1992

Effect of Custard Apple (Annona Squamosa L.) Extract on the Mortality of the Red-Flour-,Beetle, Tribolium Castaneum HBST

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EFFECT OF CUSTARD APPLE (*ANNONA SQUAMOSA* L.) EXTRACT ON THE MORTALITY OF THE RED-FLOUR BEETLE, *TRIBOLIUM CASTANEUM* HBST.

Thesis Submitted to the Institute of Biological Sciences, Rajshahi University in fulfilment of the requirements for the degree of

Master of Philosophy.

BY

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SEPTEMBER, 1992

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Dedication

To my parents

this work is most respectfully

dedicated

DECLARATION

This is to declare that the thesis submitted for the Degree of Master of Philosophy to the Institute of Biological Sciences, Rajshahi University is based on my original investigation, and was carried out under the Supervision of Professor M. Khalequzzaman, Department of Zoology, Rajshahi University.

The work as a whole or in part thereof has not been submitted in any form for any other degree at any place.

Sultana. 12.9.92.
(Mst. Shajia Sultana)

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ACKNOWLEDGEMENTS

The author is highly grateful to Professor M. Khalequzzaman, Department of Zoology, Rajshahi University, for his active supervision in all aspects of the work. She also pledges his indebtedness to him for his untiring inspiration and sincere effort to shape the work to its final goal.

The author is also indebted to Professor M.A. Quayum, Director, Institute of Biological Sciences, Rajshahi University for offering Fellowship and for his continued encouragement during the course of study.

Grateful thanks are also acknowledged to Professor M. Sayedur Rahman, Professor M. Ataur Rahman Khan, Professor K.A.M. Sahadat Hossain Mondal, Professor M.A. Salam, Department of Zoology, Rajshahi University for their useful suggestions in various acpects of the study.

The author is also greateful to the Chairman, Department of Zoology, Rajshahi University for his keen cooperation and making available of some Laboratory equipments. Thanks are also due to the Department of Agriculture and Environmental Biology, Newcastle upon Tyne University, England, for supplying experimental beetles.

The author wishes to acknowledge with great pleasure the cooperation that she received from all the Fellows, Institute of Biological sciences, Rajshahi University, during her course of study. She also wish to thank Lipy, Anis and Bidhan for their encouragement and help.

Thanks are also due to Mr. Enamul Haque, Senior Assistant, Planning and Development, Rajshahi University, for typing the manuscript.

Finally, an appreciation must go to her younger sister Mily and uncle A.M. Saleh Reza for their help and constant encouragement during the period of the study.

The author.

ABSTRACT

The needs for evolution of pest management strategies based on non-insecticidal chemicals having behavioural or physiological activity with insectistatic potential with or without selective insecticide deployment, has been recognized as an ecological imperative for well over a decade now. However, such chemicals are often highly specific, biodegradable, of low persistance, and their control potential is sophisticated and long-term. Although ecologically desirable, these very characteristics of non-insecticidal chemicals weigh against their economic feasibility and reduce their appeal to the primary users - the farmers.

For this purpose an investigation has been carried out on the effect of chemicals extracted from the seed of custard apple, Annona squamosa Linn., an insecticide-methacrifos and their combined doses on Tribolium castaneum strains local, CR-I, FSS-II and CTC 12.

Custard apple seeds after drying extracted in four chemicals viz., Petroleum Spirit, ethyl acetate, acetone and methanol. Those four type of chemicals extracted from the seeds along with methacrifos tested on the adult beetles for all the strains. The extracted materials also treated on the larvae. Again the low doses of extracted chemicals and insecticide were applied combindly on the adult T. castaneum to observe the synergistic effect.

It was found that all the chemicals extracted from the seeds by different solvents offered considerable mortality to the adult beetles. Highest toxicity was observed in the chemicals

extracted by petroleum spirit for local and FSS-II strain, and results also indicate that the strain CR-I showed maximum susceptibility and the strain local showed highest resistance to the insecticide methacrifos.

It was observed that all chemicals extracted offered mortality to the larvae of *T. castaneum*. The extraction with petroleum spirit was found more toxicant for all the experimented strains. The larvae treated with the seed extraction showed variable larval durations. Prolonged larval period was observed for all the cases with respect to control except petroleum spirit extraction. Significant ($P < 0.001$) analysis of variance were found among doses and strains in all the extraction for larval and pupal period. Only the extraction petroleum spirit showed insignificant results for both larval and pupal period.

The fecundity and hatchability of the eggs laid by the adults emarged from the treated and control larvae were also investigated. It was observed that the control insect laid more eggs and the eggs showed more hatchability then the treated ones. Analysis of variance performed for all the extractions among different doses and within the strains showed significant results for fecundity and hatchability. But the extraction in petroleum spirit showed insignificant results within the strains.

By using low doses of both extracted chemicals and insecticides methacrifos combindly, it was found that the extractions have synergistic role on methacrifos in most of the cases.

The results suggests that, custard apple plant contains some alkaloids, steroids, oils and acids which may offer a distinct antifeeding effect as well as some destructive effects on T. castaneum.

INTRODUCTION

1. INTRODUCTION

Pesticides are often considerd to be the most potent control technology for pests. Continuous or heavy usage of some pesticides has created serious problems arising from factors such as direct toxicity to parasites, predators, pollinators, fish and man (Munakata, 1977; Pimentel, 1981), Pesticide resistance (Brown, 1968; Georghiou and Taylor, 1977; Schmutterer, 1981, Waiss et al., 1981), susceptibility of crop plants to insect pests (Pimentel, 1977), and increased environmental and social costs (Pimentel et al., 1980). It has therefore, become necessary to complement our reliance on synthetic pesticides with less hazardous, safe and biodegradable substitutes.

The need for evolution of pest management strategies based on non-insecticidal chemicals having behavioral or physiological activity with insectistatic potential, with or without selective insecticide deployment, has been recognized as an ecological imperative for well over a decade now. However, such chemicals are often highly specific, biodegradable, of low persistence, and their control potential is sophisticated and long-term. Although ecologically desirable, these very characteristics of non-insecticidal chemicals weigh against their economic feasibility and reduce their appeal to the primary users - the farmers.

The increasingly serious problems of pest resistance to pesticides and of contamination of the biosphere associated with large-scale use of broad-spectrum synthetic pesticids have dictated the need for effective, biodegradable pesticides with greater selectivity (Saxena, 1983). This awarness has created a world wide interest in the re-evaluation and use of age-old, traditional botanical pest control agents.

Insect antifeedants and feeding deterrents are chemicals which appear to be reasonable alternatives to the use of commercial insecticides. Many natural plant products possess insect antifeedant activities. These compounds probably play a role as resistance factors in the defence of plants against insect attack. This can be a novel approach in pest management programmes.

Recently, the search for naturally occurring antifeedants against pests of field crops and storage has been intensified. A number of investigators isolated, identified and screened chemical compounds from leaves and seeds of many botanical families for insect feeding deterrence and growth inhabition (Jacobson et al.,1975; Bernays and Chapman, 1977; Doskotch et al., 1977; Jacobson, 1977; Sudhakar et al., 1978; Carpenter et al., 1979; Warthen, 1979; Jurd and Manners, 1980; Menn, 1980).

Unlike synthetic pesticides that kill both hosts and parasites, preys and predators, naturally occurring antifeedants or feeding deterrents are relatively safe for natural enemies of pest species because of their biodegradable natural and relative safety to useful organisms in the environment. A large number of scientific papers and reports cover the subject of naturally occurring insect antifeedants and feeding deterrents in plants (Gill and Lewis, 1971; Girish and Jain,1974; Jacobson et al., 1975; Bernays and Chapman, 1977; Doskotch *et al*.,1977; Munakata, 1977; Sudhakar *et al*. 1978; Warthen, 1979; Dethier, 1980; Jacobson, 1981; Menn, 1980; Schmutterer and Rembold, 1980).

It is an age old practice still prevalent in our country to mix dried indigenous leaves of odourous and poisonous plants with stored grain for protection against insects with much success. The available information on pyrethrins, rotenone and nicotine shows that these insecticides of plant origin are comparatively safer to mammals and higher animals (Feinstien, 1952) and suggests possibility of occurrence of such insecticides in other plant resoures hither to unexplored. Further, testing of plant materials for insecticidal properties may help in the development of new efficient synthetic insecticides. These promising attributes led to evaluate the potential use of custard apple *Annona squamosa* Linn. seed against red flour beetle, *Tribolium castaneum* (Herbst), a major pest of stored products, specially pulses, millets, and cereals (Cotton, 1947; Purthi and Singh, 1950; Dyte *et al*.,1975) in the present investigation. The seed of *A. squamosa* extracted with four solvents and treated on four varieties of *T. castaneum* to obtain dose mortality rate. One insecticide methacrifos has also been applied. The lowest doses of insecticide and seed extracts combindly treated on the same insect to observe the synergistic effect if any.

1.1 Description of the plant:

The family Annonaceae consists in the main of aromatic trees and shrubs of tropical origin. It contains from 800 to 900 species in some 80 genera, widely distributed in the tropics, with an extra tropical ramification in Atlantic North America. Among the principal genera are Asimia, Uvaria, Guatteria, Monodora, Rollinia, Xylopia, Annona and Artabotrys (Tattersfield and Potter, 1940). The genus Annona Linn. has about 90 species of trees and shrubs which are distributed mainly in tropical America, but a few are natives of the tropics of Asia and Africa. Three species are met within India, of which two may be described as naturalised (Watt, 1889)

A. squamosa popularly known as custard apple of Europeans in India; sweet-sup or sugar apple of the West Indies and America is a small tree naturalised in Bangal and the North-west provinces (Watt, 1889). Flower solitary, terminal, sepals 3, small, valvate, petals 3-6, valvate, 2-seriat, outer triquetrous, base concave, stamens numerous; anther-cell narrow, dorsal,contiguous, top of connective ovoid. Ovaries many, subconnate, style oblong, ovule, 1 erect. Ripe carpels confluent into amany - celled ovoid or globose, many-sceded fruit.

1.2 Chemistry of Annona:

The chemistry of plants of the family Annonaceae has been little investigated. Cortina (1901) reported to have found among other constituents a resin present in A. cherimola to which is ascribed the emetic-cathartic action of the seeds. Callan and

Tutin (1911) published an account of their chemical examination of the leaves of A. muricata. They isolated a steam-volatile essential oil, a small amount of uncrystallizable alkaloid, several fatty acids, myricyl alcohol, sitosterol and a compound "annonol", $C_{23}H_{38}O_4$, which was later regraded by Power and Salway (1913) as being a member of the group of phytosterol glucosides (Phytosterolines).

Trimurti (1924) isolated a minute amount of an alkaloid from the leaves of A. squamosa, but glucosides were not shown to be present. Santos (1930) obtained an alkaloid, annonaine, $C_{17}H_{16}O_3N$, in a yield of 0.03-0.04% from the bark of A. reticulata. The same alkaloid was isolated from the bark of A. squamosa by Reyes and Santos (1931), in a yield of 0.14%, but a slightly different formula was later ascribed to it $C_{17}H_{17}O_3N$ (Santos, 1932). From the bark of the closely allied genus Asimina triloba, Manske (1938) isolated the alkaloid annolobine, $C_{17}H_{17}O_3N$. Santos and Reyes (1932) and Barger and Sargent (1939) made studies of the alkaloids of Artabotrys suaveolens, N.O. Annonaceae, and the three alkaloids isolated from the bark by the latter investigators were :

(1)	Artabotrine	0.19%	$C_{20}H_{23}O_4N$
(2)	Suaveoline	0.0013%	$C_{12}H_{21}O_4N$
(3)	Artabotrinine	0.012%	$C_{18}H_{17}O_3N$

Barger and Sargent (1939) considered artabotrine probably to be ro-hydroxy - 4:5:6-trimethoxy-aporphine : suaveoline, 4:10-dihydroxy-5:6-dimethoxyaporphine; and artabotrinine, 2-methaoxy- 5:6-methylenedioxynoraporphine.

1.3 Insecticidal properties of *Annona* spp.:

In 1938 a report of the insecticidal effect of *A. reticulata* upon the scale insect, *Lacanium vride* Green, was issued by the Mysore Department of Agriculture (1938). Hot alcoholic extracts, water suspensions of the concentrated hot alcoholic extracts of seed and apparently alcoholic extracts of stem, bark and leaf and root bark were tested. All were found to be toxic : "the chemically prepared alcoholic extract of the seed was very toxic at 0.125% strength, a mortality of 70-80% being obtained". It is, however, not quite clear whether the concentration is expressed in terms of the plant material or the extract. Extracts of stem bark, leaf and root bark at 10% concentration gave respectively 100, 70 and 60% mortalities. No information is available as to the method of testing employed, but it was claimed that to this insect the hot alcoholic extracts of the seed of *A. reticulata* were more toxic than *Derris elliptica*. As, however, no particulars were given of the analytical characteristics of the derris used. This comparison may possess little value. Tests with other plants including *Mundulea Suberosa* (Sericea)were carried out. Extracts of none of them approached those of the seed of *A. reticulata* in potency.

In view of these results a supply of several species of *Annona* was obtained from Ceylon through the good offices of the colonial office and the Department of Agriculture, Peradeniya, Ceylon. They were *A. reticulata* (custard-apple), leaves, stem, root and seed; *A. palustris* (Glabra) (alligator apple), leaves, stem, root; *A. muricata* (sour sop), leaves, stem, root, seed; *A. squamosa* (sugar apple), leaves, stem, root where omitted the seed was not available at the time of collection.

MATERIALS AND METHODS

2. MATERIALS AND METHODS

2.1 Collection of the beetles *T. castaneum*:

Four strain of *Tribolium castaneum* i.e. Local, CR-I, FSS-II, (susceptible) and CTC 12 (resistant) were collected from the laboratory culture of the Crop Protection and Toxicology Laboratory, Department of Zoology, Rajshahi University, of which CR-I FSS-II and CTC 12 were previously collected from the Crop Protection Laboratory, Department of Agricultural and Environmental Science, University of Newcastle Upon Tyne, England; during August 1989.

2.2 Culture of the beetles:

Cultures were maintained for each of the strains in a beakers (500 ml) containing food medium and pieces of crumpled filter papers placed inside the food medium for the easy movement of the beetles. The beakers were covered with pieces of cloth at the top and kept in an incubator at $30^{o} \pm 0.5^{o}C$ without light and humidity control (Plate 1-4).

2.21 Preparation of food medium :

A standard mixture of whole wheat flour with powdered dry-yeast (19:1) was used as a food medium throughout the experiments (Park and Frank, 1948; Zyromska-Rudzka, 1966). Both the flour and yeast were priviously passed through a 60-mesh sieve. The food medium was sterilized at $120^{o}C$ for six hours in an oven.

Plate 1.

Culture of *T. castaneum* in a glass jar.

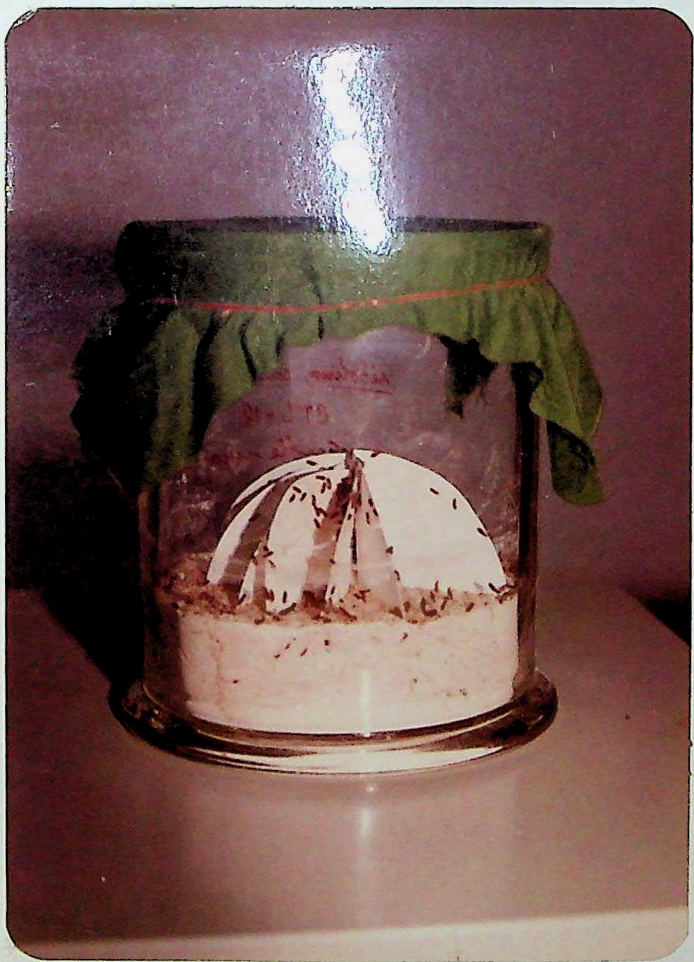


Plate 2.

Culture of *T. castaneum* in an incubator

Plate 3

Sub-cultures of <u>T.</u> <u>castaneum</u>

Plate 4.

Drying of collected seeds in an oven

Food was not used until at least 15 days after sterilization to allow its moisture content to equilibrate with the environment.

2.22 Collection of eggs:

About 200 beetles were pleaced in a 500 ml beaker containing food medium. The beaker was covered with a piece of cloth and kept in an incubator at 30°C ± 0.5°C. On the following days the eggs were collected by sieving the food medium through 30-mesh and 60- mesh sieves separating adults and eggs respectively. Eggs were transferred to petridish (30 cm in diametre) incubated in the same temperature.

2.23 Collection of newly hatched larvae:

Larvae hatched in about 5 days in that conditions. Newly hatched larvae were then collected with a fine pointed brush and transferred to the food medium.

2.24 Collection of newly formed adults:

Before starting the experiments a huge number of the flour beetles were reared to get a regular supply of the newly formed adults. For this purpose ten cultures were prepared in large glass jars (120X120 mm). Each jar contained 500 gm of wheat flour properly mixed with appropriate quantity of yeast and 50 pairs (male and female) of the adult insects were released in the medium. In regular intervals the cultures were checked and the eggs and larvae were separated by the previously mentioned method of sieving. When sufficient adults were produced in the sub-cultures they were collected for the experiments by separating them from the food medium. For this purpose some pieces of filter paper were kept inside the jar on the flour. The adult beetles crawled up on the paper. The paper was taken out with the help of a forceps and the beelts were collected in a small beaker (50 ml) with the help of a camel-hair brush.

2.3 Collection of plant seeds and process of extraction:

The seeds of custard apple (A. squamosa L.) were collected and dried in an oven at 60°C for 36 hours. The dried seeds were powdered in a morter and pestle. Extraction of the seeds was done in a soxhlet's apperatus. The solvents used were petroleum spirit, ethyl acetate, acetone, and methanol. The extraction was done in the following way :

At first known quantity of dried seed powder was kept in a thimble. The thimble was then put inside the extraction apparatus and requisite quantity of the solvent was poured inside the apparatus and extraction was done 60°C $\pm$ 1°C. Four solvents were used serially according to the order stated above. When extraction completed for one solvent the materials inside the thimble dried and weighed before starting extraction with another solvent (Plate 5 and 6).

Plate 5

Extraction of A. squamosa seeds in Soxhelet's apparatus.

Plate 6

Condensation of extract liqued in a rotary vacuum evaporator

2.4 Preparation of doses:

The extracted liquid was dried in a rotary vacuum evaporator and the dried extracted material then weighed and dissolved in the solvent according to the proportion of dry-weight in seed. This was taken as the highest dose. Then other doses were made by serial dilution with the same solvent (Plate 7).

For each extracted material five doses including control (only solvent) were used to test the mortality rate of T. castaneum adults strains local, CR-I, FSS-II and CTC 12, the former three strains are susceptible and the latter was resistant to insecticide. For each dose 1 ml liquid was dropped on a petridish (90 mm) and dried. Four plastic rings (30 mm) were placed inside the petridish and 10 adult beetles were released in each ring. Thus within the petridish each ring served as a replication.

The doses were calculated by measuring the dry-weight of the extract (μgm) in 1 ml of the solvent divided by the surface area of the petridish, i.e. μgm/sq. cm.

2.5 Dose-mortality experiments with seed extracts on the adults:

The petridishes treated with extracted materials having adult beetles were kept in the incubator at $30^{\circ} \pm 0.5^{\circ}C$. The mortality of the adults were recorded after 12 and 24 hours of treatment. Thus for each of the four extractions from seeds of custard-apple was tested on the adults of the four strains of the beetles T. castaneum having five doses including control (only solvent) with four replications in each. The recorded data were subjected

Plate 7.

Preparation of doses and seting of an experiment

to be probit analysis according to Finney (1947) and Busvine (1971).

2.6 Dose mortality experiments with insecticide on the adult:

The insecticide tested on the adults of _T. castaneum_ was methacrifos [methyl (E)-3-3(dimethoxyphos-phinothioylony)-2-methaylacrylate, commercially available of Damfin 950 Ec of Ciba-Geigy]. This insecticide was diluted in distilled water and the doses were made. The mortality of the adults were also recorded after 12 and 24 hours of the treatment and subjected to probit analysis.

2.7 Dose-mortality experiments with seed extracts on the larvae:

The newly hatched larvae were collected from the stock culture and 40 one day old larvae were placed in a treated glass vial with 1.56 gm. of food (2.7 cm. diametre) with four replications for each dose. The larvae were observed regularly until all pupated. The pupae were collected by sieving the food medium and sexed by microscopic examination of the exo-genital processes of the female pupae (Halstead, 1963). The sexed pupae were kept in the petridish and observed daily for eclosion. The resultant adults were paired (male and female) on the day of the eclosion and placed in a petridish for egg collection and the eggs were collected for 7 days at regularly (Plate 8-11).

The larval and pupal mortality, fecundity and hatchability of eggs from the adults emerged from treated and control larvae were carefully recorded.

Plate 8.

Experimental Larvae.

Plate 9.

Treated larvae.

Plate 10.

Wingless pupae resulted from the treated pupae

Plate 11.

Deformed adults resulted from the treated larvae

2.8 Experiments with combined dose of seed extracts and insecticide on the adults:

After completion of the experiments with insecticide and extraction, the lowest dose of the seed extracts and insecticide was combined and tested on the adult T. castaneum. For this purpose the lowest dose of insecticide was made with the four solvents, i.e. Petroleum Spirit, ethylacetate, acetone, and methanol. Then the lowest dose of seed extract in a solvent was properly mixed with the lowest dose of the insecticide in the same solvent. Thus four combined dose were made for four solvents and treated in the petridishes in the same way described previously. So the ecombined doses were made and applied on different strains of T. castaneum. The mortality rate was tested using chi-square based on an expected mortality for the sum of two individual effects as given by Mather (1940).

$$x^2 = \frac{(N_C X_S X_A - X_C N_S N_A)^2 N_S N_A}{X_S X_A N_C \{N_S N_A (N_S N_A - X_S X_A) + N_C N_A N_A Y_S + N_C N_S X_S Y_A\}}$$

Where, N_S, N_A and N_C are the total number of insects used in the treatments of toxicant (insecticides), test material and their combined doses respectively.

X_A, X_S and X_C represents the total numbers of insects surviving in treatments of toxicant (insecticide), test material and their combined doses respectively.

Y_S and Y_A represent the number of insects killed in (by) toxicant (insecticide) and test material individual treatment respectively, and Y_C represent the number of insects killed in their combined doses.

Significant chi-square result indicates observed mortality and combined chemicals is greater than expected and synergism is occuring. The combined effects on adult mortality were classified on the criteria for synergism (Hewlett, 1960) as described by Benz (1971).

RESULTS

3. RESULTS

Data on the adult mortality of *T. castaneum* with the seed extracts of *A. squamosa* by different solvents and with the insecticide, methacrifos are presented in Tables 1-10. Results concerning the larval mortality with seed extracts by different solvents, larval period, pupal period, fecundity, and hatchability are presented in Tables 11-24. The mortality due to combined action of methacrifos and plant extractions have been presented in Tables 25-28.

3.1 Effect of seed extractions of *A. squamosa* on the mortality of adult *T. castaneum* :

Results on the mortality of *T. castaneum* local strain are given in Table 1 and Appendix Tables I-VII. Among the four solvents viz., Petroleum Spirit, ethylacetate, acetone, and methanol, the extraction with petroleum spirit showed the highest mortality (100.0%) in the highest dose (4367.99 μgm/sq.cm) both after 12 and 24 hours of treatments. The mortality was recorded as 85.0 and 95.0%; 65.0 and 85.0%; and 87.5 and 92.5% with ethyl acetate, acetone and methanol extractions for 12 and 24 hours after treatments respectively in the highest doses (5497.95 3746.64, and 2343.98 μgm/sq.cm) for the above three extractions (Table 1). The results also shows that the extraction with methanol was more toxic followed by Petroleum Spirit, ethyl acetate, and acetone for both 12 and 24 hours. The LD_{50} values have been calculated as 405.51 and 206.06 μgm/sq.cm. in Petroleum Spirit extraction, 1749.85 and 548.28 μgm/sq.cm. in ethyl acetate extraction, and 354.81 and 117.76 µgm/sq.cm in methanol extraction for 12 and 24 hours after treatment respectively. In the extraction with acetone LD_{50} value (946.24 µgm/sq.cm) have been calculated only for 24 hours after treatments (Table 5).

Results concerning the mortality of CR-I strain are given in Table 2, and Appendix Tables VIII-XIII. The highest doses of 10060.31, 14147.52, 12268.60 and 3109.08 µgm/sq.cm showed the highest mortality of 100.0, and 100.0%; 90.0 and 92.5%; 17.5 and 42.5%; and 95.0 and 97.5, in the extractions Petroleum Spirit, ethyl acetate, acetone and methanol for 12 and 24 hours respectively (Table 2). In this case, methanol was the more toxic then other extractions. The LD_{50} values have been calculated as 477.53 and 306.90 µgm/sq.cm in Petroleum Spirit and 403.65 and 257.63 µgm/sq.cm in methanol for 12 and 24 hours after treatment respectively. The extractions with ethyl acetate and acetone offered mortality (LD_{50} values, 2857.59 and 21330.45 µgm/sq.cm) only for 24 hours after treatments (Table 6).

The results on the mortality of FSS-II strain are presented in Table 3 and Appendix Table XIV-XX. The highest mortality of 100.0 and 100.0%; 82.5 and 100.0%; 82.2 and 97.5%; and 100.0 and 100.0%, were observed in the highest doses of 4367.99, 5497.95, 3746.95 and 2343.98 µgm/sq.cm. With the extraction Petroleum Spirit, ethyl acetate, acetone, and methanol for 12 and 24 hours respectively (Table 3). In this strain maximum toxic response was observed with the extraction Petroleum Spirit followed by methanol and ethyl acetate for both 12 and 24 hours after treatments. The LD_{50} values were 130.02 and 82.04 µgm/sq.cm.

Table 1. Mortality Percentage of Adult T. castaneum (Local) with different doses of seed extract of A. squamosa.

Solvent	Dose µgm/sq.cm	Mortality Percentage After 12 hours	Mortality Percentage After 24 hours
Petroleum Spirit	A. 4367.99	100.0	100.0
	B. 436.80	50.0	70.0
	C. 43.68	7.5	12.5
	D. 4.37	-	2.5
	O. Control	-	-
Ethyl acetate	A. 5497.95	85.0	95.0
	B. 549.80	15.0	37.5
	C. 54.98	2.5	10.0
	D. 5.50	2.5	5.0
	O. Control	-	-
Acetone	A. 3746.64	65.0	85.0
	B. 374.66	-	15.0
	C. 37.47	-	10.0
	D. 3.75	-	-
	O. Control	-	-
Methanol	A. 2343.98	87.5	92.5
	B. 234.40	42.5	72.5
	C. 23.44	2.5	10.0
	D. 2.34	-	5.0
	O. Control	-	-

Table 2. Mortality Percentage of Adult *T. castaneum* (CR-I) with different doses of seed extract of *A. squamosa*.

Solvent	Dose µgm/sq.cm	Mortality Percentage After	
		12 hours	24 hours
Petroleum Spirit	A. 10060.30	100.0	100.0
	B. 1006.03	75.0	87.5
	C. 100.60	7.5	7.5
	D. 10.06	-	2.5
	O. Control	-	-
Ethyl acetate	A. 14147.52	90.0	92.5
	B. 1414.75	12.5	22.5
	C. 141.48	-	2.5
	D. 14.15	-	-
	O. Control	-	-
Acetone	A. 12268.60	17.5	42.5
	B. 1226.86	2.5	2.5
	C. 122.69	-	2.5
	D. 12.27	-	-
	O. Control	-	-
Methanol	A. 3109.08	95.0	97.5
	B. 310.91	27.5	37.5
	C. 31.09	17.5	22.5
	D. 3.11	7.5	17.5
	O. Control	5.0	7.5

Table 3. Mortality Percentage of Adult *T. castaneum* (FSS-II) with different doses of seed extract of *A. squamosa*.

Solvent		Dose µgm/sq.cm	Mortality Percentage After	
			12 hours	24 hours
Petroleum Spirit	A.	4367.99	100.0	100.0
	B.	436.80	87.5	92.5
	C.	43.68	15.0	27.5
	D.	4.37	-	5.5
	O.	Control	-	2.5
Ethyl acetate	A.	5497.95	82.5	100.0
	B.	549.80	7.5	35.0
	C.	54.98	2.5	7.5
	D.	5.50	2.5	2.5
	O.	Control	-	-
Acetone	A.	3746.64	82.2	97.5
	B.	374.66	-	32.5
	C.	37.47	-	15.0
	D.	3.75	-	-
	O.	Control	-	-
Methanol	A.	2343.98	100.0	100.0
	B.	234.40	10.0	27.5
	C.	23.44	7.5	15.0
	D.	2.34	2.5	10.0
	O.	Control	2.5	7.5

Table 4. Mortality Percentage of Adult *T. castaneum* (CTC12) with different doses of seed extract of *A. squamosa*.

Solvent	Dose µgm/sq.cm	Mortality Percentage After	
		12 hours	24 hours
Petroleum Spirit	A. 4367.99	100.0	100.0
	B. 436.80	75.0	90.0
	C. 43.68	17.5	25.0
	D. 4.37	-	5.0
	O. Control	-	-
Ethyl acetate	A. 5497.95	87.5	100.0
	B. 549.80	25.0	67.0
	C. 54.98	7.5	17.5
	D. 5.50	-	5.0
	O. Control	-	-
Acetone	A. 3746.64	100.0	100.0
	B. 374.66	5.0	15.0
	C. 37.47	-	10.0
	D. 3.75	-	7.5
	O. Control	-	-
Methanol	A. 2343.98	90.0	95.5
	B. 234.40	87.5	95.0
	C. 23.44	77.5	90.0
	D. 2.34	7.5	15.0
	O. Control	-	-

Table 5. LD_{50}, 95% confidence limit and regression equations of seed extracts on the mortality of adult T. castaneum (Local).

Solvent	LD_{50} µgm/sq.cm After		Regression equation After	
	12 hours (Lower – Upper)*	24 hours (Lower – Upper)	12 hours	24 hours
Petroleum Spirit	405.51 (234.96-699.84)	206.06 (123.31-344.35)	y=0.88+1.58x	y=1.68+1.43x
Ethyl acetate	1749.85 (1101.54-2779.71)	548.28 (325.09-924.70)	y=0.007+1.52x	y=1.96+1.11x
Acetone	-	946.24 (729.46-1227.44)	-	y=1.32+1.24x
Methanol	354.81 (229.09-549.54)	117.76 (71.94-192.75)	y=1.14+1.51x	y=2.56+1.18x

*Figures in parenthesis showed the 95% conf. limit.

Table 6. LD_{50}, 95% confidence limit and regression equations of seed extracts on the mortality of adult T. castaneum (CR-I).

Solvent	LD_{50} µgm/sq.cm After		Regression equation After	
	12 hours (Lower – Upper)*	24 hours (Lower – Upper)	12 hours	24 hours
Petroleum Spirit	477.53 (290.40-785.24)	306.90 (211.84-444.63)	y=2.15x-0.76	y=0.20+1.93x
Ethyl acetate	-	2857.59 (1945.36-4197.59)	-	y=1.84x-1.36
Acetone	-	21330.45 (8090.96-56234.13)	-	y=0.19+1.11x
Methanol	403.65 (238.23-683.91)	257.63 (215.28-308.32)	y=1.97+1.16x	y=2.80+6.91x

*Figures in parenthesis showed the 95% conf. limit.

Table 7. LD_{50}, 95% confidence limit and regression equations of seed extracts on the mortality of adult *T. castaneum* (FSS-II).

Solvent	LD_{50}/µgm/sq.cm After		Regression equation After	
	12 hours (Lower – Upper)*	24 hours (Lower – Upper)	12 hours	24 hours
Petroleum Spirit	130.02 ((91.41-184.93)	82.04 (56.10-119.95)	y=0.36+2.20x	y=1.56+1.80x
Ethyl acetate	1986.09 (1161.45-3396.25)	769.13 (376.70-1570.36)	y=1.04+1.20x	y=1.53+1.20x
Acetone	-	393.55 (239.33-647.14)	-	y=1.53+1.34x
Methanol	629.51 (306.90-1291.22)	457.09 (205.59-1016.25)	y=0.39+1.65x	y=1.41+1.16x

* Figures in parenthesis showed the 95% conf. limit.

Table 8. LD_{50}, 95% confidence limit and regression equations of seed extracts on the mortality of adult *T. castaneum* (CTC 12).

Solvent	LD_{50}/µgm/sq.cm After		Regression equation After	
	12 hours (Lower – Upper)*	24 hours (Lower – Upper)	12 hours	24 hours
Petroleum Spirit	168.66 (104.47-272.27)	79.43 (50.82-124.17)	y=1.38+1.62x	y=2.15+1.50x
Ethyl acetate	1061.70 (671.43-1678.80)	244.84 (132.43-452.90)	y=0.91+1.35x	y=2.20+1.17x
Acetone	-	1129.80 (706.32-1807.17)	-	y=1.96x-0.97
Methanol	16.90 (8.91-32.06)	7.78 (4.59-13.18)	y=3.92+0.88x	y=3.93+1.20x

* Figures in parenthesis showed the 95% conf. limit.

