Efficacy of *Lantana camara* L. and *Tephrosia vogelii* Hook against *Sitophilus zeamais* (Coleoptera: Curculionidae) in Stored Maize Grains

J.O. Ogendo\(^a\), S.R. Belmain\(^b\), Arop L. Deng\(^\$\) and D.J. Walker\(^\$\)

\(^a\)Department of Agronomy, Egerton University, P.O. Box 536, Njoro, Kenya
\(^b\)Department of Zoology, Egerton University, P.O. Box 536, Njoro, Kenya
\(^\$\)NRI, Univ. of Greenwich, Central Avenue, Chatham Maritime, Kent ME4 4TB, UK

**Keywords:** botanical insecticides, grain storage, mortality, repellence, stored product protection

**Abstract**

The toxic and repellent effects of two tropical plants, *Lantana camara* L. and *Tephrosia vogelii* Hook were evaluated against *Sitophilus zeamais* Motschulsky in stored maize grains. Five rates (1.0, 2.5, 5.0, 7.5 and 10.0\% w/w) of each powdered plant material, an untreated control and a synthetic insecticide (Actellic Super\(^TM\) 2\% dust) were used to investigate treatment efficacy on mortality of the adult insect (five to eight days old), F\(_1\) progeny emergence and repellence against *S. zeamais* adults. After 21 days, *L. camara* and *T. vogelii* caused 82.7-90.0\% and 85.0-93.7\% insect mortality, respectively. The mean lethal exposure times (LT\(_{50}\)) to achieve 50\% mortality varied from five to six days (7.5-10.0\% w/w) to seven to eight days (2.5-5.0\% w/w) for both plants. Probit regression analysis showed a significant relationship between plant powder concentration and insect mortality. The plant powders and synthetic insecticide reduced adult F\(_1\) insects by more than 75\% compared to the untreated control. *T. vogelii* was most repellent to *S. zeamais* at 7.5-10.0\% (w/w), showing that 87.5\% of insects were repelled, followed by *T. vogelii* at 2.5\% w/w and *L. camara* at 10\% w/w which showed that 65.0\% and 62.5\% of insects were repelled, respectively. The implications of these results are discussed in the context of small-scale farmer usage of these plants for stored product protection and implications on food security and poverty alleviation.

**INTRODUCTION**

The maize weevil, *Sitophilus zeamais* Motschulsky, is the most serious pest of stored maize in the tropics. Although it can be effectively controlled by synthetic insecticides (Pierce and Schmidt, 1992; Bekele et al., 1996), the majority of farmers in Africa are resource-poor and have neither the means nor the skills to obtain and handle pesticides appropriately (Saxena et al., 1990). The prohibitive costs of commercial synthetics, the increasing development of insect resistance to pesticides, toxicity concerns and the often erratic supply of insecticides have given impetus to the search for alternative insect control methods (Tembo and Murfitt, 1995).

Most of the grain produced in sub-Saharan Africa comes from small-scale farmers, many of whom use different kinds of plant products for pest control (Bekele et al., 1996; Poswal and Akpa, 1991). In recent years, research has focused on the bioactivity, application methods and sustainable use of botanical pesticides against insect pests (Fatope et al., 1995; Talukder and Howse, 1994). *Lantana camara* L. (Verbenaceae) has been used as a tonic and stimulant in folk medicine (Masinde, 1996; Siddiqui et al., 1995) and is reported to have anti-insect properties against certain field and storage insect pests (Deka et al., 1998; Facknath, 1994). *Tephrosia vogelii* Hook (Fabaceae) has been used as a source of contact insecticides, fish and arrow poisons (Lambert et al., 1993; Soko, 1999). The objective of the current study was to investigate the potential of these two plant species as sources of sustainable alternative protectants to synthetic insecticides for use in stored product protection using methods compatible with small-scale farmer practices in Africa.
MATERIALS AND METHODS

Preparation of Plant Materials and Culturing of S. zeamais
Fresh samples (mixture of leaves, succulent stems, inflorescence and fruits) of L. camara and T. vogelii were collected from the Kasipul division of Rachuonyo district in Kenya during September 1999. The plant materials were dried under shade at ambient temperatures of 27-30°C for 3 days and further oven-dried at 35°C for 48 hours. The dried plants were ground to a fine powder using an electric mill.

