SHORT COMMUNICATION

Does over-abundance of *Bambusa bambos* (L.) Voss. alter edaphic properties?

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Abstract: A preliminary study was conducted to determine any modifications to basic soil properties following over-abundance of *Bambusa bambos*, a native bamboo species, that rapidly expanding its population in Intermediate and Dry Zone forests in Sri Lanka. Soil samples taken from representative sites of bamboo-dominated (BAM) and non-bamboo (NBM) forest patches were analyzed for pH, total nitrogen (N), phosphorus (P), soil moisture and microbial biomass carbon (MBC). A growth assay was carried out with *Ricinus communis* seedlings in BAM and NBM soils (sterilized/unsterilized) in a glasshouse. The soil analysis revealed significantly higher N, P and moisture in BAM soils than in NBM. BAM soils were clayey in nature compared to silty soils in NBM. *Ricinus communis* grown in BAM soils performed better throughout the experimental period, perhaps due to higher soil nutrients. *Ricinus communis* grow better in unsterilized soils irrespective of bamboo, indicating a facilitative role of soil microbes on the growth of plants. The preliminary results suggest that either *B. bambos* spread has the potential to increase the soil fertility status or else *B. bambos* expands its population preferably on nutrient-rich clayey soils. Therefore, further studies are needed in order to confirm the impacts of *B. bambos* on edaphic properties which may eventually influence the growth of co-occurring native species.

Keywords: native bamboos, overabundance, soil microbes, *Ricinus communis*, Sri Lanka.

INTRODUCTION

The invasion of exotic species can cause drastic impacts in their introduced habitats, especially in island nations (Vitousek *et al.*, 1997; Britton-Simmons and Abbot, 2008). Until recently, native species with the ability to spread aggressively are not categorized as 'invasive', simply due to the misfit in the definition. However, recent studies have reported sudden expansion of populations of some native species, including bamboos, causing negative impacts similar to invasive species. Conventionally, native species bearing invasive traits were not taken seriously either due to their ecological status or their many cultural and economic uses. Therefore, scientists have taken a long time to recognize the fact that even some native species show the ability to expand populations in their resident communities, sometimes even encroaching adjacent natural forests. It was presumed that human interventions usually trigger the encroachment of native species in natural habitats.

However, recent studies conducted in China with native moso bamboo species proved otherwise (Bai *et al.*, 2016; Peng *et al.*, 2013; Tang *et al.*, 2013).

Expanding populations of bamboo species in their native habitats is a common occurrence in many tropical countries (Bai *et al.*, 2013; Peng *et al.*, 2013; Tang *et al.*, 2013; Prematilleke *et al.*, 2014). However, most studies have been directed towards evaluating impacts of exotic invasive species, with less attention to native species bearing similar invasive traits. Although invasion of exotics has been recognized as an emerging problem in status reports of many countries, the negative impacts of expanding populations of native species are usually overlooked. As a result, studies to quantify the expansion or overabundance of native species and their potential impacts on their resident communities are scarce. Majority of the available studies carried out on *Bambusa bambos* are focused on the above-ground aspects (Rao *et al.*, 1985). However, the impacts of plant invasion on edaphic properties has become increasingly in the focus over the last decade (Lu *et al.*, 2015; Xu *et al.*, 2015). In Sri Lanka, expansion of native bamboo species (*Ochlandra stridula* and *Bambusa bambos*) in their resident forest communities has been reported. However, few studies have been carried out to evaluate their likely impacts so far (Prematilake *et al.*, 2015; Millangoda and Madawala, 2016; Wijewickrama *et al.*, 2017). The present study aimed at evaluating any alterations of edaphic properties following overabundance of *B. bambos*. A growth assay has been carried out using field soils (BAM and NBM) with *Ricinus communis* seedlings to confirm whether these edaphic changes can affect the growth of *R. communis*, a common shrub in the forest undergrowth.

MATERIALS AND METHODS

Bambusa bambos and its sudden expansion

Bambusa bambos (L.) Voss. belongs to the family Poaceae with sympodial, pachymorph rhizomes, producing large dense clumps of closely placed, dark green, glabrous culms. The culms of the bamboo can grow erectly up to 30 m in height with a diameter of 5 - 10 cm. Branching occurs at all the nodes. Upper branches are horizontal or ascending. Small spines are seen in the upper leafy branches. *B.*

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Figure 1: The habit and the spread of *Bambusa bambos* in moist, mixed evergreen forests in Moragahakanda, Sri Lanka.

bambos has shown gradual expansion of its populations in dry and intermediate zone forests in Sri Lanka altering the forest structure notably (Figure 1). As the spread is so severe, some parts of these forests are almost replaced by this thorny bamboo species (personal observations).

