SEASONAL OCCURRENCE AND ECOFRIENDLY MANAGEMENT OF PESTS OF BLACK PEPPER (*Piper nigrum* L.)

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DECLARATION

I hereby declare that this thesis entitled "**Seasonal occurrence and ecofriendly management of pests of black pepper (*Piper nigrum* L.)**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that this thesis entitled "**Seasonal occurrence and ecofriendly management of pests of black pepper (*Piper nigrum* L.)**" is a record of research work done independently by Ms. Sangeetha. A.S. (2001-11-09) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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LIST OF ABBREVIATIONS

%	Per cent
CD	Critical difference
°C	Degree Celsius
cm	Centimetre(s)
et al.	And others
Fig.	Figure
g	Gram
HAS	Hours after spray
kg	Kilogram
m	Metre
ml	Millilitre
mm	Millimetre
spp.	Species
viz.	Namely
WAS	Weeks after spray

INTRODUCTION

1. INTRODUCTION

Black pepper (*Piper nigrum* L.) is one of the important spice commodities of commerce and trade since antiquity. The pepper plant is a perennial climbing vine belonging to the family Piperaceae and its probable centre of origin is in the natural evergreen forest ecosystem of the Western Ghats. The processed pepper berries and value added products find use as spice, condiment and in medicine, as a carminative and stimulant.

Kerala accounts for 97.40 per cent of the total area of 2.38 lakh hectares under the crop in the country. Out of the total production of around 75000 tonnes of the produce, Kerala's share is about 63.00 per cent. Processed berries and pepper products like pepper oil and oleoresin contributed to 46.50 per cent of the total export of spices in the year 2001 from India. This was valued at Rs. 1861.03 crores.

At one stage, India was the only producer and exporter of black pepper in the world. Over the years, other countries took up the cultivation on a commercial scale. Out of the total world production of pepper which ranges from 1.70 to 1.90 lakh tonnes, India's share at present is hardly 30 per cent with 50 per cent of the world area under pepper.

The per hectare productivity in India is dismally low at 315 $kgha^{-1}$ compared to 4079 kg ha^{-1} in Thailand (Sivaraman *et al.*, 2002). At present, India is facing stiff competition from countries like Vietnam, Indonesia, Thailand and Brazil in the global pepper trade.

One of the major factors attributed to low yield of black pepper in India is the ravages caused by pests and diseases. Thirty four species of insects have been recorded on pepper in India, among which pollu beetle

(*Longitarsus nigripennis* Mots.), top shoot borer (*Cydia hemidoxa* Megr.), scale insects (*Lepidosaphes piperis* Gr. and *Aspidiotus destructor* Sign.) and leaf gall thrips (*Liothrips karnyi*. Bagn.) are important (Devasahayam, 1996). The pollu beetle caused 30 to 40 per cent loss in yield of black pepper(Pillai and Abraham,1974). Hitherto the management of the pests of black pepper has relied on the use of synthetic chemical pesticides. The Package of Practices of KAU (2002) recommends the use of pesticides like endosulfan, dimethoate, quinalphos and cypermethrin. However the unwarranted use of synthetic pesticides in black pepper results in the possibility of pesticide residues in the produce (Venugopal *et al.*, 1979). This could become a major hindrance for export which is facing competition from the other pepper exporting countries. Injudicious application of pesticides also promotes pest resistance to pesticides, pest resurgence, harm to non target organisms, pesticide residue in the produce and contamination of the environment. The tirade and concern on the above issues have paved the way for the research and development of alternate pest control strategies in spices and other crops.

One important aspect in this regard is the development and use of botanical pesticides evolved from plants. These botanicals are ecofriendly, specific to pests, biodegradable and have potential for commercial use. These natural pesticides have a major role to play under the gamut of Integrated Pest Management. Deployment of botanicals in IPM can become an important tool in the organic mode of cultivation of black pepper. Pesticide free, organically grown pepper which if carefully harvested, processed and stored would fetch a premium and competitive price not only in the domestic but also in the international markets.

Information on the seasonal distribution of pests infesting black pepper is limited. Precise information on the status of pests and their

intensity of infestation at different periods *viz*., flushing, spike emergence, berry formation and maturation would be of use in scheduling ecofriendly management measures. In this context, experiments were undertaken with the following objectives.

- To study the seasonal occurrence of pests infesting black pepper
- To develop an ecofriendly strategy to manage the pests of black pepper.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Black pepper, *Piper nigrum* (L.) is one of the important and earliest known spice crops produced and exported from India. The black pepper is prone to attack by a number of insect pest species which include the pollu (*Longitarsus nigripennis* Mots.), top shoot borer (*Cydia hemidoxa* Meyr.) pepper scale (*Lepidosaphes piperis* Gr., and *Aspidiotus destructor* Sign.), marginal gall thrips (*Liothrips karnyi* Bagn.), mealy bugs (*Ferrisia virgata* Cock.), whitefly (*Bemisia tabaci* Genn.) etc. (Nair, 1999).

2.1 PESTS OF BLACK PEPPER

2.1.1 Pollu beetle

Among the pests of black pepper, the major one was pollu beetle, *L. nigripennis* (Premkumar, 1980).

L. nigripennis was first described as a species under the name *Teinodactila nigripennis* by Motschulsky in 1866 (Maulik, 1926). Later Maulik described the insect under the name *Longitarsus nigripennis* Motschulsky (Coleoptera-Chrysomelidae, Halticinae).

Biology

Biology of the pest was described by Ayyar (1919), Ayyar *et al.* (1921), Rao and Ramaswamiah (1927), Premkumar (1980) and Babu (1994). Eggs were laid singly or in groups of two to three mostly on tender berries. The incubation period of eggs varied from five to eight days. Larval stages comprising of three instars were completed in 22 to 32 days. The pupal period lasted for six to seven days.

The morphology of female and male internal reproductive system of *L. nigripennis*, a major pest of black pepper (*P. nigrum*) was studied by Devasahayam *et al.*, 1998.

Symptoms and Damage

The adult beetles fed on leaves, terminal buds, tender stems, spikes and berries. Eggs were laid on terminal bud and on the surface of the spike and within the pericarp of the berries. Grubs caused damage by tunnelling within the growing tips, spikes and berries (Premkumar, 1980).

Nambiar and Kurian (1962) estimated a damage of upto 30 per cent by pollu beetle in North Kerala. Pillai and Abraham (1974) reported 30 to 40 per cent loss in yield due to pollu beetle in pepper. According to Pillai and Abraham (1983), the cultivars of pepper that were practically free of *L. nigripennis* tended to produce low yield, while high yielding varieties suffered 40.10 to 56.80 per cent infestation. Kalluvally Type II, a fairly good yielder had negligible infestation.

Premkumar and Nair (1987a) revealed that berry damage by pollu beetle was highest in the plains and it was very low at higher elevations (300-900 m above MSL) and absent at >900 m above MSL. The damage was also higher in shaded areas than in the open. The cv. Kalluvally was the least susceptible and Arakkulam munda, the most susceptible to *L. nigripennis*. Premkumar and Nair (1987b) reported that the pollu beetle caused a loss upto 32 per cent in black pepper yield. The average annual yield loss in black pepper due to the incidence of pests, diseases and drought in Kannur district was around 33 per cent. The major contributor towards stand loss was foot rot caused by *Phytophthora capsici* (Leonian) (nine per cent loss), followed by drought (four per cent loss). Among the causal factors contributing to yield loss, the most disastrous was the incidence of pollu beetle (*L. nigripennis*) which accounted for about 13 per cent loss (Prabhakaran, 1997).

Seasonal Incidence

Premkumar and Nair (1985) studied the seasonal incidence of pollu beetle. Adults were present throughout the year. Extensive feeding and mating by adults were observed during the premonsoon showers in April to May. After September, there was a general decline in the pest population which coincided with crop maturation and harvest.

2.1.2 Leaf Gall Thrips

G. karnyi was first collected from the marginal galls of pepper in Ceylon (Bagnall, 1914). Ananthakrishnan (1952) gave further description of *G. karnyi*.

Biology

The damage, biology and bionomics of the pepper leaf gall thrips *G. karnyi* (Thripidae) has been studied by Visalakshi (1963). Eggs were laid singly within the marginal gall on the leaf surface. They hatched in six to eight days and duration of nymphal, prepupal and pupal stages were 9 to 13, one to two and three days respectively.

Symptoms and Damage

Infestation by thrips resulted in the formation of marginal galls (Visalakshi, 1963). The morphology of galls induced by thrips on a wide variety of trees and plants in India including *L. karnyi* on black pepper was studied by Raman and Ananthakrishnan (1984). Apart from the formation of marginal galls, the feeding activity of the thrips resulted in reduction in size, crinkling and thickening of the infested leaves (Premkumar and Devasahayam, 1988).

Banerjee *et al.* (1981) reported that *L. karnyi* was the only pest infesting pepper in South Wayanad. The cultivar, Kalluvally was the least

susceptible to attack by the pest, while the most susceptible was Panniyur1.Leaves on the middle portion of the vines were preferred as food. The infestation due to leaf gall thrips ranged from 25 to 75 per cent in Idukki district (KAU, 2001).

During rainy season, the population of thrips was greatly reduced which might be correlated with high humidity in the atmosphere and also the stagnation of water inside the marginal folds (Visalakshi, 1963).

2.1.3 Top shoot borer

Top shoot borer was first described by Meyrick (1931) and subsequently by Fletcher (1917, 1921) who noted its incidence in Taliparamba, Kannur. Vandeevecht (1933) observed *C. hemidoxa* infestation on black pepper in Banka, Buitenzorg Java and in Borneo.

Biology

Visalakshi (1963) studied the biology and bionomics of the pepper top shoot borer, *C. hemidoxa*. The adults were small moths with crimson and yellow forewings and grey hindwings. The eggs were laid on tender shoots. The caterpillars were greyish green and measure about 15 mm in length when fully grown. The pest completed its life cycle in about 30 days.

Symptoms and Damage

Eggs were laid on the tender shoots. On hatching, the larvae bored into them and fed on the internal tissues which resulted in drying up of the infested shoot (Visalakshi, 1963).

Top shoot borer was a serious pest in younger plantations and it caused 50 per cent damage in certain areas (Premkumar and Devasahayam, 1988).

Seasonal Incidence

During the months of August to December, top shoot borer appeared to thrive in the field. There was a sudden decrease in the population of the pest in the field from January onwards (Visalakshi, 1963).

2.1.3 Scales, Mealy Bugs and White Flies

Fletcher (1917) recorded *Mytilaspis piperis* (Gr.) as a minor pest of pepper in Wayanad.

Rao (1929) reported that mealy bug, *F. virgata* caused local injury to pepper.

Fletcher (1917) reported *Aleurocanthus piperis* Mask. as a pest of black pepper. The whitefly, *Bemisia tabaci* G. was reported in black pepper by Ranjith *et al.* (1992). Prakash and Sudharshan (2001) reported another whitefly, *Aleurocanthus valparaiensis* David and Subr, from black pepper.

Symptoms and Damage

Scale insects sucked the plant sap, which resulted in yellowing, and withering of the infested shoots and in severe cases the vines dried up (Premkumar and Devasahayam, 1988).

Mealy bugs desapped the vines and berries (Nair, 1999).

The distribution and damage caused by scale insects and mealy bugs associated with black pepper was studied by Koya *et al.* (1996).

The white flies drained the sap from very young leaves and caused light yellowish discolouration in them. Under severe attack, these spots grew larger and later turned brown (Ranjith *et al.*, 1992).

Seasonal Incidence

Seasonal population of *L. piperis* and *A. destructor* was recorded by Koya and Devasahayam (1995). The population of *A. destructor* was low during April and steadily increased upto September. The population of *L. piperis* was low during July and August. From January onwards there was an increase in the population.

2.2 EVALUATION OF DIFFERENT INSECTICIDES FOR THE MANAGEMENT OF PESTS OF BLACK PEPPER

A. Chemical Control of Pests of Black Pepper

2.2.1 Pollu Beetle

Rehiman and Nambiar (1967) found that DDT was the best insecticide for controlling the beetle infestation, which brought down the incidence to 1.30 per cent as against eight per cent in untreated control. According to Pillai and Abraham (1974), dimethoate 0.10 per cent or quinalphos 0.10 per cent when sprayed during July and October significantly reduced the beetle population. Balakrishnan *et al.* (1984) opined that endosulfan, parathion-methyl and quinalphos were equally effective against pollu beetle in black pepper and reduced the damage. Endosulfan 0.05 per cent and quinalphos 0.05 per cent were most effective in controlling the pest when applied twice a year during July and October (Premkumar *et al.*, 1986). Premkumar and Nair (1987b) reported that endosulfan when applied at 0.05 per cent effectively controlled pollu beetle in black pepper.

Pillai (1987) reported that the chrysomelid, *L. nigripennis* in black pepper could be controlled by soil application of insecticides, cultural methods and spraying of endosulfan and quinalphos. According to Premkumar and Nair (1988), methamidophos 0.05 per cent and endosulfan

0.05 per cent was effective in controlling *L. nigripennis* in black pepper. Nandakumar *et al.* (1991) revealed that insecticide treatments were superior to control in containing the damage. Monocrotophos (0.05 per cent), endosulfan (0.05 per cent) and cypermethrin (0.05 per cent) sprays were most effective in controlling the pollu beetle.

Mathew *et al.*, 1991 revealed that a minimum of three weeks time should be observed between the last round of spraying and harvesting, when quinalphos was used whereas in the case of dimethoate, a minimum of one week time was enough for the residue to reach safety limits.

Pollu flea beetle *L. nigripennis* was effectively controlled using the insecticides *viz.*, endosulfan 0.05 per cent, dimethoate 0.05 per cent, quinalphos 0.05 per cent or monocrotophos 0.05 per cent concentration. The spraying was done at the time of spike emergence (June to July), berry formation (September to October) and at berry maturity stage if needed. It can also be controlled by spraying cypermethrin 0.01 per cent twice first at the berry formation stage and the second, one month after the first spray (KAU, 2002).

2.2.2 Leaf Gall Thrips

Monocrotophos 0.05 per cent and Malathion 0.05 per cent gave maximum residual toxicity against *L. karnyi* infesting black pepper (Devasahayam, 1989).

Devasahayam (1990) reported monocrotophos 0.05 per cent and dimethoate 0.05 per cent were the most effective insecticides against leaf gall thrips when applied on new flushes. Monocrotophos 0.05 per cent and dimethoate 0.05 per cent recorded 4.10 and 3.20 per cent infested leaves, respectively after 15 days.

2.2.3 Top Shoot Borer

According to Banerjee *et al.* (1981), endosulfan 0.05 per cent was the most effective in controlling top shoot borer infestation. Since the incidence of the pest coincided with that of pollu beetle, the spray given for the latter would be sufficient to control the pest.

2.2.4 Scales and Mealy Bugs

Premkumar and Devasahayam (1988) opined that scale insects could be controlled by spraying dimethoate 0.05 per cent. A second spray might be given after 15 days if infestation persisted. The scale insects can be controlled by application of contact or systemic insecticides like malathion 0.01 per cent, dimethoate 0.01 per cent or monocrotophos 0.01 per cent applied twice at monthly intervals (Devasahayam and Koya, 1994b). Soft scales can be controlled by spraying quinalphos 0.05 per cent. This treatment was adequate to control the mealy bugs (KAU, 2002).

Control of Pests in Black Pepper using Botanicals

Devasahayam and Leela (1998) revealed that leaf extracts of *Azadirachta indica* (A.Juss), *Chromolaena odorata* L., *Strychnos nux-vomica* L., neem seed kernel extract and neem oil at one to five per cent concentration exhibited antifeedant activity against adults of *L. nigripennis*.

The crude extract of a known resistant species of pepper, *Piper attenuatum* Ham. was tested for its antifeedant activity against pollu beetle under laboratory conditions. It was found that crude extracts at six to eight per cent concentration completely inhibited feeding of the pollu beetle (Devasahayam *et al.*, 1992)

Plant and organic products such as neem oil, commercial neem products and fish oil rosin were effective in controlling both the species of scale insects (Devasahayam and Koya, 1994).

Babu *et al.* (1996a) noted high feeding deterrence against *L.nigripennis* when treated with hexane extract of leaf and chloroform extract of seed of *Annona squamosa* L. There was feeding inhibition in adults of *L. nigripennis* using isodesacetyluvaricin, insect antifeedant from a hexane extract of root bark of both *Uvaria narum* (Dunal) and *U. hookeri* (Babu *et al.*, 1996b)

Neem oil controlled *L. karnyi* in black pepper (Krishnakumar *et al.*, 1999).

Spraying of endosulfan 0.05 per cent during July (21 to 30 days after setting of berries) followed by three sprays of Neemgold (0.60 per cent) during August, September and October or four sprays of Neemgold (0.60 per cent) during July, August, September and October were effective against pollu beetle (Sarma, 2002).

B. Botanicals in Coleopteran Insect Pest Control

Neem Oil

Neem oil offered 60 to 80 per cent protection against flea beetle *Phyllotreta downsei* B. population on young radish plants (Kareem, 1981). Mishra *et al.* (1990) reported that egg plant leaves treated with 0.025, 0.05 per cent neem oil when given to epilachna beetle in the laboratory, the pre-oviposition period was 21 per cent larger than insect feeding on untreated leaves. The females had shorter oviposition period, laid few eggs and eggs were smaller in size. According to Kaethner (1992), potato leaves treated with neem oil caused morphogenetic defects in *Leptinotarsa decemlineata* (Say.). According to Rajan and Nambisan (1993), neem oil at two per cent at par with 0.07 per cent endosulfan against flea beetle *Phyllotreta cruciferа* (Goeze) on crucifers and beans.

Karanja Oil

Mukeshkumar and Singh (2002) recorded karanja oil to be effective against insect pests of stored grains, field, plantation crops and household commodities. They acted as oviposition deterrent, antifeedent and larvicide against a wide range of pests.

***Clerodendron* sp.**

Several compounds which were reported to be isolated from *Clerodendron* spp. like cycoside, Clerodendrin A, B and clerodin (Antonion and Saito, 1981) and Clerodin (Beek and Groot, 1986) showed antifeedant activity.

Lily and Saradamma (1994) and Lily (1995) demonstrated that acetone and water extracts of *Clerodendron infortunatum* (Linn.) leaf was comparable to carbaryl in controlling epilachna beetle in bittergourd.

Chandrikamohan and Nair (2000) reported insecticidal and insect growth regulatory activity of *C. infortunatum* on grubs of rhinoceros beetle, *Oryctes rhinoceros* L.

C. Control of Pests of other Spices Using Botanicals

Ahmed (1988) recorded that about 88 per cent of cardamom growers in Kerala relied on neem cake for nematode control @ 100 to 250 kg ha^{-1}. Neem cake application reduced multiplication of nematode in ginger (Mohanty *et al.*, 1992). Sheela *et al.* (1995) reported that application of neem cake at two to five tonnes per hectare at planting was effective in reducing the nematode population in soil, root and root-knot index and increasing the yield of fresh ginger.

In lab choice test, Bioneem and Margolin EC at 0.50 and 1.00 per cent concentration prevented 100 per cent settlement of cardamom aphid

Pentalonia nigronervosa f. Calladi Van Der Groot on the treated cardamom tillers three days after treatment. Nimbicidin and Margolin EC served as efficient oviposition deterrents at 1.00 per cent concentration, wherein there was 100 per cent prevention of reproduction (Mathew *et al.*, 1998).

Neem oil 0.50 per cent application at 10 to 15 days interval was effective against *Dialeurodes cardamomi* David and Subr. (Gopakumar and Kumaresan, 1991). Nymphs of cardamom white fly, *D. cardamomi* were effectively controlled by spraying the lower surface of leaves with a mixture of neem oil (500 ml) and triton (500 ml) in 100 litres of water (KAU, 2002).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

Seasonal occurrence of pests was studied in black pepper in the Instructional Farm, College of Agriculture, Vellayani from May 2002 to April 2003. A field experiment was also conducted during 2002 to evolve an eco-friendly management strategy against the major pests of black pepper.

3.1 SEASONAL OCCURRENCE OF PESTS IN BLACK PEPPER

The population of important pests of black pepper and their damage was assessed for an year from May 2002 to April 2003 in the Instructional Farm, College of Agriculture, Vellayani. The observations were recorded at fortnightly intervals. The number of vines exhibiting pest infestation / symptoms, population count of pests, nature of damage by pests on plant parts and damage score were recorded during the period of study.

The weather parameters *viz*., maximum and minimum temperature, relative humidity, rainfall and number of rainy days were recorded from the meteorological observatory of the Department of Meteorology, College of Agriculture, Vellayani.

Observations of pests and their damage were taken from twenty five yielding vines grown in different blocks of the Instructional Farm. For recording the infestation of top shoot borer, twenty five young vines were identified and observed in the different blocks of the Instructional Farm.

The methodology adopted for recording observation of population of pests and the damage done by pests on black pepper were as follows :

Methodology adopted for recording observation

Sl. No.	Pests	Method of observation
1)	Pollu beetle	(a) Number of pollu beetle adults per vine
		(b) Number of leaves damaged out of 25 leaves in each vine
		(c) Number of spikes showing damage out of twenty spikes in each vine
		(d) Number of berries showing damage from 20 spikes
		(e) Damage score in leaves on a scale from 0-4

Score	Details of score
0	Leaves with no infestation (0 per cent)
1	1-10 per cent leaf area damaged
2	11-30 per cent of the leaf area damaged
3	31-60 per cent of leaf area damaged
4	Leaves with > 61 per cent damaged

Infestation index was worked out based on the formula:

$$\frac{\text{Sum of all scores}}{\text{Total of all scores}} \times \frac{100}{\text{Maximum score}}$$

2) Top shoot borer : Number of vines damaged by top shoot borer out of 25 vines

3) Thrips : Number of leaves damaged by thrips out of 25 leaves per vine.

4) Mealy bugs : Number of spikes infested by mealy bugs out of 25 spikes per vine

5) Scale insects : (a) Number of spikes damaged by scale insects out of 25 spikes per vine

(b) Number of vines infested by scale insects out of 25 vines.

(c) Damage score on vines on a scale from 0 - 4

Score	Population of scale (Total number of scale insects in 100 cm shoot length)
0	Healthy
1	1 – 500
2	501 – 1000
3	1001 – 2000
4	>2000

6) Gall fly : Number of leaf damaged by gall fly out of 25 leaves per vine

3.1.1 Correlation between Weather Parameters and Incidence of Pests and their Damage in Black Pepper

The data were tabulated, the pest population, their percentage of infestation were correlated with weather parameters to evaluate the degree of association of abiotic factors on damage and population build up of pests of black pepper.

3.1.2 Correlation between Incidence of Pests and their Damage in Black Pepper and Weather Parameters of Previous Fortnight

The data were tabulated and the pest population and their percentage infestation were correlated with weather parameters of previous fortnight to evaluate the degree of association of abiotic factors on damage and population build up of pests of black pepper.

3.2 FIELD EVALUATION OF DIFFERENT BOTANICALS AND THEIR COMBINATIONS FOR THE MANAGEMENT OF PESTS OF BLACK PEPPER

The trial was conducted in the pepper gardens of the Instructional Farm, College of Agriculture, Vellayani. Uniformly aged pepper vines variety 'Karimunda' trailed on *Erythrina indica* (Lank) were selected for the study. The recommended Package of Practices of KAU (2002) were followed except insecticide application which were given based on the treatments selected for the study.

Experimental Design

Black pepper variety-Karimunda

Design - RBD

Treatments - Ten

Replications - Four

Each replication consisted of two uniformly spaced vines.

Details of treatments

T_1 – Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic

T_2 – Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic

T_3 – Azadirachtin 0.004 per cent

T_4 – Azadirachtin 0.003 per cent

T_5 – Clerodendron leaf and flower extract 8.00 per cent

T_6 – Karanja oil emulsion 2.00 per cent

T_7 – Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil

T_8 – Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent

T_9 – Quinalphos 0.05 per cent

T_{10} – Control

Three sprays were given one each during spike emergence, berry formation and berry maturation stage.

Labelling

Labelling of Vines

Uniformly aged vines were selected and the standards were marked with a ring of red paint. The selected vines were labeled with sunpack sheet indicating the treatment details.

Labelling of Leaves

Before each spray, the newly emerged uninfested leaves which were selected for observation of pests and infestation were marked with nail polish.

Labelling of Spikes

Before each spray, uninfested spikes which were selected for observation of pests and infestation, were marked with nail polish.

Method of preparation of sprays of treatments

Neem Oil Soap Emulsion 3 per cent + Garlic 2 per cent

Neem oil soap emulsion was prepared by taking 300 ml neem oil and 75g of ordinary washing soap. The bar soap was sliced and dissolved in 500 ml lukewarm water. The prepared 500 ml soap solution was poured into 300 ml neem oil slowly and stirred vigorously to get a good emulsion. 200 g of garlic was ground and the extracted in 200 ml water. The garlic extract was mixed in neem oil soap emulsion. Thus one litre stock solution obtained. This stock solution was diluted by adding 9 litres of water to get 10 litres of the final spray solution.

Neem oil Soap Emulsion 2 per cent + Garlic 2 per cent

Neem oil soap emulsion 2 per cent was prepared by taking 200 ml neem oil and 50 g of ordinary bar soap. The emulsion was prepared as explained in neem oil soap emulsion 3 percent + garlic 2 per cent preparation.

Azadirachtin 0.004 per cent

A commercial botanical pesticide NeemAzal containing Azadirachtin one percent supplied by M/S EID Parry (I) Ltd, Chennai was used for the experiment. Azadirachtin 0.004 per cent was obtained by dissolving 40 ml of NeemAzal in 10 litres of water.

Azadirachtin 0.003 per cent

Thirty ml of NeemAzal was dissolved in 10 litres of water to obtain the required spray solution.

Clerodendron Leaf and Flower Extract 8 per cent

Clerodendron infortunatum plants were collected from Instructional Farm, College of Agriculture, Vellayani. The leaves and freshly opened flower were separated and used for extraction.

800 g of fresh plant parts and flower was chopped and finely ground in a grinder using 500 ml water. They were then extracted with 400 ml water. The extract was then filtered twice using a fine mesh cloth and transferred to a measuring cylinder and the volume was made up to 1000 ml. Thus an 80 per cent stock solution was prepared.

The extract was further diluted with nine litres of water to obtain the eight per cent concentration spray solution required for the experiment.

Karanja oil 2 per cent Emulsion

Karanja oil (Pungam oil) was obtained from M/S Sundaresan Nair, Drugs Merchant, Chalai, Thiruvananthapuram.

Fifty grams of ordinary washing soap was dissolved in 800 ml of luke warm water. This soap solution was mixed with 200 ml Pungam oil (Karanja oil) to obtain one litre of stock solution. To this, nine litres of water was added to get 10 litres of two per cent karanja oil emulsion.

Neem Seed Oil Soap Emulsion 2 per cent + Garlic 2 per cent + Karanja oil emulsion 1 per cent

Neem seed oil soap emulsion 2 per cent + garlic 2 per cent was prepared as explained earlier.

To this 100 ml of karanja oil was added to obtain the required spray solution.

Azadirachtin 0.003 per cent + Karanja oil 1 per cent

Azadirachtin 0.003 per cent was prepared from a commercial botanical pesticide. NeemAzal by mixing 30 ml in 9.50 litres of water. Karanj oil one per cent emulsion was prepared by dissolving fifty gram ordinary washing soap in 400 ml lukewarm water. The soap solution mixed with 100 ml of karanj oil to get the emulsion. This was mixed with 9.50 litres of azadirachtin to obtain 10 litres of spray solution.

Quinalphos 0.05 per cent

This was applied as Ekalux 25 EC supplied by M/S Sandoz India Ltd. Two ml of the insecticide was dissolved in one litre of water to get 0.05 per cent spray solution.

Control

Water was used as a spray solution in all the control treatments.

For every spray solution, 0.10 per cent of plantovit was added as sticker.

Observations

3.2.1 Assessment of Pollu Beetle Population

Count of pollu beetle was taken at 24 hours, 72 hours and at weekly intervals after each spray in each of the treated vines.

3.2.2 Assessment of Infestation on Leaves by Pollu Beetle

Freshly emerged, fifteen uninfested leaves were marked with nail polish a day before spraying .The number of leaves damaged by pollu beetle after spraying was taken at 24 hours, 72 hours and at weekly intervals. The percentage of leaves damaged by pollu beetle was worked out.

3.2.3 Assessment of Intensity of Damage on Leaves by Pollu Beetle

The leaf area damaged was assessed by tracing the affected portion on graph paper and the area infested was found out. This was taken from fifteen uninfested leaves per vine selected and marked before spraying. The observations were taken at 24 hours, 72 hours and at weekly intervals after each spray. The per cent feeding deterrence due to various treatments was worked out following the methodology adopted by Devasahayam *et al.* (1993).

$$PFD = \frac{C - T}{C + T} \times 100$$

Where C = Area fed in control

T = Area fed in treatment

3.2.4 Assessment of Infestation on Spikes by Pollu Beetle

Twenty five uninfested healthy spikes were marked for taking observation before spraying of treatments. Number of spikes damaged by pollu beetle was taken at 24 hours, 72 hours and at weekly intervals after each spray and the percentage of infestation was worked out.

3.2.5 Assessment of Berry Damage by Pollu Beetle

The berry damage was assessed from the second spray onwards *i.e.* from berry formation stage. The number of berries damaged by the beetle were recorded in twenty five uninfested marked spikes at intervals of 24 hours, 72 hours and at weekly intervals after each spray. Percentage of berries damaged by the beetle was worked out.

3.2.6 Assessment of Infestation on Leaves by Leaf Gall Thrips

Fifteen uninfested fresh leaves were marked before each spray and the number of leaves infested by leaf gall thrips was recorded at 24 hours, 72 hours and at weekly intervals after each spray.

