MANAGEMENT OF PESTS OF AMARANTHUS AND BHINDI USING PLANT EXTRACTS

BY

B. SRINATH

THESIS

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1990

Dedicated to

MY MOTHER

DECLARATION

I hereby declare that this thesis entitled "Management of pests of amaranthus and bhindi using plant extracts" is a bonafied 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 to me of any degree, diploma, associateship, fellowship or other similar titles of any other University or Society.

B. SRINATH

Vellayani,

16-7-1990.

CERTIFICATE

Certified that this thesis entitled "Management of pests of amaranthus and bhindi using plant extracts" is a record of research work done independently by Sri. B. SRINATH under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

Dr. K. SASIDHARAN PILLAI
Chairman, Advisory Committee
Professor of Entomology
College of Agriculture
Vellayani, Trivandrum

Vellayani,
16-7-1990.

Approved by:

CHAIRMAN

Dr. K. SASIDHARAN PILLAI

MEMBERS

Dr. N. MOHAN DAS

Dr.(Mrs.) K. SARADAMMA

Dr.(Mrs.) P. SARASWATHY

EXTERNAL EXAMINER P.C. Sundara Babu

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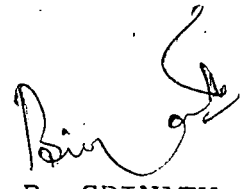

B. SRINATH

Vellayani,

16-7-1990.

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INTRODUCTION

INTRODUCTION

Ecological and toxicological problems posed by the insecticides used for the control of crop pests have been widely felt. Many of the developing countries are importing the synthetic chemicals required for the manufacture of pesticides. The prohibitive rise in the prices of such materials have reflected in the cost of plant protection operations at the farmer level in enormous proportions. Therefore it has become necessary to find out new sources of cheaper and safer materials suited for tackling pest problems. Identifying suitable effective materials which are locally available and liable for easy use will go a long way in employing cheap practices for the management of pests of crops, especially of vegetables in small farms and homesteads.

Plants are known to have allelochemicals which modulate the behaviour of insects by acting as feeding deterrents and growth inhibitors, making them suitable for pest control from the time of application (Jacobson, 1980). A large number of such plants have been identified during the last two decades in many parts of the world. Many plants available in India including the classical example Azadirachta indica Juss (Pradhan et al., 1963) are reported for their pest control potential. Plants

like Annona squamosa Linn. (Tattersfield and Pottery, 1940; Puttarudraiah and Bhatta, 1955), Acorus calamus Linn. (Trehan, 1956), Nerium oleander Linn. and Calotropis procera R.Br. (Puttarudriah and Bhatta, 1955), Ocimum basilicum Linn. (Deshpande and Tipnis, 1977; Pandey et al., 1982), Thevetia thevetiodes Juss. (Atal and Kapur, 1977 and Freedman et al., 1979), Eupotorium odoratum Linn. (Rajamma, 1982), Clerodendron infortunatum Linn. (EI Ghar and EI Sheikh, 1987), Lantana camara Linn. (Kumuda Sukumar, 1988) and Pongamia glabra Vent. (Joshi and Rao, 1968; Nigam, 1977 and Mohanty et al., 1988).

Presence of JH analogues in plants like Ocimum basilicum Linn. (Nishida et al., 1984) and antijuvenile hormones in Ageratum conyzoides Linn. (Bowers, 1976) have made pest control possible with plants products. Identification and isolation of useful plant components which can directly be utilized for pest control as suggested by Radwanski (1980) can be made applicable under the Indian conditions. Based on this approach, plants which were proved to have insect control activity under the bioecological situations and available locally (Saradamma, 1989), eight plants which were more efficient were selected. Feasibility of these plants in practical pest control as their water extracts, the easiest form of formulation, was

studied with the following objectives.

1. Screening the plants for their insect control activity with reference to the pests of amaranthus and bhindi in comparison with a conventional insecticide and an insecticide of plant origin.

2. Augmenting the toxicity of water extracts with additives that can be incorporated easily.

3. Assessing the efficacy of such water extracts in controlling the insect pests of amaranthus and bhindi, its influence on non-target organisms and impact on crop yield in a field experiment with reference to insecticide of plant origin and conventional nature.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

A comprehensive review of the work done on the use of plant extracts for insect control is attempted here.

1.1. Use of neem (*Azadirachta indica* Juss.) against insect pests

Literature on the use of neem against different insect pests are reviewed here.

1.1.1. *Acalymma vittatum* Fabr. (Chrysomelidae)

The deterrency of neem extracts against *A. vittatum* was reported by Pierce (1981) who observed that spraying of 0.1 per cent neem extract on the musk melon seedlings gave good protection for three days. Reed and Reed (1984) also found that the crude formulations of neem seed was effective on musk melon against the striped cucumber beetle.

1.1.2. *Achoea janata* Linn. (Noctuidae)

Ten per cent extract of neem leaves was found effective as feeding deterrent by Chari and Muralidharan (1985).

1.1.3. *Aphis craccivora* Koch. (Aphididae)

Saradamma (1989) observed 100 per cent mortality of *A. craccivora* in the laboratory when sprayed with water extract of *A. indica*.

1.1.3.1. A. gossypii Glover. (Aphididae)

First report of the insecticidal property of neem seed kernel was made by Cherian and Menon (1944) who found that cold extracts of neem seed kernel was efficient as an insecticide and their toxicity increased by addition of soap, against A. gossypii. Asari and Nair (1972) reported neem seed suspension against brinjal aphid effective at field level. In field trials conducted, Saradamma (1989) observed that two per cent benzene extract of A. indica could protect the crop upto 10 days after spraying and it was on par with carbaryl 0.2 per cent.

1.1.4. Amsacta moorei (Butlr.) (Arctiidae)

Larvae of A. moorei was seen to migrate from the plots sprayed with neem kernel suspension to adjoining unsprayed plots (Patel et al., 1968). Antifeedant property of neem kernel extract against A. moorei was also evaluated by Saxena (1982) in a field experiment.

1.1.5. Bagrada cruciferarum Kirk. (Pentatomidae)

Pandey et al. (1981) in experiments on the insecticidal properties of mature drupes of Melia azadirach against painted bug attacking turnip crop observed 100 and 93.33 per cent of mortality at 2 per cent concentration of petroleum ether extract, under laboratory and field

conditions respectively.

1.1.6. Brevinea brassicae Linn. (Aphididae)

Kirpal Singh and Sharma (1985) reported that the neem kernel suspension at 0.2 and 0.4 per cent, oil emulsion at 0.2 and 0.4 per cent and water extract of leaf at 2 per cent exhibited repellent effect and inhibited mean aphid population from 45 to 60 per cent in pot and field trials on cabbage and cauliflower.

1.1.7. Coccidohystrirx insolitus (Gr.) (Pseudococcidae)

In field trials conducted, Saradamma (1989) found that benzene extract of A. indica leaf gave substantial reduction in population of brinjal mealy bug.

1.1.8. Chrotogonus trachypterus Kevan. (Acridiidae)

Sandhugurmel and Darshan Singh (1975) found in the laboratory studies lucern plants sprayed with 2 per cent neem fruit suspension was not fed, while light feeding was observed on leaves treated with neem leaves.

1.1.9. Crocidolomia binotalis Zell. (Pyralidae)

Two per cent neem extract was effective against cabbage web worm in a field experiment (Fagoonee, 1980).

1.1.10. Dysdercus cingulatus (F.) (Pyrrhocoridae)

Saradamma (1989) found that neem leaf extract gave 25 per cent of nymphal mortality and 50 per cent of malformed adults.

1.1.11. Earias vitella Fb. (Noctuidae)

Water extracts of neem seed was reported toxic against 5th instar larvae of E. vitella in the laboratory by Chouhan and Qadri (1989).

1.1.12. Ephestia cautella Walker. (Pyralidae)

Toxicity of neem leaves against E. cautella was reported by Fry and Sons (1938).

1.1.13. Epitrix fuscula Harrow. (Chrysomelidae)

Reed and Reed (1984) reported that crude formulations of neem seed was effective for the control of E. fuscula on aubergene.

1.1.14. Heliothis armigera (Hb.) (Noctuidae)

Kumar and Sangappa (1984) and Srivastava et al. (1984) found that neem seed kernel extract and neem oil were successful in the field for controlling H. armigera but had no significant effect on yields.

1.1.14.1. H. zea (Boddie.) (Noctuidae)

Antifeeding and growth inhibitory activities of chloroform extracts of M. azadirachta on H. zea was reported by Mc.Millan et al. (1969).

1.1.15. Henosepilachna vigintioctopunctata (Fab.) (Coccinellidae)

Saradamma (1989) reported that benzene extract of neem leaves effectively controlled the pest on brinjal on par with carbaryl 0.2 per cent on 7th day after spraying.

1.1.16. Hypera postica Gyll. (Curculionidae)

Insecticidal property of neem leaves was first explored by Chopra (1928) against lucern weevil and recorded 25 per cent larval mortality.

1.1.17. Leptinotarsa decemlineata Linn. (Chrysomelidae)

Reed and Reed (1984) found that crude formulation of neem seed was effective against L. decemlineata on aubergene.

1.1.18. Leucinodes orbonalis Guen. (Pyralidae)

Krishnamurthy Rao (1983) reported that petroleum ether extract of neem at a dilution of 1:100 gave good control of the pest.

1.1.19. Lipaphis pseudobrassi (Kalt.) (Aphididae)

Neem kernel and mixture of soap with kerosene were found efficient in reducing the infestation of mustard aphid and increasing the yields (Kabir and Mia, 1987).

1.1.20. Melonagromyza obtusa M. (Agromyzidae)

Neem kernel extracts gave good control of the pest in field trials as reported by Srivastava et al. (1984).

1.1.21. Nephotettix virescens (Dist.) (Cicadellidae)

Saxena et al. (1987) observed that neem cake applied to soil was, quiet efficient against green leaf hoppers and transmission of tungro virus.

1.1.22. Nilaparvata lugens (Stal.) (Delphacidae)

Rao and Rao (1979) studied the efficacy of neem leaf extract spray at 1.0 per cent concentration against BPH on potted rice seedlings and observed high mortality after 48 hrs of application.

1.1.23. Orseolia oryzae (Wood-Mason) (Cecidomyidae)

Saroja (1986) reported that neem kernel extract, neem cake and neem leaf extract effectively controlled the major rice pests and were superior to phosphamidon @ 500 ml/ha against gall midge.

1.1.24. Pieris brassicae Linn. (Pieridae)

The neem fruit suspension was found effective in controlling cabbage butterfly as reported by Sandhugurmel and Darshan Singh (1975).

1.1.25. Plutella xylostella (L.) (Yponomeutidae)

Steets (1975) reported that neem leaf extract at 2 and 5 per cent concentration killed the pest on beans and cabbage. In field trials conducted, Mongting and Sudderuddin (1978) found alcohol extracts of the neem seed as most toxic to P. xylostella on turnip. Adhikary (1985) conducted field trials with crude methanol extracts, aqueous suspension of seed kernels and leaves of neem and found that crude methanol extracts of neem seed at 2 and 4 per cent was more efficient than the standard insecticides mevinphos and deltamethrin.

1.1.26. Popillia japonica Newn (Scarabaeidae)

Ladd et al. (1978) reported that sessafras and soyabean could be protected from Japanese beetle with aqueous emulsion and alcohol extracts of neem seed.

1.1.27. Rhopalosiphum nympharae (Fitsch) (Aphididae)

Goyal et al. (1971) found neem cake effective for the control of aphids.

1.1.28. Schistocerca gregaria F. (Acridiidae)

Medicago arbora treated with the extract of fresh neem leaves were not fed by S. gregaria upto 7th day (Sergent, 1944). Pradhan et al. (1963) reported that S. gregaria swarms could not feed on crops sprayed with 0.1 per cent neem kernel suspension at the rate of 300-600 l/ha. Goyal et al. (1971) also observed neem cake effective for the control of S. gregaria.

1.1.29. Scirpophaga incertulas Walk. (Pyralidae)

Saroja (1986) reported that neem kernel, neem cake and neem leaf extract were not toxic to rice stem borer.

1.1.30. Selepa docilis Btlr. (Noctuidae)

Toxicity of neem emulsion to leaf roller on aubergine was reported by Cobbinah and Osei-owusu (1988).

1.1.31. Spodoptera frugiperda Fb. (Noctuidae)

Mc. Millan et al. (1969) reported extracts of M. azadirach had the antifeeding and growth inhibitory activities on S. frugiperda.

1.1.32. S. litura Fb. (Noctuidae)

Antifeedant and repellent action of neem kernel extract on tobacco caterpillar was observed by Joshi and

Ramprasad (1975) in laboratory studies. Under field conditions one to five per cent neem seed kernel suspension in water was found as good as fentin acetate (0.0075 per cent) and fentin hydroxide 0.075 per cent. (Joshi et al., 1978). Two per cent aqueous suspension of neem seed kernel was recorded as an ovipositional repellent by Joshi and Sitaramiah (1979). Antifeedant action of neem kernel extract to larvae of S. litura on sweet potato was also reported by Abdul Kareem (1980).

Ramprasad et al. (1987) suggested that tobacco nurseries could be protected against S. litura by using the neem seed suspension. Strong hormonal effects of crude extract of neem leaves to S. litura was reported by Saradamma (1989).

1.1.33. Trichoplusia ni (Hubner) (Noctuidae)

Reed and Reed (1984) reported that crude formulation of neem seed protected musk melon in field trials against T. ni.

1.1.34. Urentius echinus (Rict.) (Tingidae)

Cherian and Menon (1944) observed cold extracts of neem seed kernel efficient for control of the pest and toxicity of neem emulsion was reported by Cobbinah and Osei-owusu (1988).

1.2. Use of yellow oleander (Thevatia spp. Juss) against insect pests

1.2.1. Acalymma vittatum Fabr. (Chrysomelidae)

Reed et al. (1981) studying the antifeedant property of 350 natural products and reported that neriiforin (T. thevetiodes) was most effective against A. vittatum.

1.2.2. A. craccivora Koch. (Aphididae)

In the laboratory trial to evaluate the insecticidal properties of plants extracted with different solvents, Saradamma (1989) found that water extract of T. neriifolia leaves produced 88.08 per cent of mortality of the aphids.

1.2.2.1. A. gossypii Glover (Aphididae)

Saradamma (1989) reported the contact toxicity of benzene extract and water extracts of yellow oleander leaves to brinjal aphid and was effective in protecting to the crop in the field.

1.2.3. Henosepilachna vigintiotopunctata (Fab.) (Coccinellidae)

Leaf extract of T. neriifolia was found toxic to epilachna beetle in brinjal and bittergourd by Saradamma (1989).

1.2.4. Ostrina nubilalis (Hb) (Pyralidae)

Mc. Laughlin et al. (1980) reported that ethanol extract of mexican yellow oleander seeds T. thevetiodes was lethal to European Corn borer producing 100 per cent larval mortality when incorporated into its diet.

1.3. Use of Clerodendron spp Linn. against insect control

1.3.1. A. gossypii Glover (Aphididae)

Saradamma (1989) observed reduction in population of aphids in brinjal when sprayed with two per cent benzene extract of C. infortunatum.

1.3.2. Cylas formicarius F. (Curculionidae)

Leaves of C. infortunatum incorporated into the soil at 5000 kg/ha one week prior to planting of sweet potato vines reduced in the infestation by sweet potato weevil (Rajamma, 1982).

1.3.3. D. cingulatus (F.) (Pyrrhocoridae)

In the laboratory studies, Saradamma (1989) found that water extracts of C. infortunatum produced 6.84 and 22.72 per cent nymphal mortality upto fifth and five days after spraying respectively and 22.72 per cent of test insects emerged as malformed adults.

1.3.4. H. vigintioctopunctata Fab. (Coccinellidae)

Benzene extract of C. infortunatum at two per cent concentration controlled epilachna beetle on bittergourd, was on par with carbaryl 0.2 per cent upto two weeks after treatment (Saradamma, 1989).

1.3.5. S. litura Fb. (Noctuidae)

Laboratory studies by Hosozawa et al. (1974) revealed that as 1 per cent ether extract of C. fragrans gave 80-100 per cent protection from third instar larvae of S. litura.

1.4. Use of oleander (Nerium oleander Linn.) against insect pests

1.4.1. A. gossypii Glover (Aphididae)

Saradamma (1989) reported that two per cent benzene extract of nerium leaves reduced the population of brinjal aphid significantly.

1.4.2. D. cingulatus (F.) (Pyrrohocoridae)

Water extracts of dried nerium leaves was found to have hormonal activity on red cotton bug (Saradamma, 1989).

1.4.3. S. litura Fb. (Noctuidae)

Two per cent water extract of leaf produced 10 and 20 per cent of test population as malformed and dead pupae

respectively found by Saradamma (1989) in laboratory studies.

1.4.4. S. gregaria F. (Acridiidae)

Chandra and Thapar (1985) reported nerium as a deterrent, when the maize leaves were sand wiched with a paste made by crushing the leaves of kaner while one per cent aqueous suspension was ineffective.

1.5. Use of eupatorium (E. odoratum Linn.) against insect pests

1.5.1. Cylas formicarius F. (Curculionidae)

Rajamma (1982) observed that the infestation by sweet potato weevil was reduced by the incorporation of eupatorium leaves into the soil prior to planting.

1.5.2. C. insolitus (Gr.) (Pseudococcidae)

Benzene extract of two per cent eupatorium leaves was found effective to brinjal mealybug by Saradamma (1989).

1.6. Use of custard apple (Annona squamosa Linn.) against insect pests

Puttarudraiah and Bhatta (1955) reported the insecticidal properties of custard apple.

1.6.1. Dactynotus carthami HRL. (Aphididae)

Alcohol extracts of A. squamosa was found useful

against safflower aphid by Deshmukh and Borle (1975).

1.6.2. Nephotettix virescens (Dist.) (Cicadellidae)

Mariappan and Saxena (1983) reported custard apple oil effective against rice green leaf hopper and reduced the incidence of rice tungro virus disease.

1.6.3. Nilaparvata lugens (Stal.) (Delphacidae)

Toxicity was enhanced against BPH when neem oil and custard apple oil was combined at 2:1 ratios (Reguraman et al., 1988).

1.6.4. S. litura Fb. (Noctuidae)

Deshmukh and Borle (1975) found that alcohol extracts of A. squamosa had effective to the tobacco caterpillar.

1.7. Use of Pongamia spp Vent. against insect control

1.7.1. Diacrisia obliqua Walk. (Arctiidae)

Mohanty et al. (1988) reported antifeedant action of seed extracts of P. pinnata against D. obliqua.

1.7.2. Holotrichia consanguinea Blanch. (Melolonthinae)

Karanjan cake was found toxic to white grubs by Nigam (1977).

1.7.3. Mesomorphus villiger (Blanch) (Tenebrionidae)

Joshi and Rao (1968) reported that cake of P. glabra

at 1, 5 or 10 g was effective to control M. villiger on tobacco seedlings under field conditions.

1.7.4. N. virescens (Dist.) (Cicadellidae)

P. pinnata was found more effective than neem oil in reducing the field population of leaf hoppers and transmission of virus (Mariappan et al., 1988).

1.7.5. Opatroides frater F. (Tenebrionidae)

In a field trial Joshi and Rao (1968) reported pongamia cake efficient for the control of the pest of tobacco seedlings.

1.7.6. Scleron latipes (Quen.) (Tenebrionidae)

Insecticidal activity of pongamia cake against S. latipes was observed by Joshi and Rao (1968).

1.7.7. S. litura Fb. (Noctuidae)

Srimanarayana et al. (1988) reported that antifeedant activity of Karanjin cake and seed extract of P. glabra against S. litura ranged from 73.33 to 86.88 per cent.

1.8. Use of extract of Calotropis gigantea R.Br against insect pests

1.8.1. S. gregaria F. (Acridiidae)

Rao and Mehrotra (1977) found that benzene and water

extracts and also alkaloid fractions of the leaves of C. gigantea were having deterrent action on S. gregaria.

1.9. Use of extract of Ageratum conyzoides Linn. against insect pests

1.9.1. Pthorimaea operculella (Zell.) (Gelechiidae)

Laboratory tests by Pandey et al. (1982) showed that two per cent leaf extract was effective against fifth instar larvae of potato tuber moth.

1.10. Use of extract of Argimone mexicana against insect pest

1.10.1. Bagrada cruciferarum Kirk (Pentatomidae)

Pandey et al. (1981) reported that petroleum ether extract of A. mexicana gave 86.66 and 56.66 per cent mortality of B. cruciferarum in the laboratory and field experiments respectively.

1.11. Use of Tulsi (Ocimum spp L.) against insect pests

1.11.1. D. obligua Wlk. (Arctiidae)

Srivastava and Pandey (1983) observed that seed extract of O. sanctum and O. basilicum produced 100 and 85 per cent of larval mortality respectively.

1.11.2. Dysdercus sp F. (Pyrrhocoridae)

While screening certain plants for their juvenile

hormone like activity to red cotton bug Gopalan and Madhusudhan (1981) found that leaves and stem extracts of O. basilicum were having active principles to Dysdercus sp.

1.11.3. H. armigera (Hb.) (Noctuidae)

Pandey et al. (1983) observed 51.11 to 90 per cent mortality of pod borer larvae with seed extracts of O. basilicum.

1.11.4. P. operculella (Zell.) (Gelechiidae)

O. basilicum seed extracts were also toxic to potato tuber moth (Pandey et al., 1982).

1.11.5. S. litura F. (Noctuidae)

Juvenile hormone property of leaf and stem extracts of O. basilicum on tobacco caterpillar was reported by Gopalan and Madhusudhan (1981).

1.12. Use of sweet flag (Acorus calamus L.) against insect pests

1.12.1. A. gossypii Glover. (Aphididae)

Pandey et al. (1983) observed that 72 hrs after treatment with petroleum ether extracts of rhizomes of A. calamus at varying concentrations produced more than 45 per cent mortality on aphids.

1.12.2. H. armigera (Hb.) (Noctuidae)

Pandey et al. (1983) evaluated the efficacy of some insecticides of plant origin to gram caterpillar and found that A. calamus was effective in minimising the population of H. armigera.

1.12.3. P. operculella (Zell.) (Gelechiidae)

Two per cent extract of rhizomes was reported toxic to fifth instar larvae of potato tuber moth by Pandey et al. (1982).

MATERIALS AND METHODS

MATERIALS AND METHODS

2.1. Evaluation of aqueous leaf extracts for the insect control activity

Water extracts of eight plants viz., Azadirachta indica Juss, Thevatia neriifolia Juss, Clerodendron infortunatum (Linn), Nerium oleander (Linn), Eupatorium odoratum (Linn), Annona squamosa (Linn), Pongamia glabra (Vent) and Calotropis gigantea (R.Br) were evaluated against the pests of amaranthus and bhindi in a pot culture experiment.

2.1.1. Preparation of water extract

2.1.1.1. Collection of leaves from the test plants

Approximately 5 kgs of fresh green leaves of each plant, excluding tender and senile ones collected from the Instructional Farm, College of Agriculture, Vellayani, were used for the preparation of water extracts.

2.1.1.2. Preparation of leaf powder

The leaves were thoroughly washed with water to remove dirt and dried in a room at room temperature with frequent raking for 10 to 15 days, till the leaves become brittle. The dried leaves were finely ground in an electric grinder.

2.1.1.3. Method of extraction

Eighty g of leaf powder of each test plant was put in muslin cloth bag and soaked in 1000 ml of water contained in a cylindrical jar for 24 hrs. The cloth bag was then squeezed repeatedly for draining off the solution completely. The extracts were filtered through cheese cloth and the volume was made upto one litre. This aqueous suspension was treated as 8 per cent (W/V) stock extract of plant material and was serially diluted to obtain solutions of two and four per cent concentrations required for the different experiments.

2.1.2. Experimental design

The experiment was conducted using a completely randomised design with three replications and nineteen treatments involving eight plants at two concentrations (2 and 4 per cent) tobacco decoction as per the recommendations in Kerala Agricultural University package of practices (1989), carbaryl 0.2 per cent spray as the insecticide standard and water spray as control were used.

2.1.3. Evaluation of plant extracts against pests of amaranthus

The evaluation was made in a pot culture experiment using completely randomised block design.

2.1.3.1. Raising amaranthus in pots

Pots of size 30 x 30 cm were filled with potting mixture of 1:1:1 proportion of soil, cowdung and sand. Twenty five day old amaranthus seedlings (variety - Kannara local) were transplanted at the rate of three seedlings per pot. The crop was raised following the recommendations in the package of practices of Kerala Agricultural University (1989).

2.1.3.2. Monitoring pest population in amaranthus

The number of P. basalis larvae present in the webbings were recorded at weekly intervals.

2.1.3.3. Application of plant extracts

Water extracts of the plants were sprayed when the pest population caused significantly visible injury. Thorough spraying was made using a pneumatic Knapsack sprayer of 9 l capacity to the run off point.

2.1.3.4. Assessment of results

Pretreatment counts just before the spraying and post treatment counts two days after spraying and thereafter at seven day intervals were recorded. The data were analysed using analysis of covariance technique with covariate as pretreatment counts.

2.1.4. Evaluation of plant extracts against pests of bhindi

The evaluation was done in a pot culture experiment using completely randomised design.

2.1.4.1. Raising bhindi crop in pots

Pots were prepared as described in para 2.1.3.1. In each pot four bhindi seeds (variety - Vellayani local) were sown and the crop was raised adopting the package of practice recommendations of Kerala Agricultural University (1989).

2.1.4.2. Monitoring insect population in potted plants

Pest population was recorded at five day intervals.

2.1.4.2.1. Bhindi aphid Aphis gossypii (Aphididae)

The aphid population was recorded from six square cm area from the second, third and fourth leaves from the tip of the plant.

2.1.4.2.2. Bhindi jassids Amrasca biguttula biguttula (Cicadellidae)

The jassid population was recorded following the procedure described by Krishnaiah et al. (1979). Counting the jassids in the second, third and fourth leaves from the tip of plant.

2.1.4.2.3. Shoot and fruit borer Earias vitella (Noctuidae)

Damage due to E. vitella was assessed by counting the total shoots and infested shoots. Damage due to boring was assessed in terms of the total number of fruits and fruits damaged at each observation.

2.1.4.2.4. Natural enemies of insect pests

Plants were examined for the predator beetle Chilomenus sexmaculata and number was recorded. The parasitised life stages of the pests were reared in the laboratory and emerging parasites were recorded daily.

2.1.4.3. Application of plant extracts

Water extracts of the plants were sprayed when the pest population attained a level that caused visible damage as mentioned in para 2.1.3.3.

2.1.4.4. Assessment of results

Pretreatment and post-treatment counts of A. gossypii, S. biguttula biguttula, E. vitella and C. sexmaculata were recorded at two days after treatment and thereafter at five day intervals. The data were analysed as described in para 2.1.3.4 and the treatments significantly superior controlling the pests were selected for further studies.

