African Journal of Agricultural Research Vol. 5(24), pp. 3369-3378, 18 December, 2010
Available online at http://www.academicjournals.org/AJAR
ISSN 1991-637X ©2010 Academic Journals

Full Length Research Paper

Toxic effects of five plant extracts against the larger grain borer, *Prostephanus truncatus*

Mweshi Mukanga[1]*, Yakub Deedat[2] and Felix S. Mwangala[3]

[1]Mount Makulu Central Research Station, Private Bag 7 Chilanga, Zambia.
[2]Department of Crop Science, University of Zambia, P. O. Box 32379, Lusaka, Zambia.
[3]National Biotechnology Laboratories, National Institute for Scientific and Industrial Research, P. O. Box 310158, Lusaka, Zambia.

Accepted 20 October, 2010

Dried leaf powders of Eucalyptus, Guava, Neem, Tephrosia and Water hyacinth were evaluated for their insecticidal activity against *Prostephanus truncatus* Horn. The powders were tested at 0.1, 0.25, 0.5, 0.1, 2.5 and 5 g/100 g of dried cassava chips or flour. Data was collected on larvae and adult mortality, larvae and adult emergence, antifeeding, and repellency. The effects varied with plant species and dose rate. Increased insect deformity and mortality and reduced fecundity were observed among the leaf powder treatments compared to untreated control. The percentage reduction in the adult insect numbers ranged from 37.2 to 99.2% and was highest in the Neem, Tephrosia and Water hyacinth treatments. Neem had the highest larvicidal effects though not significant different (P > 0.5) from the other four plant species. On the other hand, Tephrosia and Guava leaf powders exhibited both strong repellent and anti-feeding effects. The petroleum ether extracts of the leaf powders of Neem and Guava were highly toxic on *P. truncatus.* The results suggest that these materials tested have the potential in development of post-harvest protection technology against, *P. truncatus,* the major pest of stored grains and dried cassava.

Key words: *Prostephanus truncates,* antifeeding, mortality, repellency, toxicity, leaf powders, petroleum ether extracts.

INTRODUCTION

The larger grain borer, *Prostephanus truncatus* Horn (Coleoptera: Bostrichidae), is a serious pest of farm-stored maize (Golob, 2002; Vowotor et al., 2005) and dried cassava (Hodges et al., 1985). Losses to maize and dried cassava caused by this pest could be as high as 36 – 40% and 70 - 80%, respectively over a period of 6 months of storage (Wright, 1984; Golob, 1988). Damage of this magnitude is extraordinarily high and demonstrates the destructive nature of this pest, which can threaten food security at both household and national levels (Mallya, 1992). The recent introduction and spread of the larger grain borer into Africa has increased dried cassava storage problems (Schulten, 1996). Hence, effective storage protection strategies are urgently required. Current control measures for the *P. truncatus* include chemical insecticides, fumigation and biological control using of *Teretrisoma nigrescens* Lewis (Coleoptera: Histeridae), a predator of *P. truncatus* (Richter et al., 1997; Hell et al., 2006). These methods are expensive and cannot be afforded by the small-scale farmers in developing countries.

Use of naturally occurring plant materials to protect agricultural products against insect pests is an old-age practice in many parts of the world (Dales, 1996; Belmain, 1999). Obeng-ofori et al. (1996) have indicated that the use of locally available plant materials is a common practice in traditional African communities, mainly for medicinal purposes (herba l use) and in

*Corresponding author. E-mail: mmweshi@gmail.com.

agriculture.

Extracts from different plants have been known to possess insecticidal properties against a wide range of insect pests (Abdullahi and Muhammad, 2004). Plants with insecticidal properties offer a cheaper sus-tainable alternative to synthetic insecticides, store design, fumigation and thermal distribution methods. They could be an abundant source of locally available pest control agents that can be grown at the village level. The insecticidal specificity of some of the plant extracts and their lack of negative impacts on the food and the envi-ronment make them ideal candidates for incorporation into an integrated pest management strategy.

Exact quantities of botanicals from these plants that give optimum insecticidal effects are unknown. It is thus desirable to quantify the amount of the plant derived materials that provide adequate protection against insect pests and to determine how these affect insect behaviour, growth and reproduction (Jilani, 1992). Equally, plant species that are found to be effective and popular locally with the farmers need to be subjected to safety testing, at least involving basic toxicological studies (Jilani, 1992). The principal advantage of botanicals is that farmers are able to provide their own protectants (Isman, 2008). The objectives of this study were:

1. To determine the effect of leaf extracts from Tephrosia, *Tephrosia vogelii;* Neem *Azadirachta indica;* Guava, *Psidium guajava;* Eucalyptus *Eucalyptus globulus* and Water hyacinth, *Erchhornia crassipes*
2. To test for insecticidal properties of the extracts such as toxicity and morphological abnormalities and
3. To determine whether these extracts could be used as protectants against *P. truncatus*

MATERIALS AND METHODS

Study location

The experiments were conducted at Entomology laboratory, Mount Makulu Central Research Station Chilanga, Zambia (S 15°28', E28°14').

Test plant materials

The materials used were dry leaves of Tephrosia, *T. vogelii* Hook F.*;* Neem *A. indica* A.Juss*;* Guava, *P. guajava* L.*;* Eucalyptus *E. globules* Labill. were collected from the field s surrounding Mount Makulu and Water hyacinth, *Erchhornia crassipes* (Mart.) Solms. The dried leaves were ground and sieved repeatedly to obtain the finest particles using a 300 µm sieve. The leaf powders were stored in 10 g glass bottles for later use. Ground cassava chips (2 – 5 cm) were used as a food substrate for *P. truncatus* in all these studies. The cassava chips were sterilized by freezing in sealed plastics for four weeks to kill any residual insect.

Petroleum ether leaf extract was prepared using Soxhlet extraction method. Fifteen grams of leaf powder of each plant species were extracted separately 40 - 60°C for 8 h in 300 ml of the above solvent. The extract thus obtained was filtetred through a sterilized Whatman No. 1 filter paper. After which, the solvent was evaporated in a rotary evaporator at 30°C to dryness and the weight of the extract determined. Guava leaf powder yielded 251 mg, Tephrosia 477.3 mg, Eucalyptus 719.7 mg, Water hyacinth 196.8 mg and Neem 260.4 mg of extract.