3.2.7 Assessment of Spikes Damaged by Scale Insects

Twenty five uninfested spikes were marked before spraying of treatments. Number of spikes damaged by scales were taken at 24 hours, 72 hours and at weekly intervals after each spray and percentage of damage was worked out.

3.2.8 Assessment of Spikes Damaged by Mealy Bugs

Twenty five uninfested spikes were marked before spraying of treatments. Number of spikes damaged by mealy bugs were taken at 24 hours, 72 hours and at weekly intervals after each spray and percentage of damage was worked out.

3.2.4. Yield

The mature berries were harvested at fortnightly intervals. Four pickings were obtained from the vines in the experimental plot.

The harvested berries were sun dried for four days and the dry weight was taken. The yield per hectare was worked out from the mean yield of pepper berries per treated vines. The benefit : cost ratio of the treatments was also calculated after a value addition of 50 per cent (in rupees terms) for pepper receiving botanical treatment compared to chemical pesticide treatment.

3.2.5 Statistical Analysis

Seasonal occurrence of pests was correlated with weather parameters. Data obtained from the field experiment were tabulated, suitably transformed and subjected to statistical analysis.

RESULTS

4. RESULTS

4.1 SEASONAL OCCURRENCE OF PESTS AND THEIR DAMAGE IN BLACK PEPPER

The results of the studies conducted from May 2002 to April 2003 on the incidence of pests of black pepper in relation to weather parameters are presented in Table 1.

4.1.1 Pollu Beetle (*Longitarsus nigripennis* Mots)

Pollu beetle adults (Plate 1) were present in the field throughout the year. The mean population was highest during the first fortnight of November 2002 (6.20 adults per vine). This was followed by second fortnight of June 2002 and second fortnight of November 2002 (6.00 and 5.90 respectively). The lowest mean population was seen during first and second fortnight of March 2003 (1.40 adults per vine) which was followed by second fortnight of February 2003 (1.60).

4.1.1.1 Leaf Damage by Pollu Beetle

The leaf damage by pollu beetle (Plate 2A) ranged from 11.00 per cent during first fortnight of May 2002 to 45.90 per cent during second fortnight of November 2002. The second highest percentage of leaf damage (45.10) was recorded during second fortnight of June 2002 followed by second fortnight of July (41.10) and first fortnight of July 2002 (41.00). The second lowest percentage leaf damage was observed during second and first fortnight of September 2002 with a mean leaf damage of 14.60 and 14.70 respectively.

A. Pollu beetle adult

B. Pollu beetle grub

Plate 1 Adult and grub of pollu beetle, *Longitarsus nigripennis* on pepper berries

Table 1 Seasonal occurrence of pests and their damage in black pepper from May 2002 to April 2003

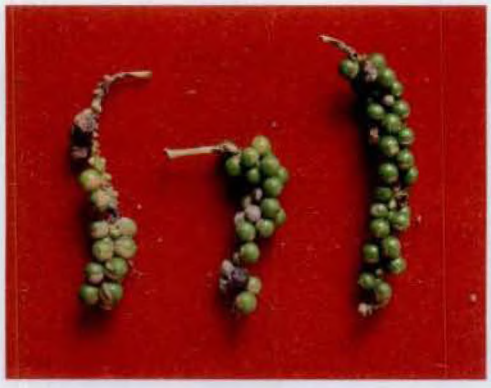
	PBC	LDP	TSB	SDP	BDP	LDT	SDM	SDS	ILP	ISL	GFL	VDS
May I 2002	2.60	11.00	0.00	5.30	0.00	12.32	0.00	0.00	6.00	4.00	1.30	16.00
May II 2002	4.90	20.40	0.00	9.60	0.00	13.00	0.00	0.00	20.50	4.00	1.30	16.00
June I 2002	5.20	38.50	0.00	15.90	0.00	13.60	0.00	0.00	28.50	4.00	1.30	16.00
June II 2002	6.00	45.10	0.00	17.80	0.00	14.10	0.00	0.00	39.60	4.00	1.40	16.00
July I 2002	5.20	41.00	16.00	18.70	0.00	13.80	0.00	0.00	40.20	4.00	1.60	16.00
July II 2002	4.10	41.10	16.00	19.10	0.00	11.40	0.00	0.00	40.20	4.00	1.80	16.00
August I 2002	4.30	32.00	20.00	19.40	0.00	10.10	0.00	0.00	39.60	6.00	2.10	16.00
August II 2002	4.80	29.10	24.00	14.80	0.00	8.50	0.00	0.00	27.00	6.00	2.00	16.00
September I 2002	3.20	14.70	16.00	15.40	1.90	8.00	0.00	0.00	19.90	7.00	2.10	16.00
September II 2002	3.50	14.60	24.00	16.30	1.80	10.20	0.00	0.00	16.60	7.00	2.10	16.00
October I 2002	3.60	21.30	16.00	24.60	4.70	11.80	0.80	4.60	16.60	7.00	2.50	16.00
October II 2002	4.60	22.20	16.00	32.70	6.20	10.40	0.80	5.00	19.00	7.00	2.90	16.00
November I 2002	6.20	37.80	20.00	33.50	6.30	10.40	1.00	5.10	28.00	7.00	2.90	16.00
November II 2002	5.90	45.90	28.00	35.20	6.60	15.00	1.40	5.60	40.20	7.00	2.00	16.00
December I 2002	4.70	40.20	28.00	35.20	6.90	15.80	1.30	5.60	41.30	12.00	3.00	20.00
December II 2002	3.80	39.20	16.00	36.20	7.00	17.10	2.10	6.60	36.80	12.00	2.90	20.00
January I 2003	3.00	36.40	12.00	36.90	7.40	17.10	2.10	7.70	28.00	14.00	2.90	20.00
January II 2003	2.00	32.00	0.00	36.90	7.70	17.90	1.90	8.00	27.00	14.00	3.00	20.00
February I 2003	2.20	29.10	0.00	37.90	8.00	19.70	2.60	8.20	26.60	15.00	3.00	24.00
February II 2003	1.60	28.50	0.00	37.90	8.00	19.70	3.20	8.50	24.50	19.00	2.10	24.00
March I 2003	1.40	25.60	0.00	0.00	0.00	20.30	0.00	0.00	24.50	19.00	2.10	24.00
March II 2003	1.40	24.00	0.00	0.00	0.00	22.60	0.00	0.00	12.30	20.00	2.00	24.00
April I 2003	2.60	19.40	0.00	0.00	0.00	23.20	0.00	0.00	12.00	20.00	2.00	24.00
April II 2003	2.40	16.50	0.00	0.00	0.00	23.50	0.00	0.00	4.00	24.00	1.90	28.00

I – First fortnight, II – Second fortnight

PBC - Pollu Beetle Count
LDP - Percentage of leaves damaged by pollu beetle
TSB - Percentage of vines damaged by top shoot borer
SDP - Percentage of spikes damaged by pollu beetle
BDP - Percentage of berries damaged by pollu beetle
LDT - Percentage of leaves damaged by leaf gall thrips
SDM - Percentage of spikes damaged by mealy bugs
SDS - Percentage of spikes damaged by scale insects
ILP - Intensity of leaves damaged by pollu beetle
ISL - Intensity of vines damaged by scale insects
GFL - Percentage of leaves damaged by leaf gall fly
VDS - Percentage of vines damaged by scale insects

A. Leaf damage

B. Tender spike damage



C. Mature spike damage

D. Berry damage

Plate 2 Different types of damages caused by pollu beetle

4.1.1.2 Infestation Index of Leaves by Pollu Beetle

The maximum intensity of leaves damaged by pollu beetle was observed during the first fortnight of December 2002 with mean value 41.30 followed by 40.20 in the first and second fortnights of July 2002 and second fortnight of November 2002. The lowest score was recorded in the second fortnight of April 2003 (4.00) which was followed by first fortnight of May 2002 and first and second fortnight of September 2002 with a mean value of 6.00 and 16.60 respectively.

4.1.1.3 Spikes Damaged by Pollu Beetle

The maximum percentage of spikes damaged by pollu beetle (Plate 2B) was observed during the period just before harvest of pepper berries viz., first and second fortnight of February 2003 with a mean percentage of 37.90. This was followed by first and second fortnights of January 2003 (36.90). Damage levels of 5.30 and 9.60 per cent were observed per vine during the first and second fortnights of May 2002 respectively.

4.1.1.4 Berry Damage by Pollu Beetle

The highest percentage of berry damage (8.00) was observed (Plate 2C and D) during first and second fortnights of February 2003. The first and second fortnights of September 2002 recorded 1.90 and 1.80 per cent berry damage respectively.

4.1.2 Top Shoot Borer *(Cydia hemidoxa*, Megr.)

The top shoot borer damage (Plate 3) was not observed in the field during May and June 2002. The damage was seen from the first fortnight of July 2002 (16.00). The maximum damage of top shoot borer on young vines was seen during second fortnight of November 2002 and first fortnight of December 2002 (28.00). The first fortnight of January 2003 the percentage of vine damage was 12.00. The damage on young vines

Plate 3 Tender shoot damaged by top shoot borer

Plate 4 Leaf damage caused by leaf gall thrips

was not observed from second fortnight of January 2003 to second fortnight of April 2003.

4.1.3 Leaf Gall Thrips *(Liothrips karnyi,* Bagn.)

The incidence of leaf gall thrips was recorded as percentage of leaves damaged (Plate 4). The highest percentage of damage was recorded during the second fortnight of April 2003 (23.50) followed by first fortnight of April 2003 and second fortnight of March 2003 with mean percentage of leaves damaged being 23.20 and 22.60 respectively. The least damage of leaves on vines was recorded during the first fortnight of September 2002 (8.00) followed by second fortnight of August 2002 and first fortnight of August 2002 (8.50 and 10.10 respectively).

4.1.4 Mealy Bugs *(Ferrisia virgata,* Cock.)

The mealy bug damage (Plate 5) was not seen in the field from May 2002 to September 2002. The population began to build up from first fortnight of October 2002 with a mean spike damage of 0.80 per cent. The highest incidence of 3.20 was observed during the second fortnight of February 2003.

4.1.5 Scale Insects on Berries *(Lepidosaphes piperis,* Gr.)

The occurrence of scale insects on spikes (Plate 6) was not observed from first fortnight of May 2002 to second fortnight of September 2002. However the population began to build up from the first fortnight of October 2002 and reached the maximum on spikes just before harvesting viz., second fortnight of February 2003 with mean damage of 8.50 per cent. It was followed by mean damage in second fortnight of February 2003 and first fortnight of January 2003 (8.20 and 8.00 per cent respectively).

Plate 5 Pepper spike attacked by mealy bugs

Plate 6 Pepper berries attacked by scale insects

4.1.5.1 Percentage of Vines Damaged by Scale Insects

The percentage of vines infested by scales was the maximum (28.00) during the second fortnight of April 2003. Scales infested sixteen percent of the vines over a period of six months from first fortnight of May 2002 to second fortnight of November 2002. The percentage of vines infested by scales was 24.00 during the first and second fortnight of February, March and first fortnight of April 2003.

4.1.5.2 Intensity of Vines Damaged by Scale Insects

The mean intensity of scale insects on vines ranged from 4.00 during the months of May, June and July 2002 to 28.00 per cent during the second fortnight of April 2003. There was an increase in the percentage of vines damaged by scales from September 2002 onwards. The highest value of 24.00 was followed by 20.00 during the first fortnight of April 2002 and second fortnight of March 2002.

4.1.6 Gall Fly Damage on Leaves

The gall fly damage on leaves was maximum during the first fortnight of December 2002, second fortnight of January 2003 and first fortnight of February 2003 with a mean damage of 3.00 per cent. However the lowest damage of 1.30 was observed during May 2002 and first fortnight of June 2002.

4.1.7 Correlation between Weather Parameters and the Incidence of Pests and their Damage in Black Pepper

Correlation coefficients between weather parameters and the incidence of pests and the damage in black pepper are presented in the Table 2.

Pollu beetle adult population had a significant negative correlation with maximum temperature. Significant positive correlation was obtained between pollu beetle count and relative humidity. The beetle count,

Table 2 Correlation coefficients between pest damage and weather parameters

	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity	Rainfall (mm)	No. of rainy days
Y_1	-0.7184**	0.1822	0.7114**	0.2588	0.4903
Y_2	-0.6137**	-0.4069	0.2717	-0.2843	-0.0791
Y_3	0.6998**	-0.2158	-0.5345**	-0.3219	-0.5451**
Y_4	-0.4331	-0.7615**	0.1504	-0.0597	-0.0885
Y_5	-0.1374	-0.7809**	-0.0324	0.0595	-0.2140
Y_6	-0.6064**	-0.2745	0.3271	-0.0562	0.0746
Y_7	0.7482**	-0.0803	-0.4980	-0.3045	-0.5099
Y_8	0.0196	-0.7448**	-0.1756	-0.2006	-0.3546
Y_9	-0.0894	-0.7763**	-0.0518	-0.0695	-0.2300
Y_{10}	0.6823**	-0.3308	-0.5907**	-0.3711	-0.5998**
Y_{11}	0.0903	-0.6046**	-0.0831	-0.0892	-0.2418

Significant at 1% - 0.5118**

Y_1 – Mean pollu beetle population
Y_2- Percentage of leaves damaged by pollu beetle
Y_3- Intensity of infestation of pollu beetle on leaves
Y_4- Percentage of spikes damaged by pollu beetle
Y_5- Percentage of berries damaged by pollu beetle
Y_6- Percentage of vines damaged by top shoot borer
Y_7- Percentage of leaves damaged by leaf gall thrips
Y_8- Percentage of spikes infested by mealy bugs
Y_9- Percentage of spikes damaged by scales
Y_{10}- Intensity of infestation by scale insects on vines
Y_{11}- Percentage of leaves infested by gall fly

rainfall and number of rainy days were positively correlated but it was not significant.

There was significant negative correlation between leaf damage by adults of pollu beetle and maximum temperature with an r value of -0.6137. Positive correlation was obtained between leaves damaged by pollu beetle and relative humidity but the value was not significant.

The intensity of leaves damaged by pollu beetle showed significant positive correlation with maximum temperature. The 'r' value was 0.6998. There was significant negative correlation between leaves damaged by pollu beetle with relative humidity and number of rainy days.

Significant negative correlation was obtained between spike damage and berry damage by pollu beetle with minimum temperature, the 'r' values being -0.7615 and -0.7809 respectively. However negative correlation was obtained between relative humidity and rainfall but the relationship was not significant.

The leaves damaged by leaf gall thrips showed significant positive correlation with maximum temperature (r value, 0.7482). There was negative correlation between leaf damage and relative humidity. The correlation between gall thrips damage and rainfall and number of rainy days was found to be negative but not significant.

The spike damage by mealy bugs was found to be correlated significantly negative with minimum temperature. However correlation between mealy bug incidence and rainfall and relative humidity were negative but not significant.

The scale insect infestation on spikes was found to be correlated negatively and significant with minimum temperature. The 'r' value was -0.7763. The relationship between spike damaged by scales and rainfall,

number of rainy days and relative humidity were found to be negative but not significant.

The intensity of infestation of scale insects on vines showed significant positive correlation with maximum temperature (r value, 0.6823). However the severity of infestation showed significant negative correlation with relative humidity and number of rainy days.

Percentage of leaves infested by gall fly did not show any significant relation with any of the weather parameters.

4.1.8 Correlation between Incidence of Pests and their Damage in Black Pepper and Weather Parameters of Previous Fortnight

Correlation coefficients between incidence of pests and their damage in black pepper and weather parameters of previous fortnight are presented in Table 3.

There was a significant negative correlation between pollu beetle adult count and maximum temperature with r value of -0.6680. The population had a positive correlation with relative humidity but was not significant.

A significant negative correlation was obtained between leaf damage by pollu beetle and maximum temperature, the r value being-0.6680. However the correlation between leaves damaged by adults of pollu beetle and relative humidity was significantly positive (r value, 0.5262). Positive correlation was obtained between leaves damaged and number of rainy days but the relationship was not significant.

The infestation index on leaves by pollu beetle recorded significant positive correlation with maximum temperature. However the correlation with minimum temperature was negative and non significant. The relative humidity had significant negative correlation with intensity of leaves

Table 3 Correlation coefficients between incidence of pests and their damage on black pepper and weather parameters of previous fortnight

	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity	Rainfall (mm)	No. of rainy days
Y_1	-0.6680**	-0.0432	0.4791	-0.0459	0.1549
Y_2	-0.5721**	0.0690	0.5262**	-0.0182	0.2135
Y_3	0.6247**	-0.3810	-0.5649**	-0.3752	-0.5832**
Y_4	-0.2018	-0.7848**	-0.0660	-0.2982	-0.3349
Y_5	-0.0890	-0.7639**	-0.1997	-0.2575	-0.3940
Y_6	-0.5228**	-0.5091	0.1672	0.0094	0.0467
Y_7	0.7545**	0.0152	-0.4445	-0.2998	-0.4599
Y_8	0.2401	-0.6575**	-0.3381	-0.3639	-0.5071
Y_9	0.1311	-0.7260**	-0.2240	-0.2802	-0.4195
Y_{10}	0.8072**	-0.1630	-0.5917**	-0.2924	0.5336**
Y_{11}	-0.2978	-0.5187**	-0.2326	-0.2243	-0.3895

Significant at 1% 0.5118**

Y_1 – Mean pollu beetle population
Y_2- Percentage of leaves damaged by pollu beetle
Y_3- Intensity of infestation of pollu beetle on leaves
Y_4- Percentage of spikes damaged by pollu beetle
Y_5- Percentage of berries damaged by pollu beetle
Y_6- Percentage of vines damaged by top shoot borer
Y_7- Percentage of leaves damaged by leaf gall thrips
Y_8- Percentage of spikes infested by mealy bugs
Y_9- Percentage of spikes damaged by scales
Y_{10}- Intensity of infestation by scale insects on vines
Y_{11}- Percentage of leaves infested by gall fly

damaged, the r value being -0.5649. The infestation index on leaves was also significantly and negatively correlated with number of rainy days (r value,-0.5832).

The spikes damaged by pollu beetle recorded negative correlation with maximum temperature but the relationship was not significant. However significant negative correlation was obtained between spike damage by pollu beetle and minimum temperature (r value, -0.7848). Spike damage by beetle was negatively correlated with relative humidity, rainfall and number of rainy days. However the correlation was not significant.

Significant negative correlation was obtained between berry damage by pollu beetle and minimum temperature (r value,-0.7639). The other weather parameters like relative humidity, rainfall and number of rainy days were also negatively correlated though not significant.

The leaf damage by leaf gall thrips recorded significant positive correlation with maximum temperature (r value,-0.7545). The correlation with minimum temperature was also positive but was not significant. Relative humidity and number of rainy days had significant negative correlation with leaf gall thrips damage. But the relation was non significant. There was negative correlation between leaf damage and rainfall, which was also not significant.

Mealy bug infestation on spikes showed significant negative correlation with minimum temperature, the 'r' value being -0.6575. Infestation by mealy bugs on spikes was negatively correlated with number of rainy days and relative humidity and rainfall but the correlation was not significant.

The percentage of spike infestation by scale insect was positively correlated with maximum temperature, the relation being not significant.

Table 4. Population of pollu beetle at different intervals after application of different treatments at spike emergence stage

Treatments	24 HAS	72 HAS	1WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	0.46 (1.21)^{abc}	0.72 (1.31)^{abc}	1.47 (1.57)^{cde}	1.96 (1.72)^{ef}	2.24 (2.06)$^{b-d}$	4.44 (2.33)^{b}	2.71 (1.93)^{de}	4.72 (2.39)^{d}	2.86 (1.97)^{b}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	0.66 (1.29)^{abcd}	0.46 (1.21)^{ab}	1.16 (1.47)^{de}	1.73 (1.65)^{ef}	3.43 (2.10)$^{b-d}$	4.96 (2.45)^{b}	2.94 (1.98)^{de}	4.09 (2.26)^{d}	2.75 (1.94)^{b}
Azadirachtin 0.004 per cent	1.00 (1.41)^{bcd}	1.23 (1.49)^{b}	1.73 (1.65)^{cd}	1.96 (1.72)^{ab}	3.49 (2.12)^{bcd}	5.22 (2.49)^{b}	3.15 (2.04)^{cde}	4.72 (2.39)^{d}	2.98 (1.99)^{b}
Azadirachtin 0.003 per cent	0.93 (1.39)^{bcde}	1.23 (1.49)^{bcde}	1.47 (1.57)^{de}	1.96 (1.72)^{ab}	3.71 (2.17)^{bcd}	4.41 (2.33)^{b}	3.49 (2.12)^{b}	3.74 (2.18)^{cd}	2.90 (1.98)^{b}
Clerodendron leaf and flower extract 8.00 per cent	1.40 (1.55)^{bcde}	1.73 (1.65)^{cde}	2.74 (1.93)^{ab}	2.97 (1.99)^{b}	4.98 (2.45)	5.22 (2.49)^{b}	3.71 (2.17)^{b}	5.49 (2.55)^{a}	3.59 (2.14)^{b}
Karanja oil emulsion 2.00 per cent	0.46 (1.21)^{abc}	0.46 (1.21)^{abcde}	1.47 (1.57)^{de}	2.71 (1.93)^{b}	2.97 (1.99)^{acd}	3.71 (2.17)^{ab}	3.97 (2.23)^{a}	3.21 (2.05)^{d}	2.75 (1.94)^{b}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	0.46 (1.21)^{ab}	0.72 (1.31)^{ab}	1.47 (1.57)^{abc}	2.24 (1.80)^{b}	2.48 (1.87)^{ab}	4.41 (2.33)^{b}	3.64 (2.15)^{ab}	3.43 (2.10)^{d}	2.60 (1.90)^{b}
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	0.72 (1.31)^{abcde}	0.93 (1.39)^{bcd}	1.23 (1.49)^{abc}	2.74 (1.93)^{b}	2.71 (1.93)^{abc}	4.24 (2.29)^{b}	2.94 (1.98)^{b}	3.68 (2.16)^{d}	2.59 (1.90)^{b}
Quinalphos 0.05 per cent	0.00 (1.00)^{a}	0.00 (1.00)^{a}	0.22 (1.10)^{e}	0.87 (1.37)^{c}	1.73 (1.65)^{ab}	2.48 (1.87)^{a}	1.96 (1.72)^{d}	3.97 (2.23)^{d}	1.81 (1.68)^{a}
Control	4.83 (2.41)	4.98 (2.45)	5.73 (2.59)	5.20 (2.49)	5.95 (2.64)	5.91 (2.63)	4.24 (2.29)	4.36 (2.31)	5.21 (2.49)

CD-treatments 5% : 0.389*, CD-Mean 5 % : 0.123*, CD-intervals : 0.123*

Figures in parentheses denote $\sqrt{x+1}$ transformed values. HAS- Hours after spraying, WAS Weeks after spraying.

*Significant at 5 per cent level

However there was significant negative correlation between spike damage by scale insects and minimum temperature. There was negative correlation between spike damage and number of rainy days.

The intensity of vines damaged by scale insects had a significant positive correlation with maximum temperature. With respect to relative humidity and number of rainy days, the intensity of damage by scale insects was significant and negatively correlated.

Gall fly leaf damage also showed positive correlation with maximum temperature, but minimum temperature had significant negative correlation, the r value being -0.5187. The gall fly leaf damage was negatively correlated to relative humidity, rainfall and number of rainy days.

4.2 FIELD EVALUATION OF BOTANICALS AND THEIR COMBINATIONS FOR THE MANAGEMENT OF PESTS OF BLACK PEPPER

4.2.1 Mean Population of Pollu Beetle at Different Intervals after Application of Different Treatments

4.2.1.1 At Spike Emergence Stage

The results of the observations on mean population of pollu beetle adults on pepper vines receiving different treatments at spike emergence are given in Table 4.

Twenty-four hours after application of treatments, pollu beetle adults were not observed in vines receiving quinalphos 0.05 per cent spray. The mean population was 0.46 in treatments, neem seed oil 3.00 per cent + garlic 2.00 per cent karanja oil emulsion 2.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, 0.66 and 0.72 in treatments neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and azadirachtin 0.003 per cent +

karanja oil 1.00 per cent respectively. These treatments were statistically on par. This was followed by treatments, azadirachtin 0.003 percent, azadirachtin 0.004 per cent and clerodendron leaf and flower extract 8.00 per cent . The mean population was significantly lesser in all the treatments compared to control, which had the highest population of 4.83.

At seventy-two hours after application of treatments, the beetles were not observed in quinalphos 0.05 per cent treated vines whereas the maximum of 4.98 was in control vines. The population was 0.46 in karanja oil emulsion 2.00 per cent followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent. All the vines receiving insecticide treatments recorded significantly lower beetle population compared to control.

One week after insecticide application, quinalphos 0.05 per cent treated vines recorded a mean population of 0.22, which was followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent with a mean population of 1.16. The mean population was the same for neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, karanja oil 2.00 per cent, azadirachtin 0.003 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent being 1.47. The highest population of pollu beetle adults was in the control vines (5.73).

The mean beetle count ranged from 0.87 in quinalphos 0.05 per cent to 5.20 in control at two weeks after spraying. The treatments quinalphos 0.05 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent was on par. Neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent was followed by azadirachtin 0.003 per cent, azadirachtin 0.004 per cent, and neem seed oil 3.00 per cent + garlic 2.00 per cent with a mean population of 1.96.

Three weeks after insecticide application, the maximum number of pollu beetle adults was recorded in control (5.95) and the minimum in quinalphos 0.05 per cent (1.73). Quinalphos 0.05 per cent was followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and karanja oil 2.00 per cent. The treatments, neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.004 per cent, azadirachtin 0.003 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent were statistically on par.

Observations taken four weeks after application of sprays indicated that quinalphos 0.05 per cent and karanja oil 2.00 per cent were found statistically on par. The highest count of pollu beetle adults was recorded in control (5.91) and lowest in quinalphos 0.05 per cent (2.48). It was followed by karanja oil 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and azadirachtin 0.003 per cent.

Five weeks after insecticide application, control vines had the maximum mean population of 4.24 per vine and minimum in quinalphos 0.05 per cent (1.95). Quinalphos 0.05 per cent was followed by neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and azadirachtin 0.004 per cent and they were found statistically on par.

Six weeks after insecticide application, there was no significant difference between any of the treatments.

The mean of all the observations revealed that the lowest population of pollu beetle adults was in those vines receiving quinalphos 0.05 per cent (1.81) and the highest in control vines (5.21). This was followed by azadirachtin 0.003 per cent + karanja oil 1.00 per cent and neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + karanja oil 1.00 per cent where the average population per vine was 2.59 and 2.60 respectively. Karanja oil 1.00 per cent and neem oil soap emulsion 2.00 per cent + garlic 2.00 per cent had a mean count of 2.75. Azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, karanja oil 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent and azadirachtin 0.004 per cent were statistically on par.

Among the different treatments tested against pollu beetle population at spike emergence stage, the most effective treatment was quinalphos 0.05 per cent followed by azadirachtin 0.003 percent + karanja oil 1.00 per cent.

4.2.1.2 At Berry Formation Stage

The results are presented in Table 5.

Twenty four hours after application of treatments, maximum count of beetle was found in control with a mean of 5.74 and minimum in quinalphos 0.05 per cent with a mean population of 0.22. Quinalphos 0.05 per cent was followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent with a mean of 0.46. Treatment quinalphos 0.05 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, azadirachtin 0.004 per cent, neem

Table 5 Population of pollu beetle at different intervals after application of different treatments at berry formation stage

Treatment	24 HAS	72 HAS	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	0.93 (1.39)^{abcd}	0.72 (1.31)^{a}	1.23 (1.49)^{ab}	1.73 (1.65)^{ab}	2.48 (1.87)^{a}	2.00 (1.73)^{a}	2.24 (1.80)^{a}	1.73 (1.65)^{a}	2.24 (1.80)^{a}	2.30 (1.99)	4.49 (2.34)	2.15 (1.77)^{ab}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	0.46 (1.21)^{ab}	0.72 (1.31)^{a}	1.47 (1.57)^{ab}	1.73 (1.65)^{ab}	2.97 (1.99)^{a}	2.24 (1.80)^{a}	2.48 (1.87)^{a}	1.96 (1.72)^{a}	1.96 (1.72)	3.21 (2.05)	4.49 (2.34)	2.20 (1.79)^{abc}
Azadirachtin 0.004 per cent	0.72 (1.31)^{abc}	0.72 (1.31)^{a}	0.87 (1.37)^{a}	1.69 (1.64)^{a}	2.97 (1.99)^{a}	2.24 (1.80)^{a}	2.41 (1.85)^{a}	1.96 (1.72)^{a}	2.24 (1.80)	2.94 (1.98)	5.22 (2.49)	2.15 (1.77)^{ab}
Azadirachtin 0.003 per cent	0.93 (1.39)^{abcd}	0.66 (1.29)^{a}	0.93 (1.39)^{a}	2.24 (1.80)^{b}	3.24 (2.06)	2.19 (1.79)^{a}	2.71 (1.93)^{a}	2.12 (1.77)^{a}	2.19 (1.79)	2.97 (1.99)	5.22 (2.49)	2.29 (1.82)^{abc}
Clerodendron leaf and flower extract 8.00 per cent	1.73 (1.65)^{d}	1.69 (1.64)	2.12 (1.76)^{abc}	3.15 (2.04)	4.24 (2.29)	2.97 (1.99)	3.74 (2.18)	2.48 (1.87)^{a}	2.48 (1.87)	3.43 (2.10)	5.22 (2.49)	3.07 (2.02)^{cd}
Karanja oil emulsion 2.00 per cent	1.23 (1.49)^{bcd}	1.47 (1.57)	1.47 (1.57)^{abc}	2.24 (1.80)^{b}	3.97 (2.23)	2.61 (1.90)	2.71 (1.93)^{a}	2.16 (1.78)^{a}	2.19 (1.79)	2.48 (1.87)	4.57 (2.36)	2.44 (1.85)
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	0.46 (1.21)^{ab}	0.46 (1.21)^{a}	0.93 (1.39)^{a}	1.96 (1.72)^{a}	2.74 (1.93)^{a}	1.47 (1.57)^{a}	2.19 (1.79)^{a}	1.73 (1.65)^{a}	2.24 (1.80)	2.97 (1.99)	4.24 (2.29)	1.95 (1.72)^{ab}
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	0.72 (1.31)^{abc}	0.93 (1.39)^{a}	1.47 (1.57)^{ab}	1.73 (1.65)^{ab}	3.71 (2.17)	1.96 (1.72)^{a}	2.71 (1.93)^{a}	1.96 (1.72)^{a}	1.96 (1.72)	2.48 (1.87)	4.93 (2.44)	2.27 (1.81)^{bcd}
Quinalphos 0.05 per cent	0.22 (1.10)^{d}	0.22 (1.10)^{a}	0.72 (1.31)^{a}	0.93 (1.39)^{a}	2.48 (1.87)^{a}	1.96 (1.72)^{a}	2.24 (1.80)^{a}	1.73 (1.65)^{a}	1.96 (1.72)	3.24 (2.06)	4.98 (2.45)	1.85 (1.69)^{a}
Control	5.74 (2.60)	5.22 (2.49)	5.18 (2.49)	4.24 (2.29)	4.98 (2.45)	2.71 (1.93)	3.18 (2.05)^{a}	2.41 (1.85)^{a}	2.24 (1.80)	2.97 (1.99)	4.93 (2.44)	4.05 (2.25)
CD-treatments at 5% : 0.340*, CD-Mean at5% 0.094*, CD-intervals at 5% : 0.107*									NS	NS	NS	

Figures in parentheses denote $\sqrt{x+1}$ transformed values. HAS- Hours after spraying. WAS – Weeks after spraying.
*Significant at 5 per cent level. NS – Non significant

seed oil 3.00 per cent + garlic 2.00 per cent and azadirachtin 0.003 per cent were statistically on par.

