EFFECTS OF EXTRACTS OF *Clerodendron infortunatum* ON THE EPILACHNA BEETLE *Henosepilachna vigintioctopunctata* F. WITH RELATION TO SAFETY OF ITS NATURAL ENEMIES

By

LILY, B.

THESIS

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DECLARATION

I hereby declare that this thesis entitled "Effects of extracts of *Clerodendron infortunatum* on the epilachna beetle *Henosepilachna vigintioctopunctata* F. with relation to safety of its natural enemies" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other university or society.

Lily

LILY. B.

Vellayani

11.12.95

CERTIFICATE

Certified that this thesis entitled "Effects of extracts of *Clerodendron infortunatum* on the epilachna beetle *Henosepilachna vigintioctopunctata* F. with relation to safety of its natural enemies" is a record of research work done independently by Kum. Lily. B. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Vellayani
11-12-95

Dr. K. Saradamma,
Chairman, Advisory Committee,
Associate Professor,
Department of Entomology,
College of Agriculture,
Vellayani.

CHAIRMAN

Dr. K. Saradamma

MEMBERS

Dr. A. Visalakshy

Dr. D. Dale

Prof. Abdul Hameed

EXTERNAL EXAMINER

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INTRODUCTION

INTRODUCTION

The botanicals have been used as pesticides by man from time immemorial. The first generation pesticides included widely used natural products like pyrethrins, derris, nicotine etc. The arrival of DDT on the scene during 1940's closely followed by an array of much more potent organic synthetic chemicals, marked the era of 'second generation pesticides'. These pesticides were highly effective against a wide range of insect and non-insect pests, easily available, comparatively cheaper and hence could easily push the first generation chemicals out of the pesticide scenario. No doubt, that the synthetic pesticides could save millions of human life by effectively controlling vectors of many dreadful human diseases and bringing humanity to a stage of self sufficiency in food by sealing the depredations of major pests. The second generation pesticides which were being widely adored for over two decades in the middle of this century became the centre of a serious controversy in subsequent years. They were shown to induce resistance in different pest species and caused pest resurgence and secondary pest outbreaks. The hazards in the production, sale and use of these pesticides, their injurious effects on non-target organisms and the adverse impact in the ecosystem were brought to light by researchers. The ensuing debates highlighted the necessity for the restricted use of synthetic organic pesticides and evolution of viable alternative technology. It is universally accepted that an 'integrated pest

management strategy' with the harmonious blending of all known methods, is the best for achieving sustained production targets in agriculture, while ensuring the healthy survival of humanity in this universe.

The global concern to overcome the undesirable effects of the synthetic organic chemicals and the research efforts to find alternative technology has led to the development of the third and fourth generation pesticides in the last decade; the former including the insect growth regulators and the latter 'behaviour modifying compounds (Parmar and Devakumar, 1993).

Within each generation of insecticides there are a number of plant derived products in use and they are collectively called as 'botanicals' and being stressed recently as an ideal component of integrated pest management system. The merits and demerits of botanicals in plant protection scenario has been extensively reviewed in recent years (Morallo-Rejesus, 1987; Ayyangar and Nagasampagi, 1990; Benner, 1993; Parmar, 1993; Bhatnagar and Sharma, 1994 and Isman, 1994) and a bright future has been predicted for these compounds in the 21st century, provided the researches ensure that the cost, availability and other requirements of these products are satisfactorily compiled (Parmar, 1993).

Among 2.5 to 7.5 lakh species of plants known, 5.0 to 15.0 per cent is estimated to have been surveyed for

biologically active compounds (Devakumar and Parmar, 1993). Knowledge of plant species with some toxic principles and their biological activity is of paramount importance in utilising them in plant protection technology.

Subramaniam (1993) listed 156 plants of India showing insecticidal activity in his compilation which itself is not claimed to be complete by the author himself. The rich tropical flora seems to possess enormous potential as pesticide source and its fringes alone seems to have been touched so far.

Kerala is famous for its floral diversity and the search for botanical pesticides from this source seems to be meagre. Saradamma (1989) screened 20 plants available in the state in comparison with neem (Azadirachta indica Juss.) the plant already established to contain potent insecticidal principles and found that Clerodendron infortunatum Linn., Nerium oleander Linn., Thevatia neriifolia Juss., and Eupatorium odoratum Linn., had high bioactivity, sometimes even higher than that of the check.

The biologically active principles in the identified plants can be utilised for plant protection in many ways. As opined by Radwanski (1980), (1) the 'western approach' is to isolate, identify and characterise the active principle with a view to standardising the procedures for synthesising the

molecules or their analogues for industrial exploitation, (2) 'tropical approach' where isolation and identification of the useful components and the production of standard commercial preparations from plant parts and their utilization and (3) the production of crude extracts of the plants at farmers' level and the direct utilization of the extracts for plant protection.

The first approach need extensive infrastructural facilities. The antifeedants and insect growth regulators (IGRS) which are highly complex chemicals molecules, are not easily amenable for synthesis. Even when they could be synthesised, it may be too costly for adoption. Even azadirachtin which could be successfully synthesised with 17 years of intensive research efforts, could not be successfully exploited so far industrially, due to the several oxidative steps in the known synthetic procedure and consequent cost involved. For the industrial utilisation of plant products, the continuous availability of large bulk of plant material in the vicinity of the factories is a prerequisite and this often remains as a serious handicap in many cases. The third approach viz., utilisation of crude extracts of the active component of identified plants, on specific pests in the farm will be an attractive technology for farmers, especially those belonging to developing countries now facing financial strain for costly agricultural inputs. In this context the bioactivity of the

botanicals have to be studied with reference to specific pest problems in each ecosystem.

Botanical pesticides are highly commended for controlling pests of vegetables and fruit crops since synthetic organic pesticides are notorious for causing residue problems on the yield of such crops.

Henosepilachna vigintioctopunctata F.(Coccinellidae) is a serious pest of solanaceous and cucurbitaceous vegetables in India (Fletcher, 1914; Lall, 1964; Ramakrishna Ayyar, 1963; Nair, 1975; Atwal, 1976; and Tewari, 1986) and particularly in Kerala (Kunjamma and Abraham, 1973; Nair, 1975; 1978). The larvae and adults feed voraciously on the leaves, skeletonising them and cause heavy yield loss upto total mortality of the plants in young stages. The pest is however kept under check by its parasites during summer months and indiscriminate use of synthetic insecticides has been proved to cause pest resurgence necessiating repeated control measures. This problem can be successfully solved, if the botanicals effective against the pest and which are normally safe to parasites are used in field condition. From Kerala, hormonal activity of extracts of Tectona grandis, Pteropus marsupium, Vertomia indicum, Anthocephalus cadamba and Phyllanthus emblica on Dysdercus cingulatus in the laboratory was reported (Prabhu et al., 1973 and Prabhu and John, 1975). They are yet to be evaluated at farm level. In this

scenario one of the potential local plants identified by Saradamma (1989) was further studied with a view to standardising the extraction and application techniques for its field level use against H. vigintioctopunctata. The study covered the following aspects:

1. Screening of different plant parts of C. infortunatum for antifeedant, insecticidal, growth inhibitory, sterilant and ovicidal actions.

2. Evaluation of different solvents viz., water, acetone, benzene, ethanol and petroleum ether for extracting antifeedant, insecticidal, growth inhibitory, sterilant and ovicidal actions.

3. To assess the effect of drying of C. infortunatum plants, under shade and in sun, on antifeedant, insecticidal, growth inhibitory, sterilant and ovicidal action on H. vigintioctopunctata.

4. To locate promising extracts of C. infortunatum on the larval parasite of H. vigintioctopunctata, Chrysocharis johnsoni.S. and

5. Evaluation of promising extracts of C. infortunatum on H. vigintioctopunctata and their impact on natural enemies under field condition.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Information available on various aspects covered in the present investigation, on the effect of botanicals against major pests with a special reference to Clerodendron infortunatum L. extracts on Henosepilachna vigintioctopunctata F. and its natural enemies, have been reviewed briefly in this chapter.

2.1. Antifeedant activity of botanicals

Acorus calamus

Petroleum ether extracts of the rhizomes of A. calamus 0.5 and 0.1 per cent gave full protection to leaves of egg plant against the grubs and adults of H. vigintioctopunctata. (Tewari and Krishnamoorthy, 1985).