2.2. Augmentation of toxicity of plant extracts by the use of additives

Water extracts of five plants found from effective in the previous experiments viz., Neem, Thevetia, Clerodendron, Nerium and Eupatorium at 2, 4 and 8 per cent concentrations (W/V) were mixed with 1 and 2 per cent of teepol, 1 and 2 per cent coconut oil and 0.4 per cent soapwater and tested against Spodoptera litura and Aphis gossypii in the laboratory.

2.2.1. Rearing of test insects

2.2.1.1. S. litura (Noctuidae)

Larvae of S. litura collected from the Instructional Farm, College of Agriculture, Vellayani were reared in the laboratory on castor leaves in glass troughs of 30 cm width. The adults emerged were provided with honey solution in cotton pad and allowed to mate in round glass jars. Castor leaves were provided in the jars for egg laying. Eggs were collected daily and transferred to separate glass troughs for hatching. The newly hatched larvae were fed with fresh castor leaves till the fourth instar stage which were used for the experiment.

2.2.1.2. A. gossypii (Aphididae)

Adults of A. gossypii were collected from bhindi

plants in the field and reared on bhindi shoots, the cut ends of which were dipped in water contained in small bottles to maintain the turgidity of leaves. The cylindrical glass troughs in which the culture was maintained were covered with muslin cloth. Fresh shoots were replenished as and when required. Aphids in the penultimate instars, were collected from the culture for the experiment.

2.2.2. Preparation of stock solutions

2.2.2.1. Water extracts of plants

Sixty g of leaf powder of each test plant was extracted in 300 ml of water as described in para 2.1.1.3 and the volume was made upto 300 ml, to obtain 20 per cent extract which were used as the stock extract.

2.2.2.2. One per cent teepol

Ten g of teepol was thoroughly mixed with 90 ml of water.

2.2.2.3. Four per cent soap water

Four g of ordinary bar soap was sliced and dissolved in 96 ml water and made upto 100 ml.

2.2.2.4. Coconut oil

Coconut oil obtained from the market was used and was treated as 100 per cent pure.

2.2.3. Preparation of spray solutions

Materials used for preparing twenty five ml of different spray solutions for different treatment combinations were prepared using calculated quantity of plant extracts of different concentrations and additives.

2.2.4. Application of spray solutions on the test insects

2.2.4.1. S. litura

One ml of each solution was sprayed topically from potter's tower on ten newly moulted fourth instar larvae of S. litura taken in clean petridishes, which formed one replication. Ten larvae sprayed with water were kept as control. The treated larvae under each replication were then transferred to glass chimney placed over petridish provided with fresh castor leaves. The open end of the chimney's were covered with muslin cloth. Three replications were maintained for each treatment.

2.2.4.2. A. gossypii

Ten aphids of penultimate instars were applied with each treatment as in para 2.2.4.1. and were then transferred to fresh tender leaves of bhindi kept in glass chimney's by using camel hair brush and allowed to feed as mentioned in para 2.2.1.2. Three replications were maintained for each treatment.

2.2.5. Assessment of results

2.2.5.1. S. litura

All the treated larvae were kept under observation for 24 hrs after spraying and thereafter at 48 hrs interval until they died or emerged as adults/adultoids. Larval mortality, larval pupal mosaic, pupal mortality and adults malformation were recorded and the data were subjected to statistical analysis.

2.2.5.2. A. gossypii

Mortality of aphids was recorded after the first 24 hrs and then at 48 hrs intervals. The data were subjected to statistical analysis.

2.3. Efficacy of selected plant extracts in the management of pests of amaranthus and bhindi in the field

Field experiment was conducted to evaluate the efficacy of selected plant extracts added with the additive seen more effective in the laboratory trial.

2.3.1. Experiment site

The experiment was laid out in the Instructional Farm, College of Agriculture, Vellayani in the summer rice fallow during the month of February to May 1990.

2.3.2. Amaranthus

2.3.2.1. Raising nursery

Seeds of amaranthus (variety - Kannara local) obtained from the Instructional Farm were used for raising the seedlings in nursery. Twenty five day old seedlings were transplanted in the main field.

2.3.2.2. Preparation of the experiment field

The experimental area was ploughed well and weeds were removed. Clods were broken to get a fine tilth and the field was levelled.

2.3.2.4. Layout

The experiment was laid out adopting a randomised block design with 15 treatments and three replications. Each plot had a whole plot size of 2.16 sq mts (1.8 x 1.2 m) with a net plot size of 0.72 sq mts leaving one row of plants on all sides and the plant population in net plot area was 12.

2.3.2.5. Raising the crop

Twenty five day old amaranthus seedlings were transplanted at a spacing of 30 x 20 cm. All the crop husbandry operations (except plant protection) were carried

out as per the package of practices recommended by the Kerala Agricultural University (1989).

2.3.3. Bhindi

2.3.3.1. Layout

The experiment was laid out adopting a randomized block design with 15 treatments and three replications. The whole plot size was 4.32 sq mts (2.4 x 1.8 m) with a net plot size of 1.44 sq mts having eight plants in the net plot.

2.3.3.2. Raising the crop

The crop was raised in shallow trenches with a spacing of 45 cm between plants and 60 cm between rows. Two seeds per pit (twelve seeds/row) were dibbled and fifteen days after germination one healthy plant per pit was retained (six in each row) and other removed. All cultural operations suggested in package of practices (1989) of the Kerala Agricultural University for raising bhindi were followed excluding the plant protection measures.

2.3.4. Treatments

Aqueous extracts of neem, thevatia, and clerodendron at 2 per cent and 4 per cent concentrations and the extracts in combination with 0.4 per cent soapwater were tried in

comparison with carbaryl 0.2 per cent (as a standard insecticide), tobacco decoction (as a standard insecticide of plant origin) and water spray (as control).

2.3.5. Preparation of stock solutions

2.3.5.1. Plant extracts

Two hundred and forty g of leaf powder of each test plant was extracted in three litres of water following the procedure described in para 2.1.1.3. The volume was made upto 3000 ml and obtained the stock extracts of 8 per cent concentration.

2.3.5.2. Soapwater

Sixty g of bar soap was dissolved in water as mentioned in para 2.2.2.3 and the volume was made upto one litre for obtaining six per cent stock solution.

2.3.6. Preparation of spray solutions

Carbaryl 0.2 per cent spray solution was prepared by mixing 8 g of 50 per cent W.D.P. obtained from Rhone-Poulene Agrochemicals (India) Ltd., in water and volume was made upto 2 l.

Tobacco decoction was prepared as per the package of practices recommended by the Kerala Agricultural University (1989).

2.3.7. Application of spray solutions

The spray solutions were applied in the respective plots using a pneumatic hand compression sprayer of nine l capacity when the pest population caused injury at visible levels. Screens were provided around the plots to prevent contamination through drift. A thorough and uniform coverage of plant parts was ensured.

2.3.8. Assessment of results

2.3.8.1. Amaranthus grasshopper Attractomorpha crenulata (Acriididae)

Early stage of the crop was damaged by grasshoppers. The leaf area damaged in four plants, selected at random, from the net plot area was observed. The intensity of damage was scored on the scale given below:

Scale	Per cent damage	Score
1	1-20	10
2	21-40	30
3	41-60	50
4	61-80	70
5	81-100	90

The middle values of scale were taken as the score values. The number of leaves damaged in 4 plants was recorded and were grouped in different scores. The number

of damaged leaves under each score was multiplied with corresponding score value. This value was then divided by the total number of damaged leaves. The derived figure was taken as the index of leaf damage in a plot. The data were then subjected to statistical analysis.

2.3.8.2. Leaf webber Psara basalis (Pyralidae)

Population of P. basalis larvae was recorded at weekly intervals by counting the larvae in the leaf folds. Four plants were selected at random from each plot for observation. Weight of the damaged leaves at harvest was also collected and the data were subjected to statistical analysis.

2.3.8.3. Yield

Weight of plants after removing the damaged leaves if any was recorded at harvest, data were subjected to statistical analysis.

2.3.9. Collection of data in bhindi

2.3.9.1. Bhindi grasshopper A. crenulata (Acrididae)

Four plants at the middle of the experimental plot, which formed the observation unit were observed and intensity of leaf damage was calculated as explained in para 2.3.8.1. The data were subjected to statistical analysis.

2.3.9.2. Bhindi aphids A. gossypii (Aphididae)

The incidence of A. gossypii on four plants in the observation unit of each plot was recorded as described in para 2.1.4.2.1.

2.3.9.3. Leaf hoppers A. biguttula biguttula (Cicadelidae)

Data on leaf hopper infestation were collected from four plants in net plot area as mentioned in para 2.1.4.2.2.

2.3.9.4. Sylepta derogata (Pyralidae) on bhindi

Number of leaf rolls with the larvae were recorded from four plants selected at random from the net plot area of each plot.

2.3.9.5. Shoot and fruit borer E. vitella (Noctuidae) of bhindi

Observation unit consisted of 8 plants in the net plot area. Fruits harvested from each plot at five day intervals were sorted out as damaged and healthy and the number and weights were recorded. The data were subjected to statistical analysis.

2.3.9.6. Natural enemies of insect pests

Observations were recorded from four plants in the net plot area as described in para 2.1.4.2.4 and subjected to statistical analysis.

2.3.9.7. Yield

The yield obtained from each net plot at 5 day intervals were recorded and the data were statistically analysed.

RESULTS

RESULTS

3. Results of different experiments carried out with a view to ascertaining the feasibility of controlling vegetable pests with plant extracts are presented in this chapter.

3.1. Evaluation of water extracts for insect control activity

3.1.1. Effect of plant extracts on amaranthus leaf webber *P. basalis*

Data relating to the experiment were subjected to statistical analysis and presented in Table 1.

At two days after spraying (DAS) the mean larval population was least in plants treated with carbaryl 0.2 per cent (1.05) followed by *T. neriifolia* four per cent (3.42) and two per cent (4.92) and *C. infortunatum* 4 per cent (5.72) in descending order. Tobacco decoction and other extracts were on par with control (9.62).

On 7th day also carbaryl 0.2 per cent (0.10) was more efficient than the plant extracts followed by *T. neriifolia* 4 per cent (2.06), *E. odoratum* 4 per cent (3.73), *C. infortunatum* 4 per cent (4.05) and *T. neriifolia* 2 per cent (4.21) in their order of efficacy. *E. odoratum* 2 per cent (6.08), *A. indica* 4 per cent (6.56) were inferior to the above superior to other treatments including control.

Table 1. Mean larval population of amaranthus leaf webber P. basalis observed at different intervals after spraying and the yield

Treatments	Mean number of larvae observed at different periods after spraying (days)			Mean*	Mean yield (gms/pot)*
	2	7	14		
A. indica extract 2 per cent	7.45 (2.90) ab	7.15 (2.85)bcd	6.79 (2.79)abcdef	6.66 (2.58)f	140 ef
" 4 per cent	7.66 (2.94)ab	6.56 (2.74)cde	4.91 (2.43)def	5.18 (2.27)g	141.7 ef
T. neriifolia extract 2 per cent	4.92 (2.43)cd	4.21 (2.28)efg	5.22 (2.49)cdef	4.86 (2.20)g	160 fg
" 4 per cent	3.42 (2.10)d	2.06 (1.78)g	1.79 (1.67)g	2.60 (1.61)h	171.7 g
C. infortunatum extract 2 per cent	8.20 (3.03)a	7.05 (2.83)bcd	6.78 (2.79)abcdef	6.81 (2.61)f	135.7 def
" 4 per cent	5.72 (2.59)bc	4.05 (2.24)efg	4.34 (2.31)efg	4.70 (2.17)g	143.3 fg
N. oleander extract 2 per cent	8.04 (3.00)ab	9.67 (3.26)abc	9.68 (3.26)a	10.11 (3.18)ab	94 a
" 4 per cent	8.80 (3.12)a	10.15 (3.33)ab	9.08 (3.17)abc	8.14 (2.85)de	96.3 a
E. odoratum extract 2 per cent	9.60 (3.25)a	6.08 (2.66)def	5.46 (2.54)bcdef	7.66 (2.77)ef	127.3 bcd
" 4 per cent	7.33 (2.88)ab	3.73 (2.17)fg	3.48 (2.11)fg	5.39 (2.32)g	125 cd
A. squamosa extract 2 per cent	9.59 (3.25)a	11.05 (3.47)a	9.99 (3.31)a	9.50 (3.08)abcd	102.7 ab
" 4 per cent	9.03 (3.16)a	7.36 (2.89)abcd	8.03 (3.00)abcde	8.44 (2.91)de	105.0 ab
P. glabra extract 2 per cent	8.49 (3.07)a	10.11 (3.33)ab	8.55 (3.09)abcd	10.22 (3.20)ab	95.3a
" 4 per cent	8.83 (3.13)a	10.22 (3.34)ab	10.22 (3.34)a	8.88 (2.98)bcde	120 bc
C. gigantea extract 2 per cent	8.23 (3.03)a	9.98 (3.31)abc	9.27 (3.20)abc	8.55 (2.92)cde	105 ab
" 4 per cent	8.05 (3.00)ab	10.36 (3.37)ab	9.36 (3.21)ab	9.87 (3.14)abc	101.7 a
Tobacco decoction	9.58 (3.24)a	10.26 (3.35)ab	8.16 (3.02)abcd	9.06 (3.01)bcd	106.7 ab
Carbaryl 0.2 per cent	1.05 (1.44)e	0.10 (0.95)h	0.33 (0.82)h	0.63 (0.80)i	173.3 g
Control	9.62 (3.25)a	10.60 (3.40)ab	9.64 (3.26)a	10.64 (3.26)a	90 a
CD	0.386	0.503	0.612	**	**

Figures in parentheses are transformed values $\sqrt{x}$

Means in columns followed by the same letter are not significantly different at 5% level

*Data compared by DMRT: rest of the data were subjected to analysis of covariance

On 14th DAS carbaryl 0.2 per cent (0.33) continued to be more efficient than leaf extracts, four per cent extract of T. neriifolia with a mean population of 1.79 ranked next on par with 4 per cent E. odoratum (3.48) and 4 per cent C. infortunatum (4.34). Plants treated with A. indica 4 per cent, T. neriifolia 2 per cent and E. odoratum 2 per cent had a mean population of 4.91, 5.22 and 5.46 respectively, and were intermediate in efficacy compared with the mean population of 9.64 in the control pot.

The mean population computed for the entire crop season was least in pots treated with carbaryl 0.2 per cent (0.63) and it was followed by 4 per cent extract of T. neriifolia (with larval population 2.60), C. infortunatum 4 per cent (4.70), T. neriifolia 2 per cent (4.86), A. indica 4 per cent (5.18) and E. odoratum 4 per cent (5.39). A. indica 2 per cent, C. infortunatum 2 per cent and E. odoratum 2 per cent had a mean population of 6.66 to 7.66 which were significantly superior to the remaining treatments. A. squamosa 2 per cent, C. gigantea 4 per cent, N. oleander 2 per cent and P. glabra 2 per cent were in efficient in reducing the pest population, and rest of the treatments viz. N. oleander 4 per cent, A. squamosa 4 per cent, C. gigantea 2 per cent, P. glabra 4 per cent and

tobacco decoction were superior to control.

The mean leaf yield obtained was highest in pots treated with carbaryl 0.2 per cent, extract of T. neriifolia 4 per cent, T. neriifolia 2 per cent and C. infortunatum 4 per cent (173.33, 171.67, 160.00 and 143.33 g respectively). Tobacco decoction, C. gigantea 2 per cent, A. squamosa 4 and 2 per cent; N. oleander 4 per cent and 2 per cent, C. gigantea 4 per cent and P. glabra 2 per cent, were on par with control and mean leaf yield varied from 106.67 to 90 g. The leaf yield of remaining treatments were significantly more than the control.

3.1.2. Evaluation of plant extracts against pests of bhindi

3.1.2.1. Effect of plant extracts on A. gossypii

Data collected on the mean aphid population (Table 2) revealed that carbaryl 0.2 per cent followed by tobacco decoction and T. neriifolia were more efficient treatments which reduced the mean aphid population to 35.52, 52.14 and 55.79 respectively. The remaining treatments except T. neriifolia 2 per cent (68.08), A. indica 4 per cent (93.66) and 2 per cent (96.52) were ineffective and on par with control (139.39) with mean population varying from 110.29 to 133.91. On 5th DAS a similar trend was observed with carbaryl 0.2 per cent, tobacco decoction and

T. neriifolia 4 per cent. The mean population in pots treated with A. indica 4 per cent (53.01) and 2 per cent (61.24) were on par with that T. neriifolia 2 per cent (52.41), followed by C. infortunatum 4 per cent (81.59). Other treatments had no significant difference with control. Efficacy of carbaryl 0.2 per cent, tobacco decoction and T. neriifolia 4 per cent continued on 10th day after spraying also. The pattern of aphid population in other treatments were similar to those in the previous observation. On 15th day after spraying no treatment was superior to control and the mean population ranged from 68.97 under N. oleander 4 per cent to 107.59 under C. infortunatum 4 per cent.

Two days after second spraying T. neriifolia 4 per cent with mean aphid population of 48.25 was ranked next to carbaryl 0.2 per cent (24.30). It was also on par with tobacco decoction (53.06) and T. neriifolia 2 per cent (56.68). The highest mean aphid population was recorded under A. squamosa (89.32) and it did not show significant variation with the rest of the treatments. On 5th day after second spraying the least mean population (13.21) was under carbaryl 0.2 per cent followed by tobacco decoction (28.55) and T. neriifolia 4 per cent (30.00). T. neriifolia 2 per cent (41.25), A. indica 4 per cent

Table 2. Mean population of bhindi aphids A. gossypii at different intervals after spraying

	Mean population of aphids observed (per 6 cm^2 leaf) at different intervals after treatment												
	days after first spraying				days after second spraying				days after third spraying				
	2	5	10	15	2	5	10	15	2	5	10	15	Mean*
A. indica extract 2 per cent	96.52 (9.88)c	61.24 (7.89)d	51.15 (7.23)c	99.75 (10.04)	69.77 (8.41)bc	57.60 (7.66)b	52.95 (7.35)abc	45.92 (6.85)bcd	32.82 (5.82)abc	26.77 (5.27)ab	20.30 (4.62)a	12.34 (3.65)abcde	49.22 (7.02)g
" 4 "	93.66 (9.73)c	53.01 (7.35)d	40.45 (6.44)c	89.60 (9.52)	62.10 (7.94)cd	54.99 (7.48)b	43.47 (7.03)bc	43.87 (6.70)bcd	27.27 (5.32)bcd	17.91 (4.35)cde	11.55 (3.54)bcd	8.82 (3.13)cdef	43.73 (6.61)h
T. periifolia extract 2 "	68.08 (8.31)d	52.41 (7.31)d	39.04 (6.33)cd	96.30 (9.86)	56.68 (7.59)de	41.25 (6.50)c	29.99 (5.57)d	41.77 (6.54)bcd	32.38 (5.78)abc	19.11 (4.48)bcde	11.61 (3.55)bcd	5.15 (2.48)fgh	38.46 (6.20)i
" 4 "	55.79 (7.54)e	35.15 (6.02)e	24.63 (5.07)d	91.96 (9.64)	48.25 (7.02)e	30.00 (5.57)d	25.98 (5.19)d	41.33 (6.51)bcd	19.18 (4.49)e	15.27 (4.03)e	9.22 (3.20)d	2.54 (1.88)gh	33.53 (5.79)j
C. infortunatum extract 2 "	128.48 (11.39)ab	103.17 (10.21)b	95.23 (9.81)ab	103.59 (0.23)(	77.32 (8.85)ab	70.44 (8.45)a	55.94 (7.55)abc	40.32 (6.43)bcd	39.06 (6.33)a	24.95 (5.09)abcd	17.39 (4.29)ab	9.08 (3.18)bcdef	67.24 (8.20)abc
" 4 "	110.29 (10.97)b	81.59 (9.09)c	86.71 (9.37)ab	107.59 (10.42)	80.51 (9.03)ab	69.78 (8.41)a	52.09 (7.29)abc	42.25 (6.58)bcd	34.41 (5.95)ab	17.05 (4.25)cde	12.88 (3.73)abcd	6.38 (2.72)efg	55.84 (7.47)f
N. Oleander extract 2 "	125.96 (11.28)ab	119.11 (10.96)ab	93.02 (9.70)ab	80.75 (9.04)	80.73 (9.04)ab	76.34 (8.79)a	55.34 (7.51)abc	39.32 (6.35)bcd	35.95 (6.08)ab	23.84 (4.98)abcd	15.54 (4.07)abcd	11.39 (3.52)bcdef	70.04 (8.37)ab
" 4 "	128.97 (11.41)ab	112.98 (10.67)ab	75.66 (8.76)b	68.97 (8.36)	70.95 (8.48)bc	69.34 (8.39)a	51.46 (7.24)abc	43.36 (6.66)bcd	34.91 (5.99)ab	17.70 (4.32)cde	16.62 (4.20)ab	16.65 (4.20)abc	69.03 (8.31)ab
E. odoratum extract 2 "	128.54 (11.38)ab	101.73 (10.14)b	96.57 (9.88)ab	102.69 (10.18)	80.70 (9.04)ab	80.49 (9.03)a	60.45 (7.84)abc	46.24 (6.87)bcd	32.07 (5.75)abc	24.61 (5.06)abcd	13.57 (3.82)abcd	12.25 (3.64)abcde	55.92 (7.48)f
" 4 "	135.62 (11.69)a	117.94 (10.91)ab	90.10 (9.55)ab	74.62 (8.69)	78.70 (8.93)ab	77.51 (8.86)a	55.42 (7.51)abc	44.04 (6.71)bcd	24.97 (5.10)cde	17.11 (4.26)cde	12.28 (3.64)bcd	12.67 (3.70)abcde	66.19 (8.14)bcd
A. squamosa extract 2 "	132.84 (11.57)ab	126.52 (11.30)a	97.69 (9.93)ab	75.94 (8.77)	89.32 (9.50)a	82.49 (9.14)a	64.97 (8.12)a	51.81 (7.27)ab	34.67 (5.97)ab	20.68 (4.66)abcde	14.56 (3.95)abcd	17.57 (4.31)ab	89.58 (9.34)ab
" 4 "	126.84 (11.30)ab	116.23 (10.83)ab	95.35 (9.82)ab	92.33 (9.66)	80.55 (9.03)ab	80.53 (9.03)a	54.38 (7.44)abc	36.62 (6.13)cd	31.63 (5.71)abc	21.91 (4.79)abcde	14.14 (3.89)abcd	13.23 (3.77)abcde	55.88 (7.48)f
P. glabra extract 2 "	132.46 (11.55)ab	115.77 (10.81)ab	92.93 (9.70)ab	70.96 (8.48)	79.09 (8.95)ab	82.59 (9.14)a	64.67 (8.10)a	50.00 (7.14)abc	29.10 (5.49)bcd	25.59 (5.16)abc	12.43 (3.66)bcd	7.95 (2.99)def	69.04 (8.31)ab
" 4 "	132.56 (11.56)ab	119.95 (10.99)ab	92.25 (9.66)ab	76.95 (8.83)	77.51 (8.86)ab	79.36 (8.96)a	63.62 (8.04)ab	60.68 (7.85)a	28.28 (5.41)bcd	23.15 (4.91)abcde	13.20 (3.77)abcd	14.47 (3.93)abcd	60.46 (7.78)def
C. gigantea extract 2 "	129.66 (11.44)ab	105.76 (10.33)ab	77.47 (8.86)ab	82.43 (9.13)	78.37 (8.91)ab	75.21 (8.73)a	55.30 (7.50)abc	33.08 (5.84)d	27.43 (5.33)bcd	23.60 (4.96)abcd	15.80 (4.10)abc	17.70 (4.32)ab	59.82 (7.73)ef
" 4 "	133.91 (11.62)ab	108.97 (10.48)ab	104.19 (10.26)a	91.05 (9.59)	73.46 (8.63)bc	72.64 (8.51)a	53.55 (7.39)abc	35.50 (6.04)d	29.43 (5.52)bcd	29.60 (5.53)a	17.63 (4.32)ab	14.90 (3.99)abcd	62.13 (7.88)cde
Tobacco decoction	52.14 (7.29)e	34.88 (5.98)e	36.78 (6.15)cd	90.63 (9.57)	53.06 (7.35)de	28.55 (5.44)d	47.70 (6.98)c	40.85 (6.47)bcd	25.26 (5.12)cde	16.72 (4.21)de	9.69 (3.27)cd	7.08 (2.84)defg	38.94 (6.24)hi
Carbaryl 0.2 per cent	35.52 (6.04)f	16.11 (4.14)f	13.10 (3.76)e	74.30 (8.68)	24.30 (5.03)f	13.21 (3.77)e	25.86 (5.18)d	36.13 (6.09)b	11.95 (3.60)f	3.64 (2.15)f	1.59 (1.61)e	1.40 (1.55)h	18.11 (4.26)k
Control	139.39 (11.85)a	126.79 (11.31)a	93.27 (9.71)ab	80.99 (9.05)	75.99 (8.77)ab	69.08 (8.37)a	57.44 (7.64)abc	45.84 (6.84)bcd	22.88 (4.89)de	21.24 (4.72)abcde	19.92 (4.57)a	21.54 (4.75)a	73.22 (8.56)a
CD	0.601	0.861	1.26	N.S.	0.642	0.672	0.885	0.877	0.677	0.774	0.756	0.983	**

Means followed by a common letter are not significantly different at 5% level

Figures in parentheses are values after $\sqrt{x}$ transformation

Mean of three leaves per plant

*Data compared by DMRT: rest of the data were subjected to analysis of covariance

(54.99) and 2 per cent (57.60) also were found to be superior to other treatments. Ten days after second spraying carbaryl 0.2 per cent, T. neriifolia 4 per cent and 2 per cent were superior to other treatments and on par, with mean population of 25.86, 25.98 and 29.99 respectively. Tobacco decoction with a mean population of 47.70 ranked next, rest of the 15 treatments were on par with control. Fifteen days after spraying all the treatments came on par with control and a gradual decrease in the control population could be observed in all the periodical observations.

Ten days after third spraying carbaryl 0.2 per cent continued to be superior to T. neriifolia 4 per cent being 11.95 and 19.18, 3.64 and 15.27, and 1.59 and 9.22 for 2, 5 and 10 days after spraying respectively. Plants sprayed with C. infortunatum 2 per cent and 4 per cent, N. oleander at both concentrations, A. squamosa at two concentrations and E. odoratum 2 per cent had a higher level of population than in control (22.88). The other treatments were on par with control. Five days after spraying the variations in population in the treatments, except carbaryl 0.2 per cent, was not statistically significant, though the population ranged from 15.27 in T. neriifolia 4 per cent to 25.59 under P. glabra 2 per cent.

Ten days after treatment T. neriifolia 4 per cent (9.22) came on par with tobacco decoction (9.69), which were also on par with A. indica 4 per cent (11.55), T. neriifolia 2 per cent (11.61), E. odoratum 4 per cent (12.28) and P. glabra 2 per cent (12.43). The other treatments were on par with control. On fifteenth day the effect of carbaryl 0.2 per cent and T. neriifolia 4 per cent were on par with a mean population 1.40 and 2.54 respectively as against the population of 21.54 under control. T. neriifolia 2 per cent, C. infortunatum 4 per cent, tobacco decoction, P. glabra 2 per cent, A. indica 4 per cent, C. infortunatum 2 per cent and N. oleander 2 per cent with mean population varying from 5.15 to 11.39 were superior to the rest of the treatments including control.