Seventy-two hours after application of treatments the highest mean population of pollu beetle adults was recorded in control (5.22) and minimum in quinalphos 0.05 per cent (0.22). Quinalphos 0.05 per cent was followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.003 per cent and azadirachtin 0.004 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent.

The mean population value ranged between 0.72 in quinalphos 0.05 per cent to 5.18 in control when observations were taken one week after treatment application. Among botanicals, azadirachtin 0.004 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.003 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent recorded minimum counts compared to others.

Two weeks after applying insecticides, it was found that control itself showed maximum population of 4.24 followed by clerodendron leaf and flower extract 8.00 per cent with 3.15. Minimum population of pollu beetle adults was observed in quinalphos 0.05 per cent with mean of 0.93 followed by azadirachtin 0.004 per cent with 1.69. The mean population of pollu beetle in azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent was 1.73.

Significant difference was recorded between treatments and control at three weeks after application of treatments. The treatments, quinalphos 0.05 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent recorded minimum population of 2.48 followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00

per cent, azadirachtin 0.004 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent.

Four weeks after application of treatments significant difference was observed between control and treatments. Neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent recorded minimum population of 1.47 followed by azadirachtin 0.003 per cent + karanja oil 1.00 per cent and quinalphos 0.05 per cent with 1.96.

Observations taken at fifth, sixth, seventh, eighth and ninth weeks after application of treatments there was no significant difference between control and the other treatments.

The mean population of pollu beetle obtained from all the observations taken at berry formation stage was the lowest (1.85) in quinalphos 0.05 per cent treated vines and maximum (4.05) in control vines. Among the plant products, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent recorded the least mean population of 1.95 followed by neem seed oil 3.00 per cent + garlic 2.00 per cent and azadirachtin 0.004 per cent with a mean count of 2.15. Neem oil soap emulsion 2.00 per cent + garlic 2.00 per cent had a population count of 2.20 per cent. Among botanicals, clerodendron leaf and flower extract 8.00 percent recorded a maximum count of 3.07.

At berry formation stage, quinalphos 0.05 percent was the best treatment against pollu beetle followed by neem oil soap emulsion 2.00 percent + garlic 2.00 percent + karanja oil 1.00 percent.

4.2.1.3 At Berry Maturation Stage

The population of pollu beetle at different intervals after application of treatments at berry maturation stage is given in Table 6.

Table 6. Population of pollu beetle at different intervals after application of different treatments at berry maturation stage

Treatment	24 HAS	72 HAS	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	1.23 (1.49)^{b}	0.93 (1.39)^{b}	1.16 (1.47)^{b}	2.24 (1.80)^{b}	3.74 (2.18)$^{a-c}$	4.24 (2.29)	2.97 (1.99)	4.72 (2.39)	4.24 (2.29)	3.49 (2.12)	2.97 (1.99)	2.96 (1.99)^{a}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	0.93 (1.39)^{ab}	1.23 (1.49)^{bc}	1.73 (1.65)^{bc}	2.24 (1.80)^{b}	4.24 (2.29)$^{a-c}$	4.22 (2.28)	3.21 (2.05)	4.44 (2.33)	4.24 (2.29)	3.21 (2.05)	3.21 (2.05)	3.04 (2.01)^{ab}
Azadirachtin 0.004 per cent	1.23 (1.49)^{b}	1.44 (1.56)^{bc}	1.91 (1.71)^{bc}	2.48 (1.87)^{bc}	4.98 (2.45)^{a}	4.49 (2.34)	4.22 (2.28)	4.44 (2.33)	4.22 (2.28)	4.22 (2.28)	2.97 (1.99)	3.40 (2.10)^{bc}
Azadirachtin 0.003 per cent	1.47 (1.57)^{b}	1.69 (1.64)^{bc}	1.47 (1.57)	2.71 (1.93)^{bc}	4.96 (2.44)^{b}	4.98 (2.45)	3.43 (2.10)	4.59 (2.36)	4.49 (2.34)	3.74 (2.18)	2.94 (1.98)	3.38 (2.09)^{bc}
Clerodendron leaf and flower extract 8.00 per cent	2.19 (1.79)	1.96 (1.72)^{bc}	2.97 (1.99)	3.97 (2.30)	5.18 (2.49)^{b}	4.98 (2.45)	3.97 (2.23)	4.91 (2.43)	4.49 (2.34)	3.97 (2.23)	3.21 (2.05)	3.96 (2.23)
Karanja oil emulsion 2.00 per cent	1.69 (1.64)^{b}	1.47 (1.57)^{bc}	2.71 (1.93)	3.21 (2.05)^{bc}	4.69 (2.39)^{b}	4.69 (2.39)	4.24 (2.29)	5.45 (2.54)	4.69 (2.39)	4.00 (2.24)	2.97 (1.99)	3.69 (2.17)^{c}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	0.93 (1.39)^{ab}	1.00 (1.41)^{bc}	1.91 (1.71)^{bc}	2.48 (1.87)^{bc}	4.74 (4.40)^{b}	4.00 (2.24)	3.49 (2.12)	4.49 (2.34)	4.00 (2.24)	3.21 (2.05)	2.49 (1.87)	3.07 (2.02)^{abc}
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	1.12 (1.46)^{b}	0.93 (1.39)^{bc}	2.24 (1.80)^{bc}	3.43 (2.10)^{b}	4.20 (2.28)^{ab}	4.66 (2.38)	3.91 (2.22)	5.22 (2.49)	4.66 (2.38)	4.22 (2.28)	3.24 (2.06)	3.49 (2.12)^{c}
Quinalphos 0.05 per cent	0.22 (1.10)^{a}	0.00 (1.00)^{a}	0.22 (1.10)^{a}	0.93 (1.39)^{a}	3.21 (2.05)^{c}	4.00 (2.24)	3.24 (2.06)	4.72 (2.39)	3.49 (2.12)	3.49 (2.12)	2.48 (1.87)	2.35 (1.83)^{a}
Control	6.69 (2.77)	6.98 (2.83)	7.22 (2.87)	6.49 (2.74)	5.98 (2.64)	4.98 (2.45)	4.74 (2.18)	4.96 (2.44)	4.24 (2.29)	3.74 (2.18)	3.49 (2.12)	5.34 (2.52)
CD-treatments at 5% : 0.312*, CD-Mean at 5% : 0.087*, CD-intervals at 5% 0.099*						NS	NS	NS	NS	NS	NS	

Figures in parentheses denote $\sqrt{x+1}$ transformed values. HAS- Hours after spraying, WAS - Weeks after spraying,
*Significant at 5 per cent level, NS - Non significant

Twenty four hours after application of treatments, control recorded highest mean population of 6.69 and the lowest in quinalphos 0.05 per cent (0.22). Quinalphos 0.05 per cent was followed by the neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent with population of 0.93. The treatments quinalphos 0.05 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent were statistically on par.

At seventy two hours after application of treatments, pollu beetle was absent in quinalphos 0,05 per cent treated vines and 6.98 in the control vines. Azadirachtin 0.003 per cent + karanja oil 1.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent had population of 0.93. The treatments, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, azadirachtin 0.004 per cent, karanja oil 2.00 per cent and azadirachtin 0.003 per cent were statistically on par with quinalphos 0.05 per cent.

One week after insecticide application, quinalphos treated vines recorded a population of 0.22 which was the least followed by neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and azadirachtin 0.004 per cent and they were statistically on par. The highest population was recorded in the control vines.

The mean beetle count ranged from 0.93 in quinalphos 0.05 per cent treated vines to 6.49 in control at two weeks after spraying insecticides. Among the botanicals, neem seed oil soap emulsion 2.00 per cent + garlic

2.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent recorded least population of 2.24 followed by azadirachtin 0.004 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent (2.48).

Three weeks after insecticide application, the maximum population was recorded in control (5.98) and minimum in quinalphos 0.05 per cent (3.21). Quinalphos 0.05 per cent was followed by neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent with population of 3.74, 4.20 and 4.24 respectively. They were statistically on par.

At four weeks after insecticidal application, highest population were observed in control, clerodendron leaf and flower extract 8.00 per cent and azadirachtin 0.003 per cent (4.98) and least in quinalphos 0.05 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent (4.00).

At five weeks, six, seven, eight and nine weeks after insecticide application, there was no significant difference between any of the treatments with the control.

The mean of all the observations taken for the population of pollu beetle at berry maturation stage revealed that quinalphos 0.05 per cent (2.35) was the best treatment and differed significantly from all other treatments in deterring pollu beetle. The highest count of the beetles was recorded in control (5.34). Among the plant products sprayed, neem oil soap emulsion 3.00 per cent + garlic 2.00 per cent (2.96) was the best followed by neem oil soap emulsion 2.00 per cent + garlic 2.00 per cent and neem oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja 1.00 per cent with mean population of 3.04 and 3.07 respectively.

Table 7. Percentage of leaves damaged by pollu beetle after application of different treatments at spike emergence stage

Treatments	24 HAS	72 HAS	1WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	-	1.08 (1.44)^{ab}	2.55 (1.88)^{ab}	8.13 (3.02)^{ab}	12.92 (3.73)^{ab}	18.96 (4.47)^{bc}	24.41 (5.04)^{bc}	26.46 (5.24)^{d}	11.58 (3.55)^{bc}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	-	0.00 (1.00)^{a}	3.57 (2.14)^{ab}	9.74 (3.28)^{abc}	13.33 (3.79)^{ab}	20.83 (4.67)^{c}	24.41 (5.09)^{c}	24.41 (5.04)^{d}	11.71 (3.57)^{bc}
Azadirachtin 0.004 per cent	-	2.55 (1.88)^{b}	7.04 (2.83)^{c}	9.74 (3.28)^{abc}	16.51 (4.18)^{bc}	21.29 (4.72)^{c}	23.22 (4.92)^{c}	23.22 (4.92)^{d}	13.59 (3.82)^{dc}
Azadirachtin 0.003 per cent	-	1.08 (1.44)^{ab}	8.13 (3.02)	13.33 (3.79)^{bc}	17.95 (4.35)^{c}	24.91 (5.05)	24.91 (5.09)	26.66 (5.26)	15.05 (4.01)^{c}
Clerodendron leaf and flower extract 8.00 per cent	-	4.41 (2.33)	9.74 (3.28)	16.51 (4.18)	21.29 (4.72)	23.22 (4.92)^{bc}	26.46 (5.24)^{bc}	28.26 (5.44)^{a}	17.46 (4.30)^{d}
Karanja oil emulsion 2.00 per cent	-	2.55 (1.88)^{b}	4.41 (2.33)^{ab}	11.47 (3.53)^{bc}	14.88 (3.98)^{abc}	19.73 (4.55)	19.73 (4.55)	21.29 (4.72)^{d}	12.32 (3.65)^{cd}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	-	0.00 (1.00)^{a}	4.41 (2.33)^{b}	8.13 (3.02)^{ab}	11.47 (3.53)^{ab}	13.33 (3.79)^{ab}	18.21 (4.38)^{ab}	21.29 (4.72)^{d}	9.58 (3.25)^{b}
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	-	1.08 (1.44)^{ab}	4.27 (2.30)^{a}	9.71 (3.28)^{abc}	12.92 (3.73)^{ab}	14.44 (3.93)^{abc}	18.96 (4.47)^{abc}	23.22 (4.92)^{d}	10.81 (3.44)^{bc}
Quinalphos 0.05 per cent	-	0.00 (1.00)^{a}	1.08 (1.44)^{a}	5.66 (2.58)^{ab}	9.74 (3.28)^{a}	9.74 (3.28)^{a}	16.05 (4.13)^{a}	18.21 (4.38)^{d}	7.24 (2.87)^{a}
Control	4.41 (2.33)	14.85 (3.98)	16.51 (4.18)	23.22 (4.92)	28.26 (5.41)	29.91 (5.56)	31.60 (5.71)	31.60 (5.71)	20.27 (4.72)

CD-treatments at 5% : 0.876*, CD-Mean at 5% : 0.331*, CD-intervals at 5% : 0.277*

Figures in parentheses denote $\sqrt{x+1}$ transformed values. HAS- Hours after spraying. WAS – Weeks after spraying.

*Significant at 5 per cent level

Quinalphos 0.05 percent was the best in reducing pollu beetle population followed by neem oil soap emulsion 3.00 percent + garlic 2.00 per cent.

4.2.2 Mean Percentage of Leaves Damaged by Pollu Beetle at different intervals after Application of Treatments

4.2.2.1 At Spike Emergence Stage

The extent of damage done by pollu beetle on leaves at spike emergence is expressed as percentage in Table 7.

Twenty four hours after spraying of insecticides, there was no damage in any of the treatments except control (4.41 per cent leaf damage).

Leaf damage was not observed in quinalphos 0.05 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent whereas it was 14.85 in control, seventy two hours after insecticide spray. The treatments, azadirachtin 0.003 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, karanja oil 2.00 per cent and azadirachtin 0.004 per cent were statistically on par.

Observation taken one week after applying insecticides revealed that control vines had the highest leaf damage of 16.51 per cent and quinalphos 0.05 per cent the least with 1.08 per cent. Quinalphos 0.05 per cent was followed by neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent with mean damage of 2.55, 3.57 and 4.27 respectively.

At two weeks after application of treatments, maximum percentage of leaf damage was observed in control (23.22) and minimum of 5.66 in quinalphos 0.05 per cent treated vines. The mean percentage damage was 8.13 in vines receiving neem seed oil 3.00 per cent + garlic 2.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and 9.74 in neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, azadirachtin 0.004 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent treatments.

The same trend of leaf damage in treatment vines was recorded three weeks after spray. The treatment, quinalphos 0.05 per cent was followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent with mean values of 11.47, 12.92 and 12.92 respectively. The treatments, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, karanja oil 2.00 per cent, azadirachtin 0.004 per cent and azadirachtin 0.003 per cent were statistically on par.

Four, five and six weeks after spray, the same trend were observed with vines under control showing maximum damage and quinalphos 0.05 per cent treated vines, the minimum. Among botanicals, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent showed minimum damage.

The mean of all the observations on leaf damage by pollu beetle at spike emergence revealed that quinalphos 0.05 per cent (7.24) was the best treatment followed by neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + karanja oil 1.00 per cent with mean percentage damage of 9.58 and azadirachtin 0.003 per cent + karanja oil 1.00 per cent with a damage of 10.81. The control vines had the maximum damage of 20.27

per cent. Neem seed oil soap emulsion 3.00 percent + garlic 2.00 per cent and neem seed oil 2.00 per cent + garlic 2.00 per cent had a mean percentage 11.58 and 11.71 respectively. Clerodendron leaf and flower extract 8.00 per cent recorded a leaf damage of 17.46.

Among the different treatments sprayed against leaf damage by pollu beetle at spike emergence stage, quinalphos 0.05 per cent recorded minimum damage followed by neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + karanja oil 1.00 per cent

4.2.2.2 At Berry Formation Stage

The percentage of leaves damaged by pollu beetle at berry formation stage is given in Table 8.

Twenty four hours after insecticide spray, no leaf damage by pollu beetle was recorded in any of the treatments except in control with a mean damage of 3.57.

Seventy two hours after application of sprays, the control vines recorded the highest damage (11.47) and quinalphos 0.05 per cent treated vines had no damage. Quinalphos 0.05 per cent was followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent with mean damage of 1.08 and azadirachtin 0.003 per cent + karanja oil 1.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent with 2.55 per cent leaves damaged.

The mean damage ranged from 2.55 in quinalphos to 14.88 in control 0.05 per cent at one week after application of different treatments. The treatments quinalphos 0.05 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent were on par. Also treatments, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil

Table 8. Percentage of leaves damaged by pollu beetle after application of different treatments at berry formation stage

Treatment	24 HAS	72 HAS	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	-	2.55 (1.88)^{bc}	6.66 (2.77)^{b}	11.47 (3.53)^{abc}	11.47 (3.53)^{abc}	16.51 (4.18)^{ab}	16.51 (4.18)^{ab}	18.21 (4.38)	20.00 (4.58)	38.14 (6.26)	48.29 (7.02)	16.92 (4.23)^{b}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	-	3.57 (2.14)^{bc}	9.66 (2.58)^{ab}	11.47 (3.53)^{bc}	11.47 (3.53)^{abc}	18.21 (4.38)^{ab}	18.21 (4.38)^{a}	19.73 (4.55)	21.58 (4.75)	34.77 (5.98)	48.17 (7.01)	17.14 (4.26)^{bcde}
Azadirachtin 0.004 per cent	-	3.57 (2.14)^{bc}	9.74 (3.28)^{bc}	11.47 (3.53)^{bc}	11.47 (3.53)^{abc}	16.51 (4.18)^{ab}	16.51 (4.18)^{a}	19.73 (4.55)	19.73 (4.55)	34.77 (5.98)	51.52 (7.25)	17.65 (4.32)^{bcde}
Azadirachtin 0.003 per cent	-	8.13 (3.02)^{c}	9.74 (3.28)^{bc}	13.33 (3.79)^{c}	13.33 (3.79)^{abc}	18.21 (4.38)^{b}	18.21 (4.38)^{a}	19.73 (4.55)	19.73 (4.55)	31.43 (5.70)	49.82 (7.13)	18.86 (4.45)^{cde}
Clerodendron leaf and flower extract 8.00 per cent	-	8.13 (3.02)^{c}	11.47 (3.51)^{d}	16.51 (4.18)^{c}	16.51 (4.18)^{ac}	20.00 (4.58)^{b}	21.58 (4.75)	21.58 (4.75)	23.22 (4.92)	38.28 (6.27)	51.52 (7.25)	21.51 (4.74)
Karanja oil emulsion 2.00 per cent	-	4.41 (2.33)^{c}	9.74 (3.28)^{dc}	14.88 (3.98)^{bc}	14.88 (3.98)^{abc}	16.51 (4.18)^{ab}	16.51 (4.18)^{a}	18.21 (4.38)	23.22 (4.92)	39.86 (6.39)	49.94 (7.14)	19.04 (4.48)^{de}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	-	1.08 (1.44)^{ab}	8.13 (3.02)^{b}	9.74 (3.28)^{ac}	9.74 (3.28)^{a}	16.51 (4.81)^{ab}	16.51 (4.18)^{a}	16.51 (4.18)	20.00 (4.58)	34.77 (5.98)	48.29 (7.02)	15.93 (4.12)^{ab}
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	-	2.55 (1.88)^{bc}	6.66 (2.77)^{b}	9.74 (3.28)^{abc}	11.47 (3.53)^{abc}	18.21 (4.38)^{ab}	18.21 (4.38)^{a}	18.21 (4.38)	18.21 (4.38)	36.42 (6.12)	53.23 (7.36)	17.04 (4.25)^{b}
Quinalphos 0.05 per cent	-	0.00 (1.00)^{d}	2.55 (1.88)^{a}	6.66 (2.77)^{abc}	9.74 (3.28)^{a}	12.92 (3.73)^{ab}	14.88 (3.98)^{a}	18.21 (4.38)	18.21 (4.38)	38.28 (6.27)	49.94 (7.14)	14.06 (3.88)^{e}
Control	3.57 (2.14)	11.47 (3.53)	14.88 (3.98)^{d}	16.51 (4.18)^{c}	18.21 (4.38)	22.92 (4.89)^{b}	24.91 (5.10)^{a}	24.91 (5.09)	26.66 (5.26)	41.62 (6.53)	49.04 (7.14)	21.52 (4.75)
CD-treatments at 5% : 0.726*, CD-Mean at 5% : 0.229*, CD-intervals at 5% : 0.229*								NS	NS	NS	NS	

Figures in parentheses denote $\sqrt{x+1}$ transformed values HAS- Hours after spraying, WAS Weeks after spraying.
* Significant at 5 per cent level, NS Non significant

1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, karanja oil 2.00 per cent, azadirachtin 0.003 per cent and azadirachtin 0.004 per cent were on par.

The highest percentage of leaf damage was observed in control with a mean of 16.51 per cent and lowest of 6.66 per cent in quinalphos 0.05 per cent, two weeks after insecticide application. The treatments, quinalphos 0.05 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent were on par. Control was on par with clerodendron leaf and flower extract 8.00 per cent, karanja oil 2.00 per cent, azadirachtin 0.003 per cent and azadirachtin 0.004 per cent.

At three weeks after spraying, the percentage of leaves damaged was the least (9.74) in quinalphos 0.05 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent treated vines. The control vines revealed the highest damage of 18.21. All the treatments were on par except control and clerodendron leaf and flower extract 8.00 per cent.

After four weeks of spray application, highest damage was observed in control (22.92) and lowest in quinalphos 0.05 per cent (12.92). The treatments, azadirachtin 0.004 per cent, karanja oil 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent were on par with quinalphos 0.05 per cent.

From the fifth week onwards all the treatments were on par, but the damage in the control vines was significantly higher compared to all the treatments.

The mean percentage of leaves damaged by pollu beetle from all the observations taken at berry formation stage was the highest (21.52 per cent)

in the control vines and the minimum of 14.06 in quinalphos 0.05 per cent treated vines, which was on par with neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent (15.93). Among botanical treatments, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil 1.00 per cent was the best followed by neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and azadirachtin 0.004 per cent and were statistically on par with mean values of 16.92, 17.04, 17.14, and 17.65 respectively.

Among the different botanicals tested against leaf damage by pollu beetle, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil 1.00 per cent was the best treatment followed by neem seed oil soap emulsion 3.00 per cent + garlic 2.00 per cent.

4.2.2.3 At Berry Maturation Stage

The extent of damage done by pollu beetle on leaves is expressed as percentage is given in Table 9.

Twenty-four hours after application of different treatments it was found that only vines treated with clerodendron leaf and flower extract 8.00 per cent and control had leaf damage of 1.08 and 3.57 per cent respectively.

At seventy-two hours after application of insecticides, no damage to leaves were observed in quinalphos 0.05 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent to 11.08 in control. The treatments,neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, azadirachtin 0.003 per cent, azadirachtin 0.004 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and karanja oil 2.00 per cent were on par.

Table 9. Percentage of leaves damaged by pollu beetle at different intervals after application of treatments at berry maturation stage

Treatment	24 HAS	72 HAS	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	-	1.08 (1.44)^{ab}	6.66 (2.77)^{bcd}	9.74 (3.28)^{bc}	11.47 (3.53)^{cde}	13.33 (3.79)^{bc}	18.21 (4.38)^{bcd}	18.21 (4.38)^{ab}	18.21 (4.38)^{ab}	20.00 (4.58)^{abcd}	20.00 (4.58)^{abcd}	12.78 (3.71)^{bc}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	-	2.55 (1.88)^{bc}	8.13 (3.02)^{bcd}	11.47 (3.53)^{bcd}	12.92 (3.73)^{bc}	12.92 (3.73)^{b}	16.51 (4.18)^{abc}	17.95 (4.35)^{ab}	17.95 (4.35)^{ab}	21.58 (4.75)^{abcd}	21.58 (4.75)^{abcd}	13.66 (3.83)^{bcd}
Azadirachtin 0.004 per cent	-	2.55 (1.88)^{bc}	5.66 (2.58)^{bc}	11.08 (3.48)^{bcd}	14.44 (3.93)^{bcde}	16.51 (4.18)^{bcd}	19.45 (4.52)^{bcde}	21.29 (4.72)^{ab}	23.22 (4.92)^{bc}	23.22 (4.92)^{abcd}	23.22 (4.92)^{abcd}	15.05 (4.01)^{e}
Azadirachtin 0.003 per cent	-	2.55 (1.88)^{bc}	9.73 (3.28)^{cd}	12.92 (3.73)^{bcd}	12.92 (3.73)^{bc}	12.92 (3.73)^{b}	17.95 (4.35)^{bcd}	19.73 (4.55)^{ab}	19.73 (4.55)^{abc}	19.73 (4.55)^{abcd}	19.73 (4.55)^{abcd}	14.14 (3.89)^{bcde}
Clerodendron leaf and flower extract 8.00 per cent	1.08 (1.44)	7.04 (2.83)^{de}	11.08 (3.48)^{de}	16.51 (4.18)^{de}	18.21 (4.38)^{cde}	18.21 (4.38)^{cd}	21.58 (4.75)^{cdef}	26.46 (5.24)	26.46 (5.24)	28.26 (5.41)	28.26 (5.41)	17.07 (4.25)
Karanja oil emulsion 2.00 per cent	-	3.57 (2.14)^{bcd}	8.13 (3.02)^{bcd}	11.47 (3.53)^{bcd}	16.51 (4.18)^{bcde}	18.21 (4.38)^{cd}	18.21 (4.38)^{bcde}	20.00 (4.58)^{ab}	20.00 (4.58)^{abc}	21.58 (4.75)^{abcd}	21.58 (4.75)^{abcd}	16.25 (4.03)^{c}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	-	0.00^{a} (1.00)	4.41 (2.33)^{ab}	8.13 (3.02)^{ab}	11.47 (3.53)^{ab}	11.47 (3.53)^{ab}	14.88 (3.98)^{ab}	19.73 (4.55)^{ab}	21.29 (4.72)^{abc}	23.22 (4.92)^{abcd}	23.22 (4.92)^{abcd}	12.33 (3.65)^{b}
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	-	1.07 (1.44)^{ab}	8.13 (3.02)^{bcd}	9.74 (3.28)^{bc}	13.33 (3.79)^{bcd}	13.33 (3.79)^{bc}	17.95 (4.35)^{bcd}	21.58 (4.75)^{ab}	21.58 (4.75)^{bc}	21.58 (4.75)^{abcd}	21.58 (4.75)^{abcd}	13.95 (3.87)^{bcde}
Quinalphos 0.05 per cent	-	0.00 (1.00)^{a}	1.08 (1.44)^{a}	4.41 (2.33)^{a}	6.66 (2.77)^{a}	6.66 (2.77)^{a}	11.47 (3.53)^{a}	12.92 (3.73)^{a}	14.88 (3.98)^{a}	17.95 (4.35)^{a}	17.95 (4.35)^{a}	8.16 (3.03)^{a}
Control	3.57 (2.14)	11.08 (3.48)^{e}	16.51 (4.18)^{e}	20.00 (4.58)^{e}	20.00 (4.58)^{e}	20.00 (4.58)^{d}	28.26 (5.41)^{f}	28.26 (5.41)	29.75 (5.55)	31.44 (5.70)	31.44 (5.70)	21.34 (4.73)

CD-treatments at 5% : 0.763*, CD-Mean at 5% : 0.241*, CD-intervals at 5% : 0.241*

Figures in parentheses denote $\sqrt{x+1}$ transformed values. HAS- Hours after spraying, WAS - Weeks after spraying, *Significant at 5 per cent level

Observations recorded one week after application of treatments revealed maximum damage of 16.51 in control and minimum of 1.08 in quinalphos 0.05 per cent. The treatments, quinalphos 0.05 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent were on par. Neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent was followed by azadirachtin 0.004 per cent. Neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and karanja oil 2.00 per cent.

The damage was highest in the control vine (20.00) at two weeks after insecticide application. Quinalphos 0.05 per cent recorded minimum damage of 4.40 per cent. Among the botanicals, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent recorded less damage of 8.13 followed by azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.004 per cent neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent karanja oil 2.00 per cent and azadirachtin 0.003 per cent.

Three weeks after treatment application, the control vines exhibited maximum damage (20.00) and quinalphos 0.05 per cent with minimum damage. The treatments, quinalphos 0.05 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent were on par with mean values of 6.66, 11.46 and 11.46 respectively.

Among the botanicals, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent was the best followed by azadirachtin 0.003 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil 3.00 per cent + garlic 2.00

per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent at four five weeks after treatment application. The highest leaf damage was recorded in control and the least in quinalphos 0.05 per cent.

Six and seven weeks after insecticide application, control vines receiving no spray recorded maximum damage. However the minimum damage was in quinalphos 0.05 per cent treated vines. Among the different botanicals, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent, karanja oil 2.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent were on par with quinalphos 0.05 per cent.

