THE EFFECT OF EXTRACTS (BOTANICALS) FROM THREE SELECTED PLANT SPECIES ON THE ARMOURED GROUND CRICKET *Acanthoplus* , Brancsk. (ORTHOPTERA: TETTIGONIIDAE, HETRODINAE)

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A dissertation submitted in partial fulfilment of the requirements of the degree of Master of Science in Agronomy (Crop Science) of the University of Zambia.

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TABLE OF CONTENTS

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DECLARATION

I, JOSÉ SANCHO CUMBI hereby declare that this dissertation represents my own work and that it has not previously been submitted for a degree at this or another University.

Signature

APPROVAL

This dissertation of JOSÉ SANCHO CUMBI is approved as fulfilling part of the requirements for the award of the degree of Master of Science in Crop Science of the University of Zambia.

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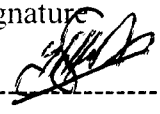
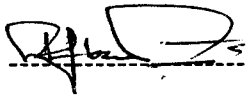
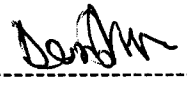
	19/2/2007
	4th Feb. 2007
	19/02/2007

ABSTRACT

Damage to sorghum and pearl millet by the armoured ground cricket, *Acanthoplus speiseri* Brancsk, is particularly high on small-scale farms. The control methods currently in use are based on the use of synthetic insecticides.The study was conducted to assess the effects of plant extracts from leaves and seeds of *Azederacta indica* A. Juss, *Melia azedaracha* L. and *Tephrosia vogelii* Hook f. The laboratory study was conducted at the University of Zambia during the period of February to July 1995. A randomised design was used and water extracts of the botanicals were applied in form of baits and topical applications. Effects of plant extracts on mortality and insect development were observed. Baits from seed extracts of *A .indica* and *M. azedarach* had the highest mortality on both third instars and adults ($p<0.5$). Extracts of *M. azedarach* delayed the development of armoured ground cricket.

DEDICATION

To my family for their sacrifices and support

and

to Mavis for her love and patience

ACKNOWLEDGMENTS

I would like to express my gratitude to the British Council for awarding me a scholarship without which, my studies at the University of Zambia would not have been possible. Special thanks are due to my supervisors Dr. Keith J. Mbata and Dr. K. Leuschner for their guidance, encouragement and useful criticisms throughout the course of this work. Thanks to my fellow Master of Science students in the School of Agricultural Sciences, University of Zambia for providing me with a favourable learning atmosphere. I also wish to acknowledge the support and friendship of all members of Crop Science Department at the school. Finally, I wish to express my gratitude to my family for their inspiration and support during the study.

ABBREVIATIONS

ANOVA	=	Analysis of variance
B	=	Bait
C.V.	=	Coefficient of variation
LEB	=	Leaf Extract Bait
LETA	=	Leaf Extract Topical Application
MSTAT C	=	Michigan State University Statistical Package, Version C
SEB	=	Seed Extract Bait
SETA	=	Seed Extract Topical Application
TA	=	Topical Application

LIST OF TABLES

CHAPTER 1

INTRODUCTION, RESEARCH PROBLEM AND OBJECTIVES

1.1 Introduction

The armoured ground cricket, *Acanthoplus speiseri* Brancski, is one of the most important pests of sorghum, millet and maize in Southern Africa. It has been reported to be a problem in low-lying areas of Zimbabwe, Botswana and Zambia (Leuschner, 1990; Musonda and Leuschner, 1989). *Acanthoplus speseri* belongs to the primitive *Tettigoniid* subfamily of the Orthoptera called *Hetrodinae*. Members of the subfamily are endemic to Africa, where they inhabit arid areas in South Africa and Savannahs or thorny woodlands further north on the continent (Rentz, 1979; Skaife, 1979).

Damage to sorghum and pearl millet is particularly high on small scale farms, where losses have been estimated to be between 10 and 30% (Wohller, 1994-personal communication). However, for reasons not yet fully understood, the armoured ground cricket was only recently recognised as a serious pest of sorghum and millet, and presently very little information is available in the literature on its biology and control. The damage to crops by armoured ground cricket is reported to be highest in small peasant mixed crop fields that are surrounded by grass vegetation. The outbreak of the pest is related to favourable weather conditions that occur in consecutive years, resulting in population build-ups in the affected areas (Mbata, 1992b).

Studies conducted under Zambian conditions (Mbata, 1992b) show that the armoured ground cricket, is a univoltine species that hatches at the beginning of the rainy

season, from eggs deposited in the soil during the previous season. Mbata (1992b), Musonda and Leuschner (1990), found six nymphal instars in the life cycle of the armoured ground cricket in the laboratory and under field conditions, respectively and that the peak pest activity occurs during March-May period.

The nymphal stage depends on immature grass seeds for food. According to Leuschner (1990), adult crickets migrate to sorghum, maize and millet fields when grass seed mature and become unpalatable, while cereals are still in flowering to soft-dough stages. The armoured ground cricket was found to feed only on species belonging to the Asteraceae, Gramineae, and Solanaceae in the environs of the University of Zambia campus (Mbata, 1991).