The extract obtained was then made to different doses that is 0.1, 0.25, 1 and 1% concentration) respectively by acetone. A 1% concentration stock solution was obtained by dissolving 100 mg of petroleum ether leaf extract from each plant in 10 ml of acetone. Lower concentrations of 0.1, 0.25 and 0.5% were prepared by further dilution of the stock solution with acetone.

Test insects

Adult *P. truncatus* used in the experiments were reared in 1L glass jars in the Protection Insectary at Mount Makulu Central Research Station, Chilanga on previously sterilized maize grain at 28 ± 2°C temperature and 70 ± 5% relative humidity and with alternating light and dark periods of 12 h. The adults and larvae were separated after sieving out the maize. They were placed in different vials for later use. The second-generation adults that emerged were used in all these trials.

Reproduction inhibition test

Dry leaf powders were applied as admixtures in six serial doses of 0.1, 0.25, 0.5, 1, 2.5 and 5 g of ground leaves per 100 g of sterilised dried cassava chips. One hundred grams of treated cassava chips were placed in 1L glass jars. The synthetic insecticide, Actellic-super dust (1.6% *Pirimphos-methyl* and 0.3% *permethrin*) treated dried cassava chips as standard check while untreated cassava chips served as control. Actellic super was applied at recommended dosage at 50 g per 90 kg shelled maize grain (Mwaya, 1997).

The treatments including the control were replicated thrice. Twenty (20), 1 - 3 days old, *P. truncatus* adults (10 male, 10 female) were introduced in each glass jar. After 10 days, the adults were removed. On the 14th, 28th, 42nd, 56th and 70th day after infesting the dried cassava chips. The number of live, dead and malformed *P. truncatus* larvae and adults in the ensuing progeny were counted after sieving. The response of the test insects in the treated cassava were corrected using the modified Abbott's formula:

100 (Number. of insects in control – Number of insects in treatment) / (Number of insects in control)

Henceforth, percentage reduction in the progeny was calculated. A treatment was judged to give complete protection against *P. truncatus* if no progeny was produced. Only the live and normal larvae were returned to the jars. Dead and malformed larvae and adults were removed.

Square root (x + 0.5) transformations were made of the data to compensate for skewness and to stabilise variance before the analysis by ANOVA was done. The total insect counts at each dosage were regressed against the time interval (days) at which insect counts were made, to determine the residual persistence of the leaf powders. The treatments and control were replicated three times for all the experiments. The data from the experiments were subjected to Analysis of Variance (ANOVA). The separation of means was done by New Duncan's Multiple Range Test (DMRT). Significance was taken at 5% level (Steel and Torries, 1980).

Repellency effects

Two and a half grams of treated cassava flour with 1, 0.25, 0.5, 1, 2.5 and 5 g of ground leaves per 100 g dried cassava chips and untreated cassava were separately placed on opposite sides on filter paper, with 10 cm space in between on a plastic Petri dish (14 cm diameter, 2 cm height), which served as an arena. Ten, 1 - 2 weeks old *P. truncatus* adults starved for 48 h were introduced in the centre of the arena using an aspirator. The number of insects found on the treated cassava was recorded twice daily, at 09:00 and 16:00 h, for five (5) consecutive days (Dales, 1996). Average insect counts for each day were converted to percent repellency (Jilani et al., 1992; Saxena et al., 1989), which was calculated after Gillenwater and McDonald (1975):

% Repellency = No. of insects on control half - No. on treated half / No. of insects on control half + No. on treated half x 100

Anti-feeding study

The potency of antifeedant effect of the dry leaf powders was determined using filter paper bioassay. The leaf powder was dusted evenly on both sides of the filter paper (113.1 cm^2), in which 1.00 g cassava flour was placed. The leaf powder was applied on the filter paper as proportion of the dose per 100 g to that per 1.00 g dried cassava, that is, 0.001, 0.0025, 0.005, 0.01, 0.025 and 0.05 g.

The wrapped cassava was placed in 35 ml vial. Cassava flour wrapped in the untreated filter paper served as control. Five, 1-week-old adults of *P. truncatus*, starved previously for 24 h were introduced in each vial and left for 7 days. The wrapped cassava served as sole food source. The numbers of holes in filter paper produced by boring insects were recorded at end of the 7 – day exposure period.

Toxicity effects of petroleum ether leaf extract vapours

Ten *P. truncatus* adults (24 – 72 h old) , were placed inside a vial (35 ml) which acted as a gas chamber with a plastic lid in which minute slits were made. A filter paper disc (15.9 cm^2) impregnated with the test solution, was suspended from the plastic lid where it was in position by one of the slits in the plastic lid. Insects exposed to the acetone impregnated filter paper disc served as control. Mortality was recorded after 24 h exposure period. Petroleum ether leaf extracts were applied at 0.1, 0.25, 0.5 and 1% concentrations.

Mortality was confirmed by exposing the insects to a light source and those that did not move were considered dead. Insect mortality data were analysed using the POLO procedure (Russell et al., 1977) using the probit analysis (Finney, 1971) to obtain the median lethal concentration of the petroleum ether leaf extracts at 50% kill (LC_{50}).

Contact toxicity by topical application of petroleum ether leaf extracts

The experiment was conducted using the method described by McDonald et al. (1970) with slight modifications. Using a micro-syringe applicator, 1 µl of the petroleum ether leaf extracts of selected plant species were applied at 0.1, 0.25, 0.5 and 1% concentrations were applied to the dorsum of thorax of each insect. Ten pairs of newly emerged *P. truncatus* adults were treated with each dose.

After treatment, insects were transferred to glass Petri-dishes (9 cm diameter, 1 cm height) containing a food substrate – untreated cassava flour. The insects were examined daily for five days; those that did not move or respond to the gentle touch were considered dead. Percentage kill of the insects was recorded every 24 h.

RESULTS

Effect on larvae and adult emergence

The effect of leaf powders on the emergence of larvae and adult *P. truncatus* are presented in Figure 1. Results showed that there was between 37.2 to 99.2% reduction in the number of larvae recovered from the leaf powder treatments compared to untreated cassava. The larvicidal effect was of the order: Neem leaf powder > Tephrosia> Eucalyptus> Water hyacinth> Guava. The percentage reduction in adult progeny in the leaf powder treatments followed similar pattern with the least recoveries occurring in Neem leaf powder treatment, followed by Water hyacinth. No insect recoveries were made in the standard check, Actellic super treatment.