Adathoda vasica

Hegazy et al. (1992) reported that phytochemical constituents from A. vasica showed significant feeding deterrency on second and fourth instar larvae of Spodoptera litura.

Ajuga spp.

Ajugarin I obtained from A. remota showed high anti-feedant activity against Plutella xylostella both in laboratory and field experiments (Picket et al., 1987).

Shin-Foon and Yu Tung (1993) reported that the chloroform extract of A. ripponensis exhibited strong antifeedant and growth inhibitory activity against fourth instar larvae of P. xylostella.

Andrographis paniculata

Hermawan et al. (1993) reported that the extracts of A. paniculata acted as an antifeedant to P. xylostella.

Annona squamosa

The petroleum ether extracts of seeds of A. squamosa exhibited high antifeedant activity against fourth instar larvae of the noctuid S. litura (Kumar and Thakur, 1988).

Rao et al. (1990) reported the antifeedant potency of petroleum ether and aqueous extracts of leaves of A. squamosa against second instar grubs of H. vigintioctopunctata.

Argemone mexicana

Antifeedant potency of petroleum ether and aqueous extracts of the leaves of the plant against second instar grubs of H. vigintioctopunctata has been reported by Rao et al. (1990).

Atalantia racemosa

Seven coumarin derivatives isolated from the n-hexane and methanol extracts of aerial parts of A. racemosa showed

antifeedant activity against the larvae of S. litura (Luthira et al., 1989).

Azadirachta indica

Sandhu and Singh (1975) observed that neem seed kernel extract at 0.4 per cent concentration significantly reduced the feeding of Pieris brassicae larvae. The effectiveness of neem oil against P. xylostella was reported by Kadam (1976).

Methanol extract (0.05 per cent) of neem seed kernel exhibited antifeedant activity against Epilachna varivestis (Ascher, 1980).

Fagoonee (1980) investigated the behavioural response of cabbage webworm Crocidolomia binotalis to neem extracts and found that the extract masked the inherent phagostimulatory property of cabbage towards its pest.

Leaf extracts of neem at three and five per cent concentrations caused high antifeedant activity against Selepa docilis attacking brinjal (KAU Annual Report, 1991).

Bougainvillea spectabilis

Rao et al. (1992) and Janardhan et al. (1992) reported that petroleum ether extracts of leaves of B. spectabilis at 0.5 per cent concentration gave cent per cent protection against H. vigintioctopunctata.

Caryopteris divaricata

Hosozava et al. (1974) reported that benzene extract of C. divaricata had feeding inhibitory activity against S. litura.

Celastrus angulatus

Angulatueoid G and H isolated from the seeds of C. angulatus showed insect antifeedant effect against Aulacophora femoralis (73.2 per cent) and P. xylostella (87.7 per cent) as reported by Wu et al., 1992).

Clerodendron sp.

Wada and Munakata (1968) isolated antifeedant compounds from C. tricotomum and it had high antifeedant activity against Prodenia litura.

A benzene extract of the leaves deterred feeding by S. litura larvae (Kato et al., 1972). Munakata (1977), Kato et al. (1973) isolated Clerodendrin A and Clerodendrin B from C. trichotomum as the active antifeedant compounds.

Laboratory studies by Hosozawa et al. (1974) revealed that one per cent ether extract of C. fragrans, C. calamitosum, C. cryptophyllum gave 80 to 100 per cent leaf protection from third instar larvae of S. litura.

The diterpenoid, 3-epicaryoptin isolated from the leaves of C. calamitosum deterred feeding by S. litura larvae (Hosozawa et al., 1974).

Cooper et al. (1980) isolated 'Myrcoside' from the roots of C. infortunatum which showed potent antifeedant activity at 10 ppm for S. exempta larvae.

Clerodendrin A and B and clerodin isolated from C. infortunatum deterred feeding by S. litura larvae (Antonius and Saito, 1981).

Clerodendrin isolated from C. infortunatum exhibited antifeedant activity against P.brassicae larvae (Geuskens et al., 1983).

Tripathi and Rizvi (1985) reported that C. inermi had antifeedant activity against Diacrisia obliqua.

Clerodin isolated from C. infortunatum showed potent antifeedant activity against S. litura at 80 ppm (Van Beek and de Groot, 1986).

Dithyrea wislizenii

Powell et al. (1991) isolated a novel sulfur containing indole alkaloid 'Dithyreanitrile' from the seeds of the cruciferous plant D. wislizenii and it inhibited feeding in larvae of the noctuid S. frugiperda.

Erysimum cheiranthoides

Gupta et al. (1993) reported that the com-pound 'cardenolides' present in the wild mustard E. cheiranthoides deterred the feeding of the larvae of cabbage butterfly P. rapae.

Hibiscus sabdariffa

The ether and ethanol extracts of H. sabdariffa calyxes exhibited antifeedant as well as oviposition deterrent activities against E. vitella (Dongre and Rahalkar, 1992).

Ipomoea carnea

The stem extracts of I. carnea at 3 per cent concentration gave 88.04 per cent leaf protection against the semilooper Achoea janata (Arivudainambi and Nachiappan, 1993).

Jatropa gossypifolia

Chockalingam et al . (1992) reported that petroleum ether extract of J. gossypifolia gave 85.3 per cent leaf protection against Pericallia ricini.

Mentha arvensis

Water extracts of M. arvensis showed significant antifeedant action against grubs of H. vigintioctopunctata (KAU Annual Report, 1981).

Ocimum sanctum

Mallick and Banerji (1989) reported that the methanol extracts of O. sanctum at five and ten per cent concentrations suppressed the feeding of Anomis sabulifera.

Plagiochila spp.

Toyota et al. (1981) reported that 'Plagiochiline A' isolated from P. fruticosa, P. hattoriana, P. ovalifolia and P. yokogurensis exhibited very strong antifeedant activity against S. exempta.

Polygonum hydropiper

Field and laboratory tests showed that natural polygodial extracted from the plant P. hydropiper using ethyl ether was an effective antifeedant when used against aphids (Zhang et al., 1993).

Pongamia glabra

Karanjin and extractives isolated from the seeds of P. glabra (petrol extractive oil), methanol extractive and residue oil (after removing karanjin) exhibited antifeedant activity ranging from 73.33 to 86.68 per cent against S. litura (Srimannarayana et al., 1988).

Psoralea corylifolia

Chintalwar et al. (1992) reported that petrol extract of roots of P. corylifolia inhibited feeding of fourth instar S. litura larvae.

Rhododendron molle

Crude dichloromethane extract of the flowers of R. molle exhibited strong antifeedant action against the third instar larvae of P. xylostella (Shin-Foon and Yu Tung, 1993).

Ricinus communis

Antifeedant property of petroleum ether and aqueous extracts of leaves of R. communis against second instar grubs of H. vigintioctopunctata has been reported by Rao et al. (1990).

Scutellaria galericulata

Scutegalin A and B isolated from the acetone extract of the aerial parts of S. galericulata exhibited antifeedant activity against S. littoralis (Rodriguez et al., 1993).

Sida acuta

Dongre and Rahalkar (1993) reported that the ether and ethyl alcohol extracts of leaves of S. acuta exhibited strong feeding inhibition against the larvae of Earias vitella.

Tanacetum vulgare

Five per cent aqueous extract of T. vulgare reduced the feeding of P. rapae as reported by Hough-Goldstein and Hahn (1992).

Tithonia diversifolia

A compound 'Tagitinin C' isolated from T. diversifolia exhibited good feeding deterrency against D. obliqua (Dutta et al., 1993).

Thevatia neriifolia

Ethanol extract of leaves and fruits of T. neriifolia exhibited good antifeedant activity against the grubs of H. vigintioctopunctata (KAU Annual Report, 1993).

Vitex negundo

Kalavathi et al. (1991) evaluated the insecticidal activity of V. negundo against vegetable pests and recorded high antifeedant activity at 0.1 and 0.01 per cent for Diaphania indica and Epilachna septima respectively.

Miscellaneous

Ascher et al. (1987) reported that new 'withanolids', a group of naturally occuring steroids, exhibited some anti-feedant action against larvae of S. littoralis and E. varivestis.

More et al. (1989) reported the antifeednat activity of extracts of Euphorbia sp. and I. carnea against S. litura.

Antifeedant activity in extracts of plants viz., A. indica, Eupatorium odoratum, C. infortunatum, T. neriifolia and

Nerium oleander against S. litura, H. vigintioctopunctata and P. ricini was observed by Saradamma (1989).