The control strategies for pest are still being developed. However, the following control methods suggested by Musonda an Leuschner (1989), have given promising results:

i. Ploughing as early as possible before planting, to destroy egg pods laid in the fields.

ii. Clean weeding during the vegetative growth phase of the crop to keep nymphs out of the field.

iii. Spraying a 1m band of insecticide on grass along the field edges to reduce nymphal populations.

iv. Intercepting cricket migration into the crop by spraying or baiting with insecticides around the field borders. The baits are made up of maize meal plus an insecticide such as cypermethrin.

The use of synthetic insecticides has proved to be difficult, dangerous and out of reach

to small-scale farmers, due to their higher cost, toxicity and sophisticated equipments required for their application. There is therefore a need to find alternative control agents that are cheaper and easily handled. The botanicals are one of those alternatives available to small-scale farmers.

1.2 Research Problem and Objectives.

The control methods currently being recommended for the armoured ground cricket have given more emphasis on the use of synthetic insecticides. However, due to the increasing cost of the synthetic insecticides, the difficulties of availability and the growing awareness of hazards associated with their large-scale use have evoked a worldwide interest in research for alternative methods for pest control.

It is presently agreed that resource-poor farmers need low cost, non-polluting pest control agents with low toxicity, if they are to achieve sustainable management of pests. Therefore it has been proposed that effective no-synthetic chemical means of pest control, both traditional and innovative, should be thoroughly explored and preferred (Patricia *et al.*, 1994).

The necessity to develop non-toxic, safe and biodegradable alternatives to synthetic insecticides has led many scientists to concentrate efforts at developing new sources from the vast store of chemical substances in plants (Saxena *et al.*,1984; Mariapan and Saxena, 1983; Julius *et al.*,1987; Simmonds *et al.*, 1992).

Saxena (1983), pointed out three major objectives motivating renewed interest in botanical pesticides:

i. To encourage traditional use of simple formulations of locally available plant materials by farmers in developing countries who can not afford commercial pesticides.

ii. To identify sources, of new botanical pesticides for commercial extraction.

iii. To elucidate, the chemical structure of active principals.

Stone (1992) and Julius *et al.* (1987) pointed out some of the useful properties of chemical substances of plant origin. These are; safety, flushing action, fast knockdown, repellence, biodegradability, good spectrum of activity, reduced or no development of insect resistance and low cost of preparation.

The major objective of this study was, to investigate the effects of plant extracts from neem *(Azadiracta indica* A. Juss), chinaberry (*Melia azedarach* L.) and *Tephrosia vogelii* Hook f. on the armoured ground cricket mortality, and to determine their potential for use in controlling the pest.

CHAPTER 2

LITERATURE REVIEW

2.1. Historical Background

Insecticides of plant origin have been available for many years (Jacobson, 1954). Indeed there is an increasing realisation that plants manufacture and store various chemical substances, which protect them from attack by insects, bacteria, fungi and viruses. Many of the oldest and most common pesticides, such as nicotine, pyretrin, and rotenone, are derived from plants. The chemical or pesticide approach had its beginnings in the use of botanical material (Saxena, 1983). Plant species reportedly screened for insecticidal properties exceeded 6000 species by 1971. Of these, more than 2000 were reported to exhibit measurable to considerable insecticidal activity (Jacobson, 1989).

Nicotine from tobacco, *Nicotiana tabacum* L. and *Nicotiana rustica* L., was first used as an insecticide in 1763 (Matsumura, 1975). Neem has been used for centuries before commercial insecticides were available on the Indian subcontinent, primarily against household and storage pests and to a limited extent, against crop pests. In the 1930s, farmers began applying neem cake to rice and sugar cane fields as a preventive measure against stem borers and termites. This application reportedly acted as antifeedants (Saxena, 1994).

Reports from McIndoo (1954) of substances in *Melia azedaracth* that are repellent and toxic to some insects, led to the inclusion of these repellents in the control programme

of the corn earworm *Heliothis zea* Boddie and the fall army worm, *Spodoptera frugiperda* J.E. Smith in the U.S.A.

After the Second World War botanicals lost their importance as pesticides with the introduction of the synthetic organic chemicals. The latter were found to be cheaper to produce and were effective in killing pests. However the success and relative safety of the pyrethroids has proved the pest control potential of the plant derived substances and revitalised the interest in plant which contain chemical compounds with pesticidal properties (Berger, 1994); Jacobson, 1989).

2.2 Mode of Action of botanicals

The pesticidal properties of many plants have been known for long time. For example, plant extracts such as rotenone, nicotine and pyrethrum were commonly used for pest control during the earlier half of the twentieth century (Berger, 1994). Many phytophagous insects are restricted in host range because of the presence of naturally distasteful chemical substances in many plants (Gil and Lewis, 1971). Neem contains several limonoids, a class of chemicals that act as feeding deterrents and growth regulators in insects (Barnby et al, 1989). The most potent of these is a compound called azaderacthin, a tetranortriterpenoid (Sieber and Rembold, 1983). Azaderacthin is similar in structure to the insect moulting hormone, ecdysone, which is needed for moulting during insect development. One way that Azaderacthin works is by blocking the ecdysone's action, thereby preventing larval stages from shedding their exoskeletons and maturing (Al-Shoroak *et al.*, 1989; Stone, 1991).