There was a preponderance of lower dosages (0.1, 0.25 and 0.5 g /100 g) compared to higher doses (0.1, 0.25 and 0.50 g /100 g) being less effective in reducing both larvae and adult population (Figure 2). The regression analysis indicated the existence of a positive linear relationship between insect count and the time interval (days) at which the counts were made (Table 2). The strongest relationship occurred in Neem applied at 5 g/100 g. The slopes for regression lines at each dosage were observed to be close suggesting similarity in the rate of decay of the leaf powders.

Effect on larvae and adult deformity and mortality

The materials tested significantly affected the longevity or survival of the *P. truncatus* larvae and adults compared to the untreated control (Table 1). The mean number of deformed larvae ranged 0.21 to 0.34 larvae per 100 g dried cassava chips in the leaf powder treatments, while the number of dead larvae were between 0.21 – 0.34. Though the analysis of variance revealed no significant difference (P > 0.05) among the leaf powder treatments for larvae mortality and deformity, numerically the highest larvae mortalities were recorded in the Neem treated cassava chips. Water hyacinth produced the lowest larvae mortality.

With respect to the number of deformed and dead adults recovered, no significant differences (P < 0.05) were found among powders of Eucalyptus, Guava, Neem, Tephrosia and Water hyacinth -treated cassava. However, on average 0.7 to 1.5% of adults in leaf powder treated cassava were deformed, and 1.7 to 3.5% died. This means that leaf powder has exhibited some amount of insecticidal effects and lowered insect reproductivity especially at higher concentrations, 2.5 and 5 g (Figure 3)

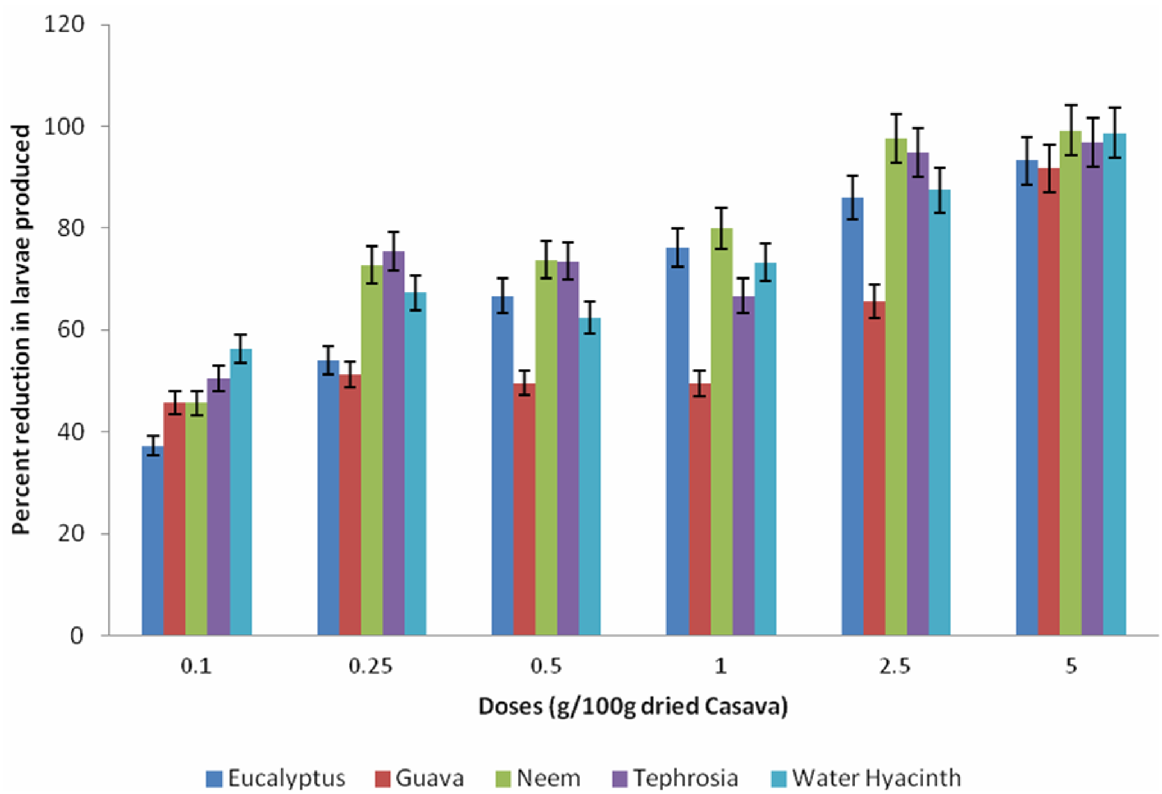

Figure 1. Mean percent reduction in the number of larvae of the larger grain borer, *P. truncatus* in dried cassava treated with different doses of five leaf powders after 70 days of storage.

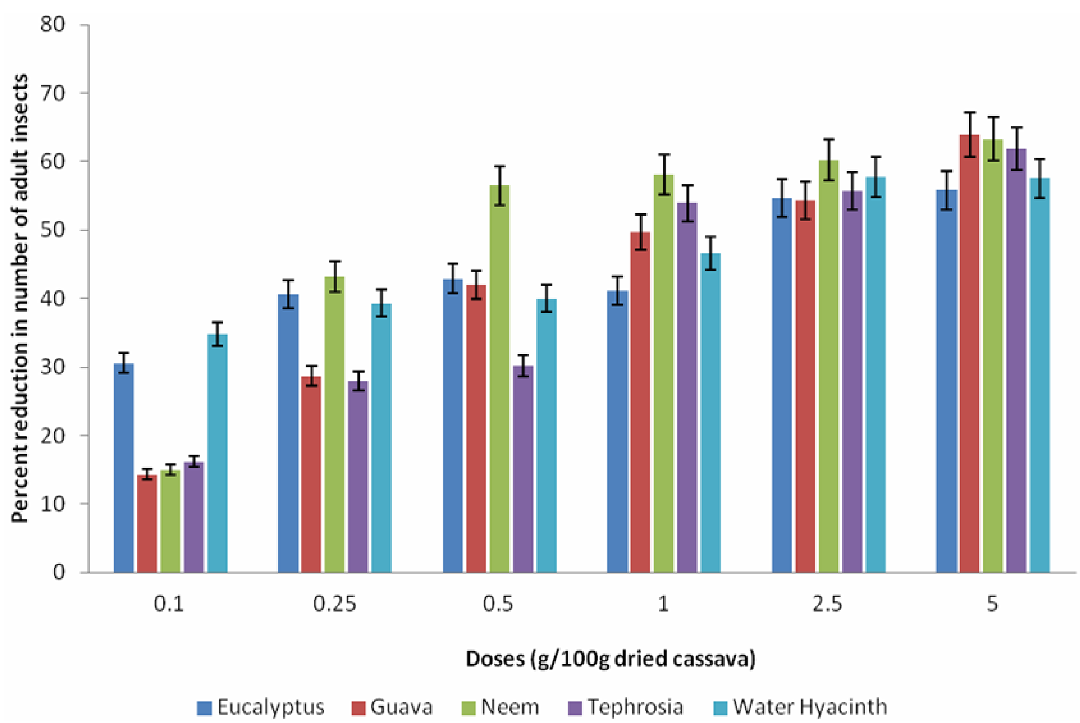

Figure 2. Percent reduction in the number of adults of the larger grain borer, *P. truncatus* in dried cassava treated with different doses of leaf powder during 70 days of storage.

