Allelopathic potential of the newly emerging weed *Solanum mauritianum* Scop. (Solanaceae) in the wet tropics of north-east Queensland

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Summary

Solanum mauritianum **(Scop.), commonly known as wild tobacco tree, has become a weed of major concern in pastoral areas and tropical rainforest restoration sites of the Atherton Tablelands, north-eastern Queensland. We examined the effects of aqueous leachates of *Solanum mauritianum* leaves on the germination of *Lactuca sativa* seeds and on the growth of four native tropical rainforest species (*Neolitsea dealbata* (Lauraceae), *Syzygium australe* (Myrtaceae), *Diploglottis diphyllostegia* (Sapindaceae), and *Elaeagnus triflora* (Elaeagnaceae).**

Both the germination and radicle development of *L. sativa* was inhibited with increasing concentrations of leachate from *S. mauritianum*. Most tropical rainforest species experienced a significant (P <0.05) reduction in shoot and root biomass after 36 days of treatment.

Solanum mauritianum **contains water-soluble phyto-inhibitors in its leaves which can have severe impacts on the growth of seedlings of native tropical rainforest species under controlled environment conditions. Whether these effects are found in the field is yet to be determined.**

Introduction

Interference from established vegetation during the establishment of the invasive or introduced species is a major deterrent to succession establishment into new areas (Hoveland *et al.* 1981). Allelopathy is one mechanism by which weeds interfere with and deter the growth of the plants in their neighbourhood (Muller 1966, Rice 1974, Putnam and Duke 1978).

Wild tobacco tree (*Solanum mauritianum* Scop.) is a 3–4 m tall shrub native to South America (Olckers 1999). It has been reported to have a major effect on pasturelands, forest edges and rainforest regrowth in high rainfall areas of coastal New South Wales and Queensland and South Africa (Everist 1974). It was introduced into Africa, Australia, India and the islands in the Atlantic and Pacific Ocean by Portuguese traders as early as in the 16th century (Roe 1972).

In South Africa, *S. mauritianum* grows vigorously in high rainfall areas, affecting agricultural lands, forestry plantations, riverine habitats, water catchments and conservation areas (Olckers 1999). It has been shown to have negative impacts on ground-dwelling invertebrates (Samways *et al*. 1996). In north Queensland, Australia, wild tobacco tree was introduced in restoration programs because of its potential to attract birds, which transport seeds of native tropical rainforest species for re-establishment (Adam 1994).

Ecological studies on *S. mauritianum* have shown that this species possesses weed-like characteristics, being an aggressive invader with high seed production (up to 20 000 seeds per tree), and high seedling recruitment (Florentine unpublished data).

The key objective of this preliminary work was to evaluate the allelopathic potential of *S. mauritianum*. The following two hypotheses were tested: i) germination of *Lactuca sativa* is not affected by water-soluble leachate from *S. mauritianum* foliage and ii) growth of *Neolitsea dealbata* (Lauraceae), *Syzygium australe* ((Myrtaceae), *Diploglottis diphyllostegia* (Sapindaceae), and *Elaeagnus triflora* (Elaeagnaceae) is not affected by leaf leachate from *S. mauritianum*. These four tropical rainforest species were selected because they are pioneer (light-loving) species that tend to grow in the gaps and along forest edges, where *S. mauritianum* is also present.

Materials and methods

Experiment I – Germination bioassay

Aqueous leachate of *S. mauritianum* leaves was prepared by soaking 30 g of fresh leaves in 240 mL of deionized water (1:8 by weight) in 500 mL flasks for 24 h at room temperature. The leachate was filtered into a labelled flask, using Whatman® filter paper (125 mm, No. 3) and stored at 5°C until use. Following filtering, four concentrations were prepared: Treatment 1 (control) = only deionized water; Treatment 2 = 25% leachate + 75% deionized water, Treatment 3 = 50% leachate + 50% deionized water, and Treatment 4 = 75% leachate + 25% deionized water.

