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ANTI-TERMITIC PROPERTIES OF *LANTANA CAMARA* (LAMIALES: VERBENACEAE)

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Abstract Fresh and dry tissues (leaves, stems, flowers and roots) of two *Lantana camara* cultivars and the soil from where the plants were growing were tested to determine their anti-termitic activities against *Reticulitermes flavipes* in 3-wk laboratory bioassays. Barriers incorporating 25% (w/w) chipped tissues, fresh and dry, in soil significantly reduced termite tunneling activity. The repellent effect was greater in fresh tissues than the corresponding oven-dry tissues and in cultivar Mozellethan cultivar New Gold. Leaves displayed greater repellence than flowers and stems, and roots were the weakest.No-choice bioassay of oven-dry aerial parts showed significant reduction in termite survival, vigor, body weight, body water content, and consumption.The soil in which Lantana had been growing exhibited no anti-termitic activity.
Key Words Non-chemical termite control, botanical termiticide, *Reticulitermes flavipes*

INTRODUCTION

The environmental concerns over the persistent use of synthetic insecticides for termite control in urban environment have recently revoked interest in the search for safer alternativesin pest management programs. These alternatives include baits and non-repellent termiticides **(**Forschler and Jenkins, 2000), plant-derived compounds (EPA, 2000), and the use of live plants (Nix et al., 2006).We have evaluated various bait products and liquid termiticides in the field during the past 11 year, and observed that not all the baits have been visited by termites. To understand what may be the causes, multiple regression analysesare performed, which have revealed that the presence of *Lantana camara* L. (Verbenaceae) nearby the stations is among the multiple factors that may be hold accountable. Our previous studies show termiticidal activity of Lantana tissues on various subterranean termite species (Ding and Hu, 2010; Yuan and Hu, 2011). The objectives of the study were to determine: 1) the anti-termitic effects of soil from where Lantana plants were growing; 2) the toxic and repellent effects of the plant aerial parts, fresh or dry; and 3) the difference in termiticidal activities between different Lantana cultivars and partson the eastern subterranean termite, *Reticulitermes flavipes* (Kollar).

MATERIALS AND METHODS

Plant and Soil Samples

Two *L. camara* cultivars (Mozelle and New Gold) were collected from Auburn, AL, USA. The roots were rinsed thoroughly with water to remove soil and debris. A portion of the aerial tissues and roots were cut with scissors into 0.5cm long pieces, respectively, and subjected to mulch barrier bioassay within 1 h of collection. The extra aerial tissues were dried in an oven (637G IsotempOven, Fisher Scientific, USA) at 40°C for 3 d, before being cut into small pieces and sieving through No. 5-mesh sieve (Hubbard Sci. Co.). Dried Southern Yellow Pine (SYP) was cut into pieces (approximately 0.5 × 0.5× 0.2 cm) and used as control.

A volume of 10 × 20 × 30 cm (length × width × depth) of soil was collected at 0.1-0.2, 0.5-0.6 and 1.0-1.1 m distance, respectively, from the central root of each plant. Soil collected from where no exposure to any chemicals for at least 6 months was used as control in container barrier design. Play sand (Short Mountain Silica, Mooresburg, TN, USA) served as control in glass tube barrier design.

Termites

*Reticulitermes flavipes*was were collected in Auburn, Alabama, using underground open-bottom bucket traps (Hu and Appel, 2004). Termites were tested within 3 d of collection in laboratory at 24 ± 1°C and 80 ± 3% RH.

Barrier Bioassays

A modified version of Bläske and Hertel (2001) was employed to determine termite tunneling activity and survival. Fresh tissues of the two cultivars and soil samples were tested using container barrier design. The bioassay unit was composed of a plastic container (27 x 15 x 9 cm) filled with a layer of 2-cm deep moistened sand partitioned in the middle by a 5-cm wide barrier, which either a mulch barrier incorporated 25% (w/w) Lantana tissue in soil or a barrier of the soil sample. Only oven-dry aerial tissues of Mozelle were tested using a modified glass-tube design (Hu, 2005), because they showed greater termiticidal activity in the container barrier bioassays. The glass tube unit was composed of a glass tube (2.2 x 20 cm) in which a 5-cm or 10-cm 25% (w/w) mulch barrierwas sandwiched between two layers of moistened sand. A group of 100 termites was introduced to either one side (the far-end) of the container, or the top of the glass tube. Each treatment and control was repeated 6 times. Termite tunneling activity was recorded for 3 wk mortality was recorded for soil bioassay.