Table 1. Relationship between total insect count and the sampling interval for different leaf powder treatments.

Treatment	Mean number/100 g dried cassava			
	Deformed		Dead	
	Larvae	Adult	Larvae	Adult
Eucalyptus	0.22 A	0.23 AB	0.36 A	0.66 C
Guava	0.31 A	0.29 A	0.37 A	0.74 C
Neem	0.34 A	0.01 C	0.39 A	0.34 C
Tephrosia	0.23 A	0.03 C	0.27 A	0.66 C
Water hyacinth	0.26 A	0.12 BC	0.37 A	0.69 C
Actellic super	0.00 B	0.00 C	0.00 B	20 A
Untreated	0.00 B	0.00 C	0.00 B	0 D
Mean	0.19	0.09	0.249	3.29
C.V%	29.6	21.7	33.7	32.1

Figures followed by the same letter in the same column are not significant different at P<0.05; Duncan multiple range test on square root (x+0.5).

Table 2. Mean number of dead and deformed larvae and adult of the larger grain borer, *P. runcates* in dried cassava treated with leaf powders.

Treatment	Mean number/100g dried cassava			
	Deformed		Dead	
	Larvae	Adult	Larvae	Adult
Eucalyptus	0.22 A	0.23 AB	0.36 A	0.66 B
Guava	0.31 A	0.29 A	0.37 A	0.74 B
Neem	0.34 A	0.01 C	0.39 A	0.34 B
Tephrosia	0.23 A	0.03 C	0.27 A	0.66 B
Water hyacinth	0.26 A	0.12 B	0.37 A	0.69 B
Actellic super	0.00 B	0.00 C	0.00 B	20.0 A
Untreated control	0.00 B	0.00 C	0.00 B	0.00 C
Mean	0.19	0.09	0.25	3.29
C.V%	29.6	21.7	33.7	32.1

(Figure 3). The highest insect mortality occurred at 5 g/100 g dried in the Guava treated cassava, followed by eucalyptus at the same rate, though not statistically different. No adult mortalities were recorded in the Neem treatment at 0.1 and 0.25 g/100 g dried cassava. All the insects in Actellic super, died within 7 days of its application while no deformity and mortality were observed in the untreated control.

Repellency bioassay

P. truncatus demonstrated negative orientation response to the cassava powder treated with leaf powder. Repellency increased significantly (P < 0.05) with increase in dosage (Figure 4). Higher dosages (2.5 and 5 g/100 g) were superior to lower dosages (0.1, 0.25, 0.5 and 1 g/100 g). Neem leaf powder exerted strong repellency (59.1%). The leaf powder of Guava was next best (50.5%). The decreasing order of efficacy of the five leaf powders was as follows: Neem>Guava≥Tephrosia>Water hyacinth>Eucalyptus.

Anti-feeding test

The leaf powder treatments produced significantly (P < 0.05) higher anti-feeding effect on the adult *P. truncatus* than the control (Figure 5). Among leaf powder treatments, the mean differences were statistically insignificant (P > 0.05) however, the highest feeding deterrence was in the Neem followed by Tephrosia where the test insects made fewer holes in the filter paper at all the doses. The least effect was in Guava. An increase in anti-feeding activity was observed with increasing dose though, not significant different (P > 0.05).

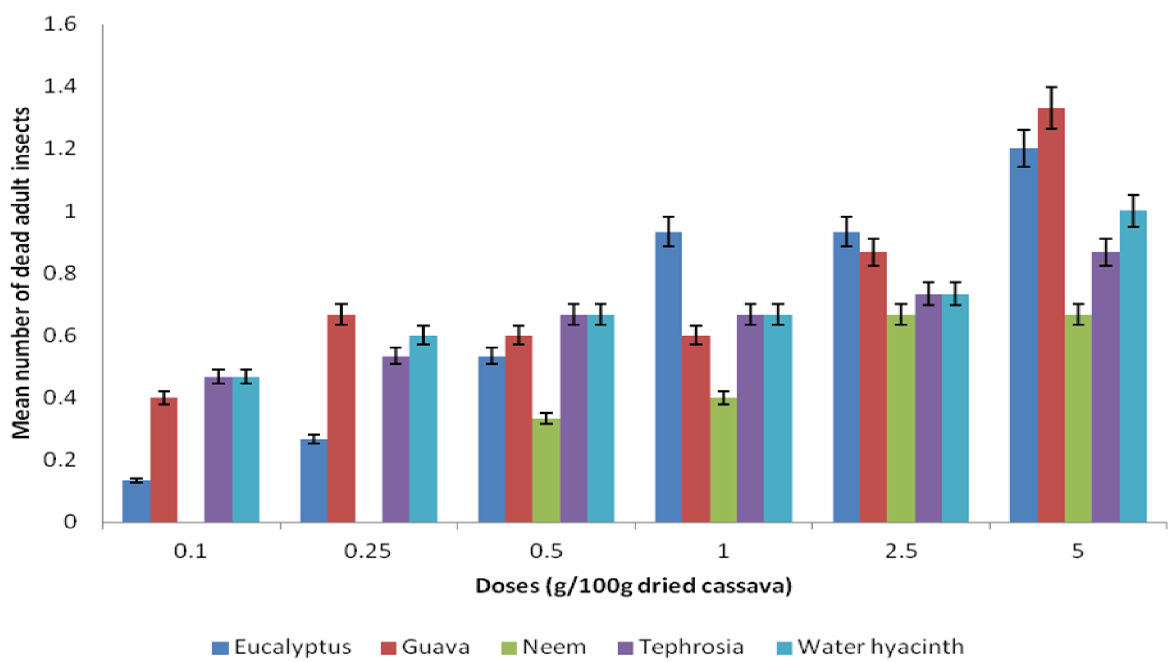

Figure 3. Mean number of dead larger grain borer, *P. truncatus* adults in dried cassava treated with different doses of leaf powder during 70 days of storage.