Al-Shoroak *et al.*. (1989) also found that A. *indica* and *M. azedarach* inhibit the formation of chitin, a polysaccharide that makes up insect exoskeleton. They also disrupt mating and sexual communications, cause sterility and decreases gut motility, preventing an insect from swallowing (Schumutter, 1990). This wide range of effects of plant extracts on insect pests makes them ideal control agents. Another advantage of plant extracts is that even though they are toxic to a wide spectrum of insect pests. they do not seem to affect many of the pest's predators. The selectivity may reflect the fact that crops take in plant extracts applied to them as insecticides and translocate them within their conducting tissues. Insects that feed on the crops are therefore affected, while no feeders (predators) escape the effect of the insecticide (Gil and Lewis, 1971).

Meliatin, a compound obtained from leaves of *M. azedarach* was found to have antifeeding activity when sprayed as aqueous suspension on leaves normally eaten by locusts (Butterworth and Morgan, 1971). Spray applications with 3% water extracts of the fruit and leaves of *M. azaderacth* at 40 ml/m^2 gave 93% and 100% mortality, respectively, of 1st instar nymphs of the migratory locust, *Lacusta migratoria* R&F in the laboratory. A 3% concentration of leave extract resulted in 93.2% mortality of 3rd instar nymphs (When and Schmutter. 1991).

There are reports that extracts from *Tephrosia sp.*, have been used as insecticides in Africa, Central and South America and Asia. These extracts are usually rich in a range of anti-insect compounds including rotenones, flavonoids, non-protein amino acids and polhydroxyalkaloids (Hassanali and Lwande, 1989). Chiu (1989) reports that acetone extracts of *T. vogelii* have potent insecticidal and antifeedant

activity against insects.

Plant extracts have been found to affect more than 200 insect pest species belonging to Coleoptera, Diptera, Hemiptera, Homoptera, Hymenoptera, Lepidoptera, Orthoptera and Thysanoptera (Saxena, 1994; Stone, 1992). It is hoped that because plant extracts mainly affect physiological processes specific to insects and other arthropods such as moulting and chitin synthesis, they will have little toxicity in higher animals (Al-Sharoak et al., 1991; Saxena, 1994; Stone, 1992).

2.3 Plants with Insecticidal Activity

The search by scientists over the past twenty years for plants with pesticidal constituents has had some success. There are numerous such plants species in the families of Meliaceae, Rutaceae, Asteraceae, Labiteae, Leguminosae, Amaranthaceae, Anonaceae and Solanaceae (Saxena, 1994, Simmonds et al., 1992; Schmutter, 1992; Gabby, 1986; Kis, 1990).

Meliaceae

Meliaceae plant products have shown to have a multitude of anti-insect activities including; repellent and antifeedant activity, growth inhibition, suppression of reproduction, mating disruption and ovicidal activity (Tanzubil and McCaffery, 1986). Many researchers have concentrated mainly on the constituents of the neem tree, in this family, from which farmers in developing countries have used home-made formulations for centuries. Its main effect from the viewpoint of pest control is on the endocrine system: it leads to a moulting disturbance, which are often lethal (Sieber

and Rembold 1983). Also the fecundity of many insects species is reduced (Schumutter,1990). In extracts from seed of the chinaberry tree, another species of the family, there are ingredients with antifeedant and growth regulator properties on insect pest. (Mwangi 1982).

Leguminosae

Some members of the family leguminosae have been utilised for long time as fish poisons and insecticides. *Tephrosia* sp. contains rotenones and related isoflavonoids in their roots and seeds (Schumutter and Ascher 1983). They show a strong antifeedant effect and also toxicity to a wide range of insects.

Asteraceae

This family contains many genera with compounds that affect insect growth. The most important of these have been the pyrethrins from Chrysanthemum. These possess a unique combination of such useful properties as; safety, flushing action, fast knockdown, repellence, biodegradability, broad spectrum of activity and minimal development of insect resistance. This has made them the most useful all-around domestic insecticides available (Pyrethrum bureau, 1986).

Other Plant families

Other plant families with insecticidal properties include Amaranthaceae, Anonaceae and Solanaceae. Amaranthaceae has species containing compounds with antifeedant activity. Anonaceae, contain compounds that contain alkaloids, such as nicotine, tomatine and solanine with antifeedant and insecticidal properties.

2.4 Preparation of Biocidal products from plants

The methods used in extracting products from plants can be either simple or complex. There are a number of problems associated with screening extracts of many plant species for insecticidal properties. The extracts activity may depend on the plant part used, the test organism, the method and time of collection, the method of extraction and solvent used. Most of the extracts tested todate have been made from seeds and leaves of plants (John 1993).

The table 1 shows some processes used by farmers for preparation of neem insecticides and the target insect pests.

Table 1 Neem insecticides produced by farmers (Schummutter et al, 1986)

Insecticide	**Process of preparation**	**Equipment required**	**Target insect pests**
Seed/cake powder	Depulping, grinding and pounding seeds.	hand mill or mortar	Stem borers
Neem oil	Pressing	hand or press	Pest of stored products
Aqueous seed cake	Extraction using water	no additional equipment necessary	Openly feeding caterpillars, leaf miners, and grasshoppers.

Oil and cakes

Oil can be obtained by pressing seeds. Alternatively, seeds are dried, decorticated, ground and mixed with boiling water. The resulting oil that floats at the top of the hot water is then skimmed off.