Seeds of *Lactuca sativa* L. cv. Great Lakes were selected to test the effects of leachate on germination, because of their uniform germination behaviour (Dietz and Winterhalter 1996) and sensitivity to germination inhibitors (Evenari and Newman 1952). Four replicates, each of 50 seeds, were placed in labelled Petri dishes lined with two No. 3 Whatman® filter papers. The filter paper was moistened with 10 mL of aqueous leachates of the respective solutions, while the control received the same amount of deionized water. Petri dishes were placed in a growth cabinet at 25°C and were kept continuously moist until the experiment was terminated at 30 days. Seed germination and radicle length were recorded from 24 hours after the onset of germination.

Experiment II – Plant growth with leachate

Seeds of *N. dealbata*, *S. australe*, *D. diphyllostegia*, and *E. triflora*, were collected from the Centre for Rainforest Studies (CRS), Yungaburra, Queensland, between February and April 2001. Seeds were immediately sown in seedling trays (8.5 × 14.0 × 5.5 cm) containing coarse sand and lined with paper towelling. These trays were kept in a CRS shade house and watered twice a day. Uniform sized seedlings (approximately 2–4 cm tall) were transplanted between May and June 2000 into pots (4.5 cm diameter and 17.0 cm tall) containing commercial potting mixture. Transplanted seedlings were kept in a shade house and watered for 10 minutes twice daily (05:30 h and 16:30 h).

Fifty seedlings of each species were chosen to examine the effects of *S. mauritianum* leaf leachates. The leachate was prepared once a week from 2.4 kg of leaf material that was collected randomly from mature *S. mauritianum* trees and soaked in 20 L of deionized water in large plastic bins for 24 hours (after Tian and Kang 1994). Soaked *S. mauritianum* leaf material was turned over a few times to make sure that all the leaves were soaking in the deionized water. The leachate was then filtered to produce a stock solution which was diluted with water to make 0% (T1 – control), 25% (T2), 50% (T3), 75% (T4) and 100% (T5) solutions before each treatment application. Ten seedlings of each of the four plant species were selected to receive one treatment. Each seedling received 75 mL of solution twice a week, whilst control seedlings received the same amount of deionized water.

Plants were harvested 36 days after the start of the treatments, by carefully removing the pots and gently extracting the contents onto a wire mesh table. Soil was gently washed away and parts were placed in separately labelled paper bags after removing excess water with paper towelling. Dry weights of shoots and roots of harvested plants were obtained after drying at 80°C for 48 hours.

Statistical analysis

Data were analysed using Super ANOVA (Abacus Concepts, Berkeley, California). Residual plots of each ANOVA were obtained to examine homogeneity of variance. Data were then arcsine, log or square root transformed as required and reanalysed. Means were compared using Tukey's HSD test (Day and Quinn 1989).

Results

L. sativa seed germination

The highest strength leaf leachate solution used in this experiment significantly (P=0.001) decreased the germination of *L. sativa* seed (Figure 1A). The effect was also evident in T2, where 76% seeds germinated compared with 96% in the control. Phytotoxic effects were also observed in the growth of *L. sativa* radicles. Radicle growth was suppressed most by treatments 2 and 3 (Figure 1B). Leaf leachate gave a progressively greater effect as strength was increased (Figures 1A and B).

Seedling biomass

Solanum mauritianum leaf leachate did not cause the death of any seedlings but generally hindered both shoot and root growth of the native rainforest species examined (Table 1), although *S. australe* root biomass was not significantly (df = 4, F 1.85, P = 0.134) affected (Table 1). All species had highest mean shoot and root biomass with deionized water and least with full strength *S. mauritianum* leaf leachate (Table 1).

Discussion

Plant leachates often result in inhibition of seed germination and subsequent plant growth (Martin and Smith 1994). *S. mauritianum* leaf leachate has a major effect on the germination and radicle growth of seeds of *L. sativa*. With the exception of *S. australe*, all the native tropical rainforest species also showed a highly significant (P <0.05) reduction in shoot and root biomass. This kind of phytotoxic effect has been reported with several weed species (e.g. Ahmed *et al*. 1984, Martin and Smith 1994, Hoffman *et al*. 1996). Because these rainforest species tend to germinate in the same places as *S. mauritianum*, the removal of *S. mauritianum* from these areas may provide suitable conditions for native tropical rainforest species to regenerate.