Extracts of Macropiper excelsum, Sophora microphylla, Coryocarpus laevigatus, Dysoxylum spectabile and Podocarpus nivalis showed antifeedant activity against larvae of S. litura (Russel and Lane, 1993).

2.2 Insecticidal action of Botanicals

Acorus calamus

An acetone extract of the rhizome of A. calamus resulted in cent per cent mortality against painted bug both when applied in a dry film in the laboratory and as an emulsion in turnip plots (Verma and Pandey, 1981).

Ageratum conyzoides

Pande et al. (1987) reported that the leaf extracts of A. conyzoides caused significantly high mortality against red pumpkin beetle Raphidopalpa foveicollis at 0.6 per cent concentration.

Agiaia odorata

Rocaglamids - a compound isolated and identified as the active insecticidal constituent in the twigs of A. odorata showed significant insecticidal activity against S. litura (Janprasert et al., 1993).

Argemone mexicana

Pandey et al. (1981) reported the toxic action of A. mexicana against B. cruciferarum. It gave 93.33 per cent mortality under laboratory condition.

Azadirachta indica

Neem leaf extracts at concentrations of two and five per cent were fatal to the larvae of E. varivestis and P. xylostella fed on treated beans and cabbage foliage respectively (Steets, 1975).

Singh et al. (1984) reported that in field neem oil was effective against pod fly and ethanolic extract of the kernel lowered the incidence of three borers. viz., Heliothis armigera, Maruca testulalis and Melanagromyza obtusa.

Water extract of neem seed kernel and neem oil controlled the cabbage leaf eating caterpillar complex (Bandara and Kudagamage, 1993).

Clerodendron infortunatum

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

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

Gynandropsis gynandra

Petroleum ether extract of G. gynandra at two per cent concentration gave 93.3 per cent mortality of B. cruciferarum (Verma and Pandey, 1981).

Chandel et al. (1987) evaluated nine plant extracts against epilachna beetle and observed that the seed extract of G. gynandra was the most toxic.

Heracleum sosnowskyki

The steam extract from the seeds of H. sosnowskyki was the most toxic to the 4th instar of larvae of Spilosoma rhodophila followed by alcohol extracts from the seeds of H. sosnowskyki (Verma et al., 1991).

Ipomoea carnea

More et al. (1989) found that the aqueous and alcohol extracts of I. carnea at 4 per cent concentration was toxic to the larvae of S. litura.

Nerium oleander

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

Ocimum sanctum

Srivatsava and Pandey (1983) observed that seed extract of O. sanctum produced 100 per cent larval mortality of D. obliqua.

Stein et al. (1988) reported that the ethanolic and methanolic extract of holy basil O. sanctum caused heavy mortality in aphids infesting cabbage.

Ocimum basilicum

Pandey et al. (1983) observed 51.1 and 90.0per ent mortality of pod borer larvae with seed extracts of O. basilicum.

Scenedesmus acutus

One and three per cent concentrations of petroleum ether emulsion were remarkably toxic, against first instar larvae of S. littoralis after 72 h of feeding. The percentages of larval mortality were directly proportional to the concentrations. (Sharaby et al., 1993).

Tabernaemontana coronaria

Guddewar et al. (1992) reported that the leaf extract of T. coronaria at 1.5 per cent concentration gave 45.0and 83.8 per cent mortality of D. cingulatus after 48 and 72 hours of treatment respectively.

'Amorpholone', a potent rotenoid insecticide isolated from petroleum ether extract of leaves of T. candida was effective against S. litura (LD 50 0.38 µg/g body weight) (Kole et al., 1992).

Thevatia neriifolia

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

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

Triptergium wilfordii

Shin-foon (1987) observed that at three per cent extract of root bark of T. wilfordii as a spray, controlled imported cabbage worm P. rapae and the red pumpkin beetle A. foveicollis.

Vitex negundo

Acetone leaf extract of V. negundo at 0.05, 0.04 and 0.5 per cent concentrations when sprayed against E. vitella, D. indica and E. septima respectively caused 100 per cent mortality (Kalavathy et al., 1991).

Miscellaneous

Saradamma (1989) observed that extracts of A. indica, E. odoratum, C. infortunatum, T. neriifolia and N. oleander reduced the population of vegetable pests like H. vigintioctopunctata and Centrococcus insolitus. Benzene extract of clerodendron, neem, pandanus and eupatorium had high systemic action against different instars of D. cingulatus.

Ethanol extracts of Chrysanthemum cinerariaefolium and avocado gave 100 and 74.8 per cent mortality of P. xylostella. Ethanol extracts of B. spectabilis, C. cinerariaefolium, Cymbopogan citratus, Lantana camera, O. sanctum, Prosopis julifera, R. communis and Tagetes patula were 60 to 100 per cent effective as botanical insecticide as reported by Stein and Klingauf (1990).

Oil emulsion of A. indica and Samadara indica were very effective in the control of american serpentine leaf miner and pea aphid. Extracts of Hyptis suaveolens was effective against the pea aphid and was on par with malathion (0.05 per cent) and quinalphos (0.03 per cent) (Reghunath and Gokulapalan, 1994).

2.3 Growth inhibitory action of botanicals

Abies balsamea

Juvabione and dehydrojuvabione isolated from balsam fir A. balsamea had JH effect on P. xylostella (Mahajan et al., 1987).

Acorus calamus

Gupta and Dogra (1993) reported that fumigation (10-200 µl oil/100 cc space) or topical application of A. calamus oil (0.06 - 0.1 µl oil/ µl acetone) to prepupae and pupae of H. vigintioctopunctata interfered with adult eclosion, induced morphological abnormalities and death due to anorexia within 6 days of ecdysis.

The extracts of rhizomes of A. calamus inhibited growth in early third instar larvae of S. litura (Koul, 1987).

Ajuga nipponensis

Shin-Foon (1990) reported that 0.5 per cent extract of A. nipponensis inhibited moulting and population in cabbage worm.

Asarum europacum

Schmutterer and Kleffner (1988) observed that leaf and rhizome extracts of A. europacum interfered with metamorphosis and caused morphogenetic defects in pupae and adults of E. varivestis.

Aristolochia spp.

Crude extracts of A. elegans and A. tagala when tested on the common cutworm S. litura showed pronounced deformations and malformations in the larval, pupal and adult stages and were toxic and growth inhibitory (Merdelyn Caasi-Lit and Belen Morallo-Rejesus, 1990).

Azadirachta excelsa

Azadirachtin and marriangin, two substances with IGR properties were purified from alcoholic extracts of the seed kernels of A. excelsa and marrangin were found to be more active than azadirachtin against fourth instar larvae of E. varivestis (Ermel et al., 1991).

Azadirachta indica

Rembold et al. (1981) observed that the purified seed fractions of neem induced larval, pupal and adult malformations and high pupal mortality of E. varivestis.

Leaf extracts of A. indica caused mortality and morphogenetic defects at concentrations of 50 to 800 ppm against coccinellid E. varivestis reported by Schmutterer (1989).

Osman (1993) found that methanol extracts of neem seeds topically applied to larvae of P. brassicae disrupted subsequent development and decreased growth rate.

Catharanthus roseus

The acetone extract of C. roseus at 500 ppm caused high larval mortality and resulted in a significant decline in percentage pupation and normal adult emergence in H. armigera and S. litura (Deshpande et al., 1988).

Clerodendron infortunatum

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

Delonix regia

Chockalingam et al. (1992) reported that the flower extract of D. regia completely inhibited the adult emergence of P. ricini at a concentration of 200 ppm.

Diffenbachia maculata

Treatment of larvae of S. littoralis with extracts of D. maculata resulted in morphological aberrations such as pupae retaining larval thoraic legs, adults with abnormal abdomen, legs and/or defective wings (Antonious et al., 1992).

El-Shaarawy et al. (1992) observed moulting inhibition, when the larvae of S. littoralis were treated with extracts D. maculata.

Melia azedarach

Zhu and Ermel (1991) reported that extracts from ground leaves of the M. azedarach inhibit growth and disrupt metamorphosis of fourth instar larvae of E. varivestis.

Nerium oleander

Water extracts of dried nerium leaves were found to have hormonal activity of D. cingulatus (Saradamma, 1989).

Two per cent water extract of leaf produced 10 and 20 per cent of test population as malformed and dead pupae respectively in laboratory studied (Saradamma, 1989).