When oil has been pressed out of seeds, a residual matter, the cake. Is left. The cake can be ground in to powder, mixed with water and used as an emulsion (Edwin, 1985; Saxena, 1983).

Water Extracts

Dried seeds or leaves are ground, and placed in a bag, The bag with its content is then soaked in water for extraction. Alternatively, ethanol or methanol could be used as extracting agents instead of water (John, 1993; Edwin, 1985).

Some chemicals can be mixed with the plant extracts obtained, to improve the results, such as the surfactants or emulgators, for example, tween, teepol and triton. Some chemicals act synergically with certain plant extracts. Edwin (1985) reported that tropital renders a methanol seed extract of neem six times more toxicity to *Epilachna sp.*

CHAPTER 3

GENERAL MATERIALS AND METHODS

Experiments were conducted in the Biological Sciences Department, School of Natural Sciences, University of Zambia. during the period February-July, 1995.

3.1. Plant Material

The experimental plants were obtained from different areas of the country:

a. *Azadiracta indica* : was obtained from the Magoye Family Farming Project, Mazabuca District.

b. *Melia azedarach*: was obtained from the trees around School of Agricultural Sciences, University of Zambia.

c. *Tephrosia vogelii.*: was obtained from Kasisi Training Centre, northeast of Lusaka.

3.2. Test insects

Adults and 3rd instar nymphs of *A. speiseri* were collected from field station of School of Agricultural Sciences and from the fields around the School of Veterinary Medicine. The insects were put in screen cages (20x15x15cm), 10 insects per cage.

The 3rd instars were identified based on descriptions by Mbata, (1992a).

Before being exposed to the different treatments the insects were starved for 24 hours and after 72 hours of exposure to the different treatments, the insects were fed on a mixture of heads of *Rottboellia cochinchinensis* (Lour) Clayton, *Setaria verticilata*

(L) Beano, *Hyparrhenia rufa* (Nees) Stapt, and *Sorghum bicolor* Anders (at dough stage).

3.3. Extracts

3.3.1. Leaf extracts

Fifty grammes of fresh leaves were pound using a mortar and pestle and then 100 ml of tap water added. stirred and allowed to rest for 6 hours and then filtered for the leaf extract.

3.3.2 Seed extracts

Fifty grammes of dry seed of *M. azedarach* and *A. indica* were ground into a powder, using grinder. 100 ml of tap water was added to the 50g of seed powder and then filtered for the seed extract.

Topical application: in order to make topical application of the test extracts on the experimental animals, first of all three drops of teepol were added to the extract to act as a surfactant and then 50 microlitres of the mixture applied on each insect using a micropipet. The extract was applied at the junction of the pronotum and abdomen on the dorsum.

Bait: The baits were prepared using 50g mealie meal plus 100 ml of extracts. Two teaspoons of bait were randomly placed inside each cage.

Synthetic insecticide: The synthetic insecticide used was CYRUX 25 EC, emulsifiable

concentrate, which contain cypermethrin as active ingredient. The cypermethrin was applied at the recommended dosage of 0.25 grams of cypermethrin per litre of water and was applied topically using a micropipet at the junction of the pronotum and abdomen on the dorsum.

4.3 Experimental design and data analysis

A completely randomised design with three replications was used in the experiments. A total of 30 insects were used per treatment. The analysis of variance was used to test the effect of the different plant extracts and method of application on the armoured ground cricket. DUNCAN's Multiple-Range test was used in separate means of treatments that were significantly different according to the procedure outlined by Montgomery, (1991).

Mortality in the treatments was corrected for the control mortality using Abbott's formula (Abbott, 1925):

$$Pt = \frac{Po - Pc}{100xPc} x100$$

Where: P_t = Corrected mortality

Po = observed mortality

and Pc = Untreated control mortality, all expressed as percentages.

Because the data did not follow a normal distribution, the percentage of dead insects per cage in each treatment was arcsine-transformed. Original data are presented in appendix 1.

The following treatments were used:

(a) M. *azedarach* leaf extract bait

(b) M. *azedarach* leaf extract topical application

(c) M. *azedarach* seed extract bait.

(d) M. *azedarach* seed extract topical application.

(e) T. *vogelli* leaf extract bait

(f) T. *vogelli* leaf extract topically application.

(g) A. *indica* leaf extract bait

(h) A. *indica* leaf extract topically application

(I) A. *indica* seed extract bait

(j) A. *indica* seed extract topically application

(k) Cypermethrin bait

(l) Cypermethrin topically application.

(m) Control

The mortality of insects was evaluated on basis of the percentage of dead insects 24, 48 and 72 hours after the insects were exposed to the various treatments according the methodology used by Richard *et al* (1983) and Donald *et al* (1970). Although slightly different test procedures were used. In this study a treatment involving baits was included. For the data analyses a statistical package, MSTAT C, was used for the ANOVA and Duncan's Multiple Range for mean comparison.

4.4. Results

Table 2 shows the effect of plant extracts on mortality of 3rd instar of armoured ground crickets, assessed 24, 48 and 72 hours after treatment.

There were significant differences in insect mortality in the three assessed period of time ($p<0.05$).

Table 2 Mean percentage mortality of 3rd instar nymphs of *A. speiseri* when treated with a synthetic insecticide and plant extracts.