The mean damage ranged between 17.95 in quinalphos treated vines to 31.44 in control when observations were taken at the eighth and ninth week after insecticide application. Treatments quinalphos 0.05 per cent, azadirachtin 0.003 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, karanja oil 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and azadirachtin 0.004 per cent were statistically on par.

The average of all the observations revealed that maximum percentage of leaf damage by pollu beetle was observed in control with mean of 21.34 and minimum in quinalphos 0.05 per cent treated vines (8.16). Quinalphos 0.05 per cent was the best treatment and it was significantly different from all the other treatments. Among the plant products, neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil was the best followed by neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent with mean values of 12.33, 12.79, 13.66 and 13.95 respectively.

4.2.3 Mean Intensity of Leaves Damaged by Pollu Beetle at Different Intervals after Application of Treatments.

4.2.3.1 At Spike Emergence Stage

Mean intensity values of leaves damaged by pollu beetle at different intervals after application of treatments at spike emergence are given in Table 10.

Twenty four hours after insecticide application, no damage was observed in any the treatment vines except the control.

The intensity of leaves damaged by pollu beetle seventy two hours after insecticide application showed that control had the maximum damage with mean intensity of 5.27 per cent. Vines treated with quinalphos 0.05 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent had no leaf damage.

The highest intensity of leaf damage (5.27) was in control vines observed at one week after giving the first spray. Quinalphos 0.05 per cent recorded the least damage of 0.15 per cent. Among the plant products, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent were the best followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent.

The intensity of leaf damage ranged from 1.44 in quinalphos 0.05 per cent to 12.54 in control at two weeks after the spray. Among the botanicals, neem seed oil soap emulsion two per cent + 2.00 per cent garlic + karanja oil 1.00 per cent recorded a mean intensity of 4.00

Table 10. Intensity of leaves damaged by pollu beetle at different intervals after application of treatments at spike emergence stage

Treatments	24 HAS	72 HAS	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	-	0.15 (1.07)^{ab}	1.35 (1.53)^{abcd}	5.35 (2.52)^{bc}	6.16 (2.68)^{abc}	7.52 (2.92)^{ab}	7.99 (3.00)^{ab}	8.55 (3.09)^{ab}	4.76 (2.40)^{bcd}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	-	0.00 (1.00)^{a}	0.66 (1.29)^{abc}	5.47 (2.54)^{bc}	6.98 (2.83)^{abcd}	6.98 (2.83)^{abc}	7.49 (2.91)^{abc}	8.19 (3.03)^{abc}	4.48 (2.34)^{bc}
Azadirachtin 0.004 per cent	-	0.56 (1.25)^{abc}	1.55 (1.60)^{abcd}	4.89 (2.43)^{bc}	6.18 (2.68)^{abcd}	7.09 (2.85)^{abc}	7.50 (2.91)^{abc}	7.76 (2.96)^{abc}	4.67 (2.38)^{bcd}
Azadirachtin 0.003 per cent	-	1.26 (1.50)^{abcd}	2.47 (1.86)^{abcd}	5.37 (2.52)^{bc}	6.47 (2.73)^{abc}	7.98 (3.00)^{abc}	8.49 (3.08)^{abc}	8.49 (3.08)^{abc}	5.45 (2.54)^{bcd}
Clerodendron leaf and flower extract 8.00 per cent	-	3.00 (2.00)^{de}	4.77 (2.40)^{de}	8.48 (3.03)^{bcd}	9.03 (3.17)^{bcd}	11.62 (3.55)^{cd}	11.94 (3.60)^{cd}	12.81 (3.72)^{cd}	8.40 (3.07)^{c}
Karanja oil emulsion 2.00 per cent	-	1.69 (1.64)^{abcd}	2.77 (1.94)^{abcd}	5.94 (2.63)^{b}	7.30 (2.88)^{abcd}	9.26 (3.20)^{abc}	9.40 (3.22)^{abc}	9.40 (3.22)^{abc}	6.18 (2.68)^{dc}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	-	0.00 (1.00)^{a}	0.89 (1.38)^{abc}	4.00 (2.24)^{ab}	4.35 (2.31)^{ab}	5.43 (2.54)^{ab}	6.19 (2.68)^{ab}	6.97 (2.82)^{ab}	3.57 (2.14)^{abc}
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	-	0.00 (1.00)^{a}	0.66 (1.29)^{abc}	6.24 (2.69)^{bc}	7.20 (2.86)$_{abcd}$	9.80 (3.29)^{bcd}	10.23 (3.35)^{abc}	10.58 (3.40)^{abc}	5.52 (2.55)^{cc}
Quinalphos 0.05 per cent	-	0.00 (1.00)^{a}	0.15 (1.07)^{a}	1.44 (1.56)^{d}	3.32 (2.08)^{d}	4.07 (2.25)^{a}	5.45 (2.54)^{a}	6.00 (2.65)^{a}	2.53 (1.88)^{a}
Control	(1.69) (1.64)	5.27 (2.50)^{e}	5.27 (2.50)^{e}	12.54 (3.68)^{d}	14.43 (3.93)^{d}	19.97 (4.58)^{d}	24.79 (5.08)^{e}	27.86 (5.37)^{d}	12.40 (3.66)^{d}

CD-treatments at 5% : 0.891*, CD-Mean at 5% : 0.337*, CD-intervals at 5% : 0.287*

Figures in parentheses denote $\sqrt{x+1}$ transformed values. HAS-Hours after spraying. WAS - Weeks after spraying.
*Significant at 5 per cent level

followed by azadirachtin 0.004 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent and azadirachtin 0.003 per cent with damage intensities of 4.89, 5.35 and 5.37 respectively.

Three weeks after application of insecticides, quinalphos 0.05 per cent and control showed minimum and maximum leaf damage intensities of 3.32 and 14.43 respectively minimum. Treatments quinalphos 0.05 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.004 per cent, azadirachtin 0.003 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and karanja oil 2.00 per cent were statistically on par.

Four weeks after application of treatments, the intensity of damage ranged from 4.07 (quinalphos 0.05 per cent) to 19.97 (control). Quinalphos 0.05 per cent was followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, azadirachtin 0.004 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent and azadirachtin 0.003 per cent and they were statistically on par.

Five and six weeks after application of treatments, the same trend was observed with minimum damage in quinalphos 0.05 per cent followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.004 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and azadirachtin 0.003 per cent. All the treatments except control and clerodendron leaf and flower extract 8.00 per cent were statistically on par.

Analysis of the average intensity of leaves damaged by pollu beetle adults after applying different insecticides at spike emergence stage

showed that control had the highest damage intensity of 12.40 and quinalphos with least damage intensity of 2.53. Among the botanicals, neem and seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + karanja oil 1.00per cent was the best with least damage intensity of 3.57 followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, azadirachtin 0.004 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent with mean values of 4.48, 4.67 and 4.76 respectively. Control vines recorded maximum leaf damage intensity of 12.40 followed by clerodendron leaf and flower extract 8.00 per cent (8.40).

4.2.3.2 At Berry Formation Stage

The mean intensity of leaves damaged by pollu beetle at different intervals after application of treatments at berry formation stage is given in Table 11.

Twenty four hours after application of insecticides, there was no damage in any of the treatment vines except control.

Seventy two hours after insecticide application, control vines recorded maximum intensity of 4.52. No damage was observed in quinalphos 0.05 per cent and this was followed by neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and azadirachtin 0.004 per cent with mean intensities of 0.43, 0.48, 0.56 and 0.80 respectively.

Observations taken one week after application of different treatments indicated the same trend. Quinalphos 0.05 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, karanja oil 2.00 per cent and azadirachtin 0.003 per cent were statistically on par.

Table 11. Intensity of leaves damaged by pollu beetle at different intervals after application of treatments at berry formation stage

Treatment	24 HAS	72 HAS	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	-	0.43 (1.20)^{abc}	1.54 (1.59)^{ab}	7.42 (2.90)^{bc}	8.73 (3.12)^{ab}	11.16 (3.49)^{ab}	11.81 (3.58)^{ab}	13.45 (3.80)^{ab}	13.91 (3.86)^{ab}	15.25 (4.03)^{b}	16.50 (4.18)^{ab}	9.08 (3.18)^{bc}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	-	0.81 (1.35)^{abc}	1.45 (1.56)^{ab}	5.60 (2.57)^{ab}	8.46 (3.08)^{ab}	10.22 (3.35)^{ab}	12.42 (3.66)^{ab}	12.58 (3.69)^{ab}	12.58 (3.69)$^{a b}$	14.91 (3.99)^{ab}	16.41 (4.17)^{ab}	8.67 (3.11)^{b}
Azadirachtin 0.004 per cent	-	0.80 (1.34)^{abc}	2.01 (1.73)^{abc}	8.61 (3.10)^{bc}	10.33 (3.37)^{bc}	12.00 (3.61)^{bc}	14.65 (3.96)^{b}	14.82 (3.98)^{b}	15.43 (4.05)^{b}	16.10 (4.13)^{b}	17.75 (4.33)^{b}	10.29 (3.36)^{bcd}
Azadirachtin 0.003 per cent	-	1.76 (1.66)^{abc}	2.29 (1.81)^{abc}	9.28 (3.21)^{bc}	10.77 (3.43)^{bc}	13.88 (3.86)^{bc}	16.04 (4.13)^{b}	16.64 (4.20)^{b}	16.67 (4.20)^{b}	17.09. (4.25)^{b}	18.49 (4.42)^{b}	11.37 (3.52)
Clerodendron leaf and flower extract 8.00 per cent	-	2.53 (1.88)^{abc}	5.08 (2.47)	10.19 (3.35)^{bc}	15.94 (4.12)	17.29 (4.28)^{d}	18.91 (4.46)	21.43 (4.74)	21.43 (4.74)	22.48 (4.85)	23.68 (4.97)^{b}	14.86 (3.98)
Karanja oil emulsion 2.00 per cent	-	1.15 (1.47)^{abc}	4.22 (2.28)^{c}	9.49 (3.24)^{bc}	11.58 (3.55)^{bc}	12.63 (3.69)^{bc}	13.37 (3.79)^{ab}	13.37 (3.79)^{ab}	15.03 (4.00)^{ab}	17.96 (4.35)^{b}	17.96 (4.35)^{b}	10.83 (3.44)^{d}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	-	0.48 (1.22)^{abc}	1.90 (1.70)^{abc}	6.59 (2.76)^{bc}	9.83 (3.29)^{bc}	10.81 (3.44)^{bc}	11.08 (3.48)^{ab}	12.48 (3.67)^{ab}	13.65 (3.83)^{ab}	16.68 (4.20)^{b}	16.89 (4.23)^{ab}	9.12 (3.18)^{b}
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	-	0.56 (1.25)^{ab}	1.84 (1.69)^{abc}	7.56 (2.93)^{bc}	10.93 (3.45)^{bc}	11.16 (3.49)^{bc}	12.49 (3.67)^{b}	13.64 (3.83)^{b}	14.98 (4.00)^{ab}	15.94 (4.12)^{b}	17.61 (4.31)^{b}	9.71 (3.27)^{bcd}
Quinalphos 0.05 per cent	-	0.00 (1.00)^{a}	0.80 (1.34)^{a}	2.95 (1.99)^{a}	4.73 (2.39)^{a}	7.14 (2.85)^{a}	8.14 (3.02)	8.96 (3.16)^{a}	9.66 (3.26)^{a}	9.65 (3.26)^{a}	11.63 (3.55)^{a}	5.68 (2.58)^{a}
Control	1.15 (1.47)	4.52 (2.35)	8.64 (3.11)	19.94 (4.58)	24.30 (5.03)	32.59 (5.80)	36.24 (6.10)	37.57 (6.21)	37.80 (6.23)	38.67 (6.30)	40.12 (6.41)	22.73 (4.87)

CD-Treatments at 5%: 0.0.799*, CD-Mean at 5% : 0.253*, CD-intervals at 5% : 0.253*

Figures in parentheses denote $\sqrt{X+1}$ transformed values. HAS-Hours after spraying , WAS - Weeks after spraying. *Significant at 5 per cent level

The mean intensity of damage ranged between 2.95 in quinalphos 0.05 per cent and 19.94 in control at two weeks after treatment application. Quinalphos 0.05 per cent was followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent with mean intensities of 5.60, 6.59, 7.42 and 7.56 respectively.

Observations recorded three weeks after spraying of treatments indicated that maximum damage was in control vines (24.30) followed by clerodendron leaf and flower extract 8.00 per cent and karanja oil 2.00 per cent. Minimum damage was seen in quinalphos 0.05 per cent treated vines. The treatments, quinalphos 0.05 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent were on par with mean intensities of 4.73, 8.46 and 8.73 respectively.

Four weeks after application of spray, the highest damage intensity in control (32.59). Minimum damage was in vines that were sprayed with quinalphos 0.05 per cent (7.14) followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent with means of 10.22, 10.81, 11.16 and 11.16 respectively.

At five weeks after insecticidal application, maximum intensity of damage was recorded in control (36.24) and minimum in quinalphos 0.05 per cent (8.14). The treatments, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent +

garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and karanja oil 2.00 per cent were on par with quinalphos 0.05 per cent.

At six weeks after application of different treatments, maximum and minimum intensities recorded the same trend. Among the botanicals, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent gave least intensity of damage (12.47) followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, karanja oil 2.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent.

At the seventh, eighth and ninth weeks after insecticidal application, maximum intensity of leaf damage were seen in control and minimum in quinalphos 0.05 per cent. The treatments, quinalphos 0.05 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent were statistically on par.

The average intensities of damage on leaves by pollu beetle based on all the observations at berry formation stage was worked out. The highest damage was seen in control vines with an average value of 22.73 and least in quinalphos 0.05 per cent treated vines (5.68). Among the plant products, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent was the best with mean damage intensity of 8.67 per cent followed by neem seed oil soap emulsion 3.00per cent + 2.00 per cent garlic and neem seed oil soap emulsion 2.00per cent + 2.00 per cent garlic + karanja oil 1.00 per cent with mean intensities of 9.08 and 9.12 respectively. The treatments, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and azadirachtin 0.004 per cent were statistically on par.

4.2.3.2 At Berry Maturation Stage

The mean intensity of leaves damaged by pollu beetle at different intervals after application of treatments at berry maturation is given in Table 12.

Twenty four after application of insecticides, only control and clerodendron leaf and flower extract 8.00 per cent treated vines showed damage.

At seventy two hours after application of treatments, the highest intensity of damage was recorded in the control vines with a mean value of 3.83 and least in quinalphos 0.05 per cent and neem seed oil soap emulsion 2.00 per cent + 2.00 garlic + 1.00 per cent karanja oil. The intensity of damage in neem seed oil 3.00 per cent + garlic 2.00 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent was 0.30.

The mean intensity value ranged from 0.30 in quinalphos 0.05 per cent to 8.66 in control at one week after application of treatments. Quinalphos 0.05 per cent was followed by neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, azadirachtin 0.004 per cent and were on par.

Two weeks after application of treatments, quinalphos 0.05 per cent showed minimum intensity of damage (2.63) followed by neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.003 per cent and karanja oil 2.00 per cent. The maximum intensity of damage was recorded in control 19.07.

Table 12. Intensity of leaves damaged by pollu beetle at different intervals after application of treatments at berry maturation stage

Treatment	24 HAS	72 HAS	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	-	0.30 (1.14)^{ab}	1.60 (1.61)^{ab}	4.98 (2.45)^{ab}	7.32 (2.88)^{ab}	12.12 (3.62)^{ab}	13.42 (3.80)^{a}	15.41 (4.05)^{b}	16.32 (4.16)^{b}	16.81 (4.22)^{ab}	16.81 (4.22)^{ab}	9.23 (3.20)^{bc}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	-	0.63 (1.28)^{ab}	2.06 (1.75)^{ab}	6.94 (2.82)^{b}	9.09 (3.18)^{b}	14.36 (3.92)^{ab}	15.69 (4.09)^{a}	16.05 (4.13)^{b}	16.05 (4.13)^{ab}	16.36 (4.17)^{ab}	16.74 (4.21)^{ab}	10.33 (3.37)^{bcde}
Azadirachtin 0.004 per cent	-	0.61 (1.27)^{ab}	2.58 (1.89)^{b}	7.04 (2.84)^{b}	8.97 (3.16)^{b}	16.04 (4.13)^{b}	17.06 (4.25)^{a}	17.80 (4.34)^{b}	17.80 (4.34)^{ab}	18.51 (4.42)^{b}	18.85 (4.46)^{b}	11.08 (3.44)^{de}
Azadirachtin 0.003 per cent	-	0.77 (1.33)^{ab}	3.35 (2.09)^{b}	5.27 (2.50)^{ab}	9.19 (3.19)^{b}	16.37 (4.17)^{b}	17.85 (4.34)^{a}	18.07 (4.37)^{b}	18.07 (4.37)^{b}	19.48 (4.53)^{b}	20.59 (4.65)^{b}	11.62 (3.55)^{f}
Clerodendron leaf and flower extract 8.00 per cent	0.30 (1.40)	2.22 (1.79)^{b}	4.02 (2.24)^{b}	10.67 (3.42)	16.00 (4.12)^{b}	19.23 (4.50)	19.23 (4.50)	19.50 (4.53)^{b}	19.50 (4.53)	20.28 (4.61)^{b}	20.46 (4.63)^{b}	12.40 (3.66)^{f}
Karanja oil emulsion 2.00 per cent	-	0.48 (1.21)^{ab}	2.88 (1.97)^{b}	6.43 (2.73)^{b}	10.72 (3.42)^{b}	14.34 (3.92)^{ab}	14.69 (3.96)^{a}	15.69 (4.68)^{b}	17.16 (4.26)^{b}	17.16 (4.26)^{b}	21.02 (4.69)^{b}	10.91 (3.45)^{de}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	-	0.00 (1.00)^{a}	1.77 (1.66)^{ab}	5.26 (2.50)^{ab}	7.00 (2.83)^{ab}	12.45 (3.67)^{ab}	12.77 (3.71)^{a}	13.99 (3.87)^{b}	15.21 (4.03)^{ab}	16.52 (4.19)^{ab}	16.74 (4.21)^{ab}	9.03 (3.17)^{bcd}
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	-	0.30 (1.14)^{ab}	2.45 (1.86)^{ab}	7.32 (2.88)^{b}	7.77 (2.96)^{ab}	10.10 (3.33)^{b}	13.90 (3.86)^{a}	14.68 (3.96)^{ab}	15.49 (4.06)^{b}	16.16 (4.14)^{ab}	16.74 (4.21)^{ab}	9.50 (3.24)^{b}
Quinalphos 0.05 per cent	-	0.00 (1.00)^{a}	0.30 (1.39)^{a}	2.63 (1.90)^{a}	4.20 (2.28)^{a}	6.00 (2.65)^{a}	7.23 (2.87)^{a}	9.67 (3.27)^{ab}	10.06 (3.33)^{a}	11.04 (3.47)^{a}	11.04 (3.51)^{a}	5.46 (2.54)^{a}
Control	0.48 (1.21)	3.83 (2.20)	8.66 (3.11)	19.07 (4.48)	21.94 (4.79)	23.91 (4.99)	33.36 (5.86)	35.00 (6.00)	35.20 (6.02)	37.31 (6.19)	37.31 (6.19)	20.52 (4.64)

CD-treatments at 5% : 0.767*, CD-Mean at 5% : 0.243*, CD-intervals at 5% : 0.243*

Figures in parentheses denote $\sqrt{x+1}$ transformed values. HAS-Hours after spraying, WAS - Weeks after spraying, *Significant at 5 per cent level

At three weeks after application of insecticide treatments the highest intensity of damage was in control. Quinalphos 0.05 per cent showed maximum damage with a mean value of 4.20 and was on par with neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent.

The treatment quinalphos 0.05 per cent was found to be significantly superior from all the treatment at four weeks after spraying of insecticides. Control vines showed maximum intensity of damage of 23.91 per cent. The treatments, neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, karanja oil 2.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent were statistically on par with quinalphos 0.05 per cent.

Five weeks after giving different treatments, it was found that maximum intensity of damage 33.35 was seen in control followed by 19.23 in clerodendron leaf and flower extract 8.00 per cent. Quinalphos 0.05 per cent was significantly superior to all the treatments. The treatments, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, karanja oil 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, azadirachtin 0.004 per cent and azadirachtin 0.003 per cent were statistically on par.

Six weeks after the application of treatments, the same trend was observed. Quinalphos 0.05 per cent was followed by azadirachtin 0.003 per cent + karanja oil 1.00 per cent which were on par. After seventh week, quinalphos 0.05 per cent was on par with neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00

per cent, azadirachtin 0.004 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent. At eighth and ninth week, quinalphos 0.05 per cent was on par with azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent.

Analysis of the average intensity of damage based on all the observations revealed that quinalphos 0.05 per cent was significantly different from all treatments and found to be the superior treatment with mean value of 5.46. Among the botanical pesticides, neem seed oil soap emulsion 2.00per cent + 2.00 per cent garlic + karanja oil 1.0 per cent showed low intensity of damage of 9.03 followed by neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic and azadirachtin 0.03 per cent + karanja oil 1.0 per cent. Treatments, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and neem seed oil 2.00 per cent + garlic 2.00 per cent were on par.

4.2.4 Mean Percentage of Spikes Damaged by Pollu Beetle at Different Intervals after Application of Treatments

4.2.4.1 At Spike Emergence Stage

The mean percentage of spikes damaged by pollu beetle at different intervals after application of treatments at spike emergence is given in Table 13.

Twenty four hours after application of treatments, no damage was observed in the sprayed vines except in control (2.71).

Table 13. Percentage of spikes damaged by pollu beetle at different intervals after application of treatments at spike emergence stage

Treatments	24HAS	72HAS	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	-	0.71 (1.31)^{ab}	1.62 (1.62)^{ab}	5.85 (2.62)^{ab}	14.95 (3.99)^{b}	14.95 (3.99)^{b}	18.87 (4.46)^{b}	19.81 (4.56)^{b}	9.37 (3.22)^{bcd}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	-	0.00 (1.00)^{ab}	3.49 (2.12)^{b}	8.68 (3.11)^{b}	14.83 (3.98)^{b}	15.88 (4.11)^{b}	18.96 (4.47)^{b}	19.90 (4.57)^{b}	10.14 (3.34)^{cd}
Azadirachtin 0.004 per cent	-	2.27 (1.81)^{b}	3.49 (2.12)^{b}	6.67 (2.77)^{ab}	13.18 (3.77)^{b}	14.66 (3.96)^{b}	18.87 (4.46)^{b}	19.90 (4.57)^{b}	10.22 (3.35)^{cd}
Azadirachtin 0.003 per cent	-	2.71 (1.93)^{b}	3.49 (2.12)^{ab}	7.53 (2.92)^{b}	14.66 (3.96)^{b}	16.96 (4.24)^{b}	19.81 (4.56)^{b}	20.87 (4.68)^{b}	11.15 (3.49)^{d}
Clerodendron leaf and flower extract 8.00 per cent	-	2.27 (1.81)^{b}	4.89 (2.43)	11.84 (3.58)	18.74 (4.44)	18.74 (4.44)	21.96 (4.79)	21.96 (4.79)	13.10 (3.76)
Karanja oil emulsion 2.00 per cent	-	0.71 (1.31)^{ab}	2.27 (1.81)^{ab}	6.67 (2.77)^{ab}	13.18 (3.77)^{b}	15.50 (4.06)^{b}	17.86 (4.34)^{b}	18.87 (4.46)^{b}	9.34 (3.22)^{bcd}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	-	0.00 (1.00)^{ab}	1.62 (1.62)^{ab}	6.67 (2.77)^{ab}	9.51 (3.24)^{ab}	12.79 (3.71)^{ab}	17.95 (4.35)^{ab}	17.95 (4.35)^{ab}	8.04 (3.01)^{b}
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	-	0.71 (1.31)^{ab}	2.71 (1.93)^{ab}	10.78 (3.43)	10.78 (3.43)^{ab}	12.95 (3.73)^{ab}	15.88 (4.11)^{ab}	15.88 (4.11)^{ab}	8.92 (3.15)^{bc}
Quinalphos 0.05 per cent	-	0.00 (1.00)^{a}	0.71 (1.31)^{a}	3.49 (2.12)^{a}	7.76 (2.96)^{a}	9.91 (3.30)^{a}	12.95 (3.73)^{a}	13.93 (3.86)^{a}	5.83 (2.61)^{a}
Control	2.71 (1.93)	9.65 (3.26)	11.84 (3.58)	16.00 (4.12)	21.78 (4.77)	22.89 (4.89)	24.89 (5.09)	27.93 (5.38)	16.03 (4.13)

CD-treatments at 5 % : 0.782*, CD-Mean at 5% : 0.295*, CD-intervals at 5% : 0.247*

Figures in parentheses denote $\sqrt{x+1}$ transformed values. HAS-Hours after spraying WAS Weeks after spraying, *Significant at 5 per cent level

Observations taken seventy two hours after treatment application indicated maximum damage in control (9.65) and no damage in quinalphos 0.05 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent. The treatments, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, karanja oil 2.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, clerodendron leaf and flower extract 8.00 per cent, azadirachtin 0.004 per cent and azadirachtin 0.003 per cent were statistically on par.

The mean values ranged from 0.71 in quinalphos 0.05 per cent to 11.84 in control at one week after application of insecticides. Quinalphos 0.05 per cent was followed by neem seed oil 3.00 per cent + garlic 2.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent with mean spike damage of 1.62. The treatments, neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, karanja oil 2.00 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent were statistically on par with quinalphos 0.05 per cent.

Maximum damage of spikes was seen in control vines followed by treatment clerodendron leaf and flower extract 8.00 per cent, two weeks after spraying insecticide. Minimum spike damage was observed in quinalphos 0.05 per cent with a mean value of 3.49. Quinalphos 0.05 per cent was followed by neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, karanja oil 2.00 per cent and azadirachtin 0.004 per cent which were statistically on par.

Three weeks after giving different insecticidal treatments, it was observed that quinalphos 0.05 per cent treated vines recorded minimum

spike damage of 7.76 followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent which were on statistically on par. The maximum percent spike damage was recorded in control (21.78).

Observations at four, five and six weeks after spray revealed the same trend of maximum spike damage in control and minimum in quinalphos 0.05 per cent. The treatments, quinalphos 0.05 per cent was followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, karanja oil 2.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent and there were statistically on par.

The mean of all the observations indicated that spike damage by pollu beetle was minimum in quinalphos 0.05 per cent (5.83) and maximum in control (16.03). Among the different botanicals tested, neem oil soap emulsion 2.00 per cent + 2.00 per cent garlic + karanj oil 1.00 per cent was the best with least value of 8.04 followed by azadirachtin 0.003 per cent + karanja oil 1.00 per cent, karanja oil 2.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent. The treatments neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, azadirachtin 0.004 per cent and azadirachtin 0.003 per cent were on par with mean spike damage of 10.14, 10.22, 11.15 respectively.

4.2.4.2 At Berry formation Stage

Mean percentage of spikes damaged by pollu beetle at different intervals after application of treatments at berry formation stage is given in Table 14.

Twenty four hour after application of insecticides, there was no damage on spikes on any of the treatment vines.

Table 14. Percentage of spikes damaged by pol u beetle at different intervals after application of treatments at berry formation stage

Treatment	24 HAS	72 HAS	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	-	(0.00 (1.00)^{a}	1.62 (1.62)^{ab}	1.62 (1.62)^{ab}	3.49 (2.12)^{ab}	3.49 (2.12)^{a}	5.85 (2.62)^{ab}	8.68 (3.12)^{ab}	8.68 (3.11)^{ab}	9.65 (3.26)^{ab}	9.65 (3.26)^{ab}	4.68 (2.38)^{b}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	-	(0.00 1.00)^{ab}	1.62 (1.62)^{ab}	1.62 (1.62)^{ab}	3.49 (2.12)^{ab}	3.49 (2.12)^{a}	6.67 (2.77)^{ab}	10.93 (3.45)^{ab}	10.93 (3.45)^{ab}	10.93 (3.45)^{ab}	10.93 (3.45)^{ab}	5.28 (2.51)^{bc}
Azadirachtin 0.004 per cent	-	(1.62 1.62)^{ab}	3.49 (2.12)^{b}	2.27 (1.81)^{b}	6.89 (2.81)^{b}	6.89 (2.81)^{b}	8.93 (3.15)^{b}	11.68 (3.56)^{b}	11.68 (3.56)^{b}	11.68 (3.56)^{b}	11.68 (3.56)^{b}	7.16 (2.86)^{de}
Azadirachtin 0.003 per cent	-	(1.62 1.62)^{ab}	3.49 (2.12)^{b}	4.33 (2.31)^{b}	5.85 (2.62)^{ab}	6.89 (2.81)^{b}	8.68 (3.11)^{b}	11.84 (3.58)^{b}	12.79 (3.71)^{b}	13.93 (3.86)^{b}	14.95 (3.99)^{b}	7.84 (2.97)^{c}
Clerodendron leaf and flower extract 8.00 per cent	-	(2.27 1.81)^{b}	8.93 (3.15)	9.76 (3.28)	10.78 (3.43)	11.84 (3.58)	13.93 (3.86)	17.95 (4.35)	17.95 (4.35)	18.96 (4.47)	18.96 (4.47)	12.51 (3.68)^{c}
Karanja oil emulsion 2.00 per cent	-	(1.62 1.62)^{ab}	3.00 (2.00)^{b}	6.89 (2.81)^{b}	6.89 (2.81)^{b}	7.76 (2.96)^{b}	8.68 (3.11)^{b}	13.93 (3.86)^{b}	13.93 (3.86)^{b}	13.93 (3.86)^{b}	14.95 (3.99)^{b}	8.54 (3.09)^{c}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	-	(0.71 (1.31)^{ab}	1.62 (1.62)^{ab}	3.00 (2.00)^{ab}	5.85 (2.62)^{ab}	5.85 (2.62)^{ab}	7.53 (2.92)^{b}	11.84 (3.58)^{b}	11.84 (3.58)^{b}	12.95 (3.73)^{b}	12.95 (3.73)^{b}	6.68 (2.77)^{d}
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	-	0.71 (1.31)^{ab}	2.27 (1.81)^{b}	3.00 (2.00)^{ab}	3.00 (2.00)^{ab}	4.33 (2.31)^{b}	6.03 (2.65)^{ab}	11.84 (3.58)^{ab}	11.84 (3.58)^{ab}	11.84 (3.58)^{ab}	12.95 (3.73)^{ab}	6.05 (2.66)^{cd}
Quinalphos 0.05 per cent	-	0.00 (1.00)^{a}	0.00 (1.00)^{a}	0.71 (1.31)^{a}	2.27 (1.81)^{a}	3.49 (2.12)^{a}	3.49 (2.12)^{a}	5.85 (2.62)^{a}	6.89 (2.81)^{a}	6.89 (2.81)^{a}	6.89 (2.81)^{a}	3.16 (2.04)^{a}
Control	-	4.89 (2.43)	9.91 (3.30)	11.84 (3.58)	15.88 (4.11)	16.63 (4.20)	17.82 (4.34)	21.96 (4.79)	21.96 (4.79)	21.96 (4.99)	23.92 (5.09)	16.32 (4.16)

CD-treatments at 5% : 0.795*, CD-Mean at 5%: 0.252* CD-intervals at 5% : 0.252*

Figures in parentheses denote $\sqrt{X+1}$ transformed values, HAS-Hours after spraying, WAS - Weeks after spraying, *Significant at 5 per cent level

Seventy two hours after application of treatments, the maximum damage was observed in control vines (4.89). Quinalphos 0.05 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent recorded no damage on spikes.