Ocimum basilicum

While screening certain plants for their juvenile hormone activity Gopalan and Madhusudhan (1981) found that leaves and stem extracts of O. basilicum were active against Dysdercus sp. and tobacco caterpillar.

Plumbago indica

Shin-Foon (1990) reported that the extracts of P. indica were found to inhibit the growth of cabbage worm.

Thevatia neriifolia

Water extracts of T. neriifolia fully inhibited emergence of adults of D. cingulatus (Saradamma et al., 1994).

Triptergium wilfordi

Shin-foon and Yu Tung (1993) obtained wilforine, an alkaloid isolated from T. wilfordii and it was more effective than dimilin against third instar larvae of P. xylostella.

Miscellaneous

Ahmed and Bhattacharya (1991) observed growth regulating effects of powdered leaves of neem, Dipalazium esculantum, Parthenium hysterophorus, B. specabilis, O. sanctum and Murraya koenigii against S. obliqua.

2.4 Sterilant Action of Botanicals

Acorus calamus

Oil of Indian calamus root caused sterility in red cotton stainer (Walker and Bowers, 1970).

Adathoda vasica

Saxena et al. (1986) investigated the insect antifertility effect of allelochemic in A. vasica and found considerable reduction in fecundity and fertility of the bugs D. koenigii.

Annona reticulata

Application of A. recticulata to the nymphs of D. cingulatus exhibited greater fecundity reduction and sterility (Thomas and Hiradhar, 1993).

Asarum europacum

Exposure of adult females of E. varivestis to food treated with extract of A. europacum resulted in reduced

fecundity upto 92 per cent. All the eggs laid were found to be sterile (Schmutterer and Kleffner, 1988).

Azadirachta indica

Singh and Srivastava (1983) observed that ethanolic extract and petroleum ether extract of neem seed kernel at 5 per cent concentration completely deterred the oviposition by melon fruitfly D. curcurbitae on bittergourd.

Koul (1984) found that injection of 1 µg azadirachtin into red cotton bug. D. Koenigii caused 50 per cent mortality alone but the reproductive behaviour in the surviving adults was affected. Mostly no eggs were laid due to failure of vitellogenesis.

Blumea eriantha

Exposure of adults of E. vitella to vapours of oil obtained from the weed B. eriantha could reduce the mating ability especially in males (Dongre and Rohalkar, 1982).

Butea monosperma

The acetone extract of dried and powdered flowers of B. monosperma at 4 per cent concentration applied on freshly moulted fifth instar larvae of D. similis caused complete suppression of oogenesis and vitellogenesis (Raju and Thakur, 1990).

Canavalia ensiformis

L-canavanine isolated from C. ensiformis showed antifertility effect on D. koenigii (Koul, 1983).

Cassia siamea

Raju and Thakar (1989) reported that the petroleum ether extract of flowers of C. siamea manifested morphogenetic and gonadotropic effects associated with growth regulating activity in D. similis causing impairment of movement, flight and progeny production.

Catharanthus roseus

Kumuda Sukumar and Osmani (1981) reported that the leaf alkaloid of C. roseus gave better sterilant action than the root alkaloid and the males of D. cingulatus were more susceptible to leaf alkaloids while the root alkaloids showed some specificity to the females.

Eucalyptus spp.

Exposure of first instar nymphs of D. koenigii to eucalyptus oil odour for two hours resulted in a marked decline in egg production and egg hatchability (Srivastava and Krishna, 1992).

Ocimum grattissimum

Areekul et al. (1989) opined that the application of extracts of O. grattissimum reduced the rate of oviposition by the oriental fruit fly Dacus sp.

Scenedesmus acutus

Petroleum ether extract of green algae S. acutus inhibited egg laying of S. littoralis at one per cent concentration (Sharaby et al., 1993).

Thevatia neriifolia

Ethanol extract of flowers of T. neriifolia reduced the reproductive potential of females of E. vitella significantly (Dassad et al., 1989).

Miscellaneous

The extracts of C. infortunatum, E. odoratum, Plumeria rubra and N. oleander caused the production of non viable egg in D. cingulatus. The malformed adults emerging from treated nymphs did not lay any viable egg (Saradamma et al., 1994).

2.5 Ovicidal action of Botanicals

Acorus calamus

Vapours of the oil affect the egg hatch of D. koenigii. The nymphs that hatched out did not moult and died within 24 hours (Saxena and Srivastava, 1972).

Annona squamosa

Ohsawa et al. (1990) reported the ovicidal action of A. squamosa against P. xylostella.

Neem oil vapours at 160 µl of oil reduced egg laying by E. fabia and afffected hatchability of egg (Pathak and Krishna, 1986).

Delonix regia

Application of the flower extract of D. regia against P. ricini significantly reduced the hatchability of eggs (Chockalingam et al., 1992).

Miscellaneous

The inhibitory effect on egg with oil extract of Echinocloa crusgalli, Blumea spp and Torreya sp on Nezara viridula was reported by Liu et al. (1983).

2.6 Effect of botanicals on natural enemies

Neem oil augmented parasitization of leaf folder larvae by the ichneumonid, encyrtid and braconid parasites since neem oil prevented the larvae from folding the rice leaves (Saxena et al., 1980).

Joshi et al. (1982) observed that application of two per cent neem seed kernal suspension to the eggs of S. litura

parasitized by Telenomus remus did not repel ovipositon by female parasite NSKS was also observed to be safe to Chrysopa scelestes.

Laboratory experiments conducted by Saxena et al. (1983) revealed that topical application of neem oil, chinnaberry oil and custard apple oil on Lycosa pseudoannulata caused only very low mortality even with the highest dose.

Schmutterer et al. (1983) revealed that the growth and development of endoparasitic hymenopterans on Cnaphalocrocis medinalis larvae feeding on neem treated rice leaves were unaffected. This may be due to the lack of contact between neem extract and the paraiste.

Parasitisation of E. vigintioctopunctata larvae by Pediobias foveolatus was significantly lower when the host larvae were freshly treated with the extracts of neem and A. calamus than when they were left untreated. However, exposure 24 hour after treatment did not adversely affect parasitization. Parasites emerging from treated larvae were normal (Tewari and Krishnamoorthy, 1985).

Wu (1986) also reported that neem seed oil was safest to the natural enemies of brown plant hopper viz., L. pseudoannulata and Apanteles crypsis.

Effect of methanol, ethanol, acetone, and pentane extracts of neem in the predatory phytoseid Phytoseilus persimilis and the tetranychid Tetranychus cinnabarinus Boisd. were compared by Mansour et al. (1987).

Application of neem products did not affect the population of insect predators like Cyrtorhinus lividipennis and the wolf spider L. pseudoannulata (Saxena, 1989).

Neem products such as NSKE and TNAU neem oil 50 EC were reported safe to the insect parasitoids, Tetrastichus israeli, Trichogramma japonicum, Bracon hebtor, Apanteles plutellae and predators such as L. pseudoannulata, Oxyopus javonus, Chrysoperla carnea (TNAU, 1992).

Patel and Yadav (1993) reported that the studies in Gujarat showed that application of botanicals like nicotine sulphate, repelin and neemark were 100 per cent safe to Menochilus sexmaculatus, an important aphid predator whereas these were highly toxic to its hyper parasite Tetrastichus coccinellae.

Application of neem seed extract to the 4th and 5th instar larvae of P. brassicae which also contained larvae of the parasitoid suffered increased mortality at all subsequent life stages and deformities in emerged adults (Osman and Bradley, 1993).

Bandara and Kudagamage (1993) opined that neem seed kernel extract and neemoil did not harm the parasite A. plutellae.

Eucalyptus sp. and Catharanthus roseus at higher concentrations had a very low level of toxicity against Lycosa sp. and Cyrtorhinus sp. than standard insecticides (Shanthi and Janarthanan, 1991).

The extracts of Eucalyptus terticornis and Tagetes erecta were toxic to Microvelia atrolineata but they were comparitively safer to Tetragnatha maxillosa spiderlings (Mahima shanthi and Mohanasundaram, 1992).

Srinivasababu et al. (1993) observed that the botanical insecticides repelin and neem guard were safe at lower concentrations to three parasites Trichogramma australicum, B. hebetor and T. israeli whereas endosulfan and Phosalone were highly toxic.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

Extracts of different parts viz., flower, leaf, root and stem of Clerodendron infortunatum L. were tested against grubs of Henosepilachna vigintioctopunctata F. for the antifeedant, toxic, growth inhibitory, ovicidal and sterilant actions and their effects on the parasite Chrysocharis johnsoni S. were assessed.