S. zeamais were reared on maize (Zea mays L.) under laboratory conditions (17-28°C, 38-69% RH, 12:12 light:dark). The maize had been previously disinfested in an oven at 40°C for 4hr (Bekele et al., 1996). Two hundred unsexed adults were placed in one litre plastic jars containing 500 g of maize. The top of each jar was covered with nylon mesh fastened tightly with elastic bands. The insects were allowed a seven-day egg laying period before all adults were removed. After 28 days, the emerging adults were removed daily and kept in separate jars according to age for experimental use.

Toxicity Bioassay
Ground powders of L. camara and T. vogelii were admixed with 250 g of maize in plastic jars at five rates (1.0, 2.5, 5.0, 7.5 and 10.0% w/w). Maize grains treated with Actellic Super™ 2% dust at 0.05% w/w and an untreated control was included. Forty unsexed 5-8 day-old S. zeamais adults were placed into the jars arranged in a completely randomised design (CRD) with four replicates. The top of each jar was covered with nylon mesh held tightly with elastic bands. A 2 cm wide band of “fluon” was smeared around the inside near the top of the jar to deter the insects from climbing out. The dead insects in each jar were counted every day for the first ten days, then on the 14th and 21st day. The percent (%) mortality was calculated by expressing the dead as a % of the total number of adult insects introduced into the jar at the start of the experiment. All adult insects were removed from the jars after 21 days. Cumulative counts of emerging F1 insects commenced on the 28th day (Bekele et al., 1996) and continued up to the 56th day.

Repellence Bioassay
The repellence of L. camara and T. vogelii against S. zeamais was evaluated in a choice bioassay consisting of a circular flat-bottomed plastic basin (45 cm diam. x 30 cm high) whose base was divided into four equal portions. Alternate treated and untreated maize (100 g) was placed equidistant from the centre of the circular base. This was repeated for all the treatments including a ‘no-choice’ control with all untreated maize. A 2 cm fluon band was smeared at 15 cm height all around the basin. The treatments were arranged in a CRD with four replicates. Forty unsexed 5-8 day-old adult S. zeamais were placed at the centre of each basin, and the top of the basin was covered with nylon mesh. The total number of insects that settled on the control and the treated grain was recorded after 3, 4 and 24 hours of exposure. The percent repulsion (PR) was calculated and assigned to repellence classes (0-V) according to Talukder and Howse (1994) as follows:

\[ \text{PR} = 2 \times (\text{C} - 50) \]

where \( \text{C} \) = the % of insects that settled on the untreated grain and trials showing a positive (+) PR value demonstrate repellence.

Data from toxicity and repellence bioassays were log-transformed to correct for heterogeneity of treatment variances (Gomez and Gomez, 1984) before being subjected to ANOVA and repeated measures analysis. The transformed means were separated by Tukey’s studentized (HSD) test (Gomez and Gomez, 1984; Scheiner and Guevetch, 1993). The relationship between the plant concentration applied and insect mortality was determined using probit regression analysis of log-transformed concentrations. The regression lines for log10 concentration and insect mortality were then computed (Talukder and Howse, 1994). Any two regression lines were considered significantly different if their standard errors did not overlap (Talukder and Howse, 1994).
RESULTS
There were significant (P<0.01) treatment, exposure time and treatment by exposure time interaction effects on the adult insect mortality (Fig. 1). No mortality was recorded from untreated control maize, whereas maize treated with Actellic Super™ 2% dust achieved 100% kill within two days. The two test plants induced insect mortality over a much longer exposure period causing less than 50% morality during the first five days and 82-95% mortality at 21 days. The lethal mean exposure times (LT50) varied from 5-6 days for higher dosages (7.5 and 10% w/w) to 7-8 days for the lower dosages (2.5 and 5% w/w). Probit regression analysis showed a significant linear relationship between weevil mortality and the concentration of plant powder applied.

Results showed significant differences among treatments and over time in the cumulative number of emerging adult F1 insects (Fig. 2). All botanical treatments and synthetic insecticide significantly reduced the adult F1 progeny production by more than 75% when compared to the untreated control. The concentration of plant powder applied showed a variable effect on F1 emergence that was not dosage dependent.