Treatment	After 24 hours	After 48 hours	After 72 hours
Cypermethrin –TA	1.548 A	1.548 A	1.548 A
Cypermethrin- B	0.769 B	1.548 A	1.548 A
A.indica- LEB	0.270 C	0.566 B	0.742 BC
A.indica- SETA	0.270 C	0.489 BC	0.647 BCD
A.indica- LETA	0.203 CD	0.489 BC	0.6910 BC
M. azadarach- SEB	0.168 CD	0.340 C	0.826 B
M. azadarach- LEB	0.034 CD	0.134 D	0.239 EF
M.azaderach- LETA	0.0 D	0.134 D	0.270 EF
A.indica- SEB	0.0 D	0.486 BC	0.802 B
A.indica- SETA	0.0 D	0.0 D	0.379 DE
T.vogelli- LEB	0.0 D	0.1690 D	0.486 CDE
T.vogelli- LETA	0.0 D	0.101 D	0.575 BCD
Control (untreated)	0.0 D	0.0 D	0.0 F
C.V. (%)	44.58	20.73	22.96

Means in the same column followed by the same letter are not significantly different ($p<0.05$) using Duncan's Multiple Range Test.

TA - Topical application

B - Bait

LEB - Leaf extract bait

LETA - Leaf extract topical application.

SETA - Seed extract topical application

SEB - Seed extract bait

Twenty-four hours after treatment no significant differences were observed between plant extracts ($p>0.05$).

ANOVA revelled significant differences in mortality between plant extracts and cypermethrin when topical applied.

Forty-eight hours after treatment significant differences were observed between the plant extracts ($p>0.05$). *A. indica* presented the highest percentage mortality among the plant extracts.

Seventy-two hours after treatment there were not significant differences between most of the plant extracts.

Melia azedarach had the highest percentage mortality among the plant extracts.

No mortality was observed in the control of the three assessed period of time.

Cypermethrin reached the highest percentage of mortality after twenty-four hours of treatment, unlike in the plant extracts where the highest mortality was observed at seventy-two hours after treatment.

The table 3, shows the effect of plant extracts on mortality of adults of armoured cricket assessed 24, 48 and 72 hours after treatment.

Significant differences among the plant extracts were observed 48 and 72 hours after the insects have been exposed to the treatments ($p>0.05$).

Table 3.Mean percentage mortality of adult *A. speiseri* when treated with synthetic insecticide and plant extracts.

Treatment	After 24 hours	After 48 hours	After 72 hours
Cypermethrin –TA	0.687 A	1.548 A	1.548 A
Cypermethrin- B	0.376 B	1.263 B	1.548 A
A. indica - SEB	0.0 C	0.236 CD	0.486 B
A.indica- LEB	0.0 C	0.067 DE	0.306 D
A.indica- SETA	0.0 C	0.306 C	0.449 BC
A.indica- LETA	0.0 C	0.168 CDE	0.34 CD
M. azedarach- SEB	0.0 C	1.168 CDE	0.564 B
M. azedarach- LEB	0.0 C	0.0 E	0.101 EF
M. azedarach- SETA	0.0 C	0.0 E	0.067 F
M.azedarach- LETA	0.0 C	0.101 DE	0.237 DE
T.vogelli- LEB	0.0 C	0.034 E	0.236 DE
T.vogelli- LETA	0.0 C	0.134 DE	0.34 CD
Control (untreated)	0.0 C	0.0 E	0.0 F
C.V. (%)	32.46	28.55	15.86

Means in the same column followed by the same letter are not significantly different ($p<0.05$) using Duncan's Multiple Range Test.

TA - Topical application

B - Bait

LEB - Leaf extract bait

LETA - Leaf extract topical application.

SETA- Seed extract topical application

SEB - Seed extract bait

Twenty-four hours after treatment no significant differences were observed between plant extracts ($p>0.05$). ANOVA revelled significant differences between plant extracts and cypermethrin.

Forty-eight hours after treatment significant differences were observed between plant extracts ($p>0.05$). *A. indica* and seed extracts of *M .azedarach* presented the highest mortality.

Seventy-two hours after the treatment significant differences were observed.

ANOVA revelled significant differences in mortality between plant extracts and cypermethrin.

Table 4. Shows the overall effect of seed and leaf extracts on mortality of nymphs and adults of the armoured ground cricket. Significant differences were observed between seed and leaf extracts on both the nymphs and adults. Overall, seed extracts presented the highest mortality of nymphs as well as adults.

seventy-two hours after treatment. No mortality was observed in the first twenty-four hours after treatment.

Cipermethrin showed high toxicity against the armoured ground cricket and rapid action and these results are in agreement with findings of Leuschner (1990). Mortality was observed twenty four hours after the insects were exposed to cipermethrin and these results are in agreement with reports that synthetic pesticides are more toxic than plant extracts (Kis, 1990). Seed extracts showed highest mortality suggesting, high concentration of toxins in the seeds as reported by John (1993).

CHAPTER 5

EFFECTS OF PLANT EXTRACT COMBINATIONS ON INSECT MORTALITY

5.1 Introduction

Synergetic activity between chemicals increases their effectiveness. Thus a grower can control pests with combinations of synergistic insecticides at much lower concentrations that are less costly (Gerald *et al*, 1984).