3.1. Preparation of plant extracts

C. infortunatum plants (Plate 1) required for the experiments were collected from the College farm and the following plant parts were separated and used for extraction.

a. Leaves - Tender leaves (2nd, 3rd and 4th from tip)
b. Flowers - Freshly opened
c. Root - Top three roots
d. Stem - Middle portion

3.1.1. Processing of fresh plant materials for extraction

Fresh plant parts collected separately, washed free of dust, chopped into pieces and minced in a mixer.

3.1.2. Processing of shade-dried plant material for extraction

The fresh plant parts collected from the field were separated and divided into 20 gram lots and were chopped and

Plate 1. *Clerodendron infortunatum*

(Peruvalam)

spread under shade in the room till the different parts were properly dried. They were finely ground in a mixer and the materials were used for extraction.

3.1.3. Processing of sun-dried plant parts for extraction

Lots of 20 gram fresh plant materials were dried in sunlight till the materials were properly dried. The plant parts were then finely ground in a mixer and used for extraction.

3.1.4. Extraction of processed plant parts and dilution of extract

Samples of processed plant parts obtained from twenty g fresh plant materials were extracted in a Soxhlet apparatus for 24 hours. The extracts thus obtained were transferred to volumetric flasks and the volume was made upto 100 ml by adding appropriate quantities of the solvent. The extracts were further diluted with water containing one per cent teepol as emulsifier for obtaining required concentrations for different experiments. The solvent concentration (excluding water) in the final spray formulation was maintained at 5 per cent level.

3.2. Rearing of test insects

The initial culture of H. vigintioctopunctata was built up in the laboratory from the eggs and grubs collected from

field. The adults obtained from the above culture were confined in circular glass jars provided with leaves of bittergourd for feeding and egg laying. Eggs laid on each day were collected and kept in separate glass troughs with fresh bittergourd leaves. The food material was changed daily. Third instar larvae of uniform age (less than 48 h) required for different experiments were collected from the cultures thus produced in the laboratory.

3.3. Assessment of leaf protected by the application of different extracts

Preweighed bittergourd leaves of uniform age and size were dipped in emulsions of 4 per cent plant extracts and were dried. Ten third instar grubs of epilachna were collected from the culture, weighed and released in each petridish which contained preweighed treated leaves. The grubs were pre-conditioned without food for four hours. Forty eight hours after exposure, the uneaten portions of the leaves were taken out, cleaned and weighed. The difference in weights gave the quantity of leaves consumed. Preweighed leaves dipped in emulsions of respective solvents and exposed to larvae in petridishes served as control. The weight loss of leaf in a similar set, kept without larvae, served to find the natural loss of weight due to evaporation and to make adjustments in the weight of leaves consumed by the grubs. Three replications were maintained for

each treatment. Forty eight hours after feeding, the larvae were taken out and weighed. The difference in weights gave the gain or loss in weight of larvae. The larvae kept without food served as starved larvae.

3.4. Leaf protected by different treatments

The percentage of leaf protected by the extracts was estimated as (A-B/A) X 100, where A = weight of leaf consumed in control and B-weight of leaf consumed in treatment.

3.5. Estimation of percentage of larval starvation

The difference between the weight gain of larvae in control and the mean weight loss of larvae starved for the same duration was treated as 100 per cent. Percentages of larval starvation in treatments were calculated as [(C-E)/(C-S)] x 100 where, C = mean weight gain of larvae in control in 48 hours, E = mean weight gain of larvae in treatments and S = mean weight gain of larvae fully starved (the value is negative).

3.6. Evaluation of contact toxicity of the extracts

Freshly emerged third instar grubs of uniform size were collected from mass culture maintained in the laboratory. The extracts were directly sprayed on the test insects taken in clean petridishes using an atomizer. One ml of 4 per cent extract was

sprayed in one dish containing ten insects which formed one replication. Three replications were taken for each treatment. Grubs sprayed with emulsions of respective solvents alone served as control. The sprayed grubs were kept exposed under a fan for the spray fluid to evaporate. The grubs were then transferred to petridishes with fresh food material. Mortality counts were taken at the end of 24 hours. The percentage mortalities in treatments were corrected for mortality in control using Abbot's formula (Abbot, 1925).

3.7. Assessment of the growth inhibition of the extracts on the larvae of H. vigintioctopunctata

3.7.1. Application of plant extracts on the test insects

The plant extracts were applied topically to the 1st, 2nd, 3rd and 4th instar grubs of H. vigintioctopunctata on the tergites using Hamilton microapplicator. Groups of ten insects each treated with one µl of 4 per cent plant extract confined in petridishes served as one replication and three such replications formed one treatment. One µl each of the solvents applied on insects served as control. The treated insects were fed on fresh untreated food material kept in petridishes.

3.7.2. Assessment of results

The effect of treatments was assessed in terms of the larval mortality, pupal mortality, emergence of abnormal and normal adults, the longevity and fecundity of the insects.

3.7.2.1. Assessment of longevity of adults

The treated insects kept with fresh food were daily observed. The normal and malformed adults were transferred to separate petridishes and were supplied with fresh bittergourd leaves for feeding. They were maintained till death allowing adults to mate and lay eggs. By noting the day of death of each insect, the longevity of normal adults and malformed adults could be assessed. The longevity of larval pupal mosaic was also assessed by observing them till death.

3.7.2.2. Assessment of fecundity of insects

The number of eggs laid by each isolated insect was counted daily and from the data the fecundity of insects in different categories and grades could be calculated.

3.7.2.3. Assessment of hatchability of eggs

The eggs laid by insects in different categories were collected separately. Leaves containing the eggs were kept over moist cotton placed in petridishes. The hatching of the eggs was observed daily. From the data, the percentage of eggs hatched was calculated.

3.7.2.4. Assessment of sterility percentage

From the data relating to the fecundity of the insects and hatching percentage of eggs, the sterility percentage was

marked out by using the formula suggested by Outram (1973). The sterility percentage (s) = 100 - (a x b) x 100/A x B, where

a - number of eggs laid/female in treatment

b - percentage of eggs hatching in treatment

A - number of eggs in control and

B - percentage of eggs hatching in control.

3.8. Evaluation of plant extracts for ovicidal action

Eggs collected from the mass culture of H. vigintioctopunctata maintained in the laboratory were used for the experiment. Freshly laid eggs were taken and kept immersed in 4% emulsions of extracts for five minutes. Eggs immersed in emulsions of respective solvents served as control. Treated eggs were then dried under a fan and transferred carefully to the petridishes for further observations. The number of eggs hatching was counted and the hatching percentage of eggs in treatments and control were calculated.

3.9. Assessment of sterilant action of different extracts on the adults of the test insects

3.9.1. Exposing the insects to the extracts

Healthy adult beetles selected on the day of emergence were used for the experiment. Bittergourd leaves were dipped in the plant extracts ensuring that both the surfaces were completely wetted. The leaves were then air - dried and placed in petridishes. For each treatment, three replications were set.

Leaves dipped in respective solvents and dried, served as control. Five pairs of one day old adults were exposed on treated leaves in each petridish for 24 hours for feeding. Then they were transferred to fresh leaves taken in petridishes.

3.9.2. Assessment of results

Observations were made on the longevity of adults in each treatment. The number of eggs laid by each insect was counted daily and the fecundity of each insect was calculated from the data. The hatching of the eggs was observed daily and the percentage of eggs hatched in each treatment was calculated. From the data, sterility percentage was worked out by using the formula suggested by Outram (1973).

3.10. Assessment of the effect of extracts of C. infortunatum on C. johnsoni, a parasite of H. vigintioctopunctata.

3.10.1. Rearing of C. johnsoni.

The parasitized grubs collected from the field were kept in the laboratory and the emerging parasites were used for the experiments.

3.10.2. Assessment of the toxic effect of the extracts

Water and acetone extracts of leaf and flowers alone were evaluated in the experiment One ml each of the extracts were transferred to rimless test tubes (25 x 25 cm) and the solvents were allowed to evaporate while rotating the tubes in a

horizontal position, so that a dry film of the solutes got deposited uniformly on the inner surface of the tubes. The tubes were placed under a fan for 1 hour for clearing the tubes of the fumes of solvent. Tubes prepared in the same way using solvents alone served as control. Each treatment was replicated four times. Ten chrysocharis adults were exposed in each tube for thirty minutes and then they were transferred to clean containers. After 24 hours, mortality was recorded. The data were corrected for the mortality in control using Abbot's formula (Abbot, 1925).