Fig.-1. The regression lines of probit mortality on log dose for T. castaneum (Local) adults treated with A. squamosa seed extracts in different solvents.

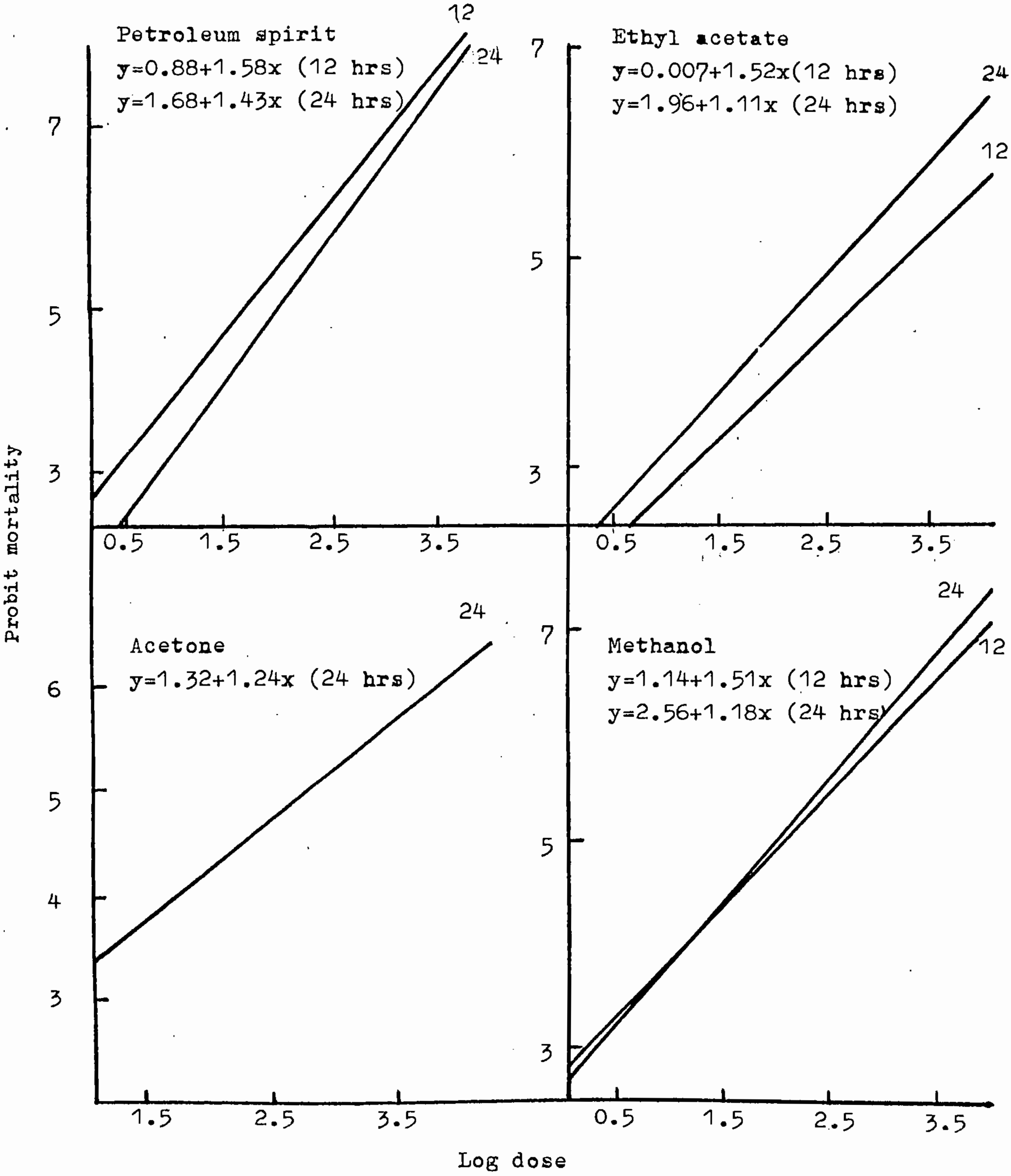


Fig.-2. The regression lines of probit mortality on log dose for T. castaneum (CR-I) adults treated with A. squamosa seed extracts in different solvents.

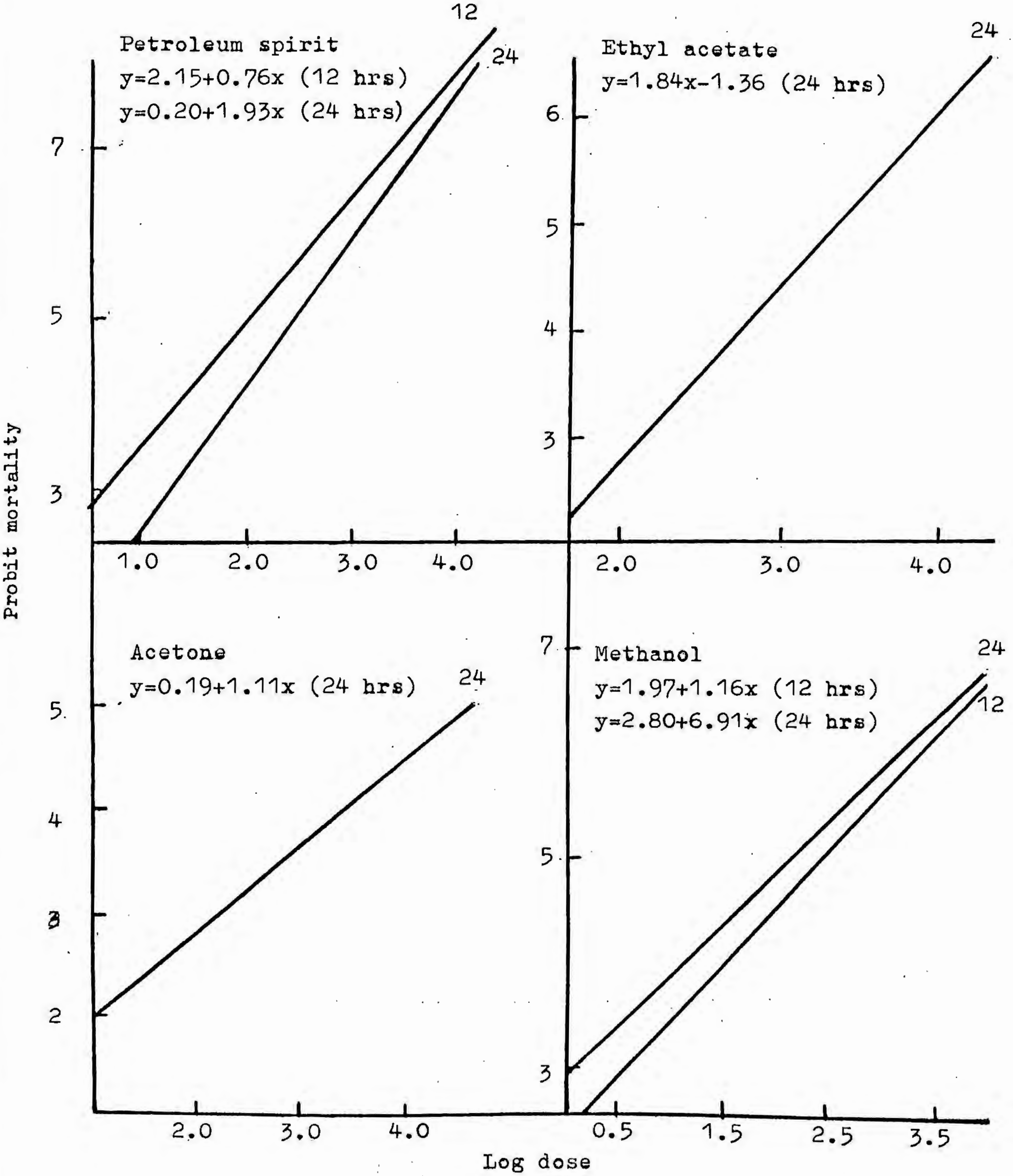


Fig.-3. The regression lines of probit mortality on log dose for *T. castaneum* (FSS-II) adults treated with *A. squamosa* seed extracts in different solvents.

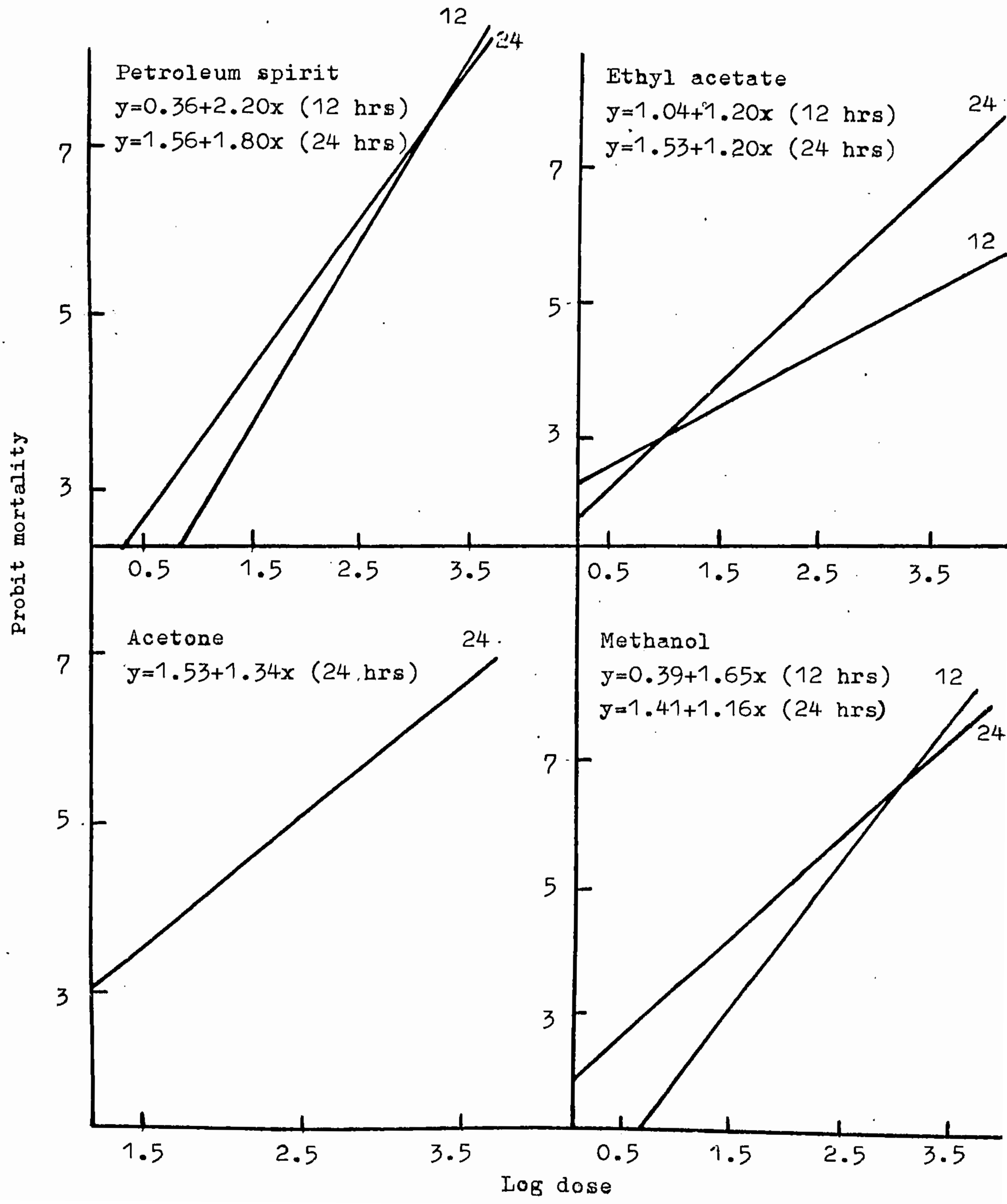
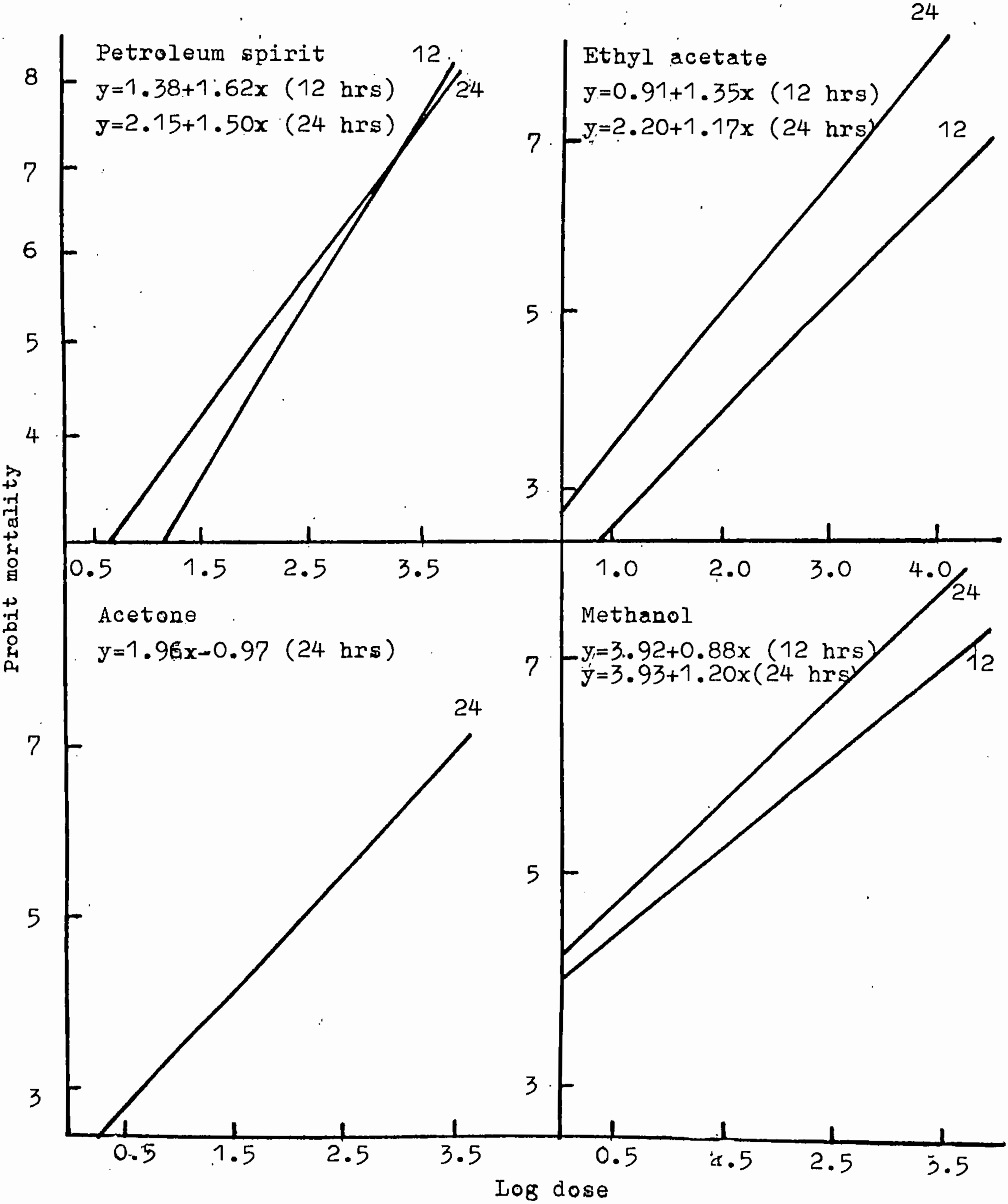


Fig.-4. The regression lines of probit mortality on log dose for *T. castaneum* (CTC 12) adults treated with *A. squamosa* seed extracts in different solvents.



in Petroleum Spirit; 1986.09 and 769.13 µgm/sq.cm. in ethyl acetate; 629.51 and 457.09 µgm/sq.cm. in methanol for 12 and 24 hours respectively. In the extraction acetone LD_{50} value (393.55 µgm/sq.cm.) was recorded only for 24 hours (Table 7).

In case of rasistant strain CTC 12(Table 4 and Appendix Tables XXI-XXVII) it was observed that the highest mortality of 100.0 and 100.0%; 87.5 and 100.0%; 100.0 and 100.0%; and 90.0 and 95.5%, were recorded in the highest doses of 4367.99, 5497.95, 3746.64 and 2343.98 µgm/sq.cm. in the extractions Petroleum Spirit, ethyl acetate, acetone and methanol for 12 and 24 hours after treatments respectively (Table 4). After 24 hours treatment the observed LD_{50} values were 79.43, 244.84, 1129.80 and 7.78 µgm/sq.cm in Petroleum spirit, ethyl acetate, acetone and methanol extractions respectively. Here the extraction methanol showed the highest toxicity on the beetles (Table 8).

The regression equation and 95% confidence limits have also been included in Tables 5-8 for different strains in different extractions of 12 and 24 hours after treatment. The regression lines plotted for the same are presented in Figures 1-4.

3.2 Effect of methacrifos on the mortality of adults. *T. castaneum* :

Results on the mortality of adult *T. castaneum* with the insecticide methacrifos have been presented in Table 9 and Appendix Tables XXVIII-XXXV. The highest dose 1.493 µgm/sq.cm.

Table 9. Mortality percentage of Adult *T. castaneum* treated with methacrifos.

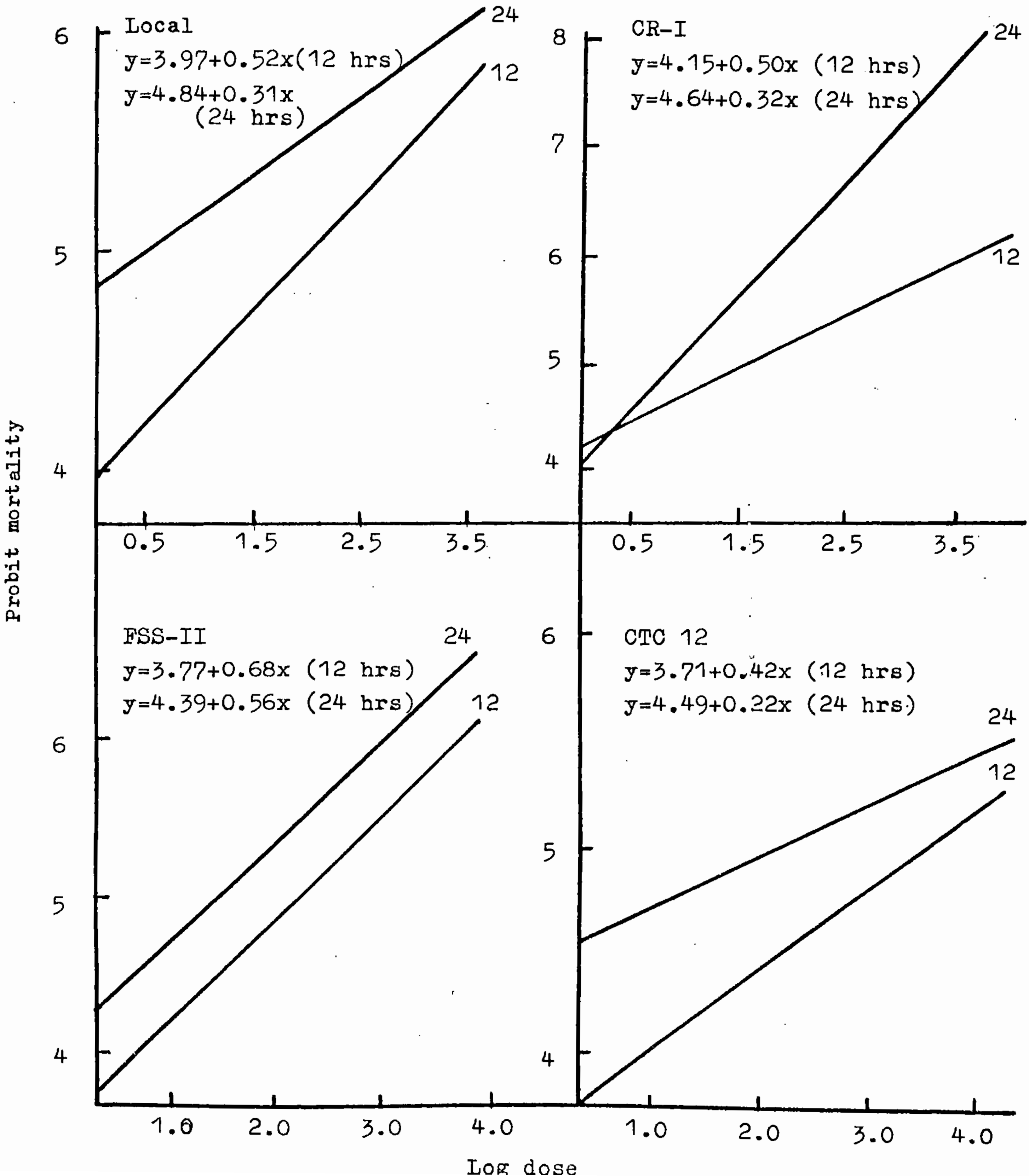
Strain	Dose µgm/sq.cm	Mortality Percentage After	
		12 hours	24 hours
Local	A. 1.493	77.5	90.0
	B. 0.1493	45.0	55.0
	C. 0.01493	37.5	55.0
	D. 0.001493	17.5	52.5
	O. Control	-	-
CR-I	A. 1.493	80.0	100.0
	B. 0.1493	55.0	62.5
	C. 0.01493	37.5	57.5
	D. 0.001493	25.0	37.5
	O. Control	-	-
FSS-II	A. 1.493	87.5	95.0
	B. 0.1493	55.0	62.5
	C. 0.01493	25.0	50.0
	D. 0.001493	20.0	35.0
	O. Control	-	-
CTC-12	A. 1.493	50.0	62.5
	B. 0.1493	38.0	50.0
	C. 0.01493	20.0	47.5
	D. 0.001493	12.5	32.5
	O. Control	-	-

Table 10. LD_{50}, 95% confidence limit and regression equations of methacrifos on the mortality of adult T. castaneum.

Strain	LD_{50}/µgm/sq.cm After		Regression equation After	
	12 hours (Lower - Upper)*	24 hours (Lower - Upper)	12 hours	24 hours
Local	0.0977 (0.0382-0.250)	0.0034 (0.00042-0.0273)	y=3.97+0.52x	y=4.84+0.31x
CR-I	0.0510 (0.0201-0.1312)	0.0135 (0.0022-0.0828)	y=4.15+0.50x	y=4.64+0.32x
FSS-II	0.0631 (0.0303-0.1315)	0.0120 (0.0046-0.0314)	y=3.77+0.68x	y=4.39+0.56x
CTC 12	1.176 (0.2087-6.6300)	0.0741 (0.0091-0.6012)	y=3.71+0.42x	y=4.49+0.22x

* Figures in parenthesis showed the 95% conf. limit.

Fig-5. The regression lines of probit mortality on log dose for different strains of *T. castaneum* adults treated with methacrifos.



showed the maximum mortality in FSS-II (87.5%) followed by CR-I (80.0%) local (77.5%) and CTC 12 (50.5%) for 12 hours after treatments while after 24 hours after treatments the highest mortality was observed in CR-I (100.0%) followed by FSS-II (95.0%) local (90.0%) and CTC 12 (62.5%) (Table 9). The LD_{50} values 0.0977 and 0.0034; 0.051 and 0.0135; o.0631 and 0.012; and 1.176 and 0.0741 μgm/sq.cm. were calculated for 12 and 24 hours after treatments for local, CR-I, FSS-II, and CTC 12 strains respectively (Table 10). The results also indicate that for 12 hours treatment CR-I strain showed maximum susceptibility to insecticide methacrifos followed by FSS-II, CTC 12 and local. For 24 hours treatment more toxicity were observed in local strain followed by FSS-II, CR-I, and CTC 12. The regression equations and 95% confidence limits are presented in Table 10 and the regression lines are presented in figure 5.

3.3 Effect of seed extractions of A. squamosa on the mortality of larvae of T. castaneum :

The mortality of larvae of different strains of T. castaneum with variable doses of extraction in different solvents have been presented in Tables 11-14 and Appendix Tables XXXVI-LI. The tables also included LD_{50} with 95% confidence limit and regression equations. The regression lines are presented in Figure 6-9.

For local strain it was observed that the extraction extracted with petroleum spirit offered the highest mortality followed by ethyl acetate and methanol. The LD_{50} in μgm/sq.cm. has been calculated as 0.0293, 0.395, 0.6893, and 4.130 at

Table 11. Mortality percentage, LD_{50}, 95% confidence limit and regression equation of seed extracts on T. castaneum (Local) larvae.

Solvent	Dose /ugm/sq.cm	Mortality percentage	LD_{50}/ugm/sq.cm (Lower-Upper)*	Regression equation
Petroleum Spirit	A. 48.53	97.5	0.0293 (0.0059-0.1455)	y=4.74 + 0.55x
	B. 4.853	87.5		
	C. 0.4853	80.0		
	D. 0.04853	60.0		
	0. Control	12.5		
Ethyl acetate	A. 61.08	92.5	0.3950 (0.1832-0.8531)	y=3.85 + 0.72x
	B. 6.108	82.5		
	C. 0.6108	77.5		
	D. 0.06108	30.0		
	0. Control	15.0		
Acetone	A. 41.63	92.5	0.6893 (0.3524-1.3450)	y=3.60 + 0.76x
	B. 4.163	80.0		
	C. 0.4163	52.5		
	D. 0.04163	35.0		
	0. Control	20.0		
Methanol	A. 26.04	75.0	4.130 (2.051-8.318)	y=3.30 + 0.65x
	B. 2.604	60.0		
	C. 0.2604	40.0		
	D. 0.02604	27.5		
	0. Control	22.5		

*Figures in parenthesis showed the 95% conf. limit.

Table 12. Mortality percentage, LD_{50}, 95% confidence limit and regression equation of seed extracts on *T. castaneum* (CR-I) larvae.

Solvent	Dose µgm/sq.cm	Mortality percentage	LD_{50} µgm/sq.cm (Lower-Upper)•	Regression equation
Petroleum Spirit	A. 48.53	97.5	0.0101 (0.0011-0.0923)	y=4.85 + 0.51x
	B. 4.853	90.0		
	C. 0.4853	85.0		
	D. 0.04853	65.0		
	O. Control	22.5		
Ethyl acetate	A. 61.08	95.0	0.0436 (0.0277-0.0685)	y=4.64 + 0.55x
	B. 6.108	90.0		
	C. 0.6108	82.5		
	D. 0.06108	57.5		
	O. Control	15.0		
Acetone	A. 41.63	95.0	0.2673 (0.1274-0.5610)	y=3.93 + 0.75x
	B. 4.163	87.5		
	C. 0.4163	67.5		
	D. 0.04163	42.5		
	O. Control	22.5		
Methanol	A. 26.04	100.0	0.0597 (0.0213-0.1671)	y=4.48 + 0.67x
	B. 2.604	87.5		
	C. 0.2604	70.0		
	D. 0.02604	45.0		
	O. Control	7.50		

•Figures in parenthesis showed the 95% conf. limit.

Table 13. Mortality percentage, LD_{50}, 95% confidence limit and regression equation of seed extracts on *T. castaneum* (FSS-II) larvae,

Solvent	Dose µgm/sq.cm	Mortaluty percentage	LD_{50} µgm/sq.cm (Lower-Upper)*	Regression equation
Petroleum Spirit	A. 48.53	100.0	0.0448 (0.0133-0.1503)	y=4.82 + 0.70x
	B. 4.853	92.5		
	C. 0.4853	80.0		
	D. 0.04853	60.0		
	0. Control	15.0		
Ethyl acetate	A. 61.08	90.0	0.2163 (0.1107-0.4227)	y=4.23 + 0.58x
	B. 6.108	87.5		
	C. 0.6108	70.0		
	D. 0.06108	40.0		
	0. Control	12.5		
Acetone	A. 41.63	97.5	0.0286 (0.0046-0.1791)	y=4.79 + 0.46x
	B. 4.163	82.5		
	C. 0.4163	70.0		
	D. 0.04163	65.0		
	0. Control	15.0		
Methanol	A. 26.04	62.5	15.539 (14.588-16.443)	y=3.66 + 0.42x
	B. 2.604	52.5		
	C. 0.2604	42.5		
	D. 0.02604	30.0		
	0. Control	22.5		

*Figures in parenthesis showed the 95% conf. limit.

Table 14. Mortality percentage, LD_{50}, 95% confidence limit and regression equation of seed extracts on <u>T. castaneum</u> (CTC 12) larvae.

Solvent	Dose µgm/sq.cm	Mortality percentage	LD_{50} µgm/sq.cm (Lower-Upper)*	Regression equation
Petroleum Spirit	A. 48.53	100.0	0.0539 (0.0356-0.0817)	y=4.34 + 0.90x
	B. 4.853	97.5		
	C. 0.4853	82.5		
	D. 0.04853	60.0		
	O. Control	20.0		
Ethyl acetate	A. 61.08	77.5	0.4046 (0.1061-1.5430)	y=4.55 + 0.28x
	B. 6.108	72.5		
	C. 0.6108	65.0		
	D. 0.06108	52.5		
	O. Control	22.5		
Acetone	A. 41.63	95.0	0.0785 (0.0329-0.1875)	y=4.32 + 0.76x
	B. 4.163	90.0		
	C. 0.4163	72.5		
	D. 0.04163	52.5		
	O. Control	20.0		
Methanol	A. 26.04	95.0	0.0153 (0.0021-0.1148)	y=4.92 + 0.43x
	B. 2.604	85.0		
	C. 0.2604	75.0		
	D. 0.02604	62.5		
	O. Comtrol	17.5		

*Figures in parenthesis showed the 95% conf. limit.

Fig-6. The regression lines of probit mortality on log dose for *T. castaneum* (Local) larvae treated with *A. squamosa* seed extracts in different solvents.

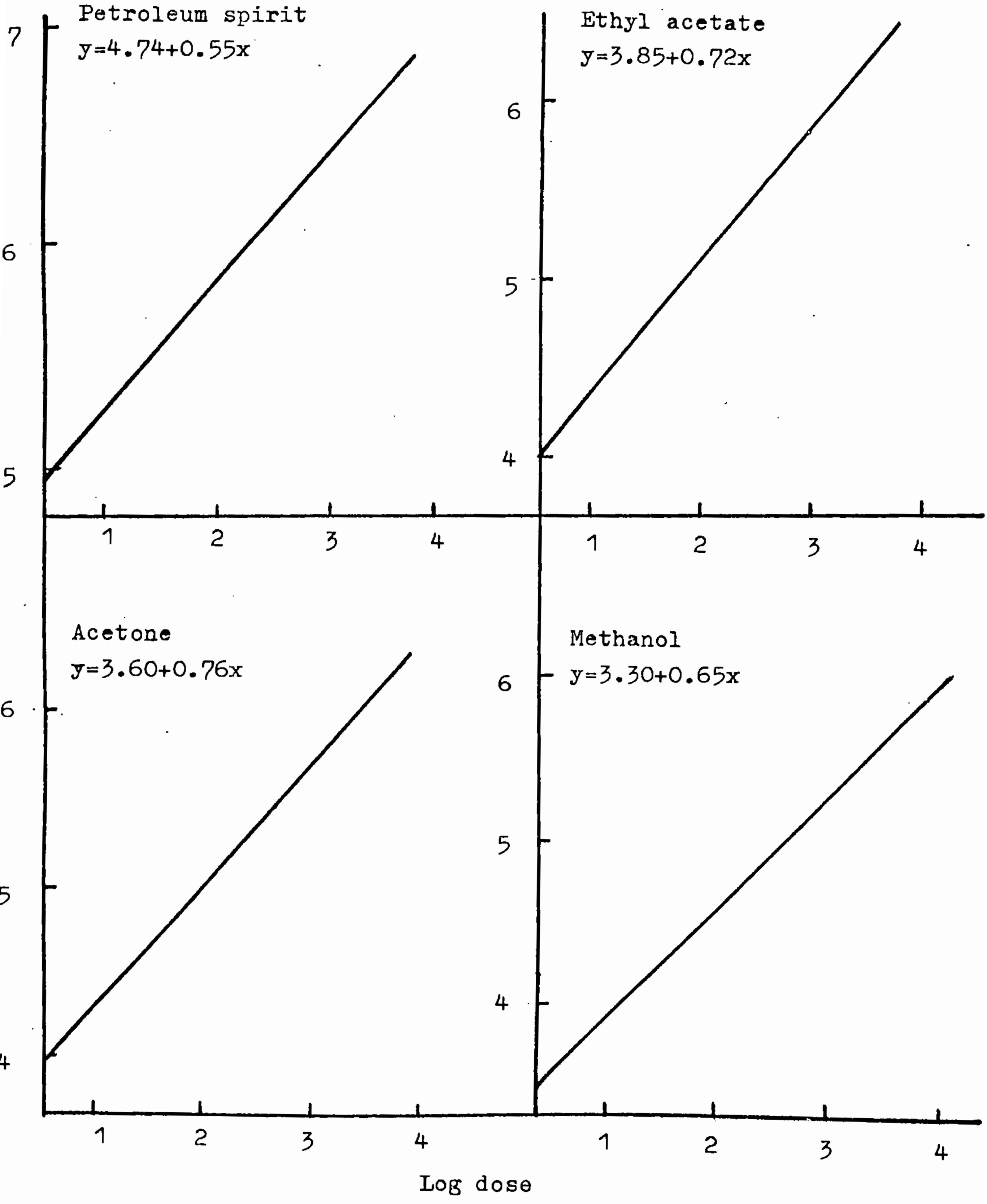


Fig-7. The regression lines of probit mortality on log dose for _T._ _castaneum_ (CR-I) larvae treated with _A._ _squamosa_ seed extracts in different solvents.