Analysis of the mean aphid population computed for the entire crop season revealed that carbaryl 0.2 per cent had the least population (18.11). T. neriifolia 4 per cent was ranked next (33.53) followed by T. neriifolia 2 per cent (38.46), which was on par with tobacco decoction (38.94) and A. indica 4 per cent (43.73). The other treatments in a descending order of efficacy were A. indica 2 per cent (49.22), C. infortunatum 4 per cent (55.84), A. squamosa 4 per cent (55.88), E. odoratum 2 per cent (55.92), C. gigantea 2 per cent (59.82), P. glabra 4 per cent (60.46)

and E. odoratum 4 per cent (66.19), the rest of the treatments were on par with control (73.22).

3.1.2.2. Effect of plant extracts on A. biguttula biguttula

All the plant extracts were significantly superior to control, but inferior to carbaryl 0.2 per cent at two days after first spraying the mean leaf hopper population varying from 15.10 to 43.90 against 52.67 in control. Population under carbaryl 0.2 per cent was the least upto 10 DAS. At 15 DAS the plant extracts A. indica 2 per cent and 4 per cent were on par with carbaryl 0.2 per cent. Two days after spraying extracts of C. infortunatum 4 per cent (15.10) and T. neriifolia 4 per cent (15.94) were the more effective in controlling the jassids than A. indica 4 per cent (21.54), T. neriifolia 2 per cent (25.65) and C. infortunatum 2 per cent (27.64). The other treatments were of moderate effect. On fifth day C. infortunatum 4 per cent (15.44), T. neriifolia 4 per cent (16.63), C. infortunatum 2 per cent (18.32) and A. indica 4 per cent (19.93) were the extracts which controlled the pest population effectively when compared to control (60.81). The other effective treatments in descending order were A. indica 2 per cent (24.31), T. neriifolia 2 per cent (25.72), P. glabra 2 per cent (31.25). Other treatments except A. squamosa 2 and 4 per cent, C. gigantea 2 per cent and tobacco decoction were of

intermediate effect. The population observed at ten days after spraying A. indica 2 per cent (39.31), followed C. infortunatum 2 per cent (41.26), A. indica 4 per cent (42.60), T. neriifolia 4 per cent (44.24) and C. infortunatum 4 per cent (46.06) were next to carbaryl 0.2 per cent with mean leaf hopper population (25.20) against the control population 62.65. But the extracts of N. oleander 4 per cent and 2 per cent which were effective at 5 DAS were on par with control on tenth day, the other inefficient treatments were A. squamosa 2 and 4 per cent, C. gigantea 2 and 4 per cent and tobacco decoction. Observation made on the 15th day A. indica 2 per cent (45.35) was the most effective plant extract, which was on par with carbaryl 0.2 per cent (48.24) and A. indica 4 per cent (49.59). T. neriifolia 2 and 4 per cent, C. infortunatum 2 and 4 per cent, E. odoratum 4 per cent and P. glabra 4 per cent were ranked next and rest of the treatments were on par with control.

Two days after second spraying carbaryl 0.2 per cent with mean population of 9.78, was most effective followed by both concentrations of A. indica, T. neriifolia and C. infortunatum with mean population ranging from 30.70 to 37.82. N. oleander 4 per cent with 48.99 and E. odoratum 4 per cent with 50.38 ranked next. No other treatment was significantly superior to control (65.47). Data collected

on fifth day after second spraying revealed T. neriifolia 4 per cent (25.16), C. infortunatum 4 per cent (26.65) as the treatments next in efficacy to carbaryl 0.2 per cent (7.45). The other effective treatments were C. infortunatum 2 per cent, A. indica 4 per cent, T. neriifolia 2 per cent and A. indica 2 per cent with mean population of 30.00, 32.56, 35.38 and 35.64 respectively. On the tenth day after second spraying showed that C. infortunatum 4 per cent (24.64) was the best treatment which was on par with T. neriifolia 4 per cent (26.63), C. infortunatum 2 per cent (28.53), carbaryl 0.2 per cent (30.01) and T. neriifolia 2 per cent (33.57). A. indica 2 and 4 per cent, N. oleander 2 and 4 per cent, E. odoratum 4 per cent were also highly effective in controlling the pest with population range of 40.12 to 51.83 compared with mean population 71.36 under control. Counts of the jassids observed on fifteenth day showed C. infortunatum 4 per cent (47.06) more efficient than carbaryl 0.2 per cent (53.61), and extracts of T. neriifolia at both concentrations and C. infortunatum 2 per cent were on par with it. The treatments A. indica 4 per cent and 2 per cent and N. oleander at both concentrations with mean population ranging from 56.31 to 60.98 were also effective in reducing the pest population compared to the control population 73.32.

Table 3. Mean population of leaf hoppers (*A. biguttula biguttula*) observed at different intervals after spraying

Treatments	Mean population of leaf hoppers observed at different intervals after treatment												Mean*
	days after first spraying				days after second spraying				days after third spraying				
	2	5	10	15	2	5	10	15	2	5	10	15	
A. indica extract 2 per cent	31.29 (5.68)efgh	24.31 (5.03)hi	39.31 (6.35)g	45.35 (6.81)g	37.05 (6.17)d	35.64 (6.05)ef	46.07 (6.86)fg	60.98 (7.87)def	54.74 (7.47)cde	46.34 (6.88)e	42.09 (6.56)f	38.79 (6.31)bcd	40.65 (6.38)h
" 4 per cent	21.54 (4.75)i	19.93 (4.57)ij	42.60 (6.60)efg	49.59 (7.11)efg	34.49 (5.96)d	32.56 (5.79)f	40.12 (6.41)g	56.31 (7.57)fg	43.49 (6.67)f	35.18 (6.01)f	25.74 (5.17)h	25.58 (5.16)e	33.39 (5.78)i
T. neriifolia extract 2 per cent	25.65 (5.16)hi	25.72 (5.17)gh	48.54 (7.04)cdef	55.85 (7.54)def	37.82 (6.23)d	35.38 (6.03)ef	33.57 (5.88)h	49.96 (7.14)hi	41.27 (6.50)f	36.09 (6.09)f	31.12 (5.67)g	27.55 (5.34)e	35.64 (5.97)i
" 4 per cent	15.94 (4.12)j	16.62 (4.20)j	44.24 (6.73)efg	56.20 (7.56)de	32.54 (5.79)d	25.16 (5.11)g	26.63 (5.26)ij	48.97 (7.07)hi	32.37 (5.78)g	25.12 (5.11)g	20.41 (4.63)i	16.29 (4.16)f	29.68 (5.43)j
C. infortunatum extract 2 per cent	27.64 (5.35)gh	18.32 (4.40)j	41.26 (6.50)fg	57.55 (7.65)cd	30.70 (5.63)d	30.00 (5.57)fg	28.53 (5.43)hij	50.13 (7.15)hi	43.42 (6.66)f	34.77 (5.98)f	31.26 (5.68)g	27.64 (5.35)e	33.80 (5.81)i
4 per cent	15.10 (4.01)j	15.44 (4.05)j	46.06 (6.86)efg	57.81 (7.67)cd	31.40 (5.69)d	26.65 (5.26)g	24.64 (5.03)j	47.06 (6.93)i	35.70 (6.06)g	26.36 (5.23)g	21.41 (4.73)i	16.79 (4.22)f	27.91 (5.28)j
N. oleander extract 2 per cent	33.61 (5.88)defg	46.61 (6.90)cd	61.76 (7.92)ab	60.25 (7.83)bcd	56.83 (7.61)abc	52.86 (7.34)c	51.83 (7.27)ef	60.91 (7.87)ef	53.17 (7.36)e	51.69 (7.26)cde	48.05 (7.00)e	39.70 (6.38)abcd	51.40 (7.17)fg
" 4 per cent	37.00 (6.16)bcde	36.61 (6.13)ef	68.07 (8.31)a	65.21 (8.14)abc	48.99 (7.07)c	42.95 (6.63)d	40.42 (6.44)g	56.84 (7.61)fg	53.73 (7.40)de	50.09 (7.15)de	47.23 (6.94)ef	39.00 (6.32)bcd	48.21 (6.94)g
E. odoratum extract 2 per cent	35.28 (6.02)def	34.42 (5.95)ef	56.26 (7.57)bcd	62.10 (7.94)abcd	58.42 (7.71)ab	55.78 (7.54)bc	55.79 (7.54)de	65.65 (8.16)cde	53.76 (7.40)de	54.16 (7.43)cd	48.66 (7.05)de	39.19 (6.34)bcd	52.31 (7.23)ef
" 4 per cent	29.19 (5.49)fgh	38.26 (6.27)e	50.25 (7.16)cde	57.42 (7.64)cd	50.38 (7.17)bc	41.85 (6.55)de	46.80 (6.91)f	66.72 (8.23)bcd	54.22 (7.43)de	57.30 (7.64)c	50.02 (7.14)cde	39.20 (6.34)bcd	48.63 (6.97)g
A. squamosa extract 2 per cent	39.80 (6.39)bcd	54.96 (7.48)ab	61.22 (7.89)ab	62.95 (8.00)abcd	56.38 (7.57)abc	59.23 (7.76)abc	63.90 (8.06)abc	71.82 (8.53)ab	64.90 (8.12)a	65.77 (8.17)b	60.81 (7.86)a	44.28 (6.73)abc	60.90 (7.80)abc
" 4 per cent	43.90 (6.70)b	56.99 (7.62)ab	64.80 (8.11)ab	62.07 (7.94)abcd	58.55 (7.72)ab	56.38 (7.57)bc	58.12 (7.69)cde	67.89 (8.31)abc	58.49 (7.71)bcde	66.64 (8.22)b	49.03 (7.07)de	36.83 (6.15)d	55.86 (7.47)de
P. glabra extract 2 per cent	36.00 (6.08)def	31.25 (5.68)fg	56.44 (7.58)bc	63.93 (8.06)abcd	59.04 (7.75)ab	55.94 (7.55)bc	63.91 (8.06)abc	69.98 (8.42)abc	63.34 (8.02)ab	67.57 (8.28)b	54.20 (7.43)bcd	43.52 (6.67)abcd	57.53 (7.58)de
" 4 per cent	37.85 (6.23)bcde	41.19 (6.50)de	47.81 (6.99)def	57.09 (7.62)cde	56.81 (7.60)abc	59.86 (7.80)abc	63.93 (8.06)abc	65.79 (8.17)cde	59.78 (7.80)abc	67.70 (8.29)ab	52.84 (7.34)bcde	42.25 (6.58)abcd	54.42 (7.38)def
C. gigantea extract 2 per cent	40.02 (6.41)bcd	57.59 (7.65)ab	66.51 (8.22)a	67.16 (8.26)ab	59.31 (7.77)ab	57.84 (7.67)bc	57.36 (7.64)cde	66.53 (8.22)bcde	65.26 (8.14)a	69.14 (8.38)ab	58.39 (7.71)ab	45.66 (6.83)ab	61.08 (7.82)abc
" 4 per cent	43.63 (6.68)bc	49.65 (7.12)bc	59.20 (7.76)ab	64.64 (8.10)abc	58.47 (7.71)ab	62.40 (7.96)ab	62.26 (7.95)bcd	70.73 (8.47)abc	64.79 (8.11)a	75.01 (8.72)a	61.25 (7.89)a	46.74 (6.91)a	61.65 (7.85)ab
Tobacco decoction	36.20 (6.10)cde	56.54 (7.59)ab	62.27 (7.95)ab	69.83 (8.42)a	59.78 (7.80)ab	60.28 (7.83)abc	67.32 (8.27)ab	71.21 (8.50)abc	58.83 (7.74)bcd	69.09 (8.37)ab	55.89 (7.54)abc	40.71 (6.46)abcd	62.41 (7.90)ab
Carbaryl 0.2 per cent	4.43 (2.33)k	4.25 (2.29)k	25.20 (5.12)h	48.24 (7.02)fg	9.78 (3.28)e	7.45 (2.91)h	30.01 (5.57)hi	53.61 (7.39)gh	19.53 (4.53)h	1.95 (1.72)h	2.66 (1.91)j	0.81 (1.35)g	16.36 (4.04)k
Control	52.67 (7.33)a	60.81 (7.86)a	62.65 (7.98)ab	70.06 (8.43)a	65.47 (8.15)a	66.53 (8.22)a	71.36 (8.51)a	73.32 (8.62)a	62.54 (7.97)ab	69.14 (8.37)ab	58.03 (7.68)ab	38.06 (6.25)cd	66.56 8.16a
CD	0.595	0.577	0.592	0.524	0.632	0.522	0.468		0.358	0.434	0.410	0.558	**

Figures in parentheses are transformed values $\sqrt{x}$

Means followed by same letter are not significantly different 5% level

* Data compared by DMRT ; rest of the data were subjected to

Data after the third spraying against leaf hopper also showed that carbaryl 0.2 per cent was the most effective treatment upto 15 DAS. It was significantly superior to all the plant extracts with mean population of 19.53, 1.95, 2.66 and 0.81 at 2, 5, 10 and 15 DAS respectively, while in control plants, mean population during this period was 62.54, 69.14, 58.03 and 38.06 respectively. Among the plant extracts T. neriifolia 4 per cent and C. infortunatum 4 per cent were superior to others with mean population of 32.37 and 35.70, 25.12 and 26.36, 20.41 and 21.41 and 16.29 and 16.79 at 2, 5, 10 and 15 DAS respectively. Both the concentrations of A. squamosa, P. glabra, C. gigantea and tobacco decoction remained ineffective at two and five DAS with the mean population ranging from 58.49 to 65.26 and 65.77 to 75.01 against the control population 62.54 and 69.14 for the two observations respectively. Rest of the treatments were superior to the control. On tenth day A. squamosa 4 per cent was found superior to control. Remaining treatments had the same trend as in previous observation. On the fifteenth day A. indica 4 per cent (25.58), T. neriifolia 2 per cent (27.55) and C. infortunatum 2 per cent (27.64) were next in effectiveness to T. neriifolia 4 per cent (16.29), C. infortunatum 4 per cent (16.79). The rest of the treatments were on par with control.

Data on the mean population of leaf hoppers, during the entire crop season, indicated C. infortunatum 4 per cent and T. neriifolia 4 per cent as the most effective leaf extracts, which supported a mean population of 27.91 and 29.48 respectively, against the insecticide check which was superior to them the population being 16.36 and control (66.56). Extracts of A. indica 4 per cent (33.39), C. infortunatum 2 per cent (33.80) and T. neriifolia 2 per cent (35.64) were ranked next followed by A. indica 2 per cent (40.65). The population under tobacco decoction (62.41), C. gigantea 2 and 4 per cent (61.08 and 61.65) and A. squamosa 2 per cent (60.90) were on par with control and the rest of the treatments were superior to these treatments.

3.1.2.3. Effect of plant extracts on shoot and fruit borer E. vitella and yield

Pooled data regarding the infestation of shoot and fruit borer and yield are presented in Table 4.

Mean percentage of shoot and fruit borer incidence was least in plants treated with carbaryl 0.2 per cent (7.30) and was on par with the extracts of T. neriifolia 4 per cent (18.88). A. indica 4 per cent (20.53) and 2 per cent (21.44), C. infortunatum 4 per cent (29.62), T. neriifolia 2 per cent (32.19), C. infortunatum 2 per cent

Table 4. Effect of plant extracts on shoot and fruit borer E. vitella of bhindi and the yield

Treatments	Mean percentage of fruits damaged by shoot and fruit borer (Pooled data)	Mean yield of healthy fruits (g/per pot)
A. indica extract 2 per cent	21.44 (27.57) def	214.3 b
" 4 per cent	20.53 (26.93) ef	238 b
T. noriifolia extract 2 per cent	32.19 (34.56)bcde	241.7 b
" 4 per cent	18.88 (25.74)ef	253.0 b
C. infortunatum extract 2 per cent	33.22 (35.18) bcde	246.7 b
" 4 per cent	29.62 (32.96) cde	255.7 b
N. oleander extract 2 per cent	47.62 (43.62) abc	127.7 a
" 4 per cent	52.82 (46.60) ab	147.0 a
E. cdoratum extract 2 per cent	44.79 (41.99) abc	107.0 a
" 4 per cent	36.93 (37.41) bcde	126.7 a
A. squamosa extract 2 per cent	53.50 (46.99) ab	105.0 a
" 4 per cent	47.14 (43.34) abc	120.0 a
P. glabra extract 2 per cent	63.11 (52.58) a	129.0 a
" 4 per cent	49.13 (44.48) abc	109.7 a
C. gigantea extract 2 per cent	60.74 (51.18) a	105.3 a
" 4 per cent	42.72 (40.30) abcd	125.0 a
Tobacco decoction	47.56 (43.58) abc	122.3 a
Carbaryl 0.2 per cent	7.30 (15.66) f	252.3 b
Control	62.21 (52.05) a	103.0 a
	*	**

Means followed by a common letter are not significantly different at 5% level(DMRT)

Figures in parentheses indicate angular values

(33.22) and E. odoratum (36.93) also recorded significantly low level of infestation compared to control (62.21). Other treatments were on par with the control.

Yield data of the healthy fruits recorded highest yield from the plants treated with 2 and 4 per cent concentration of extracts of C. infortunatum (246.66 and 255.66 g), T. neriifolia at both the concentrations (241.66 and 253.00 g) and A. indica at two concentrations (214.33 and 238.00 g) which were on par with carbaryl 0.2 per cent (252.33 g). There was no significant variation in yield between the other treatments (147 to 105 g) and control (103 g).

3.2. Augmenting toxicity of plant extracts with additives

3.2.1. Data collected on the adult emergence of S. litura from the larvae sprayed with combinations of plant extracts and additives, at different concentrations, are presented in Table 5.

Among the treatments 8 per cent extract of C. infortunatum mixed with 2 per cent teepol, 1 per cent teepol + 1 per cent coconut oil, 1 per cent teepol, 0.4 per cent soapwater + 1 per cent coconut oil, 2 per cent teepol + 1 per cent coconut oil and 0.4 per cent soapwater were more effective which reduced the mean emergence to 16.36, 19.31, 19.31, 19.31, 22.17, and 26.20 respectively, compared to

80.69 per cent in 8 per cent extract. The next set of treatments in their order of efficacy were 4 per cent extract of C. infortunatum with 2 per cent teepol (36.10), 2 per cent teepol + 1 per cent coconut oil (36.45), 1 per cent teepol (36.60) and T. neriifolia 8 per cent with 0.4 per cent soapwater + 1 per cent coconut oil (36.60) which were on par with above treatments except C. infortunatum 8 per cent with 2 per cent teepol. These were followed by T. neriifolia 8 per cent + 0.4 per cent soapwater, C. infortunatum 4 per cent + 0.4 per cent soapwater + 1 per cent coconut oil, C. infortunatum 4 per cent + 1 per cent teepol + 1 per cent coconut oil, T. neriifolia 8 per cent + 1 per cent teepol, T. neriifolia 8 per cent + 1 per cent teepol + 1 per cent coconut oil, C. infortunatum 4 per cent + 0.4 per cent soapwater and T. neriifolia 8 per cent + 2 per cent teepol + 1 per cent coconut oil with the percentage of normal adults varying from 39.36 to 43.31 and were on par among themselves.

Extract of C. infortunatum 4 per cent with 0.4 per cent soapwater was superior to 8 per cent extract of T. neriifolia with 2 per cent teepol, A. indica 8 per cent + 0.4 per cent soapwater + 1 per cent coconut oil, A. indica 8 per cent + 0.4 per cent soapwater and A. indica 8 per cent + 1 per cent teepol. Two per cent extract of C. infortunatum with

Table 5. Mean percentage of normal adults of *S. litura* obtained from fourth instar larvae sprayed with different plant extracts

extract + additives	*A. indica*			*T. noriifolia*			*C. infortunatum*			*N. oleander*			*E. odoratum*			Overall effect of additives
	2%	4%	8%	2%	4%	8%	2%	4%	8%	2%	4%	8%	2%	4%	8%	
extract + 1% teepol tion	88.40 (70.06)	63.55 (52.84)	50.00 (44.98)	63.40 (52.75)	56.84 (48.91)	43.16 (41.05)	50.00 (44.98)	36.60 (37.21)	19.31 (26.06)	83.64 (66.12)	73.80 (59.19)	63.55 (52.84)	100.00 (90.00)	100.00 (90.00	93.31 (74.98)	56.80
extract + 2% teepol tion	76.82 (61.20)	66.74 (54.76)	56.69 (48.83)	63.55 (52.84)	53.35 (46.90)	46.65 (43.06)	56.69 (48.83)	36.10 (36.92)	16.36 (23.85)	83.64 (66.12)	71.45 (57.68)	60.00 (50.75)	98.86 (83.85)	98.86 (83.85)	93.31 (74.98)	55.63
extract + 1% coconut	86.99 (68.83)	83.64 (66.12)	83.64 (66.12)	84.28 (66.61)	77.85 (61.90)	70.33 (56.97)	77.55 (61.69)	80.69 (63.90)	67.09 (54.97)	95.48 (77.69)	76.82 (61.20)	74.56 (59.68)	100.00 (90.00)	100.00 (90.00)	95.48 (77.69)	68.23
extract + 2% coconut	86.99 (68.83)	80.00 (63.41)	88.40 (70.06)	83.64 (66.12)	77.55 (61.69)	70.33 (56.97)	77.55 (61.69)	76.82 (61.20)	70.33 (56.97)	90.76 (72.27)	80.00 (63.41)	73.48 (58.98)	100.00 (90.00)	100.00 (90.00)	86.99 (68.83)	67.36
extract + 0.4% soap-r solution	76.82 (61.20)	70.33 (56.97)	46.65 (43.06)	73.48 (58.98)	56.84 (48.91)	39.36 (38.84)	60.14 (50.83)	43.16 (41.05)	26.20 (30.77)	83.64 (66.12)	63.40 (52.75)	63.40 (52.75)	98.86 (83.85)	95.48 (77.69)	86.99 (68.83)	55.51
extract + 1% teepol tion + 1% coconut oil	73.48 (58.98)	70.00 (56.77)	50.00 (44.98)	63.90 (53.05)	50.00 (44.98)	43.16 (41.05)	53.35 (46.90)	39.86 (39.13)	19.31 (26.06)	76.82 (61.20)	73.48 (58.98)	56.69 (48.83)	100.00 (90.00)	83.64 (66.12)	80.00 (63.41)	53.36
extract + 2% teepol tion + 1% coconut oil	80.00 (63.41)	66.74 (54.76)	50.00 (44.98)	60.64 (51.12)	50.00 (44.99)	43.31 (41.14)	53.35 (46.90)	36.45 (37.13)	22.15 (28.07)	70.00 (56.77)	70.33 (56.97)	56.84 (48.91)	83.64 (66.12)	86.99 (68.83)	83.64 (66.12)	51.75
extract + 0.4% soap-r + 1% coconut oil	80.69 (63.90)	63.40 (52.75)	46.65 (43.06)	71.45 (57.68)	60.14 (50.83)	36.60 (37.21)	56.84 (48.91)	39.86 (39.13)	19.31 (26.06)	73.48 (58.98)	67.22 (55.05)	60.14 (50.83)	98.86 (83.85)	90.00 (71.54)	83.64 (66.12)	53.73
extract	93.31 (74.98)	90.76 (72.27)	83.64 (66.12)	84.28 (66.61)	80.00 (63.41)	73.48 (58.98)	86.99 (68.83)	83.64 (66.12)	80.69 (63.90)	83.64 (66.12)	76.82 (61.20)	70.33 (56.97)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	70.37
rall effect of different concentrations of plant racts	65.709	58.962	52.465	58.418	52.502	46.143	53.285	46.365	37.413	65.709	58.492	53.394	85.295	80.891	72.328	
rall effect of plant racts		59.045			52.354			45.688			59.198			79.505		

Critical differences

Between concentrations of leaf extract = 3.726

Between different additives = 2.886

Between the plant extracts = 2.151

Interaction between plants and additives = 11.179

Figures in parentheses indicate angular values

1 per cent teepol recorded 50.00 per cent adults emergence on par with 9 numbers of 8 per cent extracts, and 10 number of 4 per cent extract and 9 numbers of 2 per cent extract of A. indica, T. neriifolia, C. infortunatum, and N. oleander.

The plant extracts combined with both the concentrations of coconut oil did not give any reduction in the normal adult emergence compared to the emergence with the leaf extract alone. In majority of the treatments the higher concentrations were more effective than the lower concentrations along with the additives. With the extracts of C. infortunatum 4 and 8 per cent additives other than coconut oil reduced the adult emergence significantly compared to those of leaf extract alone and were on par among themselves at the particular concentrations. Most of the treatments with the extract of E. odoratum had no effect on the development of the insect.

Data computed on the overall effect of different concentration of the plant extracts barring the effect of different additives showed that 8 per cent extract of C. infortunatum (37.41) was significantly superior to other extracts and four per cent extract (46.36) was next in effectiveness on par with 8 per cent extracts of

T. neriifolia (46.14). Two per cent extract of C. infortunatum (53.29), 4 per cent extract of T. neriifolia (52.50), 8 per cent extract of A. indica (52.47) and 8 per cent extract of N. oleander (53.39) were ranked next. The remaining extracts in their order of efficacy were T. neriifolia 2 per cent (58.42), N. oleander 4 per cent (58.49), and A. indica 4 per cent (58.96) followed by A. indica 2 per cent and N. oleander 2 per cent. The overall effect of the different plants, irrespective of the concentrations and additives, revealed C. infortunatum as the most effective plant against S. litura followed by T. neriifolia with a mean percentage of adult emergence of 45.69 and 52.35 respectively. A. indica, N. oleander and E. odoratum recorded 59.05, 59.20, and 79.51 per cent of adults emergence respectively.

Computation on the effect of additives ignoring the effect of plant extracts had shown that leaf extracts mixed with 2 per cent teepol with 1 per cent coconut oil (51.75), 1 per cent teepol + 1 per cent coconut oil (53.36), 0.4 per cent soapwater + 1 per cent coconut oil (53.73) were more effective treatments. All other additive combinations applied with 4 per cent and 8 per cent extracts of C. infortunatum, T. neriifolia, A. indica were superior to the leaf extract alone. Non of the additives could

augment the efficacy of the extract of N. oleander at any of the concentrations used. Eight and 4 per cent extracts of E. odoratum combined with 0.4 per cent soapwater, 1 per cent teepol + 1 per cent coconut oil, 2 per cent teepol + 1 per cent coconut oil, 0.4 per cent soapwater + 1 per cent coconut oil were moderately effective than the leaf extract.