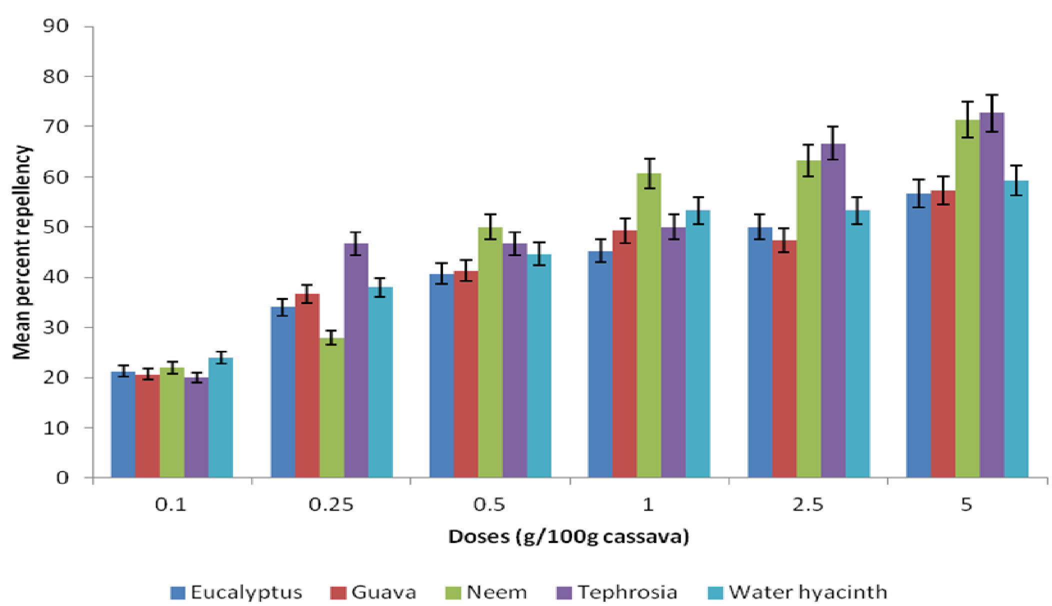

Figure 4. Mean percent repellency of leaf powders to the larger grain borer, *P. truncatus*

Contact toxicity of petroleum ether leaf extracts vapours

The petroleum ether extracts were moderate toxic. The median lethal concentration (LC_{50}) of the petroleum ether leaf extract vapours are shown in Table 3. Neem vapours were the most toxic against *P. truncatus* adults followed by the Tephrosia. The LC_{50} ranged from 0.384% for Neem to 4.027% for Guava vapours. Vapours from Neem were 8 times more toxic to the test insects than those of Guava. The confidence limits and slopes of dosage-mortality curves obtained indicated no difference in the

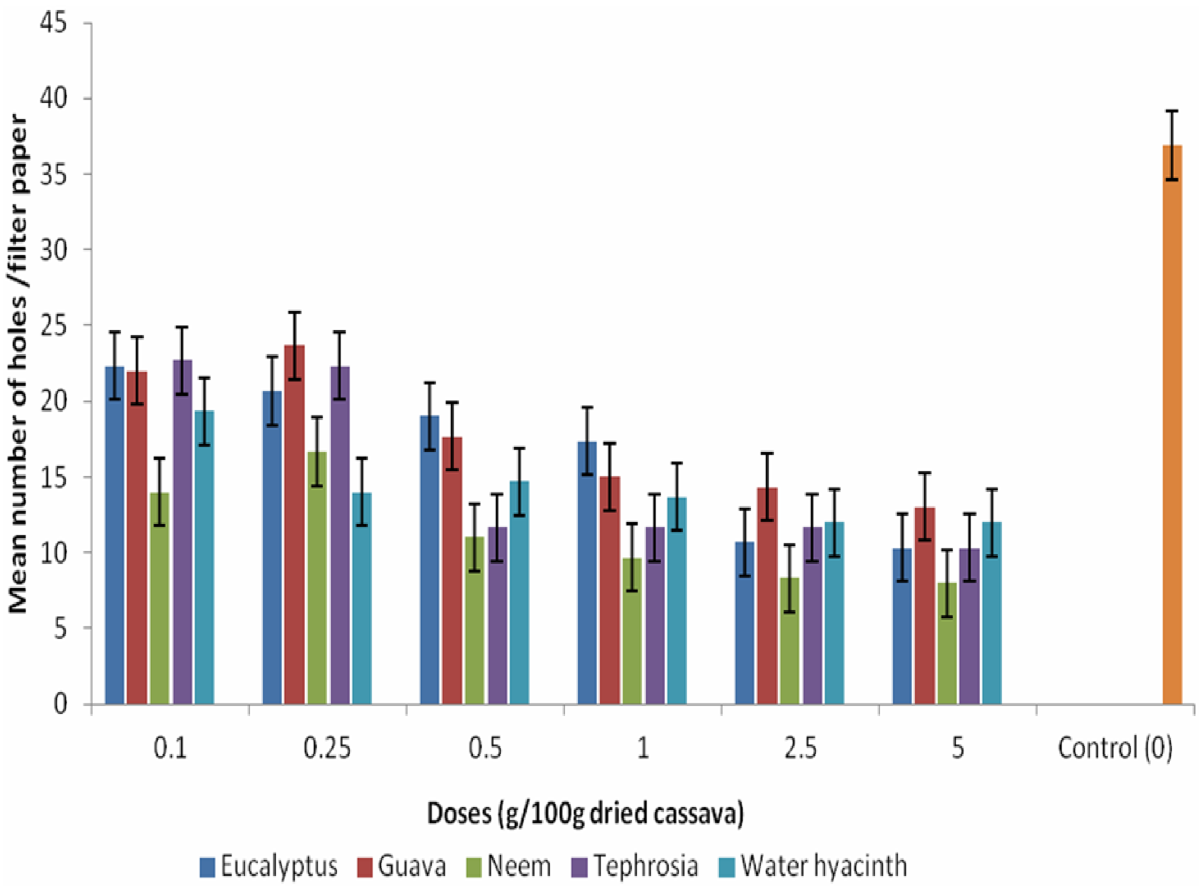

Figure 5. Antifeeding effect of different doses of leaf powders on the feeding behaviour of the adults of the larger grain borer, *P. truncatus*

toxicity of Neem, Tephrosia and Water hyacinth. Toxicity of the vapours that emitted from the impregnated filter papers on the test insects were of the following order: Neem > Tephrosia > Water hyacinth > Eucalyptus > Guava.