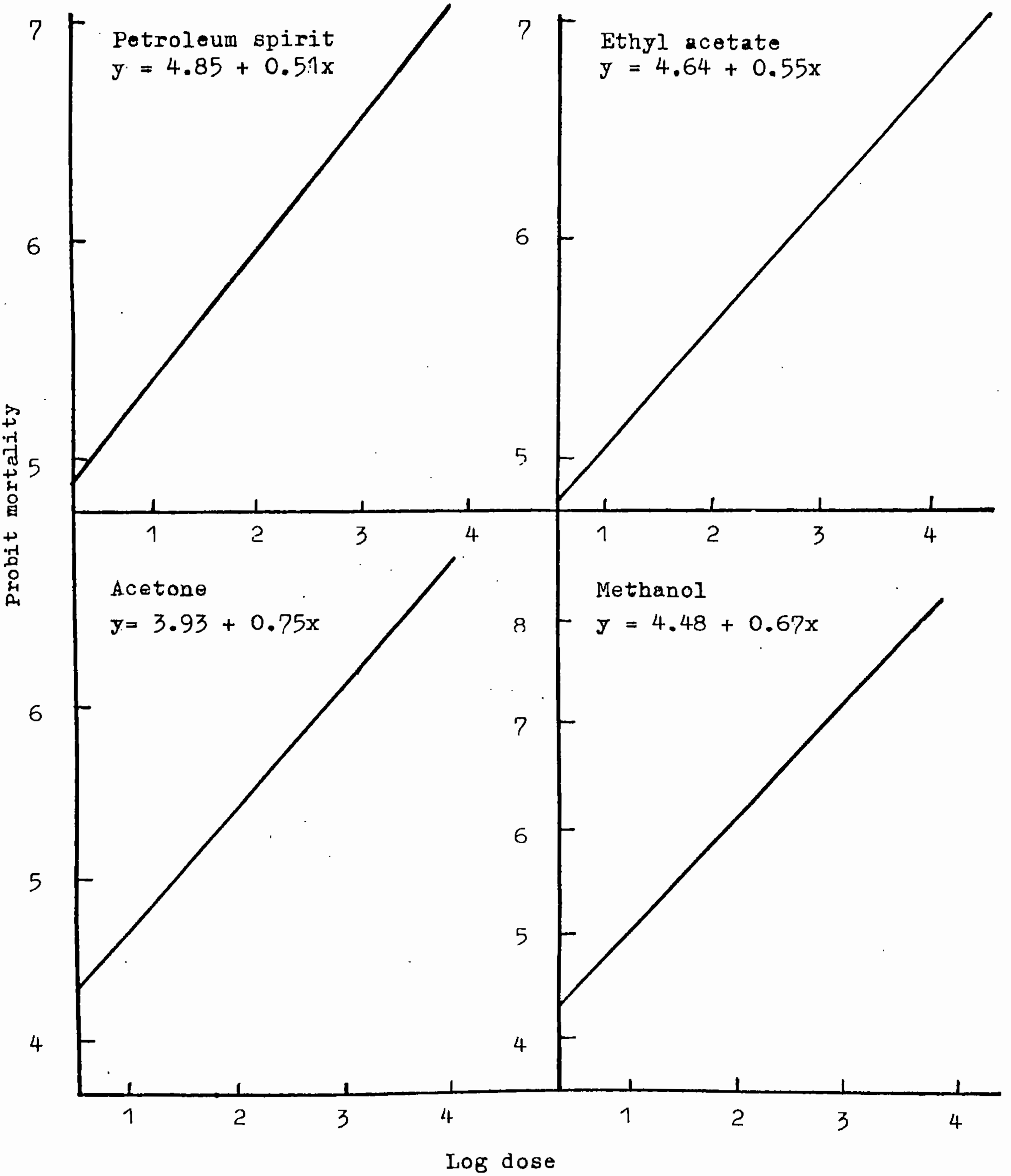


Fig-8. The regression lines of probit mortality on log dose for T. castaneum (FSS-II) larvae treated with A. squamosa seed extracts in different solvents.

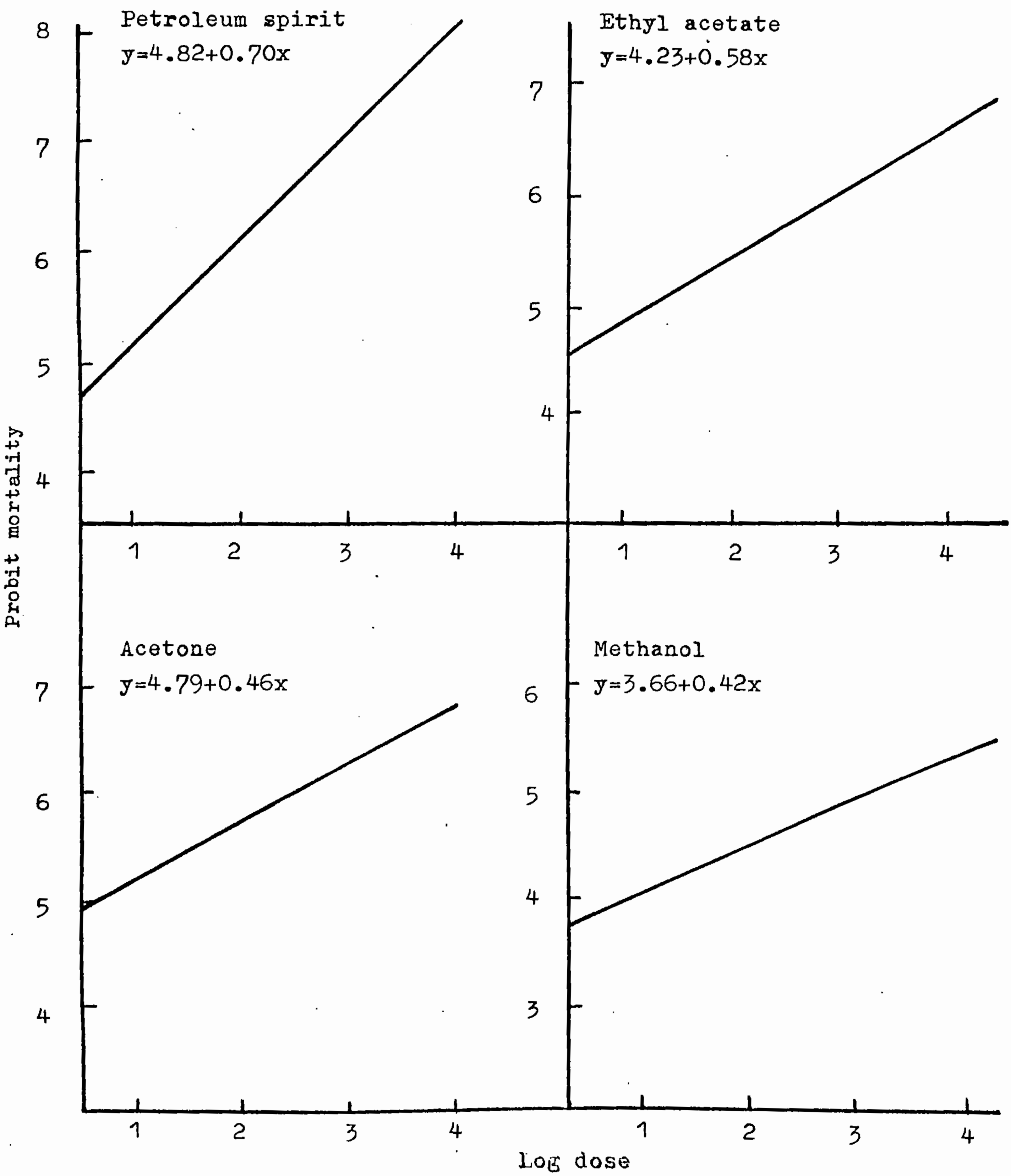
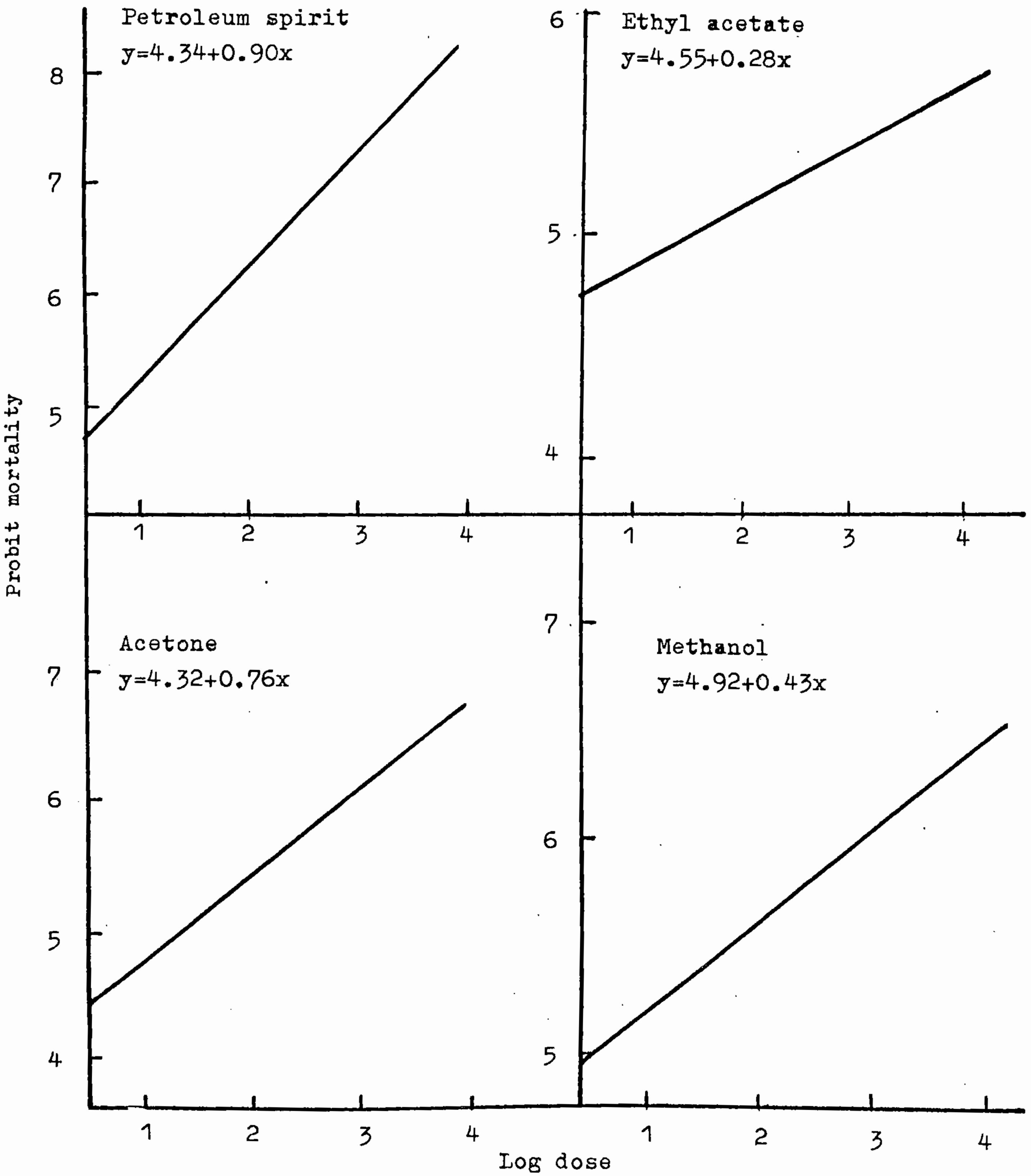


Fig-9. The regression lines of probit mortality on log dose for *T. castaneum* (CTC 12) larvae treated with *A. squamosa* seed extracts in different solvents.



petroleum spirit, ethyl acetate, acetone, and methanol extractions respectively. For CR-I strain the LD_{50} values were 0.0101, 0.0436, 0.2673, and 0.0597 µgm/sq.cm. in the above extractions respectively. In case of FSS-II strain the values were 0.0448, 0.2163, 0.0286 and 50.539 µgm/sq.cm, and for CTC 12 strain the values were 0.0539, 0.4046, 0.0785 and 0.0513 µgm/sq.cm. in the above mentioned extraction respectively. From the results it has been observed that seed extractions with petroleum spirit offered the highest mortality of larvae.

3.4 Effect of seed extraction of A. squamosa on the duration of the immature stages of T. castaneum :

The larvae treated with different doses of seed extract in different solvents showed variable larval periods which are presented in Table 15 and Figure 10. It was observed that in all cases the larval period prolonged with respect to control.

The analysis of variance on the larval period between the strains and between the doses has been shown in Appendix Table LII-LV. The larval period of the treated larvae was insignificant within doses and control and within strains, when they were treated with petroleum spirit extraction. But in case of ethyl acetate, acetone, and methanol extractions larval period of the treated larvae significantly varied with control ($P < 0.001$).

The pupal period was also affected with the larval treatment of extractions and it varied with control in all extractions (Table 16 and Figure 11). The analysis of variance of the pupal period among different doses and control showed similar trend as

Table 15. Larval period (mean ± SD) of different strains of *T. castaneum* treated with different extractions.

Solvent	Doses µgm/sq.cm	Strain			
		Local	CR-I	FSS-II	CTC 12
Petroleum Spirit	A. 48.53	24.89±0.140	25.10±0.143	-	24.28±0.150
	B. 4.853	23.05±0.150	23.21±0.157	24.31±0.223	23.51±0.120
	C. 0.4853	22.27±0.141	22.20±0.086	22.56±0.217	22.13±0.135
	D. 0.04853	21.18±0.104	21.21±0.144	21.94±0.217	21.28±0.093
	0. Control	20.62±0.082	20.20±0.066	21.09±0.140	20.76±0.105
Ethyl acetate	A. 61.08	25.19±0.081	25.07±0.142	25.61±0.158	25.04±0.163
	B. 6.108	23.59±0.120	23.71±0.105	24.35±0.152	23.40±0.126
	C. 0.6108	22.50±0.100	22.53±0.181	23.48±0.121	22.46±0.110
	D. 0.06108	21.38±0.121	21.35±0.188	21.99±0.156	21.71±0.109
	0. Control	20.62±0.082	20.20±0.066	21.09±0.140	20.76±0.105
Acetone	A. 41.63	25.48±0.142	25.13±0.155	25.60±0.243	25.41±0.152
	B. 4.163	24.24±0.141	23.22±0.210	24.35±0.152	24.74±0.093
	C. 0.4163	23.21±0.116	22.50±0.132	23.48±0.121	23.25±0.186
	D. 0.04163	22.05±0.107	21.30±0.112	21.99±0.156	22.17±0.154
	0. Control	20.62±0.082	20.20±0.066	21.09±0.140	20.76±0.105
Methanol	A. 26.04	24.70±0.084	25.15±0.125	25.02±0.181	24.83±0.194
	B. 2.604	23.72±0.101	23.61±0.111	23.65±0.168	23.26±0.173
	C. 0.2604	22.34±0.109	22.46±0.136	22.42±0.186	22.44±0.199
	D. 0.02604	21.10±0.128	21.19±0.089	21.36±0.185	21.82±0.114
	0. Control	20.62±0.082	20.20±0.066	21.09±0.140	20.76±0.105

Table 16. Pupal period (mean ± SD) of different strains of *T. castaneum* emerged from the larvae treated with different extractions.

Solvent	Doses µgm/sq.cm	Strain			
		Local	CR-I	FSS-II	CTC 12
Petroleum Spirit	A. 48.53	6.88±0.059	6.85±0.077	-	7.12±0.058
	B. 4.853	6.68±0.052	6.69±0.068	6.73±0.075	6.82±0.084
	C. 0.4853	6.37±0.069	6.21±0.054	6.32±0.058	6.42±0.048
	D. 0.04853	6.07±0.058	5.92±0.054	5.92±0.073	6.19±0.049
	0. Control	5.81±0.039	5.61±0.058	5.43±0.054	5.91±0.054
Ethyl acetate	A. 61.08	6.80±0.073	6.79±0.059	6.66±0.068	7.06±0.048
	B. 6.108	6.52±0.062	6.53±0.047	6.41±0.062	6.77±0.062
	C. 0.6108	6.26±0.060	6.17±0.049	6.05±0.072	6.47±0.054
	D. 0.06108	5.95±0.045	5.76±0.057	5.73±0.091	6.12±0.050
	0. Control	5.81±0.039	5.61±0.058	5.43±0.054	5.91±0.054
Acetone	A. 41.63	6.83±0.038	6.86±0.054	6.81±0.071	6.95±0.075
	B. 4.163	6.65±0.054	6.45±0.051	6.57±0.048	6.60±0.057
	C. 0.4163	6.45±0.046	6.18±0.061	6.26±0.059	6.40±0.070
	D. 0.04163	6.14±0.047	5.91±0.058	5.73±0.068	6.16±0.047
	0. Control	5.81±0.039	5.61±0.058	5.43±0.054	5.91±0.054
Methanol	A. 26.04	6.76±0.065	6.91±0.067	6.74±0.076	7.16±0.055
	B. 2.604	6.50±0.064	6.54±0.056	6.47±0.083	6.77±0.049
	C. 0.2604	6.23±0.048	6.29±0.057	6.19±0.062	6.52±0.066
	D. 0.02604	6.08±0.039	5.85±0.064	5.81±0.061	6.23±0.050
	0. Control	5.81±0.039	5.61±0.058	5.43±0.054	5.91±0.054

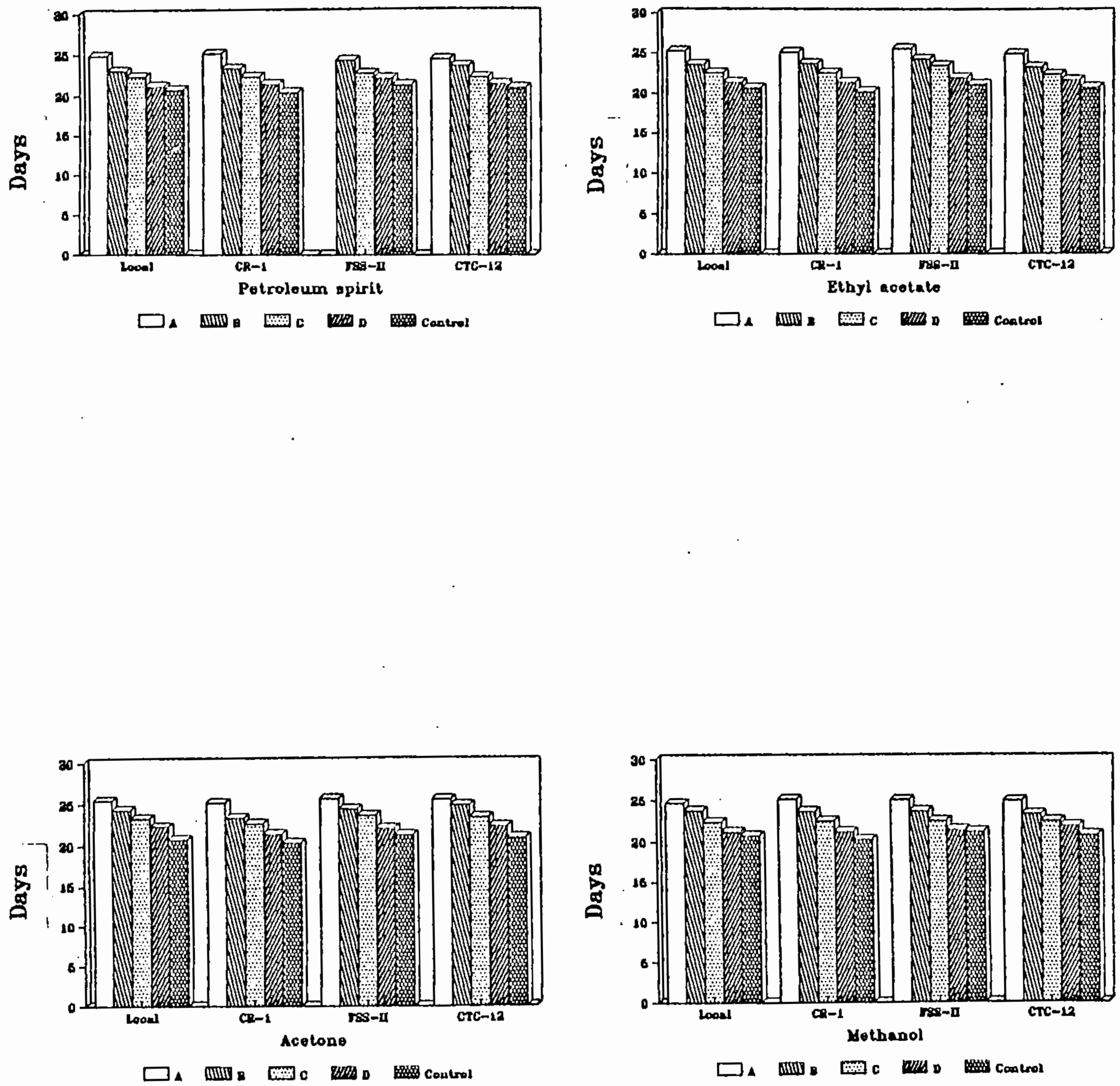


Fig10. Larval period by different strains of *T.castaneum* in different doses seed extraction of *A. squamosa* by different solvents.

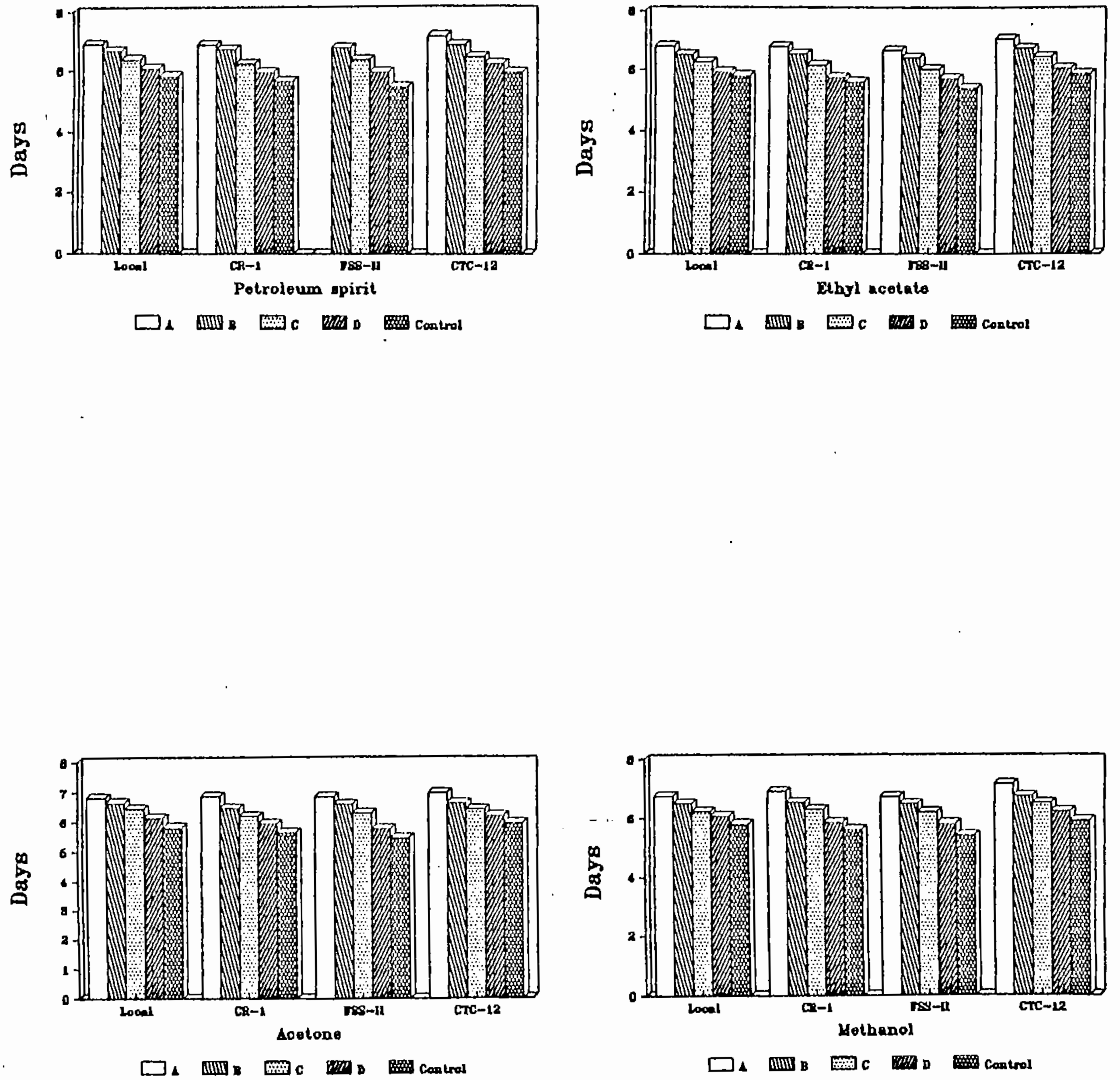


Fig11. Pupal period by different strains of *T.castaneum* in different doses seed extraction of *A.squamosa* by different solvents.

as observed for larval period, i.e., only the pupae and larvae of ethyl acetate, acetone and methanol extractions showed significance difference with control and for petroleum spirit extraction treated larvae the pupal period was insignificant (Appendix Tables LVI-LIX).

3.5 Fecundity and hatchability of eggs of the adults resulted from the treated larvae with plant extracts :

The adults emerged from the treated larvae were kept for oviposition and the number of eggs laid in first saven days has been presented in Tables 17-20 and Figure 12. It was observed that the larvae treated with the extraction in petroleum spirit gave the adults which oviposited 4.14, 7.14, 10.71, 14.00, and 22.42 eggs per day in A, B, C, D doses and control respectively for Local strain. The fecundity was 3.71, 6.71, 9.42, 14.57, and 21.85 for CR-I strain; in the above doses respectively. In FSS-II and CTC 12 strain 100% mortality of larvae occured in the highest dose A. In doses B,C,D and control the fecundity was recorded as 8.00, 11.85, 16.57, and 24.00, for FSS-II strains and 4.71, 7.71, 12.14, and 21.14 in CTC 12 strains respectively.

For the extraction with ethyl acetate the fecundity was recorded for Local strain as 4.71, 9.42, 13.00, 16.14 and 24.14; in CR-I strain it was 4.42, 7.57, 11.85, 16.14 and 23.71; in FSS-II strain it was 6.57, 10.85, 14.14, 19.24 and 24.28; and in CTC 12 strain the fecundity was 7.28, 11.57, 15.75, 19.57 and 25.14 eggs per day per female in the doses A, B, C, D and control respectively. For the extraction with acetone the fecundity was recorded for Local strain as 4.14, 7.57, 11.71, 17.71, and 23.42; in CR-I strain if 7.28, 10.57, 13.85, 18.71 and 24.42; in FSS-II strain it was 6.85, 10.28, 13.85, 19.14, and 24.57; and CTC 12 strain the fecundity was 7.71, 11.57, 16.00, 19.42 and 26.00 eggs per day per female in the doses A, B, C, D and control respectively. For the extraction with methanol the fecundity was recorded for Local strain as 6.42, 8.57, 13.28, 19.28, and 25.71; in CR-I strain it was 6.71, 10.28, 13.38, 18.42, and 25.14; in FSS-II strain it was 4.57, 8.42, 13.71, 18.42, and 23.57; and CTC 12 strain the fecundity was 7.42, 10.85, 15.57, 19.71 and 24.14 eggs per day per female in the doses A, B, C, D and control respectively.

In all cases the fecundity among different dose of all extractions differ significantly ($P<0.001$). But in case of the fecundity among different strains with petroleum spirit extraction it differ significantly ($P<0.05$) and the mean number of eggs laid per day per female of CTC 12 strain significantly differ with all other strains. There occured no significant difference between the mean number of eggs laid of local and CR-I strain (Appendix Table LX). In ethyl acetate extraction the mean number of eggs laid among the four strain differ significantly, and the LSD value 0.1% level of significance shows that there is no differences among the number of eggs laid of local, CR-I, and among FSS-II and CTC 12 strains (Appendix Tables LXI). In acetone extraction the fecundity (Appendix Table LXII) among different strains differ significantly ($P<0.001$). But in case of methanol extraction the LSD value at 5% level of significance shows that the mean number of eggs laid of FSS-II strain significantly differ with CR-I and CTC 12 only (Appendix Table LXIII). So it was observed that the control insects always laid more eggs than the adults emarged from the treated larvae with extractions.

The hatchability of the eggs laid by the adults emarged from the treated and control larvae has been presented in Tables 21-24. It was observed that the hatchability of the eggs laid by the female emarged from the petroleum spirit treated larvae were 43.06, 46.94, 55.95, 61.94, and 100.0% in A, B, C, D doses and control respectively for local strain. It was 46.67, 51.50, 59.23, 63.50 and 96.61% for CR-I strain; in the above doses respectively. In FSS-II and CTC 12 strain 100% mortality of larvae was occur in the highest doses A. In doses B, C, D and control the hatchability was recorded as 45.34, 51.23, 56.37 and 98.44%, for FSS-II strain and 46.77, 53.08, 59.34 and 100.0% in CTC 12 strain respectively.

For the extraction with ethyl acetate the hatchability was recorded for local strain as 44.55, 50.94, 58.19, 62.86 and 100.0%; in CR-I strain it was 44.36, 49.64, 52.86, 60.27, and 98.70%; in FSS-II strain it was 50.41, 55.05, 60.01, 64.72, and 99.10%; and CTC 12 strain in hatchability was 51.77, 54.36, 58.83, 65.49 and 100.0% in the doses A, B, C, D and control respectively. For the extraction with acetone the hatchability was recorded for local strain as 40.69, 44.68, 53.66, 63.43 and 100.0%; in CR-I strain it was 50.48, 53.59, 58.06, 64.05 and

Table 17. The number of egg-laid by *T. castaneum* per female per day in different doses of petroleum spirit seed extraction of *A. squamosa*.

Strain	Doses µgm/sq.cm	Replication (days) 1	2	3	4	5	6	7	Mean
Local	A. 48.53	1	2	3	3	6	6	8	4.14
	B. 4.853	2	3	4	7	9	11	14	7.14
	C. 0.4853	3	5	6	9	13	17	22	10.71
	D. 0.04853	5	6	7	12	17	22	29	14.00
	0. Control	8	8	10	19	30	36	46	22.42
CR-I	A. 48.53	1	1	3	3	4	6	8	3.71
	B. 4.853	2	3	4	6	7	10	15	6.71
	C. 0.4853	2	3	5	9	13	15	19	9.42
	D. 0.04853	4	6	7	13	19	22	31	14.57
	0. Control	7	9	9	21	29	35	43	21.85
FSS-II	A. 48.53	-	-	-	-	-	-	-	-
	B. 4.853	2	3	6	7	11	12	15	8.00
	C. 0.4853	4	6	8	11	13	19	22	11.85
	D. 0.04853	5	8	10	19	20	24	30	16.57
	0. Control	7	10	13	29	31	36	42	24.00
CTC 12	A. 48.53	-	-	-	-	-	-	-	-
	B. 4.853	1	2	3	5	6	7	9	4.71
	C. 0.4853	2	4	5	7	9	12	15	7.71
	D. 0.04853	4	6	7	12	15	19	22	12.14
	0. Control	7	10	12	20	29	27	43	21.14

Table 18. The number of egg-laid by *T. castaneum* per female per day in different doses of Ethyl acetate seed extraction of *A. squamosa*.

Strain	Doses ugm/sq.cm	Replication (days)							Mean
		1	2	3	4	5	6	7	
Local	A. 61.08	1	2	4	5	5	7	9	4.71
	B. 6.108	3	4	6	9	11	15	18	9.42
	C. 0.6108	4	6	7	12	16	20	26	13.00
	D. 0.06108	5	7	9	15	19	24	34	16.14
	0. Control	9	11	12	23	34	38	42	24.14
CR-I	A. 61.08	1	2	3	4	4	7	10	4.42
	B. 6.108	1	3	4	5	9	14	17	7.57
	C. 0.6108	3	5	6	9	16	19	25	11.85
	D. 0.06108	5	7	9	14	20	26	32	16.14
	0. Control	9	10	11	26	33	37	40	23.71
FSS-II	A. 61.08	2	3	4	7	8	10	12	6.57
	B. 6.108	3	5	7	10	12	17	22	10.85
	C. 0.6108	4	6	8	15	18	22	26	14.14
	D. 0.06108	6	9	11	22	23	30	35	19.42
	0. Control	8	11	12	26	34	38	41	24.28
CTC 12	A. 61.08	2	2	4	7	10	11	15	7.28
	B. 6.108	3	5	6	13	12	17	25	11.57
	C. 0.6108	4	6	7	16	20	25	31	15.75
	D. 0.06108	6	8	9	21	25	31	37	19.57
	0. Control	9	11	14	25	31	36	50	25.14

Table 19. The number of egg-laid by T. castaneum per female per day in different doses of Acetone seed extraction of A. squamosa.