3.2.2. Data collected on the mortality of aphids observed at 2 DAS with different combinations of plant extracts and additives at different concentrations are presented in Table 6. Among the five plants A. indica and T. neriifolia were more effective against the aphids than the others. Extracts of A. indica at 4 and 8 per cent concentration with 0.4 per cent of soapwater, T. neriifolia 4 and 8 per cent with 0.4 per cent of soapwater and T. neriifolia 8 per cent + 1 per cent teepol + 1 per cent coconut oil were treatments which gave cent per cent mortality, while the extracts of A. indica 8 per cent + 2 per cent teepol (98.86), T. neriifolia 8 per cent + 2 per cent teepol + 1 per cent coconut oil (98.86), A. indica 8 per cent + 1 per cent teepol (97.64), A. indica 2 per cent + 0.4 per cent soapwater (94.90), A. indica 8 per cent + 2 per cent teepol + 1 per cent coconut oil (93.31), T. neriifolia 4 per cent + 2 per cent teepol + 1 per cent coconut oil

(93.31), A. indica 4 per cent + 0.4 per cent soapwater + 1 per cent coconut oil (93.31) were on par with it. The treatments next in effectiveness were T. neriifolia 8 per cent + 2 per cent teepol (91.25), T. neriifolia 2 per cent + 0.4 per cent soapwater (91.25), A. indica 8 per cent + 0.4 per cent soapwater + 1 per cent coconut oil (90.76), A. indica 8 per cent (90.76) and T. neriifolia 4 per cent + 1 per cent teepol + 1 per cent coconut oil (86.99).

Treatments of A. indica 4 per cent with 2 per cent coconut oil, 1 per cent teepol + 1 per cent coconut oil and 1 per cent coconut oil though recorded higher mortality, were statistically on par with 8 per cent extract. The treatments which were ranked next in descending order where T. neriifolia 8 per cent + 0.4 per cent soapwater + 1 per cent coconut oil (84.28), T. neriifolia 8 per cent + 1 per cent teepol (81.65), A. indica 4 per cent + 1 per cent teepol (80.70), T. neriifolia 2 per cent + one per cent teepol + 1 per cent coconut oil (80.69), T. neriifolia 2 per cent + 0.4 per cent soapwater + 1 per cent coconut oil (80.69), T. neriifolia 4 per cent (80.69), A. indica 4 per cent + 1 per cent teepol + 1 per cent coconut oil (80.00) and A. indica 4 per cent leaf extract (77.85).

Table 6. Mean percentage of mortality of *A. aegypti* observed at two days after sprayed with different plant extracts

Leaf extract + additives	*A. indica*			*T. neriifolia*			*C. infortunatum*			*N. oleander*			*E. odoratum*			Overall effect of additives
	2%	4%	6%	2%	4%	8%	2%	4%	8%	2%	4%	8%	2%	4%	8%	
Leaf extract + 1% teepol solution	67.22 (55.05)	80.70 (63.92)	97.64 (81.14)	56.84 (48.91)	67.70 (55.34)	81.65 (64.60)	0 (0.00)	13.01 (21.14)	19.31 (26.06)	0 (0.00)	0 (0.00)	6.70 (14.99)	0 (0.00)	2.37 (8.85)	0 (0.00)	29.334
Leaf extract + 2% teepol solution	63.90 (53.05)	73.80 (59.19)	98.86 (83.85)	53.86 (47.20)	74.55 (59.66)	91.25 (72.77)	0 (0.00)	13.01 (21.14)	9.25 (17.70)	0 (0.00)	1.15 (6.14)	13.01 (21.14)	0 (0.00)	0 (0.00)	14.20 (22.13)	30.932
Leaf extract + 1% coconut oil	56.84 (48.91)	66.04 (53.13)	71.58 (57.76)	46.65 (43.06)	50.00 (44.98)	67.22 (55.05)	0 (0.00)	1.15 (6.14)	0 (0.00)	0 (0.00)	0 (0.00)	1.15 (6.14)	1.15 (6.14)	0 (0.00)	1.15 (6.14)	21.331
Leaf extract + 2% coconut oil	46.65 (43.06)	60.64 (51.12)	76.82 (61.20)	39.36 (38.84)	53.35 (46.90)	70.33 (56.97)	0 (0.00)	2.37 (8.85)	3.69 (11.07)	0 (0.00)	4.53 (12.29)	2.37 (8.85)	0 (0.00)	0 (0.00)	0 (0.00)	22.610
Leaf extract + 0.4% soapwater	94.90 (76.92)	100.00 (90.00)	100.00 (90.00)	91.25 (72.77)	100.00 (90.00)	100.00 (90.00)	13.01 (21.14)	13.01 (21.14)	22.45 (28.27)	6.70 (14.99)	4.53 (12.29)	18.35 (25.36)	0 (0.00)	0 (0.00)	0 (0.00)	42.191
Leaf extract + 1% teepol solution + 1% coconut oil	70.33 (56.97)	80.00 (63.41)	75.00 (59.98)	80.69 (63.90)	86.99 (68.83)	100.00 (90.00)	6.70 (14.99)	19.31 (26.06)	26.52 (30.98)	0 (0.00)	20.00 (26.55)	25.44 (30.28)	13.01 (21.14)	6.70 (14.99)	20 (26.55)	39.643
Leaf extract + 2% teepol solution + 1% coconut oil	76.82 (61.20)	70.80 (57.27)	93.31 (74.98)	67.22 (55.05)	93.31 (74.98)	98.86 (83.85)	4.53 (12.29)	6.70 (14.99)	23.18 (28.77)	6.70 (14.99)	2.37 (8.85)	23.18 (28.77)	10 (18.43)	22.15 (28.07)	25.44 (30.28)	39.517
Leaf extract + 0.4% soapwater + 1% coconut oil	74.56 (59.62)	93.31 (74.98)	90.76 (72.27)	80.69 (63.90)	63.90 (53.05)	84.28 (66.61)	4.53 (12.29)	23.18 (28.77)	26.52 (30.98)	0 (0.00)	4.53 (12.29)	11.61 (19.92)	0 (0.00)	4.53 (12.29)	1.15 (6.14)	34.211
Leaf extract	56.69 (48.83)	77.85 (61.90)	90.76 (72.27)	63.40 (52.75)	80.69 (63.90)	71.46 (57.69)	0 (0.00)	4.53 (12.29)	6.70 (14.99)	0 (0.00)	1.15 (6.14)	4.53 (12.29)	0 (0.00)	0 (0.00)	15.72 (23.35)	28.426
Overall effect of different concentrations of plant extracts	55.963	63.880	72.605	54.043	61.904	70.837	6.744	17.835	20.981	3.332	9.394	18.637	5.079	7.133	12.734	
Overall effect of plant extracts		64.149			62.281			15.186			10.454			8.315		

Critical differences

Between concentrations of leaf extract = 5.101

Between different additives = 3.951

Between the plant extracts = 2.945

Interaction between plants and additives = 15.304

Figures in parenthoses indicate angular values

Eight per cent extract of T. neriifolia caused only 71.46 per cent mortality compared to 80.69 under the 4 per cent extract. But they were on par. With additives, the higher concentration gave higher mortality. Treatments with T. neriifolia 4 per cent + 2 per cent teepol (74.55), T. neriifolia 8 per cent + 2 per cent coconut oil (70.33), T. neriifolia 4 per cent + 1 per cent teepol (67.70), and T. neriifolia 8 per cent + 1 per cent coconut oil (67.22) gave mortality less than with leaf extract alone, though the difference was not statistically significant. Extracts of A. indica 4 per cent with 2 per cent teepol, 2 per cent teepol + 1 per cent coconut oil, 1 per cent coconut oil, and 2 per cent coconut oil were inferior to A. indica 4 per cent extract alone. The remaining combinations of additives with A. indica 2 per cent extract, except with that of 2 per cent coconut oil, recorded higher mortality though statistically they were on par with leaf extract in combination with 2 per cent coconut oil. Two per cent extracts of T. neriifolia with 2 per cent teepol + 1 per cent coconut oil (67.22), one per cent teepol (56.84) and two per cent teepol (53.86) were not having significant difference with T. neriifolia 2 per cent leaf extract (63.40). The other plant extracts namely C. infortunatum, N. oleander and E. odoratum were not having much impact on the aphids. The mortality recorded with different

concentrations of pure leaf extract of the three plants were only negligible. But extract of C. infortunatum in combination with soapwater, 1 per cent teepol + 1 per cent coconut oil, 2 per cent teepol + 1 per cent coconut oil and 0.4 per cent soapwater + 1 per cent coconut oil produced mortality ranging from 13.01 to 22.45, 6.70 to 26.50, 4.53 to 23.18 and 4.53 to 26.52 per cent respectively under the three concentrations. With extracts of N. oleander combination with soapwater, 2 per cent teepol + 1 per cent coconut oil only could gave mortality under all the three concentrations varying from 6.70 to 18.35 and 6.70 to 23.18 per cent respectively. Extract of E. odoratum with both the concentration of teepol + 1 per cent coconut oil could bring the mortality from 6.70 to 25.44 per cent.

On computing the overall effect of the different concentrations of the plant extracts irrespective of the different additives used, 8 per cent of A. indica and T. neriifolia were found as superior with mean percentage mortality of 72.61 and 70.84 respectively. The 4 per cent extracts of these plants were ranked next with 63.88 and 61.96 per cent mortality followed by 2 per cent concentrations with 55.96 and 54.04 per cent mortality respectively.

The overall effect of the plants, irrespective of the different concentrations, showed that the extracts of

A. indica and T. neriifolia were with the average percentage mortality of 64.15 and 62.28 respectively were superior to C. infortunatum, N. oleander and E. odoratum which recorded 15.19, 10.45 and 8.32 per cent mortalities respectively.

The data computed on the effectiveness of the different additives, irrespective of the plant extracts, revealed 0.4 per cent soapwater, 1 per cent teepol + 1 per cent coconut oil, and 2 per cent teepol + 1 per cent coconut oil were effective and they augmented the mortality to the levels of 42.19, 39.64 and 39.52 per cent respectively compared to 28.43 per cent in the leaf extract alone. The additive next in effectiveness was mixture of 0.4 per cent soapwater + 1 per cent coconut oil with 34.21 mean per cent of mortality.

3.3. Efficacy of selected plant extracts in the management of pests of amaranthus and bhindi in the field

3.3.1. Pests of amaranthus

3.3.1.1. Amaranthus grasshopper A. crenulata

Data recorded on the damage caused by grasshoppers A. crenulata to amaranthus crop at it early stage, when sprayed with plant extracts, are presented in Table 7. Observation made two days after spraying revealed variations

Tabel 7. Intensity of leaf damage caused by A. crenulata observed at different occasions after spraying with plant extracts

Treatments	Mean indices of leaf damage observed at different intervals after first spraying(days)			Mean*
	2	7	14	
A. indica extract 2 per cent	31.93 (5.65)abc	32.07 (5.66)abcde	31.83 (5.64)bc	33.68 (5.80)bc
" 4 per cent	25.50 (5.05)cd	25.00 (5.00)cdef	23.71 (4.87)cd	25.83 (5.08)efgh
T. neriifolia extract 2 per cent	24.01 (4.90)cd	24.67 (4.97)cdef	24.04 (4.90)cd	23.97 (4.90)gh
" 4 per cent	24.65 (4.96)cd	28.63 (5.35)cdef	31.77 (5.64)bc	28.18 (5.31)defg
C. infortunatum extract 2 per cent	28.68 (5.36)bcd	28.07 (5.30)cdef	32.48 (5.70)bc	29.31 (5.41)cdef
" 4 per cent	30.90 (5.56)bcd	25.38 (5.04)cdef	27.42 (5.24)bcd	28.15 (5.31)defg
A. indica extract + soapwater 2 per cent	23.64 (4.86)cd	21.80 (4.67)ef	26.40 (5.14)cd	24.18 (4.92)gh
" 4 per cent	25.27 (5.03)cd	26.35 (5.13)cdef	21.38 (9.62)d	23.20 (4.82)h
T. neriifolia extract + soapwater 2 per cent	21.86 (4.68)d	22.93 (4.79)def	27.29 (5.22)bcd	24.62 (4.96)fgh
" 4 per cent	29.26 (5.41)bcd	32.85 (5.73)abcd	29.37 (5.42)bcd	29.47 (5.43)cde
C. infortunatum extract + soapwater 2 per cent	30.51 (5.52)bcd	34.85 (5.90)abc	38.71 (6.22)ab	35.04 (5.92)b
" 4 per cent	29.32 (5.41)bcd	31.02 (5.57)bcdef	33.64 (5.80)bc	31.21 (5.59)bcd
Tobacco decoction	36.74 (6.06)ab	43.34 (6.58)a	46.45 (6.82)a	40.66 (6.38)a
Carbaryl 0.2 per cent	25.61 (5.06)cd	21.02 (4.58)f	29.11 (5.40)bcd	25.07 (5.01)efgh
Control	41.48 (6.44)a	40.87 (6.39)ab	47.00 (6.36)a	44.97 (6.71)a
CD	0.776	0.851	0.868	**

Foliar damage based on visual scale 1-5

Mean intensity of damage from four observational plants

Means followed by same letter are not significantly different at 5% level

Figures in parentheses are transformed values, $\sqrt{x}$

* Data compared by DMRT: rest of the data were subjected to analysis of covariance

in the leaf damage among the treatments. Two per cent extract of T. neriifolia added with soapwater reduced the mean damage index to 21.86 on par with that of carbaryl 0.2 per cent (25.61) compared to 47.48 in plots sprayed with water. Treatments with A. indica 2 per cent and tobacco decoction were not having any effect on grasshopper and others could reduce the damage to levels varying from 23.64 to 30.90 on par with carbaryl 0.2 per cent. On seventh day after spraying carbaryl 0.2 per cent recorded the least leaf damage (21.02) and it was on par with A. indica 2 per cent with soapwater (21.80). T. neriifolia 2 per cent with soapwater (22.93), T. neriifolia 2 per cent (24.67), A. indica 4 per cent (25.00), A. indica 4 per cent in combination with soapwater (26.35), C. infortunatum 2 per cent (28.07), T. neriifolia 4 per cent (28.67) in descending order. Other treatments were ineffective and on par with control. On 14th day also A. indica 4 per cent added with soapwater (21.38) continued to be effective, on par with carbaryl 0.2 per cent (29.11). But the other treatments except C. infortunatum 2 per cent with soapwater (38.71), tobacco decoction (46.45) were effective and on par with carbaryl 0.2 per cent with the damage indices ranging from 23.71 to 33.64.

Data on the average leaf damage indices indicated A. indica 4 per cent mixed with soapwater (23.20) was the

most effective treatment against A. crenulata and it was on par with T. neriifolia 2 per cent (23.97), A. indica 2 per cent with soapwater (24.18), T. neriifolia 2 per cent with soapwater (24.62), carbaryl 0.2 per cent (25.07) and A. indica 4 per cent (25.83). Other treatments next in efficacy were C. infortunatum 4 per cent (28.15), T. neriifolia 4 per cent (28.18) followed by T. neriifolia 4 per cent mixed with soapwater (29.47), C. infortunatum 4 per cent with soapwater (31.21), A. indica 2 per cent (33.68) and C. infortunatum 2 per cent added with soapwater (35.04). Tobacco decoction alone was on par with control (44.97).

3.3.1.2. Leaf webber P. basalis

Data on the mean larval population of P. basalis observed at different periods are presented after statistical analysis in Table 8.

Data showed that no plant extract except T. neriifolia 4 per cent with soapwater (7.18) was on par with carbaryl 0.2 per cent (4.14). All other treatments with mean number of larvae varying from 8.76 under A. indica 4 per cent to 13.34 under tobacco decoction were on par with control (13.32). On seventh day the mean larval population in the plots sprayed with carbaryl 0.2 per cent (0.69) and

plots treated with T. neriifolia 4 per cent were most effective among the plant extracts. It was also on par with A. indica 4 per cent with soapwater, T. neriifolia 4 per cent with soapwater, A. indica 4 per cent and T. neriifolia 2 per cent with soapwater with mean number of larvae 4.28, 5.77, 5.91 and 6.54 respectively. The other treatments with mean larval population varying from 6.71 to 13.95 were on par with control (12.21). During next observation at fourteen days A. indica 2 per cent with soapwater was the best treatment, which recorded 7.19 mean larval population against 13.59 under the control was on par with carbaryl 0.2 per cent (7.28) followed by T. neriifolia 2 per cent (7.58). The rest of the treatments with mean population ranging from 7.92 to 17.79 were not significantly different from control.

Observations recorded at two days after second spraying revealed that no plant extract was comparable to carbaryl 0.2 per cent which recorded a mean larval population of 2.43. The most effective plant extract, T. neriifolia 4 per cent had a larval population of 7.26 against 8.98 in the control plot. Other plant extracts were on par control with mean population varying from 7.26 to 12.57. After second spraying a gradual decrease in the mean number of larvae in the control plot was observed.

Table 8. Effect of spraying different plant extracts in field on P. basalis and on the yield

Treatments	Mean number of larvae observed at different intervals after treatment						*Mean weight of leaves damaged by leaf webber g/plot	*Mean yield after removing damaged leaves g/plot
	Days after second spraying			Days after third spraying		Mean*		
	2	7	14	2	7			
A. indica extract 2 per cent	10.00° (3.16)ab	8.66 (2.94)abcd	10.31 (3.21)bcd	9.31 (3.05)abcde	5.55 (2.35)cde	8.74 (2.96)ef	183.33b	1806bc
" 4 per cent	8.76 (2.96)ab	5.92 (2.43)cde	7.92 (2.81)bcd	9.03 (3.01)bcde	3.61 (1.90)de	6.68 (2.59)gh	138.33c	1935bcd
T. neriifolia extract 2 per cent	9.97 (3.14)ab	7.91 (2.81)abcde	7.58 (2.75)cd	8.09 (2.84)cde	4.32 (2.08)de	8.31 (2.88)efg	150.33bc	1900bc
" 4 per cent	8.78 (2.96)ab	3.97 (1.99)e	8.08 (2.84)bcd	7.26 (2.69)e	3.82 (1.95)de	6.56 (2.56)h	143.33c	1967bcd
C. infortunatum extract 2 per cent	10.56 (3.25)ab	12.22 (3.50)ab	13.81 (3.72)ab	11.00 (3.32)abc	12.05 (3.47)a	11.55 (3.40)bcd	160.00bc	1730b
" 4 per cent	9.68 (3.11)ab	10.64 (3.26)abc	13.27 (3.64)abc	9.58 (3.10)abcde	10.30 (3.21)ab	11.07 (3.33)cd	141.67c	1860bc
A. indica extract + soapwater 2 per cent	9.39 (3.06)ab	6.71 (2.59)bcde	7.19 (2.68)d	11.76 (3.43)ab	5.55 (2.35)cde	6.99 (2.64)gh	135.00c	1967bcd
" 4 per cent	10.61 (3.26)ab	4.28 (2.07)de	8.14 (2.85)bcd	7.46 (2.73)de	3.26 (1.80)e	6.27 (2.50)h	130.00c	2010cd
T. neriifolia extract + soapwater 2 per cent	9.60 (3.10)ab	6.54 (2.56)cde	8.08 (2.84)bcd	11.47 (3.39)ab	3.96 (1.99)de	6.77 (2.60)gh	148.33c	1803bc
" 4 per cent	7.18 (2.68)bc	5.77 (2.40)cde	10.36 (3.22)bcd	10.29 (3.21)abcd	4.65 (2.16)de	7.51 (2.74)fgh	138.33c	2013cd
C. infortunatum extract + soapwater 2 per cent	13.36 (3.65)a	13.95 (3.73)a	17.79 (4.22)a	12.57 (3.55)a	12.30 (3.51)a	15.00 (3.87)a	153.33bc	1748b
4 per cent	10.90 (3.30)ab	13.12 (3.62)a	12.38 (3.52)abcd	10.27 (3.20)abcd	11.10 (3.33)ab	10.12 (3.18)de	150.00bc	1833bc
Tobacco decoction	13.36 (3.65)a	12.11 (3.48)ab	12.61 (3.55)abcd	10.54 (3.25)abc	9.31 (3.05)abc	13.66 (3.70)ab	246.67a	1463a
Carbaryl 0.2 per cent	4.14 (2.04)c	0.69 (0.43)f	7.28 (2.70)d	2.43 (1.56)f	0.22 (0.47)f	3.05 (1.75)i	75.00d	2173d
Control	13.32 (3.65)a	12.21 (3.49)ab	13.59 (3.69)ab	8.98 (3.00)bcde	7.23 (2.69)bcd	12.83 (3.58)abc	228.33a	1403a
CD	0.718	0.805	0.774	0.436	0.685	**	**	**

Figures in parentheses are transformed values $\sqrt{x}$

Mean of four observational plants

Means followed by same letter are not significantly different at 5% level

* Data compared by DMRT: rest of the data were subjected to analysis of covariance

In the data recorded on seventh day also carbaryl 0.2 per cent (0.22) was superior to the plant extracts and A. indica 4 per cent with soapwater (3.26) ranked next to the above treatment. Other extracts were on par with control (7.23) statistically even though the mean population ranged from 3.82 to 12.30.

Data on the average population were also revealed the superiority of carbaryl 0.2 per cent over the plant extracts with mean number of larvae being 3.05 per plant, as against A. indica 4 per cent mixed with soapwater (6.27), most effective plant extract, and T. neriifolia 4 per cent (6.56). Other treatments in their order of efficacy were A. indica 4 per cent, T. neriifolia 2 per cent with soapwater, T. neriifolia 4 per cent in combination with soapwater, T. nerifolia 2 per cent, A. indica 2 per cent, and C. infortunatum 4 per cent with soapwater with mean population of 6.68, 6.77, 7.51, 8.31, 8.74 and 10.12 respectively against 12.83 in the control plot.

The mean weight of leaves damaged by P. basalis under the different treatments also showed that least damage was in the plots treated with carbaryl 0.2 per cent (75 g) and it was followed by A. indica extract (4 per cent) mixed with soapwater (130 g), A. indica extract (2 per cent) mixed with soapwater (135 g), A. indica 4 per cent and

T. neriifolia 4 per cent with soapwater (138.33 g), C. infortunatum 4 per cent (141.67 g), T. neriifolia 4 per cent (143.33 g) and T. neriifolia 4 per cent with soapwater (148.33 g). Tobacco decoction (246.67 g) was on par with control (228.33) and rest of the treatments showed significant reduction in leaf damage compared to that of control.

Carbaryl 0.2 per cent offered the maximum protection and obtained an yield of 2173 g uninfested produce. This was on par with the other highly effective plant extracts viz. T. neriifolia 4 per cent with soapwater, A. indica 4 per cent in combination with soapwater, A. indica 2 per cent with soapwater, T. neriifolia 4 per cent and A. indica 4 per cent with a mean yield of 2013, 2010, 1967, 1967 and 1935 g respectively. Extracts of T. neriifolia 2 per cent (1900), C. infortunatum 4 per cent (1860), C. infortunatum 4 per cent with soapwater (1833), A. indica 2 per cent (1806), T. neriifolia 2 per cent with soapwater (1803), C. infortunatum 2 per cent with soapwater (1748) and C. infortunatum 2 per cent (1730) g were superior to the control and tobacco decoction with mean yields of 1403 g and 1463 g respectively.

3.3.2. Pests of bhindi

3.3.2.1. Aphids (A. gossypii) on bhindi

Data pertaining to the mean aphid population observed at different intervals after the spraying are presented in Table 9. Two days after spraying itself carbaryl 0.2 per cent could reduce the mean aphid population to 144.06 as against 1131.60 present in the control plot and it was superior to all the plant extracts. Among the plant extracts T. neriifolia 2 per cent with soapwater (321.98), T. neriifolia 4 per cent (331.90) and T. neriifolia 4 per cent with soapwater (351.45) followed by tobacco decoction (421.45) were the effective treatments and they ranked next to carbaryl 0.2 per cent. Extracts of A. indica 4 per cent with soapwater (596.76), T. neriifolia 2 per cent (667.77), A. indica 4 per cent (713.43) and A. indica 2 per cent (732.49) were effective against the aphids compared to control. Rest of the treatments were on par with control. The relative efficacy of the extracts continued in the same trend on fifth day after spraying also, where carbaryl 0.2 per cent remained superior to plant extracts with a mean population of 57.19 as against 872.90 in the control plot. Tobacco decoction was ranked next (219.20), on par with T. neriifolia 2 per cent with soapwater (315.32), T. neriifolia 4 per cent (324.86), T. neriifolia

2 per cent (333.93), T. neriifolia 4 per cent added with soapwater (410.05) and A. indica 4 per cent with combination of soapwater (471.58). Other treatments were on par with control though the mean population varied from 539.39 to 1274.66. On 10th DAS T. neriifolia with soapwater was on par with carbaryl 0.2 per cent and tobacco decoction, their respective population being 155.04, 102.16 and 165.10 respectively, T. neriifolia 2 per cent (252.09) followed the above treatments and they were on par with T. neriifolia 4 per cent (300.27), T. neriifolia 2 per cent with soapwater (469.50), A. indica 4 per cent with soapwater (469.52), A. indica 4 per cent (496.81) and A. indica 2 per cent (524.61). The rest of the treatments were on par with control (1064.02). It was observed that on 15th DAS the mean population of aphids in the different treatments including control showed an increasing trend. Carbaryl 0.2 per cent (453.71) was on par with tobacco decoction (522.44) and T. neriifolia 4 per cent with soapwater (549.32). The mean population in other treatments including control varied from 584.72 to 1319.32.