Contact toxicity through topical application

The probit statistics, estimate of the LC_{50} values of insect mortality data are presented in Table 4. Comparison of the LC_{50} values showed that Neem was most toxic (LC_{50} 0.079%) within 48 h after treatment, while Guava was the least toxic (LC_{50} 0.260%). After 96 h, Tephrosia was observed to be more toxic extract (LC50 value: 0.033%) followed by Water hyacinth (0.036%). At 120 h after application, Tephrosia and Water hyacinth extracts were most toxic (LC_{50} 0.027%) and least was Guava, LC_{50} value of 0.092%. Increased *P. truncatus* mortality was observed in all five extracts, during the 120 h observational period. The closeness of the dose-mortality curves as indicated by the slopes indicates there were no marked differences in contact toxicity amongst the extracts, except with Guava.

DISCUSSION

Leaf powders clearly suppressed the emergence of *P. truncatus* populations in dried cassava chips. The reproduction potential was reduced but not completely inhibited. The effect was observed to be plant-specific and dose-related. Several workers (Pierce and Schmidt, 1992; Niber et al., 1994; Osiptian et al., 2010; Mulungu et al., 2010) have also reported the ability of some leaf extracts to inhibit the reproductive capacity of *P. truncatus*. The reduction in the numbers of *P. truncatus* progenies in the leaf powder treated cassava may be attributed to anti-oviposition, delayed egg-hatching and insect growth disrupting effects of the leaf powders. The absence of F_1 insects at 14 DAT in the leaf powder treatments could have been as a result of these effects.

The insect species sensitivity for a same plant extract might be different for different dosages (Illoba and

Table 3. Toxicity effect of vapours of petroleum ether leaf extracts on the adults of the larger grain borer, *P. truncates.*

Extracts	LC_{50}	95% C.L	Slope + SE	Chi-square	Df	Heterogeneity
Eucalyptus	1.3256	0.678 – 2.72	0.931 ± 0.346	1.651	10	.17
Guava	4.0279	1.228 – 6.821	0.783 ± 0.371	1.940	10	.19
Neem	0.3841	0.227 – 0.692	1.138 ± 0.327	3.324	10	.33
Tephrosia	0.5120	0.331 – 1.058	1.288 ± 0.339	6.116	10	.61
Water Hyacinth	0.5149	0.281 – 0.870	0.824 ± 0.321	2.791	10	.28

LC_{50} = concentration (%) calculated to give 50% mortality, S.E = Standard Error, C.L=Confidence limit, Df = Degree. of freedom

Table 4. Response of the adults of larger grain borer, *P. truncatus* to the petroleum ether leaf extracts after topical application.

Extract	LC_{50} Observational period (h)				
	24	48	72	96	120
Eucalyptus	0.379 (0.000 ± 3987126)	0.158 (2.221 ± 0.911)	0.083 (0.719 ± 0.348)	0.048 (0.323 ± 0.320)	0.034 (0.300 ± 0.319)
Guava	0.573 (0.875 ± 0.228)	0.260 (0.775 ± 0.225)	0.171 (0.806 ± 0.226)	0.108 (0.788 ± 0.230)	0.092 (0.739 ± 0.231)
Neem	0.135 (0.666 + 0.225)	0.079 ().767 ± 0.231)	0.057 ().585 ± 0.232)	0.042 (0.575 ± 0.235)	0.040 (0.594 ± 0.236)
Tephrosia	0.189 (0.737 + 0.224)	0.110 (0.020 ± 0.226)	0.042 (0.597 ± 0.234)	0.033 (0.506 ± 0.237)	0.027 (0.492 ± 0.239)
Water hyacinth	0.197 (0.567 ± 0.222)	0.105 (0.664 ± 0.226)	0.048 (0.629 ± 0.233)	0.036 (0.623 ± 0.236)	0.027 (0.560 ± 0.240)

LC_{50} = concentration (%) calculated to give 50% mortality, Slope + Standard Error are in the parenthesis.

Erakene, 2006) however, physiological responses ought to be noted for different plant extracts. The use of plant extracts powders were observed to be slightly detrimental to the development of later stages of the *P. truncates* as seen by the low numbers of deformed and dead adults.

Increased insect F_1 population in the leaf powder treatments with time suggests possible re-adaptation of the adult progeny to presence of the plant extracts and the decay of the leaf powder, which resulted in reduced potency. It was observed that the higher the dose of leaf powders, the lower the numbers of offspring in the subsequent generations. These findings are in agreement with those of Akob and Ekwete (2007) and Nukenine et al. (2010) on *Sitophilus* species.

Neem leaf powders showed excellent repro-duction and growth inhibitory effect, followed by Tephrosia and Water hyacinth. The closeness of regression coefficients (Steel and Torries, 1980) calculated for different leaf powder treatments when regressed against the time intervals at which the *P. truncatus* counts were made, indicates that the rate of breakdown of these leaf powders was similar. Though the relationship was strongest in Neem when applied at 5.0 g/100 g dried cassava, the significantly low numbers of *P. truncatus* recorded in Neem treated cassava at each sampling time indicates that Neem was more persistent in its effect than other leaf powders. The high *P. truncatus* populations in the Guava and Eucalyptus treatments could be a result of the rapid loss in toxicity most probably caused by the strong breakdown of the leaf powders of these two plants that belong to the same genera (Sharaby, 1988).

The repellency effect of the powders was sustained throughout the study period. The strong repellent effect of this leaf powders admixed cassava may have been largely dependent on olfactory and gustatory sensation (Schmutterer, 1990) of the test insects. Properties like the repellent odour may have caused the insects to be restless (Ogendo et al., 2003). The insects were observed to be turning away and settling on the untreated cassava. The choice for the untreated cassava was because of the repellent chemicals inherent in the leaf powders (Jilani et al., 1988*)*. Insect repellents are secondary metabolites which have been identified to be alcohols, alkaloids, phenolics, flavonoids and terpenes (Dales, 1996). Tephrosia leaf powder showed excellent repellency activity followed by Neem. In the preference test, the insect were seen to be crawling more towards untreated cassava than leaf powder treated cassava. Neem and Tephrosia treated cassava were the least preferred food media.