The percentage of spikes damaged ranged from 0.00 in quinalphos 0.05 per cent to 9.90 in control one week after application of treatments. The neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent had a mean value of 1.62 per cent and the treatments were on par with quinalphos 0.05 per cent.

The highest damage on spikes was recorded on control vines (11.84) and least in quinalphos 0.05 per cent (0.71) at two weeks after application of treatment sprays. Among the botanicals, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent (1.62) were followed by azadirachtin 0.003 per cent + karanja oil 1.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent (3.00).

Three weeks after insecticide application, control recorded maximum damage of 15.88 and quinalphos 0.05 per cent (2.27), the minimum. Quinalphos 0.05 per cent was followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and azadirachtin 0.003 per cent, with mean values of 3.49, 3.49, 5.85 and 5.85 respectively and were statistically on par.

The same trend was observed four weeks after treatment application. Quinalphos 0.05 per cent, neem seed oil soap emulsion 2.00 per cent +

garlic 2.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent were found to be on par. Azadirachtin 0.003 per cent, azadirachtin 0.004 per cent, karanja oil 2.00 per cent and clerodendron leaf and flower extract 8.00 per cent were also statistically on par.

At the fifth, sixth, seventh, eighth and ninth week after application of insecticides also, control recorded the maximum and quinalphos 0.05 per cent the minimum spike damage. The treatments, quinalphos 0.05 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent were statistically on par among themselves.

The mean values of all the observations on spike damage by pollu beetle at berry maturation revealed maximum spike damage in control (16.32) and minimum in quinalphos 0.05 per cent with 3.16 per cent damage. The second best treatment was neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic (4.68 per cent) followed by neem seed oil soap emulsion per cent + 2.00 per cent garlic (5.28 per cent) and were on par. The treatments, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and azadirachtin 0.004 per cent were on par.

4.2.4.3 At Berry maturation Stage

Table 15 gives the mean percentage of spikes damaged by pollu beetle at different intervals after application of treatments at berry maturation stage.

Twenty four hours after application of treatments, there was no damage in any of the treatment vines including control.

Table 15. Percentage of spikes damaged by pollu beetle at different intervals after application of treatments at berry maturation stage

Treatment	24 HAS	72 HAS	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	-	0.00 (1.00)^{a}	0.71 (1.31)^{ab}	4.89 (2.43)^{ab}	4.89 (2.43)^{ab}	9.91 (3.30)^{ab}	9.91 (3.30)^{ab}	10.78 (3.43)^{ab}	17.95 (4.35)	24.89 (5.09)	8.04 (3.01)^{ab}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	-	0.71 (1.31)^{ab}	1.62 (1.62)^{ab}	5.85 (2.62)^{b}	5.85 (2.62)^{ab}	9.91 (3.30)^{ab}	10.78 (3.43)^{ab}	11.84 (3.58)^{ab}	18.87 (4.46)	25.81 (5.18)	9.05 (3.17)^{bc}
Azadirachtin 0.004 per cent	-	0.71 (1.31)^{ab}	3.49 (2.12)^{b}	5.85 (2.62)^{b}	5.85 (2.62)^{ab}	9.91 (3.30)^{ab}	10.78 (3.43)^{ab}	12.79 (3.71)^{ab}	20.87 (4.68)	27.93 (5.38)	9.81 (3.29)^{cd}
Azadirachtin 0.003 per cent	-	0.71 (1.31)^{ab}	3.49 (2.12)^{b}	5.85 (2.62)^{b}	5.85 (2.62)^{ab}	11.68 (3.56)^{ab}	12.79 (3.71)^{ab}	14.66 (3.96)^{ab}	21.96 (4.79)	28.98 (5.48)	10.64 (3.41)
Clerodendron leaf and flower extract 8.00 per cent	-	2.27 (1.81)^{b}	5.85 (2.62)	8.68 (3.11)	8.68 (3.11)^{b}	12.95 (3.73)^{b}	13.93 (3.86)^{b}	14.95 (3.99)^{b}	24.89 (5.09)	30.84 (5.64)	12.67 (3.70)
Karanja oil emulsion 2.00 per cent	-	1.62 (1.62)^{ab}	4.89 (2.43)	5.85 (2.62)^{b}	5.85 (2.62)^{ab}	10.78 (3.43)^{ab}	11.84 (3.58)^{ab}	12.95 (3.73)^{ab}	21.78 (4.77)	27.93 (5.38)	10.51 (3.39)^{cd}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	-	0.71 (1.31)^{ab}	1.62 (1.62)^{ab}	5.85 (2.62)^{ab}	5.85 (2.62)^{ab}	8.93 (3.15)^{ab}	11.68 (3.56)^{ab}	13.93 (3.86)^{ab}	19.90 (4.57)	27.93 (5.38)	9.60 (3.26)^{cd}
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	-	1.62 (1.62)^{ab}	2.71 (1.93)^{b}	4.00 (2.24)^{b}	4.00 (2.24)^{ab}	9.91 (3.30)^{ab}	13.93 (3.86)^{ab}	13.93 (3.86)^{ab}	21.40 (4.73)	28.98 (5.48)	9.97 (3.31)^{c}
Quinalphos 0.05 per cent	-	0.00 (1.00)^{a}	0.71 (1.31)^{a}	2.71 (1.93)^{a}	4.00 (2.24)^{a}	8.00 (3.00)^{a}	10.78 (3.43)^{a}	12.95 (3.73)^{a}	17.95 (4.35)	25.96 (5.19)	7.95 (2.99)^{a}
Control	-	1.89 (2.43)	9.91 (3.30)	9.91 (3.30)	9.91 (3.30)	13.93 (3.86)	14.95 (3.99)	18.96 (4.47)	25.84 (4.98)	30.92 (5.65)	14.81 (3.98)
CD-treatments at 5% : 0.645*, CD-Mean at 5% : 0.204*, CD-intervals at 5% : 0.204*									NS	NS	

Figures in parentheses denote $\sqrt{x+1}$ transformed values HAS-Hours after spraying, WAS Weeks after spraying, *Significant at 5 per cent level
NS Non significant

Seventy two hours of insecticidal application, there was no damage on spikes of vines receiving neem seed oil 3.00 per cent + garlic 2.00 per cent and quinalphos 0.05 per cent. Control recorded maximum damage of 4.89. Treatments quinalphos 0.05 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, T_3, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and karanja oil 2.00 per cent were statistically on par.

The percentage of spike damage ranged from 0.71 in quinalphos 0.05 per cent to 9.91 in control, when observations were taken one week after application of insecticides. The treatments, quinalphos 0.05 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent were on par.

Observations taken two weeks after application of different treatments revealed minimum damage in quinalphos 0.05 per cent (2.71) followed by azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, karanja oil 2.00 per cent, azadirachtin 0.003 per cent, azadirachtin 0.004 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent. These treatments were statistically on par.

Three weeks after application of treatments, the control vines showed the maximum spike damage of 9.91 and minimum was in quinalphos 0.05 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent with mean percentage damage of 4.00. It was followed by neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent,

karanja oil 2.00 per cent, azadirachtin 0.003 per cent, azadirachtin 0.004 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and were statistically on par.

Four weeks after application of insecticides, the minimum spike damage of 8.00 per cent was in quinalphos 0.05 per cent whereas control recorded the maximum spike damage of 13.93 per cent. Quinalphos 0.05 per cent was followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, azadirachtin 0.004 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, karanja oil 2.00 per cent and azadirachtin 0.003 per cent and was found to be on par.

Observations taken at fifth, sixth, seventh and eighth week after insecticide application showed the same trend in maximum and minimum damage. There was no significant difference between any of the treatments except control till the eighth week. During ninth week, all the treatments were on par including control.

The overall percentage of spike damage based on all observations at berry formation stage was the maximum damage in control (14.81) and the least in quinalphos 0.05 per cent (7.95). Quinalphos 0.05 per cent was followed by neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and azadirachtin 0.004 per cent with a mean values of 8.04, 9.05, 9.60 an 9.81 respectively. Quinalphos 0.05 per cent was on par with neem seed oil 3.00 per cent + garlic 2.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent. Among the botanicals, clerodendron leaf and flower extract 8.00 per cent recorded highest spike damage of 12.67 per cent.

4.2.5 Mean Percentage of Berries Damaged by Pollu Beetle at Different Intervals after Application of Treatments

4.2.5.1 At Berry Formation Stage

The mean percentage of berries damaged by pollu beetle at different intervals after application of treatments at berry formation stage are given in Table 16.

Twenty four hours after application of treatments, no damage was observed in any of the treated as well as in control vines.

Seventy two hours after treatment application, maximum damage was seen in control (0.27) and no damage was observed in quinalphos 0.05 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent. It was followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.004 per cent azadirachtin 0.003 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent. There was no significant difference between any of the treatments.

One week after insecticide application revealed that control vines recorded the maximum berry damage of 1.25 and no damage was seen in quinalphos 0.05 per cent treated vines. The treatments, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, azadirachtin 0.003 per cent and azadirachtin 0.004 per cent were found statistically on par with quinalphos 0.05 per cent.

Table 16. Percentage of berries damaged by pollu beetle at different intervals after application of treatments at berry formation stage

Treatment	24 HAS	72 HAS	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	-	0.00 (1.00)^{a}	0.12 (1.06)^{ab}	0.17 (1.08)^{a}	0.30 (1.14)^{ab}	0.39 (1.18)^{ab}	0.60 (1.26)^{ab}	0.77 (1.33)^{ab}	1.26 (1.50)^{ab}	1.26 (1.50)^{ab}	1.40 (1.55)^{ab}	0.59 (1.26)^{ab}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	-	0.05 (1.02)^{a}	0.02 (1.01)^{ab}	0.07 (1.04)^{a}	0.32 (1.15)^{ab}	1.84 (1.19)^{b}	0.70 (1.30)^{b}	0.84 (1.36)^{b}	1.38 (1.54)^{b}	1.43 (1.56)^{b}	1.58 (1.61)^{b}	0.63 (1.28)^{bc}
Azadirachtin 0.004 per cent	-	0.07 (1.04)^{a}	0.19 (1.09)^{ab}	0.47 (1.21)^{a}	0.59 (1.26)^{ab}	0.65 (1.28)^{ab}	0.80 (1.34)^{ab}	1.20 (1.48)^{ab}	1.67 (1.63)^{ab}	1.75 (1.66)^{ab}	1.84 (1.69)^{ab}	0.87 (1.37)
Azadirachtin 0.003 per cent	-	0.10 (1.05)^{a}	0.20 (1.10)^{ab}	0.34 (1.16)^{a}	0.86 (1.36)^{ab}	0.86 (1.36)^{b}	0.95 (1.40)^{b}	1.12 (1.46)^{b}	1.44 (1.56)^{b}	1.67 (1.63)^{b}	1.84 (1.69)^{b}	0.89 (1.38)
Clerodendron leaf and flower extract 8.00 per cent	-	0.30 (1.14)^{a}	0.37 (1.17)^{b}	0.47 (1.21)^{a}	0.50 (1.23)^{b}	1.10 (1.45)^{b}	1.39 (1.55)^{b}	2.10 (1.76)^{b}	2.35 (1.83)^{b}	2.47 (1.86)^{b}	2.52 (1.88)^{b}	1.27 (1.51)
Karanja oil emulsion 2.00 per cent	-	0.17 (1.08)^{a}	0.30 (1.14)^{ab}	0.32 (1.15)^{a}	0.90 (1.38)^{ab}	0.67 (1.29)^{b}	1.03 (1.42)^{b}	1.67 (1.63)^{b}	1.97 (1.72)^{ab}	2.02 (1.74)^{ab}	2.02 (1.74)^{ab}	1.04 (1.43)
Neem seed oil soap emulsion 2.00 per cent – 2.00 per cent garlic – 1.00 per cent karanja oil	-	0.05 (1.02)^{a}	0.07 (1.04)^{ab}	0.27 (1.13)^{a}	0.49 (1.22)^{ab}	0.40 (1.18)^{ab}	0.57 (1.25)^{ab}	0.92 (1.39)^{ab}	1.29 (1.51)^{ab}	1.41 (1.55)^{ab}	1.74 (1.65)^{ab}	0.68 (1.30)^{b}
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	-	0.10 (1.05)^{a}	0.17 (1.08)^{ab}	0.21 (1.10)^{a}	0.37 (1.17)^{ab}	0.65 (1.28)^{ab}	0.85 (1.36)^{ab}	1.17 (1.47)^{ab}	1.27 (1.51)^{ab}	1.47 (1.57)^{ab}	1.57 (1.60)^{ab}	0.74 (1.32)^{c}
Quinalphos 0.05 per cent	-	0.00 (1.00)^{a}	0.00 (1.00)^{a}	0.07 (1.04)^{a}	0.17 (1.08)^{a}	0.17 (1.08)^{a}	0.41 (1.19)^{a}	0.69 (1.30)^{a}	1.02 (1.42)^{a}	1.14 (1.46)^{a}	1.22 (1.49)^{a}	0.46 (1.21)^{a}
Control	-	0.27 (1.13)^{a}	1.25 (1.50)^{b}	1.34 (1.53)	1.74 (1.66)	2.41 (1.85)	3.07 (2.02)	3.71 (2.17)	4.10 (2.26)	4.73 (2.39)	5.06 (2.46)	2.59 (1.90)

CD-treatments at 5% : 0.134*, CD-Mean at 5% : 0.042*, CD-intervals at 5% : 0.042*

Figures in parentheses denote $\sqrt{x+1}$ transformed values. HAS- Hours after spraying, WAS – Weeks after spraying, *Significant at 5 per cent level

The percentage damage ranged from 0.07 in quinalphos 0.05 per cent to1.34 in control and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent at two weeks after insecticide spray. Neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, karanja oil 2.00 per cent and azadirachtin 0.003 per cent were on par with neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and quinalphos 0.05 per cent.

The highest berry damage by pollu beetle was recorded in control (1.74) and least in quinalphos 0.05 per cent (0.17) at three weeks after treatment application. Quinalphos 0.05 per cent was followed by neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, and azadirachtin 0.003 per cent + karanja oil 1.00 per cent and were statistically on par.

At four weeks after treatment spray, the maximum berry damage was observed in control and minimum in quinalphos 0.05 per cent. Among the common plant products tested, neem seed oil 3.00 per cent + garlic 2.00 per cent was the best with mean of 0.39 followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.004 per cent with mean berry damage of 0.40 and 0.65 respectively.

Five, six, seven, eight and nine weeks after insecticide application, control vines recorded maximum damage and quinalphos 0.05 per cent the minimum. Quinalphos 0.05 per cent was followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent and they all were on par with one another.

The mean of all the observations taken after application of treatments at berry formation stage indicated highest mean berry damage of 2.59 in control vines and least damage in quinalphos 0.05 per cent treated vines. The treatments, neem seed oil soap emulsion 3.00 per cent + garlic 2.00 percent was found to be superior among botanicals with mean damage of 0.59 followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent (0.63). Treatments, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.004 per cent and azadirachtin 0.003 per cent recorded mean berry damage of 0.68, 0.87 and 0.89 respectively.

4.2.5.2 At Berry Maturation Stage

Mean percentage of berries damaged by pollu beetle at different intervals after application of different treatments at berry formation stage is given in Table 17.

Twenty four hours after spray, pollu beetle damage was not observed on the berries of the treatment and control vines.

Seventy two hours after application of treatments, the damage percentage ranged from 0.00 in quinalphos 0.05 per cent to 0.27 in control. All the treatments were statistically on par.

Observations taken one week after treatment application revealed that the maximum damage to berries was seen in control (0.46) and minimum in quinalphos 0.05 per cent (0.05). Quinalphos 0.05 per cent was followed by neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, azadirachtin 0.004 per cent and karanja oil 2.00 per cent and they were statistically on par.

Table 17. Percentage of berries damaged by pollu beetle at different intervals after application of treatments at berry maturation stage

Treatment	24 HAS	72 HAS	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	-	0.00 (1.00)^{a}	0.05 (1.02)^{ab}	0.19 (1.09)^{ab}	0.32 (1.15)^{ab}	0.55 (1.24)^{ab}	0.55 (1.24)^{a}	0.80 (1.34)^{a}	1.59 (1.61)^{a}	1.70 (1.64)^{a}	2.12 (1.77)^{a}	0.72 (1.31)^{a}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	-	0.05 (1.02)^{a}	0.14 (1.07)^{ab}	0.19 (1.09)^{ab}	0.33 (1.55)^{ab}	0.40 (1.18)^{ab}	0.70 (1.30)^{ab}	1.02 (1.42)^{ab}	1.21 (1.49)^{ab}	1.67 (1.64)^{ab}	2.20 (1.79)^{ab}	0.73 (1.32)^{a}
Azadirachtin 0.004 per cent	-	0.08 (1.02)^{a}	0.24 (1.12)^{ab}	0.39 (1.18)^{ab}	0.55 (1.24)^{ab}	0.62 (1.27)^{ab}	0.72 (1.31)^{ab}	1.10 (1.45)^{ab}	1.69 (1.64)^{ab}	1.97 (1.72)^{ab}	2.21 (1.82)^{ab}	0.90 (1.38)^{b}
Azadirachtin 0.003 per cent	-	0.08 (1.04)^{a}	0.20 (1.10)^{ab}	0.25 (1.12)^{ab}	0.52 (1.23)^{ab}	0.77 (1.33)^{b}	0.92 (1.39)^{ab}	1.12 (1.46)^{ab}	1.72 (1.65)^{ab}	1.96 (1.72)^{ab}	2.44 (1.85)^{ab}	0.93 (1.39)^{b}
Clerodendron leaf and flower extract 8.00 per cent	-	0.14 (1.07)^{a}	0.40 (1.18)^{b}	0.50 (1.22)^{b}	0.65 (1.28)^{b}	1.12 (1.46)^{b}	1.54 (1.59)^{b}	1.94 (1.72)^{b}	2.45 (1.80)^{b}	2.47 (1.86)^{b}	2.89 (1.97)^{b}	1.30 (1.52)
Karanja oil emulsion 2.00 per cent	-	0.09 (1.65)^{a}	0.32 (1.15)^{ab}	0.42 (1.92)^{ab}	0.52 (1.23)^{b}	0.77 (1.33)^{b}	1.12 (1.46)^{b}	1.64 (1.62)^{b}	1.94 (1.72)^{b}	2.17 (1.78)^{b}	2.86 (1.97)^{b}	1.10 (1.45)
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	-	0.48 (1.02)^{a}	0.14 (1.07)^{ab}	0.19 (1.09)^{ab}	0.32 (1.45)^{b}	0.62 (1.27)^{ab}	0.74 (1.32)^{a}	1.23 (1.46)^{ab}	1.25 (1.50)^{a}	1.42 (1.56)^{a}	2.02 (1.74)^{a}	0.74 (1.32)^{a}
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	-	0.05 (1.02)^{a}	0.20 (1.09)^{ab}	0.24 (1.12)^{ab}	0.35 (1.16)^{ab}	0.62 (1.27)^{b}	1.12 (1.46)^{b}	1.48 (1.58)^{b}	1.55 (1.60)^{b}	2.09 (1.76)^{b}	2.16 (1.78)^{b}	0.91 (1.38)^{b}
Quinalphos 0.05 per cent	-	0.00 (1.00)^{a}	0.05 (1.02)^{ab}	0.14 (1.07)^{ab}	0.30 (1.14)^{a}	0.42 (1.19)^{a}	0.57 (1.25)^{a}	1.00^{a} (1.41)	1.27 (1.51)^{a}	1.59 (1.61)^{a}	2.70 (1.76)^{a}	1.68 (1.29)^{a}
Control	-	0.27 (1.28)^{a}	0.46 (1.21)^{a}	1.63 (1.42)	1.07 (1.44)	2.28 (1.81)	3.07 (2.02)	3.61 (2.15)	4.70 (2.39)	5.43 (2.54)	6.23 (2.69)	2.53 (1.88)

CD-treatments at 5% : 0.142*, CD-Mean at 5% : 0.045*, CD-intervals at 5% : 0.045*

Figures in parentheses denote $\sqrt{x+1}$ transformed values. WAS - Weeks after spraying. *Significant at 5 per cent level

The maximum berry damage by pollu beetle was recorded in control (1.03) and minimum in quinalphos 0.05 per cent (0.14) two weeks after treatment application. Quinalphos 0.05 per cent was followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, azadirachtin 0.003 per cent, azadirachtin 0.004 per cent and karanja oil 2.00 per cent and were on par.

The percentage of berries infested by pollu beetle ranged from 0.30 in quinalphos 0.05 per cent to 1.07 in control at three weeks after insecticide application. There was no significant difference between damage in the treatment vines except clerodendron leaf and flower extract 8.00 per cent and control.

At four weeks after insecticide application, the highest damage of 2.28 per cent was in control vines and least damage of 0.40 in neem oil 2.00 per cent + garlic 2.00 per cent treated vines. Neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent was followed by quinalphos 0.05 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent. azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and azadirachtin 0.004 per cent and were found statistically on par.

During fifth and sixth weeks after insecticide application, control vines exhibited maximum berry damage and neem seed oil soap emulsion 3.00 per cent + 2 .00 per cent garlic, the minimum damage of 0.55 and 0.85 respectively. Neem seed oil 3.00 per cent + garlic 2.00 per cent was followed by quinalphos 0.05 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, azadirachtin 0.004 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and they were on par.

Seven, eight and nine weeks after treatment application, control recorded maximum damage and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent recorded the minimum damage. neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent was followed by quinalphos 0.05 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent and azadirachtin 0.004 per cent.

The mean of all the observations taken during the berry formation period on the berry damage by pollu beetle was worked out. The highest damage was seen in the control vines with a mean of 2.53 and least in quinalphos 0.05 per cent treated vines. Among the botanicals, neem seed oil soap emulsion 3 per cent + 2.00 per cent garlic was the best (0.72) followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent with mean damage of 0.73 and 0.74 respectively. The treatments, quinalphos 0.05 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent were on par. Also treatments azadirachtin 0.004 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and azadirachtin 0.003 per cent were on par.

4.2.6 Percentage of Leaves Damaged by Leaf Gall Thrips at Different Intervals after Application of Treatments

4.2.6.1 At Spike Emergence Stage

Twenty four hours after spray application, no damage was seen in any of the treatments, Table 18.

At seventy two hours, the mean percentage of leaves damaged in control was 6.66 and there was no damage in vines receiving neem seed

Table 18. Percentage of leaves damaged by leaf gall thrips at different intervals after application of treatments at spike emergence stage

Treatments	24 HAS	72 HAS	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	-	0.00 (1.00)^{a}	1.08 (1.44)^{ab}	1.08 (1.44)^{ab}	2.55 (1.88)^{ab}	2.55 (1.88)^{a}	4.41 (2.33)^{a}	8.13 (3.02)^{a}	2.45 (1.86)^{ab}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	-	0.00 (1.00)^{a}	2.55 (1.88)^{ab}	2.55 (1.88)^{ab}	4.40 (2.33)^{ab}	4.41 (2.33)^{ab}	9.74 (3.28)$^{a-ab}$	9.74 (3.28)$^{a-b}$	4.21 (2.28)^{c}
Azadirachtin 0.004 per cent	-	2.55 (1.88)^{a}	5.66 (2.58)	5.66 (2.58)	8.13 (3.02)	8.13 (3.02)^{ab}	8.13 (3.02)^{ab}	8.13 (3.02)^{ab}	6.47 (2.73)^{c}
Azadirachtin 0.003 per cent	-	1.08 (1.44)^{a}	3.57 (2.14)^{b}	3.57 (2.14)^{b}	5.66 (2.58)^{b}	8.13 (3.02)^{ab}	8.13 (3.02)^{ab}	8.13 (3.02)^{ab}	5.16 (2.48)^{d}
Clerodendron leaf and flower extract 8.00 per cent	-	2.55 (1.88)^{a}	8.54 (3.09)	8.54 (3.09)	11.47 (3.53)	11.47 (3.53)	12.92 (3.73)^{b}	12.92 (3.73)^{b}	9.41 (3.23)
Karanja oil emulsion 2.00 per cent	-	1.08 (1.44)^{a}	3.57 (2.14)^{b}	3.57 (2.14)^{b}	8.13 (3.02)	9.74 (3.28)^{ab}	11.47 (3.53)^{ab}	11.47 (3.53)$^{a-b}$	6.43 (2.73)^{c}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	-	0.00 (1.00)^{a}	0.00 (1.00)^{a}	1.08 (1.44)^{ab}	2.55 (1.88)^{ab}	2.55 (1.88)^{a}	4.41 (2.33)^{a}	6.66 (2.77)^{a}	2.09 (1.76)^{ab}
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	-	0.00 (1.00)^{a}	1.08 (1.44)^{ab}	1.08 (1.44)^{ab}	2.55 (1.88)^{ab}	4.41 (2.33)^{ab}	6.66 (2.77)^{ab}	6.66 (2.77)^{ab}	2.79 (1.95)^{c}
Quinalphos 0.05 per cent	-	0.00 (1.00)^{a}	0.00 (1.00)^{a}	1.08 (1.44)^{a}	1.08 (1.44)^{a}	1.88 (2.88)^{a}	4.41 (2.33)^{a}	4.41 (2.33)^{a}	1.66 (1.63)-a
Control	-	6.66 (2.77)	11.47 (3.53)	11.47 (3.53)	15.51 (4.10)	16.50 (4.08)	21.29 (4.72)	21.29 (4.72)	14.50 (3.94)

CD-treatments at 5% : 1.094*, CD-Mean at 5% : 0.414*, CD-intervals at 5% : 0.346*

Figures in parentheses denote $\sqrt{x+1}$ transformed values. HAS-Hours after spraying , WAS - Weeks after spraying.
*Significant at 5 per cent level

oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and quinalphos 0.05 per cent treatments.

No damage on leaves was observed in quinalphos 0.05 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent one week after application of treatments. Control vines recorded leaf damage of 11.47 per cent. The treatments,quinalphos 0.05 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent. azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent were on par.

Observations taken two weeks after application of insecticides recorded maximum leaf damage of 11.47 in control and no damage in quinalphos 0.05 per cent. Quinalphos 0.05 per cent was followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, karanja oil 2.00 per cent and azadirachtin 0.003 per cent. There was no significant difference between control, clerodendron leaf and flower extract 8.00 per cent and azadirachtin 0.004 per cent.

Maximum damage of 15.51 per cent was seen in the control vines and minimum of 1.08 in quinalphos 0.05 per cent at three weeks after insecticide spray. Treatment quinalphos 0.05 per cent was followed by azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00

per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and were on par. There was no significant difference between control and clerodendron leaf and flower extract 8.00 per cent.

During the fourth fifth and sixth week after application of treatments, quinalphos 0.05 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent recorded the minimum leaf damage by thrips whereas the maximum damage was in the control vines. The treatments, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent, azadirachtin 0.004 per cent and karanja oil 2.00 per cent were statistically on par.

The average leaf damage based on all the observations was the minimum (1.66) in quinalphos 0.05 per cent treated vines and maximum (14.50) in control. Quinalphos 0.05 per cent was followed by neem oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanj oil 1.00 per cent (2.09) and neem oil soap emulsion 3.00 per cent + garlic 2.00 per cent (2.45) and they were on par with quinalphos 0.05 per cent. Azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, azadirachtin 0.003 per cent and karanja oil 2.00 per cent showed mean damage of 2.79, 4.20, 5.16 and 6.43 respectively.

4.2.6.2 At Berry Formation Stage

Twenty four hours after application of treatments, leaf gall thrips damage was not observed in any of the treatment vines.(Table 19).