Extrapolating from controlled experiments to field conditions should always be done with caution, since there are many biotic and abiotic factors that may interact in the field to influence the result. Further experiments need to be carried out in natural rainforest systems. The leaf leachate concentrations applied to *L. sativa* seeds and native tropical rainforest seedlings in this study are likely to be higher than the concentration of leachate obtained after rain in the field. This study is a first attempt to understand how mature *S. mauritianum* trees can hinder the natural recruitment of rainforest species beneath its canopy. This knowledge is important in the formulation and application of management practices for *S. mauritianum* in the disturbed areas, and particularly at the edges of tropical rainforests and reforested areas in the Atherton Tablelands.

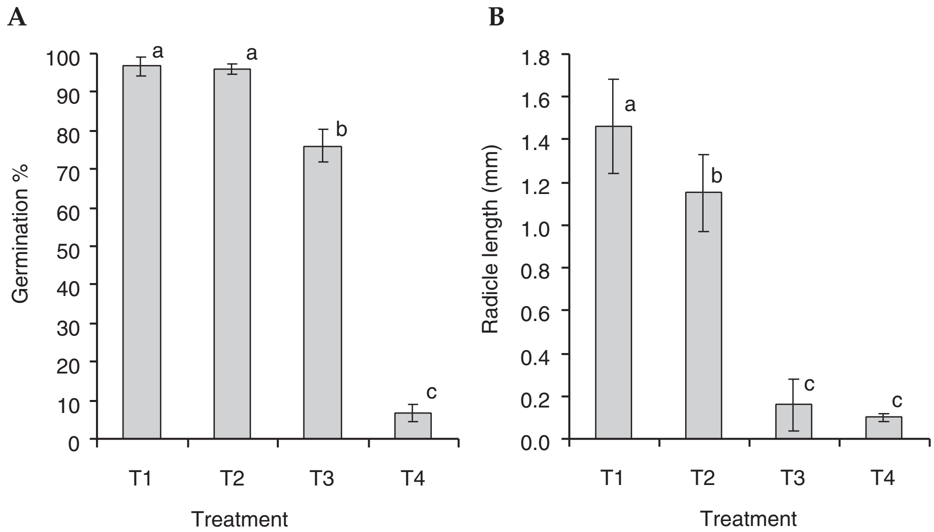

Figure 1. *Lactuca sativa* seed germination (A) and radicle length (B) subject to *S. mauritianum* leaf leachate. T1 (control) = only deionized water; T2 = 25% leachate + 75 % deionized water, T3 = 50% leachate and deionized water, T4 = 75% fresh leachate. Columns topped by the same letter are not significantly different (P <0.05) as determined by Tukey's Pairwise comparison. Vertical bars indicate standard error.

Table 1. Mean shoot and root dry weights (± SD) (mg) of different test species (n = 10), subject to *S. mauritianum* leaf leachate. T1 = only deionized water; T2 = 25% leachate + 75% deionized water, T3 = 50% leachate + 50% deionized water, T4 = 75% leachate + 25% deionized water, and T5 = 100% leachate.