Possible synergetic effects of the leaf plant extracts used were studied on the adults.

5.2 Material and methods

Leaf extracts were used in the experiment. Laboratory experiment was carried out by topical treatment of insects in cages or by exposing the caged insects to the baits. Ten insects were placed in each cage.

The following combinations were tested both in topical and bait forms: Neem + Melia; Neem +Tephrosia and Melia +Tephrosia. All the combinations were done in 1:1 ratio.

5.3 Experimental design and data analysis

A completely randomised design with three replications was used in the experiment. In each replication ten insects were used per treatment. The analysis of variance was used to test the effect of different plant extracts combination on the armoured ground cricket. The percentage mortality of armoured ground cricket was calculated based on the number of dead insect in a particularly treatment.

DUNCAN's Multiple-Range test was used in separate means of treatments that were significantly different according to procedure outlined by Montgomery, (1991).

Because the data did not follow a normal distribution, the percentage of dead insects per cage in each treatment was square root-transformed for the 24 and 48 hours data and arc sine for the 72 hours data. The analyses was done using the statistical package, MSTAT C. Original data are shown on appendix 2.

5.4 Results

The effect of plant extracts combinations on adults of armoured ground mortality is presented in the table 6.

Twenty-four and forty eight hours after treatment no significant differences were observed between plant extracts ($p>0.05$). ANOVA revelled significant differences in percentage mortality between the different combinations of plant extracts and the control.

Seventy-two hours after treatment significant differences were observed ($p>. 0.05$).

Topical application of *A.indica* combined with *M. azedarach* showed the highest mortality.

No mortality was observed in the control during the assessed period of time.

Table 6 Mean percentage mortality of adults of the armoured ground cricket, *A. speiseri* when treated with synthetic insecticide and combination of leaf plant extracts.

Treatment	After 24 hours	After 48 hours	After 72 hours
A.indica + M. azedarach – B	2.396 A	3.599 A	0.685 AB
A.indica + M. azedarach – TA	0.981 A	3.934 A	1.027 A
A.indica + T.vogelli – B	1.552 A	2.88 A	0.47 B
A.indica + T.vogelli – TA	1.552 A	2.981 A	0.661 AB
M. azedarach + T.vogelli – B	1.552 A	4.988 A	0.47 B
M. azedarach + T.vogelli – TA	0.707 A	4.036 A	0.531 B
Control (untreated)	0.0 B	0.0 B	0.0 C
C.V. (%)	94.32	35.7	28.34

Means in the same column followed by the same letter are not significantly different ($p<0.05$) using Duncan's Multiple Range Test.

B -Bait

TA- Topical application

5.5 Discussion

The results of this experiment are not conclusive, however significant differences were observed between the treatments. The combinations of *A. indica* and *M. azedarach* showed the highest mortality of adult when topical applied. Although the observed mortality is lower than observed in the single extracts applications.

There is no much information on synergetic effects of plant extracts combinations; therefore there is a need to conducted further studies particularly with young stages of the insects.

6.3. Experimental design.

A completely randomised design with three replications was used in the experiment. The analysis of variance was used to test the effect of different plant extracts on the armoured ground cricket. Ten insects were used per replicate of each treatment. The number of moulted insects was calculated based on the mean of insects moulted in a period of eight weeks.

DUNCAN's Multiple-Range test was used in separate means of treatments that were significantly different according to procedure outlined by Montgomery, (1991).

6.4. Results

The table 7 shows the mean number of armoured cricket moulted in a period of eight weeks.

ANOVA test showed significant differences between the treatments. The highest number of moulted insects was observed in the control.

The lowest number of moulted insects was observed in the treatment with seed extracts of *M. Azedarach.*

No significant differences were observed between treatments with leaf extracts of M. *Azedarach* and the control.

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Table 7 Number of 3rd instar of *A. speiseri* moulted in eight weeks period when exposed to a plant extracts.

Treatment	Mean number of moulted insects
Control (untreated)	5.7 A
M. azedarach- LETA	5.0 AB
M. azedarach- LEB	4.9 AB
T. vogelli- LEB	4.4 BC
T. vogelli- LETA	4.1 BC
A. indica- LEB	3.7 CD
A. indica – SETA	3.7 CD
A .indica – LETA	3.5 CD
A. indica- SEB	3.4 DE
M. azedarach – SEB	2.6 EF
M. azedarach- SETA	2.4 F
C.V. (%)	12.48

Means in the same column followed by the same letter are not significantly different ($p<0.05$) using Duncan's Multiple Range Test.

TA - Topical application

B - Bait

LEB - Leaf extract bait

LETA - Leaf extract topical application.

SETA - Seed extract topically applied

SEB - Seed extract bait

6.5 Discussion

This experiment showed that plant extracts inhibit the development of insects, confirming earlier findings by various scientists. Al-Shoroak *et al.*, 1989; Stone. 1992. Seed extracts of *M. azedarach* the lowest number of moulted insects and this is in accordance with the statement from Al-Shoroak et at (1989), about the fact that *M. azedarach* inhibit the formation of chitin. It seems that leaves do not contain significant amounts of substances with inhibitory properties as their extracts did not show significant differences with the control (untreated).

The mode of action of botanicals of disrupting of development in insects, explains as suggested by Julius et al (1987). the reason why botanicals exhibit slow effect when used as control agents for insect pests.