Seventy two hours after application of treatments, maximum damage of 4.40 was observed in control vines and there was no leaf damage in

Table 19. Percentage of leaves damaged by leaf gall thrips at different intervals after application of treatments at berry formation stage

Treatment	24 HAS	72 HAS	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	-	0.00 (1.00)[a]	0.00 (1.00)[a]	0.00 (1.00)[a]	2.55 (1.88)[a]	4.41 (2.33)[a]	4.41 (2.33)[a]	8.13 (3.62)[a]	11.08 (3.48)[a]	11.08 (3.48)[a]	14.44 (3.93)[a]	4.49 (2.34)[ab]
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	-	0.00 (1.00)[a]	0.00 (1.00)[a]	0.00 (1.00)[a]	2.55 (1.88)[a]	2.55 (1.88)[a]	3.58 (2.14)[a]	9.38 (3.22)[a]	11.08 (3.48)[a]	11.08 (3.48)[a]	14.88 (3.98)[a]	4.32 (2.31)[ab]
Azadirachtin 0.004 per cent	-	1.08 (1.44)[a]	1.08 (1.44)[a]	2.55 (1.88)[a]	2.55 (1.88)[a]	2.55 (1.88)[a]	2.55 (1.88)[a]	5.66 (2.58)[a]	9.74 (3.28)[a]	9.74 (3.28)[a]	17.95 (4.35)[a]	4.72 (2.39)[ab]
Azadirachtin 0.003 per cent	-	1.08 (1.44)[a]	2.55 (1.88)[a]	2.55 (1.88)[a]	2.55 (1.88)[a]	2.55 (1.88)[a]	4.41 (2.33)[a]	4.41 (2.33)[a]	9.74 (3.28)[a]	9.74 (3.28)[a]	19.45 (4.52)[a]	5.10 (2.47)[ab]
Clerodendron leaf and flower extract 8.00 per cent	-	2.55 (1.88)[a]	2.55 (1.88)	3.57 (2.14)	8.13 (3.02)	8.13 (3.02)	8.13 (3.02)[a]	9.74 (3.28)[a]	12.92 (3.73)[a]	14.88 (3.98)[a]	21.58 (4.75)[a]	8.44 (3.07)[b]
Karanja oil emulsion 2.00 per cent	-	1.08 (1.44)[a]	1.08 (1.44)[a]	2.55 (1.88)[a]	3.57 (2.14)[a]	3.57 (2.14)[a]	5.66 (2.58)[a]	7.04 (2.83)[a]	8.54 (3.09)[a]	11.47 (3.53)[a]	19.73 (4.55)[a]	5.57 (2.56)[b]
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	-	0.00 (1.00)[a]	0.00 (1.00)[a]	0.00 (1.00)[a]	1.08 (1.44)[a]	1.08 (1.44)[a]	1.08 (1.44)[a]	3.57 (2.14)[a]	7.04 (2.83)[a]	12.92 (3.73)[a]	16.51 (4.18)[a]	3.07 (2.02)[a]
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	-	0.00 (1.00)[a]	1.08 (1.44)[a]	1.08 (1.44)[a]	1.88 (1.70)[a]	1.88 (1.70)[a]	3.57 (2.14)[a]	5.66 (2.58)[a]	11.08 (3.48)[a]	14.88 (3.98)[a]	19.73 (4.55)[a]	4.76 (2.40)[ab]
Quinalphos 0.05 per cent	-	0.00 (1.00)	0.00 (1.00)[a]	0.00 (1.00)[a]	2.55 (1.88)[a]	2.55 (1.88)[a]	2.55 (1.88)[a]	4.41 (2.33)[a]	5.66 (2.58)[a]	9.74 (3.28)[a]	18.21 (4.38)[a]	3.50 (2.12)[b]
Control	-	4.41 (2.33)	8.13 (3.02)	8.13 (3.02)	11.47 (3.53)	11.47 (3.53)	14.88 (3.98)	16.51 (4.18)	17.95 (4.35)	17.95 (4.35)	23.22 (4.92)	12.86 (3.72)

CD-treatments at 5% : 1.154*, CD Mean at 5% : 0.365*, CD-intervals at 5% : 0.365*

Figures in parentheses denote $\sqrt{x+1}$ transformed values. HAS-Hours after spraying , WAS – Weeks after spraying. *Significant at 5 per cent level

neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and quinalphos 0.05 per cent. Among the botanicals, maximum damage was recorded in Clerodendron leaf and flower extract 8.00 per cent (2.55).

Observations taken one week after treatment application revealed that maximum damage of 8.13 in control vines and damage was not observed in neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and quinalphos 0.05 per cent treated vines. The same trend was observed two weeks after application of treatments.

During the third and fourth week after spray, the maximum leaf damage of 11.47 was observed in the control vines and minimum damage in neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent (1.08) treatments neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, quinalphos 0.05 per cent, azadirachtin 0.003 per cent, azadirachtin 0.004 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent and karanja oil 2.00 per cent were on par among themselves.

During the fifth and sixth weeks after treatment application also, the same trend was observed in maximum and minimum damage. The treatments, quinalphos 0.05 per cent, azadirachtin 0.004 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent, azadirachtin 0.004 per cent, azadirachtin 0.003 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent and karanja oil 2.00 per cent were found statistically on par.

Observation taken during seventh, eighth week recorded maximum damage in control and minimum quinalphos 0.05 per cent. All the treatments were found to be on par except control.

Pooled mean leaf damage by leaf gall thrips at berry formation stage was the maximum in control vines (12.86). Neem oil soap emulsion 2.00 per cent + garlic 2 per cent + karanja 11 per cent had the minimum damage of 3.06. Quinalphos 0.05 per cent (3.50) was the next best treatment. Quinalphos 0.05 per cent was followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent with mean leaf damage values of 4.31 and 4.49 respectively.

4.2.6.3 At Berry Maturation Stage

The results are presented in Table 20.

The observations taken at 24 hours, 72 hours, one week, two weeks, three weeks and four weeks after spraying revealed no damage by the leaf by gall thrips was recorded in the treatment and control vines.

Five weeks after spraying, the maximum damage was observed in control (9.74) and no damage was observed in neem seed oil 3.00 per cent + garlic 2.00 per cent and quinalphos 0.05 per cent followed by neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent with mean percentage leaf damage of 1.08 and 1.88 respectively.

At six weeks after application of treatments, the highest leaf damage was recorded in control (13.33) and minimum in neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and quinalphos 0.05 per cent with a damage of 1.08 followed by azadirachtin 0.003 per cent + karanja oil 1.00 per cent and karanja oil 2.00 per cent.

Table 20. Percentage of leaves damaged by leaf gall thrips at different intervals after application of treatments at berry maturation stage

Treatments	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	-	0.00 (1.00)[a]	1.08 (1.44)[a]	2.55 (1.88)[a]	2.55 (1.88)[a]	4.41 (2.33)[a]	1.91 (1.71)[a]
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	-	2.55 (1.88)[a]	3.57 (2.14)[a]	3.57 (2.14)[a]	5.66 (2.58)[a]	8.13 (3.02)[a]	4.54 (2.35)[ab]
Azadirachtin 0.004 per cent	-	2.55 (1.88)[a]	3.57 (2.14)[a]	3.58 (2.14)[a]	7.04 (2.83)[a]	9.74 (3.28)[a]	5.02 (2.45)[cd]
Azadirachtin 0.003 per cent	-	3.57 (2.14)[a]	3.57 (2.14)[a]	5.66 (2.58)[a]	8.13 (3.02)[a]	9.74 (3.28)[a]	5.92 (2.63)[d]
Clerodendron leaf and flower extract 8.00 per cent	-	3.58 (2.14)[a]	4.73 (2.39)[a]	9.74 (3.28)	9.74 (3.28)[a]	14.88 (3.98)[a]	8.08 (3.01)
Karanja oil emulsion 2.00 per cent	-	2.55 (1.88)[a]	2.55 (1.88)[a]	4.41 (2.33)[a]	5.66 (2.58)[a]	11.47 (3.53)[a]	4.96 (2.44)[abcd]
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	-	1.08 (1.44)[a]	1.08 (1.44)[a]	2.55 (1.88)[a]	4.41 (2.33)[a]	5.66 (2.58)[a]	2.74 (1.94)[abc]
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	-	1.88 (1.70)[a]	1.88 (1.70)[a]	3.57 (2.14)[a]	3.57 (2.14)[a]	5.66 (2.58)[a]	3.20 (2.05)[ab]
Quinalphos 0.05 per cent	-	0.00 (1.00)[a]	1.08 (1.44)[a]	2.55 (1.88)[a]	4.41 (2.33)[a]	6.66 (2.77)[a]	2.55 (1.88)[ab]
Control	-	9.74 (3.28)	13.33 (3.79)	16.51 (4.18)	19.73 (4.55)	23.22 (4.92)	16.17 (4.14)

CD-treatments at 5% : 1.399*, CD-Mean at 5% : 0.625*, CD-intervals at 5% : 0.442*

Figures in parentheses denote $\sqrt{x+1}$ transformed values WAS – Weeks after spraying, *Significant at 5 per cent level

During the seventh, eight and ninth week after treatment application, there was no significant difference between any of the treatments except control.

Based on the observations at berry maturation stage, the pooled mean percentage of leaves damaged by gall thrips was the highest in control vines 16.17. The lowest damage was in neem oil soap emulsion 3.00 per cent + garlic 2.00 per cent with 1.91 per cent leaf damage followed by quinalphos 0.05 per cent and neem oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent (neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent) with mean damage of 2.55 and 2.74 respectively.

4.2.7 Mean Percentage of Spikes Damaged by Scale Insects at Different Intervals after Application of Treatments

4.2.7.1 At Berry Formation Stage

The mean percentage of spikes damaged by scale insects at different intervals after application of treatments at berry formation stage is given in the Table 21.

There was no damage on spikes at 24 hours, 72 hours, one week, two weeks, three and four weeks after application of treatments.

Five weeks after application of treatments, the highest percent damage of 8.37 was observed in control vines and in quinalphos treated vines the least (0.00). This was followed by 0.71 percent damage in neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent.

In the subsequent weeks, there was no significant difference between any of the treatments except control.

Table 21. Percentage of spikes damaged by scale insects at different intervals after application of treatments at berry formation stage

Treatments	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	-	1.25 (1.50)^{a}	1.73 (1.65)^{a}	1.73 (1.65)^{a}	1.73 (1.65)^{a}	2.59 (1.90)^{a}	1.79 (1.67)^{abc}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	-	3.00 (2.00)^{a}	3.63 (2.15)^{a}	3.63 (2.15)^{a}	3.63 (2.15)^{a}	4.92 (2.43)^{a}	3.74 (2.18)^{abc}
Azadirachtin 0.004 per cent	-	1.25 (1.50)^{a}	1.25 (1.50)^{a}	1.25 (1.50)^{a}	1.73 (1.65)^{a}	1.73 (1.65)^{a}	1.44 (1.56)^{cd}
Azadirachtin 0.003 per cent	-	4.20 (2.28)^{a}	6.16 (2.68)^{a}	6.16 (2.68)^{a}	6.16 (2.68)^{a}	6.16 (2.68)^{a}	5.59 (2.60)^{d}
Clerodendron leaf and flower extract 8.00 per cent	-	2.17 (1.78)^{a}	4.74 (2.40)^{a}	6.79 (2.79)^{a}	6.79 (2.79)^{a}	6.79 (2.79)^{a}	5.30 (2.51)^{d}
Karanja oil emulsion 2.00 per cent	-	1.25 (1.50)^{a}	3.00 (2.00)^{a}	5.56 (2.56)^{a}	5.56 (2.56)^{a}	5.56 (2.56)^{a}	5.00 (2.24)^{bcd}
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	-	0.71 (1.31)^{a}	1.25 (1.50)^{a}	2.17 (1.78)^{a}	2.17 (1.78)^{a}	2.17 (1.78)^{a}	1.66 (1.63)^{abc}
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	-	0.71 (1.31)^{a}	1.25 (1.50)^{a}	1.73 (1.65)^{a}	2.17 (1.78)^{a}	2.17 (1.78)^{a}	1.57 (1.60)^{abc}
Quinalphos 0.05 per cent	-	0.00 (1.00)^{a}	1.25 (1.50)^{a}	1.25 (1.50)^{a}	1.73 (1.65)^{a}	1.73 (1.65)^{a}	1.13 (1.46)^{d}
Control	-	8.37 (3.06)	9.83 (3.29)	9.83 (3.29)	9.83 (3.29)	9.83 (3.29)	9.55 (3.25)

CD-treatments at 5% : 1.172*, CD-Mean at 5% : 0.769*, CD-intervals at 5% : 0.543*

Figures in parentheses denote $\sqrt{X+1}$ transformed values. WAS – Weeks after spraying. *Significant at 5 per cent level

The pooled mean percentage of spikes damaged by scale insects from all the observations at berry formation stage was the maximum (9.53) in control and minimum (1.46) in quinalphos 0.05 per cent treated vines. Quinalphos 0.05 per cent was followed by azadirachtin 0.003 per cent + karanja oil 1.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent neem seed oil 3.00 per cent + garlic 2.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and were statistically on par.

4.2.7.2 At Berry Maturation Stage

The results are presented in Table 22.

There was no damage on spikes by scales at 24 hours, 72 hours, one week, two week, three and four week after application of treatments.

Five weeks after application of treatments maximum damage was observed in control with a damage of 5.56 percent and the least 0.00 in quinalphos treated vines followed by neem seed oil 3.00 per cent + garlic 2.00 per cent with mean damage of 0.71. There were no significant difference between any of the treatments with the control.

The pooled mean of all observations of spike damage by scale insects at berry maturation stage was the highest (7.53 per cent) in control and least damage (0.00) in neem oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja 1.00 per cent followed by quinalphos 0.05 per cent treated vines with mean damage of 0.88. All the treatments were on par except control and azadirachtin 0.003 per cent + karanja oil 1.00 per cent.

4.2.8 Percentage of Spikes Damaged by Mealy Bugs at Different Intervals after *Application of Treatments*

4.2.8.1 At Berry Formation Stage

The results are presented in Table 23.

Table 22. Percentage of spikes damaged by scale insects at different intervals after application of treatments at berry maturation stage

Treatments	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	-	0.71 (1.31)	1.25 (1.50)	3.37 (2.09)	3.37 (2.09)	3.37 (2.09)	2.30 (1.82)[a]
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	-	1.25 (1.50)	3.45 (2.11)	2.17 (1.78)	2.17 (1.78)	2.17 (1.78)	2.20 (1.79)[a]
Azadirachtin 0.004 per cent	-	1.25 (1.50)	2.17 (1.78)	2.17 (1.78)	2.17 (1.78)	2.17 (1.78)	1.98 (1.72)[a]
Azadirachtin 0.003 per cent	-	1.25 (1.50)	1.73 (1.65)	2.59 (1.90)	2.59 (1.90)	2.59 (1.90)	2.13 (1.77)[a]
Clerodendron leaf and flower extract 8.00 per cent	-	2.17 (1.78)	2.17 (1.78)	2.17 (1.78)	2.17 (1.78)	2.17 (1.78)	2.17 (1.78)[a]
Karanja oil emulsion 2.00 per cent	-	0.00 (1.00)	1.73 (1.65)	1.73 (1.65)	1.73 (1.65)	1.73 (1.65)	1.31 (1.52)[a]
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	-	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)[a]
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	-	1.25 (1.50)	3.63 (2.15)	4.92 (2.43)	5.56 (2.56)	5.56 (2.56)	4.02 (2.24)
Quinalphos 0.05 per cent	-	0.00 (1.00)	0.71 (1.31)	0.71 (1.31)	1.62 (1.62)	1.62 (1.62)	0.88 (1.37)[a]
Control	-	5.56 (2.56)	7.38 (2.90)	8.00 (3.00)	8.30 (3.05)	8.60 (3.10)	7.53 (2.92)
CD-treatments : NS, CD-Mean : 0.865*, CD-intervals : NS		NS	NS	NS	NS	NS	

Figures in parentheses denote $\sqrt{x+1}$ transformed values. WAS : Weeks after spraying.
*Significant at 5 per cent level, NS : Non significant

Table 23. Percentage of spikes damaged by mealy bugs at different intervals after application of treatments at berry formation stage

Treatments	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	1.25 (1.50)	1.25 (1.50)	1.62 (1.62)	3.00 (2.00)	3.63 (2.15)	2.08 (1.75)
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	1.25 (1.50)	1.25 (1.50)	3.00 (2.00)	5.05 (2.46)	5.05 (2.46)	2.94 (1.98)
Azadirachtin 0.004 per cent	1.25 (1.50)	1.73 (1.65)	1.73 (1.65)	3.63 (2.15)	3.63 (2.15)	2.32 (1.82)
Azadirachtin 0.003 per cent	1.73 (1.61)	1.73 (1.62)	3.63 (2.15)	3.63 (2.15)	3.63 (2.15)	2.81 (1.95)
Clerodendron leaf and flower extract 8.00 per cent	1.25 (1.50)	3.00 (2.00)	3.00 (2.00)	5.25 (2.50)	6.03 (2.65)	3.54 (2.13)
Karanja oil emulsion 2.00 per cent	3.00 (2.00)	3.63 (2.15)	3.49 (2.12)	3.49 (2.12)	4.33 (2.31)	3.58 (2.14)
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	3.00 (2.00)	3.63 (2.15)	3.63 (2.15)	3.63 (2.15)	3.63 (2.15)	3.50 (2.12)
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	1.25 (1.50)	2.84 (1.96)	3.63 (2.15)	3.63 (2.15)	3.63 (2.15)	2.93 (1.98)
Quinalphos 0.05 per cent	0.00 (1.00)	0.71 (1.31)	2.27 (1.81)	2.27 (2.81)	2.27 (1.81)	1.39 (1.55)
Control	3.00 (2.00)	3.63 (2.15)	6.03 (2.65)	8.55 (3.09)	11.25 (3.50)	6.18 (2.68)
	NS	NS	NS	NS	NS	

CD-treatments : NS, CD-Mean : NS, CD-intervals : NS

Figures in parentheses denote $\sqrt{X+1}$ transformed values. WAS Weeks after spraying
NS Non significant

There was no spike damage by mealy bugs after 24 hours, 72 hours, one week, two weeks, three weeks and four weeks after application of insecticide treatments except in control.

Five weeks after application of insecticides, highest damage of 3.00 per cent observed in control, karanj oil emulsion 2.00 per cent and neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil 1.00 per cent and least (0.00) in quinalphos treated vines. There was no significant difference between any of the treatments and control.

The pooled mean damage was maximum (6.18) in control and minimum (1.39) in quinalphos 0.05 per cent. There was no significant difference between any of the treatments except the control.

4.2.8.2 At Berry Maturation Stage

The results are presented in Table 24.

Mealy bugs were observed only after five weeks of insecticide application.

Six weeks after application of treatments, the highest damage of 4.33 was observed in control. No damage was seen in neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent, azadirachtin 0.004 per cent, azadirachtin 0.003 per cent + karanja oil 1.00 per cent and quinalphos 0.05 per cent treated vines. Almost all the treatments were on par except control.

Seven, eight and nine weeks after treatment application, the same trend was observed and there was no significant difference between any of the treatments except control and clerodendron leaf and flower extract 8.00 per cent.

At berry maturation stage, recorded no damage was recorded in quinalphos 0.05 per cent and neem seed oil 3.00 per cent + garlic 2.00 per cent treated vines. The pooled mean percentage of spikes damaged by mealy bugs at berry maturation was the highest (6.16) in the control vines.

Table 24. Percentage of spikes damaged by mealy bugs at different intervals after application of treatments at berry maturation stage

Treatments	6 WAS	7 WAS	8 WAS	9 WAS	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	0.00 (1.00) [a]	0.00 (1.00) [a]	0.00 (1.00) [a]	0.00 (1.00) [a]	0.00 (1.00) [a]
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	0.00 (1.00) [a]	0.00 (1.00) [a]	0.71 (1.31) [a]	0.71 (1.31) [a]	1.40 (1.55) [ab]
Azadirachtin 0.004 per cent	0.00 (1.00) [a]	0.00 (1.00) [a]	0.00 (1.00) [a]	0.71 (1.31) [a]	0.16 (1.08) [ab]
Azadirachtin 0.003 per cent	1.25 (1.50) [a]	1.25 (1.50) [a]	1.25 (1.50) [a]	1.25 (1.50) [a]	1.25 (1.50) [ab]
Clerodendron leaf and flower extract 8.00 per cent	3.63 (2.15) [a]	4.20 (2.28) [a]	4.92 (2.43)	4.92 (2.43)	4.40 (2.32) [b]
Karanja oil emulsion 2.00 per cent	1.25 (1.50) [a]	3.00 (2.00) [a]	3.00 (2.00) [a]	3.63 (2.15) [a]	2.66 (1.91) [b]
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	1.25 (1.50) [a]	0.00 (1.00) [a]	3.63 (2.15) [a]	3.63 (2.16) [a]	2.81 (1.95) [b]
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	0.00 (1.00) [a]	0.00 (1.00) [a]	0.00 (1.00) [a]	1.25 (1.50) [a]	0.27 (1.13) [ab]
Quinalphos 0.05 per cent	0.00 (1.00) [a]	0.00 (1.00) [a]	0.00 (1.00) [a]	0.00 (1.00) [a]	0.00 (1.00) [a]
Control	4.33 (2.31)	5.71 (2.59)	5.71 (2.59)	9.32 (3.21)	6.16 (2.68)

CD-treatments at 5% : 1.245*, CD-Mean at 5% : 0.623*, CD-intervals at 5% : 0.394*

Figures in parentheses denote $\sqrt{x+1}$ transformed values. WAS - Weeks after spraying

*Significant at 5 per cent level

4.2.9 Yield of Black Pepper

The results of the effect of insecticide treatments on yield of black pepper and benefit cost ratio of treatments are presented in Table 25.

The average yield per hectare ranged from 932. 40 kg in control to 1720.50 kg of dried pepper in vines treated with quinalphos 0.05 per cent and was found to be significantly different. Quinalphos 0.05 per cent was followed by vines treated with neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil (1598.40 kg ha^{-1}) and neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic and neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic recorded 1587.3 kg ha^{-1} and 1520.70 kg ha^{-1} respectively with regard to yield treatments, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil emulsion 1.00 per cent, neem seed oil 3.00 per cent + garlic 2.00 per cent, neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent and azadirachtin 0.003 per cent + karanja oil 1.00 per cent were on par.

The yield in control vines and clerodendron leaf and flower extract 8.00 per cent treated vines were on par with an average of 932.40 kg ha^{-1} and 1087.80 kg ha^{-1} respectively and they differed significantly from the rest of the treatments.

The benefit : cost ratio was the highest (3.20) in neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent treated vines. This was followed by combinations of neem seed oil soap emulsion 2.00 per cent + garlic 2.00 per cent + karanja oil 1.00 per cent and neem seed oil soap emulsion 3.00 per cent + garlic 2.00 per cent treatments which recorded B:C ratios of 3.11 and 3.10 respectively. The benefit:cost ratio ranged from 0.88 to 2.60 among the other treatments.

Table 25 Yield of black pepper and benefit:cost ratio of the treatments in field experiment

Treatments	Yield (kg ha^{-1})	B:C ratio
Neem seed oil soap emulsion 3% + garlic 2%	1587.30[b]	3.10
Neem seed oil soap emulsion 2% + garlic 2%	1520.70[b]	3.20
Azadirachtin 0.004%	1365.30[c]	2.16
Azadirachtin 0.003%	1320.90[d]	2.50
Clerodendron leaf and flower extract 8%	1087.80[e]	0.88
Karanja oil emulsion 2%	1332.00[d]	2.44
Neem seed oil soap emulsion 2% + garlic 2% + karanja oil emulsion 1%	1598.40[b]	3.11
Azadirachtin 0.003 % + karanja oil emulsion 1%	1465.20[c]	2.65
Quinalphos 0.05%	1720.50[a]	2.60
Control	932.40[e]	
CD (0.05)	160.05*	

*Significant at 5 per cent level

DISCUSSION

5. DISCUSSION

5.1 SEASONAL INCIDENCE OF PESTS IN BLACK PEPPER

The population and damage caused by important pests of black pepper was assessed for an year from May 2002 to April 2003 in the Instructional Farm, College of Agriculture, Vellayani and the results are discussed.

Adults of pollu beetle were observed in pepper vines throughout the year. A similar observation was made by Premkumar (1980). The mean population was the highest during the first fortnight of November 2002 followed by second fortnight of June 2002. In this study, the maximum rainfall (212.2 mm) received during the second fortnight of October contributed to the generation of flushes. The availability of food attracted pollu beetle adults which contributed to the maximum population during November. The population was maximum during south-west monsoon and north-east monsoon period (Table 26). However surveys undertaken by Premkumar and Nair (1985) revealed the presence of maximum population of adults during the pre-monsoon showers. After September-October there was a general decline in the pest population.

The lowest mean population was seen during the first and second fortnight of March 2003. The adult population was low when pepper berries were not available during the summer months. During these periods, the adults lived by feeding on mature leaves. Similar observations were made by Devasahayam and Premkumar, 1988).

The percentage of leaves damaged by the beetle was the maximum during second fortnight of November 2002. This period coincided with the period of maximum population of adult beetles. The reason attributed was the production of flushes, shoot tips and tender stems during this period. However the leaf damage and intensity of leaf damage had no significant difference with any of the seasons.

Table 26 Seasonal occurrence of pests and their damage in black pepper during south-west monsoon, north-east monsoon and summer season

Season	PBC	LDP	TSB	SDP	BDP	LDT	SDM	SDS	ILP	ISL	GFL	VDS
South-west monsoon season	4.64	32.28	9.50	15.08	0.00	12.10	0.00	0.00	30.20	4.50	1.60	16.00
North-east monsoon season	4.44	29.49	20.50	28.64	5.17	12.33	0.92	4.06	27.30	8.25	2.55	17.00
Summer season	2.08	26.44	1.50	18.70	3.88	20.50	1.22	4.05	19.86	18.12	2.37	23.50
CD (0.05)	0.973*	11.037*	7.520*	13.440*	2.817*	6.701*	0.922*	3.027*	11.236*	2.591*	0.439*	1.898*

*Significant at 5 per cent level

PBC - Pollu Beetle Count
LDP - Percentage of leaves damaged by pollu beetle
TSB - Percentage of vines damaged by top shoot borer
SDP - Percentage of spikes damaged by pollu beetle
BDP - Percentage of berries damaged by pollu beetle
LDT - Percentage of leaves damaged by leaf gall thrips
SDM - Percentage of spikes damaged by mealy bugs
SDS - Percentage of spikes damaged by scale insects
ILP - Intensity of leaves damaged by pollu beetle
ISL - Intensity of vines damaged by scale insects
GFL - Percentage of leaves damaged by leaf gall fly
VDS - Percentage of vines damaged by scale insects

As soon as the spikes emerged, the pollu beetle started feeding on them. Maximum percentage of spike and berry damage by the beetle (37.90 and 8.00 respectively) was seen during the first and second fortnight of February. These are the periods when adult numbers were lower in the field but the grubs were active within the berries. Premkumar (1980) observed maximum spike damage of 22.10 per cent in Kottayam district. Premkumar and Nair (1987) reported less than ten per cent berry damage in black pepper in Thiruvananthapuram. The present investigation also supported this finding.

Top shoot borer damage was first observed in July 2002. The maximum damage of top shoot borer was observed during the second fortnight of November 2002. This concurred with the observations made by Visalakshi (1963). These months which form part of monsoon season contributed to the growth period of young pepper vines which produced new succulent shoots. The damage of top shoot borer was not observed in the field from January 2003 onwards. These are the summer months characterized by high temperature, low rainfall and low relative humidity, which limited the emergence and development of new shoots. This was also in line with the earlier observations made by Visalakshi (1963).

The damage of leaves by leaf gall thrips was maximum during the months of March and April 2002 *i.e.*, the summer season (Table 26). These are the periods of low humidity and high temperature, which are congenial for the buildup of pest population and consequent damage. The minimum damage by leaf gall thrips was observed during May to November 2002. These observations corroborated with the findings of Visalakshi (1963).

The population of mealy bugs was at first observed from October. The spikes infested by mealy bugs turned dark in colour due to insect desapping and formation of sooty mould. The highest incidence was observed during February 2003 *i.e.*, summer season (Table 26).

Twenty eight per cent of the vines under observation were infested by scale insects during the month of April 2003. However only 16.00 per cent infestation

was recorded for a period of six months from May 2002 to November 2002. Infestation by the hard scale, *L. piperis* (range from 6.76 to 24.40 per cent) in Thiruvananthapuram was reported by Koya and Devasahayam (1995).

The intensity of scale insects was low during months of May, June and July 2002. There was an increase in the percentage of vines damaged by scales from September 2002 onwards. The months of March and April 2002 when the scale infestation was maximum were the periods of high temperature which were congenial for the multiplication of the insect. During summer season a maximum of 23.50 per cent of vines were affected (Table 26). Similar observations were made by Koya and Devasahayam (1995).

Spike damage by scale insects started from second fortnight of September 2002 and recorded the maximum during second fortnight of February 2003 just before the harvest of the crop. Berries infested by the scales were shrivelled and smaller compared to the normal uninfested ones.

5.1.1 Correlation between Weather Parameters and Pest Population and Damage

The population fluctuation of pollu beetle in relation to various climatic factors is presented in Figure 1.

Among the different climatic factors, the pollu beetle population was significantly related with maximum temperature and relative humidity. The maximum temperature had a significant negative correlation. The higher temperature unfavourably affected the population of the pest. The finding was in accordance with the observations of Premkumar (1980). Rainfall was also positively correlated but not significant. Relative humidity had a significant positive correlation with pollu beetle population indicating that it was congenial for the population build up. However, Premkumar and Nair (1985) reported that variation in humidity had no effect on pollu beetle population.

The extent of leaves damaged by pollu beetle in relation to various climatic factors is presented in Figure 2.