Strain	Doses µgm/sq.cm	Replication (days) 1	2	3	4	5	6	7	Mean
Local	A. 41.63	1	2	3	4	5	6	8	4.14
	B. 4.163	2	3	6	7	9	11	15	7.57
	C. 0.4163	3	6	8	11	14	18	22	11.71
	D. 0.04163	6	7	9	19	21	29	33	17.71
	0. Control	7	9	11	24	31	34	48	23.42
CR-I	A. 41.63	2	2	3	7	11	12	14	7.28
	B. 4.163	3	4	5	11	13	17	21	10.57
	C. 0.4163	4	6	6	14	17	23	27	13.85
	D. 0.04163	6	8	9	19	23	30	36	18.71
	0. Control	8	9	10	25	35	39	45	24.42
FSS-II	A. 41.63	2	3	4	6	9	11	13	6.85
	B. 4.163	3	5	6	11	13	15	19	10.28
	C. 0.4163	4	7	9	14	19	20	24	13.85
	D. 0.04163	6	9	12	20	26	29	32	19.14
	0. Control	8	13	15	27	31	35	43	24.57
CTC 12	A. 41.63	2	3	5	6	11	13	14	7.71
	B. 4.163	3	6	7	10	14	19	22	11.57
	C. 0.4163	4	7	8	17	21	26	29	16.00
	D. 0.04163	5	8	10	20	26	30	37	19.42
	0. Control	10	13	15	29	33	37	45	26.00

Table 20. The number of egg-laid by T. castaneum per female per day in different doses of Methanol seed extraction of A. squamosa.

Strain	Doses µgm/sq.cm	Replication (days)							Mean
		1	2	3	4	5	6	7	
Local	A. 26.04	2	3	5	5	8	10	12	6.42
	B. 2.604	2	4	6	8	10	14	16	8.57
	C. 0.2604	4	6	9	11	16	22	25	13.28
	D. 0.02604	6	8	10	21	21	31	38	19.28
	O. Control	8	10	12	27	35	39	49	25.71
CR-I	A. 26.04	2	3	3	6	9	11	13	6.71
	B. 2.604	3	4	5	10	14	16	20	10.28
	C. 0.2604	4	7	8	14	17	22	25	13.~~85~~ 38
	D. 0.02604	6	9	9	18	24	29	34	18.42
	O. Control	8	11	12	28	30	40	47	25.14
FSS-II	A. 26.04	1	2	4	5	6	6	8	4.57
	B. 2.604	2	4	5	9	12	14	13	8.42
	C. 0.2604	4	5	8	13	20	22	24	13.71
	D. 0.02604	5	8	9	19	24	30	34	18.42
	O. Control	9	9	11	26	35	35	40	23.57
CTC 12	A. 26.04	2	3	4	9	11	11	12	7.42
	B. 2.604	3	5	6	11	13	18	20	10.85
	C. 0.2604	5	7	9	16	19	25	28	15.57
	D. 0.02604	6	9	11	22	24	32	34	19.71
	O. Control	8	12	14	27	30	36	42	24.14

Table 21. Hatching percentage of eggs laid by *T. castaneum* in different doses of petroleum spirit seed extractions of *A. squamosa*,

Strain	Doses µgm/sq.cm	Replication (days)							Mean
		1	2	3	4	5	6	7	
Local	A. 48.53	0	50.00	33.33	66.67	50.00	33.33	25.00	43.06
	B. 4.853	50.00	33.33	50.00	42.86	55.56	45.45	50.00	46.~~74~~94
	C. 0.4853	66.67	40.00	66.67	55.56	46.15	52.94	63.64	55.95
	D. 0.04853	60.00	75.00	42.86	66.67	58.82	68.18	62.07	61.94
	0. Control	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
CR-I	A. 48.53	0	0	33.33	66.67	50.00	33.33	50.00	46.67
	B. 4.853	50.00	33.33	50.00	66.67	57.14	50.00	53.33	51.50
	C. 0.4853	50.00	66.67	60.00	55.56	61.54	60.00	63.16	59.23
	D. 0.04853	75.00	66.67	42.86	53.85	68.42	72.73	74.19	63.50
	0. Control	100.00	88.89	100.00	100.00	93.10	94.29	100.00	96.61
FSS-II	A. 48.53	0	0	0	0	0	0	0	0
	B. 4.853	50.00	33.33	66.67	42.85	36.36	41.67	46.67	45.34
	C. 0.4853	50.00	66.67	75.00	36.36	38.46	42.11	50.00	51.23
	D. 0.04853	60.00	62.50	60.00	42.11	55.00	58.33	56.67	56.37
	0. Control	100.00	100.00	92.31	100.00	96.77	100.00	100.00	98.44
CTC 12	A. 48.53	0	0	0	0	0	0	0	0
	B. 4.853	0	50.00	33.33	60.00	50.00	42.86	44.44	46.77
	C. 0.4853	50.00	75.00	40.00	57.14	44.44	58.33	46.67	53.08
	D. 0.04853	75.00	66.67	42.86	50.00	53.33	68.42	59.09	59.34
	0. Control	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 22. Hatching percentage of eggs laid by T. castaneum in different doses of ethyl acetate seed extraction of A. squamosa,

Strain	Doses /ugm/sq.cm	Replication (days)							Mean
		1	2	3	4	5	6	7	
Local	A. 61.08	0	50.00	50.00	40.00	40.00	42.85	44.44	44.55
	B. 6.108	33.33	50.00	66.67	55.56	54.55	46.67	50.00	50.9~~1~~4
	C. 0.6108	75.00	66.67	42.86	50.00	56.25	55.00	61.54	58.~~79~~19
	D. 0.06108	60.00	57.14	66.67	60.00	73.68	66.67	55.88	62.86
	0. Control	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
CR-I	A. 61.08	0	50.00	33.33	50.00	50.00	42.86	40.00	44.36
	B. 6.108	0	33.33	50.00	60.00	44.44	57.14	52.94	49.64
	C. 0.6108	33.33	60.00	50.00	55.55	62.50	52.63	56.00	52.86
	D. 0.06108	60.00	57.14	66.67	57.14	60.00	61.54	59.38	60.27
	0. Control	100.00	100.00	90.91	100.00	100.00	100.00	100.00	98.70
FSS-II	A. 61.08	50.00	33.33	75.00	42.86	50.00	60.00	41.67	50.41
	B. 6.108	66.67	60.00	42.85	50.00	58.33	52.94	54.54	55.05
	C. 0.6108	75.00	66.67	50.00	46.67	61.11	59.09	61.54	60.01
	D. 0.06108	66.67	77.76	54.55	63.64	60.86	66.67	62.86	64.72
	0. Control	100.00	100.00	100.00	96.15	100.00	100.00	97.56	99.10
CTC 12	A. 61.08	50.00	50.00	75.00	42.86	50.00	54.54	40.00	51.77
	B. 6.108	66.67	60.00	66.67	46.15	50.00	47.06	44.00	54.36
	C. 0.6108	75.00	66.67	42.86	50.00	60.00	56.00	61.29	58.83
	D. 0.06108	66.67	75.00	55.56	61.90	64.00	67.74	67.56	65.49
	0. Control	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 23. Hatching percentage of eggs laid by T. castaneum in different doses of acetone seed extractions of A. squamosa.

Strain	Doses µgm/sq.cm	Replication (days)							Mean
		1	2	3	4	5	6	7	
Local	A. 41.63	0	50.00	33.33	50.00	40.00	33.33	37.50	40.69
	B. 4.163	50.00	33.33	50.00	42.86	44.44	45.45	46.67	44.68
	C. 0.4163	66.67	50.00	62.50	36.36	50.00	55.56	54.55	53.66
	D. 0.04163	66.67	71.42	44.44	57.89	61.90	68.96	72.73	63.43
	0. Control	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
CR-I	A. 4163	50.00	50.00	33.33	57.14	54.55	58.33	50.00	50.48
	B. 4.163	66.67	50.00	40.00	54.55	53.84	52.94	57.14	53.59
	C. 0.4163	50.00	66.67	66.67	50.00	52.94	60.86	59.26	58.06
	D. 0.04163	66.67	75.00	55.56	68.42	56.52	66.67	63.89	64.05
	0. Control	100.00	100.00	100.00	100.00	97.14	100.00	100.00	99.59
FSS-II	A. 41.63	50.00	33.33	50.00	66.67	55.56	54.55	53.85	51.99
	B. 4.163	33.33	60.00	50.00	45.45	53.85	60.00	68.42	53.01
	C. 0.4163	50.00	57.14	55.55	42.86	57.89	60.00	66.67	55.73
	D. 0.04163	66.67	66.67	58.33	60.00	53.85	62.07	62.50	61.44
	0. Control	100.00	92.30	100.00	100.00	100.00	100.00	100.00	98.90
CTC 12	A. 41.63	50.00	66.67	40.00	50.00	54.55	53.85	57.14	53.17
	B. 4.163	66.67	50.00	57.14	60.00	50.00	52.63	54.55	55.85
	C. 0.4163	75.00	42.85	62.50	47.05	61.90	61.54	65.52	59.48
	D. 0.04163	60.00	75.00	60.00	65.00	61.54	66.67	67.56	65.11
	0. Control	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 24. Hatching percentage of eggs laid by *T. castaneum* in different doses of methanol seed extractions of *A. squamosa*.

Strain	Doses /ugm/sq.cm	Replication (days)							Mean
		1	2	3	4	5	6	7	
Local	A. 26.04	50.00	33.33	40.00	60.00	37.50	40.00	33.33	42.02
	B. 2.604	50.00	50.00	33.33	62.50	40.00	42.85	43.75	46.06
	C. 0.2604	25.00	66.67	55.56	54.55	50.00	50.00	52.00	50.54
	D. 0.02604	66.67	62.50	60.00	57.14	52.38	54.83	57.89	58.77
	0. Control	100.00	100.00	100.00	100.00	100.00	100.00	97.96	99.71
CR-I	A. 26.04	50.00	33.33	33.33	66.67	55.56	45.45	53.85	48.31
	B. 2.604	66.67	50.00	40.00	50.00	57.14	50.00	50.00	51.97
	C. 0.2604	50.00	57.14	62.50	57.14	52.94	59.09	56.00	56.40
	D. 0.02604	66.67	55.56	55.56	61.11	62.50	62.07	58.82	60.33
	0. Control	100.00	90.91	100.00	100.00	100.00	100.00	100.00	98.70
FSS-II	A. 26.04	0	50.00	50.00	40.00	50.00	66.67	37.50	49.03
	B. 2.604	50.00	50.00	60.00	55.56	58.33	57.14	46.15	53.88
	C. 0.2604	50.00	60.00	62.50	61.54	60.00	63.64	62.50	60.03
	D. 0.02604	60.00	62.50	66.67	63.16	62.50	66.67	61.76	63.32
	0. Control	100.00	100.00	100.00	100.00	100.00	100.00	97.50	99.64
CTC 12	A. 26.04	50.00	66.67	50.00	55.56	45.45	45.45	41.67	50.69
	B. 2.604	66.67	40.00	50.00	54.55	46.15	55.56	55.55	52.64
	C. 0.2604	60.00	57.14	55.56	56.25	52.63	56.00	57.14	56.39
	D. 0.02604	66.67	66.67	45.45	59.09	62.50	62.50	64.71	61.08
	0. Control	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

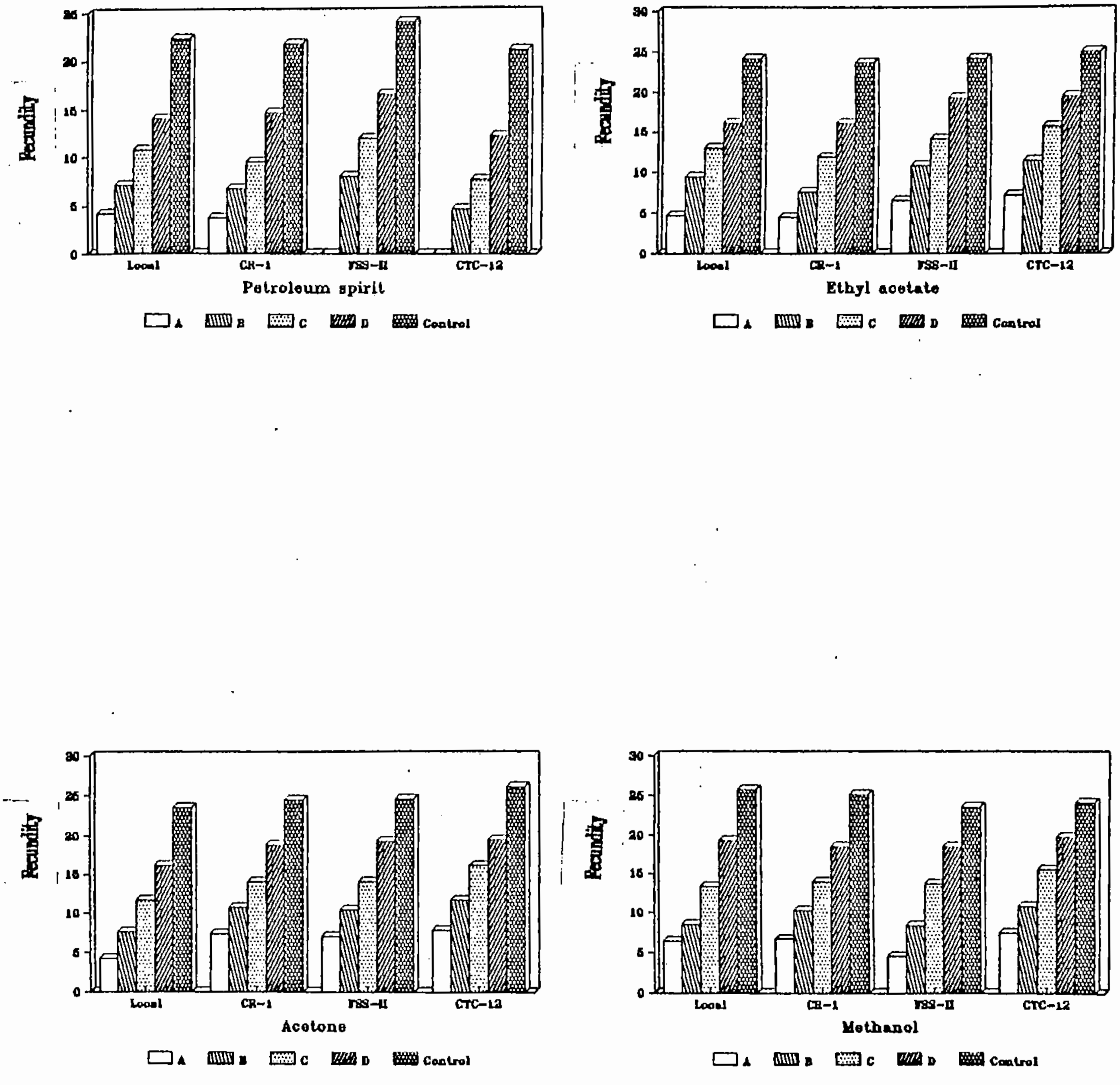


Fig 12. Number of eggs-laid by *T.castaneum* per female per day in defferent doses seed extraction of *A.*squamosa by different solvents.

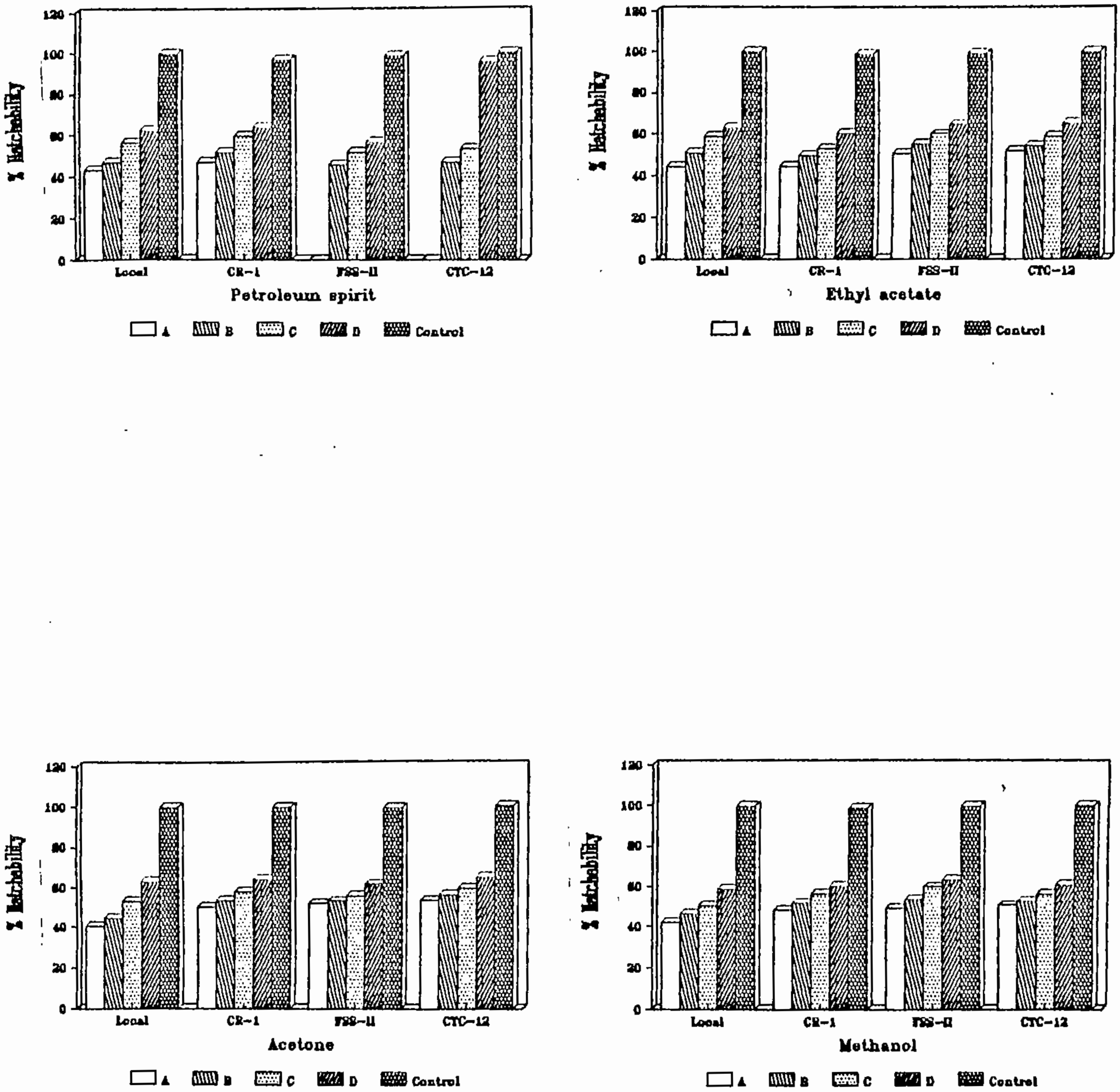


Fig 13. Hatchability of *T.castaneum* in different doses seed extraction of *A.squamosa* by different solvents.

99.59%; in FSS-II strain it was 51.99, 53.01, 55.73, 61.44 and 98.90%; and CTC 12 strain the hatchability was recorded for local strain as 42.02, 46.06, 50.54, 58.77 and 99.71%; in CR-I strain they were 48.31, 51.97, 56.40, 60.33, and 98.70%; in FSS-II strain it was 49.03, 53.88, 60.02, 63.32 and 99.64%; and CTC 12 strain the hatchability was 50.69, 52.64, 56.39, 61.08 and 100.0% in the doses A, B, C, D and control respectively.

The analysis of variance of hatchability among different strains and among different doses are performed. Within strains the results is significant in all extractions except in petroleum spirit. But among the doses and control it shows always highly significant ($P<0.01$) results.

In petroleum spirit extraction the hatchability of eggs laid by female emarged from the treated larvae shows that the mean control hatchability percentage differ significantly with the treated ones. The LSD value shows that in all extractions the control mean always differ significantly at 0.1% level of significance with the treated ones (Appendix Table LXIV-LXVII).

3.6 Effect of combined doses of seed extractions of <u>A. squamosa</u> and methacrifos on the adult of <u>T. castaneum</u> :

The results for the combined action of seed extracts and methacrifos are presented in Tables 25-28. Seed extracts of <u>A. squamosa</u> played a synergistic role on methacrifos killing significantly higher numbers of the flour beetle, <u>T. castaneum</u> with the mortality due to the individual action of the seed extracts and methacrifos for all the strains. But the extraction with ethyl acetate showed no synergistic effect on T. castaneum except CTC 12, where significant result is found. Also the insignificant results were obtained in case of extraction methanol for CR-I after 12 and 24 hours of treatment and CTC 12 strain only for 24 hours.

The mortality of the adults due to low dose of insecticide, seed extracts, and their combined doses for four studied strain after 12 and 24 hours after treatment have been presented in figures 14-21.

Table 25. Mortality of adult T. castaneum (Local) treated in insecticide A. squamosa seed extractions and their combined doses.

Treat-ment	Dose of extraction µgm/sq.cm	N_S	Y_S	X_S	N_A	Y_A	X_A	N_C	Y_C	X_C	Chi-sq.
SPS12	4.37	40	7	33	40	0	40	40	18	22	10.476**
SEA12	5.50	40	7	33	40	1	39	40	13	27	2.151
SAC12	3.75	40	7	33	40	0	40	40	16	24	7.013**
SME12	2.34	40	7	33	40	0	40	40	20	20	14.632***
SPS24	4.37	40	21	19	40	1	39	40	32	8	5.638*
SEA24	5.50	40	21	19	40	2	38	40	28	12	1.893
SAC24	3.75	40	21	19	40	0	40	40	30	10	4.060*
SME24	2.34	40	21	19	40	2	38	40	31	9	4.236*

Dose of insecticide = 0.001493 µgm/sq.cm

Notes :

N_S = number of insects used in insecticide

Y_S = number of insects killed in insecticide

X_S = number of insects surviving in insecticide

N_A = number of insects used in extract

Y_A = number of insects killed in extract

X_A = number of insects surviving in extract

N_C = number of insects used in combined dose

Y_C = number of insects killed in combined dose

X_C = number of insects surviving in combined dose

SPT= Seed extract in petroleum spirit

SET= Seed extract in ethyl acetate

SAT= Seed extract in acetone

SMT= Seed extract in methanol

12 and 24 indicate the duration of treatment (in hours)

* $P < 0.05$, ** $P < 0.01$ and *** $P < 0.001$

Table 26. Mortality of adult *T. castaneum* (CR-I) treated in insecticide *A. squamosa* seed extractions and their combined dose.

Treatment	Dose of extraction µgm/sq.cm	N_S	Y_S	X_S	N_A	Y_A	X_A	N_C	Y_C	X_C	Chi-sq.
SPS12	10.060	40	10	30	40	0	40	40	19	21	5.400*
SEA12	14.148	40	10	30	40	0	40	40	16	24	2.400**
SAC12	12.269	40	10	30	40	0	40	40	21	19	8.067
SME12	3.109	40	10	30	40	3	37	40	18	22	2.007
SPS24	10.060	40	15	25	40	1	39	40	25	15	4.671*
SEA24	14.148	40	15	25	40	0	40	40	21	19	1.920
SAC24	12.269	40	15	25	40	0	40	40	24	16	4.320*
SME24	3.109	40	15	25	40	7	33	40	25	15	1.699

Dose of insecticide = 0.001493 µgm/sq.cm.

Notes :

N_S = number of insects used in insecticide

Y_S = number of insects killed in insecticide

X_S = number of insects surviving in insecticide

N_A = number of insects used in extract

Y_A = number of insects killed in extract

X_A = number of insects surviving in extract

N_C = number of insects used in combined dose

Y_C = number of insects killed in combined dose

X_C = number of insects surviving in combined dose

SPT= Seed extract in petroleum spirit

SET= Seed extract in ethyl acetate

SAT= Seed extract in acetone

SMT= Seed extract in methanol

12 and 24 indicate the duration of treatment (in hours)

$^{*}P < 0.05$ and $^{**}P < 0.01$

Table 27. Mortality of adult T. castaneum (FSS-II) treatment in insecticide A. squamosa seed extractions and their combined dose.

Treat-ment	Dose of extraction /ugm/sq.cm	N_S	Y_S	X_S	N_A	Y_A	X_A	N_C	Y_C	X_C	Chi-sq.
SPS12	4.37	40	8	32	40	0	40	40	16	24	5.000*
SEA12	5.50	40	8	32	40	1	39	40	14	26	1.992
SAC12	3.75	40	8	32	40	0	40	40	19	21	9.453**
SME12	2.34	40	8	32	40	1	39	40	17	23	4.954*
SPS24	4.37	40	14	26	40	2	38	40	24	16	4.099*
SEA24	5.50	40	14	26	40	1	39	40	21	19	2.198
SAC24	3.75	40	14	26	40	0	40	40	28	12	10.769**
SME24	2.34	40	14	26	40	3	37	40	25	15	4.416*

Dose of insecticide = 0.001493/ugm/sq.cm

Notes :

N_S = number of insects used in insecticide

Y_S = number of insects killed in insecticide

X_S = number of insects surviving in insecticide

N_A = number of insects used in extract

Y_A = number of insects killed in extract

X_A = number of insects surviving in extract

N_C = number of insects used in combined dose

Y_C = number of insects killed in combined dose

X_C = number of insects surviving in combined dose

SPT= Seed extract in petroleum spirit

SET= Seed extract in ethyl acetate

SAT= Seed extract in acetone

SMT= Seed extract in methanol

12 and 24 indicate the duration of treatment (in hours)

$^{*}P<0.05$ and $^{**}P<0.01$

Table 28. Mortality of adult T. castaneum (CTC 12) treated in insecticide A. squamosa seed extractions and their combined dose.

Treat-ment	Dose of extraction µgm/sq.cm	N_S	Y_S	X_S	N_A	Y_A	X_A	N_C	Y_C	X_C	Chi-sq.
SPS12	4.37	40	5	35	40	0	40	40	13	27	7.314**
SEA12	5.50	40	5	35	40	0	40	40	17	23	16.457***
SAC12	3.75	40	5	35	40	0	40	40	18	22	19.314**
SME12	2.34	40	5	35	40	3	37	40	15	25	4.518*
SPS24	4.37	40	13	27	40	2	38	40	24	16	5.848*
SEA24	5.50	40	13	27	40	2	38	40	26	14	7.546*
SAC24	3.75	40	13	27	40	3	37	40	17	13	7.899**
SME24	2.34	40	13	27	40	6	34	40	24	16	2.619

Dose of insecticide = 0.001493 µgm/sq.cm

Notes :

N_S = number of insects used in insecticide

Y_S = number of insects killed in insecticide

X_S = number of insects surviving in insecticide

N_A = number of insects used in extract

Y_A = number of insects killed in extract

X_A = number of insects surviving in extract

N_C = number of insects used in combined dose

Y_C = number of insects killed in combined dose

X_C = number of insects surviving in combined dose

SPT = Seed extract in petroleum spirit

SET = Seed extract in ethyl acetate

SAT = Seed extract in acetone

SMT = Seed extract in methanol

12 and 24 indicate the duration of treatment (in hours)

* $P < 0.05$, ** $P < 0.01$ and *** $P < 0.001$

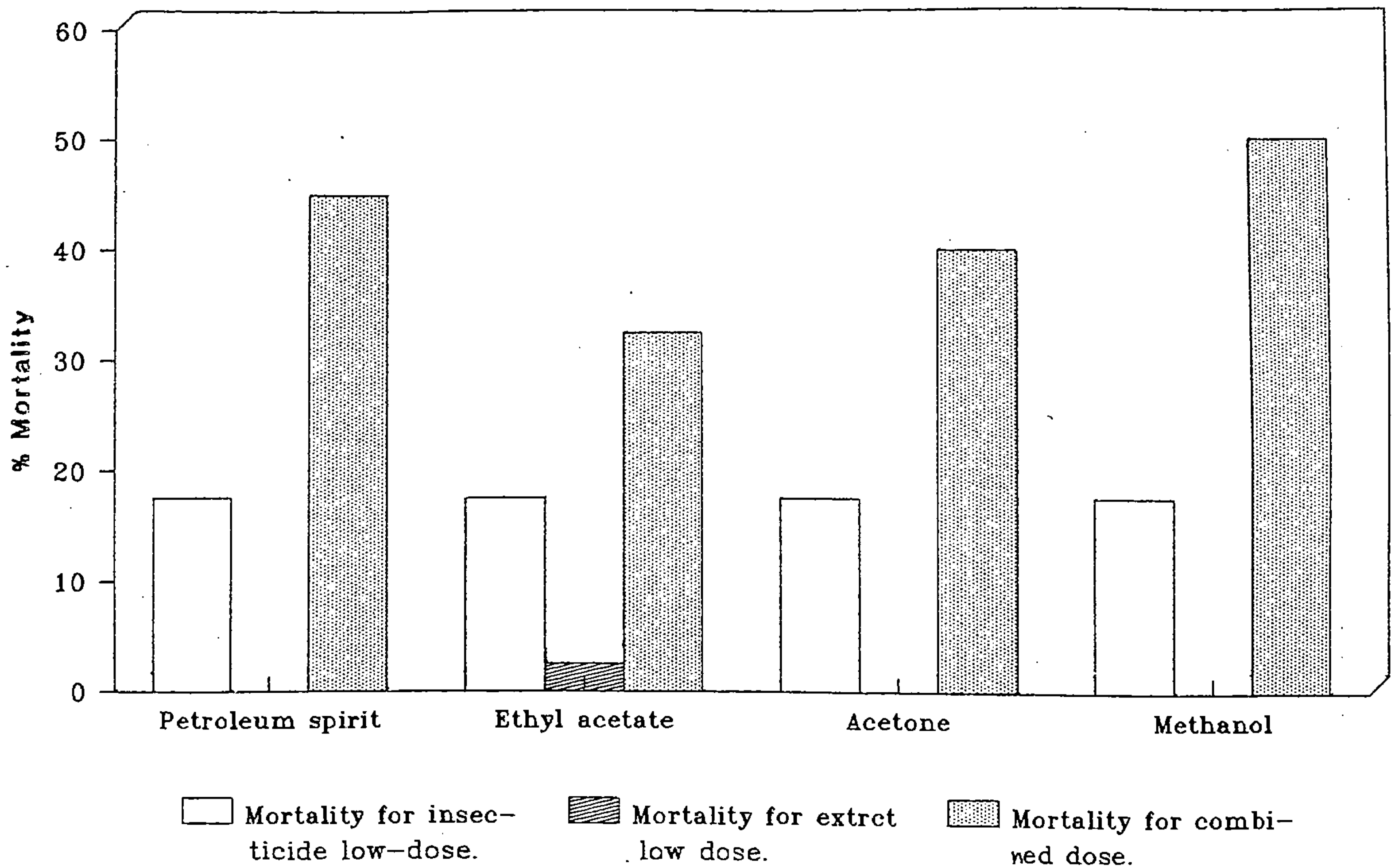


Fig 14. Mortality percentage of adult *T.castaneum* (Local) treated with seed extraction *A.squamosa*, methacrifos and their combined doses after 12 hours treatment.

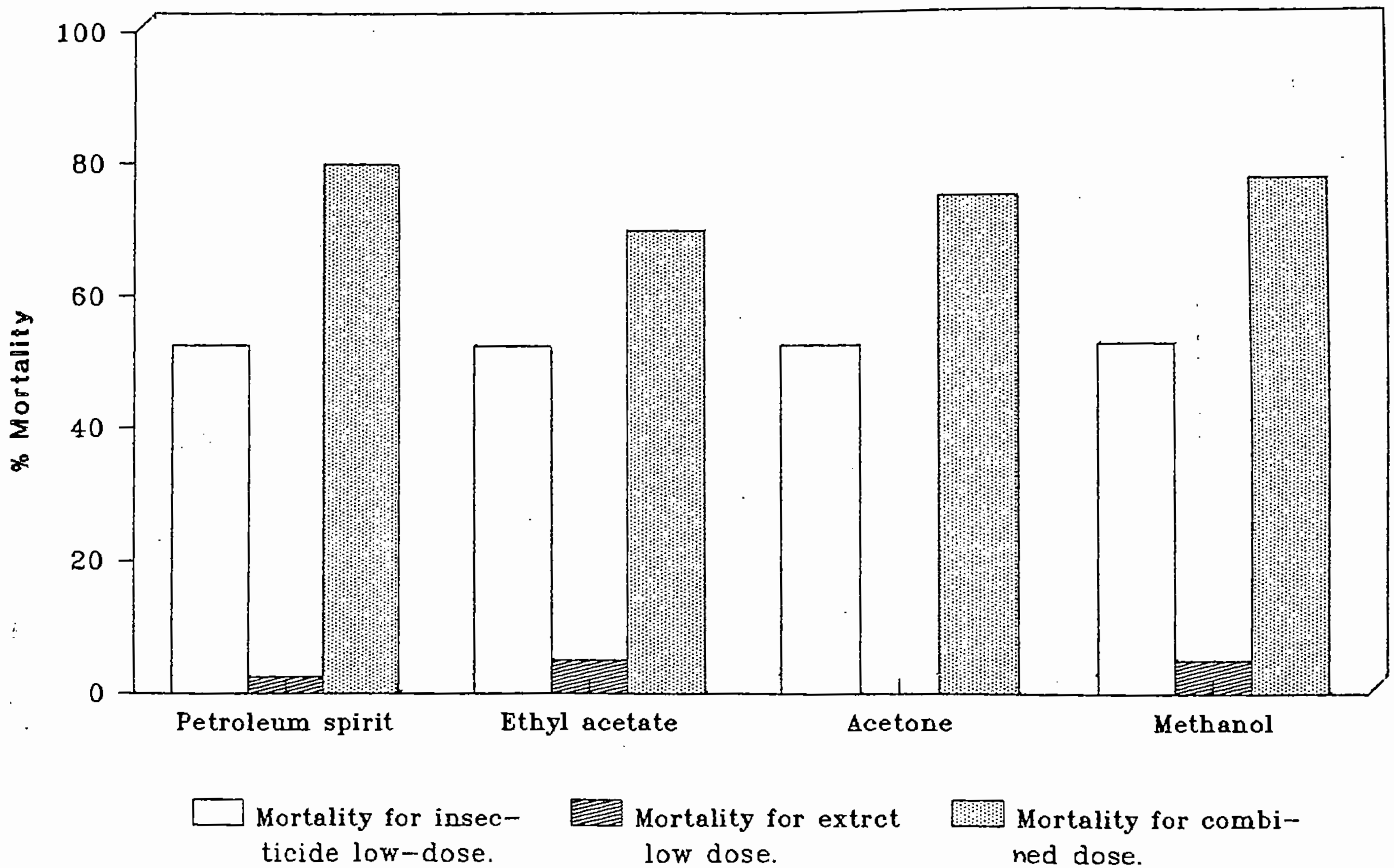


Fig 15. Mortality percentage of adult *T.castaneum* (Local) treated with seed extraction *A.squamosa*, methacrifos and their combined doses after 24 hours treatment.