CHAPTER 7

GENERAL DISCUSSION

The main emphasis of this study was to investigate the effects of plant extracts from *A. indica*, *M. azedarach* and *T. vogelli* on armoured ground cricket and to determine their potential for use in the control of the pest.

Small-scale farmers can use plant extracts to control pests with low cost and little harm to the environment. In the present study, the mortality of the armoured ground cricket was assessed over a period of twenty four, forty eight and seventy two hours following application of plant extracts on them and use of extract bait and increase on mortality was observed as the time passed confirming the slow action of biopesticides as reported by Julius et al (1987); Stone (1992).

Nymphs of the armoured ground cricket showed the highest rate of mortality suggesting that immature stages are more susceptible. Seed extracts of *A. indica* presented the highest mortality of third instars of the armoured ground cricket.

The highest mortality in adults was observed in the treatments with seed extracts of *A. indica* and *M. azedarach*. Plant extracts were less toxic to adults of the armoured ground cricket, this probably was due to the fact that adults have more elaborate metabolic systems for detoxification as reported by Rembold and Schmutter(1980).
Seed extracts presented the highest rate of mortality (Table 4) and this confirms early reports that seeds have more concentrated insecticidal substances than leaves (John

1993). Bait applications showed overall. to be more effective, as the insects directly take in the toxic substance in them through indigestion.

The combination of different plant extracts did not give significant synergetic effect. The highest percentage of dead insects in such combinations was less than one observed in the single extract applications on the adults. However this experiment was not conducted with nymphs, and this makes it difficult to conclude how great the synergetic effect can be in different insect growing stages.

Plant extracts affected insect development (Table 7). Significant differences between plant extracts applications and control were observed. The highest number of insect moulted during tl.e assessed period was observed in the control and the lowest in topical application of seed extracts of *M. azedarach*. This confirms that plant extracts inhibit the insect development by preventing the formation of chitin (Rembold and Schmuter, 1980; Sami *et al.*, 1991).

CHAPTER 8

CONCLUSIONS AND RECOMENDATIONS FOR FUTURE RESEARCH

8.1 Conclusions

Based on the results of the study, plant extracts from *A .indica, M. azedarach* and T. *vogelii* have the potential to be used as control agents for the armoured ground cricket. Since treatment with water extracts from *A. indica* and *T. Vogelii* produced high mortality of third instar nymphs, it may provide an advantage for practical application, for example in the form of baits or sprays. One limitation of water plant extracts as this study has shown is that are less effective against adults. There was no evidence of any synergetic effect of any combination of the plant water extracts used in this study. *Melia azedarach* seems to have some anti-moulting effect on the armoured ground cricket.

8.2 Recommendations for future research

More research is required to test the effect of the selected plant extracts on the armoured ground cricket, both in laboratory and under field conditions. A study should be carried out to test the effect of plant extracts on all development stages of the armoured ground cricket. The synergetic effect of the plant extracts should be further tested on early nymphal instars. In order to facilitate the identification of the different nymphal instars it is recommended that the insects be reared in the laboratory.

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APPENDICES

Appendix 1: Original data and ANOVA used in chapter 4

Table1.1. Percentage mortality of nymphs of *Acanthoplus speiseri* when treated with a synthetic insecticide and plant extracts.

Treatments	Twenty four hours			Forty eight hours			Seventy two hours		
	Repl	repII	repIII	repl	repII	repIII	repl	repII	repl
M.azedarach-LEB	0	10	0	20	0	20	30	0	40
M.azedarach-LETA	0	0	0	10	20	10	20	30	30
M.azedarach-SEB	10	20	20	30	40	30	70	80	70
M.azedarach-SETA	0	0	0	0	0	0	20	50	20
A.indica-LEB	20	30	30	40	60	60	50	70	80
A.indica-LETA	30	0	30	60	40	40	70	50	70
A.indica-SEB	0	0	0	50	50	50	90	60	60
A.indica-SETA	30	20	30	60	40	40	70	60	50
T.Vogelli-LEB	0	0	0	0	20	30	50	50	50
T.Vogelli-LETA	0	0	0	20	0	10	70	30	60
Cypermethrin-TA	100	100	100	100	100	100	100	100	100
Cypermethrin-B	70	40	90	100	100	100	100	100	100
Control(untreated)	0	0	0	0	0	0	0	0	0

TA - Topial application

B - Bait

LEB - Leaf extract bait

LETA - Leaf extract topically applied.

SETA - Seed extract topically applied

SEB - Seed extract bait

Table1.2 Percentage mortality of adults of the *Acanthoplus speiseri* when treated with a synthetic insecticide and plant extracts.

Treatments	Twenty four hours			Fourty eigth hours			Seventy two hours		
	RepI	repII	repIII	repI	repII	repIII	repI	repII	rep
M.azedarach-LEB	0	0	0	0	0	0	0	20	10
M.azedarach-LETA	0	0	0	0	10	20	10	30	30
M.azedarach-SEB	0	0	0	20	10	20	50	50	60
M.azedarach-SETA	0	0	0	0	0	0	0	20	0
A.indica-LEB	0	0	0	0	10	10	30	40	20
A.indica-LETA	0	0	0	20	20	10	40	30	30
A.indica-SEB	0	0	0	30	20	30	50	40	50
A.indica-SETA	0	0	0	40	30	20	50	40	40
T.Vogelli-LEB	0	0	0	10	0	0	20	30	20
T.Vogelli-LETA	0	0	0	10	20	10	40	30	30
Cypermethrin-TA	60	60	70	100	100	100	100	100	100
Cypermethrin-B	40	30	40	100	90	90	100	100	100
Control(untreated)	0	0	0	0	0	0			

TA - Topial application

B - Bait

LEB - Leaf extract bait

LETA - Leaf extract topical application.