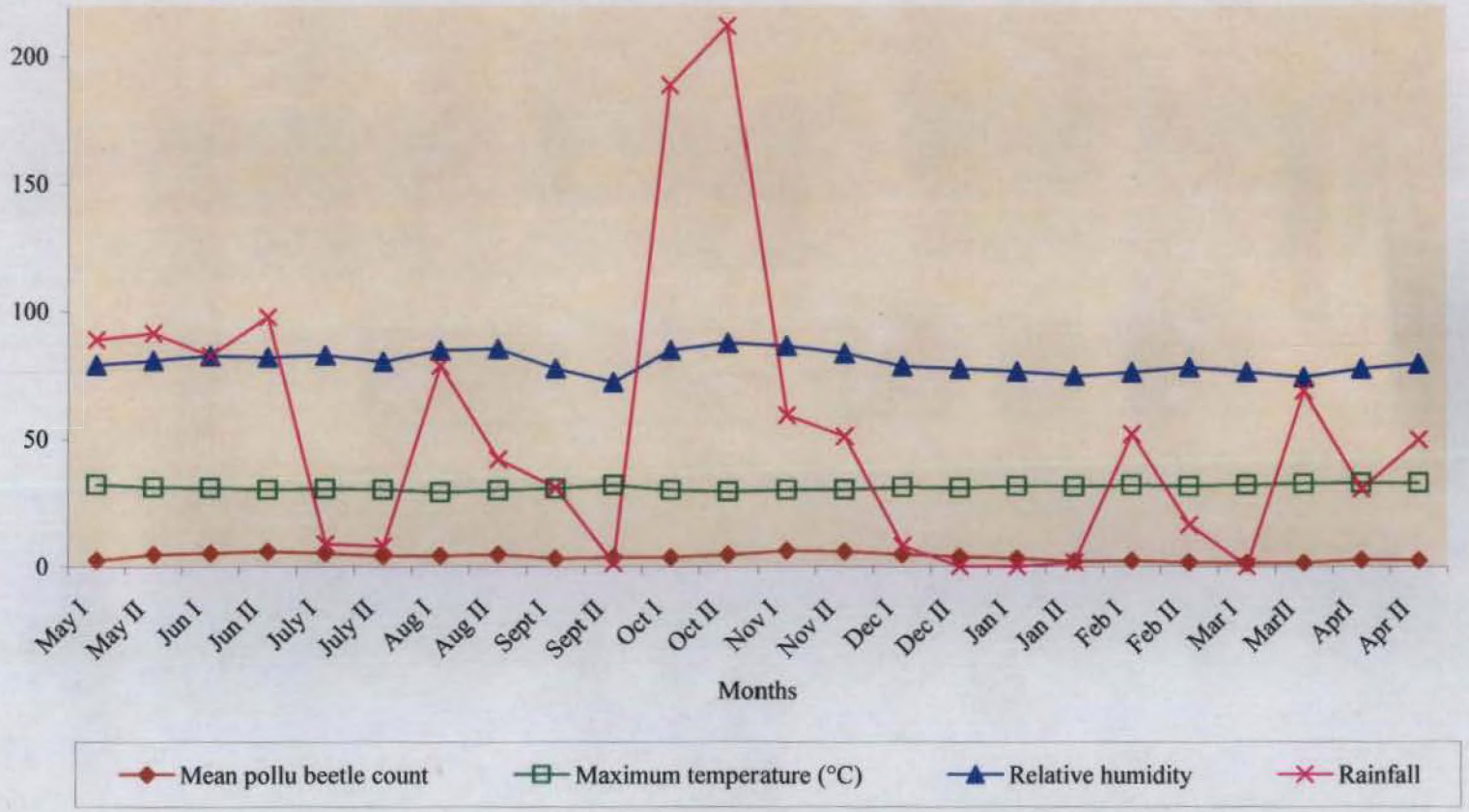


Fig. 1 Population fluctuation of pollu beetle in relation to maximum temperature, relative humidity and rain fall

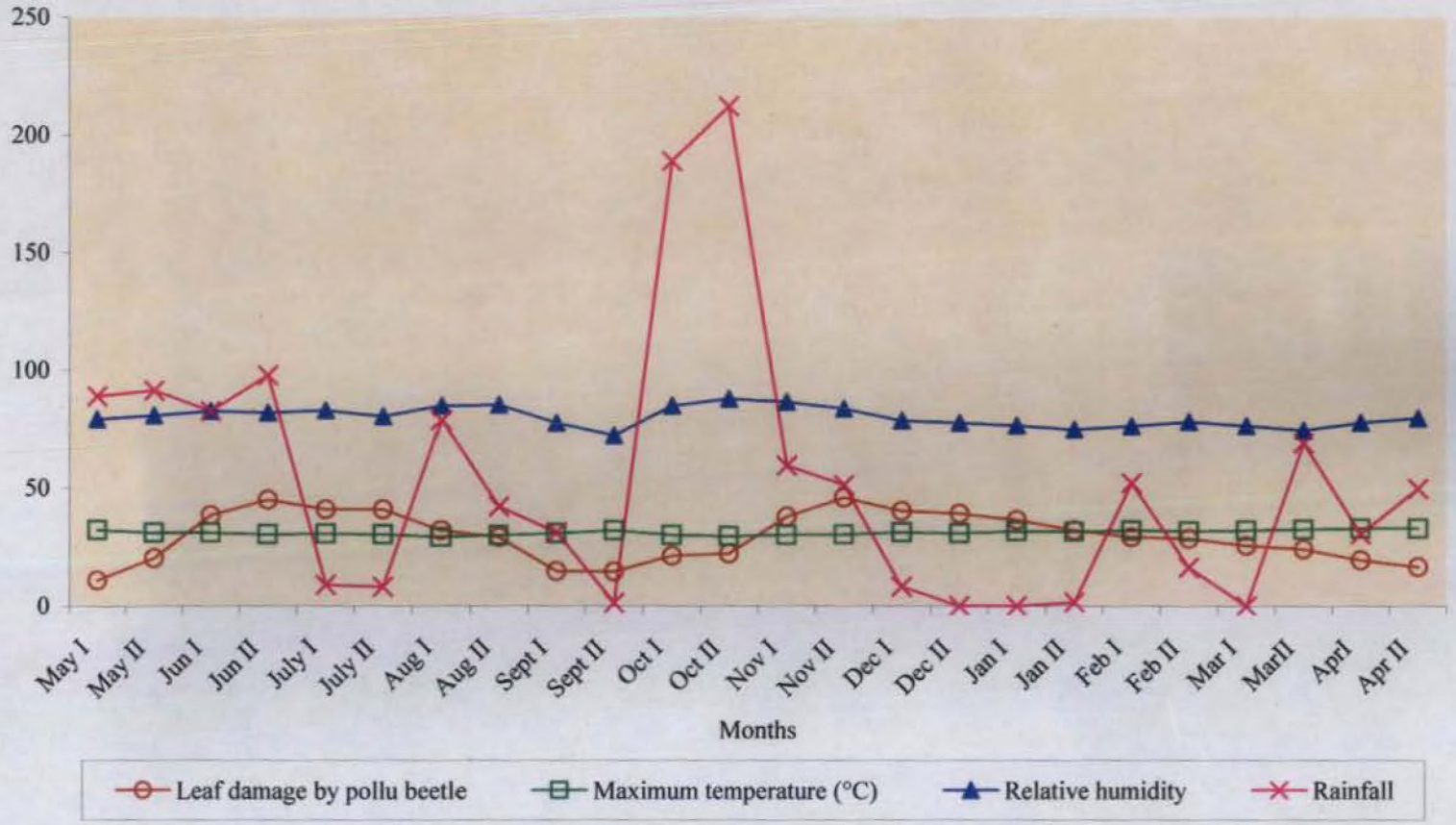


Fig. 2 Extent of leaf damage by pollu beetle in relation to maximum temperature, relative humidity and rainfall

There was significant negative correlation between leaves damaged by pollu beetle and maximum temperature. As the population of adults was low at higher temperature, the damage caused by them was less. However the intensity of infestation on leaves by pollu beetle had significant positive correlation with maximum temperature and negative correlation with relative humidity and number of rainy days. During periods of high temperature and low rainfall, the availability of new flushes was less. So the beetles thrived on the already infested leaves thereby increasing the intensity of infestation on older leaves.

The correlation between percentage of spikes and berries damaged by pollu beetle and minimum temperature was significantly negative. This indicated that when minimum temperature increased the spike and berry damage by pollu beetle decreased.

The damage of vines by top shoot borer had significant negative correlation with maximum temperature. Low temperature and high rainfall period (characteristic of the monsoon season) contributed to the growth period of pepper vines which gave out many new succulent shoots and top shoot borer appeared to thrive in the field. When the temperature increased from January onwards there was a sudden decrease in the population of the pest in the field. This concurred with the observations of Visalakshi (1963).

However damage on leaves by leaf gall thrips had significant positive correlation with maximum temperature. Relative humidity and rainfall was negatively correlated with leaf damage by leaf gall thrips. High temperature, low rainfall and humidity were congenial for multiplication of gall thrips leaf damage. During rainy season, the temperature would be low and humidity in the atmosphere high. In addition, stagnation of water within the marginal fold might have adversely affected different stages of the pest. Similar findings were made by Visalakshi (1963).

Percentage of spikes damaged by scales and mealy bugs was negatively correlated with minimum temperature. However the intensity of infestation of

scale insects on pepper vines was positively correlated with maximum temperature and negatively correlated with relative humidity and number of rainy days.

Correlation coefficients were worked out between incidence of pests and their damage in black pepper with weather parameters of previous fortnight. The degree of association of pests of pepper, their damage and weather parameters of the current and previous fortnight was almost the same. Significantly positive correlation was obtained between pollu beetle damage on leaves and relative humidity in this correlation.

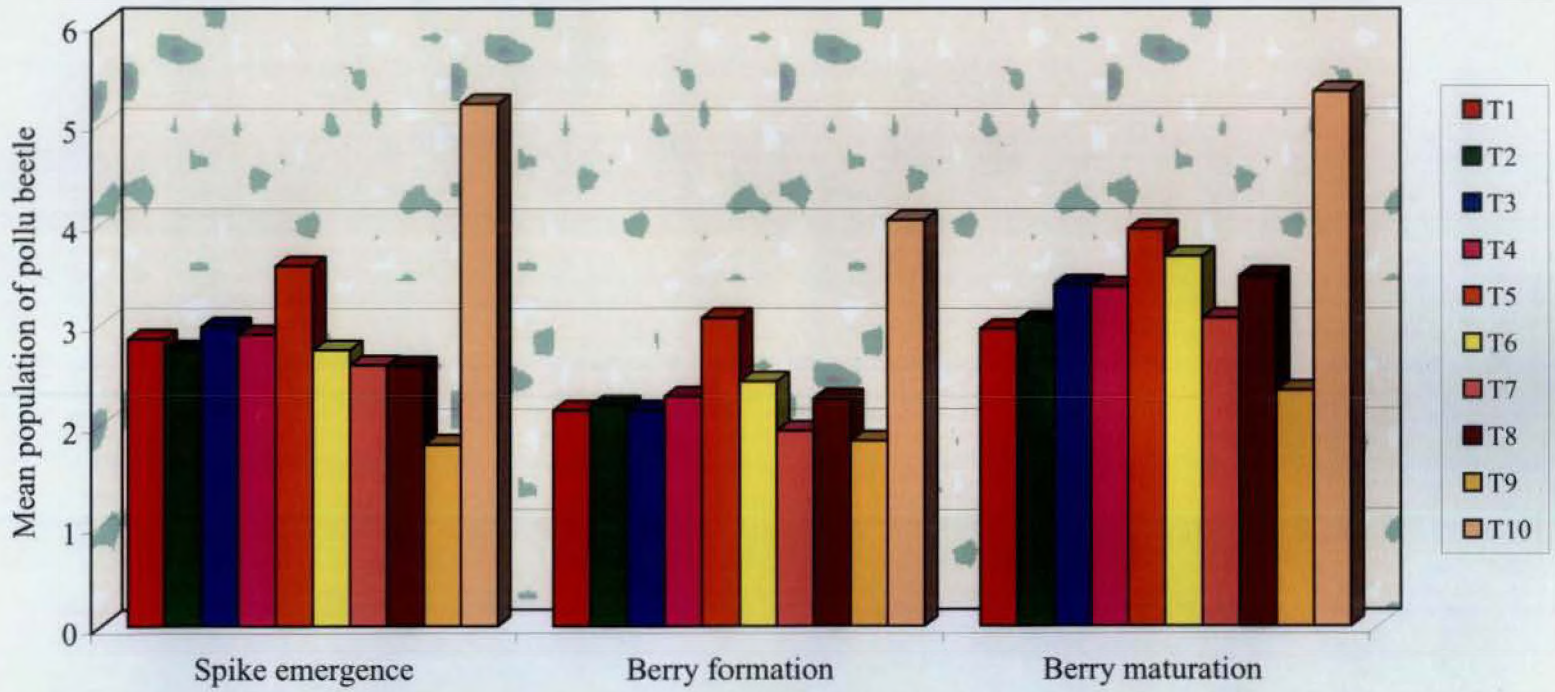
5.2 FIELD EVALUATION OF BOTANICALS AND THEIR COMBINATIONS FOR THE MANAGEMENT OF PESTS OF BLACK PEPPER

A field experiment was conducted to evaluate the efficacy of different insecticides including botanicals against major pests of black pepper. The experiment was conducted in the Instructional Farm, College of Agriculture, Vellayani. Three sprays were given to the crop *viz.*, at spike emergence, berry formation and berry maturation stage. The observations were recorded at 24 hours, 72 hours after spraying and then at weekly intervals till the next spraying. The results of the experiment are discussed below.

5.2.3.1 Mean Population of Adults of Pollu Beetle at Different Stages after Application of Treatments

The effect of different insecticide sprays(eight botanicals and one chemical) on population of pollu beetle indicated that all the insecticide treatments were effective in deterring the population compared to control (Figure 3).

The mean of all observations taken on population of pollu beetle at spike emergence revealed the lowest population of pollu beetle adults in quinalphos 0.05 per cent treated vines. The effectiveness of quinalphos in controlling the pest was reported earlier by Pillai and Abraham (1974), Balakrishnan *et al.* (1984) and



T1 – Neem seed oil soap emulsion 3 % + garlic 2 %
T2 – Neem seed oil soap emulsion 2 % + garlic 2 %
T3 – Azadirachtin 0.004 %
T4 – Azadirachtin 0.003 %
T5- Clerodendron leaf and flower extract 8%
T6- Karanja oil emulsion 2%
T7- Neem seed oil soap emulsion 2% + garlic 2% + Karanja oil 1%
T8- Azadirachtin 0.003% + Karanja oil emulsion 1%
T9- Quinalphos 0.05%
T10- Control

Fig. 3 Mean population of adults of pollu beetle after application of treatments at different stages

Nandakumar *et al.* (1991). Among the botanical treatments, the combination of azadirachtin 0.003 per cent plus karanja oil emulsion one per cent and the combination of neem seed oil soap emulsion two per cent plus garlic two per cent plus karanja oil one per cent gave the least count of beetles. Similar observations were made by Sarma (2001) who reported that Neemgold, a commercial neem formulation was effective against the pollu beetle.

The population of beetles observed after spray at berry formation stage was the lowest in quinalphos 0.05 per cent treated vines. Out of the eight botanical treatments, neem oil soap emulsion two per cent in combination with garlic two per cent and one per cent karanja oil, neem oil soap emulsion three per cent plus two per cent garlic and azadirachtin 0.004 per cent were equally as effective as quinalphos 0.05 per cent.

At berry maturation stage, the count of pollu beetle differed significantly between the control vines compared to all the treatment vines at 24 hours, 72 hours and one week after spraying. The population buildup of the pest was observed during the subsequent weeks in the treatment vines. However population of beetles declined after four weeks even in the control vines. This was due to the adverse weather conditions and also the non-availability of food as the berries were in the harvesting stage.

Among the botanicals, combination of neem plus garlic and combination of neem plus garlic plus karanja gave good control. Neem exhibit oviposition deterrence, antifeedant and larvicidal action against the pest. Efficacy of neem oil in controlling flea beetle pests in other crops was reported earlier by Rajan and Nambisan (1993). The findings in this experiment were in line with those of Mukeshkumar and Singh (2002) who reported that karanja was effective against insect pests of plantation crops.

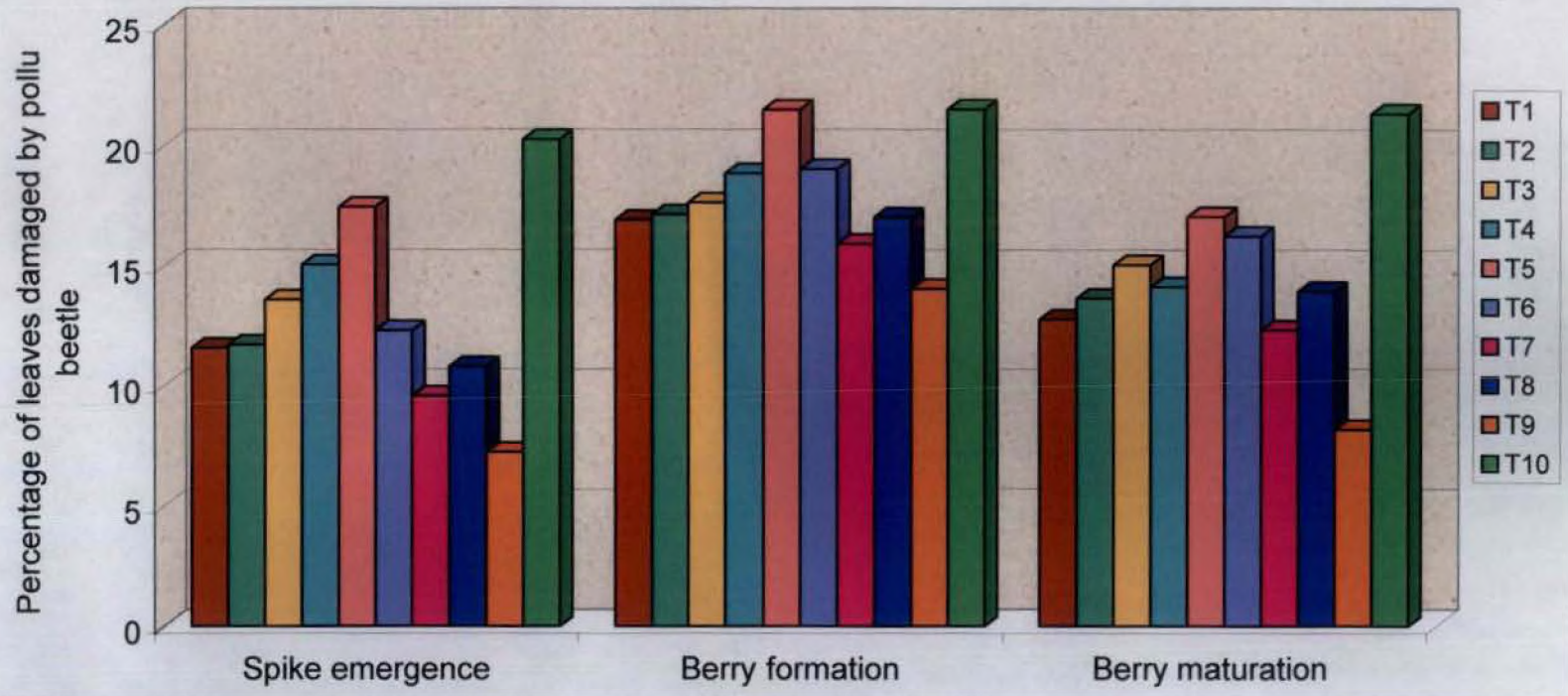
5.2.3.2 Mean Percentage of Leaves Damaged by Pollu Beetle after Application of Treatments at Different Stages

The leaf damage caused by the beetle reduced the photosynthetic area which in turn affected spike and berry development and ultimately reduced the yield.

Mean percentage of leaves damaged by pollu beetle at different stages(spike emergence,berry formation, berry maturation) is shown in Figure 4. The damage on leaves was not observed twenty four hours after treatment application except in the control vines indicating that all the treatments were equally effective in deterring the pollu beetle. In all the stages, it was found that quinalphos 0.05 per cent treated vines exhibited lowest percentage of leaf damage by the beetle. Among the plant products, the combination of neem seed oil soap emulsion two per cent, garlic two per cent and karanja oil one per cent was the best during spike emergence, berry formation and berry maturation stage. Rhizomes of garlic, *Allium sativum* was found to possess antifeedant property against a number of insects (Pandey *et al.*, 1987). The synergistic effect of neem oil with garlic in their combination treatment was responsible for lesser percentage of leaf damage on vines treated with the same.

The second best treatment was the combination of azadirachtin 0.003 per cent and karanja oil one per cent during spike emergence whereas neem oil soap emulsion two per cent and garlic two per cent was the second best treatment during berry formation and berry maturation stage. In all the stages, among the treatments, clerodendron leaf and flower extract eight per cent treated vines had recorded maximum leaf damage. This indicated that clerodendron extracts were less effective compared to the other botanicals in containing the leaf damage by the pollu beetle.

Percentage deterrence on leaves by pollu beetle at different stages after application of treatments is given Table 26. At spike emergence and berry formation stages quinalphos 0.05 per cent offered maximum protection of 66.10



T1 – Neem seed oil soap emulsion 3 % + garlic 2 %
T2 – Neem seed oil soap emulsion 2 % + garlic 2 %
T3 – Azadirachtin 0.004 %
T4 – Azadirachtin 0.003 %
T5- Clerodendron leaf and flower extract 8%
T6- Karanja oil emulsion 2%
T7- Neem seed oil soap emulsion 2% + garlic 2% + Karanja oil 1%
T8- Azadirachtin 0.003% + Karanja oil emulsion 1%
T9- Quinalphos 0.05%
T10- Control

Fig. 4 Mean percentage of leaves damaged by pollu beetle after application of treatments at different stages

Table 27. Percentage feeding deterrence on leaves of black pepper by pollu beetle at different stages

Treatments	At spike emergence	At berry formation	At berry maturation	Mean
Neem seed oil soap emulsion 3.00 per cent + 2.00 per cent garlic	44.50	42.91	37.95	41.79
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic	46.91	44.78	33.03	41.57
Azadirachtin 0.004 per cent	45.28	37.67	29.87	37.61
Azadirachtin 0.003 per cent	38.93	33.31	37.69	33.31
Clerodendron leaf and flower extract 8.00 per cent	19.23	20.94	24.06	21.61
Karanja oil emulsion 2.00 per cent	33.48	35.45	30.58	33.17
Neem seed oil soap emulsion 2.00 per cent + 2.00 per cent garlic + 1.00 per cent karanja oil	55.29	42.76	38.88	45.63
Azadirachtin 0.003 per cent + karanja oil emulsion 1.00 per cent	38.39	40.14	36.71	38.41
Quinalphos 0.05 per cent	66.10	60.01	57.97	61.36

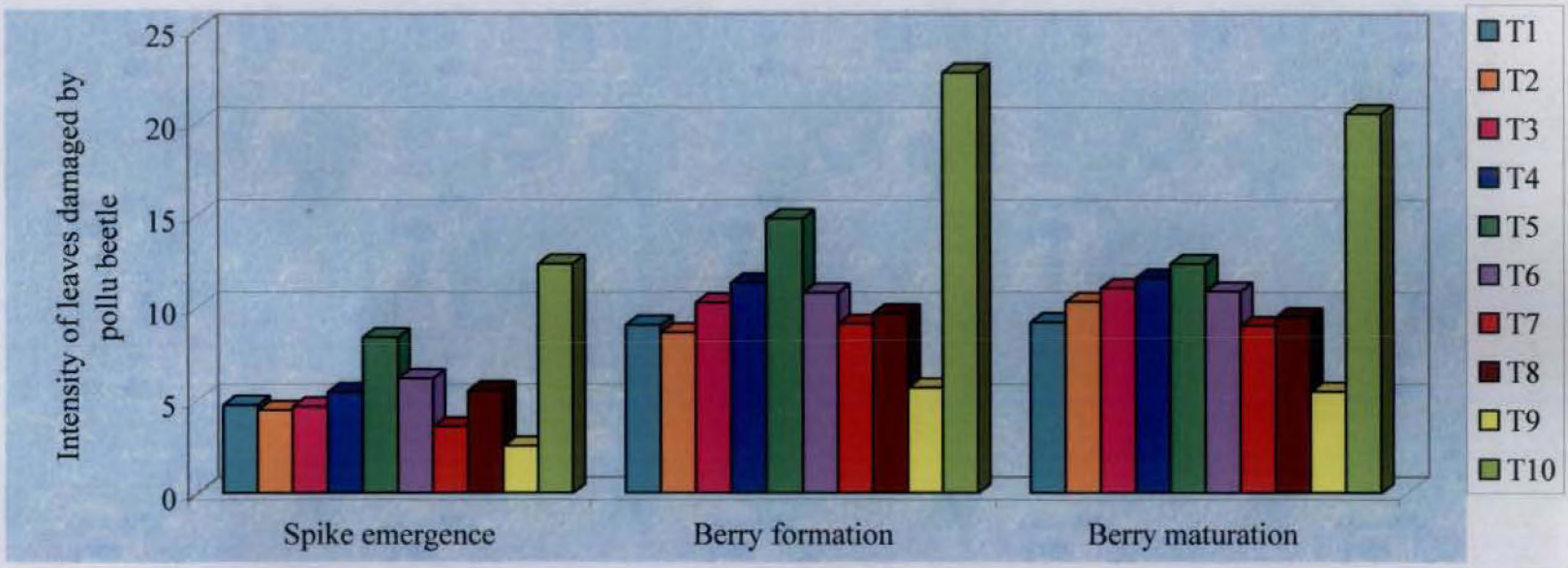
per cent followed by neem seed oil soap emulsion two per cent, garlic two per cent and karanja oil one per cent and neem seed oil soap emulsion two per cent, garlic two per cent with mean values of 55.29 and 46.91 respectively. At berry maturation stage, quinalphos 0.05 per cent offered maximum protection to leaf followed by neem seed oil soap emulsion two per cent, garlic two per cent, karanja oil one per cent and neem seed oil soap emulsion two per cent, garlic three per cent. The presence of 0.30 per cent azadirachtin (A, B, C, H, I isomers), 1.40 per cent salanin, 0.50 per cent nimbin etc. (Gahukar, 1988) might have been responsible for the deterrent effect in neem oil.

5.2.3.3 Mean Intensity of Leaves Damaged by Pollu Beetle after Application of Treatments at Different Stages

The mean intensity of leaves damaged by pollu beetle at different stages is described in Figure 5.

There was no damage on leaves by pollu beetle at twenty four hours after treatment application except in control vines. The intensity of damage increased in all treatments in the subsequent weeks probably due to the non-persistence of the insecticides on the treated vines. At spike emergence, the lowest intensity of damage was observed in quinalphos 0.05 per cent treated vines. The efficacy of quinalphos in reducing the damage by pollu beetle was reported by Premkumar *et al.*, 1986. Among the botanicals, combination of neem seed oil soap emulsion two per cent, two per cent garlic and karanja oil one per cent recorded least intensity of damage during spike emergence and berry maturation stage. The antifeedant and growth inhibitor effect of neem in combination with karanja oil on pests of other crops was reported by Rao *et al.*, 2002. However during berry formation, combination of neem seed oil soap emulsion two per cent and garlic two per cent was the best in reducing the intensity of leaf damage.

The antifeedant property of neem was responsible in reducing the leaf damage by pollu beetle in vines treated with neem based treatments. This may be due to the presence of inhibitory stimulus or absence of gustatory stimulus of the



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T6- Karanja oil emulsion 2%
T7- Neem seed oil soap emulsion 2% + garlic 2% + Karanja oil 1%
T8- Azadirachtin 0.003% + Karanja oil emulsion 1%
T9- Quinalphos 0.05%
T10- Control

Fig. 5 Mean intensity of leaves damaged by pollu beetle after application of treatments at different stages

plants sprayed with neem insecticides which may prevent the insect from sustained feeding (or oviposition). Twenty four hours after spray, neem oil combinations and their products showed maximum antifeedant and deterrent activity. Similar observations were made by Isman *et al.* (1990) and Schmutterer (1990).

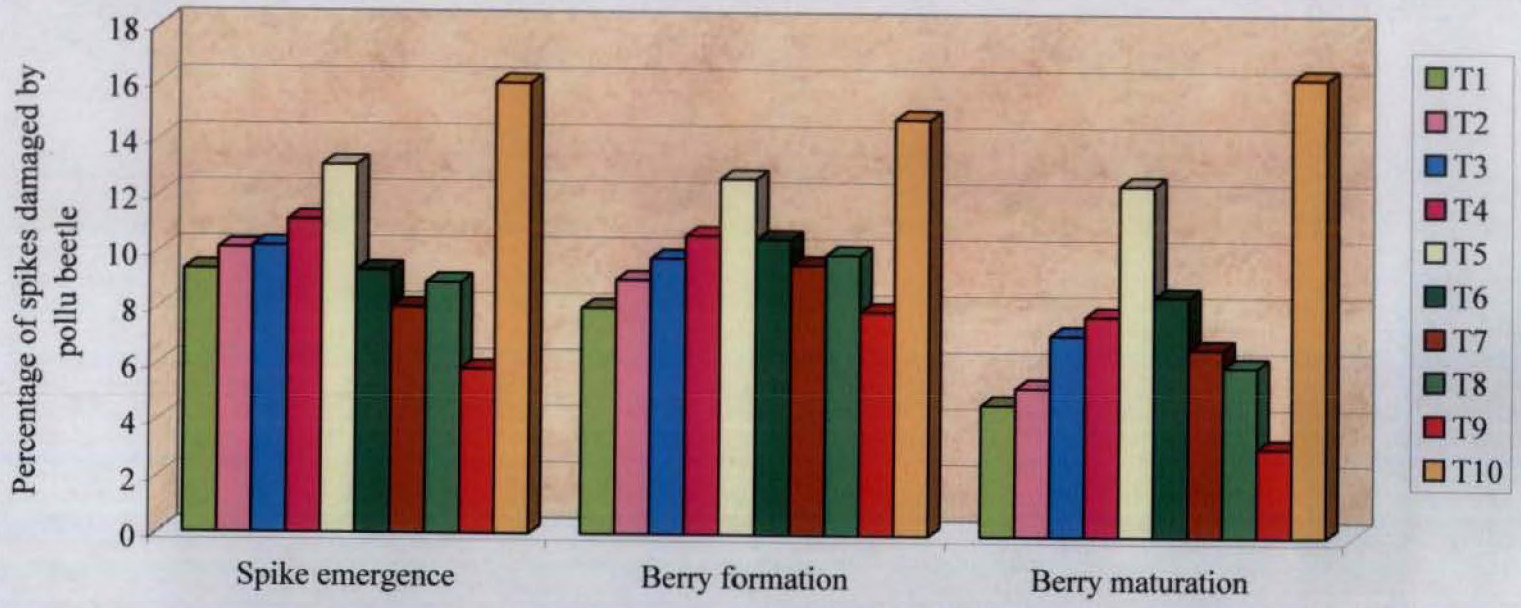
5.2.3.4 Mean Percentage of Spikes Damaged by Pollu Beetle after Application of Treatments at Different Stages

Observations on the effect of insecticidal sprays on spike damage indicated that all the insecticide treatments were equally effective at twenty four hours in preventing the damage. However from the first week onwards, there was an increase in the extent of damage to spikes. The mean percentage of spikes damaged by pollu beetle at different stages after application of treatments is shown in Figure 6.