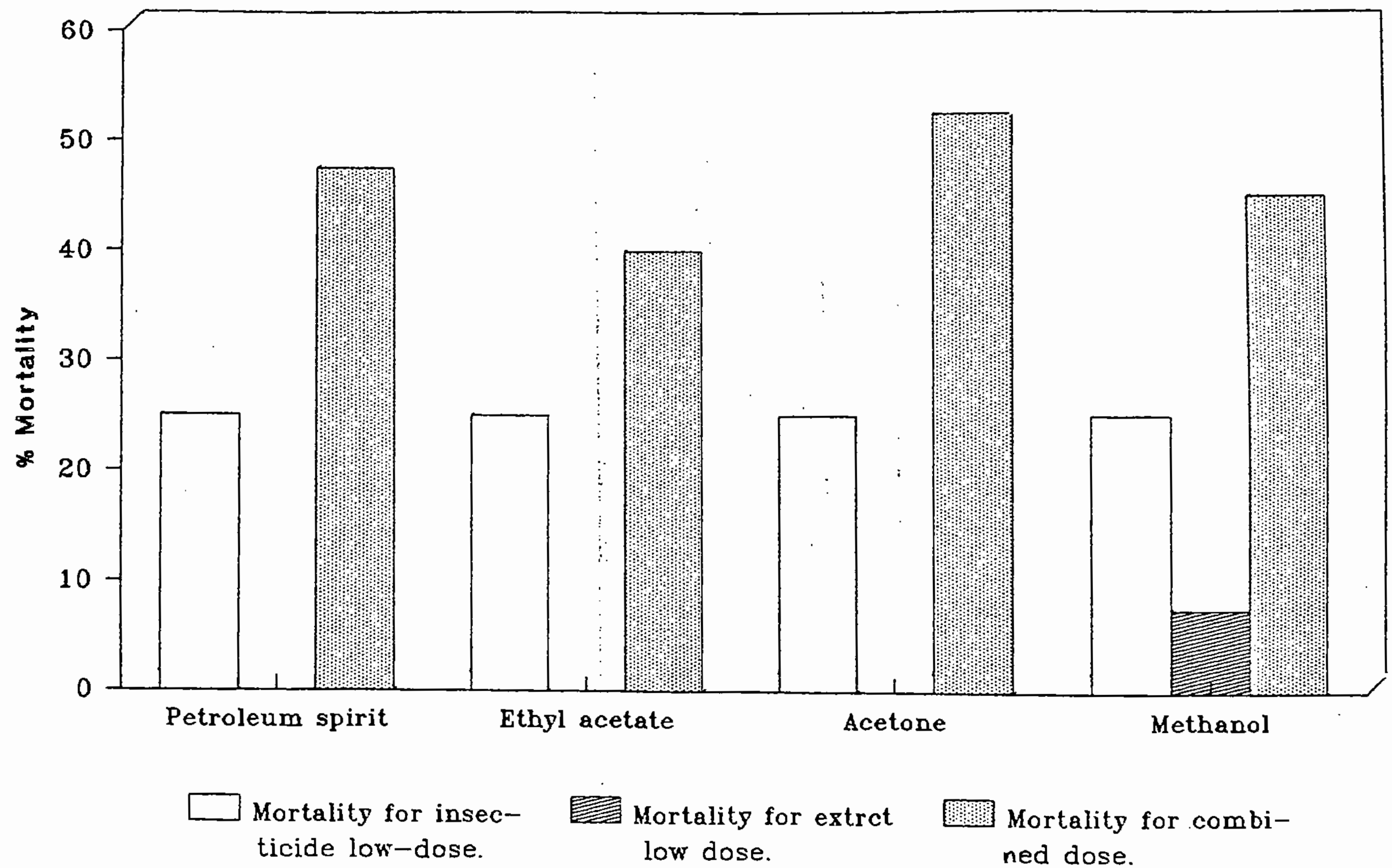


Fig 16. Mortality percentage of adult *T.castaneum* (CR- I) treated with seed extraction *A.squamosa*, methacrifos and their combined doses after 12 hours treatment.

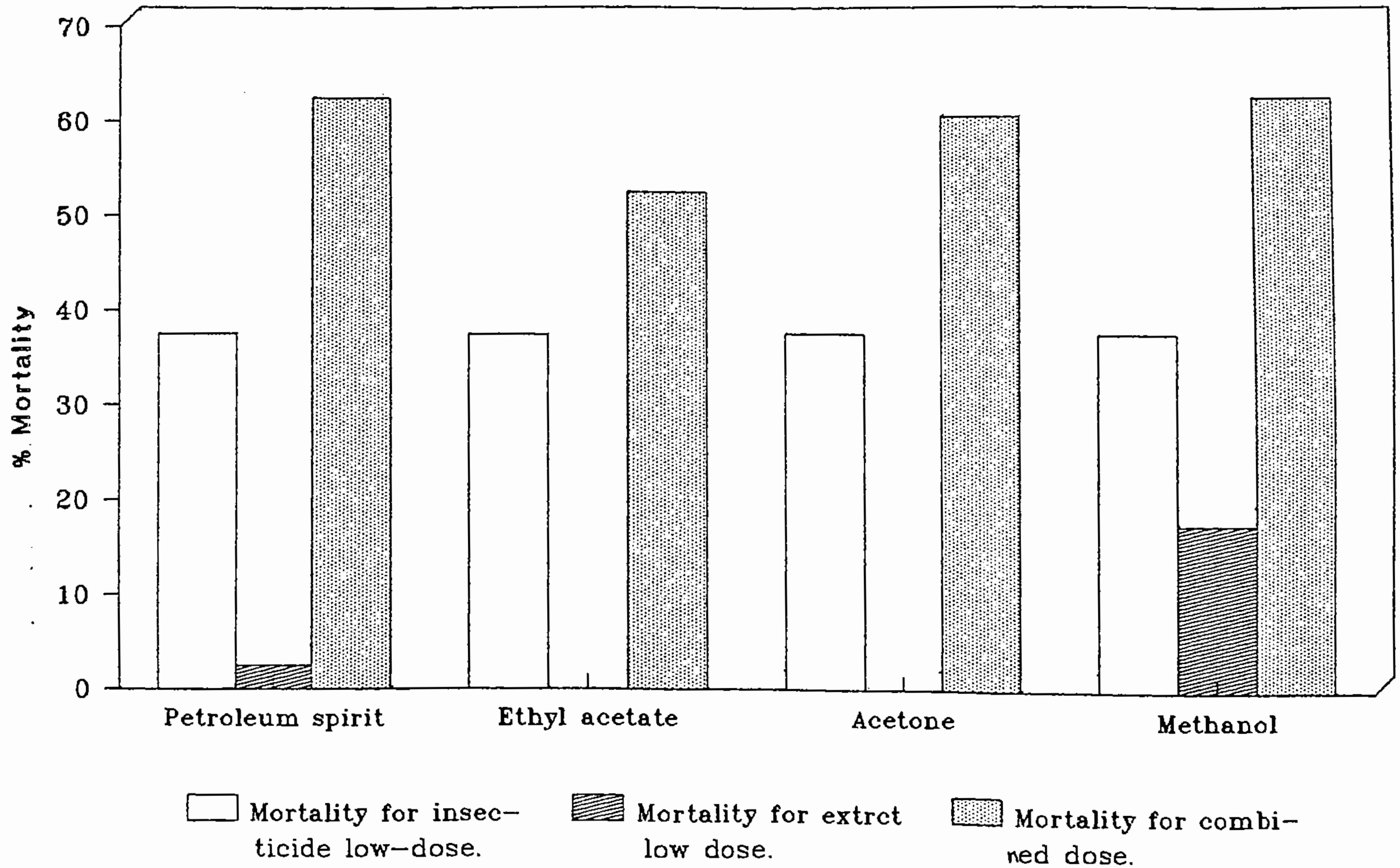


Fig 17. Mortality percentage of adult *T.castaneum* (CR- I) treated with seed extraction *A.squamosa*, methacrifos and their combined doses after 24 hours treatment.

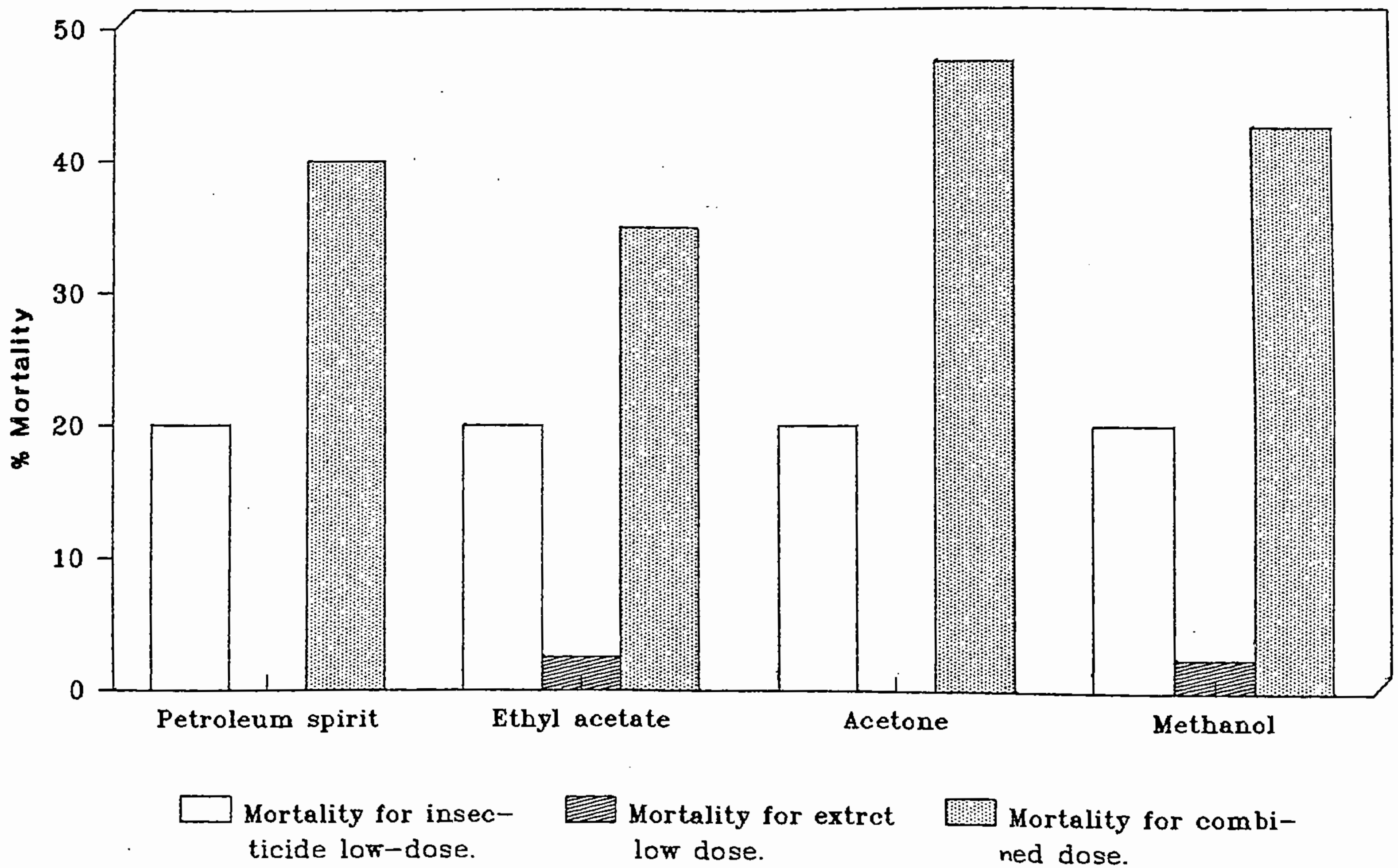


Fig 18. Mortality percentage of adult *T.castaneum* (FSS-II) treated with seed extraction *A.squamosa*, methacrifos and their combined doses after 12 hours treatment.

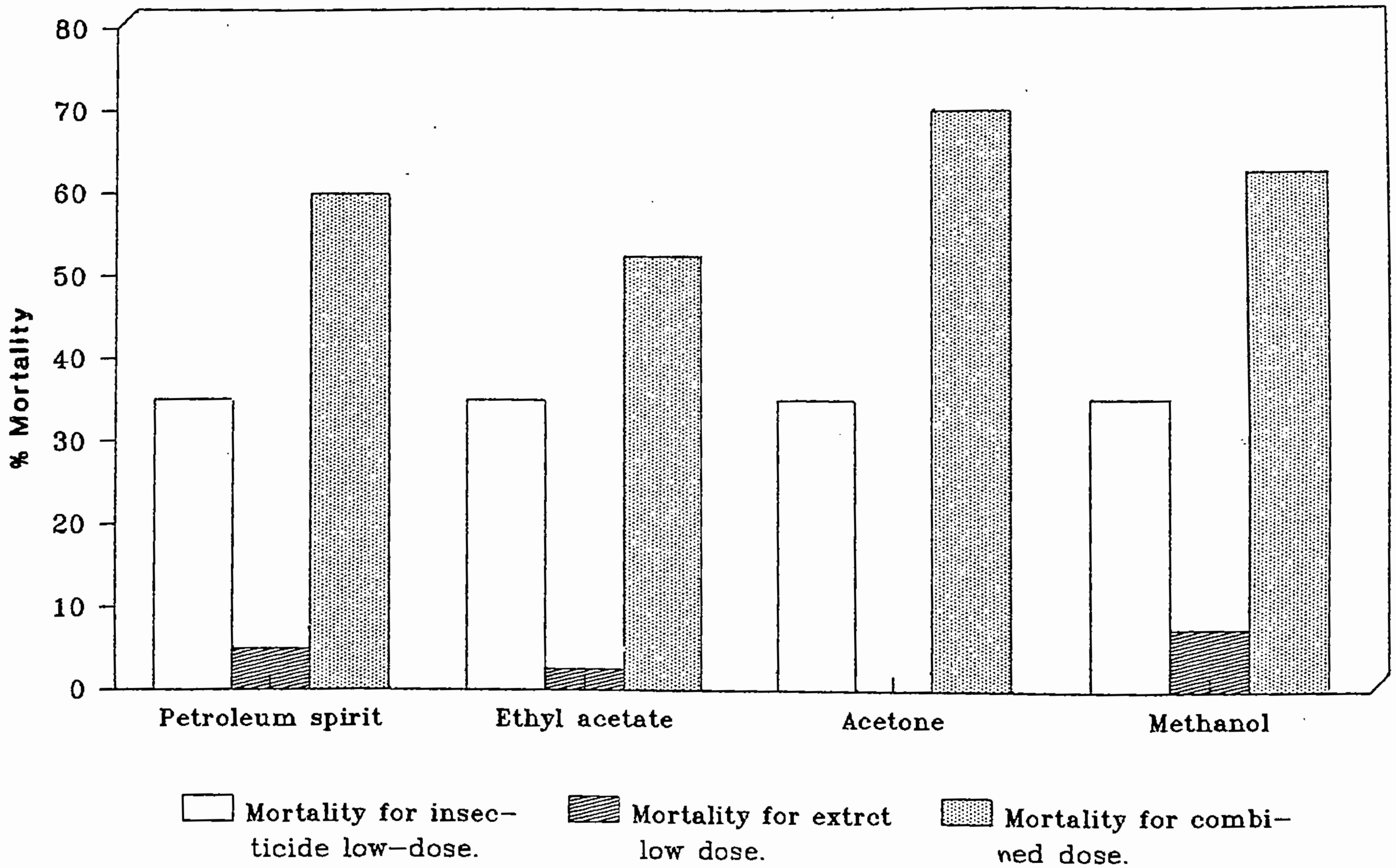


Fig 19. Mortality percentage of adult *T.castaneum* (FSS-II) treated with seed extraction *A.squamosa*, methacrifos and their combined doses after 24 hours treatment.

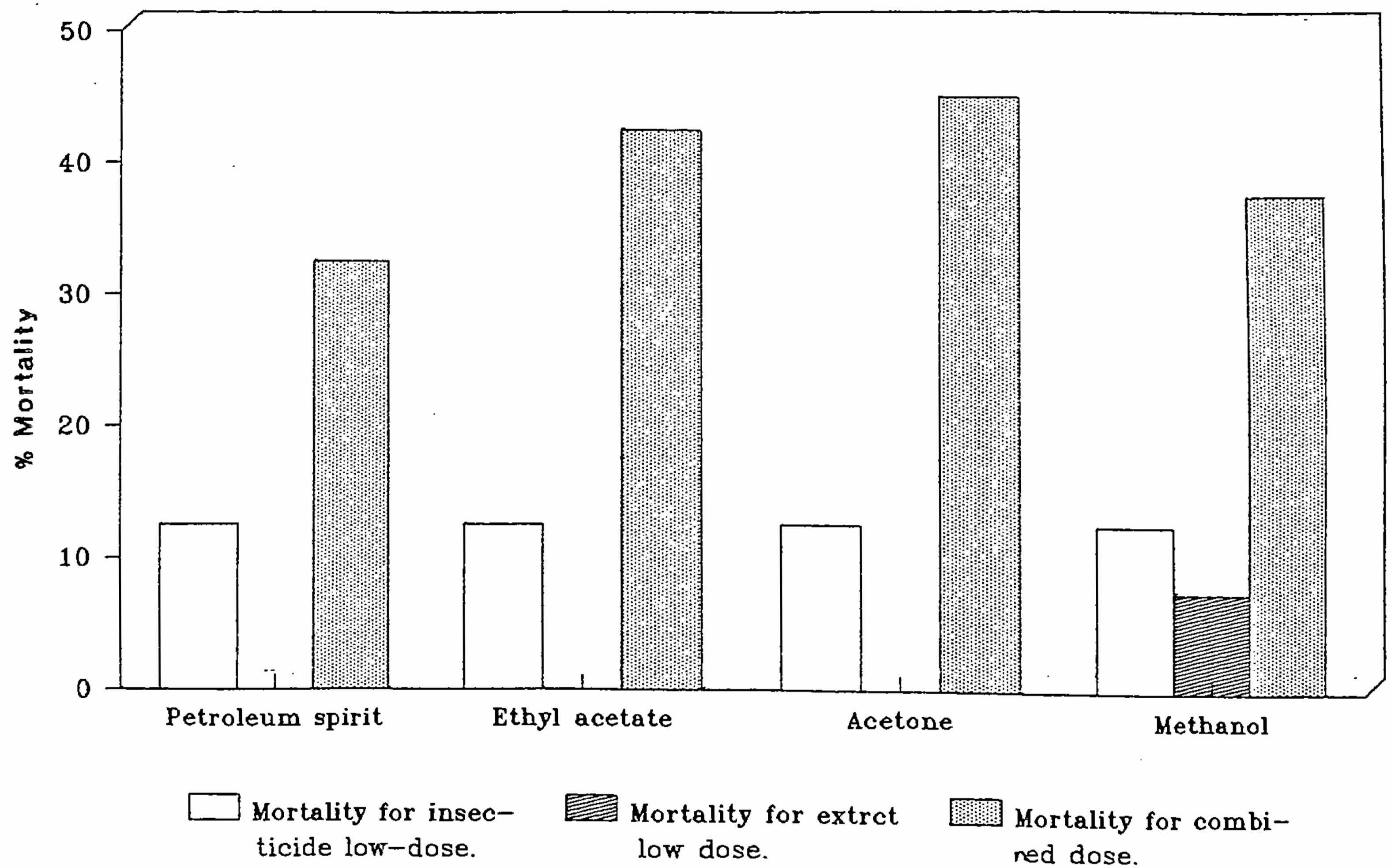


Fig 20. Mortality percentage of adult *T.castaneum* (CTC 12)treated with seed extraction *A.squamosa*, methacrifos and their combined doses after 12 hours treatment.

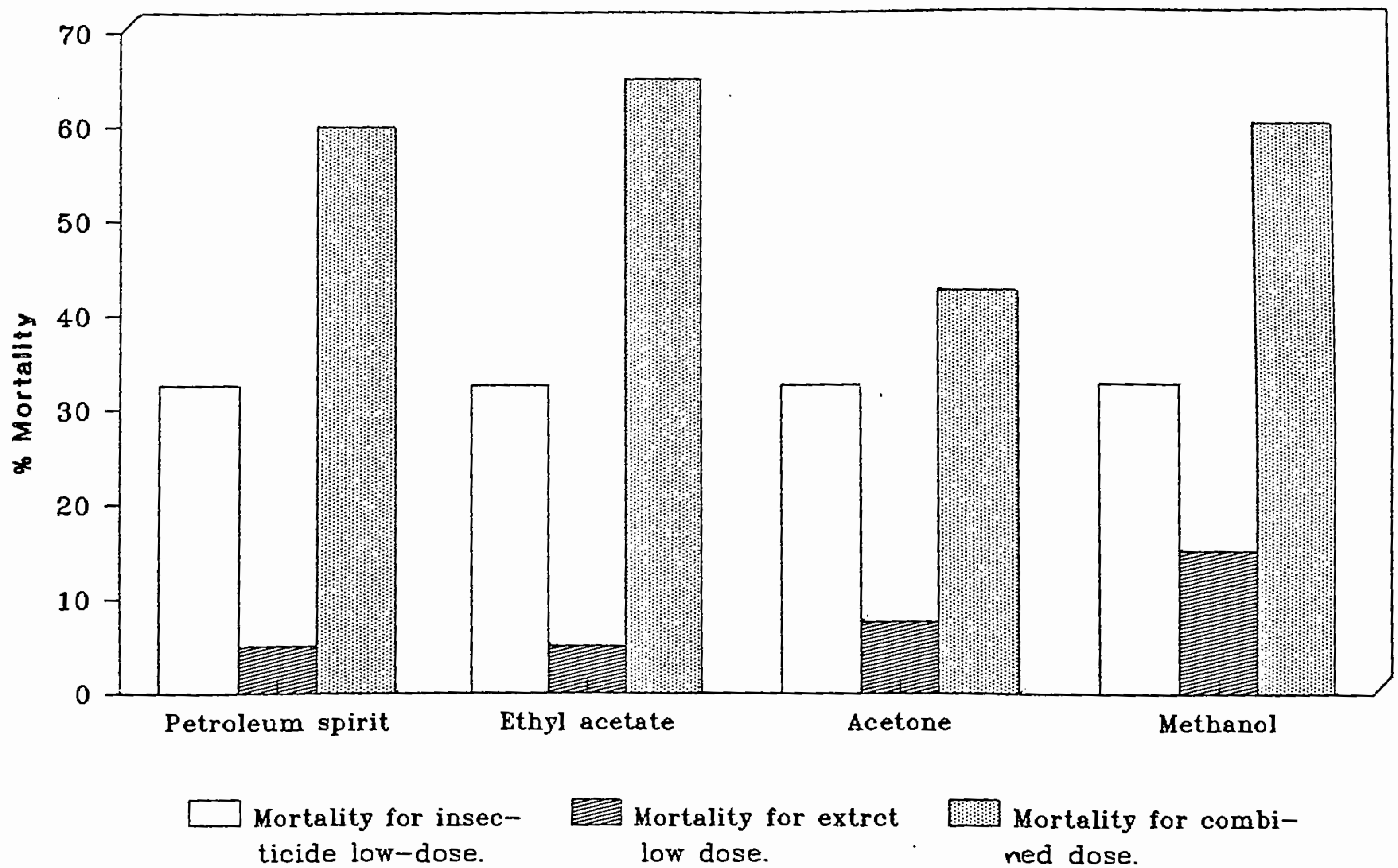


Fig 21. Mortality percentage of adult *T.castaneum* (CTC 12) treated with seed extraction *A.squamosa*, methacrifos and their combined doses after 24 hours treatment.

DISCUSSION

4. DISCUSSION

Secondary plant substances so far identified as "a insect feeding deterrerts" vary widely in structural types and molecular complexivity. This diversity, coupled with a paucity of experimental work on modes of action of antifeedants, makes any attempt to identify a common structural basis for activity, even within the same class of compounds, an extremely difficult task (Hassanali et al., 1983).

The suitability of a plant as food for insects depends on its chemical composition. In many cases, feeding inhibitors are of primary importance in determining which plants are eaten and the extent to which they can be consumed (Thorsteinson, 1960 ; Hsiao, 1969). Antifeedants are of significant importance in insect pest management because they are pest specific, non-poisonous, and hence harmless to pest's natural enemies. Antifeedants, which retard feeding activities of pest insects and reduce their damage by rendering treated plants unattractive, offer considerable scope in crop proction (Munakata, 1970). These materials could be applied to crop plants in much the same way as insecticide.

The chemistry of plants of the family Annonaceae has been little investigated. Cortina (1901) reported to have found among other constituents a resin present in *A. cherimola* to which is ascribed the emetic-cathartic action of the seeds. Callan and Tutin (1911) published an account of their chemical examination of the leaves of *A. muricata*. They isolated a steam-volatile essential oil, a small amount of uncrystallizable alkaloid,several fatty acids, myricyl alcohol, sitosterol and a compound "annonol" $C_{23}H_{38}O_4$. Which was later regarded by Power and Salway (1913) as being a member of the group of phytosterol glucosides (phytosterolines).

Trimurti (1924) isolated a minute amount of an alkaloid from the leaves of A. squamosa, but glucosides were not shown to be present. Santos (1930) obtained an alkaloid, anonaine, $C_{17}H_{16}O_3N$ in a yield of 0.03-0.04% from the bark of A. reticulata. The same alkaloid was isolated from the bark of A. squamosa by Reyes and Santos (1931), in a yield of 0.14% but a slightly different formula was later ascribed to it $C_{17}H_{17}O_3N$ (Santos, 1932). From the bark of the closely allied genus Asimina Sp. triloba Manske (1938) isolated the alkaloid annolobine, $C_{17}H_{17}O_3N$. Santos and Reyes (1932), and Barger and Sargent (1939) made studies of the alkaloids of Artabotrys suaveolens and the three alkaloids isolated from the bark by the latter investigators were Arbabotrine (0.19%, $C_{20}H_{23}O_4N$), Suaveoline (0.0013%, $C_{12}H_{21}O_4N$) and Artabotrinine (0.012%, $C_{18}H_{17}O_3N$).

Barger and Sargent (1939) considered attabotrine probably to be 10 hydroxy - 4:5:6 - trimethoxy - aporphine, Suaveoline, 4:10 - dihydroxy - 5:6 - dimethoxy - aporphine; and artabotrinine, 2-methoxy - 5:6 - methylenedioxynoraporphine.

Bhatta and Narayanan (1938) reported the insecticidal effect of A. reticulata upon the scale insect Lecanium viride

Green in Mysore, India. Hot alcoholic extracts water suspensions of the concentrated hot alcoholic extracts of seed and apparently alcoholic extracts of stem, bark and leaf and root bark were tested. All were found to be toxic : "the chemically prepared alcoholic extract of the seed was very toxic at 0.125% strength, a mortality of 70-80% being obtained". It is however, not quite clear whether the concentration is expressed in terms of the plant material or the extract. Extracts of stem bark, leaf and root bark at 10% concentration gave respectively 100, 70 and 60% mortalities. No information is available as to the method of testing employed, but it was claimed that to this insect the hot alcoholic extracts of the seed of A. reticulata were more toxic than Derris elliptica. As however no particulars were given of the analytical characteristics of the derris used this comparison may possess little value.

Harper et al. (1947) examined the effect of the petroleum ether insoluable extract of the seed of A. squamosa on Macrosiphoniella sanborni and recorded the LD_{50} as 7.8 mg/1 with regression equation Y=3.07 + 2.18x. The present experiment shows that the petroleum spirit extraction of A. squamosa offered the highest mortality of the adult followed by ethyl acetate, methanol, and acetone extractions. Khanam et al. (1991) used the methanol extract of A. squamosa on Sitophilus oryzae and recorded the LD_{50} values as 21244.86, 4980.54, 3623.71, 1923.17 and 2420.50 ppm after 2, 4, 6, 8, and 10 days of treatment respectively. Deshmukh and Borle (1975) tested the seed extracts of A. squamosa and observed highest mortality of aphid, Dactynotus carthami as 20% in petroleum spirit and 85.33% in absolute alchohol extract with regression equation as Y = 2.63 + 1.65x for the later.

In the present investigation the extraction was done serially with four solvents for separating different compounds. Petroleum spirit generally extracts oils, fat and fatty acids; ethyl acetate extracts, tarpin, alkaloids, flavour compounds and steroids; acetone separates chlorophyl, dye and other alkaloid which are not soluble in ethyl acetate; and methanol extracts all kinds of remaining alkaloids and acidic compounds (Islam, 1991).

Flour beetles may be utilized for biological assessment of nutritive values of certain foodstaffs for humans and live-stocks (Birk and Applebaum, 1960; Chirigos et al., 1960). Since general nutritional requirements of Tribolium are in many respects similar to those of warmblooded animals. Further more they have a ubiquitous distribution and are easily reared on synthetic diet (Hinton, 1956; Birk et al., 1962). As the red flour beetle T. castaneum is probably one of the most frequently kept laboratory insect, four strain of them used in present study to compare to mortality by plant extracts as well as insecticide. From the results of the plant extracts it is found that LD_{50} value is higher incase of CTC 12 strain with petroleum spirit extraction, FSS-II strain with ethyl acetate extraction, CR-I strain with acetone extraction and FSS-II with methanol extraction. But incase of insecticide the LD_{50} value is always higher in CTC 12 strain. FSS-II strain is a recognized susceptible variety of _T. castaneum_, so the mortality rate was always higher in comparison to other strain. It was also observed that due to larval treatment with plant extracts in low doses some deform larvae were occured. The larvae which became adult also laid fewer number of eggs effecting the reproductive system of the beetle.

From tables 25 to 28 it is evident that most of the combined doses offered synergism having significant Chi-square. In 1940, Eagleson succeeded in synergising pyrethrum with sesame oil, seven years later, Dove (1947) demonstrated that the efficacy of pyrethrum could be increased by maxing it with piperonyl butoxide, subsequently, many substances were discovered which could be used as pyrethrum synergists. In addition, other insecticides, especially natural insecticides, like ryania dust (Reed & Filmer, 1950), Sabadilla (Blum & Kearns, 1957) and Rotenone (Brannon, 1947), could be symergistic.

There could be two hypotheses for the mode of action of the synergist. The first one, according to Hewlett (1960) and to Metcalf (1967), is that the synergists inhibit the enzymes responsible for toxicant degradation. Othaki _et al._ (1968) and Othaki & Williams (1970) showed that the insect body contains enzymes for the degradation of hormones like the molting hormone (MH), which may be a mode of action of seed extracts. Another possible explanation was advanced by Leuschner (1974) and by Walker & Thompson (1973) who found that simultaneous application of MH and juvenile hormone (JH) caused an increase in MH-activity.

A hypothesis for the mode of action of MH and JH when applied together was advanced by Socha & Sehnal in 1972. They suggested that the MH activated the synthesis of ribonucleic acid (RNA) and JH simultaneously induced a duplication of the deribonucleic acid (DNA). This process causes such a severe disturbance in the insect that it leads to its death because the DNA and RNA syntheses are mutually separated and perhaps, exclude each other (Du Praw, 1967).

Classical insecticide "synergists" were investigated as potential modifiers of formamidine toxicity to acarines and insects, and both antagonistic and synergistic interactions were observed. The toxicity of chlordimeform to southern cattle tick larvae was antagonized in order of potency by sesamex, piperonyl butoxide and tropital (Knowles and Roulston, 1972, 1973). Dittrich (1966) found that a mixture of vapors of chlordimeform and dichlorvos was synergistic to the carmine spider mite and a number of observations along similar lines subsequently have been made. Thus mixtures of chlordimeform with organophosphates, pyrethroids, carbamates toxaphene or diflubenzuron were synergistic to tobacco budworm larvae (Plapp, 1976). In another study, Plapp (1979) tested four formamidines (chlordimeform, amitraz, U-42662, and U-4650) as synergists for the synthetic pyrethroids permethrin, fenvalerate and decamethrin against larvae of the bollowrm and the tobacco budworm; chlordimeform and U-42662 were most active, increasing toxicity of permethrin and fenvalerate by 2-15 times. Dittrich et al., (1981) working with Spodoptera littoralis found that chlordime-form was synergistic with monocrotophos and resmethrin in some cases. Mixtures of amitraz with endosulfan (Weighton and Kerry, 1979), methomyl (Kerry and Weighton, 1979a), or pyrethroids (Badmin and Knight, 1979) were synergistic amitraz-permethrin mixture was synergistic to larvae of Spodoptera littoralis (Kerry and Weighton, 1979b); and armitraz-organophosphate mixture was synergistic to the tobacco budworm (Zeck, 1978).

The synergistic action of the plant extracts, used in the present experiment, is to some extent similar to the results of Dyte and Rowlands (1970) who reported higher mortality of T. castaneum adults in combined doses of insecticide, e.g., Fenitrothion and Bromoxon and Malaoxon and Synergist (e.g., Sesa Sexamax, SKF 525 A and PAOB-1) in comparison with the mortality due to individual action of the chemicals. This result is also similar to that of Ishaaya et al., (1983) who reported higher mortality of T. castaneum in combined doses of insecticide (e.g., trans and sis-cypermethrin) and synergist pyperonyl butoxide in comparison with the mortality due to individual action of the chemicals.

5. CONCLUSION

The unqualified success of chemical pesticides, ironically, created a dilemma. Many of our requisites in life coevolved with pesticide technology to such an extent that we have become, in large part, dependent on this technology. Yet, there are warnings that make us question how secure this technology is for the future.