SETA - Seed extract topical application

SEB - Seed extract bait

Table1.3 ANOVA of nymph mortality for the armoured ground cricket,

A. speiseri, 24 hours after treatment with plant extracts.

Source of variation	df	SS	MS	F Value	Prob.
Replication	2	0.040	0.020	1.5887	
Treatments	12	7.158	0.597	47.6279	0.000
Error	24	0.301	0.013		
Total	38	7.499			

Table1.4 ANOVA of nymph mortality for the armoured ground cricket,

A. speiseri, 48 hours after treatment with plant extracts.

Source of variation	df	SS	MS	F Value	Prob.
Replication	2	0.005	0.003	0.2929	
Treatments	12	9.739	0.812	88.4629	0.000
Error	24	0.220	0.009		
Total	38	9.965			

Table1.5 ANOVA of nymphs mortality for the armoured ground cricket,

A. speiseri, 72 hours after treatment with plant extracts

Source of variation	df	SS	MS	F Value	Prob.
Replication	2	0.028	0.014	0.5788	
Treatments	12	7.539	0.628	26.2660	0.0000
Error	24	0.574	0.024		
Total	28	8.141			

Table1.6 ANOVA of adults mortality for the armoured ground cricket,

A. speiseri, 24 hours after treatment plant extracts.

Source of variation	df	SS	MS	F Value	Prob.
Replication	2	0.002	0.001	1.5524	0.2323
Treatments	12	1.579	0.132	185.7589	0.0000
Error	24	0.017	0.001		
Total	38	1.599			

Table1.7 ANOVA of adults mortality for the armoured ground cricket,

A. speiseri, 48 hours after treatment with plant extracts.

Source of variation	df	SS	MS	F Value	Prob.
Replication	2	0.018	0.009	1.1715	0.3270
Treatments	12	8.957	0.746	95.5779	0.0000
Error	24	0.187	0.008		
Total	38	9.162			

Table1.8 ANOVA of adults mortality for the armoured ground cricket,

A. speise"i, 72 hours after treatment with plant extracts.

Source of variation	df	SS	MS	F Value	Prob.
Replication	2	0.007	0.004	0.6472	
Treatments	12	9.071	0.756	131.1236	0.0000
Error	24	0.138	0.006		
Total	38	9.217			

Appendix 2: Original data and ANOVA used in chapter 5

Table2.1 Percentage mortality of adults mortality of the

A. speiseri when treated with combination of plant extracts.

Treatments	Twenty four hours			Fourty eigth hours			Seventy two hour		
	repI	repII	RepIII	repI	repII	repIII	repI	repII	rep
A.indica +M.azaderach-B	10	0	10	10	10	20	20	40	5(
A.indica+ M.azaderach-TA	0	0	20	0	40	30	30	50	6(
A.indica+ T.Vogelli-B	0	10	0	0	30	10	20	40	2(
A.indica+ T.Vogelli -TA	0	10	0	0	20	20	40	40	3(
M.azaderach+ T.Vogelli-B	0	10	0	10	30	40	10	30	4(
M.azaderach+ T.Vogelli-TA	0	0	0	10	20	20	20	30	4(
Control(untreated)	0	0	0	0	0	0	0	0	0

TA - Topical application B - Bait

Table.2.2 ANOVA of adult mortality for the armoured ground cricket,

A. speiseri, 24 hours after treatment with combination of plant extracts.

Source of variation	df	SS	MS	F Value	Prob.
Replication	2	4.204	2.102	0.7047	
Treatments	6	10.409	1.735	0.5815	
Error	12	35.796	2.983		
Total	20	50.409			

Table.2.3 ANOVA of adult mortality for the armoured ground cricket,

A. speiseri, 48 hours after treatment with combination of plant extracts.

Source of variation	df	SS	MS	F Value	Prob.
Replication	2	0.428	0.214	3.6631	
Treatments	6	1.718	0.286	4.8988	0.0094
Error	12	0.701	0.058		
Total	20	2.848			

Table.2.4 ANOVA of adult mortality for the armoured ground cricket,

A. speiseri, 72 hours after treatment with combination of plant extracts.

Source of variation	df	SS	MS	F Value	Prob.
Replication	2	35.902	17.951	9.0621	
Treatments	6	44.949	7.492	3.782	0.0238
Error	12	23.77	1.981		
Total	20	104.6			

Appendix 3: ANOVA used in chapter 6

Table 3.1 ANOVA of number of insects of the armoured ground cricket, *A. speiseri* moulted after eight weeks

Source of of variation	df	SS	MS	F Value	Prob.
Replication	2	0.896	0.448	1.8345	0.1856
Treatments	10	29.057	2.906	11.9034	0.0000
Error	20	4.882	0.244		
Total	32	34.835			