The antifeedant effects of the leaf powders might be the result of different kinds of insect anti-feeding allelochemicals (Saxena et al., 1989) in the extracts that may have been working together, they deterred the insects from penetrating the filter papers. The anti-feeding effect of the leaf powders may have also resulted from the bitter taste that rendered the wrapped cassava unpalatable to the test insects. The Neem followed by Water hyacinth leaf powders were more effective feeding deterrents. The outstanding effectiveness of Neem leaf powders have also been reported by other scientists (Saxena, 1993; Niber, 1994; 1995; Schmutterer, 1990; Facknath, 2006; Illoba and Erakene, 2006).

Petroleum ether leaf extracts produced considerable high mortality and growth regulatory effects on almost all the treated insects. Significantly higher effects were produced by Tephrosia, Neem and Water hyacinth extracts. *P. truncatus* mortality was dose-dependent, increasing with an increase in dose. The levels of mortality caused by vapour from the leaf extracts were comparably low to those reported on pulse beetle, *Callosobruchus chinensis* by Pajni and Gill (1991). However, Neem vapours were most toxic to *P. truncatus* adults, followed by Tephrosia. In topical treatment, the active fractions in the petroleum ether leaf extracts may have caused mortality by direct interference with insect physiological balance (Pierce and Schmidt, 1993). The restlessness in the treated insects before death suggests hormonal involvement in the action of these compounds (Rani and Jamil, 1989). Similar observations have been reported for other plant extracts (Ogendo et al., 2004). These morphological features may be due to the failure of the wings to expand and flatten after adult insect emergence.

The LC_{50} values of the petroleum ether extracts indicates that Tephrosia, Neem and Water hyacinth displayed the highest potency against test insects while Guava was the least toxic. The toxicity effect may be attributed to the secondary metabolites (Dales, 1996), which have been isolated from various plant parts. These tend to affect insects in several ways such as disrupting major metabolic pathways and causing rapid death, acting as deterrents, phagostimulants or anti-feedants, or modifying oviposition (Jilani, 1992). These secondary compounds may also retard or accelerate development, or interfere with the life cycle of the insects. The differences in the toxicity of Eucalyptus and Guava to *P. truncatus*, although, belonging to the same family, *Myrtaecae*, may be attributed to a species-specific factor (Kamal et al., 1988). In general, the amounts and toxicity of these compounds in the leaf powders will depends on the maturity of the plants, the season (temperature, photoperiod, and hygrometry) and the geographical and pedological conditions.

Conclusion

Besides exhibiting the repellency, antifeeding and reproduction inhibition effects, the leaf extracts exhibited vapour and contact toxicity on *P. truncatus*. These plant-derived materials appear to be effective in reducing *P. truncatus* infestation. The presence of toxicants and growth inhibitors in these candidate plants suggest good potential for their use in storage pest management especially farm stored grain and pulses. The present findings indicate a piquant toxic nature of Neem, Tephrosia, Water hyacinth and Guava extracts on *P. truncatus* that can be utilized in farm stores against this pest. However, further work is required to investigate the isolation of their insecticidal bio-molecules.

REFERENCES

Abdullahi YM, Muhammad S (2004). Assessment of the toxic potentials of some plants powders on survival and development of

Callosobuchus maculates. Afr. J. Biotech., 3: 60-64.

Akob CA, Ewete FK (2007). The efficacy of ashes of four locally used plant materials against *Sitophilus zeamais* (Coleoptera: Curculionidae) in Cameroon. Int. J. Trop. Ins. Sci., 27: 21-26.

Belmain SR (1999). Final technical report. Project R6501. Chatham, UK:Natural Resources Institute

Dales MJ (1996). A Review of Plant Materials used for controlling Insects pest of Stored Products. NRI bulletin No. 65. Natural Resources Institute Chatham, UK p. 84.

Finney DJ (1971). Probit analysis. 3rd ed., Cambridge University Press, London, p. 318.

Facknath S (2006). Combination of neem and physical disturbance for the control of four insect pests of stored products. Inter. J. Trop. Insect Sci., 26: 16-27.

Gillenwater HB, Mc Donald LL (1975). Repellency of nineteen candidate compounds to adult *Tribolium confusum*. J. Ga.Ent. Soc., 10: 151-155.

Golob P (2002). Physical, chemical and cultural control of *P. Truncates*. Int. Pest Manage. Rev., 7: 245-257

Golob P (1988). Current Status of the Larger Grain Borer *Prostephanus truncatus* (Horn) in Africa. Insect Sci. Appl., 9: 737 – 745.

Hell K, Lambonia Y, Houndekona T, Alidoua GM (2006). Augmented release of *Teretrius nigrescens* Lewis (Coleoptera: Histeridae) for the control of *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) in stored cassava chips. J. Stored Prod. Res., 42: 367-376

Iloba BN, Ekrakene T (2006). Comparative assessment of insecticidal effect of *Azadirachta indica*, *Hyptis suaveolens* and *Ocimum gratissimum* on *Sitophilus zeamais* and *Callosobruchus maculatus*. J. Biol. Sci., 6: 626-630.

Isman M (2008). Botanical insecticides: for richer, for poorer. Pest Manage. Sci., 64: 8–11.

Jilani G, Saxena RC, Rueda, BP (1988). Repellent and Growth-inhibiting effects of Turmeric oil, Sweet Flag, Neem oil and "Margosan-o" on Red flour beetle (Coleoptera: Tenebrionidae). J. Eco. Entomol., 81: 1226 – 1230

Jilani G (1992). Botanicals and Pheromones in IPM p. 50-57In. BALOCH, U. K. (ed.) Integrated Pest Management in Food Grains. FAO/PARC. Islamabad, Pakistan.

Kamal R, Mangala M, Prakash D, Sharma GL, Srivastava RC (1988). Relative Toxicity of Natural Pyrethrins against *Mesocyclops Leuckarti sensu lato*-the carrier of Dracunculiarsis. Insect Sci. Appl., 9: 437 – 440

Mallya GA (1992). *Prostephanus truncatus* (Horn), the Larger Grain Borer (LGB), and its control in Tanzania. 4 -13 pp. *In*: J. Boeye, M. Wright and G. A. Laborius (eds.) Implementation of and further Research on Biological Control of the Larger Grain Borer. Proceedings of a FAO/GTZ Co-ordination Meeting. Lome, Togo. 1990. Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) GmbH, Hamburg, Federal Republic of Germany.