3.10.3. Assessment of the effect of extracts on the parasitization of H. vigintioctopunctata by C. johnsoni.

Fourth instar epilachna grubs were collected from culture maintained in the laboratory. One ml of 4 per cent extract was sprayed in one dish containing 15 insects which formed one treatment. Four replications were taken for each treatment. Grubs sprayed with respective solvents alone served as control. Two such lots were maintained. The grubs in lot 1 was transferred to fresh bittergourd leaves in petridishes 12 hours after treatment and were exposed to 5 pairs of male and female of C. johnsoni. Second lot was similarly exposed to the parasite 24 hours after treatment. The percentage of parasitization of the beetle grub was worked out on the basis of the blackening of the body.

3.10.4. Effect of extracts on C. johnsoni developing in parasitized grubs of H. vigintioctopunctata

Fourth instar grubs of epilachna collected from laboratory culture were exposed to chrysocharis and the parasitized grubs were collected on the 3rd day of parasitization and were treated with plant extracts by direct spraying. Ten parasitized grubs treated in petridishes served as one replication and four such replications were made for each experiment. In the control, the grubs were treated with respective solvent alone. The number of adult parasites emerging in each replication was recorded. The mortality if any of the larva/pupa of the parasite within the parasitized grub was also observed by dissecting out the treated grubs after the parasite emergence.

3.11. Field evaluation of plant extracts for the control of H. vigintioctopunctata

A microplot trial was conducted with four promising treatments along with an insecticide check. The treatments included in the experiment were

T_1 - Acetone extract of leaf 4%

T_2 - Acetone extract of leaf + teepol 4%

T_3 - Water extract of leaf 4%

T_4 - Water extract of leaf + teepol 4%

T_5 - Carbaryl 0.15%

T_6 - Control

3.11.1. Lay out of the experiment

The experiment was laid in field adopting a randomized block design, the plot size being 2.0 x 2.0 M. There were six treatments including control and each treatment was replicated four times. Application of fertilizer and other crop husbandry practices recommended in the package of practices (KAU, 1993b) were adopted excluding the plant protection measures.

3.11.2. Application of plant extracts

The plant extracts were applied in the respective plots using a pneumatic knapsack sprayer of 3 l capacity when the pest population caused injury at visible levels. Border rows were provided around the plots to prevent contamination through drift. A thorough and uniform coverage of plant parts was ensured.

3.11.3. Assessment of results

Pretreatment and post treatment counts of H. vigintioctopunctata grubs were recorded at second, fourth and eighth day after treatment. Extent of leaf damage and the occurrence of natural enemies in the plant were also observed at different intervals. The data were subjected to statistical analysis.

RESULTS

RESULTS

4.1 Effects of extracts of fresh plant parts of clerodendron on the extent of leaf fed by H. virgintioctopunctata grubs and on the larval starvation

The relevant data and the results of statistical analysis of the same are presented in Table 1.

4.1.1 Leaf protection

The mean percentage of leaf protection in different treatments showed that, among the plant parts tried, flower (86.6 per cent) and leaf (86.3 per cent) were on par and significantly superior to root (68.4 per cent) and stem (48.2 per cent), the latter two varying significantly between themselves.

Different extracts of flower showed significantly higher activity (84.3 to 93.9 per cent) than those of leaf (80.2 to 92.1 per cent). All the root extracts were far more effective (43.9 to 72.7 per cent) than the stem extract (44.0 to 60.0 per cent).

Mean percentage of protection given by the solvents showed that acetone (77.6) and benzene (77.6) were on par and most effective. Benzene was followed by ethanol extract (74.3 per cent); it was significantly superior to water (65.1 per cent) and petroleum ether extracts (60.0 per cent).

Table 1. Antifeedant action of extracts of fresh plant parts o Clerodendron infortunatum on third instar grubs o Henosepilachna vigintioctopunctata, when exposed o bitterguard leaves dipped in four percent emulsion.

Plant part used	Solvents used					
	Water	Acetone	Benzene	Ethanol	Petroleum ether	Mean
Leaf protection (%)						
Flower	86.7 (68.5)	93.9 (75.6)	91.8 (73.3)	85.7 (67.8)	84.3 (66.6)	86.6 (68.4)
Leaf	85.8 (67.3)	92.1 (73.6)	91.2 (72.7)	82.8 (65.4)	80.2 (63.8)	86.3 (68.0)
Root	43.9 (41.3)	72.7 58.4)	72.7 (58.4)	68.5 (55.5)	58.4 (50.0)	68.4 (55.8)
Stem	44.0 (41.5)	51.5 (45.8)	54.5 (47.5)	60.0 (50.7)	31.2 (33.9)	48.2 (43.9)
Mean	65.1 (53.8)	77.6 (61.7)	77.6 (61.7)	74.3 (59.5)	60.0 (50.8)	
Mean larval starvation (%)						
Flower	78.1 (62.0)	89.2 (70.7)	87.0 (68.8)	76.6 (61.0)	61.8 (52.0)	78.5 (62.4)
Leaf	75.0 (59.9)	85.7 (67.7)	83.8 (66.2)	73.3 (58.9)	69.2 (56.3)	77.4 (61.6)
Root	65.6 (54.1)	64.2 (53.2)	54.8 (47.7)	63.3 (52.8)	70.3 (57.0)	63.6 (52.9)
Stem	62.5 (52.2)	60.7 (57.2)	51.6 (45.8)	56.6 (49.0)	48.1 (43.9)	55.9 (48.3)
Mean	70.3 (57.0)	75.0 (60.0)	69.3 (56.4)	67.5 (55.2)	62.4 (52.2)	

Figures in the parentheses are transformed values - $\sin^{-1}\sqrt{p}$

CD (0.05)	Leaf protection	Larval starvation
Plant part	0.45	0.81
Solvent	0.47	0.83

In the case of flower and leaf extracts, water gave significantly higher protection (86.7 and 85.9 per cent) than ethanol extract (85.7 and 82.8 per cent) while in the case of root and stem, water extract (43.9 and 44.0 per cent) was far less effective than ethanol extract (68.5 and 60.0 per cent).

4.1.2 Larval starvation

The mean larval starvation in different treatments showed that among the plant parts tested, flower (78.5 per cent) and leaf (77.4 per cent) were on par and more effective than root (63.6 per cent)and stem (55.9 per cent) the latter two being significantly different from one another.

The percentages of larval starvation in flower extracts ranged from 76.6 to 89.2 and were significantly superior to the corresponding activity of leaf extracts (73.3 to 85.7) except in petroleum ether in which the larval starvation were 61.8 and 69.2 per cent respectively. Root and stem extracts caused less than 70.0 per cent of larval starvation except petroleum ether extract of root, where the larval starvation was 70.0 per cent. The least percentage of larval starvation was observed in petroleum ether extract of stem (48.1).

Mean larval starvation (in per cent) caused by different solvents used for different plant parts showed that acetone extract (75.0) had the highest activity and it was

significantly superior to all other treatments. It was followed by water (70.3 per cent) and benzene extracts (69.3) which were on par and superior to ethanol (67.5 per cent) and petroleum ether extracts (62.4 per cent).

4.2 Effect of extracts of shade-dried clerodendron extracts on the extent of leaf fed by grubs of H. vigintioctopunctata and on larval starvation

The data on the percentage weight of leaf protected over control and percentage of larval starvation are furnished in Table 2.

4.2.1 Leaf protection

Among the plant parts tested, leaf extract gave the highest mean percentage of leaf protection (73.5) followed by flower extract (63.3). Root and stem extracts had low activity of 43.5 and 35.1 per cent respectively.

The leaf extracts of C. infortunatum gave 61.1 to 81.8 per cent leaf protection while in flower extract protection ranged from 53.3 to 72.7 per cent only. The root and stem extracts exhibited low activity and the leaf protection ranged from 29.0 to 48.8 per cent only.

Based on mean per cent of leaf protection caused by extracts of different plant parts, acetone was found to be

Table 2. Antifeedant action of extracts of shade-dried plant parts of Clerodendron infortunatum on third instar grubs of Henosepilachna vigintioctopunctata, when exposed on bittergourd leaves dipped in four percent emulsion.