The mean percentage of damage at spike emergence, berry formation and berry maturation was least in quinalphos 0.05 per cent treated vines. A mean spike damage of 4.39 per cent was recorded by Premkumar (1980) when treated with quinalphos 0.05 per cent. Among the plant products, combinations of neem seed oil soap emulsion two per cent plus garlic two per cent plus karanja oil one per cent was the best during spike emergence. During berry formation and berry maturation stage, the most effective botanical in reducing spike damage was neem seed oil soap emulsion three per cent plus garlic three per cent. Neem oil activated with garlic had been shown to possess the highest deterrent effect against beetle pests of brinjal (Bernice, 2000).

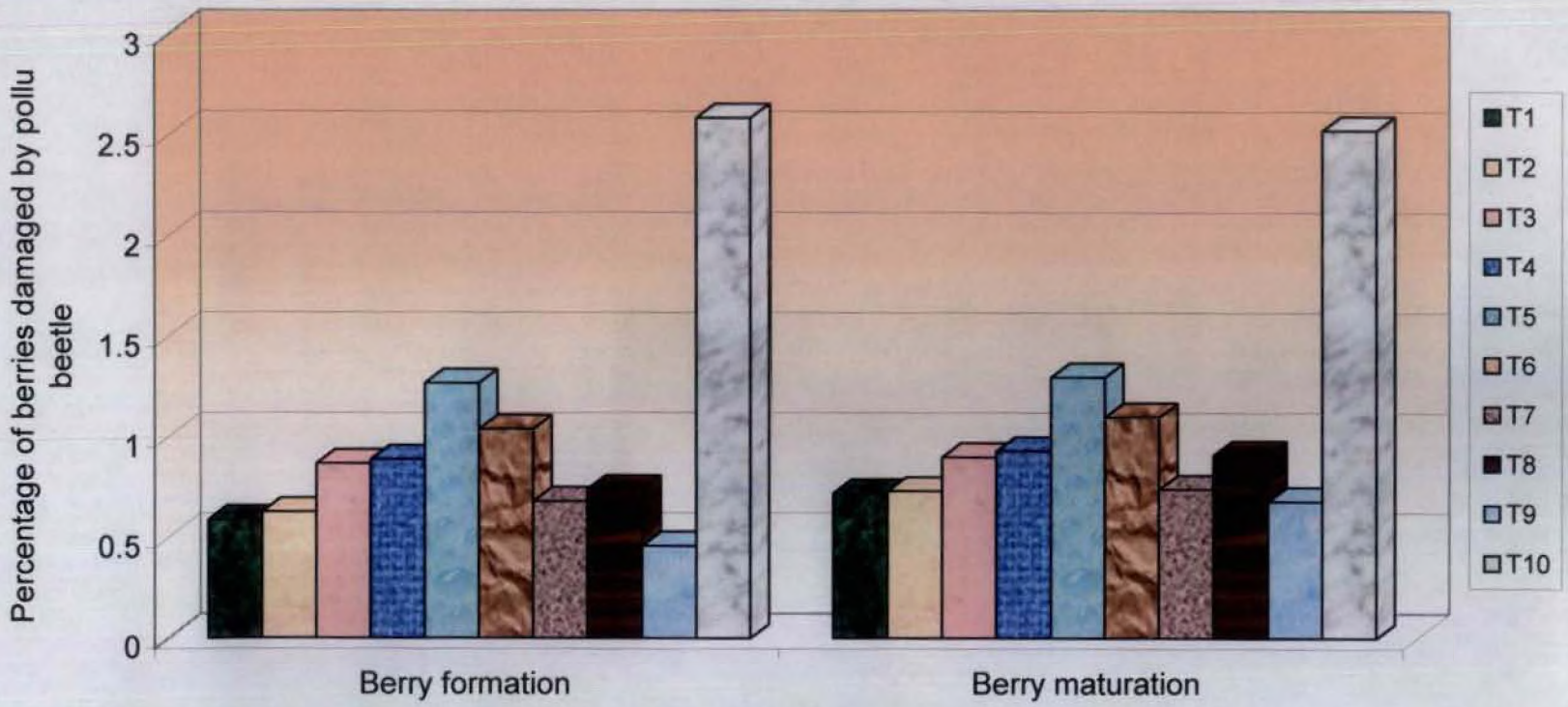
5.2.3.5 Mean Percentage of Berries Damaged by Pollu Beetle After Application of Treatments at Different Stages

Mean percentage of berries damaged by pollu beetle at berry formation and berry maturation stage is presented in the Figure 7. The effect of treatments in controlling the berry damage besides the spike damage was also ascertained. The



T1 – Neem seed oil soap emulsion 3 % + garlic 2 %
T2 – Neem seed oil soap emulsion 2 % + garlic 2 %
T3 – Azadirachtin 0.004 %
T4 – Azadirachtin 0.003 %
T5- Clerodendron leaf and flower extract 8%
T6- Karanja oil emulsion 2%
T7- Neem seed oil soap emulsion 2% + garlic 2% + Karanja oil 1%
T8- Azadirachtin 0.003% + Karanja oil emulsion 1%
T9- Quinalphos 0.05%
T10- Control

Fig. 6 Mean percentage of spikes damaged by pollu beetle after application of treatments at different stages



T1 – Neem seed oil soap emulsion 3 % + garlic 2 %
T2 – Neem seed oil soap emulsion 2 % + garlic 2 %
T3 – Azadirachtin 0.004 %
T4 – Azadirachtin 0.003 %
T5- Clerodendron leaf and flower extract 8%
T6- Karanja oil emulsion 2%
T7- Neem seed oil soap emulsion 2% + garlic 2% + Karanja oil 1%
T8- Azadirachtin 0.003% + Karanja oil emulsion 1%
T9- Quinalphos 0.05%
T10- Control

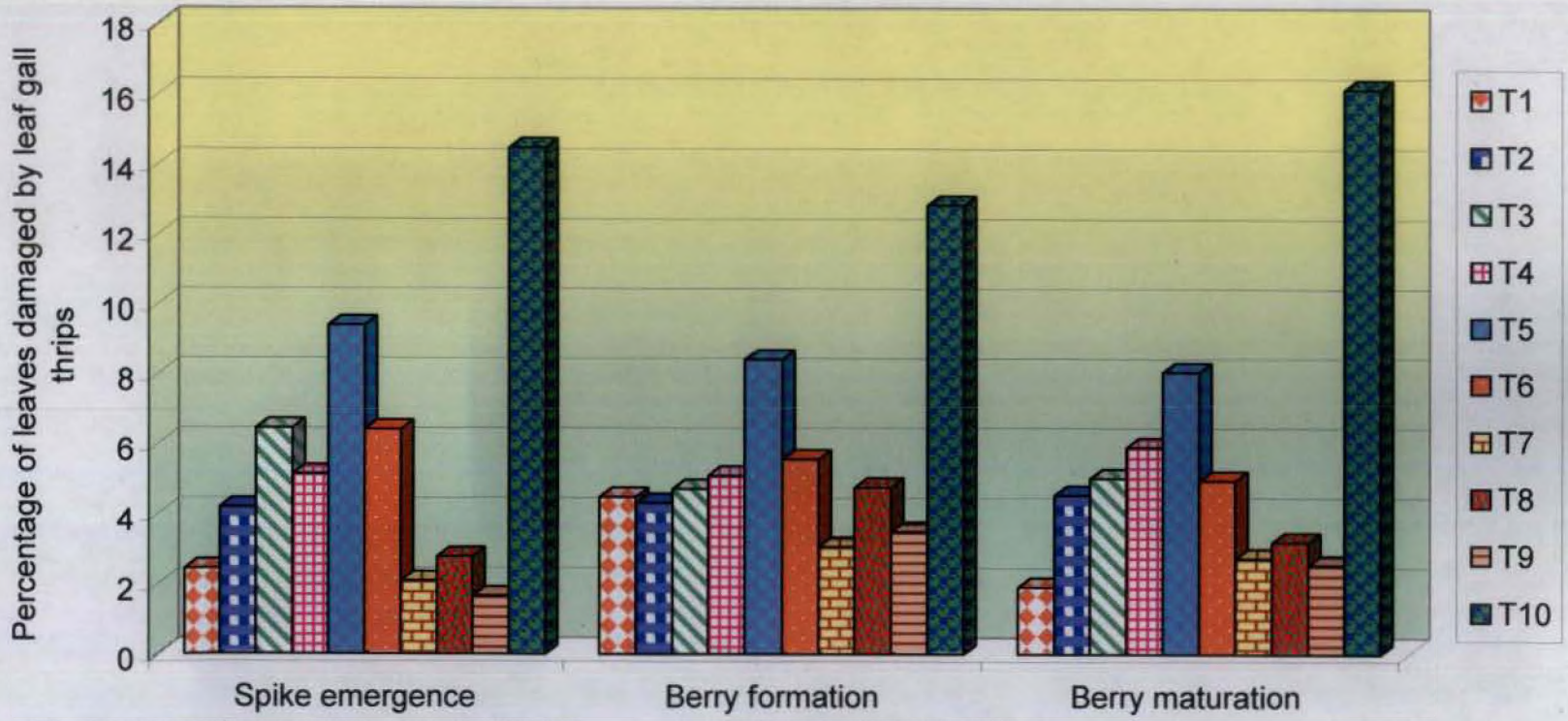
Fig. 7 Mean percentage of berries damaged by pollu beetle after application of treatments at different stages

second application coincided with the early stages of berry development, when the berries were tender and soft. There was no damage on berries twenty four hours after application of treatments indicating that all the treatments were equally effective. At berry maturation, the most effective treatment in controlling berry damage was quinalphos 0.05 per cent. Premkumar (1980) recorded a mean berry damage of 0.36 at berry formation and 0.49 at berry maturation when quinalphos 0.05 per cent was applied. However a mean berry damage of 0.46 per cent and 1.68 per cent was recorded at berry formation and berry maturation respectively in the present investigation when quinalphos 0.05 per cent was applied. Among the botanicals, neem seed oil soap emulsion three per cent plus two per cent garlic was the best followed by neem seed oil soap emulsion two per cent plus garlic two per cent. These treatments were on par with quinalphos 0.05 per cent. At berry maturation stage, no damage on berries was seen at twenty four hours after application of treatments. At seventy two hours, damage was absent in quinalphos 0.05 per cent and neem oil soap emulsion three per cent plus garlic two per cent treated vines. There was an increase in the damage on berries after each week as evidenced from the damage on the berries in the control vines. During this stage, even though adult population was low, the berry damage was high due to the higher population of the grubs feeding within this berries.

The lowest mean percentage of damage to berries was observed in quinalphos 0.05 per cent followed by neem seed oil soap emulsion three per cent plus garlic two per cent and neem seed oil soap emulsion two per cent plus garlic two per cent. These two treatments were on par and they differed significantly from quinalphos 0.05 per cent.

5.2.3.6 Mean Percentage of Leaves Damaged by Leaf Gall Thrips after Application of Treatments at Different Stages

Mean percentage of leaves damaged by leaf gall thrips at different stages after application of treatments, shown in Figure 8.



T1 – Neem seed oil soap emulsion 3 % + garlic 2 %
T2 – Neem seed oil soap emulsion 2 % + garlic 2 %
T3 – Azadirachtin 0.004 %
T4 – Azadirachtin 0.003 %
T5- Clerodendron leaf and flower extract 8%
T6- Karanja oil emulsion 2%
T7- Neem seed oil soap emulsion 2% + garlic 2% + Karanja oil 1%
T8- Azadirachtin 0.003% + Karanja oil emulsion 1%
T9- Quinalphos 0.05%
T10- Control

Fig. 8 Mean percentage of leaves damaged by leaf gall thrips after application of treatments at different stages

The vines treated with quinalphos 0.05 per cent recorded minimum damage by leaf gall thrips at spike emergence stage. Quinalphos 0.05 per cent application reduced the damage by thrips and increased the yield in cardamom (Gopakumar and Kumaresan, 1991). Among the plant products, neem oil soap emulsion two per cent plus garlic two per cent plus karanja oil one per cent and neem oil soap emulsion three per cent plus garlic two per cent recorded minimum damage. At berry formation and berry maturation stages, the neem combination insecticides *viz*., neem oil soap emulsion two per cent plus garlic two per cent, karanja oil one per cent and neem oil soap emulsion three per cent plus garlic two per cent were found to be superior compared to quinalphos 0.05 per cent. Krishnakumar *et al.* (1999) reported that neem oil can be used to control pepper leaf gall thrips. Santhoshkumar (2000) also opined that neem oil emulsion was effective against thrips in chillies.

5.2.3.7 Mean Percentage of Spikes Damaged by Scale Insects after Application of Treatments at Different Stages

At berry formation and berry maturation stages, spike damage by scale insects was not observed twenty four hours, seventy hours, one, two, three and four weeks after treatment application. The damage was recorded five weeks after application of treatments. At berry formation, quinalphos 0.05 per cent was the best treatment when compared with botanicals. Among botanicals, neem seed oil soap emulsion two per cent plus garlic two per cent plus karanj oil one per cent and azadirachtin 0.003 per cent plus karanja oil one per cent were the most effective treatments against scales. At berry maturation phase, neem oil soap emulsion two per cent plus garlic two per cent plus karanja oil one percent was the best followed by quinalphos 0.05 per cent in reducing damage of scale insects. This result corroborated with the findings of Devashayam *et al.* (1994) who revealed that plant and organic products such as neem oil, commercial neem products and fish oil rosin soap were effective in controlling both the species of scale insects in black pepper.

5.2.3.8 Mean Population of Spike Infested by Mealy Bugs after Application of Treatments at Different Stages

Upto the fourth week after treatments, there was no infestation on spikes by mealy bugs in any of the vines. At berry formation stage, there was no significant difference between any of the treatments except the control. During berry maturation, quinalphos 0.05 per cent was the best and was on par with neem oil soap emulsion three per cent plus garlic two per cent and neem oil soap emulsion two per cent and garlic one per cent treatments. Neem oil three per cent gave 49.30 per cent control against mealy bug, *Ferrisia virgata* in other crops (Saminathan and Jayaraj, 2001). The effect of neem was enhanced when garlic was added. The presence of diallyl disulphide and triallyl trisulphide in garlic by itself possesses insecticidal activity (David and Kumaraswami, 1996; Parmar and Devakumar, 1993).

5.2.3.9 Yield of Black Pepper

The highest yield of 1720.00 kg/ha of dried pepper was obtained from the vines treated with quinalphos 0.05 per cent (Figure 9). The control vines recorded the lowest yield of 932.40 kg ha^{-1}. However an yield of 1026.75 kg ha^{-1} was obtained by Nandakumar *et al.* (1991) when sprayed with quinalphos 0.05 per cent as against control with an average yield of 752.72 kg ha^{-1}. Among the botanical treatments, the maximum yield was from the vines treated with combination of neem seed oil two per cent plus garlic two per cent plus karanja oil one per cent (1598.40 kg ha^{-1}).

The benefit : cost ratio obtained from neem seed oil two per cent plus garlic two percent treatment was the highest (3.20) followed by neem seed oil soap emulsion two per cent plus garlic two per cent plus karanja oil one per cent (3.11) and neem seed oil soap emulsion three per cent plus garlic two per cent (3.10). However quinalphos 0.05 per cent treated vines registered a B: C ratio of 2.60. Nandakumar *et al.* (1991) had obtained a higher B: C ratio of 4.73 from vines treated with quinalphos 0.05 per cent. This could be attributed to lower cost of

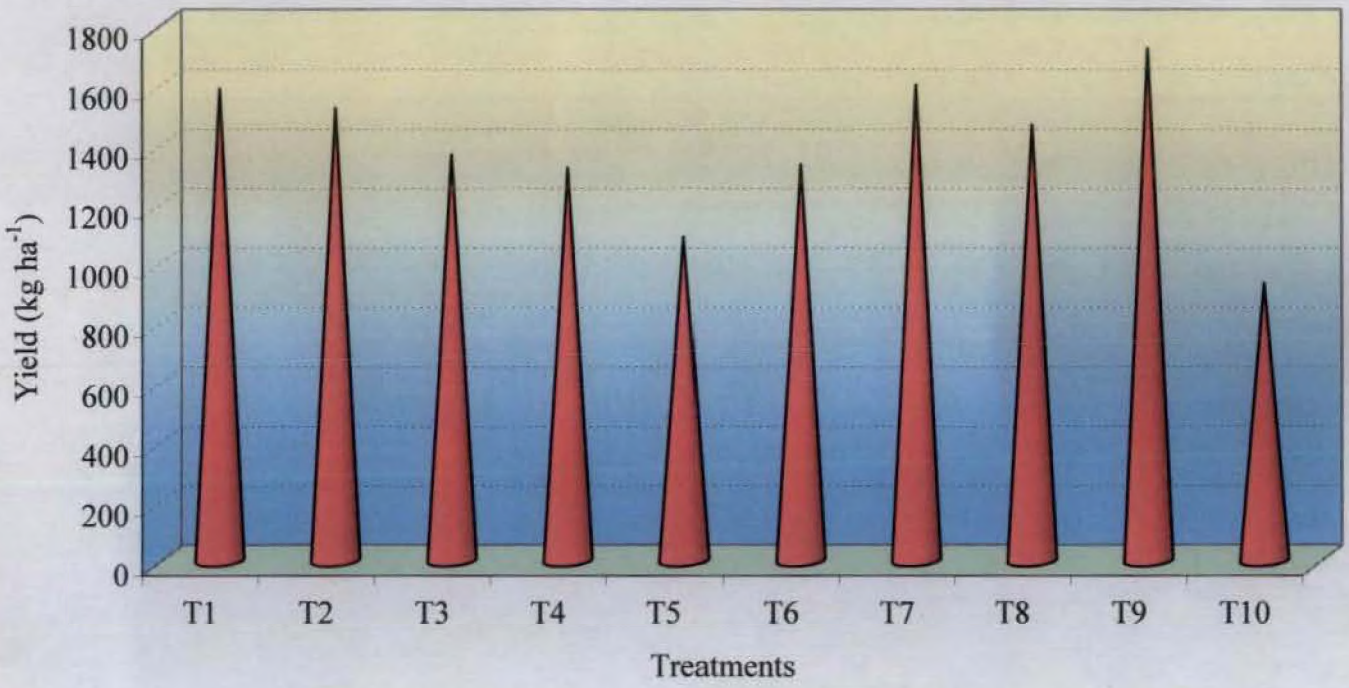


Fig. 9 Effect of different treatments on the yield of black pepper

plant protection measures and comparatively reasonable price for the produce in the late eighties. A fifty per cent increase in value was given to dried pepper from the vines protected by botanicals. Thus eventhough quinalphos treated vines gave a higher yield than botanicals, the benefit : cost ratio was greater from the neem combination treated vines.

Hence it could be concluded that the pests of black pepper could be controlled in an ecofriendly organic mode by the application of either neem oil soap emulsion two per cent plus garlic two per cent (B: C ratio 3: 20) or neem oil soap emulsion two per cent plus garlic two per cent plus karanja oil one per cent (B: C ratio 3: 11). Three sprays of either of the above botanical combinations could be recommended *viz.*, at spike emergence, berry formation and berry maturation stage of the pepper crop.

One way of boosting our pepper export in the global pepper trade would be the export of organic pepper. The government agencies and a few NGOs are in the process of attracting more farmers into organic cultivation of crops. 'Indocert' (Indian Organic Certification Agency), the first indigenous accreditation agency for giving certificate to organic farmers has been constituted in October 2002. Farmers growing pepper would have to wait for at least two years as 'conversion period' to certify as organic growers. In this context, the recommendation on use of botanicals against pests of black pepper will be of benefit to the organic pepper growers.

The study of the chemistry, bioefficacy, toxicity and other relevant information of botanical based pesticides has to be given utmost priority. More research and development on botanicals and their commercialization is required for use in IPM of not only pepper but also other crops. This would go a long way in meeting the domestic demand and improving our export of organic products and earning valuable foreign exchange.

SUMMARY

6. SUMMARY

The present study entitled "Seasonal occurrence and ecofriendly management of pests of black pepper (*Piper nigrum* L.) was conducted during May 2002 to April 2003 in the Instructional Farm, College of Agriculture, Vellayani. The main objectives were to study the seasonal occurrence of the major pests of black pepper and their damage and to evolve suitable ecofriendly pest management practices.

Studies on the seasonal occurrence of pests revealed that the pollu beetle adults were present in the field throughout the year. The population was high from June 2002 to August 2002. However maximum population was observed during the first fortnight of November 2002. From January 2003 onwards, the population declined. There was significant positive correlation between population density of pollu beetle and relative humidity and significant negative correlation with maximum temperature.

The extent of leaf damage by the pollu beetle ranged from 11.00 per cent during first fortnight of May 2002 to 45.90 per cent during second fortnight of November 2002. Significant negative correlation was obtained between leaf damage by pollu beetle and maximum temperature.

The intensity of leaves damaged by pollu beetle was maximum during the first fortnight of December 2002 and minimum during the second fortnight of April 2003. The intensity ranged from 4.00 to 41.30. The intensity of leaf damage was significantly and positively correlated with maximum temperature and negatively correlated to relative humidity.

Spike damage and berry damage by pollu beetle was maximum during the first and second fortnight of February 2003. There was a significant negative correlation between spike and berry damage with minimum temperature.

The highest percentage of leaf damage by leaf gall thrips was recorded during the second fortnight of April 2003 (23.50) and the least damage during first fortnight of September 2002 (8.00). The damage showed significant positive correlation with maximum temperature.

The infestation on vines by scales was the maximum during the second fortnight of April 2003 (28.00 per cent). Scales infested sixteen per cent of the vines over a period of six months from first fortnight of May 2002 to second fortnight of November 2002. The intensity of infestation of scale insects on vines showed significant positive correlation with maximum temperature.

The damage of scales and mealy bugs on spikes was the maximum during the second fortnight of February 2003.The percentage of vines damaged by scales and mealy bugs showed significant negative correlation with minimum temperature.

The results of the field experiment revealed that among the different insecticides tried against different pests at various stages of the pepper crop, quinalphos 0.05 per cent was the best treatment in reducing population of pollu beetle. Among the botanicals, the combination of azadirachtin 0.003 per cent plus karanja oil one per cent treatment was the best during spike emergence (with mean population of 2.59 adults per vine). Neem seed oil soap emulsion two per cent plus garlic two per cent plus karanja oil one per cent was the best during berry formation with a mean count of 1.95 adults per vine and during berry maturation, neem seed oil soap emulsion three per cent plus garlic two per cent with a mean count of 2.96 adults per vine.

The percentage of leaves damaged by pollu beetle was the least in quinalphos 0.05 percent treated vines. Botanical pesticides like neem oil soap emulsion two per cent plus garlic two per cent plus karanja oil one per cent and the two concentrations of neem seed oil *i.e.*, three per cent and two per cent plus two per cent garlic were the next best treatments.

The treatments, neem seed oil soap emulsion three per cent plus garlic two per cent, neem seed oil soap emulsion two per cent plus garlic two per cent and neem seed oil soap emulsion two per cent plus garlic two per cent plus karanja oil one per cent were superior in reducing the damage by pollu beetle on spikes and berries after quinalphos 0.05 per cent. Leaf damage by leaf gall thrips was the lowest in vines treated with combination of neem oil two per cent plus garlic two per cent plus karanja oil one per cent than quinalphos 0.05 per cent during berry formation stage and during berry maturation stage, neem seed oil soap emulsion three per cent plus garlic two per cent offered maximum protection.

The spike damage by scale insects and mealy bugs was the least in quinalphos 0.05 per cent followed by azadirachtin 0.003 per cent plus karanja oil one per cent during berry formation stage. During berry maturation stage, there was no significant variation between any of the treatments and the control.

Quinalphos 0.05 per cent treated vines recorded the highest yield of 1720 kg ha^{-1} dried pepper and control vines the least (932.40 kg ha^{-1}). Among the botanical treatments, combination of neem seed oil soap emulsion two per cent plus garlic two per cent plus karanja oil one per cent recorded maximum yield (1598.40 kg ha^{-1}).

The benefit: cost ratio was highest for the treatment, neem seed oil two per cent plus garlic two per cent (3.20) followed by neem seed oil two per cent plus garlic two per cent plus karanja oil one per cent (3.11).

Three sprays of either of the above botanical combinations, one each at spike emergence, berry formation and at berry maturation stage can be recommended as an ecofriendly pest management strategy in black pepper.

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* Original not seen.

APPENDIX

APPENDIX - I

Weather parameters at Instructional Farm, College of Agriculture, Vellayani from May 2002 to April 2003

Fortnight	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity	Rainfall	Number of rainy days
May I	32.3	25.4	79.15	89.0	7
May II	31.2	24.7	80.8	91.5	8
June I	31.0	24.4	82.7	82.7	8
June II	30.3	24.1	82.1	98.0	6
July I	30.6	24.3	83.0	8.9	3
July II	30.4	23.6	80.5	8.1	4
August I	29.3	23.0	85.0	78.8	11
August II	30.0	23.7	85.4	42.2	3
September I	30.7	23.4	77.8	31.1	3
September II	32.0	23.3	72.4	1.3	1
October I	30.1	23.2	85.0	189.1	11
October II	29.5	23.0	87.9	212.2	11
November I	30.1	23.4	86.6	59.5	9
November II	30.2	23.0	83.7	51.2	4
December I	31.2	22.8	78.6	8.2	1
December II	30.8	21.2	77.6	0	0
January I	31.6	21.9	76.5	0	0
January II	31.4	21.4	74.8	1.6	1
February I	31.9	22.3	76.2	52.0	2
February II	31.6	22.7	78.1	16.3	1
March I	32.1	23.2	76.3	0	0
March II	32.5	23.5	74.4	69.0	2
April I	32.8	24.9	77.6	30.5	4
April II	32.8	24.6	79.5	49.7	3

SEASONAL OCCURRENCE AND ECOFRIENDLY MANAGEMENT OF PESTS OF BLACK PEPPER (*Piper nigrum* L.)

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Abstract of the
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ABSTRACT

Seasonal occurrence of the pests of black pepper was studied in the Instructional Farm, College of Agriculture, Vellayani from May 2002 to April 2003. Pollu beetle adults were present in the field throughout the year. Maximum population was observed during first fortnight of November 2002. There was significant negative correlation between the pollu beetle population and maximum temperature and significant positive correlation with relative humidity.

Leaf damage by pollu beetle was maximum during second fortnight of November 2002. Significant negative correlation was obtained between leaf damage by pollu beetle and maximum temperature. The intensity of leaves damaged was maximum during first fortnight of December 2002. The relationship was significantly positive with maximum temperature and negative with relative humidity.

Spike and berry damage by pollu beetle was maximum during the first and second fortnight of February 2003. There was significant negative correlation between spike and berry damage and minimum temperature.

The top shoot borer damage had a significant negative correlation with maximum temperature and maximum damage was observed during second fortnight of November 2002.

The damage of leaf gall thrips on leaves had significant positive correlation with maximum temperature. Maximum damage on leaves was observed during the month of April 2003.

Intensity of damage by scale insects on vines had significant negative correlation with maximum temperature and maximum damage was observed during first fortnight of April 2002.

Eight botanical pesticides including their combinations were evaluated with quinalphos 0.05 per cent as a check against pests of black pepper in a field experiment in the Instructional Farm, College of Agriculture, Vellayani from May 2002 to February 2003. Three sprays of the treatments were applied one each at spike emergence, berry formation and at berry maturation stage. In general, the treatments were effective and superior to control in containing the pests. Quinalphos 0.05 per cent treatment afforded maximum protection against all the pests of black pepper studied in the trial. Among the botanicals, neem seed oil soap emulsion two per cent plus garlic two per cent plus karanja oil one per cent offered maximum protection followed by neem seed oil soap emulsion at two and three per cent plus garlic two per cent. Clerodendron leaf and flower extract eight per cent was the least effective botanical.

The yield of dried pepper was the maximum in quinalphos 0.05 per cent treated vines followed by neem seed oil soap emulsion two per cent plus garlic two per cent plus karanja oil one per cent and neem seed oil soap emulsion three per cent plus garlic two per cent and neem seed oil soap emulsion two percent plus two per cent garlic.

The benefit : cost ratio was maximum for the treatment, neem seed oil two per cent plus garlic two per cent (3.20) followed by neem seed oil two per cent plus garlic two per cent plus karanj oil one per cent (3.11).

Three sprays of either of the above botanical combinations, one each at spike emergence, berry formation and at berry maturation stage can be recommended as an ecofriendly pest management strategy in black pepper