Species	T1	T2	T3	T4	T5	F	P value
Shoot dry weight (mg)							
N. dealbata	1.97 (0.67)[a]	1.85 (0.79)[a]	0.92 (0.29)[b]	0.41 (0.20)[bc]	0.14 (0.4)[c]	28.27	***
S. australe	1.26 (0.32)[a]	1.02 (0.32)[b]	0.88 (0.25)[ab]	0.84 (0.44)[ab]	0.67 (0.53)[b]	3.20	*
D. diphyllostegia	1.97 (0.67)[a]	1.85 (0.79)[a]	0.91 (0.29)[ab]	0.41 (0.20)[ab]	0.14 (0.41)[c]	28.27	***
E. triflora	1.58 (0.22)[a]	0.93 (0.29)[b]	0.46 (0.10)[c]	0.25 (0.06)[d]	0.03 (0.02)[e]	12.43	***
Root dry weight (mg)							
N. dealbata	0.56 (0.20)[a]	0.54 (0.05)[a]	0.33 (0.05)[b]	0.22 (0.02)[c]	0.08 (0.02)[d]	43.21	***
S. australe	0.62 (0.13)[a]	0.67 (0.24)[a]	0.57 (0.18)[a]	0.47 (0.34)[a]	0.40 (0.32)[a]	1.85	NS
D. diphyllostegia	0.56 (0.20)[a]	0.54 (0.05)[a]	0.33 (0.05)[b]	0.23 (0.02)[c]	0.08 (0.02)[d]	43.21	***
E. triflora	0.90 (0.06)[a]	0.84 (0.03)[a]	0.58 (0.10)[b]	0.36 (0.09)[c]	0.29 (0.09)[c]	11.89	***

Means followed by the same letter are not significantly different. *P <0.05; *** P <0.001; as determined by a Tukey's Pairwise comparison. NS = not significant.

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References

Adam, P. (1994). 'Australian rainforests'. (Oxford University Press, New York).

Ahmed, N., Hussain, F. and Akram, M. (1984). The allelopathic potential of *Eucalyptus tereticornis* Sm. *Pakistan Journal of Science and Industrial Research* 27, 88-91.

Day, R.W. and Quinn G.P. (1989). Comparisons of treatments after an analysis of variance in ecology. *Ecological Monographs* 59, 133-38.

Dietz, H. and Winterhalter, P. (1996). Phytotoxic constituents from *Bunian orientalis* leaves. *Phytochemistry* 42, 1005-10.

Evenari, M. and Newman, G. (1952). The germination of lettuce seeds. II The influence of fruit coat and endosperm upon germination. *Bulletin of Research Council of Israel* 2, 75-8.

Hoffman, M.L., Weston, L.A., Snyder, J.C. and Regnier, E.E. (1996). Allelopathic influence of germinating seeds and seedlings of cover crops on weed species. *Weed Science* 44, 579-84.

Hoveland, C.S., Allison, M.W., McCromick, R.F. Jr, Webster, W.B., Calvert, V.H., Eason, J.T., Ruf, M.E., Griffey, W.A., Burgess, H.E., Smith, L.A. and Grimes, H.W. (1981). Seeding legumes into tall fescue sod. *Alabama Agricultural Experiment Station Bulletin* 531, 22 pp.

Martin, L.D. and Smith, A.E. (1994). Allelopathic potential of some warm-season grasses. *Crop Protection* 13, 388-92.

Muller, C.H. (1966). The role of chemical inhibition (allelopathy) in vegetation composition. *Bulletin of Torrey Botanical Club* 93, 332-51.

Olckers, T. (1999). Biological control of *Solanum mauritianum* Scopoli (Solanaceae) in South Africa: review of candidate agents, progress and future prospects. *African Entomological Memoir* 1, 65-73.

Putnam, A.R. and Duke, W.B. (1978). Allelopathy in agroecosystems. *Agricultural Review of Phytopathology* 16, 431-51.

Rice, E.L. (1974). 'Allelopathy', 2nd edition. (Academic Press, New York).

Roe, K.E. (1972). A revision of *Solanum* sect. Brevantherum (Solanaceae). *Brittonia* 24, 239-78.

Samways, M.J., Caldwell, P.M. and Osborn, R. (1996). Ground living invertebrate assemblages in native, planted and invasive vegetation in South Africa. *Agriculture Economics and Environment* 59, 19-32.

Tian, G. and Kang, B.T. (1994). Evaluation of phytotoxic effects of *Gliricidia sepium* (Jacq.) Walp pruning on maize and cowpea seedlings. *Agroforestry Systems* 26, 249-54.