Plant part used	Solvents used					
	Water	Acetone	Benzene	Ethanol	Petroleum ether	Mean
Leaf protection (%)						
Flower	68.3 (55.7)	72.7 (58.7)	69.2 (56.3)	53.3 (46.9)	55.5 (48.1)	63.8 (53.0)
Leaf	78.3 (62.2)	81.8 (64.7)	76.9 (61.2)	69.3 (56.3)	61.1 (51.3)	73.5 (59.0)
Root	41.6 (40.1)	45.4 (42.4)	38.4 (38.3)	43.3 (41.1)	48.8 (44.3)	43.5 (41.3)
Stem	38.3 (38.2)	34.5 (35.9)	33.8 (35.8)	39.1 (38.7)	29.9 (33.2)	35.1 (36.3)
Mean	56.6 (48.8)	58.6 (50.0)	54.5 (47.6)	51.3 (45.7)	48.8 (44.3)	
Mean larval starvation (%)						
Flower	66.6 (54.6)	53.1 (46.7)	54.6 (47.6)	56.2 (48.5)	62.5 (52.2)	58.6 (50.0)
Leaf	73.3 (58.9)	75.0 (59.9)	83.3 (65.8)	68.8 (56.0)	71.8 (57.9)	74.4 (59.6)
Root	60.0 (50.7)	50.0 (44.9)	43.3 (41.1)	65.6 (54.0)	40.6 (39.5)	51.9 (46.1)
Stem	46.6 (43.0)	62.5 (52.2)	46.6 (43.0)	53.1 (46.7)	46.8 (43.1)	51.1 (45.6)
Mean	61.6 (51.7)	60.2 (50.9)	57.0 (49.0)	60.0 (50.7)	55.4 (48.1)	

Figures in the parentheses are transformed values - $\sin^{-1}\sqrt{P}$.

CD (0.05)	Leaf protection	Larval starvation
Plant part	0.45	0.81
Solvent	0.47	0.83

significantly superior to other solvents (58.6 per cent). It was followed by water (56.6 per cent), benzene (54.5 per cent) and ethanol (51.3 per cent). The petroleum ether had the least activity (48.8 per cent). Different treatments varied significantly from one another.

The above sequence of efficacy was observed in the case of leaf and flower extracts in different solvents. In the case of root extract, petroleum ether was the best and it was followed by acetone, ethanol, water and benzene. For the extraction of stem, ethanol and water were on par and best. These were followed by acetone and ethanol which were also on par and the least effective extractant was petroleum ether.

4.2.2 Larval starvation

Among the plant parts tried, leaf had significantly higher activity than other plant parts, the mean larval starvation being 73.5 per cent. It was followed by flower extract (63.8 per cent). Stem (43.5 per cent) and root extracts (35.1 per cent) showed low activity.

The mean percentages of larval starvation in leaf extract using different solvents ranged from 68.8 to 75.0. Water and ether extract of flower gave 66.6 and 62.5 per cent of larval starvation. In the remaining solvents, it ranged from 53.1 to 56.2 per cent only. Larval starvation in ethanol extracts of

Table 3. Antifeedant action of extracts of sun-dried plant parts of Clerodendron infortunatum on third instar grubs of Henosepilachna vigintioctopunctata, when exposed on bittergourd leaves dipped in four percent emulsion.

Plant part used	Solvents used					
	Water	Acetone	Benzene	Ethanol	Petroleum ether	Mean
Leaf protection (%)						
Flower	41.6 (40.1)	63.6 (52.8)	61.5 (57.6)	39.9 (39.7)	55.6 (48.2)	52.4 (46.3)
Leaf	75.0 (60.0)	72.7 (58.5)	72.3 (58.3)	56.0 (48.4)	57.7 (49.4)	66.7 (54.8)
Root	33.3 (35.2)	36.3 (37.0)	38.9 (38.6)	35.5 (36.6)	33.3 (35.2)	35.5 (36.5)
Stem	25.0 (29.9)	35.4 (36.4)	39.2 (38.7)	32.9 (35.0)	24.3 (29.5)	31.4 (34.0)
Mean	43.7 (41.4)	52.0 (46.1)	52.9 (46.7)	41.1 (39.9)	42.7 (40.3)	
Mean larval starvation (%)						
Flower	58.8 (50.0)	62.5 (52.2)	53.3 (46.8)	53.1 (46.8)	56.3 (48.6)	56.3 (48.9)
Leaf	64.7 (53.5)	75.0 (60.0)	80.0 (63.4)	59.3 (50.3)	62.5 (52.2)	68.3 (55.7)
Root	50.0 (44.9)	49.8 (43.1)	43.3 (41.1)	56.3 (48.5)	43.7 (41.3)	48.0 (43.9)
Stem	47.0 (43.2)	50.0 (44.9)	44.6 (41.8)	50.0 (44.9)	46.5 (43.1)	47.6 (43.6)
Mean	55.1 (47.9)	58.6 (49.9)	55.3 (48.0)	54.7 (47.7)	52.3 (46.3)	

Figures in the parentheses are transformed values - $\sin^{-1}\sqrt{P}$.

CD (0.05)	Leaf protection	Larval starvation
Plant part	0.45	0.81
Solvent	0.47	0.83

root and acetone extract of stem reached 65.6 and 62.5 per cent level while in the remaining extracts, it ranged from 43.3 to 60.0 per cent.

Water extract gave the maximum mean larval starvation (61.6 per cent) and it was on par with ethanol (60.0 per cent) and acetone extracts (60.2 per cent). They were followed by benzene (57.6 per cent) and petroleum ether extract (55.4 per cent). For leaf, benzene was the best extractant and it was followed by acetone and water and the latter two being on par. Petroleum ether and ethanol were less effective. For root and stem the best extractants were ethanol and acetone respectively while in remaining solvents the activity was much less.

4.3 Effect of extracts of sun-dried clerodendron extracts on the extent of leaf fed by grubs of H. vigintioctopunctata and on the larval starvation

Data on the extent of leaf protection and larval starvation and the results of statistical analysis of the same are presented in Table 3.

4.3.1. Leaf protection

The mean percentage of protection in different treatments showed that leaf (66.7) was significantly superior to other

plant parts tested. Flower extract (52.4 per cent) though inferior to leaf was far more effective than the root (35.5 per cent) and stem extracts (31.4 per cent).

Water, acetone and benzene extracts of leaf caused high leaf protection and the percentage ranged from 72.3 to 75.0. The ethanol and petroleum ether gave 56.0 and 57.7 per cent leaf protection respectively. In flower extract, leaf protection ranged from 39.9 to 63.3 per cent. Different extracts of root and stem caused less than 40.0 per cent leaf protection only. A very low percentage of leaf protection was observed in petroleum ether and water extracts of stem, 24.3 and 25.0 respectively.

Among the solvents, benzene (mean leaf protection of 52.9 per cent) and acetone (52.0 per cent) were on par and significantly superior to the rest. These were followed by water (43.7 per cent). Petroleum ether extract (40.3 per cent) was on par with ethanol (39.9 per cent) and least effective. Acetone was the best extractant for flower and leaf and it was followed by water and benzene. For root, petroleum ether was the best and it was followed by acetone and ethanol; while for stem ethanol and water were on par and best.

4.3.2 Larval starvation

Among the plant parts tested, leaf (68.3 per cent) was found to be significantly superior to flower (56.3 per cent).

Table 4. Reduction in percentage of leaf protection and larval starvation caused by extracts different parts of Clerodendron infortunatum plants, dried in sun and under shade, over the percentage caused by extracts of fresh plant parts.

