apical dominance, and, thus, by providing more sites for the development of reproductive structures, a more frequent and intense defoliation regime could also be capable of contributing to the reduction of the available carbon and energy for the development of reproductive structures. For example, although in the study of Wilaipin & Humphreys (1976) seed yield of *S. hamata* was increased by a single defoliation, in the same study intermittent grazing and mowing decreased seed yield of that species. In the present study the defoliation regime was relatively not severe, and simulated a common management observed in pasture areas in the Brazilian Amazonia (Dias Filho, 1990): a single manual or mechanical mowing of *Stachytarpheta*, at the beginning of its reproductive phase, followed by at least a four-month period without mowing. The results suggested that fecundity in *Stachytarpheta* under this regime is not ultimately affected, because mowed plants had the ability to compensate for a significant reduction in the number of branches, caused by defoliation, by increasing the number of spikes and seeds per branch. This compensatory development of reproductive structures allowed mowed *Stachytarpheta* to maintain seed output to a level similar to that of unmowed plants.

CONCLUSIONS

This research has important practical implications for the management of *Stachytarpheta* in

agricultural areas and to the knowledge of the biology of this species. It suggests that a single mowing at the beginning of the reproductive phase does not contribute to the control of *Stachytarpheta*, as fecundity is not reduced. In addition, the present results also indicate that *Stachytarpheta* seems to be adapted to defoliation, being able to compensate for this stress by increasing the output of the remaining reproductive structures. Finally, it could be hypothesized that this species is capable of succeeding as a weed in areas under this management system. Additional studies are needed to determine the effect of mowing during other stages of *Stachytarpheta* development. Furthermore, the effect of a more severe defoliation regime, such as burning, on this species' fecundity needs to be assessed.

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REFERENCES

CHAPARRO, C.J.; SOLLENBERGER, L.E.; LINDA, S.B. Grazing management effects on aeschynomene seed production. **Crop Science**, v. 31, p. 197-201, 1991.

COFFIN, D.P.; LAUENROTH, W.K. Spatial variability in seed production of the perennial bunchgrass *Bouteloua gracilis* (Gramineae). **American Journal of Botany**, v. 79, p. 347-353, 1992.

DIAS FILHO, M.B. **Plantas invasoras em pastagens cultivadas da Amazônia:** estratégias de manejo e controle. Belém: EMBRAPA-CPATU, 1990. 103p. (EMBRAPA-CPATU . Documentos, 52)

ENDE, C.N. von. Repeated-measures analysis: growth and other time-dependent measures. In: SCHEINER, S.M.; GUREVITECH, J.G. (Eds.). **Design and analysis of ecological experiments.** New York: Chapman and Hall, 1993. p. 113-137.

FISHER, M.J. Effect of times, height and frequency of defoliation on growth and development of Townsville stylo in pure ungrazed swards at Katherine, N.T. **Australian Journal of Experimental Agriculture and Animal Husbandry**, v.13, p. 389-397, 1973.

GEORGE, J.R.; REIGH, G.S.; MULLEN, R.E.; HUNCZAK, J.J. Switchgrass herbage and seed yield and quality with partial spring defoliation. **Crop Science**, v. 30, p. 854-849, 1990.

HASELWOOD, E.L.; MOTTER, G.G. **Handbook of Hawaiian Weeds**. 2nd. ed. Honolulu: University of Hawaii Press, 1983. 491p.

KLEINSCHMIDT, H.E.; JOHNSON, R.W. **Weeds of Queensland**. Queensland: Queensland Department of Primary Industries, 1987. 469p.

LORENZI, H. **Plantas daninhas do Brasil: terrestres, aquáticas, parasitas, tóxicas e medicinais**. 2.ed. Nova Odessa: Plantarum, 1991. 440p.

McFADYEN, R.E. Weeds of Australia: 4 Verbenaceae – the lantanas, fog fruit, verbenas and sankeweeds. **Australian Weeds**, v. 3, p. 20-24, 1984.

NAIR, N.C., MOHANAN, C.N.; SREEKUMAR, P.V. *Stachytarpheta cayennensis* (L.C. Rich) Schan.- A new record for India with a key to Indian species. **Journal of Bombay Natural History Society**, v. 79, p. 230-232, 1982.

STATISTICA FOR WINDOWS **General conventions and statistics I**. Tulsa: StatSoft, Inc., 1994. v.1, 717p.

STAVER, C. The role of weeds in the productivity of Amazonian bush follow agriculture. **Experimental Agriculture**, v. 27, p. 287-304, 1991.

STEINER, J.J.; GRABE, D.F. Sheep grazing effects on subterranean clover development and seed production in western Oregon. **Crop Science**, v. 26, p. 367-372, 1986.

WILAIPIN, P.; HUMPHREYS, L.R. Grazing and mowing effects on the seed production of *Stylosanthes hamata* cv. Verano. **Tropical Grasslands**, v.10, p. 107-111, 1976.