No-choice Bioassay

Experimental unit was a Petri dish (50 x 13 mm) consisted of 0.5 g dried tissue moistened with 0.5 ml water. A group of 100 termites was introduced into the area not covered by the tissue.There were 6 replicates of each treatment and 4 extra units per treatment for destructive determination of body water content. Termite survival rate, walking speed, body water content and live weight were obtained on 8, 16, and 24 days. Consumption was measured on day 24.

Data Analysis

Total length of tunnel and survival from soil barrier bioassay were analyzed using ANOVA using completely randomized design. Times of tunneling across mulch barriers were analyzed using ANOVA using split-plot design, with cultivar as the main-plot factor and tissues as the subplot factorof the fresh-tissue barrier bioassay, and barrier thickness as the main-plot factor and tissues as the subplot factor of the dry-tissue bioassay. ANOVA was also used to determine the significance of differences between each of the responding variables attributable to the tested tissues in no-choice test. The means were separated with Tukey's HSD at $\alpha = 0.05$. The percentage and proposition data were transformed to the arcsine of the square root before ANOVA, to ensure a normal distribution of the data. Untransformed means are presented in figures and table.All the data analyses were performed by Statistix analytical software (2009).

RESULTS

Barrier Bioassays

The soil collected from the field where Lantana had been growing had no effect on termite foraging, survival, and the distribution of survivors (Table 1), regardless where the soil was sampled ($P > 0.89$).

The mulch barriers significantly reduced termite foraging towards and crossing the mulch barriers incorporating 25% (w/w) Lantana tissues. The fresh tissues (Figure 1)exhibited greater repellency in cultivar Mozelle compared with cultivar New Gold ($F_{1,71}$= 22.44, P< 0.05). Fresh Mozelle tissues had greater repellent activity than corresponding oven-dry tissues (Figure 2). It took more than 21 days for termites to tunnel across a 5-cm fresh leaf-mulch barrier, but only less than 12 days to go through the barrier incorporated of oven-dry leaves.

Table 1. Tunnel length, survival (mean ± SD) and distribution of *R. flavipes* survivors after 3-wk soil barrier bioassay.

Distance of soil sample from Lantana plant	Total length of tunnel (cm)	Survival after 3 weeks (%)	Number of surviving termites in introduction site (%)
Control	145.6 ± 11.2a [b]	94.5 ± 3.7a	47.7 ± 6.2a
0.1 – 0.2 m	167.4 ± 16.1a	92.6 ± 5.2a	56.7 ± 5.4a
0.5 – 0.6 m	152.5 ± 16.4a	93.2 ± 4.8a	52.4 ± 3.5a
1.0 – 1.1 m	157.8 ± 11.3a	92.2 ± 5.5a	39.5 ± 5.7ab

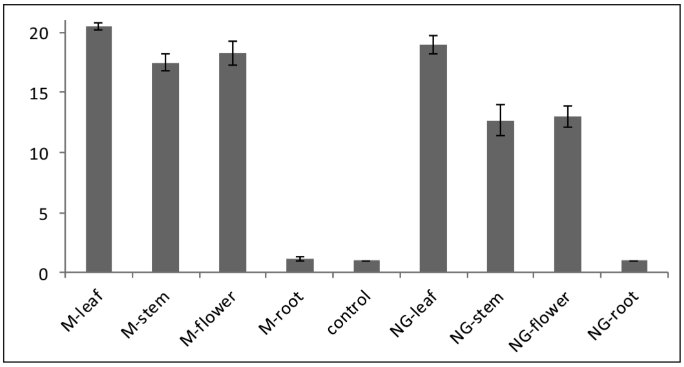

Figure 1. Days required by termites to tunnel across 5-cm 25% (w/w) fresh Lantana tissue mulch barrier in a 3-wk bioassay (cultivar: NG=New Gold; M=Mozelle)

It took significantly longer time for termites to penetrate through aerial-part mulch barriers, disregard the aerial parts were fresh ($F_{3,71}$= 279.1, P< 0.05) or oven-dry ($F_{3,47}$= 474.71, P< 0.05), compared to roots and control which did not significantly differ from each other. The oven-dry tissue mulch barrier bioassay showed significant effect of the barrier thickness on termite tunneling activity ($F_{1,47}$= 165.14, P< 0.05)(Figure 2). It took significant longer times for termite to go across the 10-cm barrier than the 5-cm barrier, irrespective of the tissues.