Increased pest resistance is limiting the effectiveness of many pesticides. Worldwide, there presently are at least 305 species of insects, mites, and ticks that possess strains resistant to one or more chemical pesticides (II). Resistance in certain rodents and plant pathogens is currently limiting the effectiveness of pesticides against these pests (12). Despite efforts taken by the Environmental Protection Agency in the past five years to prohibit or restrict the use of pesticides that pose intolerable risks, the effects of pesticides on human health and the environment remain a continual concern for us all. A study recently completed by the council on Environmental quality suggests a general trend toward reduced aquatic contamination by chlorinated hydrocarbon insecticides in several major rivers in the southern United States, even though low levels of these materials still persist. Difficult to assess are the longterm effects of the less persistent replacements such as organophosphorus insecticides.

Effective control of crop pests and vectors by the small-scale farmer in developing countries of Asia and Africa has been limited because of the prohibitive costs of insecticides. These farmers are constrained to spend either very little on pesticides or to resort to underdosing. As cost of synthetically derived, commercial products rise progressively, their usage will decline further, resulting in lower yields. On the other hand, plants like custard-apple can be grown by marginal farmers in Asia and Africa with minimal maintenance, and their oils can be extracted using simple devices. Although these oil may not match synthetic insecticides in efficacy, even the partial pest control obtained by using them is better than no control at all. Effectiveness against pests, safety for the environment, low cost, and availability of these oils emphasize that they should be considered seriously for pest and vector control.

LITERATURE CITED

LITERATURE CITED

BADMIN, J.S., and KNIGHT, R.J. 1979. Pesticide composition. Brazil Patent 7805,081; Chem. Abstr. 91 : 135617.

BARGER, G. and SARGENT, L.J. 1939. The alkaloids of *Artabotrys suvaveolens*, J. chem soc. 991 p.

BENZ, G. 1971. Synergism of miro-organisms and chemical insecticides. In microbial control of insects and mites. (Eds. H.D. Burges and H.W. Husscy). Academic press, London and New York. 145-163.

BERNAYS, E.A. and CHAPMAN, R.A. 1977. Deferrent chemicals a basis of oligophagy in *Locusta migratoria* L. Ecol. Ent. 2:1-18.

BHATTA, K.L. and NARAYANAN, B.T. 1938. Report of work done in Mysore on the insecticidal value of plant fish poisons and other forest products. (From April 1936 to March, 1937). New Delhi : Govt. India Press. (Rev. Appl. Ent. 1938. 26 : 360).

BIRK, Y. and APPLEBAUM, S.W. 1960. Effect of soybean trypsin inhibitors on the development and midgut proteolytic activity of *Tribolium castaneum* larvae. Engymologia 22 : 318-326.

BIRK, Y., HARPES, I., ISHAAYA, I. and BONDI, A. 1962. Studies on the proteolytic activity of the beetles *Tenebria* and *Tribolium*. J. Insect Physiol. 8 : 417-429.

BLUM, L.W. and KEARNS, C.W. 1957. The effect of Pyrethrum activators on the toxicity of Sabidilla to house files. J. econ. Ent. 49 : 283.

BRANNON, L.W. 1947. Piperonyl Cyclonene and Piperonyl butoxide as sysergist with rotenone. J. econ. Ent. 40 : 933-934.

BROWN, A.W.A. 1958. Insecticide resistance course of age. Bull. Ent. Soc. Am. 14 : 3-9.

BUSVINE, J.R. 1971. A critical review of the techniques for testing insecticides. CAB, London. 345 pp.

CALLAN, T and TUTIN, F. 1911. Chemical examination of the leaves of *Annona muricata*. Pharm. J. 33 : 743.

CARPENTER, T.L., NEEL, W.W. and HEDIN, P.A. 1979. A review of host plant resistance of Pecan, Carya illinocusis, to insect and Acarina. Bull. Ent. Soc. Ann. 25 : 251-257.

CHIRIGOS, M.A. MEISS, A.N., PISANO, J.J. and TAYLOR, M.W. 1960. Growth response of the confused flour beetle Tribolium confusum (Duval) to six sedected protein source. J. Nutrition 72 : 121-130.

CORTINA. 1901. Uribina. Nuturaleza. 7: 222.

COTTON, R.T. 1947. Insect pests of stored grains and grain products. Burgess, Minnesota. 306 pp.

DESHMUKH, S.D. and BORLE, M.N. 1975. Studies on the insecticidal properties of indigenous plant products. Indian J. Ent. 37 (1) : 11-18

DETHIER, V.G. 1980. Evolution of receptor sensitivity of secondary plant substance with special reference to deterrents. Ann. Nat. 115: 45-66.

DITTRICH, V. 1966. Synergistic effect between vapors of C-8514/ schering 36268 and dichlorvos against the carmine spider mite. J. econ. Ent. 59: 893-896.

DITTRICH, V., GISIN, D. and STUDER, I. 1981. Chlorodimeform tested for synergism with two pyrethoids and monocrotophos in resistant and sensitive strains of the noctuid Spodoptera littoralis (Boisd.). Z. Angew Ent. 92: 499-504.

DOSKOTCH, R.W., ODELL, T.M. and GODWIN, P.A. 1971. Feeding response of gipsy moth larvae, Lymantria dispar, to extracts of plant leaves. Envir. Ent. 6: 563-566.

DOVE, W.E. 1947. Piperonyl butoxide, a new safe insecticide for household and field. Ann. J. Trop. med. 27: 339-345.

DU PRAW, F.T. 1967. Cell and Molecular Biology. Academic Press, New York, U.S.A.

DYTE, C.E., GREEN, A.A. and PINNIGER, D.B. 1975. Some consequences of the development of insecticide resistance in stored product insects. Proc. Ist. Int. Wkg. Conf. stored Prod. Ent. Savannals. 261-271.

EAGLESON, C. 1940. U.S. Pat. 2.202, 145 (cited in Perkow, W. 1966. Insechtizide: chem. Wirknngsweise and Toxizitata. I. Aufi., Dr. A. Huthis Verlag. (Heidelberg).

FEINSTEIN, L. 1952. Insecticides from plants. In: Insects : The Year Book of Agriculture. W.S.D.A. Washington, D.C. pp 222-229.

FINNEY, D.J. 1947. Probit analysis. University Press, Cambridge. pp. 333.

GEORGHIOU, G.P. and TAYLOR, C.E. 1977 pesticide resistance as an evolutionary Phenomenon. Proc. XVth Int. cong. Ent. (Washington, D.C. 1976). p. 759.

GILL, J.S. and LEWIS, C.T. 1971. Systematic action of an insect feeding deterrent. Nature 232: 402-403.

GIRISH, G.K. and JAIN, S.K. 1974. Studies on the efficacy of neem seed kernel powder against stored grain pest. Bull. Grain Technol. 12: 226-228.

HALSTEAD, D.G.H. 1963. Enternal sex differences in stored-products Coleoptera. Bull. Ent. Res. 54: 119-134.

HARPER, S.H., POTTER, C. and GILLMAN, E.M. 1947. Annona species as insecticides. Ann. Appl. Biol. 34(1) : 104-112.

HASSANALI, A., LWANDE,W.and GEBREYESUS, T. 1983. Structure - activity studies of Acridone feeding deterrents. Proc. 2nd Int. Neem conf., Rauischholzhausen. pp. 75-80.

HEWLETT, P.S. 1960. Joint action of insecticides. Adv. pest control Res. 3 : 27-74.

HINTON, H.E. 1956. Dietary requirements of insects. Amino acids and vitamins. Sci. Progr. 44: 292-309.

HSIAO, T. 1969. Chemical basis of host selection and plant resistance in oligophagous insects. Entomologia exp. appl. 12 : 423-440.

ISHAAYA, I., ELSNER, A, ASCHER, K.R.S. and CASIDA, J.E. 1983. Synthetic pyrethroids : Toxicity and synergism on dietary exposure of Tribolium castaneum (Herbst) Larvae. Pestic. Sci. 14 : 367-372.

ISLAM, N. 1991. Effects of dhutura (Datura metel L. Leaf and seed extracts and methacrifos in Tribolium castaneum Hbst. adults : M.Sc. Thesis, Dept. of Zoology. Rajshahi University. pp. 86.

JACOBSON, M. 1977. Isolation and identification of toxic agents from plants. In : Host Plants Resistance to Pests. ACS symp ser. 62 : 153-164.

JACOBSON, M. 1981. Neem research in the U.S. Department of Agriculture, Chemical, Biological and Cultural aspects. Proc. 1st. Int. Neem Conf. pp. 33-42.

JACOBSON, M., REDEERN, R.E. and MILLS, G.D. Jr. 1975. Naturally occuring insect growth regulators. II. Sercening of insect and plant extracts as insect juvenile minnics. L. Ioydia. 33 : 455-472.

JURD, L. and MANNERS, G.D. 1980. Wood extractiress as models for the development of new types of pest control agents. J. Agric. FD. Chem. 28 : 183-188.

KERRY, J.C. and WEIGHTON, D.M. 1979a, Agueous Pesticide composition for protecting plants. Brazil patent 7804,094. Chem. Abstr. 91 : 1379

KERRY. J.C. and WEIGHTON, D.M. 1979b. Pesticidal composition. Brazil patent 7804,095. Chem. Abstr. 91: 118684.

KHANAM, L.A.M, KHAN, A.R. and TALUKDER, D. 1991, Use of some indigenous plant materials in controlling Sitophilus oryzae L. infesting wheat. J. Asiat. Soc. Bangladesh, (Sci): 17(1) : 75-78.

KNOWLES, C.O. and ROULSTON, W.J. 1972. Antagonism of chlordimeform toxicity to the cattle tick, Boophilus micropjus by piperonyl butoxide. J. Aust. Ent. Soc. 11: 349-350.

LEUSCHNER, K. 1974. Wirknng Von Juvenilhormon - Analoga and phytoecdysonen any Entwicklug; Fortpflanzung, Paarungs-Verhalten and Eiparasiten ostajrik-amichen Kaffeewenzen Antestiopsis orbitalis bechnana Kirk and Antestiopsis orbitalis ghesquirer car. Ph.D. thesis. University Gressen, F.R.G.

MANSKE, R.H.F. 1938. Anolobina an alkaloid from Asimina triloba Dunal. Canad. J. Res. B. 16: 76.

MATHER, K. 1940. The design and significance of synergic action tests. J. Hyg. camb. 40 : 513-531.

METCALF, R.L. 1967. Mode of action of insecticide synergists. Ann. Rev. Ent. 12 : 229-256.

MENN, J.J. 1980. Contemporary fronteiers in Chemical pesticide research. J. agric. 28: 2-8

MUNAKATA, K. 1970. Insect antifeedants in plant. In: Wood, D.L.; Silverstein, P.M. and Nakajima, M. (Eds) Control of Insect Behavior by Natural Products, Academic Press, NY. pp. 179-187.

MUNAKATA, K. 1977. Insect feeding deterrents in plants. In: Shorey, H.H. and Mckelvey, J.J. Jr. (Eds.) Chemical Control of Insect Beháviour. Wiley, New York. 93-102.

OTHAKI, T. MILKMA, R.D. and WILLIAMS, C.M. 1968. Dynamics of ecdysome secretion and action in the fleshfly. Sacrophaga peregrina. Biol. Bull. mar. biol. lab., Woods Hole. 135: 322-334.

OTHAKI, J. and WILLIAMS. C.M. 1970. Inactireation of Becdysone and cyasterone by larvae of the fleshfly, Sacrophaga peregrina and pupae of the silkworm, Sesamia cynthia, Biol. Bull. mar. biol. lab. Woods Hole. 138:

PARK. T. and FRANK, M.B. 1948. The fecundity and development of the flour beetles, Tribolium confusum and Tribolium castaneum at three constant temperatures. Ecology 29: 368-375.

PIMENTEL, D. 1977. Ecological basis of insect pest, pathogen and Weed problems. In: Cherrett, S.M. and Sagar, G.R. (Eds) Origin of pest, parasites Disease and weed problems. Blackwell's Scientific Publications, Oxford, p.3.

PIMENTEL, D. 1981. An overview of integrated Pest management. Department of Ecology and Systematics, cornell University, Ithaca, NY. (mimeo. 55 pp.)

PIMENTEL, D. ANDOW, D., DYSON-HUDSON, R., GALLAHAN, D., JACOBSON, S., IRISH, M., K ROOP, S., MOSS, A., SCHERINER, I., SHEPARD, M., THOMPSON, T., and VINZANT, B. 1980. Environmental and social costs of pesticides : a preliminary assessment. Oikos. 34: 125-140.

PLAPP, F.W. Jr. 1976. Chlordimeform as a synergist for insecticides against the tobacco budworm. J. econ. Ent. 69: 91-92.

PLAPP, F.W., Jr. 1979. Synergism of pyrethroid insecticides by formanidines against Heliothis pests of cotton. J. econ. Ent. 72: 667-670.

POWER, F.B. and SALWAY, A.H. 1913. The identification of ipuranol and some allied compounds as phytosterol glucosides. F. Chem. Soc. 103 : 399.

PURTHI, H.S. and SINGH, M. 1950. Pests of stored grains and their control. Indian J. Agric. Sci. 18: 1-88.

REED, R,P. and FILMER, R.S. 1950. Activation of ryania dust by piperonyl cyclonene and N-propyl isome. J. econ. Ent. 43: 161-164.

REYES. F.R. and SANTOS, A.C. 1931. Isolation of anonaine from Annona squamosa Linn. Philipp. J. Sci. 44: 409.

SANTOS, A.C. 1930. Alkaloid from Annona reticulata Linn. Philipp. F. Sci. 43: 561.

SANTOS, A.C. 1932 . Anonaine, Philipp. J. Sci. 47: 357.

SANTOS, A.C. and REYES, F.R. 1932. Bull. Univ. Philipp. Nat. Appl. Sci. 2: 409.

SAXENA, R.C. 1983. Naturally occuring Pesticides and the potential. In: Chemistry and world food supplies : The New Frontiers CHEMRAWN II. Manila. Phillippines, Pergamon Press, Oxford, New York, NY; 143-161.

SCHMUTTERER, H. and REMBOLD, H. 1980. Zur Wirkung einiger Reinfraktionen aus Samen Von Azadirachta indica auf FraBaktivitat Matamorphose Von Epilachna varivestis (Cel. : Coccinellidae). Z. ang. Ent. 89: 179-188.

SCHMUTTERER, H. 1981. Ten years of Neem research in the Federal Republic of Germany. Proc. 1st. Int. Neem conf. (Rottach-Egern, 1980). pp. 21-22.

SOCHA, R. and SEHNAL, F. 1972. Inhibition of insect development by simultaneous action of prothoracic gland hormone and juvenile hormone. J. Insect physiol. 19 : 1449-1453.

SUDHAKAR, T.R., PANDEY. N.D. and TEWARI, G.C. 1978. Antifeeding property of some indigenous plants against mustard Sawfly, Athalia proxima (Hymenoptera : Tenthredinidae). Indian J. Agric. Sci. 48 : 16-18.

TATTERSFIELD, F. and POTTER, C. 1940. The insecticidal properties of certain species of Annona and of an indian strain of mundulea sericea ("Supli"). Dept. Ins. & Fun. Rot. Exp. Station, Harpenden, Herts. Ann. Appl. Bial. 27(2) 262-273.

THORSTEINSON, A. 1960. Host Selection in phytophagous insect. Ann. Rev. Ent. 5 : 193-218.

TRIMURTI, N. 1924. An alkaloid from Annona squamosa leaves. J. Indian Inst. Sci. 7: 193-218.

WAISS, A.C. Jr., CHEN, B.G., ELLIGER, C.A., DREYER, D.L., BINDER, R.G. and GUELDNER, R.C. 1981, Insect growth inhibitors in crop plants. Bull. Ent. Soc. Ann. 27 : 217-221.

WALKER, W.F. and THOMPSON, M.J. 1973. 22-25- Bisdeoxyecdysone : Pathological effects on the Mexican bean beetle and Synergism with Juvenile hormone compound. J. econ. Ent. 66 : 64-67.

WARTHEN, J.D. Jr. 1979. Azardirachta indica : A source of insect feeding inhabitors and growth regulators. U.S. Dept. Agric. Rev. Man. ARM-NE-4

WATT, G. 1889. A dictionary of the Economic products of India (2nd reprint, 1972). International Book Distributors, DehraDun. India. pp 559.

WEIGHTON, D.M. and KERRY, J.C. 1979. Pesticidal composition containing amitraz and a chlorinated hydrocarbon. Brazil Patent 7803,533; Chem. Abstr. 90: 181610.

ŻECK, W.M. 1978. Synergistic composition for the control of insects. Res. Discl. 170: 5-7.

ZYROMSKA-RUDZKA, H. 1966. Abundance and envigration of Tribolium Laboratory model. Ekol. pole. A 14: 491-518.

APPENDICES

APPENDIX TABLE - I

Dose-mortality data of adult *T. castaneum* (Local) treated with seed extract in Petroleum spirit after 12 hours.

Dose µgm/sq.cm	Log dose x	No. of insect used n	No. of insect killed r	% Killed p	Emp. prob.	Exp. prob. Y	Work prob. y
A. 4367.99	3.640	40	40	100.0	8.09	7.81	8.12
B. 436.80	2.640	40	20	50.0	5.00	5.56	4.92
C. 43.68	1.640	40	3	7.5	3.59	3.31	3.63
D. 4.37	0.640	40	-	-	-	-	-
O. Control	-	40	-	-	-	-	-

Weighting co-eff. w'	Weight W=w'n	wx	wy	wx^2	wy^2	wxy
0.025	1.00	3.64	8.12	13.25	65.93	29.56
0.558	22.32	58.92	109.81	155.55	540.29	289.90
0.238	9.52	15.61	34.56	25.60	125.44	56.68
-	-	-	-	-	-	-
-	-	-	-	-	-	-
	32.84	78.18	125.49	194.40	731.66	376.13

$\bar{x}$ = 2.38

$\bar{y}$ = 4.64

y = 0.88 + 1.58x

Results :

v = 0.0147

m = 405.51

m_1 = 234.96

m_2 = 699.84

Chi-sq. = 26.99***

APPENDIX TABLE - II

Dose-mortality data of adult *T. castaneum* (Local) treated with seed extract in Petroleum spirit after 24 hours.

Dose µgm/sq.cm	Log dose x	No. of insect used n	No. of insect killed r	% killed p	Emp. prob.	Exp. prob. Y	Work prob. y
A. 4367.99	3.640	40	40	100.0	8.09	7.63	7.94
B. 436.80	2.640	40	28	70.0	5.52	5.98	5.41
C. 43.68	1.640	40	5	12.5	3.87	4.32	3.93
D. 4.37	0.640	40	1	2.5	3.12	2.67	3.35
O. Control	-	40	-	-	-	-	-

Weighting co-eff. w'	Weight W=w'n	wx	wy	wx^2	wy^2	wxy
0.040	1.60	5.82	12.70	21.20	100.87	46.23
0.439	17.56	46.36	94.99	122.39	513.95	250.77
0.532	21.28	34.90	83.63	57.23	328.67	137.15
0.062	2.48	1.59	8.31	1.02	27.83	5.32
-	-	-	-	-	-	-
	42.92	88.67	199.64	201.84	971.32	439.47

$\bar{x}$ = 2.07

$\bar{y}$ = 4.65

y = 1.68 + 1.93x

Results :

V = 0.0129

m = 206.06

m_1 = 123.31

m_2 = 344.35

Chi-sq. = 5.506

APPENDIX TABLE - III

Dose-mortality data of adult *T. castaneum* (Local) treated with seed extract in Ethylacetate after 12 hours.

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Emp. prob.	Exp. prob.	Work prob.
	x	n	r	p		Y	y
A. 5497.95	3.740	40	34	85.0	6.04	5.50	6.03
B. 549.80	2.740	40	6	15.0	3.96	4.54	4.05
C. 54.98	1.740	40	1	2.5	3.12	3.58	2.23
D. 5.50	0.740	40	1	2.5	3.12	2.62	3.35
0. Control	-	40	-	-	-	-	-

Weighting co-eff.	Weight					
w'	W=w'n	wx	wy	wx^2	wy^2	wxy
0.439	17.56	65.67	105.89	245.62	638.50	396.03
0.581	23.24	63.68	94.12	174.48	381.19	257.89
0.302	12.08	21.02	26.94	36.57	60.07	46.88
0.062	2.48	1.84	8.31	1.36	27.83	6.15
-	-	-	-	-	-	-
	55.36	152.21	235.26	458.03	1107.59	706.94

$\bar{x}$ = 2.75

$\bar{y}$ = 4.25

y = 0.07 + 1.52x

Results :

V = 0.0105

m = 1749.85

m_1 = 1101.54

m_2 = 2779.71

Chi-sq. = 16.573***

APPINDIX TABLE - IV

Dose-mortality data of adult *T. castaneum* (Local) treated with seed extract in Ethylacetate after 24 hours,

Dose µgm/sq.cm	Log dose x	No. of insect used n	No. of insect killed r	% killed p	Emp. prob.	Exp. prob. Y	Work prob. y
A. 5497.95	3.740	40	38	95.0	6.64	6.22	6.53
B. 549.80	2.740	40	15	37.5	4.69	5.14	4.69
C. 54.98	1.740	40	4	10.0	3.72	4.06	3.79
D. 5.50	0.740	40	2	5.5	3.36	2.98	3.51
0. Control	-	40	-	-	-	-	-

Weighting co-eff. w'	Weight W=w'n	wx	wy	wx^2	wy^2	wxy
0.370	14.80	55.35	96.64	207.01	631.06	361.43
0.634	25.36	69.49	118.94	190.40	557.83	325.90
0.471	18.84	32.78	71.40	57.04	270.61	124.24
0.131	5.24	3.88	18.39	3.88	64.55	13.61
-	-	-	-	-	-	-
	64.24	161.50	305.37	458.33	1524.05	825.17

$\bar{x} = 2.51$

$\bar{y} = 4.75$

$y = 1.96 + 1.11x$

Results :

V = 0.0135

m = 548.28

m_1 = 325.09

m_2 = 924.70

Chi-sq. = 8.395*

APPENDIX TABLE - V

Dose-mortality data of adult *T. castaneum* (Local) treated with seed extract in Acetone after 24 hours.

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Emp. prob.	Exp. prob.	Work prob.
	x	n	r	p		Y	y
A. 3746.64	3.574	40	34	85.0	6.04	5.73	5.99
B. 374.66	2.574	40	6	15.0	3.96	4.57	4.07
C. 37.47	1.574	40	4	10.0	3.72	3.41	3.81
D. 3.75	0.574	40	-	-	-	-	-
0. Control	-	40	-	-	-	-	-

Weighting co-eff.	Weight					
w'	W=w'n	wx	wy	wx^2	wy^2	wxy
0.532	21.28	76.05	127.46	271.82	763.53	455.54
0.601	24.04	61.88	97.84	159.28	398.22	251.84
0.238	9.52	14.98	36.27	23.59	138.19	57.09
-	-	-	-	-	-	-
-	-	-	-	-	-	-
	54.84	152.92	261.57	454.69	1299.94	764.47

$\bar{x}$ = 2.79

$\bar{y}$ = 4.77

y = 1.32 + 1.24x

Results :

V = 0.0127

m = 946.24

m_1 = 729.46

m_2 = 1227.44

Chi-sq. = 9.236*

APPENDIX TABLE - VI

Dose-mortality data of adult *T. castaneum* (Local) treated with seed extract in Methanol after 12 hours.

Dose µgm/sq.cm	Log dose x	No. of insect used n	No. of insect killed r	% killed p	Emp. prob.	Exp. prob. Y	Work prob. y
A. 2343.98	3.370	40	35	87.5	6.18	6.24	6.15
B. 234.40	2.370	40	17	42.5	4.82	4.71	4.81
C. 23.44	1.370	40	1	2.5	3.12	3.18	3.06
D. 2.34	0.370	40	-	-	-	-	-
0. Control	-	40	-	-	-	-	-

Weighting co-eff. w'	Weight W=w'n	wx	wy	wx^2	wy^2	wxy
0.370	14.80	49.88	91.02	168.08	559.78	306.74
0.616	24.64	58.40	118.52	138.40	570.07	280.89
0.180	7.20	9.86	22.03	13.51	67.42	30.18
-	-	-	-	-	-	-
-	-	-	-	-	-	-
	46.64	118.14	231.57	319.99	1197.27	617.81

$\bar{x} = 2.53$

$\bar{y} = 4.97$

$y = 1.14 + 1.51x$

Results :

$V = 0.0094$

$m = 354.81$

$m_1 = 229.07$

$m_2 = 549.54$

Chi-sq. = 1.859

APPENDIX TABLE - VII

Dose-mortality data of adult *T. castaneum* (Local) treated with seed extract in Methanol after 24 hours.

Dose µgm/sq.cm	Log dose x	No. of insect used n	No. of insect killed r	% killed p	Emp. prob.	Exp. prob. Y	Work prob. y
A. 2343.98	3.370	40	37	92.5	6.48	6.48	6.43
B. 234.40	2.370	40	29	72.5	5.61	5.36	5.59
C. 23.44	1.370	40	4	10.0	3.72	4.23	3.82
D. 2.34	0.370	40	2	5.0	3.36	3.11	3.42
O. Control	-	40	-	-	-	-	-

Weighting co-eff. w'	Weight W=w'n	wx	wy	wx^2	wy^2	wxy
0.269	10.76	36.26	69.18	122.20	444.83	233.14
0.601	24.04	56.97	134.38	135.03	751.20	318.48
0.503	20.12	27.56	76.86	37.76	293.60	105.30
0.154	6.16	2.28	21.07	0.84	72.05	7.80
-	-	-	-	-	-	-
	61.08	123.08	301.49	295.83	1561.68	664.71

$\bar{x}$ = 2.02

$\bar{y}$ = 4.94

y = 2.56 + 1.18x

Results :

V = 0.0118

m = 117.76

m_1 = 71.94

m_2 = 192.75

Chi-sq. = 6.593

APPENDIX TABLE - VIII

Dose-mortality data of adult *T. castaneum* (CR-I) treated with seed extract in Petroleum spirit after 12 hours.

Dose µgm/sq.cm	Log dose x	No. of insect used n	No. of insect killed r	% killed p	Emp. prob.	Exp. prob. Y	Work prob. y
A.10060.301	4.003	40	40	100.00	8.09	8.03	8.30
B.1006.030	3.003	40	30	75.00	5.67	5.78	5.67
C.100.603	2.003	40	3	7.50	3.59	3.53	3.56
D.10.060	1.003	40	0	-	-	-	-
0.Control	-	40	0	-	-	-	-

Weighting co-eff. w'	Weight W= w'n	wx	wy	wx^2	wy^2	wxy
0.015	0.60	2.40	4.98	9.61	41.33	19.93
0.503	20.12	60.42	114.08	181.44	646.84	342.58
0.269	10.76	21.55	38.31	43.17	136.37	76.73
-	-	-	-	-	-	-
-	-	-	-	-	-	-
	31.48	84.37	157.37	234.22	824.55	439.25

$\bar{x}$ = 2.68

$\bar{y}$ = 5.00

y = 2.15x - 0.76

Results :

V = 0.0121

m = 477.53

m_1 = 290.40

m_2 = 785.24

Chi-sq. = 0.078

APPENDIX TABLE - IX

Dose-mortality data of adult *T. castaneum* (CR-I) treated with seed extract in Petroleum spirit after 24 hours.

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Emp. prob.	Exp. prob.	Work. prob.
	x	n	r	p		Y	y
A.10060.301	4.003	40	40	100.0	8.09	7.87	8.21
B.1006.030	3.003	40	35	87.5	6.18	6.12	6.15
C.100.603	2.003	40	3	7.5	3.59	4.37	3.81
D.10.060	1.003	40	1	2.5	3.12	2.62	3.34
0.Control	-	40	0	-	-	-	-

Weighting co-eff.	Weight					
w'	W= w'n	wx	wy	wx^2	wy^2	wxy
0.019	0.76	3.04	6.24	12.169	51.23	24.98
0.405	16.20	48.65	99.63	146.100	612.72	299.19
0.558	22.32	44.71	85.04	89.550	324.00	170.34
0.062	2.48	2.49	8.28	2.500	27.66	8.30
-	-	-	-	-	-	-
	41.76	98.89	199.19	250.320	1015.61	502.81

$\bar{x} = 2.37$

$\bar{y} = 4.77$

$y = 0.20 + 1.93x$

Results :

$V = 0.0067$

$m = 306.90$

$m_1 = 211.84$

$m_2 = 444.63$

Chi-sq. = 5.972

APPENDIX TABLE - X

Dose-mortality data of adult *T. castaneum* (CR - I) treated with seed extract in Ethylacetate after 24 hours.

Dose µgm/sq.cm	Log dose x	No. of insect used n	No. of insect killed r	% killed p	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 14147.518	4.151	40	37	92.5	6.48	6.30	6.43
B. 1414.752	3.151	40	9	22.5	4.26	4.62	4.27
C. 141.475	2.151	40	1	2.5	3.12	2.94	3.06
D. 14.148	1.151	40	-	-	-	-	-
0. Control	-	40	-	-	-	-	-

Weighting co-eff. w'	Weight W= w'n	wx	wy	wx^2	wy^2	wxy
0.336	13.44	55.79	86.42	231.58	555.68	358.73
0.601	24.04	75.75	102.65	238.69	438.32	323.45
0.110	4.40	9.46	13.46	20.35	41.19	28.95
-	-	-	-	-	-	-
-	-	-	-	-	-	-
	41.88	141.00	202.53	490.62	1035.18	711.13

$\bar{x} = 3.37$

$\bar{y} = 4.84$

$y = 1.84x - 1.36$

Results :

V = 0.0072

m = 2857.59

m_1 = 1945.36

m_2 = 4197.59

Chi-sq. = 2.304

APPENDIX TABLE - XI

Dose-mortality data of adult *T. castaneum* (CR - I) treated with seed extract in Acetone after 24 hours,

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Emp. prob.	Exp. prob.	Work. prob.
	x	n	r	p		Y	y
A. 12268.603	4.089	40	17	42.5	4.82	4.54	4.83
B. 1226.860	3.089	40	1	2.5	3.12	3.69	3.29
C. 122.686	2.089	40	1	2.5	3.12	2.84	3.11
D. 12.269	1.089	40	0	-	-	-	-
0. Control	-	40	0	-	-	-	-

Weighting co-eff.	Weight					
w'	W= w'n	wx	wy	wx^2	wy^2	wxy
0.581	23.24	95.03	112.25	388.58	542.17	458.99
0.336	13.44	41.52	44.22	128.26	145.48	136.60
0.092	3.68	7.69	11.44	16.06	35.58	23.89
-	-	-	-	-	-	-
-	-	-	-	-	-	-
	40.36	144.23	167.91	532.89	723.23	619.48

$\bar{x}$ = 3.57

$\bar{y}$ = 4.16

Y = 0.19 + 1.11x

Results :

V = 0.0463

m = 21330.45

m_1 = 8090.96

m_2 = 56234.13

Chi-sq. = 2.479

APPENDIX TABLE - XII

Dose-mortality data of adult *T. castaneum* (CR - I) treated with seed extract in Methanol after 12 hours.

Dose µgm/sq.cm	Log dose x	No. of insect used n	No. of insect killed r	% killed p	Corr. % killed	Emp. prob.	Exp. prob. Y	Work. prob. y
A.3109.075	3.493	40	38	95.0	94.74	6.64	6.13	6.48
B.310.908	2.493	40	11	27.5	23.68	4.29	5.03	4.29
C.31.091	1.493	40	7	17.5	13.16	3.87	3.93	3.88
D.3.109	0.493	40	3	7.5	2.63	3.12	2.83	3.15
0.Control	-	40	2	5.0	-	-	-	-

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.405	16.20	56.59	104.98	197.670	680.27	366.27
0.532	21.28	53.05	91.29	132.250	391.63	227.59
0.405	16.20	24.19	62.86	36.120	243.90	93.85
0.092	3.68	1.81	11.59	0.893	36.51	5.71
-	-	-	-	-	-	-
	57.36	135.64	270.72	366.93	1352.31	693.84

$\bar{x} = 2.37$

$\bar{y} = 4.72$

$Y = 1.97 + 1.16x$

Results :

V = 0.0138

m = 403.65

m_1 = 238.23

m_2 = 683.91

Chi-sq. = 13.921***

APPENDIX TABLE - XIII

Dose-mortality data of adult *T. castaneum* (CR - I) treated with seed extract in Methanol after 24 hours,

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Corr. % killed	Emp. prob.	Exp. prob.	Work. prob.
	x	n	r	p			Y	y
A.3109.075	3.493	40	39	97.5	97.29	6.88	6.28	6.71
B.310.908	2.493	40	15	37.5	32.43	4.53	5.29	4.53
C.31.091	1.493	40	9	22.5	16.22	4.01	4.31	4.05
D.3.109	0.493	40	7	17.5	10.81	3.77	3.32	3.98
0.Control	-	40	3	7.5	-	-	-	-

Weighting co-eff.	Weight					
w'	W = w'n	wx	wy	wx^2	wy^2	wxy
0.336	13.44	46.95	96.18	163.99	645.37	315.03
0.616	24.64	61.43	111.62	153.14	505.64	278.28
0.532	21.28	31.77	86.18	47.43	349.03	128.67
0.208	8.32	4.10	33.11	2.02	131.78	16.32
-	-	-	-	-	-	-
	67.68	144.25	321.10	366.60	1631.81	738.30

$\bar{x} = 2.13$

$\bar{y} = 4.74$

$Y = 2.80 + 0.91x$

Results :

V = 0.0016

m = 257.63

m_1 = 215.28

m_2 = 308.32

Chi-sq. = 60.331***

APPENDIX TABLE - XIV

Dose-mortality data of adult *T. castaneum* (FSS - II) treated with seed extract in Petroleum spirit after 12 hours.