McDonald LL, Guy RH, Speirs RD (1970). Preliminary evaluation of new candidate materials as toxicants, repellents and attractants against stored-product insects-1.Marketing Research Report No.882. Agril.Res.Service, U.S. Dept. Agric.,Washington p. 8.

Mulungu LS, Ndilahomba B, Nyange CJ, Mwatawala MW, Mwalilino JK, Joseph CC, Mgina CA (2010). Efficacy of *Chrysanthemum cinerariaefolium, Neorautanenia mitis* and *Gnidia kraussiana* against Larger Grain Borer (*Prostephanus truncatus* Horn) and Maize Weevil (*Sitophilus zeamays* Motschulsky) on Maize (*Zea mays* L.) Grain Seeds (*Sitophilus zeamays* Motschulsky) on Maize (*Zea mays* L.) Grain Seeds. J Entomol., 8: 81-87,

Mwaya W (1997). Chemical control of grain storage pests with special reference to the Larger Grain Borer (LGB). p 32-35. *In*: A.J. Sumani, A. Chalabesa, J.M. Milimo, K. Kashweka, R.C. Mulenga and J. Kalaba (eds.) Proceedings of NLCCP, Prov. LGB Coor. Workshop 7-11th October, Lusaka, Zambia 1997. Ministry of agriculture, Food and Fisheries.

Niber BT (1994). The ability of Powders and Slurries from Ten plant species to protect stored grain from attack by *Prostephanus truncatus* Horn (Coleoptera: Bostrichidae) and *Sitophilus oryzae* L. (Coleoptera: Curculionidae). J. Stored. Prod. Res., 30: 297 – 301.

Niber BT (1995). The protectant and toxicity effects of four plant species on stored maize against *Prostephanus truncatus* Horn (Col.: Bostrichidae) Trop. Sci. 35: 371 – 375.

Ogendo JO, Deng AL, Belmain SR, Walker DJ, Musandu AO (2004). Effect of insecticidal plant materials, *Lantana camara* L. and *Tephrosia vogelii* Hook, on the quality parameters of stored maize grains. J. Food Technol. Africa. 9: 29-35.

Nukenine EN, Adler C, Reichmuth C (2010). Efficacy of *Clausena anisata* and *Plectranthus glandulosus* leaf powder against *Prostephanus truncatus* (Coleoptera: Bostrichidae) and two strains of *Sitophilus zeamais* (Coleoptera: Curculionidae) on maize. J. Pest Sci., 83: 181-190.

Obeng-Ofori D, Reichmuth CH, Bekele A, Hassanali A (1996). Efficacy of Products derived from indigenous plants for the control of Larger Grain Borer *Prostephanus truncatus*, p.379 – 384. *In* Proceedings of an International Conference, Pests and Diseases, Brighton, UK. pp. 18–21.

Osipitan AA, Odebiyi JA, Lawal OA, Somade AA (2010). Evaluation of the extracts of some tropical plants in the management of *Prostephanus truncatus* (Horn) infestation in maize (*Zea mays* L.) Arch. Phytopathol. Plant Prot., pp. 1001-1010.

Pajni HR, Gill M (1991). Use of new pesticides of plant origin for the control of bruchids. 1671– 678 pp. *In* F. Fleurat -Lessard. and P. Ducom.(eds.): Proc. of the 5th Int. Work. Conf. on Stored-Prod. Prot., September 4 -14, 1990. Bordeaux, France.

Pierce S, Schmidt GH (1993). Effects of etheric *Acornus calamus* oil and beta-asarone on the Larger corn borer *Prostephanus truncatus* Horn (Col., Bostrichidae) *Anzeiger-frer-Schaedlingskunde Planzenschultz Umweltschultz,* Germany, F.R. 66:89 - 96

Rani PU, Jamil K (1989). Effect of water hyacinth leaf extract on mortality, growth and metamorphosis of certain pests of stored products. Insect Sci. Appl., 10: 327 – 332.

Richter J, Biliwa A, Helbig J, Henning-Helbig S (1997) Impact of *Teretriosoma nigrescens* Lewis (Coleoptera: Histeridae) on *Prostephanus truncatus* Horn (Coleoptera: Bostrichidae) and losses in traditional maize stores in Southern Togo. J. Stored. Prod. Res., 33: 137 – 142,

Russell RM, Robertson JL, Savin NE (1977). POLO: a new computer program for Probit analysis. Bull. Entomol. Society Am., 28: 209-213.

Saxena RC, Jilani G, Kareem A (1989) Effects of Neem on Stored Grain Insects. p. 97 –112. *In* M. Jacobson (ed.): Focus on Phytochemical Pesticides, The Neem tree. Boca Raton, US: CRC Press, Inc. Vol. 1

Saxena RC (1993). The Neem tree: its potential for developing countries. Global. Pesticide Campaigner 4: 3 – 5.

Schmutterer H (1990). Properties and potential of natural insecticides from Neem tree, *Azadirachta indica* A. Juss. Ann. Rev. Entomol., 35: 271 – 297.

Schulten GG (1996). From Crisis Control to Integrated Storage Pest Management. p. 13-28. *In*. G. Farrell, H. A.Greathead, M. G. Hill and G. N. Kibata (eds.): Proceedings of East and Central Africa Storage Pest Management Workshop 14-19 April, Naivasha, Kenya. Berks, UK.

Sharaby A (1988). Evaluation of some Myrtaceae plant leaves as protectant against the infestation by *Sitophilus oryzae* L. and *Sitophilus granarius* L. Insect Sci. Appl., 9: 465 – 468.

Steel RGD, Torries JH (1980). Principles and Procedures of Statistics. A Biometrical Approaches (2nd ed) McGraw-Hill New York. USA, p. 633.

Vowotor KA, W.G Meikle WG, Ayertey JN, Markham RH (2005) Distribution of and association between the larger grain borer *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) and the maize weevil *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae) in maize stores. J. Stored. Prod. Res., 41: 498-512.

Wright VF (1984). World distribution of *Prostephanus truncatus* (Horn) p11-16. *In*: GASGA Workshop on the Larger Grain Borer *Prostephanus truncatus* (Horn) Tropical Development Research Institute, Storage Department, Slough. GTZ, Eschborn, FRG.