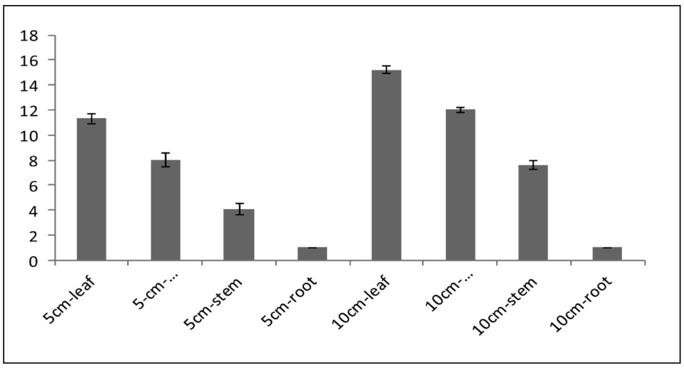

Figure 2. Days requested by termites to tunnel across the 25% (w/w) oven-dry Lantana (Mozelle) tissue mulch barrier (5-cm and 10-cm thickness, glass tube design)

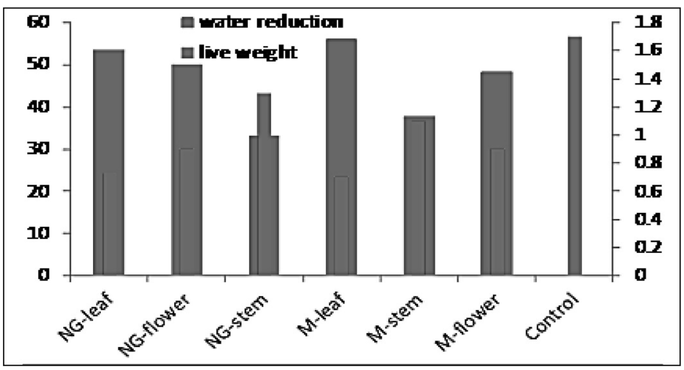

Figure 3. Mean body weight (mg/termite) and body water reduction (%) of live termites after 24-d exposure to oven-dry Mozelle tissues in no-choice bioassay

No-choice Bioassay

Termites exposed to oven-dry tissues gradually reduced survival rate, walking ability, body weight, body water content, and consumption during the 3-wk bioassay period (Figure 3). The reductions were greater in Mozelle compared with New Gold Cultivar (F > 13.6, P < 0.05), and greater in leaves than other tissues (F > 83.2, P < 0.05). Termites exposed to Lantana exhibited lethargic behavior and a tendency to aggregate after 8 days. Visible difference in physical appearances was not observed until 16 days and after. Consumption of leaves, stems and flowers were < 40, 75, and 80 mg, significantly less than 120 mg of control ($F_{6,30}$= 242.6, P< 0.05)

DISCUSSION

Termites readily tunneled through the barrier of the soil from where *L. camara* had been growing, indicating no termiticidal activity of Lantana-associated soil. This result clearly fails in correlating the field observed absence of termites in bait stations with nearby the plants. Possible explanations to the field observation are: 1) the root system does not produce or dismiss anti-termitic compounds into soil, or if it does, the compounds are extremely volatile and have very short life in soil; 2) the aerial parts of the plant that fall on ground could be account for dismissing volatile compounds that repel termites from foraging nearby,or 3) the no-visitation of certain stations was merely a coincidence.

The significantly reduction of foraging activity in termites exposed to the 25% (w/w) mulch barriers accepts the second explanation aforementioned, indicating the repellent property of the aerial parts. Leaves, fresh or oven-dried, possess the greatest repellent activity than other parts. The repellency activity maybe greater in tissues that are fresh than after they are dry. However, the dried aerial parts are toxic (or it could be an anti-feeding property that should be investigatedin the future) to termites, as indicated by the significantly decreases of survival, vigor, body weight, body water content, and consumption in termites exposed to no-choice bioassay.

Early studies reported insecticidal activities of Lantana against a variety of insects, including bees, beetles, mosquitoes, flies, and termites (Abdel-Hady et al., 2005; Dua et al., 2010; Ogendo et al., 2004; Verma and Verma, 2006; Ding and Hu, 2010; Yuan and Hu, 2011).Early studies also documented chemical composition differences in Lantana of different cultivar at different seasons and regions (Sharma and Sharma, 1989; Ganjewala et al., 2009). The compounds are mostly alkaloids including flavonoids, iridoid glycosides, sesquiterpenes, oligosaccharides, and triterpenes (Ghisalberti, 2000).

The empirical data from this study indicate that the aerial parts of Lantana can be used as an additive to garden mulch as an alternative for termite control. Because Lantana plants are a popular fast-growing ornamental around homes and in landscapes and request frequent pruning (Ghisalberti, 2000), the use of the pruned plant material and naturally fallen parts as mulch-barrier could be an economic-efficient alternative to synthetic insecticides. Future researches will examine the biological activity of leaf extracts, chemical compositions from different tissues, fresh and dried tissues, cultivars, seasons, and regions. Furthermore, assessment of the chemical compositions (including metabolites and allelochemicals) on environment and safety should be conducted before recommending this practice.

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