Collection of soil samples

Eight well-composite soil samples were collected from bamboo-dominated (BAM) and non-bamboo (NBM) forest patches from a depth of 0 - 10 cm. The two forest patches (BAM and NBM) are located approximately 4 km apart, and categorized based on the bamboo cover (BAM: bamboo cover > 90 % and NBM: cover < 10%). Field-fresh soil samples were analyzed for pH, gravimetric soil moisture content (Anderson, 1998), total Nitrogen (Kjeldahl method), total phosphorus (Colourimetric method) and microbial biomass carbon (Chloroform fumigation method). The colour and texture of the soil samples were determined using the 'feel method' and 'Munsell Soil Colour Chart' respectively.

Growth Assay

Ricinus communis (Family: Euphorbiaceae) is a perennial shrub, known as 'tel edaru' in Sinhala, 'castor bean' in English and 'amanakku' in Tamil, that can grow up to 1.8 to 2.4 m in height. It is a native of Mediterranean Basin, Eastern Africa and India, but widespread in the tropics. It is a fast-growing shrub found in most parts of Sri Lanka (Lucas, 2006).

Surface soil samples (well mixed, composite), collected from the two forest patches (BAM and NBM) were used in the pot experiment. Coarse roots and other debris were removed from the soil samples before mixing with river sand in 1:1 ratio, separately. Half of the potting mixture (forest soil: sand) from each forest type (BAM and NBM) was sterilized by autoclaving at 120 °C. Four treatments were used in the experiment viz., bamboo-dominated, sterilized (BAM/ST), bamboo-dominated, unsterilized

(BAM/UNST), non-bamboo, sterilized (NBM/ST) and non-bamboo, unsterilized (NBM/UNST). Thirty-two plastic pots (height of 6"; diameter of 5.5") were filled with differently treated soils, with 8 replicates for each treatment. The plantlets of *Ricinus communis*, raised from seeds in sterilized sand, were uprooted carefully and re-planted in each pot (one seedling/pot). The pots were randomly arranged in a glasshouse and watered as required. Dead seedlings were replaced until all seedlings were established well. Initial dry biomass of a seedling was determined by taking the average of 10 seedlings (after oven-drying) similar to the seedlings used for planting. Pots were re-arranged weekly to avoid any position effect. Height measurements of plants were taken weekly. After nine weeks, the plants were harvested (shoots and roots separately) and their dry masses were determined. Growth increments (Growth Increment (%) = $[H_t - H_0]/H_0 \times 100$ where H_t = height at time t, H_0 = initial height) were also calculated.

Data analysis

The data were analyzed using the General Linear Model (GLM) after testing for normal distribution of data. Minitab 16.0 version was used for statistical analysis. Mean separations were carried out using Tukey's Test. As shoot, root and total dry weights (recorded at the time of the destructive harvest) showed no significant differences between treatments, the data were pooled under BAM/NBM and sterilized (ST)/unsterilized (UNST), and compared using ANOVA.

RESULTS AND DISCUSSION

Edaphic parameters

The texture and consistency showed contrasting differences between BAM and NBM soils (Table 1). Soil texture is a stable character showing more resilience to above-ground changes, thus indicating that bamboos spread preferentially on clayey soils (Darabant, 2007). The fibrous roots in

bamboos improve the soil structure, making them friable in nature (Metzner, 1976). Therefore, the results suggest that *B. bambos* expands its population preferably in clay-rich soils rather than its invasion makes soils clay-rich. Clay-rich soils also contain higher nutrient and moisture retention abilities compared to soils low in clay. Therefore, present findings support the fact that *B. bambos* prefers nutrient-rich, clayey soils to expand their populations.

Table 1: Comparison of soil physical parameters of bamboo-dominated (BAM) and non-bamboo (NBM) sites.