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Emp. prob.	Exp. prob.	Work. prob.
	x	n	r	p		Y	y
A. 4367.99	3.640	40	40	100.00	8.09	8.14	8.40
B. 436.80	2.640	40	35	87.50	6.18	6.08	6.15
C. 43.68	1.640	40	6	15.00	3.96	4.01	3.96
D. 4.37	0.640	40	-	-	-	-	-
0. Control	-	40	-	-	-	-	-

Weighting co-eff.	Weight					
w'	W= w'n	wx	wy	wx^2	wy^2	wxy
0.001	0.44	1.60	3.70	5.82	31.08	13.47
0.405	16.20	42.77	99.63	112.91	612.72	263.02
0.439	17.56	28.80	69.54	47.23	275.38	114.05
-	-	-	-	-	-	-
-	-	-	-	-	-	-
	34.20	73.17	172.86	165.97	919.18	390.54

$\bar{x} = 2.14$

$\bar{y} = 5.05$

$y = 0.36 + 2.20x$

Results :

V = 0.0061

m = 130.02

m_1 = 91.41

m_2 = 184.93

Chi-sq. = 0.874

APPENDIX TABLE - XV

Dose-mortality data of adult *T. castaneum* (FSS - II) treated with seed extract in Petroleum spirit after 24 hours.

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Corr. % killed	Emp. prob.	Exp. prob.	Work. prob.
	x	n	r	p			Y	y
A. 4367.99	3.640	40	40	100.00	100.00	8.09	8.04	8.30
B. 436.80	2.640	40	37	92.50	92.31	6.41	6.34	6.42
C. 43.68	1.640	40	11	27.50	25.64	4.36	4.65	4.37
D. 4.37	0.640	40	2	5.50	2.56	3.12	2.95	3.05
0. Control	-	40	1	2.50	-	-	-	-

Weighting co-eff.	Weight					
w'	W = w'n	wx	wy	wx^2	wy^2	wxy
0.015	0.60	2.184	4.98	7.95	41.33	18.13
0.336	13.44	35.480	86.28	93.67	553.92	227.78
0.616	24.64	40.410	107.68	66.27	470.56	176.60
0.131	-	3.350	15.98	2.14	48.74	10.23
-	-	-	-	-	-	-
	43.92	81.420	214.92	170.03	1114.55	432.74

$\bar{x} = 1.85$

$\bar{y} = 4.89$

$y = 1.56 + 1.80x$

Results :

$V = 0.0071$

$m = 82.04$

$m_1 = 56.10$

$m_2 = 119.95$

Chi-sq. = 0.343

APPENDIX TABLE - XVI

Dose-mortality data of adult *T. castaneum* (FSS - II) treated with seed extract in Ethylacetate after 12 hours.

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Emp. prob.	Exp. prob.	Work. prob.
	x	n	r	p		Y	y
A. 5497.95	3.740	40	33	82.5	5.95	5.29	5.84
B. 549.80	2.740	40	3	7.5	3.59	4.39	3.81
C. 54.98	1.740	40	1	2.5	3.12	3.50	3.17
D. 5.50	0.740	40	1	2.5	3.12	2.60	3.35
0. Control	-	40	-	-	-	-	-

Weighting co-eff.	Weight					
w'	W= w'n	wx	wy	wx^2	wy^2	wxy
0.616	24.64	92.15	143.90	344.64	840.38	538.19
0.558	22.32	61.16	85.04	167.58	324.00	233.01
0.269	10.76	18.72	34.11	32.57	180.13	59.35
0.062	2.48	1.84	8.31	1.36	27.84	6.15
-	-	-	-	-	-	-
	60.20	173.87	271.35	546.15	1300.35	836.70

$\bar{x} = 2.89$

$\bar{y} = 4.51$

$y = 1.04 + 1.20x$

Results :

V = 0.0142

m = 1986.09

m_1 = 1161.45

m_2 = 3396.25

Chi-sq. = 13.563**

APPENDIX TABLE - XVII

Dose-mortality data of adult *T. castaneum* (FSS - II) treated with seed extract in Ethylacetate after 24 hours,

Dose µgm/sq.cm	Log dose x	No. of insect used n	No. of insect killed r	% killed p	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 5497.95	3.740	40	40	100.00	8.09	7.24	7.59
B. 549.80	2.740	40	14	35.00	4.61	5.65	4.39
C. 54.98	1.740	40	3	7.50	3.59	4.06	3.69
D. 5.50	0.740	40	1	2.50	3.12	2.46	3.58
0. Control	-	40	-	-	-	-	-

Weighting co-eff. w'	Weight W= w'n	wx	wy	wx^2	wy^2	wxy
0.092	3.68	13.76	27.93	51.47	211.99	104.46
0.532	21.28	58.31	93.42	159.76	410.11	255.97
0.471	18.84	32.78	69.52	57.04	256.53	120.96
0.050	2.00	1.48	7.16	1.10	25.63	5.30
-	-	-	-	-	-	-
	45.80	106.33	198.03	269.37	904.26	486.69

$\bar{x} = 2.32$

$\bar{y} = 4.32$

$y = 1.53 + 1.20x$

Results :

V = 0.025

m = 769.13

m_1 = 376.70

m_2 = 1570.36

Chi-sq. = 16.058**

APPENDIX TABLE - XVIII

Dose-mortality data of adult *T. castaneum* (FSS - II) treated with seed extract in Acetone after 24 hours.

Dose µgm/sq.cm	Log dose x	No. of insect used n	No. of insect killed r	% killed p	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 3746.64	3.574	40	39	97.5	7.05	6.74	6.90
B. 374.66	2.574	40	13	32.5	4.56	5.19	4.55
C. 37.47	1.574	40	6	15.0	3.96	3.65	4.02
D. 3.75	0.574	40	-	-	-	-	-
0. Control	-	40	-	-	-	-	-

Weighting co-eff. w'	Weight W= w'n	wx	wy	wx^2	wy^2	wxy
0.208	8.32	29.74	57.41	106.28	396.12	205.18
0.627	25.08	64.56	114.11	166.17	519.22	293.72
0.336	13.44	21.15	54.03	33.30	217.20	85.04
-	-	-	-	-	-	-
-	-	-	-	-	-	-
	46.84	115.45	225.55	305.75	1132.54	583.95

$\bar{x} = 2.46$

$\bar{y} = 4.82$

$y = 1.53 + 1.34x$

Results :

$V = 0.0123$

$m = 393.55$

$m_1 = 239.33$

$m_2 = 647.14$

Chi-sq. = 6.399

APPENDIX TABLE - XIX

Dose-mortality data of adult *T. castaneum* (FSS - II) treated with seed extract in Methanol after 12 hours.

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Corr. % killed	Emp. prob.	Exp. prob.	Work. prob.
	x	n	r	p			Y	y
A. 2343.88	3.370	40	40	100.0	100.00	8.09	7.36	7.76
B. 234.40	2.370	40	4	10.0	7.69	3.59	5.04	3.94
C. 23.44	1.370	40	3	7.5	5.13	3.45	2.72	4.13
D. 2.34	0.370	40	1	2.5	-	-	-	-
0. Control	-	40	1	2.5	-	-	-	-

Weighting co-eff.	Weight					
w'	W = w'n	wx	wy	wx^2	wy^2	wxy
0.062	2.48	8.36	19.24	28.17	149.34	64.84
0.637	25.48	60.39	100.39	143.12	395.54	237.92
0.076	3.04	4.16	12.56	5.71	51.85	17.21
-	-	-	-	-	-	-
-	-	-	-	-	-	-
	31.00	72.91	132.19	177.00	596.73	319.97

$\bar{x}$ = 2.35

$\bar{y}$ = 4.26

Y = 0.39 + 1.65x

Results :

V = 0.0253

m = 629.51

m_1 = 306.90

m_2 = 1291.22

Chi-sq. = 18.217***

APPENDIX TABLE - XX

Dose-mortality data of adult *T. castaneum* (FSS - II) treated with seed extract in Methanol after 24 hours,

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Corr. % killed	Emp. prob.	Exp. prob.	Work. prob.
	x	n	r	p			Y	y
A. 2343.98	3.370	40	40	100.0	100.00	8.09	7.09	7.51
B. 234.40	2.370	40	11	27.5	21.62	4.23	5.54	4.15
C. 23.44	1.370	40	6	15.0	8.11	3.59	3.98	3.67
D. 2.34	0.370	40	4	10.0	2.70	3.12	2.43	4.05
0. Control	-	40	3	7.5	-	-	-	-

Weighting co-eff.	Weight					
w'	W = w'n	wx	wy	wx^2	wy^2	wxy
0.110	4.40	14.83	33.04	49.97	248.16	111.34
0.581	23.24	55.08	96.45	130.54	400.25	228.59
0.439	17.56	24.06	64.45	32.96	236.51	88.30
0.040	1.60	0.59	6.48	0.22	26.24	2.40
-	-	-	-	-	-	-
	46.80	95.56	200.42	213.69	911.16	430.63

$\bar{x}$ = 2.04

$\bar{y}$ = 4.28

Y = 1.91 + 1.16x

Results :

V = 0.0312

m = 457.09

m_1 = 205.59

m_2 = 1016.25

Chi-sq. = 28.105***

APPENDIX TABLE - XXI

Dose-mortality data of adult *T. castaneum* (CTC -12) treated with seed extract in Petroleum spirit after 12 hours.

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Emp. prob.	Exp. prob.	Work. prob.
	x	n	r	p		Y	y
A. 4367.99	3.640	40	40	100.0	8.09	7.95	8.30
B. 436.80	2.640	40	30	75.0	5.67	5.95	5.62
C. 43.68	1.640	40	7	17.5	4.08	3.94	4.08
D. 4.37	0.640	40	-	-	-	-	-
0. Control	-	40	-	-	-	-	-

Weighting co-eff.	Weight					
w'	W= w'n	wx	wy	wx^2	wy^2	wxy
0.015	0.60	21.84	4.98	7.95	41.33	18.13
0.439	17.56	46.36	98.69	122.39	554.62	260.54
0.405	16.20	26.57	66.10	43.57	269.67	108.40
-	-	-	-	-	-	-
-	-	-	-	-	-	-
	34.36	75.11	169.76	173.91	865.62	387.07

$\bar{x} = 2.19$

$\bar{y} = 4.94$

$y = 1.38 + 1.62x$

Results :

V = 0.0112

m = 168.66

m_1 = 104.47

m_2 = 272.27

Chi-sq. = 2.227

APPENDIX TABLE - XXII

Dose-mortality data of adult *T. castaneum* (CTC - 12) treated with seed extract in Petroleum spirit after 24 hours.

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Emp. prob.	Exp. prob.	Work. prob.
	x	n	r	p		Y	y
A.4367.99	3.640	40	40	100.0	8.09	7.94	8.21
B. 436.80	2.640	40	36	90.0	6.28	6.32	6.29
C. 43.68	1.640	40	10	25.0	4.33	4.71	4.36
D. 4.37	0.640	40	2	5.0	3.36	3.09	3.42
0.Control	-	40	-	-	-	-	-

Weighting co-eff.	Weight					
w'	W =w'n	wx	wy	wx^2	wy^2	wxy
0.019	0.76	2.77	6.24	10.07	51.23	22.71
0.336	13.44	35.48	84.54	93.67	531.74	223.19
0.616	24.64	40.41	107.43	66.27	468.40	176.19
0.154	6.61	4.23	22.61	2.71	77.31	14.47
-	-	-	-	-	-	-
	45.00	82.89	220.81	172.72	1128.68	436.55

$\bar{x}$ = 1.84

$\bar{y}$ = 4.91

y = 2.15 + 1.50x

Results :

V = 0.0099

m = 79.43

m_1 = 50.82

m_2 = 124.17

Chi-sq. = 0.887

APPENDIX TABLE - XXIII

Dose-mortality data of adult *T. castaneum* (CTC - 12) treated with seed extract in Ethylacetate after 12 hours,

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Emp. prob.	Exp. prob.	Work. prob.
	x	n	r	p		Y	y
A. 5497.95	3.740	40	35	87.5	6.18	6.00	6.13
B. 549.80	2.740	40	10	25.0	4.33	4.70	4.36
C. 54.98	1.740	40	3	7.5	3.59	3.41	3.59
D. 5.50	0.740	40	-	-	-	-	-
0. Control	-	40	-	-	-	-	-

Weighting co-eff.	Weight					
w'	W= w'n	wx	wy	wx^2	wy^2	wxy
0.439	19.60	73.30	120.15	274.16	736.51	449.36
0.616	24.64	67.51	107.43	184.99	468.40	294.36
0.238	9.52	16.56	34.18	28.82	122.69	59.47
-	-	-	-	-	-	-
-	-	-	-	-	-	-
	53.76	157.38	261.76	487.97	1327.60	803.19

$\bar{x}$ = 2.93

$\bar{y}$ = 4.87

Y = 0.91 + 1.35x

Results :

V = 0.0104

m = 1061.70

m_1 = 671.43

m_2 = 1678.80

Chi-sq. = 3.914

APPENDIX TABLE - XXIV

Dose-mortality data of adult T. castaneum (CTC - 12) treated with seed extract in Ethylacetate after 24 hours.

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Emp. prob.	Exp. prob.	Work. prob.
	x	n	r	p		Y	y
A. 5497.95	3.740	40	40	100.0	8.09	7.59	7.94
B. 549.80	2.740	40	27	67.5	5.47	6.03	5.31
C. 54.98	1.740	40	7	17.5	4.08	4.47	4.12
D. 5.50	0.740	40	2	5.0	3.36	2.91	3.63
0. Control	-	40	-	-	-	-	-

Weighting co-eff.	Weight					
w'	W = w'n	wx	wy	wx^2	wy^2	wxy
0.040	1.60	5.98	12.70	22.38	100.87	47.50
0.439	17.56	48.11	93.24	131.83	495.12	255.48
0.581	23.24	40.44	95.75	70.36	394.49	166.61
0.110	4.40	3.26	15.97	2.41	57.98	11.82
-	-	-	-	-	-	-
	46.80	97.79	217.67	226.98	1048.41	481.40

$\bar{x}$ = 2.09

$\bar{y}$ = 4.65

y = 2.20 + 1.17x

Results :

V = 0.0185

m = 244.84

m_1 = 132.43

m_2 = 452.90

Chi-sq. = 5.275

APPENDIX TABLE - XXV

Dose-mortality data of adult *T. castaneum* (CTC - 12) treated with seed extract in Acetone after 24 hours.

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Emp. prob.	Exp. prob.	Work. prob.
	x	n	r	p		Y	y
A. 3746.64	3.574	40	40	100.0	8.09	6.90	7.34
B. 374.66	2.574	40	6	15.0	3.96	5.53	3.97
C. 37.47	1.574	40	4	10.0	3.72	4.14	3.79
D. 3.75	0.574	40	3	7.5	3.59	2.78	4.52
0. Control	-	40	-	-	-	-	-

Weighting co-eff.	Weight					
w'	W = w'n	wx	wy	wx^2	wy^2	wxy
0.154	6.61	23.62	48.52	84.43	356.12	173.41
0.581	23.24	59.82	92.26	153.98	366.28	237.48
0.471	18.84	29.65	17.40	46.68	270.62	27.39
0.092	3.68	2.11	16.63	1.21	75.18	9.55
-	-	-	-	-	-	-
	51.92	115.21	174.81	286.30	1068.20	447.82

$\bar{x}$ = 2.22

$\bar{y}$ = 3.37

y = 1.96x - 0.97

Results :

V = 0.0109

m = 1129.80

m_1 = 706.32

m_2 = 1807.17

Chi-sq. = 361.996***

APPENDIX TABLE - XXVI

Dose-mortality data of adult *T. castaneum* (CTC - 12) treated with seed extract in Methanol after 12 hours.

Dose µgm/sq.cm	Log dose x	No. of insect used n	No. of insect killed r	% killed p	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 2343.98	3.370	40	36	90.0	6.28	6.73	6.11
B. 234.40	2.370	40	35	87.5	6.18	5.88	6.12
C. 23.44	1.370	40	31	77.5	5.77	5.03	5.70
D. 2.34	0.370	40	3	7.5	3.59	4.18	3.73
0. Control	-	40	-	-	-	-	-

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.208	8.32	28.04	50.84	94.49	310.60	171.33
0.471	18.84	44.65	115.30	105.82	705.64	273.26
0.637	25.48	345.91	145.24	47.82	827.85	198.98
0.503	20.12	7.44	74.97	2.75	279.65	27.74
-	-	-	-	-	-	-
	72.76	115.04	386.35	250.88	2123.74	671.31

$\bar{x}$ = 1.58

$\bar{y}$ = 5.31

y = 3.92 + 0.88x

Results :

V = 0.0202

m = 16.90

m_1 = 8.91

m_2 = 32.06

Chi-sq. = 18.649***

APPENDIX TABLE - XXVII

Dose-mortality data of adult *T. castaneum* (CTC - 12) treated with seed extract in Methanol after 24 hours,

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Emp. prob.	Exp. prob.	Work. prob.
	x	n	r	p		Y	y
A. 2343.98	3.370	40	39	97.5	7.05	7.43	6.64
B. 234.40	2.370	40	38	95.0	6.64	6.46	6.62
C. 23.44	1.370	40	36	90.0	6.28	5.50	6.10
D. 2.34	0.370	40	6	15.0	3.96	4.54	4.05
0. Control	-	40	-	-	-	-	-

Weighting co-eff.	Weight					
w'	W = w'n	wx	wy	wx^2	wy^2	wxy
0.062	2.48	8.36	16.47	28.17	109.34	55.50
0.269	10.76	25.50	71.23	60.44	471.55	168.82
0.581	23.24	31.84	141.76	43.62	864.76	144.21
0.581	23.24	8.60	94.12	3.18	381.19	34.82
-	-	-	-	-	-	-
	59.72	74.30	323.58	135.41	1826.84	453.35

$\bar{x} = 1.24$

$\bar{y} = 5.42$

$y = 3.98 + 1.20x$

Results :

V = 0.0136

m = 7.78

m_1 = 4.59

m_2 = 13.18

Chi-sq. = 10.503*

APPENDIX TABLE - XXVIII

Dose-mortality data of adult *T. castaneum* (Local) treated with methacrifos after 12 hours,

Dose µgm/sq.cm	Log dose x(+3)	No. of insect used n	No. of insect killed r	% killed P	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 1.493	3.174	40	31	77.5	5.77	5.64	5.75
B. 0.1493	2.174	40	18	45.0	4.87	5.12	4.87
C. 0.01493	1.174	40	15	37.5	4.69	4.59	4.68
D. 0.001493	0.174	40	7	17.5	4.08	4.07	4.07

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.558	22.32	70.884	128.34	244.86	737.96	407.35
0.634	25.36	55.133	123.50	119.86	601.93	268.50
0.601	24.04	28.233	112.51	33.13	526.55	132.08
0.471	18.84	3.278	76.80	0.57	312.58	13.34
	90.56	157.48	441.03	378.42	2179.02	821.27

$\bar{x}$ = 1.74

$\bar{y}$ = 4.87

y = 3.97 + 0.52x

Results :

V = 0.0431

m = 0.0977

m_1 = 0.0382

m_2 = 0.250

Chi-sq. = 3.187

APPENDIX TABLE - XXIX

Dose-mortality data of adult *T. castaneum* (Local) treated with methacrifos after 24 hours.

Dose µgm/sq.cm	Log dose x(+3)	No. of insect used n	No. of insect killed r	% killed P	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 1.493	3.174	40	36	90.0	6.28	5.95	6.24
B. 0.1493	2.174	40	22	55.0	5.13	5.59	5.07
C. 0.01493	1.174	40	22	55.0	5.13	5.23	5.13
D. 0.001493	0.174	40	21	52.5	5.08	4.87	5.06

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.439	17.56	55.74	109.57	176.92	683.72	347.78
0.558	22.32	48.52	113.16	105.48	573.72	246.01
0.627	25.08	29.44	128.66	34.56	660.03	151.05
0.634	25.36	4.41	128.32	0.77	649.30	22.33
	90.32	138.11	479.71	317.73	2566.77	767.17

$\bar{x} = 1.53$

$\bar{y} = 5.31$

$y = 4.84 + 0.31x$

Results :

V = 0.2131

m = 0.0034

m_1 = 0.00042

m_2 = 0.0273

Chi-sq. = 9.214*

APPENDIX TABLE - XXX

Dose-mortality data of adult *T. castaneum* (CR - I) treated with methacrifos after 12 hours.

Dose µgm/sq.cm	Log dose x(+3)	No. of insect used n	No. of insect killed r	% killed p	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 1.493	3.174	40	32	80.0	5.84	5.74	5.84
B. 0.1493	2.174	40	22	55.0	5.13	5.25	5.12
C. 0.01493	1.174	40	15	37.5	4.69	4.75	4.68
D. 0.001493	0.174	40	10	25.0	4.33	4.25	4.33

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.532	21.28	67.54	124.28	214.37	725.80	394.46
0.616	24.64	53.57	126.16	116.46	645.94	274.27
0.627	25.08	29.44	117.37	34.56	549.29	137.79
0.532	21.28	3.70	92.14	0.64	398.97	16.03
	92.28	154.25	459.95	366.03	2319.00	822.56

$\bar{x} = 1.67$

$\bar{y} = 4.98$

$y = 4.15 + 0.50x$

Results :

$V = 0.0434$

$m = 0.0513$

$m_1 = 0.0201$

$m_2 = 0.1312$

Chi-sq. = 1.227

APPENDIX TABLE - XXXI

Dose-mortality data of adult *T. castaneum* (CR - I) treated with methacrifos after 24 hours.

Dose µgm/sq.cm	Log dose x(+3)	No. of insect used n	No. of insect killed r	% killed p	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 1.493	3.174	40	40	100.0	8.09	7.38	7.76
B. 0.1493	2.174	40	25	62.5	5.33	6.34	4.68
C. 0.01493	1.174	40	23	57.5	5.20	5.31	5.15
D. 0.001493	0.174	40	15	37.5	4.69	4.28	4.73

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.062	2.48	7.87	19.24	24.98	149.30	61.07
0.336	13.44	29.21	62.90	63.50	294.37	136.74
0.616	24.64	28.92	126.90	33.95	653.54	148.98
0.532	21.28	3.70	100.64	0.64	476.03	17.51
	61.84	69.70	309.68	123.07	1573.24	364.30

$\bar{x} = 1.12$

$\bar{y} = 5.00$

$y = 4.64 + 0.32x$

Results :

V = 0.1617

m = 0.0135

m_1 = 0.0022

m_2 = 0.0828

Chi-sq. = 19.253***

APPENDIX TABLE - XXXII

Dose-mortality data of adult *T. castaneum* (FSS - II) treated with methacrifos after 12 hours.

Dose µgm/sq.cm	Log dose x (+3)	No. of insect used n	No. of insect killed r	% killed p	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 1.493	3.174	40	35	87.5	6.18	5.98	6.13
B. 0.1493	2.174	40	22	55.0	5.13	5.29	5.12
C. 0.01493	1.174	40	10	25.0	4.33	4.61	4.34
D. 0.001493	0.174	40	8	20.0	4.16	3.92	4.20

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.439	17.56	55.73	107.64	176.89	659.83	341.65
0.616	24.64	53.56	126.16	116.44	645.94	274.27
0.601	24.04	28.22	104.33	33.13	452.79	122.48
0.405	16.20	2.81	68.04	0.49	285.77	11.84
	82.44	140.32	406.17	326.95	2044.33	750.24

$\bar{x} = 1.70$

$\bar{y} = 4.93$

$y = 3.77 + 0.68x$

Results :

V = 0.0266

m = 0.0631

m_1 = 0.0303

m_2 = 0.1315

Chi-sq. = 1.281

APPENDIX TABLE - XXXIII

Dose-mortality data of adult *T. castaneum* (FSS - II) treated with methacrifos after 24 hours.

Dose µgm/sq.cm	Log dose x (+3)	No. of insect used n	No. of insect killed r	% killed P	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 1.493	3.174	40	38	95.0	6.64	6.36	6.61
B. 0.1493	2.174	40	25	62.5	5.33	5.72	5.27
C. 0.01493	1.174	40	20	50.0	5.00	5.07	5.00
D. 0.001493	0.174	40	14	35.0	4.61	4.43	4.63

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.302	12.08	38.34	79.85	121.69	527.81	253.44
0.532	21.28	46.26	112.15	100.57	591.03	243.81
0.634	25.36	29.77	126.80	34.95	634.00	148.86
0.558	22.32	3.88	103.34	0.68	478.46	17.98
	81.04	118.26	422.14	257.89	2231.30	664.09

$\bar{x} = 1.46$

$\bar{y} = 5.21$

$y = 4.39 + 0.56x$

Results :

V = 0.0453

m = 0.012

m_1 = 0.0046

m_2 = 0.0314

Chi-sq. = 5.202

APPENDIX TABLE - XXXIV

Dose-mortality data of adult *T. castaneum* (CTC - 12) treated with methacrifos after 12 hours,

Dose µgm/sq.cm	Log dose x (+3)	No. of insect used n	No. of insect killed r	% killed p	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 1.493	3.174	40	20	50.0	5.00	5.02	5.01
B. 0.1493	2.174	40	12	38.0	4.69	4.63	4.69
C. 0.01493	1.174	40	8	20.0	4.16	4.23	4.16
D. 0.001493	0.174	40	5	12.5	3.87	3.84	3.85

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.633	25.32	80.36	126.85	255.06	635.52	402.62
0.601	24.04	52.26	112.75	113.61	528.80	245.12
0.503	20.12	23.62	82.70	27.73	344.03	97.09
0.370	14.80	2.57	56.98	0.45	219.37	9.91
	84.28	158.81	379.28	396.85	1727.72	754.74

$\bar{x} = 1.88$

$\bar{y} = 4.50$

$y = 3.71 + 0.42x$

Results :

V = 0.1466

m = 1.176

$m_1 = 0.2087$

$m_2 = 6.63$

Chi-sq. = 3.448

APPENDIX TABLE - XXXV

Dose-mortality data of adult *T. castaneum* (CTC - 12) treated with methacrifos after 24 hours.

Dose µgm/sq.cm	Log dose x (+3)	No. of insect used n	No. of insect killed r	% killed p	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 1.493	3.174	40	25	62.5	5.33	5.31	5.32
B. 0.1493	2.174	40	20	50.0	5.00	5.08	5.01
C. 0.01493	1.174	40	19	47.5	4.95	4.84	4.94
D. 0.001493	0.174	40	13	32.5	4.56	4.61	4.54

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.616	24.64	78.20	131.08	248.21	697.35	416.05
0.637	25.48	55.39	127.65	120.42	639.53	277.51
0.627	25.08	29.44	123.90	34.56	612.07	145.46
0.601	24.04	4.18	109.14	0.73	495.50	18.99
	99.24	167.21	491.77	403.92	2444.45	858.01

$\bar{x} = 1.69$

$\bar{y} = 4.96$

$y = 4.49 + 0.22x$

Results :

V = 0.2155

m = 0.0741

m_1 = 0.0091

m_2 = 0.6012

Chi-sq. = 0.651

APPENDIX TABLE - XXXVI

Dose-mortality data of larvae *T. castaneum* (Local) treated with seed extract in Petroleum spirit,

Dose µgm/sq.cm	Log dose x(+2)	No. of insect used n	No. of insect killed r	% killed P	Corr. % of killed	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 48.53	3.686	40	39	97.5	97.14	6.88	6.80	6.90
B. 4.853	2.686	40	35	87.5	85.71	6.08	6.23	6.05
C. 0.4853	1.686	40	32	80.0	77.14	5.74	5.67	5.74
D. 0.04853	0.686	40	24	60.0	54.29	5.10	5.10	5.11
0. Control	-	40	5	12.5	-	-	-	-

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.180	7.20	26.54	49.68	97.83	312.79	183.12
0.370	14.80	39.75	89.54	106.79	541.72	240.50
0.532	21.28	35.88	122.15	60.49	701.14	205.94
0.634	25.36	17.40	129.59	11.94	662.20	88.90
-	-	-	-	-	-	-
	68.64	119.57	390.96	277.05	2247.85	718.46

$\bar{x} = 1.74$

$\bar{y} = 5.70$

$Y = 4.74 + 0.55x$

Results :

V = 0.126

m = 0.0293

m_1 = 0.0059

m_2 = 0.1455

Chi-sq. = 1.626

APPENDIX TABLE - XXXVII

Dose-mortality data of larvae T. castaneum (Local) treated with seed extract in Ethyl acetate.

Dose µgm/sq.cm	Log dose x(+2)	No. of insect used n	No. of insect killed r	% killed p	Corr. % of killed	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 61.08	3.786	40	37	92.5	91.18	6.34	6.51	6.33
B. 6.108	2.786	40	33	82.5	79.41	5.81	5.82	5.82
C. 0.6108	1.786	40	31	77.5	73.53	5.64	5.12	5.59
D. 0.06108	0.786	40	12	30.0	17.65	4.08	4.43	4.11
0. Control	-	40	6	15.0	-	-	-	-

Weighting co-eff. w'	Weight W= w'n	wx	wy	wx^2	wy^2	wxy
0.269	10.76	40.74	68.11	154.23	431.14	257.86
0.503	20.12	56.05	117.10	156.17	681.51	326.24
0.634	23.36	41.72	130.58	74.51	729.96	233.22
0.558	22.32	17.54	91.74	13.79	377.03	72.11
-	-	-	-	-	-	-
	76.56	156.06	407.53	398.70	2219.64	889.43

$\bar{x}$ = 2.04

$\bar{y}$ = 5.32

Y = 3.85 + 0.72x

Results :

V = 0.029

m = 0.395

m_1 = 0.1832

m_2 = 0.8531

Chi-sq. = 9.771*

APPENDIX TABLE - XXXVIII

Dose mortality data of larvae *T. castaneum* (Local) treated with seed extract in Acetone.

Dose µgm/sq.cm	Log dose x(+2)	No. of insect used n	No. of insect killed r	% killed p	Corr. % of killed	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 41.63	3.619	40	37	92.5	90.63	6.34	6.36	6.31
B. 4.163	2.619	40	32	80.0	75.00	5.67	5.60	5.67
C. 0.4163	1.619	40	21	52.5	40.63	4.77	4.85	4.76
D. 0.04163	0.619	40	15	35.0	18.75	4.12	4.09	4.12
0. Control	-	40	8	20.0	-	-	-	-

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.302	12.08	43.72	76.22	158.21	480.98	275.84
0.558	22.32	58.46	126.55	153.10	717.56	331.43
0.634	25.36	41.06	120.71	66.47	574.60	195.43
0.471	18.84	11.66	77.62	7.22	319.80	48.05
-	-	-	-	-	-	-
	78.60	154.89	401.11	385.00	2092.94	850.75

$\bar{x} = 1.97$

$\bar{y} = 5.10$

$Y = 3.60 + 0.76x$

Results :

V = 0.022

m = 0.6893

m_1 = 0.3524

m_2 = 1.345

Chi-sq. = 1.251

APPENDIX TABLE - XXXIX

Dose-mortality data of larvae *T. castaneum* (Local) treated with seed extract in Methanol.

Dose µgm/sq.cm	Log dose x(+2)	No. of insect used n	No. of insect killed r	% killed p	Corr. % of killed	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 26.04	3.416	40	30	75.0	67.74	5.47	5.55	5.45
B. 2.604	2.416	40	24	60.0	48.39	4.95	4.87	4.96
C. 0.2604	1.416	40	16	40.0	22.58	4.26	4.20	4.25
D. 0.02604	0.416	40	11	27.5	6.45	3.45	3.52	3.48
0. Control	-	40	9	22.5	-	-	-	-

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.558	22.32	76.25	121.64	260.45	662.96	415.52
0.634	25.36	61.27	125.79	148.03	623.90	303.91
0.503	20.12	28.49	85.51	40.34	363.31	15.58
0.269	10.76	4.48	37.44	1.86	130.31	15.58
-	-	-	-	-	-	-
	78.56	170.48	370.38	450.68	1780.59	856.09

$\bar{x}$ = 2.17

$\bar{y}$ = 4.71

Y = 3.30 + 0.65x

Results :

V = 0.024

m = 4.130

m_1 = 2.051

m_2 = 8.318

Chi-sq. = 2.063

APPENDIX TABLE - XL

Dose-mortality data of larvae *T. castaneum* (CR - I) treated with seed extract in Petroleum spirit.

Dose µgm/sq.cm	Log dose x(+2)	No. of insect used n	No. of insect killed r	% killed P	Corr. % of killed	Emp. prob.	Exp. prob. Y	work. prob. y
A. 48.53	3.686	40	39	97.5	96.77	7.05	6.95	6.82
B. 4.853	2.686	40	36	90.0	87.10	6.13	6.35	6.08
C. 0.4853	1.686	40	34	85.0	80.65	5.88	5.75	5.86
D. 0.04853	0.686	40	26	65.0	54.84	5.13	5.15	5.12
O. Control	-	40	9	22.5	-	-	-	-

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.131	5.24	19.31	35.74	71.18	243.75	131.74
0.302	12.08	32.45	73.45	87.16	446.58	197.29
0.503	20.12	33.02	117.90	57.19	690.90	198.78
0.627	25.08	17.20	128.41	11.80	647.46	88.09
-	-	-	-	-	-	-
	62.52	102.88	355.50	227.33	2028.69	615.90

$\bar{x} = 1.65$

$\bar{y} = 5.69$

$Y = 4.85 + 0.51x$

Results :

$V = 0.241$

$m = 0.0101$

$m_1 = 0.0011$

$m_2 = 0.0923$

Chi-sq. = 9.061*

APPENDIX TABLE - XLI

Dose-mortality data of larvae *T. castaneum* (CR - I) treated with seed extract in Ethyl acetate,

Dose µgm/sq.cm	Log dose x(+2)	No. of insect used n	No. of insect killed r	% killed p	Corr. % of killed	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 61.08	3.786	40	38	95.0	94.12	6.55	6.58	6.57
B. 6.108	2.786	40	36	90.0	88.24	6.18	6.01	6.16
C. 0.6108	1.786	40	33	82.5	79.41	5.81	5.45	5.80
D. 0.06108	0.786	40	23	57.5	50.00	5.00	4.88	5.00
O. Control	-	40	6	15.0	-	-	-	-

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.238	9.52	36.04	62.55	136.46	410.93	236.81
0.439	17.56	48.92	108.17	136.30	666.32	301.36
0.581	23.24	41.51	134.79	74.13	781.79	240.73
0.634	25.36	19.93	126.80	15.67	634.00	99.66
-	-	-	-	-	-	-
	75.68	146.40	432.31	362.56	2493.04	878.58

$\bar{x}$ = 1.93

$\bar{y}$ = 5.71

Y = 4.64 + 0.55x

Results :

V = 0.0101

m = 0.0436

m_1 = 0.0277

m_2 = 0.0685

Chi-sq. = 0.228

APPENDIX TABLE - XLII

Dose-mortality data of larvae _T._ _castaneum_ (CR - I) treated with seed extract in Acetone.