Results from the repellence bioassay showed significant (P<0.01) differences in repellence between the untreated control and the treatments (Fig. 3). There were also significant differences between Actellic Super™ and the two plant materials at all rates except for L. camara at 1.0% (w/w). Maize treated with T. vogelii had higher PR values than maize treated with L. camara. Maize treated with Actellic Super™ registered a negative PR value, indicating an arrestment of S. zeamais by the chemical. The PR values for all plant treatments significantly increased with increasing exposure time (Fig. 3).

DISCUSSION
In the toxicity bioassays, the botanicals showed two distinct types of effects on S. zeamais: reduction of adult mortality and F1 emergence. A slow but direct insecticidal activity was manifest in the cumulative adult mortality. Toxicity induced by the plant species in the current study compare favourably with the findings of Kasa and Tadese (1996) in which crude powders from eight plant species caused 58-88% mortality of S. zeamais. Similarly, Regnault-Roger and Hamroui (1993) reported that plant materials produced a slow insecticidal effect on the bean beetle, Acanthoscelides obtectus, during a 12-day period. The linear relationship between the treatment concentration of T. vogelii and L. camara and the percent insect mortality of S. zeamais showed that a 100% kill could be achieved if the insects were exposed for over 21 days. The botanicals caused a significant effect on the reproductive potential by reducing the F1 progeny by more than 75%. Throughout the bioassays, the relative humidity and ambient conditions in the laboratory were conducive for oviposition and subsequent development of S. zeamais to the adult stage (Haines, 1991). The recorded reduction in F1 progeny could be due to the observed adult mortality and potential anti-oviposition, ovicidal and/or larvicidal effects caused by the botanicals. The presence of insecticidal properties in T. vogelii has been noted previously, even when dried T. vogelii had been stored for 22 years (Lambert et al., 1993; Oliver-Bever, 1986). Various bio-active isoflavonoids have been isolated from T. vogelii and are likely to be partly responsible for the insecticidal properties observed in the current study (Ibrahim et al., 2000; Lambert et al., 1993; Oliver-Bever, 1986). L. camara has been reported to have insecticidal, anti-oviposition and growth regulating effects against field and storage insect pests (Facknath, 1994; Saxena et al., 1992). However, for both plants, the bioactive constituents and their mode(s) of action against S. zeamais remain unknown.

Maize treated with L. camara and T. vogelii was significantly repellent against adult S. zeamais. The degree of repellency was greatly influenced by the plant species, dosage of powder applied and the exposure time. T. vogelii powder was more repellent (mean PR value = 70.5%) than L. camara (mean PR value = 49%). Although many studies on botanicals have been conducted in the past (Bekele et al., 1996; Regnault-Roger and Hamroui, 1993; Talukder and Howse, 1994), no data are available on the bioactivity of L. camara and T. vogelii as grain protectants against major stored product insects. The toxic and repellent action of L. camara and T. vogelii suggests that there exists good potential for
the use of the two local plant species as grain protectants in the traditional resource-poor farming communities in sub-Saharan Africa. Sustainable use of botanical pesticides will boost the food security in those environments where investment in synthetic pest control is uneconomical. However, the promotion of botanicals as an alternative to synthetics must acknowledge that natural product toxicity could be high. Future studies must still confirm whether a botanical treatment can be safely used as a food additive before promotion to farmers.

Literature Cited
Haines, C.P. (ed.). 1991. Insects and Arachnids of Tropical Stored Products: Their Biology and Identification. 2nd ed., Natural Resources Institute, Chatham, UK.


Fig. 1. Cumulative mean (± sem) percent adult mortality of *S. zea*mais over 21 days when exposed to maize admixed with different concentrations of ground a) *L. camara* and b) *T. vogelii*.
Fig. 2. Effect of admixing maize with *L. camara* or *T. vogelii* powder on the cumulative mean (± sem) number of F1 progeny of *S. zeamais* emerging over time.

Fig. 3. The effect of exposure time and dosage on the repellent properties (mean percent ± sem) of *L. camara* and *T. vogelii* against *S. zeamais* adults.