Observations made at 2 days after second spraying revealed the effectiveness of carbaryl 0.2 per cent with mean population of 173.33 but statistically it was on par with T. neriifolia 4 per cent (268.31), T. neriifolia

Table 9. Mean number of aphids observed at different intervals after spraying plant extracts on bhindi

Treatments	Mean number of aphids at different intervals after spraying								
	days after first spraying				days after second spraying				Means
	2	5	10	15	2	5	10	15	
A. indica extract 2 per cent	732.49 (27.06)bc	539.39 (23.22)cdef	524.61 (22.90)bc	875.96 (29.60)	445.58 (21.11)cdef	284.15 (16.86)bcde	198.12 (14.08)bcd	77.38 (8.80)bc	464.90 (21.56)c
" 4 per cent	713.43 (26.71)bc	694.33 (26.35)bcde	496.81 (22.29)bcd	864.49 (29.40)	482.04 (21.96)cdef	580.94 (24.10)ab	442.15 (21.03)a	82.28 (9.07)abc	572.68 (23.93)b
T. nerrifolia extract 2 per cent	667.77 (25.84)cd	333.93 (18.27)fg	252.09 (15.88)def	649.41 (25.48)	379.17 (19.47)defg	122.86 (11.08)e	314.84 (17.74)abc	61.34 (7.83)bc	366.47 (19.14)d
" 4 per cent	331.90 (18.22)e	323.86 (18.02)fg	300.27 (17.32)cde	584.72 (24.18)	268.31 (16.38)fg	98.28 (9.91)e	133.95 (11.57)cd	112.47 (10.61)ab	273.45 (16.54)ef
C. infortunatum extract 2 per cent	1019.84 (31.73)ab	1141.82 (33.79)ab	1005.54 (31.71)a	914.59 (30.24)	782.56 (27.97)abc	639.92 (25.30)a	139.85 (11.83)cd	88.85 (9.43)ab	731.49 (27.04)a
" 4 per cent	1005.09 (31.70)ab	1274.66 (35.70)a	1195.52 (34.58)a	1013.46 (31.83)	885.47 (29.76)ab	556.41 (23.59)ab	293.42 (17.13)abc	69.64 (8.34)bc	745.27 (27.30)a
A. indica extract + soapwater 2 per cent	783.39 (27.99)abc	1085.34 (32.94)ab	782.76 (27.98)ab	961.73 (31.01)	626.51 (25.03)bcde	593.87 (24.37)ab	277.68 (16.66)abc	50.81 (7.13)bcd	623.51 (24.97)b
" 4 per cent	596.76 (24.43)cd	471.58 (21.72)defg	469.52 (21.67)bcd	754.39 (27.47)	391.62 (19.79)defg	208.91 (14.45)cde	130.61 (11.43)cd	46.72 (6.84)bcd	373.46 (19.33)d
T. neriifolia extract + soapwater 2 per cent	321.98 (17.94)e	315.32 (17.76)fg	469.50 (21.67)bcd	770.05 (27.75)	337.14 (18.36)defg	168.18 (12.97)de	152.77 (12.36)cd	54.34 (7.37)bcd	332.81 (18.24)de
" 4 per cent	351.45 (18.75)e	410.05 (20.25)efg	155.04 (12.45)ef	549.32 (23.44)	288.24 (16.98)fg	179.89 (13.41)de	90.15 (9.49)de	44.28 (6.65)bcd	272.90 (16.52)ef
C. infortunatum extract + soapwater 2 per cent	1091.37 (33.04)a	932.58 (30.54)abc	1048.07 (32.37)a	846.14 (29.09)	1099.71 (33.16)a	473.54 (21.76)abc	296.35 (17.21)abc	104.23 (10.21)ab	791.15 (28.13)a
" 4 per cent	1051.91 (32.43)ab	824.35 (28.71)abcd	816.83 (28.58)ab	742.87 (27.26)	629.78 (25.09)bcde	403.71 (20.09)abcd	254.29 (15.95)abcd	106.78 (10.33)ab	601.00 (24.52)b
Tobacco decoction	421.65 (20.53)de	219.20 (14.81)g	165.10 (12.85)ef	522.44 (22.86)	297.60 (17.25)efg	84.44 (9.19)e	169.21 (13.01)cd	28.88 (5.37)cd	235.00 (15.33)f
Carbaryl 0.2 per cent	144.06 (12.00)f	57.19 (7.56)h	102.16 (10.11)f	458.71 (21.42)	173.53 (13.17)g	0.00 (0)f	14.72 (3.84)e	13.54 (3.68)d	120.41 (10.97)g
Control	1131.60 (33.64)a	872.90 (29.54)abc	1064.02 (32.62)a	1319.23 (36.32)	649.99 (25.49)bcd	684.31 (26.16)a	416.28 (20.40)ab	162.63 (12.75)a	826.15 (28.74)a
CD	5.192	6.840	6.228	NS					**

Figures in parentheses are transformed values $\sqrt{x}$

Mean of twelve leaves from four observational plants

Means followed by a common letter are not significantly different at 5% level

*Data compared by DMRT; rest of the data were subjected to analysis of covariance

4 per cent added with soapwater (288.24), tobacco decoction (297.60), T. neriifolia 2 per cent with soapwater (337.14) and T. neriifolia 2 per cent (379.17). Other treatments, except C. infortunatum 2 per cent with soapwater which recorded an increased population of 1099.71 were on par with control (649.99) and the population ranged from 445.58 to 885.47. On fifth day after spraying aphid population maintained a similar trend as in the previous observation. But plots treated with carbaryl 0.2 per cent were absolutely free from aphid infestation and treatments with tobacco decoction, T. neriifolia 4 per cent and T. neriifolia 2 per cent with a mean population of 84.44, 98.28 and 122.86 respectively, reduced the population efficiently to a level next to carbaryl 0.2 per cent. T. neriifolia 2 per cent with soapwater, T. neriifolia 4 per cent with soapwater, A. indica 4 per cent added with soapwater, and A. indica 2 per cent were the other treatments which were superior to control and rest of the treatments were on par with control. On tenth day after second spraying T. neriifolia 4 per cent with soapwater was on par with carbaryl 0.2 per cent, with a population of 90.15 and 14.72, were the effective treatments. Plots treated with A. indica 4 per cent with combination of soapwater (130.61), T. neriifolia 4 per cent (133.95), C. infortunatum 2 per cent (139.85), T. neriifolia 2 per cent with soapwater (152.77)

and tobacco decoction (169.21) recorded significantly lower population compared to that of control (416.28). Rest of the treatments were on par with the control, though the mean population varied from 198.12 to 442.15. On 15th day after spraying there was a natural decline in the mean population including control (162.63), but the insect control activity of carbaryl 0.2 was on par with tobacco decoction, T. neriifolia 4 per cent with soapwater, A. indica 4 per cent with soapwater, A. indica 2 per cent added with soapwater and T. neriifolia 2 per cent with soapwater with mean population of 13.54, 44.28, 46.72, 50.81 and 54.34 respectively. T. neriifolia 2 per cent (61.34) and A. indica 2 per cent (77.38) were also superior to control and the rest of the treatments were on par with control.

Mean population revealed that no plant extract was comparable to the carbaryl 0.2 per cent (120.41). The effective plant extracts were tobacco decoction (235.00), T. neriifolia 4 per cent with soapwater (272.90) and T. neriifolia 4 per cent (273.45) followed by T. neriifolia 2 per cent (332.81). Treatments with C. infortunatum at 2 and 4 per cent concentrations (731.49 and 745.27) were ineffective and on par with control (826.15). The remaining treatments were superior to control and intermediate ineffect.

3.3.2.2. Grasshoppers (A. crenulata)

Data on the leaf damage caused by grasshoppers A. crenulata are presented in Table 10 after statistical analysis.

In the observation recorded two days after spraying, A. indica 4 per cent (leaf damage 23.30) was the only treatment superior to control (33.11). It was also on par with other treatments except C. infortunatum 2 per cent (37.06), C. infortunatum 4 per cent with soapwater (35.66) and tobacco decoction (32.72). But five days after spraying A. indica 4 per cent and 2 per cent and A. indica 4 per cent with soapwater were effective treatments with the mean damage indices varying from 23.89, 23.90 and 24.71 respectively as against control with an index of 39.34. It was also on par with A. indica 2 per cent added with soapwater, carbaryl 0.2 per cent and C. infortunatum 4 per cent. All other treatments were on par with control and had little variation in the intensity of damage. On 10th and 15th days after spraying no treatment showed significant effect in reducing the damage compared to the control.

The mean damage indices showed that A. indica 4 per cent was the most effective treatment (23.19) and it was on par with A. indica 4 per cent with soapwater

Table 10. Intensity of leaf damage caused by A. crenulata observed at different periods after spraying plant extracts on bhindi

Treatments	Mean indices of leaf damage observed at different intervals after spraying (days)				Mean*
	2	5	10	15	
A. indica extract 2 per cent	25.93 (5.09)cd	23.90 (4.89)c	27.83 (5.28)	30.63 (5.53)	27.21 (5.22)efg
" 4 per cent	22.80 (4.78)d	23.89 (4.89)c	27.80 (5.27)	26.47 (5.14)	23.19 (4.82)g
T. neriifolia extract 2 per cent	30.85 (5.55)abcd	30.57 (5.53)abc	32.81 (5.73)	42.04 (6.48)	40.86 (6.39)a
" 4 per cent	25.91 (5.09)cd	31.67 (5.63)abc	36.20 (6.02)	38.79 (6.23)	33.60 (5.80)bc
C. infortunatum extract 2 per cent	37.06 (6.09)a	29.93 (5.47)abc	34.02 (5.83)	36.46 (6.04)	34.10 (5.84)bc
" 4 per cent	25.52 (5.05)cd	28.51 (5.34)bc	31.62 (5.62)	33.01 (5.75)	28.82 (5.37)def
A. indica extract + soapwater 2 per cent	26.43 (5.14)bcd	26.64 (5.16)bc	31.76 (5.64)	31.18 (5.58)	30.42 (5.52)cde
" 4 per cent	25.67 (5.07)cd	24.71 (4.97)c	25.25 (5.02)	26.40 (5.14)	24.67 (4.97)fg
T. neriifolia extract + soapwater 2 per cent	29.21 (5.40)abcd	30.30 (5.50)abc	32.49 (5.70)	35.49 (5.96)	32.82 (5.73)cd
" 4 per cent	28.94 (5.38)abcd	29.63 (5.44)abc	30.92 (5.56)	31.87 (5.65)	29.73 (5.45)cde
C. infortunatum extract + soapwater 2 per cent	30.67 (5.54)abcd	31.63 (5.62)abc	37.00 (6.08)	35.92 (5.99)	33.85 (5.82)bc
" 4 per cent	35.66 (5.97)ab	35.81 (5.98)ab	32.53 (5.70)	32.21 (5.68)	33.28 (5.77)bcd
Tobacco decoction	32.72 (5.72)abc	31.71 (5.63)abc	36.93 (6.08)	33.82 (5.81)	30.48 (5.52)cde
Carbaryl 0.2 per cent	26.12 (5.11)bcd	27.14 (5.21)bc	30.87 (5.56)	29.52 (5.43)	30.21 (5.51)cde
Control	33.11 (5.75)abc	39.34 (6.27)a	39.34 (6.27)	45.52 (6.75)	38.27 (6.19)ab
CD	0.744	0.729	NS	NS	

Mean intensity of damage from four observational plants

(24.67) and A. indica 2 per cent (27.21). The damage in the control plot (38.27) was on par with these of the plots treated with T. neriifolia 2 per cent (40.86), C. infortunatum 2 per cent (34.10), C. infortunatum 2 per cent with soapwater (33.85), T. neriifolia 4 per cent (33.60) and C. infortunatum 4 per cent with soapwater (33.28). The other treatments were superior to control.

3.3.2.3. Bhindi leaf hoppers A. biguttula biguttula

Mean population of leaf hoppers observed in different treatments are presented in Table 11.

On second DAS C. infortunatum 2 and 4 per cent with soapwater were on par with carbaryl 0.2 per cent the mean number of jassids being 123.14, 144.75 and 87.00 respectively, as against the population in control (412.62). The treatments next in the order of efficacy were T. neriifolia 4 per cent with soapwater (169.98). A. indica 2 per cent with soapwater (184.77), A. indica 4 per cent with soapwater (190.67), C. infortunatum 4 per cent (199.47), T. neriifolia 4 per cent (200.03), C. infortunatum 2 per cent (216.19) and T. neriifolia 2 per cent (239.38) which were on par among themselves. A. indica 4 per cent and tobacco decoction were on par with control. Remaining treatments were moderate in action and superior to control. On fifth

day after spraying also C. infortunatum 2 per cent with soapwater was as effective as carbaryl 0.2 per cent with mean population of 70.32 and 34.45, followed C. infortunatum 4 per cent with soapwater (78.50), T. neriifolia 4 per cent with soapwater (102.98), C. infortunatum 2 per cent (124.19) and C. infortunatum 4 per cent (127.44). A. indica 2 and 4 per cent and tobacco decoction were ineffective in controlling the pest. Other treatments with mean population ranging from 163.08 to 247.89 were superior to control (367.71). Ten days after spraying no plant extract was effective as carbaryl 0.2 per cent. The population recorded under carbaryl 40.53 was only as against the control population of 402.15. The most effective treatment among the plant extracts was C. infortunatum 2 and 4 per cent with soapwater, and C. infortunatum 2 and 4 per cent with mean number of jassids 96.82 and 98.13, 110.20 and 128.83 respectively. Tobacco decoction (365.81) was the only treatment on par with control. All other treatments could control the pest population to different levels. A decline in population was observed on 15th and 20th days in the control plot (197.83). Carbaryl 0.2 per cent (44.86) continued as the most effective treatment which was on par with C. infortunatum 4 and 2 per cent mixed with soapwater (65.30 and 82.02), C. infortunatum 2 per cent (81.82). The treatments C. infortunatum 4 per cent (99.67), T. neriifolia 4 per cent with soapwater (104.10),

Table 11. Mean number of leaf hoppers observed at different intervals after spraying plant extracts on bhindi

Treatments	Mean number of leaf hoppers observed at different intervals after spraying										
	days after second spraying						days after third spraying				
	2	5	10	15	20	25	2	5	10	15	Mean*
A. indica extract 2 per cent	299.90 (17.32)bcd	283.37 (16.83)abc	225.91 (15.03)c	182.06 (13.49)ab	145.75 (12.07)ab	288.53	247.06 (15.72)b	205.74 (14.34)b	200.04 (14.14)b	160.16 (12.66)a	187.12 (13.68)b
" 4 per cent	366.99 (19.16)abc	357.77 (18.91)a	304.89 (17.46)b	123.64 (11.12)bcde	99.64 (9.98)bcde	303.01	207.94 (14.42)bc	172.27 (13.13)bcd	186.71 (13.66)b	114.22 (10.69)abc	187.22 (13.60)b
T. peltifolia extract 2 per cent	239.38 (15.47)def	247.89 (15.74)bc	222.05 (14.90)c	105.13 (10.25)cdef	80.00 (8.94)cdef	267.17	238.30 (15.44)b	187.34 (13.69)bc	184.20 (13.57)b	128.47 (11.33)ab	146.36 (12.10)cd
" 4 per cent	200.03 (14.14)efg	228.35 (15.11)cd	227.00 (15.07)c	135.07 (11.62)abcd	103.86 (10.19)bcde	338.38	183.09 (13.53)cd	130.97 (11.44)def	143.98 (12.00)cd	87.21 (9.34)bcd	146.58 (12.11)cd
C. infortunatum extract 2 per cent	216.19 (14.70)defg	124.19 (11.14)ef	110.20 (10.50)ef	81.22 (9.05)efg	70.21 (8.38)ef	308.76	141.85 (11.91)ef	87.10 (9.33)fgh	95.92 (9.79)efg	56.67 (7.53)def	93.48 (9.67)g
" 4 per cent	199.47 (14.12)efg	127.44 (11.29)ef	128.23 (11.32)ef	99.67 (9.98)def	75.50 (8.69)def	372.81	153.36 (12.38)de	90.00 (9.49)fgh	118.66 (10.89)cdef	55.18 (7.43)def	109.65 (10.46)fg
A. indica extract + soapwater 2 per cent	184.77 (13.59)fgh	206.15 (14.36)cd	230.03 (15.17)c	169.86 (13.03)ab	129.06 (11.36)abc	364.20	190.86 (13.82)cd	128.41 (11.33)def	146.44 (12.10)c	85.12 (9.23)bcd	150.91 (12.28)c
" 4 per cent	190.67 (13.80)fgh	241.79 (15.55)cd	232.80 (15.26)c	149.52 (12.23)abcd	120.13 (10.96)abcd	350.45	198.39 (14.09)	104.21 (10.21)efg	126.59 (11.25)cde	76.88 (8.77)cde	140.43 (11.85)cd
T. peltifolia extract + soapwater 2 per cent	281.16 (16.77)cde	163.08 (12.77)de	202.44 (14.23)cd	135.98 (11.66)abcd	104.56 (10.23)bcde	317.98	188.85 (13.74)cd	107.14 (10.35)ef	107.83 (10.38)def	67.75 (8.23)de	129.21 (11.32)de
" 4 per cent	169.98 (13.04)fgh	102.98 (10.15)ef	153.91 (12.41)de	104.10 (10.20)cdef	81.83 (9.05)cdef	286.64	244.10 (15.62)b	140.36 (11.85)cde	141.68 (11.90)cd	84.41 (9.19)bcd	114.22 (10.69)ef
C. infortunatum extract + soapwater 2 per cent	123.14 (11.10)hi	70.32 (8.39)fg	96.82 (9.84)f	82.02 (9.06)efg	72.42 (8.51)def	300.61	141.34 (11.89)ef	66.09 (8.13)ghi	86.93 (9.32)fg	55.68 (7.46)def	77.41 (8.80)fi
" 4 per cent	144.75 (12.03)ghi	78.50 (8.86)f	98.13 (9.91)f	65.30 (8.08)fg	48.14 (6.94)fg	295.04	129.28 (11.37)ef	58.12 (7.62)hi	73.87 (8.59)gh	36.36 (6.03)f	70.07 (8.37)h
Tobacco decoction	397.83 (19.95)ab	341.93 (18.49)ab	365.81 (19.13)ab	161.14 (12.69)abc	133.90 (11.57)ab	305.29	350.23 (18.71)a	372.00 (19.29)a	315.68 (17.77)a	123.26 (11.10)ab	244.50 (15.64)a
Carbaryl 0.2 per cent	87.00 (9.33)i	34.45 (5.87)g	40.53 (6.37)g	44.86 (6.70)g	26.92 (5.19)g	213.35	108.31 (10.41)f	47.52 (6.89)i	54.72 (7.40)h	47.51 (6.89)ef	37.17 (6.10)i
Control	412.62 (20.31)a	367.71 (19.18)a	402.15 (20.05)a	197.83 (14.07)a	166.59 (12.91)a	401.54	301.59 (17.37)a	317.89 (17.83)a	292.75 (17.11)a	115.50 (10.75)abc	262.71 (16.21)a
CD	2.610	2.657	2.011	2.253	2.173		1.478	1.960	1.472	1.901	**

Figures in parentheses are values after $\sqrt{x}$ transformation

Mean of twelve leaves from four observational plants

Means followed by a common letter are not significantly different at 5% level

*Data compared by DMRT: rest of the data were subjected to analysis of covariance

T. neriifolia 2 per cent (105.13) and A. indica 4 per cent (123.64) were also effective in the descending order. Other treatments were on par with control. On 20th day plots treated with water recorded a mean population of 166.59 and it was on par with tobacco decoction (133.90) and A. indica 2 per cent (45.75) carbaryl 0.2 per cent (26.92) was the best treatment followed by C. infortunatum 4 per cent with soapwater (48.14). In other treatments the mean number of jassids ranged from 72.42 to 120.13.

Two days after the third spraying C. infortunatum 4 per cent with soapwater, C. infortunatum 2 per cent with soapwater and C. infortunatum 2 per cent were on par with carbaryl 0.2 per cent, the mean population in the treatments being 129.28, 141.34, 141.86 and 108.31 respectively. Tobacco decoction was on par with control with mean population of 350.23 and 301.59 respectively. Other treatments were superior to control, but inferior to the effective treatments, the mean population varying from 153.36 to 247.06. In the observation recorded on fifth day C. infortunatum 4 per cent with soapwater and C. infortunatum 2 per cent with soapwater were on par with carbaryl 0.2 per cent, the population being 58.12, 66.09 and 47.52 respectively. The treatments next in efficacy were C. infortunatum 2 per cent (87.10), and C. infortunatum 4 per cent (90.00).

All other treatments except tobacco decoction were superior to control and population ranged from 104.21 to 205.74 against 317.89 in control plot. On tenth day C. infortunatum 4 per cent with soapwater (73.87) was on par with carbaryl 0.2 per cent (54.72), followed by C. infortunatum 2 per cent with soapwater and C. infortunatum 2 per cent. The other treatments except tobacco decoction were significantly superior to the control. At 15 days after third spraying all the treatments with C. infortunatum were found as effective as carbaryl 0.2 per cent (47.51) and they were in the following descending order of efficacy: C. infortunatum 4 per cent with soapwater (36.36), C. infortunatum 4 per cent (55.18), C. infortunatum 2 per cent with soapwater (55.68) and C. infortunatum 2 per cent (56.67).

Analysis of the average leaf hopper population computed during the crop season showed that carbaryl 0.2 per cent supported least population of 37.17 against 262.71 under control. All the plant extracts except tobacco decoction (244.50) were found effective in reducing the mean leaf hopper population. At 2 and 4 per cent concentrations C. infortunatum with soapwater was inferior to carbaryl 0.2 per cent and superior to all other treatments with mean leaf hopper population of 77.41 and 70.07 respectively. C. infortunatum 2 and 4 per cent were ranked next

to the above treatments (93.48 and 109.45 respectively). The other effective treatments in their order of efficacy were T. neriifolia 4 per cent with soapwater, T. neriifolia 2 per cent with soapwater, A. indica 4 per cent with soapwater, A. indica 2 and 4 per cent, A. indica 2 per cent with soapwater, A. indica 2 per cent and A. indica 4 per cent with mean hopper population of 114.22, 128.21, 140.43, 146.34, 146.58, 150.91, 187.12 and 187.22 respectively.

3.3.2.4. Bhindi shoot and fruit borer E. vitella

Data collected on the incidence of shoot and fruit borer are presented in Table 12 after statistical analysis.

No significant variations among the different treatments were observed at two days after spraying. On fifth day the plots receiving carbaryl 0.2 per cent recorded the least incidence of 1.95 per cent against 56.97 in control, and it was on par with A. indica 2 per cent with soapwater (2.37). The treatments following carbaryl were A. indica 4 per cent with soapwater (8.80), T. neriifolia 4 per cent (9.15), T. neriifolia 4 per cent with soapwater (9.68), C. infortunatum 2 per cent (10.39) and T. neriifolia 2 per cent with soapwater (12.47). In the observation at 10 days after spraying the plots treated with T. neriifolia 4 per cent (0.00) were free from shoot and fruit borer infestation and it was on par with A. indica 4 per cent,

Table 12. Control of bhindi shoot and fruit borer E. vitella in field using plant extracts

Treatments	Mean percentage of shoot and fruit borer incidence observed at different periods after spraying												Mean*
	days after second spraying						days after third spraying			days after fourth spraying			
	2	5	10	15	20	25	2	5	10	15	2	5	
A. indica extract 2 per cent	19.12 (25.92)	16.11 (23.65)b	2.14 (8.41)cde	1.44 (6.90)	3.93 (11.44)	22.10 (28.03)	12.38 (20.59)	20.68 (27.04)bc	9.53 (17.98)bc	36.33 (37.05)	18.33 (25.75)	11.28 (19.62)	15.94 (23.52)bcd
" 4 per cent	1.44 (6.90)	18.81 (25.69)b	1.44 (6.90)de	0.95 (5.59)	15.23 (22.96)	23.40 (28.92)	23.35 (28.88)	9.25 (17.70)bc	7.22 (15.59)bc	23.46 (28.96)	4.75 (12.58)	1.44 (6.90)	12.23 (20.46)fg
T. peltifolia extract 2 per cent	10.10 (18.52)	20.45 (26.88)b	7.66 (16.06)bcd	1.66 (7.40)	2.37 (8.85)	19.84 (26.44)	31.10 (33.88)	14.20 (22.13)bc	12.92 (21.06)bc	25.93 (30.60)	5.12 (13.07)	3.49 (10.77)	15.68 (23.32)bcd
" 4 per cent	11.01 (19.37)	9.15 (17.60)bcd	0.00 (0)	3.93 (11.44)	2.14 (8.41)	28.03 (31.96)	11.33 (19.66)	18.61 (25.55)bc	6.84 (15.16)c	9.58 (18.03)	3.02 (10.00)	17.03 (24.36)	12.13 (20.38)fg
C. infortunatum extract 2 per cent	16.84 (24.22)	10.39 (18.80)bcd	13.56 (21.60)bc	2.14 (8.41)	4.82 (12.67)	16.81 (24.19)	23.35 (28.88)	16.49 (23.95)bc	17.61 (24.80)bc	33.94 (35.62)	20.73 (27.07)	25.00 (29.99)	18.05 (25.13)bc
" 4 per cent	11.57 (19.88)	15.09 (22.85)bc	12.58 (20.76)bc	1.44 (6.00)	1.66 (7.40)	14.67 (22.52)	24.51 (29.67)	13.48 (21.53)bc	14.36 (22.26)bc	20.45 (26.87)	2.65 (9.37)	15.47 (23.15)	15.22 (22.95)cde
A. indica extract + soapwater 2 per cent	1.95 (8.03)	2.37 (8.85)cd	8.01 (16.44)bcd	7.84 (16.25)	1.95 (8.03)	27.05 (31.33)	9.99 (18.42)	13.71 (21.73)bc	16.23 (23.75)bc	30.03 (33.21)	11.46 (19.78)	19.83 (26.43)	14.24 (22.16)def
" 4 per cent	1.04 (5.85)	8.80 (17.25)bcd	5.49 (13.54)bcde	1.28 (6.49)	2.65 (9.37)	26.57 (31.01)	12.59 (20.77)	11.40 (19.72)bc	10.14 (18.56)bc	12.24 (20.47)	24.21 (29.46)	12.97 (21.10)	11.50 (19.82)g
T. peltifolia extract + soapwater 2 per cent	1.79 (7.69)	12.47 (20.67)bcd	10.83 (19.21)bcd	6.64 (14.93)	1.44 (6.90)	32.62 (34.82)	21.61 (27.69)	17.04 (24.37)bc	9.45 (17.89)bc	29.27 (32.74)	27.89 (31.87)	16.99 (24.33)	16.07 (23.62)bcd
" 4 per cent	6.07 (14.26)	9.68 (18.12)bcd	6.00 (14.17)bcd	3.49 (10.77)	0.95 (5.59)	31.47 (34.11)	21.47 (27.59)	7.92 (16.34)c	13.74 (21.75)bc	11.89 (20.16)	6.11 (14.30)	10.31 (18.72)	12.64 (20.61)efg
C. infortunatum extract + soapwater 2 per cent	11.70 (19.99)	17.86 (24.99)b	10.75 (19.13)bcd	0.87 (5.36)	2.76 (9.57)	27.03 (31.31)	10.58 (18.97)	16.57 (24.01)bc	13.51 (21.56)bc	30.45 (33.48)	8.47 (16.91)	17.64 (24.82)	18.57 (25.52)bc
" 4 per cent	4.15 (11.75)	20.38 (26.83)b	14.64 (22.48)b	1.79 (7.69)	1.44 (6.90)	26.53 (30.99)	11.20 (19.55)	24.65 (29.75)bc	26.94 (31.26)bc	27.17 (31.41)	25.93 (30.60)	25.52 (30.33)	16.44 (23.91)bcd
Tobacco decoction	16.99 (24.33)	56.32 (48.61)a	68.49 (55.83)a	20.45 (26.88)	1.66 (7.40)	22.65 (28.41)	34.28 (35.82)	56.08 (48.47)a	68.08 (55.58)a	39.72 (39.05)	27.70 (31.74)	23.54 (29.01)	38.54 (38.36)a
Carbaryl 0.2 per cent	1.66 (7.40)	1.95 (8.03)d	2.37 (8.85)bcde	0.00 0	0.00 0	8.44 (16.88)	4.38 (12.08)	12.19 (20.43)bc	13.03 (21.15)bc	16.86 (24.23)	2.14 (8.41)	2.65 (9.37)	7.22 (15.58)h
Control	18.45 (25.43)	56.97 (48.99)a	60.92 (51.28)a	19.83 (25.43)	15.61 (23.26)	32.11 (34.51)	39.77 (39.08)	63.78 (52.98)a	71.50 (57.71)a	43.42 (41.20)	11.70 (20.00)	12.39 (20.60)	39.07 (38.67)a
	NS	*	**	NS	NS	NS	NS	*	**	NS	NS	NS	**

Figures in parentheses are angular transformed values

Means followed by same letter are not significantly different at 5% level based on DMRT

A. indica 2 per cent, carbaryl 0.2 per cent and A. indica 4 per cent with soapwater with mean percentage incidence of 1.44, 2.14, 2.37 and 5.49 respectively. Other treatments which recorded incidence varying from 6.00 per cent under T. neriifolia 4 per cent with soapwater to 14.64 per cent under C. infortunatum 4 per cent with soapwater were superior to tobacco decoction and control which had mean incidence of 68.49 and 60.92 per cent respectively. There was no variations among the population in different treatments on 15th, 20th and 25th days after spraying with the incidence varying from 0 to 20.45, 0 to 15.61 and 8.44 to 32.11 per cent respectively. The infestation had declined on 15th, 20th days, but increased on 25th day.