Dose µgm/sq.cm	Log dose x(+2)	No. of insect used n	No. of insect killed r	% killed P	Corr. % of killed	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 41.63	3.619	40	38	95.0	93.55	6.55	6.63	6.52
B. 4.163	2.619	40	35	87.5	83.87	5.99	5.89	5.98
C. 0.4163	1.619	40	27	67.5	58.06	5.20	5.16	5.21
D. 0.04163	0.619	40	17	42.5	25.81	4.36	4.42	4.35
0. Control	-	40	9	22.5	-	-	-	-

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.238	9.52	34.45	62.04	124.68	404.70	224.52
0.471	18.84	49.34	110.97	129.23	653.60	290.63
0.627	25.08	40.60	130.67	65.74	680.77	211.55
0.558	22.32	13.82	97.09	8.55	422.35	60.10
-	-	-	-	-	-	-
	75.76	138.22	400.80	328.20	2161.42	786.81

$\bar{x} = 1.82$

$\bar{y} = 5.29$

$y = 3.93 + 0.75x$

Results :

$V = 0.027$

$m = 0.2673$

$m_1 = 0.1274$

$m_2 = 0.561$

Chi-sq. = 1.828

APPENDIX TABLE - XLIII

Dose-mortality data of larvae *T. castaneum* (CR - I) treated with seed extract in Methanol.

Dose µgm/sq.cm	Log dose x(+2)	No. of insect used n	No. of insect killed r	% killed p	Corr. % of killed	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 26.04	3.416	40	40	100.0	100.0	8.09	7.69	8.03
B. 2.604	2.416	40	35	87.5	86.49	6.08	6.63	5.88
C. 0.2604	1.416	40	28	70.0	67.57	5.47	5.57	5.45
D. 0.02604	0.416	40	18	45.0	40.54	4.77	4.52	4.77
0. Control	-	40	3	7.5	-	-	-	-

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.031	1.24	4.24	9.96	14.47	79.96	34.02
0.238	9.52	23.00	55.98	55.57	329.15	135.25
0.558	22.32	31.61	121.64	44.75	662.96	172.24
0.581	23.24	9.67	110.85	4.02	528.78	46.11
-	-	-	-	-	-	-

$\bar{x} = 1.22$

$\bar{y} = 5.30$

$y = 4.48 + 0.67x$

Results :

V = 0.052

m = 0.0597

m_1 = 0.0213

m_2 = 0.1671

Chi-sq. = 3.396

APPENDIX TABLE - XLIV

Dose-mortality data of larvae *T. castaneum* (FSS - II) treated with seed extract in Petroleum spirit.

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Corr. % of killed	Emp. prob.	Exp. prob.	Work. prob.
	x(+2)	n	r	P			Y	y
A. 48.53	3.686	40	40	100.0	100.00	8.09	7.75	8.12
B. 4.583	2.686	40	37	92.5	91.18	6.34	6.79	6.14
C. 0.4853	1.686	40	32	80.0	76.47	5.71	5.82	5.72
D. 0.04853	0.686	40	24	60.0	52.94	5.08	4.86	5.07
0. Control	-	40	6	15.0	-	-	-	-

Weighting co-eff.	Weight					
w'	W = w'n	wx	wy	wx^2	wy^2	wxy
0.025	1.00	3.686	8.12	13.59	29.93	29.93
0.180	7.20	19.34	44.21	51.95	271.44	118.75
0.503	20.12	33.92	115.09	57.19	658.29	194.04
0.634	25.36	17.40	128.58	11.93	651.88	88.21
-	-	-	-	-	-	-
	53.68	74.34	295.99	134.66	1647.54	430.93

$\bar{x} = 1.38$

$\bar{y} = 5.51$

$Y = 4.82 + 0.70x$

Results :

V = 0.072

m = 0.0448

m_1 = 0.0133

m_2 = 0.1503

Chi-sq. = 0.910

APPENDIX TABLE - XLV

Dose-mortality data of larvae *T. castaneum* (FSS - II) treated with seed extract in Ethyl acetate.

Dose µgm/sq.cm	Log dose x(+2)	No. of insect used n	No. of insect killed r	% killed P	Corr. % of killed	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 61.08	3.786	40	36	90.00	88.50	6.23	6.47	6.12
B. 6.108	2.786	40	35	87.50	85.71	6.18	5.88	6.05
C. 0.6108	1.786	40	28	70.00	65.71	5.41	5.28	5.40
D. 0.06108	0.786	40	16	40.00	31.43	4.50	4.69	4.52
O. Control	-	40	5	12.50	-	-	-	-

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.269	10.76	40.74	65.85	154.23	403.01	249.31
0.471	18.84	52.48	113.98	146.23	689.59	317.55
0.616	24.64	44.01	133.06	78.60	718.50	237.65
0.616	24.64	19.37	111.37	15.22	503.41	87.54
-	-	-	-	-	-	-
	78.88	156.60	424.26	394.28	2377.51	892.04

$\bar{x} = 1.99$

$\bar{y} = 5.38$

$y = 4.23 + 0.58x$

Results :

V = 0.022

m = 0.2163

$m_1 = 0.1107$

$m_2 = 0.4227$

Chi-sq. = 67.288***

APPENDIX TABLE - XLVI

Dose-mortality data of larvae *T. castaneum* (FSS - II) treated with seed extract in Acetone.

Dose µgm/sq.cm	Log dose x(+2)	No. of insect used n	No. of insect killed r	% killed P	Corr. % of killed	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 41.63	3.619	40	39	97.50	97.06	6.88	6.63	6.83
B. 4.163	2.619	40	33	82.50	79.41	5.81	6.10	5.77
C. 0.4163	1.619	40	28	70.00	64.71	5.39	5.56	5.36
D. 0.04163	0.619	40	26	65.00	58.82	5.23	5.02	5.23
0. Control	-	40	6	15.00	-	-	-	-

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.238	9.52	34.45	65.02	124.68	444.10	235.31
0.405	16.20	42.43	93.47	111.12	539.34	244.80
0.558	22.32	36.14	119.64	58.50	641.24	193.70
0.637	25.48	15.77	133.26	9.76	696.95	82.49
-	-	-	-	-	-	-
	73.52	128.79	411.39	304.06	2321.63	756.29

$\bar{x} = 1.75$

$\bar{y} = 5.60$

$Y = 4.79 + 0.46x$

Results :

V = 0.165

m = 0.0286

$m_1 = 0.0046$

$m_2 = 0.1791$

Chi-sq. = 1.682

APPENDIX TABLE - XLVII

Dose-mortality data of larvae *T. castaneum* (FSS - II) treated with seed extract in Methanol.

Dose µgm/sq.cm	Log dose x(+2)	No. of insect used n	No. of insect killed r	% killed p	Corr. % of killed	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 26.04	3.416	40	25	62.50	51.61	5.05	5.12	5.04
B. 2.604	2.416	40	21	52.50	38.71	4.72	4.68	4.71
C. 0.2604	1.416	40	17	42.50	25.81	4.36	4.25	4.36
D. 0.02604	0.416	40	12	30.00	9.68	3.72	3.81	3.71
O. Control	-	40	9	22.50	-	-	-	-

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.634	25.36	86.63	127.81	295.93	644.18	436.60
0.616	24.64	59.53	116.05	143.83	546.62	280.38
0.532	21.28	30.13	92.78	42.67	404.52	131.38
0.370	14.80	6.16	54.91	2.56	203.71	22.80
-	-	-	-	-	-	-
	86.08	182.45	391.56	484.99	1799.03	871.15

$\bar{x} = 2.12$

$\bar{y} = 4.55$

$y = 3.66 + 0.42x$

Results :

V = 0.00018

m = 15.539

m_1 = 14.588

m_2 = 16.443

Chi-sq. = 0.189

APPENDIX TABLE - XLVIII

Dose-mortality data of larvae *T. castaneum* (CTC - 12) treated with seed extract in Petroleum spirit.

Dose µgm/sq.cm	Log dose x(+2)	No. of insect used n	No. of insect killed r	% killed p	Corr. % of killed	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 48.53	3.686	40	40	100.0	100.00	8.09	7.99	8.30
B. 4.853	2.686	40	39	97.5	96.88	6.88	6.95	6.84
C. 0.4853	1.686	40	33	82.5	78.13	5.77	5.92	5.77
D. 0.04853	0.686	40	24	60.0	50.00	5.00	4.88	5.00
O. Control	-	40	8	20.0	-	-	-	-

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.015	0.60	2.21	4.98	8.15	41.33	18.36
0.131	5.24	14.07	35.84	37.79	245.15	96.27
0.471	18.84	31.76	108.71	53.55	627.26	183.29
0.634	25.36	17.67	126.80	12.12	634.00	86.98
-	-	-	-	-	-	-
	50.04	65.71	276.33	111.61	1547.74	384.89

$\bar{x}$ = 1.31

$\bar{y}$ = 5.52

Y = 4.34 + 0.90x

Results :

V = 0.0084

m = 0.0539

m_1 = 0.0356

m_2 = 0.0817

Chi-sq. = 1.970

APPENDIX TABLE - XLIX

Dose-mortality data of larvae *T. castaneum* (CTC - 12) treated with seed extract in Ethyl acetate.

Dose µgm/sq.cm	Log dose x(+2)	No. of insect used n	No. of insect killed r	% killed P	Corr. % of killed	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 61.08	3.786	40	31	77.5	70.79	5.55	5.61	5.55
B. 6.108	2.786	40	29	72.5	64.52	5.39	5.34	5.37
C. 0.6108	1.786	40	26	65.0	54.84	5.13	5.06	5.12
D. 0.06108	0.786	40	21	52.5	38.71	4.72	4.79	4.71
0. Control	-	40	9	22.5	-	-	-	-

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.558	22.32	84.50	123.88	319.93	687.51	469.01
0.616	24.64	68.65	132.32	191.25	710.54	368.64
0.634	25.36	45.29	129.84	80.89	664.80	231.89
0.627	25.08	19.71	118.13	15.49	556.38	92.85
-	-	-	-	-	-	-
	97.40	218.16	504.16	607.56	2619.23	1162.40

$\bar{x} = 2.24$

$\bar{y} = 5.18$

$Y = 4.55 + 0.28x$

Results :

$V = 0.008$

$m = 0.4046$

$m_1 = 0.1061$

$m_2 = 1.543$

Chi-sq. = 1.582

APPENDIX TABLE - L

Dose-mortality data of larvae *T. castaneum* (CTC - 12) treated with seed extract in Acetone.

Dose µgm/sq.cm	Log dose x(+2)	No. of insect used n	No. of insect killed r	% killed P	Corr. % of killed	Emp. prob.	Exp. prob. Y	Work. prob. y
A. 41.63	3.619	40	38	95.0	93.75	6.55	6.64	6.54
B. 4.163	2.619	40	36	90.0	87.50	6.18	6.03	6.83
C. 0.4163	1.619	40	29	72.5	65.63	5.41	5.42	5.41
D. 0.04163	0.619	40	21	52.5	40.63	4.77	4.81	4.76
O. Control	-	40	8	20.0	-	-	-	-

Weighting co-eff. w'	Weight W = w'n	wx	wy	wx^2	wy^2	wxy
0.238	9.52	34.45	62.26	124.68	407.19	225.32
0.439	17.56	45.99	119.93	120.45	819.15	314.10
0.601	24.04	38.92	130.06	63.01	703.61	210.57
0.627	25.08	15.52	119.38	9.61	568.25	73.80
-	-	-	-	-	-	-
	76.20	134.89	413.63	317.75	2498.20	823.88

$\bar{x} = 1.77$

$\bar{y} = 5.66$

$Y = 4.32 + 0.76x$

Results :

$V = 0.039$

$m = 0.0785$

$m_1 = 0.0329$

$m_2 = 0.1875$

Chi-sq. = 9.654*

APPENDIX TABLE - LI

Dose-mortality data of larvae *T. castaneum* (CTC - 12) treated with seed extract in Methanol.

Dose µgm/sq.cm	Log dose	No. of insect used	No. of insect killed	% killed	Corr. % of killed	Emp. prob.	Exp. prob.	Work. prob.
	x(+2)	n	r	P			Y	y
A. 26.04	3.416	40	38	95.0	93.94	6.55	6.48	6.54
B. 2.604	2.416	40	34	85.0	81.82	5.92	6.01	5.90
C. 0.2604	1.416	40	30	75.0	69.70	5.52	5.55	5.51
D. 0.02604	0.416	40	25	62.5	54.55	5.13	5.08	5.11
O. Control	-	40	7	17.5	-	-	-	-

Weighting co-eff.	Weight					
w'	W = w'n	wx	wy	wx^2	wy^2	wxy
0.269	10.76	36.76	70.37	125.56	460.22	240.38
0.439	17.56	42.42	103.60	102.50	611.26	250.30
0.558	22.32	31.61	122.98	44.75	677.64	174.14
0.634	25.36	10.55	129.59	4.39	662.20	53.91
-	-	-	-	-	-	-
	76.00	121.34	426.54	277.70	2411.32	718.73

$\bar{x}$ = 1.60

$\bar{y}$ = 5.61

Y = 4.92 + 0.43x

Results :

V = 0.199

m = 0.0153

m_1 = 0.0[illegible]

m_2 = 0.1148

Chi-sq. = 2.836

APPENDIX TABLE-LII

Analysis of variance for larval period of *T. castaneum* among different strains and different doses of treatment with extraction of *A. squamosa* in petroleum spirit solvent.

Dose µgm/sq.cm	Strain				Total	Mean
	Local	CR-I	FSS-II	CTC 12		
A. 48.53	24.89	25.10	0	24.28	74.27	18.57
B. 4.853	23.05	23.21	24.31	23.51	94.08	23.52
C. 0.4853	22.27	22.20	22.56	22.13	89.16	22.29
D. 0.04853	21.18	21.21	21.94	21.28	85.61	21.40
O. Control	20.62	20.20	21.09	20.76	82.67	20.67
Total	112.01	111.92	89.90	111.96	425.79	106.45
Mean	22.40	22.38	17.98	22.39	85.16	21.29

Correction factor (CF) = 9064.86

Total sum of square (TSS) = 517.02

Dose sum of square (DSS) = 55.14

Strain sum of square (SSS) = 73.02

Source	d.f.	S.S.	M.S.	F
Dose(D)	4	55.14	13.785	0.425
Strain(S)	3	73.02	24.340	0.751
Error	12	388.86	32.405	
Total	19	517.02		

APPENDIX TABLE-LIII

Analysis of variance for larval period of *T. castaneum* among different strains and different doses of treatment with extraction of *A. squamosa* in ethyl acetate solvent.

Dose µgm/sq.cm	Strain				Total	Mean
	Local	CR-I	FSS-II	CTC 12		
A.61.08	25.19	25.07	25.61	25.04	100.82	25.21
B.6.108	23.59	23.71	24.35	23.04	94.69	23.67
C.0.6108	22.50	22.53	23.48	22.46	90.97	22.74
D.0.06108	21.38	21.35	21.99	21.71	86.43	21.61
O.Control	20.62	20.20	21.09	20.76	82.67	20.67
Total	113.19	112.86	116.52	113.01	455.58	113.89
Mean	22.64	22.57	23.30	22.60	91.12	22.78

Correction factor (CF) = 10377.66

Total sum of square (TSS) = 52.559

Dose sum of square (DSS) = 50.06

Strain sum of square (SSS) = 1.845

Source	d.f.	S.S.	M.S.	F
Dose(D)	4	50.04	12.510	223.393***
Strain(S)	3	1.85	0.617	11.018***
Error	12	0.67	0.056	
Total	19	52.56		

***P < 0.001

LSD(D) = 0.723

LSD(D) = 0.664

APPENDIX TABLE-LIV

Analysis of variance for larval period of *T. castaneum* among different strains and different doses of treatment with extraction of *A. squamosa* in acetone solvent,

Dose µgm/sq.cm	Strain				Total	Mean
	Local	CR-I	FSS-II	CTC 12		
A. 41.63	25.48	25.13	25.60	25.41	101.62	25.41
B. 4.163	24.24	23.22	24.35	24.74	96.55	24.14
C. 0.4163	23.21	22.50	23.48	23.25	92.44	23.11
D. 0.04163	22.05	21.30	21.99	22.17	87.51	21.88
0. Control	20.62	20.20	21.09	20.76	82.67	20.67
Total	115.60	112.35	116.51	116.33	460.79	115.20
Mean	23.12	22.47	23.30	23.27	92.16	23.04

Correction factor (CF) = 10616.37

Total sum of square (TSS) = 57.92

Dose sum of square (DSS) = 55.13

Strain sum of square (SSS) = 2.256

Source	d.f.	S.S.	M.S.	F
Dose(D)	4	55.13	13.783	313.250***
Strain(S)	3	2.26	0.753	17.114***
Error	12	0.53	0.044	
Total	19	57.92		

*** $P < 0.001$

LSD(D) = 0.640

LSD(S) = 0.589

APPENDIX TABLE-LV

Analysis of variance for larval period of *T. castaneum* among different strains and different doses of treatment with extraction of *A. squamosa* in methanol solvent.

Dose µgm/sq.cm	Strain				Total	Mean
	Local	CR-I	FSS-II	CTC 12		
A, 26.04	24.70	25.15	25.02	24.83	99.70	24.93
B, 2.604	23.72	23.61	23.65	23.26	94.24	23.56
C, 0.2604	22.34	22.46	22.42	22.44	89.66	22.42
D, 0.02604	21.10	21.19	21.36	21.82	85.47	21.37
0, Control	20.62	20.20	21.09	20.76	82.67	20.67
Total	112.48	112.61	113.54	113.11	451.74	112.94
Mean	22.50	22.52	22.71	22.62	90.35	22.59

Correction factor (CF) = 10203.45

Total sum of square (TSS) = 47.43

Dose sum of square (DSS) = 46.47

Strain sum of square (SSS) = 0.143

Source	d.f.	S.S.	M.S.	F
Dose(D)	4	46.47	11.618	170.853***
Strain(S)	3	0.143	0.048	0.706
Error	12	0.817	0.068	
Total	19	47.43		

*** $P < 0.001$ LSD(D = 0.796

APPENDIX TABLE-LVI

Analysis of variance for pupal period of *T. castaneum* among different strains and different doses of treatment with extraction of *A. squamosa* in petroleum spirit solvent.

Dose µgm/sq.cm	Strain				Total	Mean
	Local	CR-I	FSS-II	CTC 12		
A. 48.53	6.88	6.85	0	7.12	20.85	5.21
B. 4.853	6.68	6.69	6.73	6.82	26.92	6.73
C. 0.4853	6.37	6.21	6.32	6.42	25.32	6.33
D. 0.04853	6.07	5.92	5.92	6.19	24.10	6.03
O. Control	5.81	5.61	5.43	5.91	22.76	5.69
Total	31.81	31.28	24.40	32.46	119.95	29.99
Mean	6.36	6.26	4.88	6.49	23.99	5.99

Correction factor (CF) = 719.40

Total sum of square (TSS) = 41.93

Dose sum of square (DSS) = 5.43

Strain sum of square (SSS) = 8.47

Source	d.f.	S.S.	M.S.	F
Dose(D)	4	5.43	1.358	0.581
Strain(S)	3	8.47	2.823	1.208
Error	12	28.03	2.336	
Total	19	41.93		

APPENDIX TABLE-LVII

Analysis of variance for pupal period of *T. castaneum* among different strains and different doses of treatment with extraction of *A. squamosa* in ethyl acetate solvent.

Dose µgm/sq.cm	Strain				Total	Mean
	Local	CR-I	FSS-II	CTC 12		
A. 61.08	6.80	6.79	6.66	7.06	27.31	6.83
B. 6.108	6.52	6.53	6.41	6.77	26.23	6.56
C. 0.6108	6.26	6.17	6.05	6.47	24.95	6.24
D. 0.06108	5.95	5.76	5.73	6.12	23.56	5.89
O. Control	5.81	5.61	5.43	5.91	22.76	5.69
Total	31.34	30.86	30.28	32.33	124.81	31.20
Mean	6.27	6.17	6.06	6.47	24.96	6.24

Correction factor (CF) = 778.88

Total sum of square (TSS) = 3.96

Dose sum of square (DSS) = 3.48

Strain sum of square (SSS) = 0.449

Source	d.f.	S.S.	M.S.	F
Dose(D)	4	3.48	0.870	310.714***
Strain(S)	3	0.449	0.149	53.214***
Error	12	0.031	0.0026	
Total	19	3.96		

*** $P < 0.001$

LSD(D) = 0.156

LSD(S) = 0.143

APPENDIX TABLE-LVIII

Analysis of variance for pupal period of *T. castaneum* among different strains and different doses of treatment with extraction of *A. squamosa* in acetone solvent.

Dose µgm/sq.cm	Strain				Total	Mean
	Local	CR-I	FSS-II	CTC 12		
A. 41.63	6.83	6.86	6.81	6.95	27.45	6.86
B. 4.163	6.65	6.45	6.57	6.60	26.27	6.57
C. 0.4163	6.45	6.18	6.26	6.40	25.29	6.32
D. 0.0413	6.14	5.91	5.73	6.16	23.94	5.99
0. Control	5.81	5.61	5.43	5.91	22.76	5.69
Total	31.88	31.01	30.80	32.02	125.71	31.43
Mean	6.38	6.20	6.16	6.40	25.14	6.29

Correction factor (CF) = 790.15

Total sum of square (TSS) = 4.15

Dose sum of square (DSS) = 3.44

Strain sum of square (SSS) = 0.225

Source	d.f.	S.S.	M.S.	F
Dose(D)	4	3.440	0.860	21.500***
Strain(S)	3	0.225	0.075	1.875
Error	12	0.485	0.040	
Total	19	4.15		

***$P < 0.001$

LSD(D) = 0.611

APPENDIX TABLE-LIX

Analysis of variance for pupal period of *T. castaneum* among different strains and different doses of treatment with extraction of *A. squamosa* in methanol solvent,

Dose µgm/sq.cm	Strain				Total	Mean
	Local	CR-I	FSS-II	CTC 12		
A. 26.04	6.76	6.91	6.74	7.16	27.57	6.89
B. 2.604	6.50	6.54	6.47	6.77	26.28	6.57
C. 0.2604	6.23	6.29	6.19	6.52	25.23	6.31
D. 0.02604	6.08	5.85	5.81	6.23	23.97	5.99
0. Control	5.81	5.61	5.43	5.91	22.76	5.69
Total	31.38	31.20	30.64	32.59	125.81	31.45
Mean	6.28	6.24	6.13	6.52	25.16	6.29

Correction factor (CF) = 791.41

Total sum of square (TSS) = 4.05

Dose sum of square (DSS) = 3.56

Strain sum of square (SSS) = 0.402

Source	d.f.	S.S.	M.S.	F
Dose(D)	4	3.560	0.890	121.918***
Strain(S)	3	0.402	0.134	18.356***
Error	12	0.088	0.0073	
Total	19	4.05		

***$P < 0.001$

LSD(D) = 0.261

LSD(S) = 0.240

APPENDIX TABLE-LX

Analysis of variance for fecundity of *T. castaneum* among different Strains and different doses of treatment with extraction of *A. squamosa* in Petroleum Spirit solvent.

Dose µgm/sq.cm	Strain				Total	Mean
	Local	CR-I	FSS-II	CTC 12		
A 48.53	4.14	3.71	0	0	7.85	1.96
B 4.853	7.14	6.71	8.00	4.71	26.56	6.64
C 0.4853	10.71	9.43	11.86	7.71	39.71	9.93
D 0.04853	14.00	14.57	16.57	12.14	57.28	14.32
O Control	22.43	21.86	24.00	21.14	89.43	22.36
Total	58.42	56.28	60.43	45.70	220.83	55.21
Mean	11.68	11.26	12.09	9.14	44.17	11.04

Correction factor (CF) = 2438.29

Total sum of square (TSS) - 1012.62

Dose sum of square (DSS) = 967.371

Strain sum of square (SSS) = 25.827

Source	d.f.	S.S.	M.S.	F
Dose(D)	4	967.371	241.843	149.378***
Strain(S)	3	25.827	8.609	5.317*
Error	12	19.422		
Total	19	1012.62		

*$P < 0.05$ and ***$P < 0.001$

LSD(D) = 3.885

LSD(S) = 1.753

APPENDIX TABLE-LXI

Analysis of variance for fecundity of *T. castaneum* among different strains and different doses of treatment with extraction of *A. squamosa* in Ethyl acetate solvent.

Dose µgm/sq.cm	Strain				Total	Mean
	Local	CR-I	FSS-II	CTC 12		
A. 61.08	4.71	4.43	6.57	7.29	23.00	5.75
B. 6.108	9.43	7.57	10.86	11.57	39.43	9.86
C. 0.6108	13.00	11.86	14.14	15.75	54.75	13.69
D. 0.06108	16.14	16.14	19.43	19.57	71.28	17.82
O. Control	24.14	23.71	24.29	25.14	97.28	24.32
Total	67.42	63.71	75.29	79.32	285.74	71.44
Mean	13.48	12.74	15.06	16.86	58.14	14.54

Correction factor (CF) = 4082.37

Total sum of square (TSS) = 859.883

Dose sum of square (DSS) = 824.011

Strain sum of square (SSS) = 30.563

Source	d.f.	S.S.	M.S.	F
Dose(D)	4	824.011	206.003	466.070***
Strain(S)	3	30.563	10.188	23.050***
Error	12	5.309	0.442	
Total	19	859.883		

*** $P < 0.001$

LSD(D) = 2.030

LSD(S) = 1.816

APPENDIX TABLE-LXII

Analysis of variance for fecundity of *T. castaneum* among different strains and different doses of treatment with extraction of *A. squamosa* in Acetone solvent.

Dose µgm/sq.cm	Strain				Total	Mean
	Local	CR-I	FSS-II	CTC 12		
A. 41.63	4.14	7.29	6.86	7.71	26.00	6.50
B. 4.163	7.57	10.57	10.29	11.57	40.00	10.00
C. 0.4163	11.71	13.86	13.86	16.00	55.43	13.86
D. 0.04163	17.71	18.71	19.14	19.43	74.99	18.75
O. Control	23.42	24.43	24.57	26.00	98.42	24.61
Total	64.55	74.86	74.72	80.71	294.84	73.71
Mean	12.91	14.97	14.94	16.14	58.96	14.74

Correction factor (CF) = 4346.53

Total sum of square (TSS) = 848.938

Dose sum of square (DSS) = 818.090

Strain sum of square (SSS) = 27.051

Source	d.f.	S.S.	M.S.	F
Dose(D)	4	818.090	204.523	647.225***
Strain(S)	3	25.051	9.017	28.535***
Error	12	3.797	0.316	
Total	19	848.938		

***$P < 0.001$

LSD(D) = 1.716

LSD(S) = 1.535

APPENDIX TABLE-LXIII

Analysis of variance for fecundity of T. castaneum among different strains and different doses of treatment with extraction of A. squamosa in Methanol solvent.

Dose µgm/sq.cm	Strain				Total	Mean
	Local	CR-I	FSS-II	CTC 12		
A. 26.04	6.43	6.71	4.57	7.43	25.14	6.29
B. 2.604	8.57	10.29	8.43	10.86	38.15	9.54
C. 0.2604	13.29	13.86	13.71	15.57	56.43	14.11
D. 0.02604	19.29	18.43	18.43	19.71	75.86	37.93
O. Control	25.71	25.14	23.57	24.14	98.56	24.64
Total	73.29	74.43	68.71	77.71	294.14	73.54
Mean	14.66	14.89	13.74	15.54	58.83	14.71

Correction factor (CF) = 4325.92

Total sum of square (TSS) = 875.211

Dose sum of square (DSS) = 859.230

Strain sum of square (SSS) = 8.311

Source	d.f.	S.S.	M.S.	F
Dose(D)	4	859.230	214.808	336.163***
Strain(S)	3	8.311	2.770	4.335*
Error	12	7.670	0.639	
Total	19	875.211		

* $P < 0.05$ and *** $P < 0.001$

LSD(D) = 2.441

LSD(S) = 1.102

APPENDIX TABLE-LXIV

Analysis of variance for hatching percentage of *T. castaneum* among different strains and different doses of treatment with extraction of *A. squamosa* in Petroleum Spirit solvent.

Dose µgm/sq.cm	Strain				Total	Mean
	Local	CR-I	FSS-II	CTC 12		
A. 48.53	43.06	46.67	0	0	89.73	22.43
B. 4.853	46.94	51.50	45.34	46.77	190.55	47.64
C. 0.4853	55.95	59.23	51.23	53.08	219.49	54.87
D. 0.04853	61.94	63.50	56.37	59.34	241.15	60.29
O. Control	100.00	96.61	98.44	100.00	395.05	98.76
Total	307.89	317.51	251.38	359.19	1135.97	283.99
Mean	61.58	63.50	50.28	51.84	227.20	56.80

Correction factor (CF) = 64521.39

Total sum of square (TSS) = 14281.77

Dose sum of square (DSS) = 674.65

Strain sum of square (SSS) = 12167.23

Source	d.f.	S.S.	M.S.	F
Dose(D)	4	12167.23	3041.808	25.350***
Strain(S)	3	674.65	224.883	1.874
Error	12	1439.89	119.991	
Total	19	14281.77		

*** $p < 0.001$

LSD(D) = 33.446

APPENDIX TABLE-LXV

Analysis of variance for hatching percentage of *T. castaneum* among different strains and different doses of treatment with extraction of *A. squamosa* in Ethyl acetate solvent.

Dose µgm/sq.cm	Strain				Total	Mean
	Local	CR-I	FSS-II	CTC 12		
A. 61.08	44.55	44.36	50.41	51.77	191.09	47.77
B. 6.108	50.97	49.64	55.05	54.36	210.02	52.51
C. 0.6108	58.19	52.86	60.01	58.83	229.89	57.47
D. 0.06108	62.86	60.27	64.72	65.49	253.34	63.34
O. Control	100.00	98.70	99.10	100.00	397.80	99.45
Total	316.57	305.83	329.29	330.45	1282.14	320.54
Mean	63.31	61.17	65.86	66.09	256.43	61.11

Correction factor (CF) = 82194.15

Total sum of square (TSS) = 6893.64

Dose sum of square (DSS) = 6780.65

Strain sum of square (SSS) = 81.38

Source	d.f.	S.S.	M.S.	F
Dose(D)	4	6780.65	1695.16	643.569***
Strain(S)	3	81.38	27.127	10.299**
Error	12	31.61	2.634	
Total	19			

** $p < 0.01$ and *** $p < 0.001$

LSD(D) = 4.955

LSD(S) = 3.136

APPENDIX TABLE-LXVI

Analysis of variance for hatching percentage of T. castaneum among different strains and different doses of treatment with extraction of A. squamosa in Acetone,

Dose µgm/sq.cm	Strain				Total	Mean
	Local	CR-I	FSS-II	CTC 12		
A. 41.63	40.69	50.48	51.99	53.17	196.33	49.08
B. 4.163	44.68	53.59	53.01	55.85	207.13	51.78
C. 0.4163	53.66	58.06	55.73	59.48	226.93	56.73
D. 0.04163	63.43	64.05	61.44	65.11	254.03	63.51
O. Control	100.00	99.59	98.90	100.00	398.49	99.62
Total	302.46	325.77	321.07	333.61	1282.91	320.73
Mean	60.49	65.15	64.21	66.72	256.58	64.15

Correction factor (CF) = 82292.90

Total sum of square (TSS) = 6971.88

Dose sum of square (DSS) = 6774.86

Strain sum of square (SSS) = 105.04

Source	d.f.	S.S.	M.S.	F
Dose(D)	4	6774.86	1693.715	220.967***
Strain(S)	3	105.04	35.013	4.568*
Error	12	91.98	7.665	
Total	19	6971.88		

* $P < 0.05$ and *** $P < 0.001$

LSD(D) = 8.453

LSD(S) = 3.815

APPENDIX TABLE-LXVII

Analysis of variance for hatching percentage of T. castaneum among different strains and different doses of treatment with extraction of A. squamosa in Methanol.

Dose µgm/sq.cm	Strain				Total	Mean
	Local	CR-I	FSS-II	CTC 12		
A. 26.04	42.02	48.38	49.03	50.69	190.05	47.51
B. 2.604	46.06	51.97	53.88	52.64	204.55	51.14
C. 0.2604	50.54	56.40	60.03	56.39	223.36	55.84
D. 0.02604	58.77	60.33	63.32	61.08	243.50	60.88
O. Control	99.71	98.70	99.64	100.00	398.05	99.51
Total	297.10	315.71	325.90	320.80	1259.51	314.88
Mean	59.42	63.14	65.18	64.16	251.90	62.98

Correction factor (CF) = 79318.27

Total sum of square (TSS) = 7215.51

Dose sum of square (DSS) = 7078.09

Strain sum of square (SSS) = 99.66

Source	d.f.	S.S.	M.S.	F
Dose(D)	4	7078.09	1769.52	562.288***
Strain(S)	3	99.66	33.22	10.556**
Error	12	37.76	3.147	
Total	19	7215.51		

** $P < 0.01$ and *** $P < 0.001$

LSD(D) = 5.416

LSD(S) = 3.485