Physical Parameter	BAM	NBM
Texture	Clayey	Silty
Consistency	Friable	Firm
Soil Colour	Dark Reddish Brown	Dark Reddish Brown

The soil moisture, total N and P levels were significantly higher in BAM soils than in NBM, with no significant difference in soil pH (Figure 2). Exotic invasive species have shown the potential to change soil nutrient pools (Ehrenfeld, 2010). Some studies showed increases in soil nutrients (Levine *et al.*, 2003; Vitousek *et al.*, 1987), attributed to high litter turnover and rapid decomposition rates, while others noted nutrient depletions possibly through rapid uptake by fast-growing exotics (Asner and Vitousek, 2005). However, present results suggest that bamboos prefer nutrient-rich clayey soils over nutrient-poor silty soils for their establishment, thus supporting the fact that the over-dominance of bamboos may not be the reason for altered soil nutrients.

The microbial biomass carbon (%) showed no significant difference between the two soil types (Figure 3). The soil microbial biomass did not show any changes due to

Figure 2: Soil chemical parameters of bamboo-dominated (BAM) and non-bamboo (NBM) sites: A - soil moisture (%), B - pH, C - Total N (%) and D - Total P (mg ml⁻¹). Significant differences were indicated by different lowercase letter. Error bars indicate the standard error of the mean (SEM) values.

the overabundance of bamboo, in spite of higher fertility status in BAM soils. In contrast, a previous study showed an increase in soil microbial biomass in a bamboo-invaded native forest in China, despite decreased plant diversity (Xu *et al.*, 2015).

Performance of *Ricinus communis*

Ricinus grown in BAM soils showed relatively higher growth increments (in terms of height) throughout the experiment compared to that in NBM, irrespective of whether soils are sterilized or not. Better performance of *Ricinus* in BAM soils may be due to higher soil fertility and moisture status in BAM compared to that in NBM. Though not significantly, *Ricinus* performed comparatively better when soils are unsterilized in both soil types. The shoot, root, total biomasses and root weight ratio of *R. communis*

showed no significant differences between treatments at the time of the final harvest (after 9 weeks) in differently treated soils (Figure 5). The pooled data showed that *R. communis* performed consistently better in UNST soils than that of ST soils, while RWR showed significantly higher values in ST soils indicating a relatively high allocation of biomass to roots when grown in ST soils (Figure 6).

Higher shoot biomass in *R. communis* in unsterilized soils (UNST) compared to that of sterilized soils (ST), irrespective of BAM or NBM soils, indicate that the soil microbes play a critical role in the growth of *Ricinus*, though it is not directly due to the overabundance of bamboo. Present results favor the general understanding that soil microbes play a beneficial role in plant growth (Grover *et al.*, 2011; Glick, 2012; Baligar *et al.*, 2001). *R.*

Figure 3: Soil microbial biomass carbon (%) in BAM and NBM forest soils. Significant differences were indicated by different lowercase letter. Error bars indicate the standard error of the mean (SEM) values.

Figure 4: Growth increments (as a % height) of *Ricinus communis* during the experiment under four differently treated soils, BAM/ ST, BAM/ UNST, NBM/ ST and NBM/ UNST. Vertical lines denote standard error of means.

Figure 5: Shoot, root biomass and root weight ratio (RWR) in *Ricinus communis* after 9 weeks of growth under differently treated soils bamboo-dominated/sterilized (BAM/ST), bamboo-dominated/unsterilized (BAM/UNST), non-bamboo/sterilized (NBM/ST) and non-bamboo/unsterilized (NBM/UNST) (ANOVA; shoot, $F=2.63$, $p=0.0691$; root, $F=0.567$, $p=0.641$; RWR, $F=0.158$, $p=0.0695$).

Figure 6: Pooled data of shoot weight (g) and Root Weight Ratio (RWR) of *R. communis* under sterilized (ST) and unsterilized (UNST) (ANOVA: shoot $F = 7.633$, $p = 0.0096$; RWR, $F = 8.154$, $p = 0.0077$).

communis grown in sterilized soils showed higher RWR indicating more allocation of biomass to below-ground parts compared to above-ground parts, possibly as an adaptation to lack of soil microbes in soils to facilitate nutrient uptake by plants. Plants survive in less-productive soils tend to partition a larger share of total biomass to below-ground structures (Cambui *et al.*, 2011), possibly to enhance their efficiency in absorbing nutrients under low soil fertility.

CONCLUSIONS

This preliminary study suggests that the overabundance of *B. bambos* may either enhance soil nutrients through higher accumulation of litter or else preferably expand their population in clayey soils, which is usually rich in nutrients. However, further studies are essential to confirm these findings.

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