The data recorded on two days after third spraying also did not show significant variations among the treatments. In the observations recorded five days after spraying T. neriifolia 4 per cent with soapwater showed lowest incidence (7.92) compared to 63.78 in control plot. But T. neriifolia was statistically on par with other treatments (9.25 to 24.65) except tobacco decoction (56.08). The data obtained at 10 days after spraying also showed significant effect for carbaryl and plant extracts compared to control and tobacco decoction. T. neriifolia 4 per cent with 6.84 per cent of incidence appeared the lowest, but

it was on par with other treatments.

On second and fifth days after fourth spraying also there was no significant variations among the treatments and control though infestation ranged from 2.14 to 27.89 and 1.44 to 25.52 respectively.

Mean incidence of shoot and fruit borer over the season revealed that A. indica 4 per cent with soapwater (11.50) was the most effective plant extract which was on par with T. neriifolia 4 per cent, A. indica 4 per cent and T. neriifolia 4 per cent with soapwater, but inferior to carbaryl 0.2 per cent. Control and tobacco decoction were on par with 39.07 and 38.54 per cent damage respectively.

3.3.2.5. Bhindi leaf roller S. derogata

Data collected on the mean number of larvae S. derogata observed at different occasions after spraying are presented in Table 13.

At two days after spraying plots receiving carbaryl 0.2 per cent recorded the least population (4.65) and it was followed by T. neriifolia 4 per cent with soapwater (10.28). All other treatments were on par with control. At five days after spraying also carbaryl 0.2 per cent (2.49)

Table 13. Mean population of leaf roller larvae observed at different intervals after spraying plant extracts on bhindi

Treatments	Mean number of larvae observed at different intervals after spraying						Mean number* of larvae observed during entire crop period
	days after third spraying			days after fourth spraying			
	2	5	10	15	2	5	
A. indica extract 2 per cent	12.10 (3.48)abc	9.29 (3.05)cde	7.33 (2.71)bc	11.30 (3.36)bcd	5.57 (2.36)c	3.64 (1.91)d	8.43 (2.90)de
" 4 per cent	12.95 (3.60)abc	11.07 (3.33)abc	7.28 (2.70)bc	8.95 (2.99)cdef	5.89 (2.43)c	5.62 (2.37)abcd	8.71 (2.95)cde
T. neriifolia extract 2 per cent	14.30 (3.78)ab	11.63 (3.41)abc	6.93 (2.63)bc	10.21 (3.21)bcde	6.93 (2.63)bc	6.33 (2.52)abc	9.48 (3.08)bcde
" 4 per cent	14.08 (3.75)ab	15.58 (3.95)a	9.29 (3.05)bc	10.30 (3.21)bcde	6.15 (2.48)bc	5.48 (2.34)bcd	10.75 (3.28)b
C. infortunatum extract 2 per cent	13.58 (3.69)abc	10.23 (3.20)bcd	7.61 (2.76)bc	6.30 (2.51)f	9.35 (3.06)ab	8.45 (2.91)ab	8.45 (2.91)de
" 4 per cent	11.70 (3.42)abc	6.56 (2.56)de	5.63 (2.37)c	10.63 (3.26)bcde	7.55 (2.75)abc	6.89 (2.63)abc	8.11 (2.85)de
A. indica extract + soap-water 2 per cent	12.58 (3.55)abc	9.89 (3.14)cd	8.49 (2.91)bc	12.27 (3.50)bc	6.59 (2.57)bc	5.03 (2.24)ed	9.54 (3.09)bcd
" 4 per cent	10.95 (3.31)bc	8.98 (3.00)cde	11.57 (3.40)ab	8.23 (2.87)def	11.04 (3.32)a	8.77 (2.96)a	9.50 (3.08)bcd
T. neriifolia extract + soap-water 2 percent	12.69 (3.56)abc	10.80 (3.29)abc	9.25 (3.04)bc	6.93 (2.63)ef	5.72 (2.39)c	5.85 (2.42)abcd	8.32 (2.88)de
" 4 per cent	10.28 (3.21)c	5.91 (2.43)e	10.60 (3.26)b	9.33 (3.05)cdef	8.30 (2.88)abc	5.69 (2.39)abcd	7.98 (2.83)e
C. infortunatum extract + soapwater 2 per cent	14.33 (3.79)ab	11.99 (3.46)abc	8.94 (2.99)bc	10.23 (3.20)bcde	8.51 (2.92)abc	6.80 (2.61)abc	10.01 (3.16)abc
" 4 per cent	13.72 (3.70)abc	11.26 (3.36)abc	9.29 (3.05)bc	9.79 (3.13)bcde	6.36 (2.52)bc	5.41 (2.33)bcd	9.26 (3.04)bcde
Tobacco decoction	13.73 (3.71)abc	15.27 (3.91)ab	11.57 (3.40)ab	13.97 (3.74)ab	6.30 (2.51)bc	4.52 (2.13)cd	10.58 (3.25)ab
Carbaryl 0.2 per cent	4.65 (2.16)d	2.49 (1.58)f	0.22 (0.47)d	7.19 (2.68)ef	7.41 (2.72)bc	0.74 (0.86)e	3.66 (1.91)f
Control	15.32 (3.91)a	12.84 (3.58)abc	16.21 (4.03)a	17.58 (4.19)a	9.22 (3.04)ab	3.47 (1.86)d	14.22 (3.77)a
CD	0.439	0.633	0.659	0.540	0.518	0.517	**

Figures in parentheses are transformed values $\sqrt{x}$

Mean of four observational plants

remained as the most effective treatment, and it was followed by T. neriifolia 4 per cent with soapwater (5.91) and C. infortunatum 4 per cent (6.56). The population in other treatments varied from 8.98 to 15.58 and all were on par with control (12.84). In the observation collected on 10th day after spraying the mean number of larval population was least under carbaryl 0.2 per cent (0.22) followed by C. infortunatum 4 per cent (5.63). Remaining treatments except A. indica 4 per cent with soapwater and tobacco decoction had significantly lesser population than in control plot (16.21) ranging from 6.93 to 10.60 and were on par among themselves. In the data collected on 15th day all the treatments except tobacco decoction were seen superior to control. Among them A. indica 2 per cent (11.30) and A. indica 2 per cent with soapwater (12.27) were inferior and rest of the treatments were on par with carbaryl 0.2 per cent.

In the observations made at two days after fourth spraying A. indica 2 per cent (5.57), T. neriifolia 2 per cent with soapwater (5.72) and A. indica 4 per cent (5.89) were effective when compared to control and other treatments, including carbaryl 0.2 per cent, were on par with control.

Table 14. Mean number of C. sexmaculata observed at different intervals after spraying plant extracts on bhindi

Treatments	Mean number observed at different intervals after treatment								Mean*
	days after first spraying				days after second spraying				
	2	5	10	15	2	5	10	15	
A. indica extract 2 per cent	17.78 (4.22)ab	16.64 (4.08)ab	12.61 (3.55)ab	10.75 (3.29)	9.55 (3.09)cde	7.28 (2.70)ab	6.56 (2.56)	3.61 (1.90)	10.61 (3.26)f
" 4 per cent	15.36 (3.92)ab	12.27 (3.50)b	10.23 (3.20)b	11.59 (3.40)	12.58 (3.55)abcd	6.98 (2.64)bc	5.66 (2.38)	3.10 (1.76)	9.25 (3.04)g
T. neriifolia extract 2 per cent	16.73 (4.09)ab	14.86 (3.85)ab	13.64 (3.69)ab	12.84 (3.58)	13.21 (3.63)abcd	6.48 (2.54)bc	4.32 (2.08)	3.44 (1.85)	10.70 (3.27)ef
" 4 per cent	13.79 (3.71)b	15.15 (3.89)ab	12.86 (3.59)ab	14.19 (3.77)	16.99 (4.12)a	6.27 (2.50)bc	4.52 (2.13)	4.08 (2.02)	11.10 (3.33)def
C. infortunatum extract 2 per cent	14.60 (3.82)ab	15.57 (3.95)ab	10.96 (3.31)b	11.63 (3.41)	14.05 (3.75)abcd	9.85 (3.14)ab	5.90 (2.43)	6.30 (2.51)	11.20 (3.35)def
" 4 per cent	15.31 (3.91)ab	18.61 (4.31)a	16.28 (4.03)ab	13.05 (3.61)	11.24 (3.35)abcd	7.66 (2.77)ab	7.54 (2.75)	5.26 (2.29)	12.21 (3.49)cd
A. indica extract + soapwater 2 per cent	16.81 (4.10)ab	15.92 (3.99)ab	15.57 (3.95)ab	11.48 (3.39)	9.57 (3.09)cde	12.64 (3.55)a	9.16 (3.03)	4.62 (2.15)	12.13 (3.48)cd
" 4 per cent	14.37 (3.79)ab	17.97 (4.24)a	13.02 (3.61)ab	13.46 (3.67)	12.30 (3.51)abcd	9.25 (3.04)ab	8.66 (2.94)	5.55 (2.35)	12.00 (3.46)cd
T. neriifolia extract + soapwater 2 per cent	13.76 (3.71)b	19.29 (4.39)a	16.16 (4.02)ab	10.96 (3.31)	9.59 (3.10)cde	10.65 (3.26)ab	9.64 (3.11)	4.58 (2.14)	11.94 (3.46)cde
" 4 per cent	15.64 (3.96)ab	17.66 (4.20)a	11.57 (3.40)ab	14.56 (3.82)	11.94 (3.46)abcd	8.35 (2.89)ab	9.24 (3.04)	5.59 (2.37)	11.82 (3.44)cdef
C. infortunatum extract + soapwater 2 per cent	18.51 (4.30)a	12.25 (3.50)b	14.75 (3.84)ab	12.45 (3.53)	10.90 (3.30)bcd	9.59 (3.10)ab	7.33 (2.71)	6.21 (2.49)	11.56 (3.40)cdef
" 4 per cent	16.00 (4.00)ab	16.93 (4.11)a	12.45 (3.53)ab	14.54 (3.81)	8.92 (2.99)de	7.84 (2.80)ab	4.89 (2.21)	5.26 (2.29)	10.93 (3.31)def
Tobacco decoction	17.25 (4.15)ab	17.94 (4.24)a	11.15 (3.34)b	16.06 (4.00)	14.86 (3.85)abc	10.89 (3.30)ab	7.23 (2.69)	5.89 (2.43)	12.68 (3.56)bc
Carbaryl 0.2 per cent	7.77 (2.79)c	4.91 (2.22)c	2.85 (1.69)c	9.93 (3.15)	6.30 (2.51)e	3.32 (1.82)c	2.78 (1.67)	4.25 (2.06)	5.54 (2.35)h
Control	17.95 (4.24)ab	19.94 (4.47)a	17.94 (4.24)a	15.47 (3.93)	15.58 (3.95)ab	10.56 (3.25)ab	10.90 (3.30)	8.29 (2.88)	14.80 (3.85)a
CD	0.473	0.532	0.728	NS	0.698	0.758	NS	NS	**

Figures in parentheses are transformed values $\sqrt{x+1}$

18.51. On fifth day also the toxicity of carbaryl towards the predator was the maximum with the least population of 4.91 against 19.94 in the control. But C. infortunatum 2 per cent with 0.4 per cent soapwater and A. indica 4 per cent were also found toxic (12.25 and 12.27 respectively) and they ranked next to carbaryl 0.2 per cent. Other treatments had no deleterious effect on the predator and were on par with control. On tenth day plots treated with carbaryl 0.2 per cent had a mean number of 2.85 predators as against 17.94 in the control plot. Other treatments which reduced the population of predators were A. indica 4 per cent (10.23), C. infortunatum 2 per cent (10.96) and tobacco decoction (11.15), the rest were being on par with control. Data on 15th day showed that there was no significant variation among the treatments and mean population ranged from 9.93 to 16.06 in the plots receiving carbaryl 0.2 per cent and tobacco decoction.

Two days after second spraying carbaryl 0.2 per cent was most toxic (6.30) and the treatments C. infortunatum 4 per cent with soapwater (8.92), A. indica 2 per cent (9.55), A. indica 2 per cent + soapwater (9.57), T. neriifolia 2 per cent with soapwater (9.59) were also toxic and on par with carbaryl 0.2 per cent. Other treatments were less toxic with mean population ranging from

10.90 to 16.99, compared to 15.58 in control. But at 5 days after spraying though carbaryl 0.2 per cent remained as the most toxic treatment (3.32), the other treatments were on par with control (10.56). Observations recorded on tenth and fifteenth day after second spraying did not show significant variations among the treatments though the mean population in carbaryl 0.2 per cent treated plot was the least (2.78 and 4.25 for the two observations) and maximum was in control (10.90 and 8.29 for the two observations) respectively.

Data computed on the mean predator population also revealed maximum toxicity for carbaryl 0.2 per cent (5.54) followed by A. indica 4 per cent (9.25). All the plant extracts including tobacco decoction affected the predator population with values ranging from 10.61 to 12.68 as against 14.80 in control. The treatments of A. indica 2 per cent (10.61), T. neriifolia 2 per cent (10.70), C. infortunatum 4 per cent with soapwater (10.93), T. neriifolia 4 per cent (11.10), C. infortunatum 2 per cent (11.20), C. infortunatum 2 per cent with soapwater (11.56), and T. neriifolia 4 per cent with soapwater (11.82) were on par among themselves, and ranked next to A. indica 4 per cent (12.68).

3.3.2.7. Yield

The data relating to the damaged fruits and healthy fruits of bhindi obtained from the experimental plots are presented in Table 15.

Plots treated with carbaryl 0.2 per cent recorded least fruit damage of 161 g and it was on par with A. indica 4 per cent (198.33) as against 409.33 g in control. Fruit damage was significantly less in plots treated with T. neriifolia 4 per cent (216.00), A. indica 2 per cent with soapwater (231.67), and A. indica 4 per cent with soapwater (212.00) and they were on par with A. indica 4 per cent. Other treatments except tobacco decoction were effective against the pest and were in the following descending order in efficacy: A. indica 2 per cent (240.00), T. neriifolia 4 per cent with soapwater (245.00), T. neriifolia 2 per cent with soapwater (247.00 g), C. infortunatum 2 per cent (253.67 g), C. infortunatum 4 per cent (274.33 g), C. infortunatum 4 per cent with soapwater (293.33 g) and C. infortunatum 2 per cent with soapwater (303.33 g).

The yield of healthy fruits obtained from the plots treated with 0.2 per cent of carbaryl (1962 g) was the highest and the least was under control (1052 g). Among

Table 15. Effect of plant extracts and Carbaryl on the yield of bhindi

Treatments	Mean weight of damaged fruits (g/plot)	Mean weight of healthy fruits (g/plot)
A. *indica* extract 2 per cent	240.00def	1430b
" 4 per cent	198.33 gh	1520bcde
T. *neriifolia* extract 2 per cent	273.33bcd	1505bcd
" 4 per cent	216.00efg	1585bcde
C. *infortunatum* extract 2 per cent	253.67cde	1490bc
" 4 per cent	274.33bcd	1577bcde
A. *indica* extract + soapwater 2 per cent	231.67efg	1560bcde
" 4 per cent	212.00fg	1685cde
T. *neriifolia* extract + soapwater 2 per cent	247.00def	1718e
" 4 per cent	245.00def	1712e
C. *infortunatum* extract + soapwater 2 per cent	303.33bc	1548bcde
" 4 per cent	293.33b	1600bcde
Tobacco decoction	431.67a	1030a
Carbaryl 2 per cent	161.00h	1962f
Control	409.33a	1052a
	**	**

Means followed by a common letter are not significantly different at 5% level DMRT

the plots treated with plant extracts T. neriifolia 4 and 2 per cent with soapwater recorded high yield of 1718 and 1712 g respectively. They were on par with A. indica 4 per cent, C. infortunatum 2 per cent with soapwater, A. indica 2 per cent with soapwater, C. infortunatum 4 per cent, T. neriifolia 4 per cent, C. infortunatum 4 per cent with soapwater and A. indica 4 per cent with soapwater with mean yield of 1520, 1548, 1560, 1577, 1585, 1600, and 1685 g per plot. The yield in A. indica 2 per cent and C. infortunatum (1430 and 1490 g) were significantly lower than the above treatments but they were superior to the tobacco decoction (1030 g) and control.

DISCUSSION

DISCUSSION

4.1. Evaluation of plants

Neem is well known as a source of insecticidal constituents. Earlier studies have revealed the usefulness of other locally available plants also for controlling the important crop pests. Saradamma (1989) reported that water acetone and benzene extracts of T. neriifolia, L. camara, A. indica, N. oleander, E. odoratum, C. infortunatum, C. variegatum, P. odoratissimus, M. esculenta suppressed adult emergence of many test insects. Considering the easy availability of the plants locally, these eight plants viz., A. indica, T. neriifolia, C. infortunatum, N. oleander, E. odoratum, A. squamosa, P. glabra, and C. gigantea were used to study their efficacy for controlling the crop pests in the field. The phytochemicals present in these plants include behaviour modifying compounds, those interfering with the normal development and to a limited extent toxic principles also (Redfern et al., 1981; Ruscoe, 1972 and Steets and Schmutterer, 1975). Since leaves are plant parts easily available throughout the year and in sufficient quantities for practical field application they were utilised for the studies. The active principle available in the leaf extracted with different solvents like acetone, methanol, benzene, petroleum ether and water. Since the chemical solvents are costly and not easily available at the farmers level, water, which was found effective when tested with

many insect pests (Kuhn et al., 1950; Maxwell et al., 1965 and Rao and Mehrotra, 1977), was used here.

4.1.1. Screening of plants against pests of amaranthus

The plants in pot culture experiment were infested with leaf webber P. basalis, and the effect of the different plant extract were presented in para 3.1.1 carbaryl, used as an insecticide check for comparing the effects of the plant extracts, was most effective treatment upto 14 days after application and recorded the least average population throughout the crop season. Among the plant extracts T. neriifolia 4 per cent was top ranking and it was next to carbaryl 0.2 per cent. It could suppress the pest population from the second day to fourteen days after spraying. Tobacco decoction used as an insecticide of plant origin was much inferior to T. neriifolia.

The efficacy of related species of plants Thevetia spp viz., T. thevetiodes and T. neriifolia in controlling hemipteran pests (Saradamma, 1989), Coleoptera (Reed et al., 1981), Lepidoptera (Mc. Laughlin et al., 1980) were reported. Mc. Laughlin (1980) has reported cent per cent larval mortality of O. nubilalis (European corn borer) when seeds of mexican yellow oleander, T. thevetiodes was incorporated into the diet. The present finding on

the efficacy of leaf extract against P. basalis indicated the possibility of using T. neriifolia for plant protection at field level.

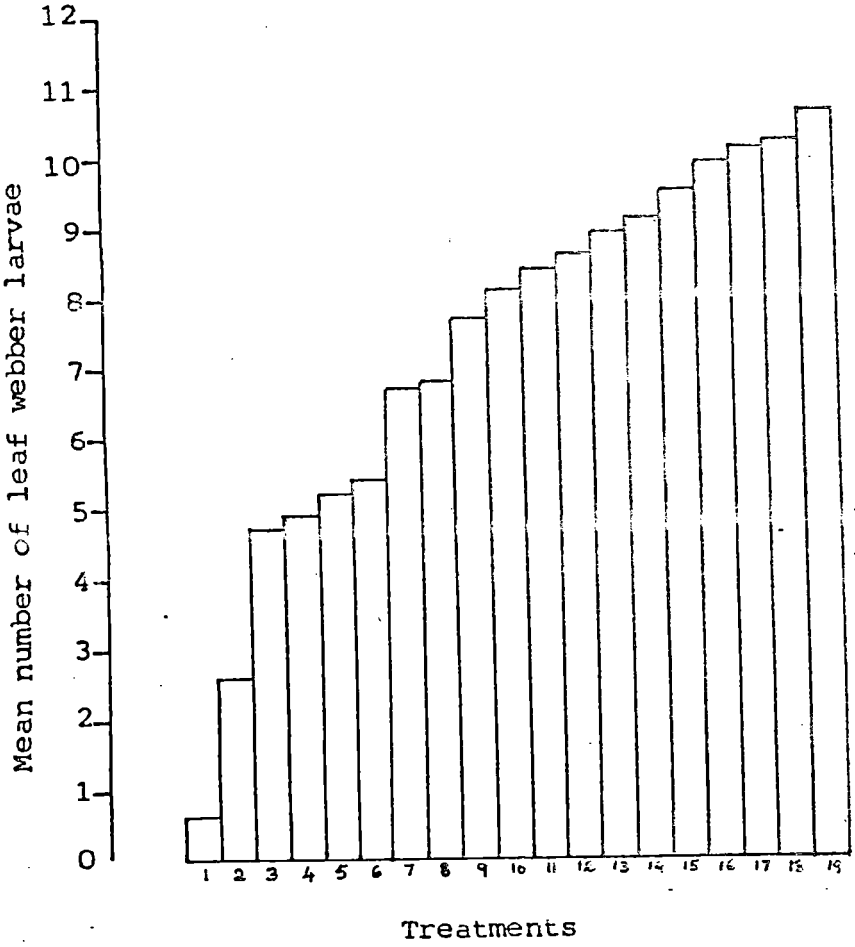
The mean yield obtained from the plants treated with T. neriifolia was almost the same as obtained from carbaryl treatment. Carbaryl had immediate and acute toxicity leading to the heavy mortality and low survival of pest and thereby increasing the yield. Other plant extracts also could produce a yield on par with insecticide by the multichemical principles, discouraged feeding, and other normal activities of the insect.

C. infortunatum at 4 per cent concentration also reduced the population of P. basalis from second to fourteenth day on par with T. neriifolia with slight decrease in yield, but 2 per cent extract being inferior, it can be ranked only next to T. neriifolia. The insecticidal activity of C. infortunatum was reported against C. formicarius earlier by Rajamma (1982). One per cent ether extract of C. fragrans also gave cent per cent protection from third instar larvae of S. litura (Hosozawa et al., 1974).

E. odoratum and A. indica exerted toxicity only from seventh day onwards that too at the higher concentration,

1. Efficacy of aqueous plant extracts in comparison with carbaryl on the control of amaranthus leaf webber P. basalis

Fig. 1



1. Carbaryl 0.2%
2. T. neriifolia 4%
3. C. infortunatum 4%
4. T. neriifolia 2%
5. A. indica 4%
6. E. odoratum 4%
7. A. indica 2%
8. C. infortunatum 2%
9. E. odoratum 2%
10. N. oleander 4%
11. A. squamosa 4%
12. C. gigantea 2%
13. P. glabra 4%
14. Tobacco decoction
15. A. squamosa 2%
16. C. gigantea 4%
17. N. oleander 2%
18. P. glabra 2%
19. Control

though the average population under these treatments were statistically on par with that of T. neriifolia 2 per cent. A. indica could produce comparatively higher yield than that of E. odoratum probably due to its well known deterrent action, reported against wide variety of insects (Chari and Muraleedharan, 1985; Patel et al., 1968 and Saxena, 1982). The other plant extracts including the tobacco decoction did not have any effect. The higher concentrations of these plants extracts reduced average pest population compared to control, but the effect was not reflected in yield.

The effect of different plant extracts on the leaf webber P. basalis is represented in Fig. 1. Four and 2 per cent extracts of T. neriifolia, C. infortunatum, A. indica, E. odoratum, and 4 per cent extract of N. oleander and A. squamosa which ranked over others were selected for further studies.

4.1.2. Screening of plants against pests of bhindi

Bhindi plants under the experiment were infested with aphids (A. gossypii), leaf hoppers (A. biguttula biguttula) and shoot and fruit borer (E. vitella).

As presented in para 3.1.2.1 carbaryl was more effective than the plant extracts and persisted for a period

of ten days for the first two sprayings and fifteen days for the third spraying. The population in the control plot recorded 15 per cent natural decline compared to original population during the course of 45 days. Among the plant extracts T. neriifolia 4 per cent was ranked first followed by 2 per cent extract which was on par with and tobacco decoction during the crop period. Upto tenth day the two per cent extract of T. neriifolia was inferior to 4 per cent extract. But the overall effect was on par with tobacco decoction. Tobacco decoction has been an effective insecticide of plant origin against soft bodied insects. T. neriifolia which is a locally available plant that can be easily collected without incurring much cost was found as an effective substitute for tobacco decoction. The aphicidal effect of water extract of T. neriifolia was reported by Saradamma (1989) with A. gossypii and A. cracivora. Extracts of A. indica were also effective against A. gossypii. Insecticidal property of neem seed kernel against A. gossypii was reported as early as in 1944 by Cherian and Menon and subsequently Asari and Nair in 1972. Saradamma (1989) reported that benzene extract of neem could protect the crop upto ten days on par with carbaryl 0.2 per cent. In the present studies also the crop could be protected for a period of ten days but it was not on par with carbaryl and this could be due to

the lower toxicity of water extracts. Two per cent water extract of neem leaves exhibited repellent effect and inhibited the mean population of B. brassicae on cabbage and cauliflower from 45 to 60 per cent in pot and field trials (Kirpal Singh and Sharma, 1985). The present studies was in full agreement with this finding.

Four per cent extract of C. infortunatum, A. squamosa, P. glabra and 2 per cent extract of E. odoratum and C. gigantea also exhibited a reduction in population. However the higher concentrations of E. odoratum and C. gigantea remained less toxic.

The results presented in para 3.1.2.2 revealed the supremacy of carbaryl in producing an immediate reduction in population of leaf hoppers compared to that of plant extracts. The toxicity of carbaryl persisted upto fifteen days after application and it could reduce the population significantly throughout the crop period compared to plant extracts. Four per cent extract of C. infortunatum and T. neriifolia were effective and came close to carbaryl. They reduced the pest population from two days after application to fifteen days. The mortality observed at two days after spraying is to be attributed to the insecticidal activity of the materials. Nymphal mortality of D. cingulatus was reported with C. infortunatum by Saradamma

(1989). She reported a reduction in population of A. gossypii when sprayed with the benzene extract of C. infortunatum.

Contact toxicity of T. neriifolia against A. gossypii and its insecticidal property against A. craccivora were reported by Saradamma (1989). It may be the same phenomina that brought a reduction in population at two days after application. Throughout the crop period the population remained below 50 per cent of the population in control, on plants treated with C. infortunatum and T. neriifolia. It can be effectively incorporated as a tool in the management programme against this pest. Extracts of A. indica 4 per cent and C. infortunatum 2 per cent were effective. The higher concentrations have evidently gave better results in controlling of the pest. Toxicity of neem to a wide range of sucking insects have been reported earlier (Saxena, 1987; Goyal et al., 1971). Rao and Rao (1979) reported high mortality of N. lugens with 1 per cent neem 48 h after application. Two per cent extract of neem leaf could reduce the overall population by 40 per cent. The extracts of N. oleander, E. odoratum, and P. glabra, both the concentrations, were effective against leaf hoppers. But persistent toxicity of these materials were not consistent at different occasions. Tobacco decoction was not

Fig. 2. Efficacy of aqueous plant extracts in comparison with carbaryl on the pests of bhindi

(a) aphids

(b) leaf hopper

(c) shoot and fruit borer

Fig. 2a.

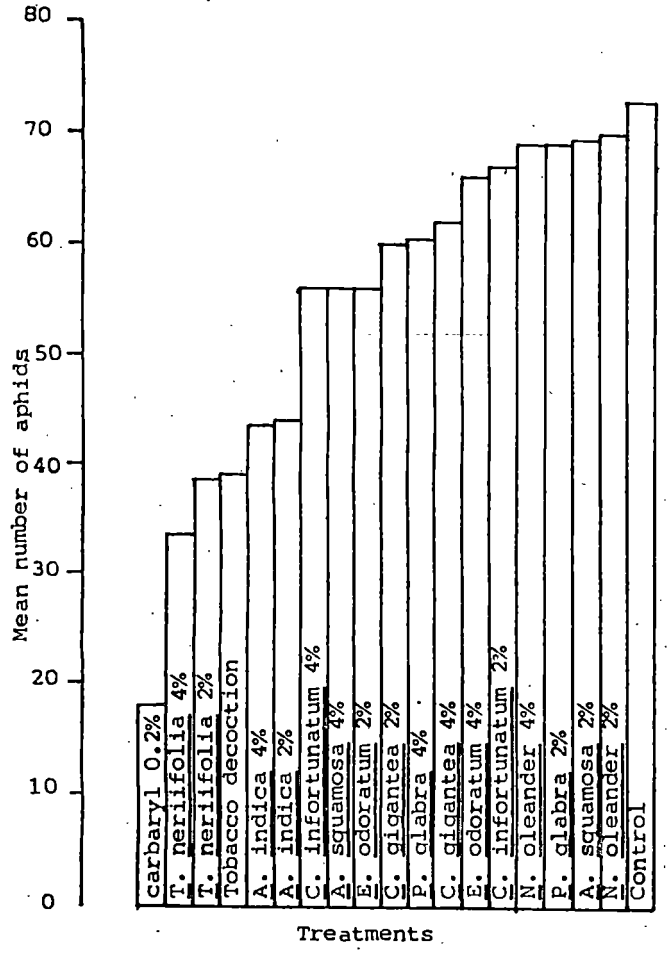


Fig. 2b

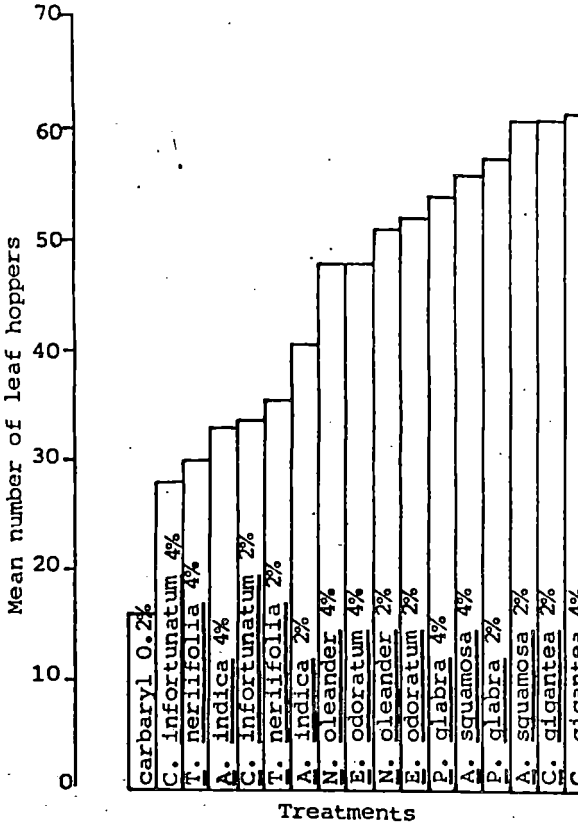
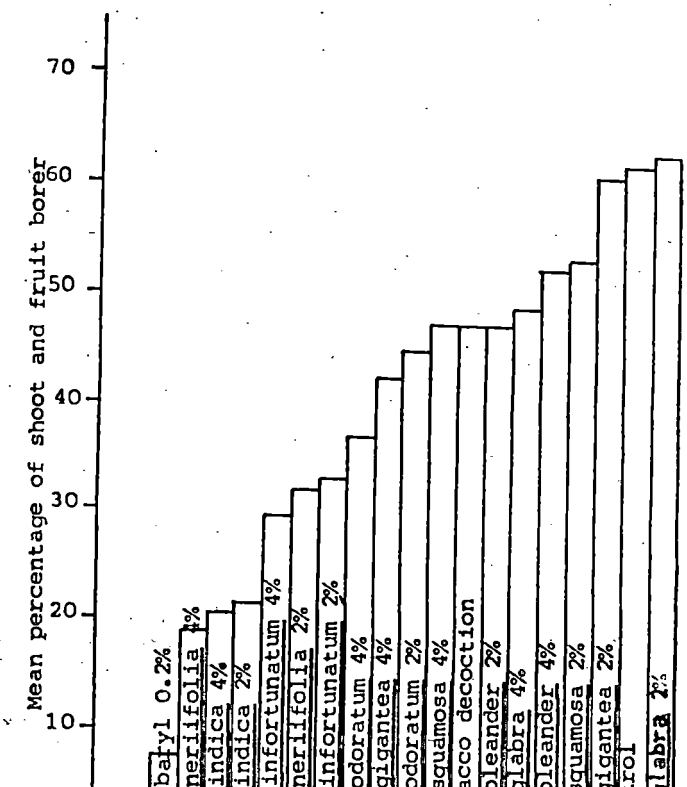


Fig. 2c



at all effective in controlling the pest though some toxicity was noticed at two days after first spraying compared to that of control.

Against shoot and fruit borer E. vitella (para 3.1.2.3) carbaryl remained as the most effective treatment with 7.3 per cent fruit damage compared to 62.21 under control. T. neriifolia 2 per cent and A. indica at both the concentrations limited the incidence of the pest during the entire crop season. Toxicity of neem against fruit borers like E. vitella (Chouhan and Qadri, 1989) L. orbonalis (Krishnamurthy Rao, 1983) and L. decemlineata (Reed and Reed, 1984) were reported earlier. Though carbaryl was best in reducing the population of aphids, leaf hoppers and shoot and fruit borers the effect was not reflected in the yield since carbaryl came on par with extracts of C. infortunatum, T. neriifolia and A. indica with reference to the yield. There was no earlier report on the effectiveness of C. infortunatum and T. neriifolia against the fruit borers.

The plant extracts are ranked in their order of efficacy against aphids, leaf hoppers, shoot and fruit borer in Fig. 2. T. neriifolia 4 and 2 per cent, A. indica 4 and 2 per cent and C. infortunatum 4 per cent were effective against all the three pests and were ranked below the

carbaryl. C. infortunatum 2 per cent, E. odoratum 2 and 4 per cent though they were effective against the insects. N. oleander 4 and 2 per cent were found effective against leaf hoppers.

Based on the extent of control of amaranthus and bhindi pests five plants viz. A. indica, T. neriifolia, C. infortunatum, N. oleander, and E. odoratum were selected for further studies.

4.2. Augmenting toxicity of plant extracts by use of different additives

The data presented in para 3.2.1 revealed that 8 and 4 per cent extracts of C. infortunatum and 8 per cent extract of T. neriifolia significantly reduced the adult emergence of S. litura (Fig. 3). The overall effect of the plant extracts computed irrespective of different additives showed C. infortunatum extract kept the population of the S. litura at safe levels. The combinations of 8 per cent leaf extract with one or two per cent teepol was more effective. Though the combination of soapwater with 8 per cent extract of C. infortunatum came next to teepol combination the mean per cent of normal adults emergence did not vary significantly in the two treatments. The overall effects of teepol 2 per cent and soapwater as represented in

Fig. 3. Effect of aqueous extracts of plants and additives in augmenting the toxicity against larvae of *S. litura*

(a) Effect of aqueous plant extracts at different concentration

(b) Overall effect of additives

Fig. 3a

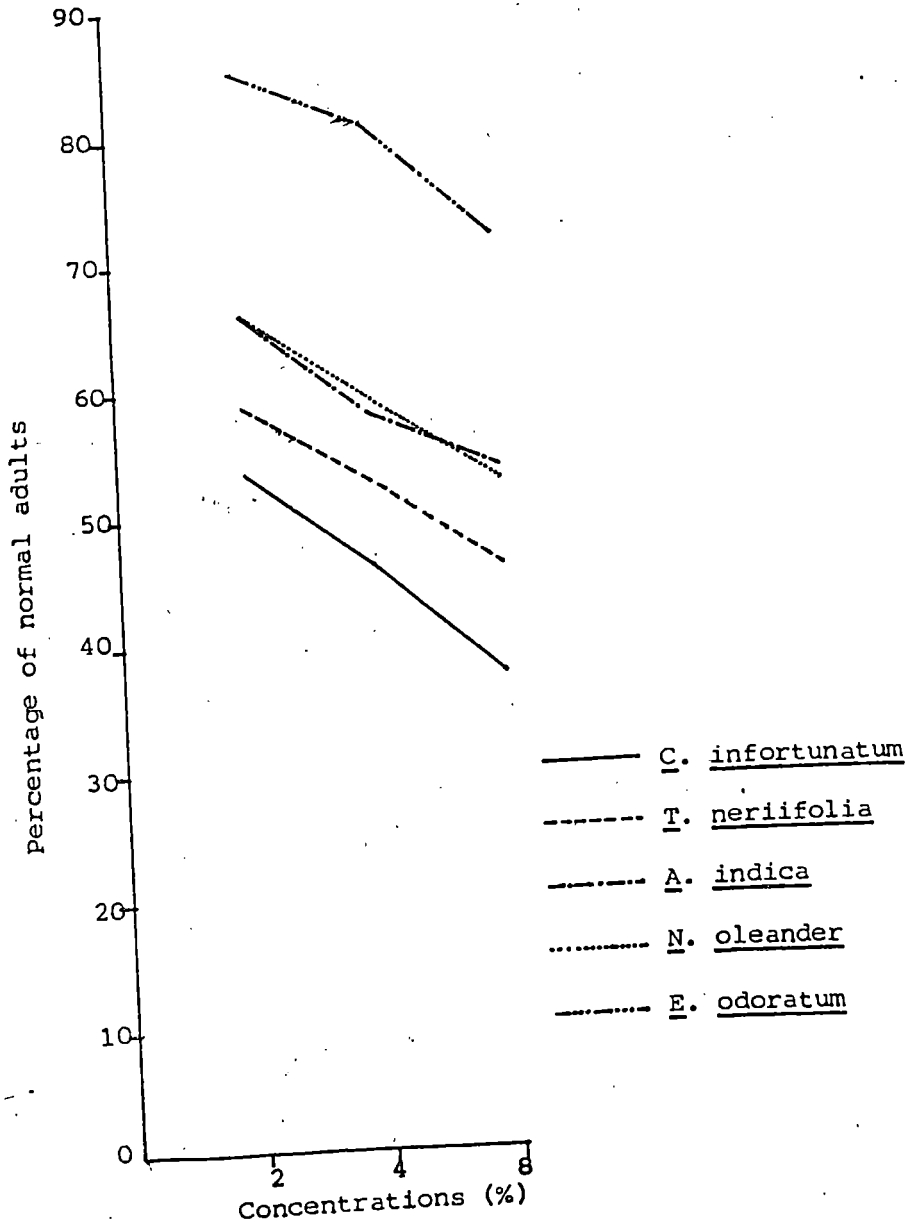

90
80
70
60
50
40
30
20
10
0
percentage of normal adults
2
4
8
Concentrations (%)
C. infortunatum
T. nerifolia
A. indica
N. oleander
E. odoratum

Fig. 3b

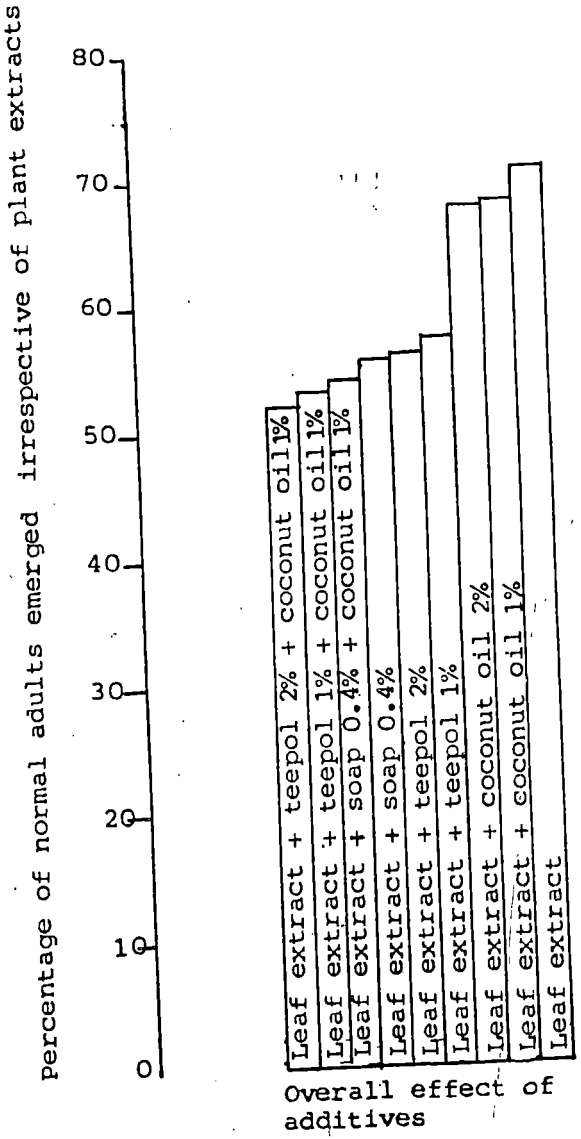

80
70
60
50
40
30
20
10
0
percentage of normal adults emerged irrespective of plant extracts
Leaf extract + teepol 2% + coconut oil 1%
Leaf extract + teepol 1% + coconut oil 1%
Leaf extract + soap 0.4% + coconut oil 1%
Leaf extract + soap 0.4%
Leaf extract + teepol 2%
Leaf extract + teepol 1%
Leaf extract + coconut oil 2%
Leaf extract + coconut oil 1%
Leaf extract
Overall effect of additives

Fig. 3b were on par. The combination of teepol with coconut oil showed low percentage of adult emergence compared to that of the combination of the leaf extract with coconut oil alone and was ineffective in controlling the normal adult emergence. This phenomena may be due to the additive effect of teepol. The combinations of 8 and 4 per cent extracts of C. infortunatum with teepol one per cent + coconut oil one per cent and 0.4 per cent soapwater + 1 per cent coconut oil had the same percentage of normal adult emergence (19.31 and 39.31 respectively). It may be observed that teepol and soapwater had similar action in augmenting the toxicity of leaf extracts (55.63 and 55.51 respectively). Though soap was known to increase the toxicity of plant extracts against aphids (Cherian and Menon, 1944; Kabir and Mia, 1987) the information that soap could be used in combination with plant extracts to prevent adult emergence of S. litura (54.49 per cent) is a new finding. Saradamma (1989) observed 50 per cent adult emergence of S. litura treated with cent per cent concentration of C. infortunatum, and the emerging adults were sterile and did not lay eggs. In the present study 8, 4 and 2 per cent leaf extracts C. infortunatum caused 80.69, 83.64, and 86.99 adult emergence whereas the corresponding values in combination with soapwater were 26.20, 43.16 and 60.14 per cent. Evidently the toxicity

of leaf extract was augmented three fold and two fold by using soapwater with 8 and 4 per cent leaf extract respectively. Since soap is an easily available and cheap material it can be used advantageously in plant protection operations. Though 8 per cent concentrations of the plant extracts were more effective 4 per cent concentration also could reduce the adult emergence to 46.37 per cent. As it involves labour for collecting leaves to prepare extracts, effective extracts of lesser concentrations will be preferable. Hence for field experiments 4 and 2 per cent extracts with soap as additive were selected.

Results presented in para 3.2.2 on the mean percentage mortality of A. gossypii indicated the efficacy of the combinations of 4 or 8 per cent extracts of A. indica and T. neriifolia with 0.4 per cent soapwater and the combination of T. neriifolia 8 per cent extract with 1 per cent teepol and 1 per cent coconut oil. These two plants were superior to rest of the plants at different concentrations as represented in Fig. 4a. The plant extracts alone produced a mortality of 56.69 to 90.76 per cent and 63.40 to 80.69 per cent under different concentrations of A. indica and T. neriifolia respectively and the mortality was enhanced by the additives by 38.21 to 9.24 per cent and 27.85 to 19.31 per cent for the two plants respectively.

Fig.4. Effect of aqueous extracts of the plants and additives in augmenting the toxicity against aphids A. gossypii

(a) Effect of aqueous plant extracts at different concentration

(b) Overall effect of additives

Fig. 4a

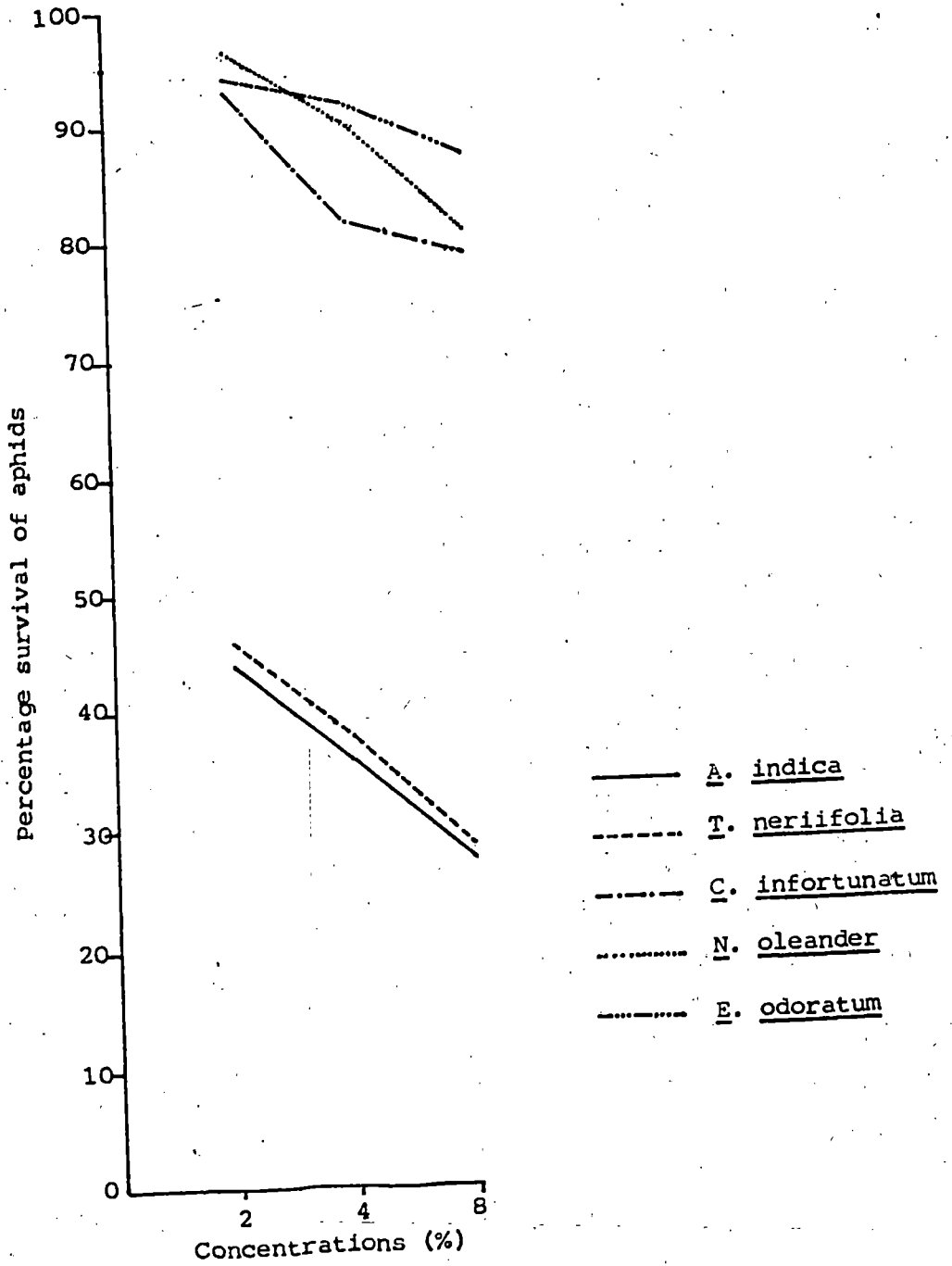
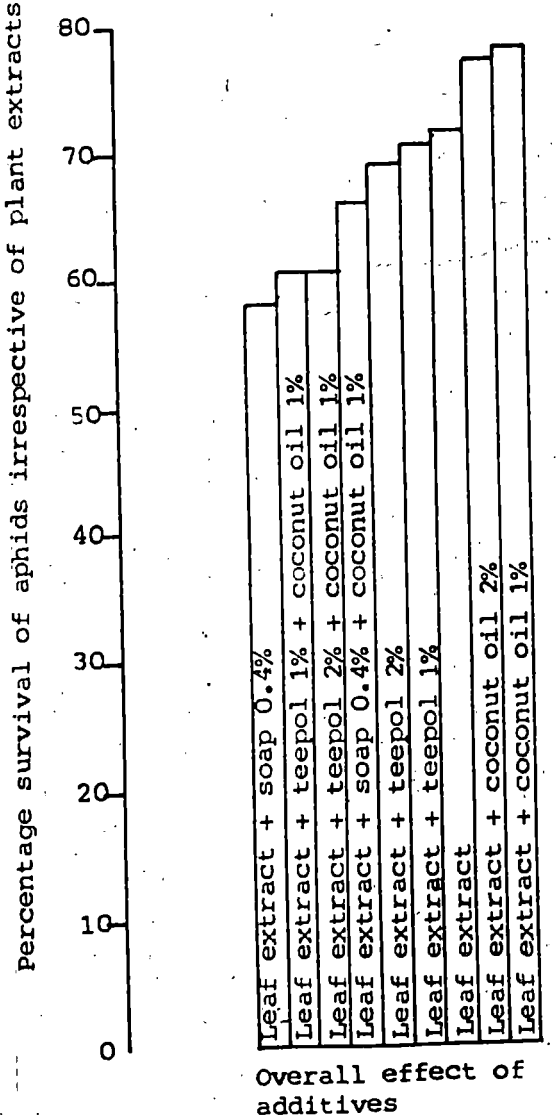

100
90
80
70
60
50
40
30
20
10
0
Percentage survival of aphids
2
4
8
Concentrations (%)
A. indica
T. neriifolia
C. infortunatum
N. oleander
E. odoratum

Fig. 4b


80
70
60
50
40
30
20
10
0
Percentage survival of aphids irrespective of plant extracts
Leaf extract + soap 0.4%
Leaf extract + teepol 1% + coconut oil 1%
Leaf extract + teepol 2% + coconut oil 1%
Leaf extract + soap 0.4% + coconut oil 1%
Leaf extract + teepol 2%
Leaf extract + teepol 1%
Leaf extract
Leaf extract + coconut oil 2%
Leaf extract + coconut oil 1%
Overall effect of additives

Of the additives tried 0.4 per cent soapwater augmented the toxicity more effectively as shown in Fig. 4b. In general it may be observed that the augmentation was more at lower concentrations and addition of soapwater to 2 per cent extract increased the toxicity of the leaf extract by 4.14 per cent more than that with eight per cent extract of A. indica. In case of T. neriifolia, however 4 per cent and 8 per cent extracts were on par. Toxicity of the 2 per cent extract (63.40) was enhanced to the extent of 10.56 per cent above the most effective concentration of the leaf extract. Aphicidal activity of the extracts of A. indica and T. neriifolia was reported earlier (Saradamma, 1989). Workers like Cherian and Menon (1944) also reported about enhancement in the toxicity of plant extracts by the addition of soap. In the present studies 4 per cent extract of A. indica and T. neriifolia with soapwater produced cent per cent mortality of aphids and 2 per cent extract with soapwater was also on par with it. The lower concentrations of the plant extracts in combination with soapwater may be chosen for controlling the aphid population.

In the experiment C. infortunatum was found most effective with least percentage of adult emergence. Against A. gossypii extracts of A. indica and T. neriifolia were

effective and upto cent per cent mortality was counted by the treatments. Hence the three plants in combination with soapwater, one of the effective but the cheapest additive, were selected for the field trial. They were compared with the leaf extracts alone and carbaryl for controlling pests of amaranthus and bhindi.

4.3. Control of pests of amaranthus and bhindi using plant extracts in field

As presented in para 3.3.1.1 extracts of A. indica 4 per cent, T. neriifolia 2 and 4 per cent, C. infortunatum 2 and 4 per cent could control the foliage damage caused by A. crenulata from second day to fourteenth day after spraying. Addition of soap to 2 per cent extract of A. indica and T. neriifolia could augment the toxicity while there was no such enhancement in the case of 4 per cent extract. The plant extracts with and without soapwater could protect the crop on par with carbaryl upto 14th day after treatment. The efficacy of the extract of A. indica is known for preventing the feeding by grasshoppers like C. trachypterus and S. gregaria (Sandhugurmel and Darshan Singh, 1975; Sergent, 1944). Extract of T. neriifolia at 2 per cent concentration with and without soap had the same effect as A. indica extract. The two extracts, especially at the lower concentrations, fared

better than the carbaryl considering its overall effect throughout the season, while tobacco decoction was not at all effective against grasshoppers. Addition of soap to C. infortunatum could not produce any impact against this pest. T. neriifolia, since it is a locally available plant may be preferred for managing the foliar damage in amaranthus caused by A. crenulata.

Results presented in para 3.3.1.2 indicated the superiority of conventional insecticide, carbaryl over plant extracts to provide immediate control of the leaf webber P. basalis. But on fourteenth day it came on par with the plant extracts. It could reduce the mean number of larvae and corresponding leaf damage to the minimum during the crop season. The differences in mean number of larvae (3.22) and mean weight of damaged leaves (55 g) between the carbaryl, 4 per cent extract of A. indica with soapwater and 4 per cent extract of T. neriifolia were slight. The extracts of A. indica, T. neriifolia with and without soap (except 2 per cent extract of A. indica) could reduce the larval infestation by to half compared to the population on plants sprayed with water and there was corresponding reduction in the leaf damage. Though the addition of soap has augmented the toxicity of the extracts only in the case of 2 per cent extract of A. indica.

there was a general enhancement. Two per cent extract of neem with soapwater (6.99) brought the mean larval kill to the level of mortality in 4 per cent extract of A. indica (6.68). The effectiveness of neem against leaf caterpillars like cabbage Web worm C. binotalis (Fagoonee, 1980), P. xylostella (Steets, 1975) and M. separata (Sharma et al., 1983) had been already reported. Against P. xylostella Adhikary (1985) reported that crude methanol extract of neem seed at 2 and 4 per cent were more efficient than mevinphos and deltamethrin. But in the study 4 per cent aqueous extract of neem was found inferior to carbaryl. The extract of T. neriifolia 4 per cent with and without soap and 2 per cent extract with soap were as effective as the 4 per cent extracts of neem. The pest control activity of this locally available plant against P. basalis is a new information.

It may be observed that 2 per cent extract of A. indica and T. neriifolia added with 0.4 per cent soap solution protected the crop against A. crenulata and P. basalis on par with the respective 4 per cent extract. But plots treated with 4 per cent extracts of A. indica and T. neriifolia with and without soap and 2 per cent extract of A. indica with soap recorded maximum yield and they were on par with carbaryl. Though carbaryl was superior

to plant extracts in reducing the pest population, it was not superior to A. indica and T. neriifolia in increasing the yield. This may be due to the different behavioural, physiological and insecticidal stress exerted by the extracts for a prolonged period and they reduced the damage due to feeding better than carbaryl. These characters were more pronounced at the higher concentrations with the exception of A. indica in which the potency of 2 per cent extract was augmented and brought to the level of 4 per cent when mixed with soap. Mere application of the aqueous leaf extract of A. indica and T. neriifolia with a little soap added to the 2 per cent concentration could protect amaranthus crop against grasshoppers and leaf webber on par with a potent conventional insecticide like carbaryl. This practice can be used as major component in the pest management system for amaranthus as these plant materials can be easily collected, prepared and applied in homestead gardens even by housewives and a crop uncontaminated by insecticides can be harvested.

The finding obtained in the laboratory trial that the soapwater enhanced the toxicity of extract was not evident in field except in the case of A. indica 4 per cent. The extract of T. neriifolia at 2 and 4 per cent concentration produced aphid mortality and it was on par with tobacco

decoction which ranked next to carbaryl. Contact toxicity of the water extract against A. gossypii and its effectiveness in field to protect the crop had been reported by Saradamma (1989). This disagreement may be due to the high population level of aphids combined with congenial conditions for multiplication. In plots which received carbaryl had an immediate suppression of aphid from 1171.80 to 144.06 at two days after spraying whereas in other treatments there was only a gradual decline which facilitated the population to build up at a rapid stage from the surviving ones. As the addition of soapwater to the extracts could augment the toxicity under laboratory conditions addition of soap at higher concentrations will have to be investigated further for reaching a confirmative conclusion in the field. Anyhow the finding that 4 per cent extract of T. neriifolia could reduce the mean population of aphids, on par with tobacco decoction is of practical importance. Tobacco being a costly commodity, can be substituted with this cheap and locally available plant T. neriifolia. Though the toxicity of 4 per cent extract of A. indica was enhanced by addition of soap it was not on par with carbaryl 0.2 per cent as reported by Saradamma (1989) with 2 per cent benzene extract. 45 to 60 per cent reduction in population of B. brassicae reported Kirpal Singh and Sharma (1986), with 2 per cent water extract of A. indica

could be obtained in the present study also.

The results presented in para 3.3.2.2 revealed that the damage caused by grasshoppers in the early stage of the crop was controlled by extracts of A. indica better than with carbaryl. Soap added to the extracts of T. neriifolia could enhance the toxicity of extract at 2 per cent level. In this experiment carbaryl was found inferior to 4 per cent extract of A. indica during the crop season though such efficacy was not evident at the individual observations. The plant extracts and carbaryl were effective upto the fifth day after spraying though effective persistence for seven days against S. gregaria was reported by Sergent (1944). The difference exhibited by carbaryl in its persistent toxicity on amaranthus and bhindi against A. crenulata may be due to the bioecological situation and the time of application. It may be observed that the data collected on 10th and 15th days after spraying did not show significant variations among the treatments. Extract of 4 per cent C. infortunatum and T. neriifolia 2 and 4 per cent with soap also reduced the leaf damage on par with carbaryl. The same efficacy was observed on both the crops against A. crenulata with these extracts. Though the antifeedant property of A. indica against the grasshoppers is known the information that

4 per cent extract of C. infortunatum and T. neriifolia added with soap can be used efficiently for substituting carbaryl for controlling grasshoppers is a new one.

Against leaf hoppers (para 3.3.2.3) carbaryl 0.2 per cent was the most effective treatment upto 20 days after spraying. But the extracts of C. infortunatum added with soapwater was statistically on par with carbaryl from the second day to twentyth day after spraying in many of the individual observations. Though majority of the treatments were toxic to this insect from second day onwards only C. infortunatum with soap could reduce the population effectively when compared with the conventional insecticide. A. indica extracts were comparatively ineffective against this pest. Extracts of T. neriifolia were moderately toxic to leaf hoppers and toxicity was augmented in case of 4 per cent extract with soap. Effect of the second and third sprayings were similar with regard to the different treatments and C. infortunatum with soap was on par with carbaryl 0.2 per cent. The high rate of mortality produced by C. infortunatum may be due to the insecticidal action since the population reduction was immediate. Nymphal mortality of D. cingulatus, five days after spraying, was reported by Saradamma (1989), reduction in population of other insects such as A. gossypii (Saradamma, 1989).

C. formicarius (Rajamma, 1982) were also reported. But it was not having higher persistent toxicity compared to that of carbaryl, as in the overall effect, it was ranked next to carbaryl. Antifeedant action of this plant against S. litura (Hosozawa et al., 1974), D. obliqua (Tripathi and Razvi, 1985) and C. chinensis (EI Ghar and EI Sheikh, 1987) were reported earlier. Though tobacco decoction had no effect at any stage after its application C. infortunatum extract added with soapwater could reduce the infestation upto 70 per cent.

Effectiveness of the plant extracts in controlling the shoot and fruit borer of bhindi has been established in para 3.3.2.4. The data were significant only on fifth and tenth day after second and third sprayings. The second spraying hit the aphids and leaf hoppers. The incidence of shoot and fruit borer happened to be low at the time of application. The ineffectiveness of the treatments on second day after application could be explained as the in sufficiency of the time by between the application and observation for exerting the effect. Though T. neriifolia extract (with and without soap) could suppress the shoot and fruit borer incidence to zero level in one observation, in the long run it had to be ranked below carbaryl and on par with 4 per cent extract of A. indica. The addition

of soap could not make any impact on the pest control activity of the extract. C. infortunatum had moderate toxicity, while tobacco decoction had no effect against the pest. Ability of A. indica to control the fruit borer E. vitella was reported earlier by Chouhan and Qadri, 1989 as observed in the present experiment. Other fruit borers like H. armigera (Kumar and Sangappa, 1984), E. insulana (Meisher et al., 1978) and L. orbonalis (Krishnamurthy Rao, 1983) were also reported to have been controlled by A. indica.

Laughin et al. (1980) obtained cent per cent larval mortality of European corn borer O. nubilalis when seeds of T. thevetiodes was incorporated into its diet. No field level results was reported on the efficacy of T. neriifolia against borer pests of crops. Its effectiveness against E. vitella on par with A. indica is a new information of economic importance.

For controlling the leaf roller in para 3.3.2.5 the plant extracts were not effective as the conventional insecticide. The data showed inconsistent results with respect to different treatments at different observations. On fifth day after third spraying, 4 per cent extract of T. neriifolia with soap was effective and it was below carbaryl but on fifteenth day it came on par with carbaryl.

Two days after fourth spraying 2 per cent extracts of A. indica also was seen effective and at five days after spraying since the population in the control declined very much, no significant variations could be observed. The data on the average population during the crop season indicated that T. neriifolia 4 per cent extract with soap was effective plant extract which reduced the population to 50 per cent compared to control which was also on par with 2 per cent extract. It was also indicated that the conventional insecticide was superior to the plant extracts though majority of the treatments protected the crop significantly when compared to control. The addition of soap to the extract did not show consistent effect on the inset. In the long run, extracts of C. infortunatum was also effective like other plant extracts. Cobbinah and Osei-Owusu (1988) reported that neem was toxic to leaf roller Selepa docilis on aubergine. Such toxicity was not observed in present study and the population in plots which received neem was less compared to that of control. Since extract of T. neriifolia was observed effective against shoot and fruit borer also its efficacy against lepidopteran pests required investigations in detail.

Data presented in para 3.3.2.6 revealed that the plant extracts were not as toxic as carbaryl to

C. sexmaculatus, the aphid predator. At the same time the predator was not free from the deletorius effect of plant extracts. While the predator population in the carbaryl treated plot was reduced to 63 per cent, the reduction in the population in plots treated with plant extracts ranged only from 14.5 to 37.5 per cent compared to that of control. Among the plant extracts A. indica, 4 per cent was most toxic to the predators. But in the absence of any previous record on their role over the predator population the results obtained in the present study are to be confirmed with further trials.

The yield data of healthy fruits (para 3.3.2.7) has shown carbaryl as superior to plant extracts giving an increase in yield and decrease in damage due to fruit borer. Among the plots which received plant extracts maximum yield was recorded in plots treated with T. neriifolia with soap and the least damage was recorded in plots treated with A. indica 4 per cent. Soap was having additive action only in the case of T. neriifolia 2 per cent extract. Though the variation was not statistically significant with many other treatments, 2 per cent of T. neriifolia with soap could produce the highest yield among plant extracts while it was 12.64 per cent less than with carbaryl. Superiority of conventional insecticides

over A. indica in the control of pod borer of red gram was reported by Singh et al. (1984). In the present studies A. indica 4 per cent extract could control the fruit damage by E. vitella on par with carbaryl and it confirmed the finding by Chouhan and Qadri (1989). But this protection was not reflected in the mean weight of healthy fruits. This may be due to the fact that though A. indica controlled fruit borer to larger extent, other insects like leaf hoppers which interfered with the healthy growth of the plant would not have been controlled by the treatment. Since yield is a function of the growth and vigour of the plant and fruit damage was caused by a particular pest, treatments which afford protection against more number of pest, species will naturally bring more yield.

As the yield in plots treated with 2 per cent extract of T. neriifolia (with soap) was significantly higher than in plots treated with 2 per cent extract, evident that addition of soap to the 2 per cent extract of plant has augmented its effectiveness against different pests. So that it would increase yield by 8.39 per cent than in 4 per cent extract, though the difference was not statistically significant. Extracts of C. infortunatum were moderate in their action in producing a higher yield of healthy fruits and controlling the fruit borer damage. The effect

of this plant extract was not enhanced by the addition of soap. Tobacco decoction though recommended as an insecticide that can be used in homesteads against the pests of vegetables its effectiveness against specific pests did not reflect in the yield and it did not give any protection against the fruit borer.

The different pests that infested bhindi crop were controlled by one or other of the plant extracts. The grasshoppers were controlled by extracts of A. indica, aphids by T. neriifolia, leaf hoppers by C. infortunatum, shoot and fruit borer by A. indica and T. neriifolia and leaf roller by T. neriifolia without causing much deleterious effects on the predator population. Though the plant extracts have not acted like broad spectrum insecticide in reducing the population of different pests drastically, it could increase the yield of the crop substantially.

In general the plant extracts helped to suppress the population of one or other of the pests and to increase the yield though they were not as effective as carbaryl. The impact of the plant extracts on the yield of amaranthus was not merely a function of insect population. There was no significant variations in yield of amaranthus in plots treated with carbaryl 0.2 per cent. T. neriifolia 4 per cent and A. indica 4 per cent though the individual pests could

not be controlled by these extracts on par with carbaryl. In pest management, the drastic reduction of population of a particular pest species is not vitae; the aim should be the maintenance of the different species in the ecosystem in a balanced nature without affecting the yield of the crop adversely. Thevetia and neem were potential in this regard and can be successfully incorporated into the pest management system of the crop. In the present studies, extracts of A. indica at 2 per cent concentration and T. neriifolia at 4 per cent concentration with 0.4 per cent soapwater were identified for protecting amaranthus crop from insects and thereby increasing the crop yield.

For bhindi, 2 per cent extract of T. neriifolia with soap and 4 per cent extracts of A. indica and C. infortunatum were highly effective against the different pests and recorded substantially higher yield. The addition of soap with A. indica and C. infortunatum increased the yield, though not to a significant level. Any of the three plants hence can be incorporated into the pest management system of bhindi crop.

SUMMARY

SUMMARY

Aqueous leaf extracts of eight locally available plants proven for their insecticidal activity were evaluated against the pests of amaranthus and bhindi at the College of Agriculture, Vellayani during 1989-'90. It consisted three experiments viz.,

(i) Screening of leaf extracts of A. indica, T. neriifolia, C. infortunatum, N. oleander, E. odoratum, A. squamosa, P. glabra and C. gigantea at 2 and 4 per cent concentrations in comparison with carbaryl 0.2 per cent (insecticide check) and tobacco decoction (insecticide of plant origin) against the pests of amaranthus and bhindi in pot culture experiment.

(ii) A laboratory trial for augmenting the toxicity of 2, 4 and 8 per cent plant extracts of A. indica, T. neriifolia, C. infortunatum, N. oleander and E. odoratum, adding teepol, soap and coconut oil at different concentrations and combinations.

(iii) Field experiment to assess the efficacy of selected plant extracts (A. indica, T. neriifolia and C. infortunatum with and without the additive (soap-water 0.4 per cent) against the pests of amaranthus and bhindi in comparison with carbaryl and tobacco

decoction as standards.

In the screening trial T. neriifolia 4 per cent was found as the most effective plant extract followed by C. infortunatum 4 per cent, T. neriifolia 2 per cent, A. indica 4 per cent and E. odoratum 4 per cent against P. basalis, and were inferior to carbaryl but superior to tobacco decoction. Four per cent extract of N. oleander and A. squamosa were also effective. The mean crop yield obtained from plants treated with T. neriifolia 4 and 2 per cent, C. infortunatum 4 per cent and carbaryl 0.2 per cent were on par. Tobacco decoction had no effect in increasing the yield.

T. neriifolia 4 per cent followed by its 2 per cent extract and A. indica 4 per cent on par with tobacco decoction were the most effective extracts against bhindi aphid, but inferior to carbaryl. A. indica 2 per cent, C. infortunatum 4 per cent, A. squamosa 4 per cent, E. odoratum 2 and 4 per cent, C. gigantea 2 per cent and P. glabra 4 per cent were superior to control but moderate in action.

C. infortunatum 4 per cent and T. neriifolia 4 per cent controlled the population of Ⓐ. biguttula biguttula and were ranked next to carbaryl 0.2 per cent, followed by A. indica 2 and 4 per cent, C. infortunatum 2 per cent and

T. neriifolia 2 per cent. Extracts of N. oleander, E. odoratum and P. glabra at both the concentrations were moderately effective.

Extracts of T. neriifolia 4 per cent and A. indica 4 and 2 per cent were highly effective, but less than carbaryl, in reducing the shoot and fruit borer incidence (E. vitella), followed by C. infortunatum 4 and 2 per cent, T. neriifolia 2 per cent and E. odoratum 4 per cent. No reduction in infestation was observed with tobacco decoction.

The mean yield obtained from the plants treated with A. indica, T. neriifolia and C. infortunatum (at 2 and 4 per cent concentrations) were on par with carbaryl 0.2 per cent. Tobacco decoction was ineffective in increasing the yield.

In the screening trial A. indica, T. neriifolia, C. infortunatum, N. oleander and E. odoratum were found superior to others and were selected for further studies.

In the experiment for augmenting the toxicity of plant extracts 8 and 4 per cent extracts of C. infortunatum and 8 per cent extract of T. neriifolia with teepol, coconut oil and soapwater reduced the adult emergence of S. litura. Combinations with teepol and soapwater were on par irrespective of the plant extracts.

Toxicity of 4 and 8 per cent extracts of A. indica and T. neriifolia was augmented highest with 0.4 per cent soapwater against A. gossypii. T. neriifolia 8 per cent in combination with 1 per cent teepol and 1 per cent coconut oil was also effective to the same level.

Extracts of A. indica, T. neriifolia and C. infortunatum (2 and 4 per cent) with and without soapwater as additive were tried in a field experiment for ascertaining their efficacy.

In the field experiment, extracts of A. indica (4 per cent), T. neriifolia (2 and 4 per cent) and C. infortunatum (2 and 4 per cent) protected the amaranthus crop against A. crenulata for 14 days after spraying on par with carbaryl 0.2 per cent. Toxicity of 2 per cent extract of A. indica and T. neriifolia was augmented with the addition of soap. Tobacco decoction was not effective in controlling A. crenulata.

Four per cent extract of A. indica with soapwater and 4 per cent extract of T. neriifolia controlled P. basalis effectively (inferior to carbaryl 0.2 per cent) on par with A. indica 4 per cent, T. neriifolia 2 and 4 per cent with soapwater, T. neriifolia 2 per cent, A. indica 2 per cent and C. infortunatum 4 per cent with soapwater.

Extract of T. neriifolia (2 and 4 per cent) caused high mortality of A. gossypii on bhindi, on par with tobacco decoction and inferior to carbaryl. A. indica extracts were moderate in action.

Four per cent extract of A. indica was superior to carbaryl in controlling the A. crenulata on bhindi. Extracts of C. infortunatum (2 and 4 per cent) with soap, T. neriifolia (4 per cent) and T. neriifolia 2 per cent with soap were also effective.

C. infortunatum extract with soap was found efficient in controlling the leaf hopper A. biguttula biguttula, and found inferior to carbaryl whereas tobacco decoction had no effect on leaf hopper.

Four per cent extracts of T. neriifolia and A. indica were highly effective against the shoot and fruit borer, E. vitella. Extract of C. infortunatum had moderate toxicity while tobacco decoction had no effect on the pest.

Extracts of T. neriifolia 4 per cent with soapwater was the most effective plant extract against S. derogata and there was not much the variation between the extracts of other plants. All of them were inferior to carbaryl.

The plant extracts were not as toxic as carbaryl to the predatory beetle C. sexmaculata. Among the plant

extracts A. indica 4 per cent was found slightly toxic.

Extracts of T. neriifolia with soapwater increased the yield, next to carbaryl on par with other plant extracts except the two per cent concentrations without soap. Tobacco decoction had no impact on the yield.

Fruit damage was least under 4 per cent extract of A. indica and was on par with carbaryl. Tobacco decoction had no effect on fruit damage.

Augmentation of toxicity of the extracts was observed only in the case of 2 per cent extract of T. neriifolia against the different pests of bhindi. The augmentation noticed in laboratory was not observed under field conditions in the case of other extracts.

A. indica (2 per cent) and T. neriifolia (4 per cent) with 0.4 per cent soapwater were found promising for controlling the pests of amaranthus and in increasing the yield.

Two per cent extract of T. neriifolia with soap and 4 per cent extracts of A. indica and C. infortunatum were found suitable for being incorporated into the pest management system of bhindi.

Extract of the three plants viz., neem, Thevetia, Clerodendron controlled the pests of amaranthus and bhindi, and increased the yield, whereas tobacco decoction controlled only aphids on bhindi and could not make any increase in yield.

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*Original not seen

APPENDICES

Appendix I

Abstract of analysis of covariance

1.

Source		df	Mean number of leaf webber larvae observed at different intervals (in days) after spraying		
			2	7	14
Treatments	(adj)	18	0.646**	1.39**	1.30**
Error	(adj)	37	0.09	0.09	0.14

2.

Source		df	Mean number of aphids observed at different intervals (in days) after spraying											
			2	5	10	15	2	5	10	15	2	5	10	15
Treatments	(adj)	18	9.51**	14.15**	11.41**	1.18 NS	3.25**	6.70**	2.39**	0.67**	1.22**	1.56**	1.29**	2.13**
Error	(adj)	37	0.13	0.27	0.58	1.48	0.15	0.16	0.29	0.28	0.17	0.22	0.21	0.35

3.

Source		df	Mean number of leaf hoppers observed at different intervals (in days) after spraying											
			2	5	10	15	2	5	10	15	2	5	10	15
Treatments	(adj)	18	3.89**	6.75**	1.76**	0.55**	2.94**	3.73**	2.95**	0.75**	1.09**	3.79**	2.97**	3.1**
Error	(adj)	37	0.26	0.24	0.26	0.20	0.29	0.20	0.16	0.09	0.09	0.13	0.12	0.23

*Significant at 5% level

**Significant at 1% level

NS - Not significant

Appendix II

Abstract of analysis of completely randomised design relating to Table 5 and 6

Table 5

Source	df	Percentage of normal adults obtained (S. litura)
Treatments	134	687.45**
Between different additives	8	2387.84**
Between concentrations of leaf extracts	14	4562.81**
Interaction between plants and additives	112	81.59**
Error	270	48.80

Table 6

Source	df	Percentage of aphids mortality (A. gossypii)
Treatments	134	2374.50**
Between different additives	8	2453.76**
Between concentrations of leaf extracts	14	19896.96**
Interaction between plants and additives	112	178.53**
Error	270	91.46

*Significant at 5% level

**Significant at 1% level

Abstract of analysis of covariance

Table 7.

Source	df	Mean index of leaf damage observed at different intervals (in days) after spraying		
		2	7	14
Treatments (adj)	14	0.677**	1.06**	1.29**
Error (adj)	27	0.219	0.264	0.274

Table 8.

Source	df	Mean number of leaf webber larvae observed at different intervals (in days) after spraying				
		2	7	14	2	7
Treatments (adj)	14	0.50*	1.86**	0.67**	0.58**	1.98**
Error (adj)	27	0.19	0.24	0.22	0.09	0.17

*Significant at 5% level

**Significant at 1% level

Appendix III

Abstract of analysis of covariance

Table 9.

Source	df	Mean number of aphids observed at different intervals (in days) after spraying							
		2	5	10	15	2	5	10	15
Treatments (adj)	14	130.42**	187.29**	195.79**	46.22 NS	64.31**	172.24**	59.78**	15.48**
Error (adj)	27	9.82	17.04	14.13	18.14	17.02	18.10	12.46	4.12

Table 10.

Source	df	Mean index of leaf damage observed at different intervals (in days) after spraying			
		2	5	10	15
Treatments (adj)	14	0.435*	0.445*	0.343 NS	0.605 NS
Error (adj)	27	0.20	0.19	0.29	0.33

Table 11.

Source	df	Mean number of leaf hoppers observed at different intervals (in days) after spraying								
		2	5	10	15	20	2	5	10	15
Treatments (adj)	14	29.88**	49.00**	41.67**	13.19**	12.32**	14.77**	35.36**	22.96**	10.65**
Error (adj)	27	2.49	2.74	1.48	1.86	1.72	0.794	1.40	0.784	1.32

Abstract of analysis of Randomised Block Design with DMRT

Table 12.

Source	df	Mean percentage of shoot and fruit borer incidence observed at different periods (in days) after spraying									
		2	5	10	15	20	25	2	5	10	15
Treatments	14	168.52NS	406.08*	686.89**	112.65NS	164.88NS	72.35NS	171.29NS	330.60*	519.55**	140.04NS
Error	28	187.22	153.69	135.57	143.42	166.79	92.60	151.85	128.25	180.57	74.49

Abstract of analysis of covariance

Table 13.

Source	df	Mean number of leaf roller larvae observed at different intervals (in days) after spraying					
		2	5	10	15	2	5
Treatments (adj)	14	0.528**	1.08**	1.77**	0.56**	0.24*	0.74**
Error (adj)	27	0.09	0.15	0.16	0.11	0.09	0.09

*Significant at 5% level

MANAGEMENT OF PESTS OF AMARANTHUS AND BHINDI USING PLANT EXTRACTS

BY

B. SRINATH

ABSTRACT OF A THESIS

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for the degree

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Kerala Agricultural University

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
COLLEGE OF AGRICULTURE
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ABSTRACT

Water extracts of eight locally available plants of known insect control potential were screened at 2 and 4 per cent concentrations against pests of amaranthus and bhindi in a pot culture experiment in comparison with carbaryl and tobacco decoction.

T. neriifolia followed by A. indica, C. infortunatum and E. odoratum were highly effective against P. basalis on amaranthus and A. gossypii on bhindi. C. infortunatum and T. neriifolia followed by A. indica, N. oleander and E. odoratum were effective against A. biguttula biguttula. T. neriifolia and A. indica followed C. infortunatum and E. odoratum reduced damage caused by E. vitella. Carbaryl 0.2 per cent was superior to plant extracts and tobacco decoction was effective only against aphids.

A laboratory study was undertaken for augmenting the toxicity of five aqueous plant extracts by adding with teepol, soap and coconut oil at varying concentrations and combinations.

Toxicity of eight and four per cent extracts of C. infortunatum and eight per cent extract of T. neriifolia with teepol, coconut oil and soap reduced the adult emergence of S. litura. A. indica and T. neriifolia were more

effective against A. gossypii when the extracts were mixed with soapwater. Teepol and coconut oil also had the same effect with eight per cent T. neriifolia.

Field experiment was conducted with the extracts of A. indica, T. neriifolia and C. infortunatum at two and four per cent concentrations without and with soap against pests of amaranthus and bhindi using carbaryl and tobacco decoction as standards.

Carbaryl was superior to plant extracts in controlling the population of pests. Four per cent extracts of A. indica, two and four per cent extracts of T. neriifolia and C. infortunatum protected amaranthus against A. crenulata and P. basalis. Toxicity of the extracts A. indica and T. neriifolia was augmented with soap at lower concentration.

All the plant extracts increased the crop yield but lesser than carbaryl. Tobacco decoction failed to control the pests incidence and to increase the yield.

Two and four per cent extracts of T. neriifolia caused heavy mortality of A. gossypii. Four per cent extracts of A. indica was more effective than carbaryl followed by C. infortunatum, and T. neriifolia against A. crenulata on bhindi. C. infortunatum with soap was

efficient against A. biguttula biguttula. Four per cent extracts of T. neriifolia and A. indica were highly effective against E. vitella. T. neriifolia four per cent was effective against S. derogata. Plant extracts were not toxic as carbaryl to C. sexmaculata. All the plant extracts other than at 2 per cent concentration increased the yield and T. neriifolia recorded maximum, but lesser than carbaryl. Tobacco decoction had no impact on yield. Toxicity of 2 per cent extract of T. neriifolia was augmented with soap against pests of bhindi.