Treatments	Solvents Used					
	Water	Acetone	Benzene	Ethanol	Petroleum ether	Mean
LEAF PROTECTION						
Shade-dried flower	21.2	22.5	24.6	37.8	4.9	28.0
Shade-dried leaf	8.7	11.1	15.6	16.3	7.7	11.9
Shade-dried root	5.2	37.5	47.1	36.7	42.2	28.6
Shade-dried stem	12.9	33.0	37.9	34.8	4.1	24.5
Mean	12.0	26.0	31.3	31.4	14.7	
Sun dried flower	52.0	32.2	33.0	53.4	4.7	40.9
Sun dried leaf	12.5	21.0	20.7	32.3	12.8	19.9
Sun dried root	24.1	49.9	46.4	48.1	60.5	42.3
Sun dried stem	43.1	31.2	28.0	45.1	22.1	33.9
Mean	32.9	33.6	32.0	44.7	25.0	
LARVAL STARVATION						
Shade-dried/flower	14.7	35.2	37.2	26.6	-1.1	22.5
Shade-dried leaf	2.2	12.4	0.5	6.1	-3.75	3.5
Shade-dried root	0.85	22.1	20.9	-3.63	42.2	16.5
Shade-dried stem	25.4	-2.9	9.6	6.1	2.7	8.2
Mean	10.7	16.7	17.0	8.7	10.0	
Sun dried flower	24.7	29.9	38.7	30.0	8.8	26.4
Sun dried leaf	13.7	12.4	4.5	19.0	9.6	11.8
Sun dried root	23.1	27.1	20.9	11.0	37.8	23.9
Sun dried stem	24.8	17.6	13.5	11.6	3.3	14.2
Mean	21.5	21.8	19.4	17.9	14.8	

Root (48.0 per cent) and stem extracts (10.6 per cent) had much lesser activity and they were on par.

The percentages of larval starvation with different extracts of leaf ranged between 59.3 and 80.0 while in different flower extracts larval starvation ranged between 53.1 to 62.5 per cent only. In all the extracts, leaf showed more activity than flower. In root extract, the percentage of larval starvation ranged from 43.7 to 56.6. Acetone and ethanol extracts of stem gave 50.0 per cent of larval starvation while in the remaining extracts it ranged from 44.6 to 47.0 per cent.

The maximum mean larval starvation was observed in acetone extract (58.6 per cent). This was followed by benzene extract (49.9 per cent) and it was on par with water (47.9 per cent) and ethanol (48.0 per cent). The least activity was observed in petroleum ether (46.3 per cent). While acetone caused higher larval starvation in the case of flower, benzene, ethanol, acetone/ethanol were the best for extracting leaf, root and stem respectively.

4.4 Effect of drying of *C. infortunatum* plants, under shade and in sun, on the antifeedant action on *H. vigintioctopunctata*.

The percentage reduction in leaf protection and larval starvation compared to the values in fresh plant parts are presented in Table 4. The means of the treatment showed that the

least reduction in the antifeedant action as evidenced by fall in the leaf protection percentage was in leaf extract (11.9) and it was followed by stem (24.5), flower (28.0) and root (28.6). The loss in activity when dried directly in sun was significantly higher than when dried under shade. The mean reduction ranged from 11.9 to 28.5 per cent in the former, while in the latter the range was 19.9 to 42.3 per cent. The relative ranking of the different plant parts was the same for shade drying and drying in sun.

The antifeedant activity of plant parts dried under shade suffered less loss with water and petroleum ether as solvent (12.0 and 14.7 per cent) while in acetone, benzene and ether the reduction was much higher (26.0 to 31.4 per cent). In the case of sun dried materials the loss in activity among the different solvents ranged from 25.0 to 44.7 per cent and they came in the following descending order: petroleum ether, benzene, water, acetone and ethanol.

With reference to the larval starvation also shade dried leaf had the lowest reduction in activity (3.49 per cent) and it was followed by stem (8.18 per cent) root (16.48 per cent) and flower (22.52 per cent). The same sequence was noted with reference to loss in larval starvation observed on sundried parts. Loss with shade dried materials (3.5 to 22.5 per cent) was comparatively less than those observed with sundried parts

Table 5. Contact toxicity of clerodendron extracts to the third instar grubs of Henosepilachna vigintioctopunctata assessed 24 hours after treatment.

Solvents used	Plant parts extracted	Corrected percentage mortality		
		Fresh	Shade-dried	Sun-dried
Water	Flower	6.6	3.3	0.0
	Leaf	10.0	6.6	0.0
	Root	6.6	0.0	0.0
	Stem	6.6	0.0	0.0
Acetone	Flower	6.6	0.0	3.3
	Leaf	10.0	6.6	6.6
	Root	10.0	3.3	3.3
	Stem	3.3	0.0	0.0
Benzene	Flower	10.0	6.6	3.3
	Leaf	13.3	6.6	6.6
	Root	6.6	6.6	0.0
	Stem	3.3	3.3	0.0
Ethanol	Flower	10.0	6.6	0.0
	Leaf	10.0	6.6	3.3
	Root	6.6	3.3	0.0
	Stem	3.3	0.0	0.0
Petroleum ether	Flower	3.3	0.0	0.0
	Leaf	6.6	3.3	0.0
	Root	6.6	0.0	0.0
	Stem	3.3	0.0	0.0

Data were not statistically analysed since the mortality was low in all treatments.

One ml. of 4 per cent emulsion sprayed on 10 grubs in each replication.

(11.8 to 26.4 per cent). The different solvents did not show wide variations in causing the reduction in larval starvation with shade dried as well as the sundried plant parts; the mean reductions being 8.7 to 17.0 per cent and 17.9 to 21.8 per cent in the two lots of treatments. When dried under shade, the larval starvation recorded a marginal increase with flower and leaf extracted with petroleum ether and root with ethanol when compared to extracts of corresponding fresh plant parts.

4.5 Screening of different plant parts of C. infortunatum for insecticidal activity

Data relating to the experiment are presented in Table 5. Insecticidal action observed with extracts of different plant parts of C. infortunatum was very low. Among the treatments, leaf extract of fresh plant material was more toxic than flower, stem and root, and that too caused mortality ranging from 3.3 to 13.3 per cent only. Shade and sundried plant parts were less toxic causing mortalities ranging from only 3.3 to 6.6 per cent.

4.6 Growth inhibitory activity of clerodendron extracts

Effects of the extracts of different plant parts of clerodendron on the biology and morphological changes in development, were assessed in various experiments.

Table 6. Hormonal effects of extracts of fresh plant parts of Clerodendron infortunatum (1 µl of 4% emulsion/insect) topically applied on the last instar grubs of Henosepilachna vigintioctopunctata

Solvents used	Plant parts used	Pupal duration	Mean percentage of grubs						
			Dying	Dying after pupation	Developing as abnormal adult	Developing as normal adult	Longevity of abnormal adult	Longevity of normal adult	Number of eggs laid per female
Water	Flower	4.0	10.0(3.3)	6.6(2.8)	3.3(2.1)	80.0(63.43)	0.0	7.0	15.0
	Leaf	4.3	0.0(1.0)	16.6(4.2)	3.3(2.1)	80.0(63.43)	0.0	7.3	16.0
	Root	5.0	0.0(1.0)	10.0(3.3)	0.0(1.0)	90.0(71.56)	0.0	7.6	16.0
	Stem	5.0	0.0(1.0)	10.0(3.3)	0.0(1.0)	90.0(71.56)	0.0	7.0	16.7
	Control	5.0	0.0(1.0)	0.0(1.0)	0.0(1.0)	100.0(89.09)	0.0	8.0	17.0
Acetone	Flower	5.0	10.0(3.3)	30.0(5.6)	10.0(3.3)	50.0(45.0)	1.3	7.0	10.0
	Leaf	5.0	0.0(1.0)	30.0(5.6)	30.0(5.6)	40.0(39.23)	2.0	7.3	10.0
	Root	5.0	0.0(1.0)	0.0(1.0)	20.0(4.6)	80.0(63.43)	0.0	7.0	15.3
	Stem	5.0	0.0(1.0)	0.0(1.0)	10.0(3.3)	90.0(71.56)	0.0	7.3	15.0
	Control	5.0	0.0(1.0)	0.0(1.0)	0.0(1.0)	100.0(89.09)	0.0	7.3	16.0
Benzene	Flower	4.7	0.0(1.0)	30.0(5.6)	20.0(4.6)	50.0(45.0)	1.0	7.0	10.0
	Leaf	5.0	20.0(4.6)	10.0(3.3)	10.0(3.3)	60.0(50.76)	0.0	7.0	10.3
	Root	5.0	0.0(1.0)	20.0(4.6)	10.0(3.3)	70.0(56.78)	0.0	7.0	16.6
	Stem	5.0	0.0(1.0)	10.0(3.3)	10.0(3.3)	80.0(63.43)	0.0	7.3	16.0
	Control	5.0	0.0(1.0)	0.0(1.0)	0.0(1.0)	100.0(89.09)	0.0	7.0	16.3
Ethanol	Flower	5.0	10.0(3.3)	0.0(1.0)	20.0(4.6)	70.0(56.78)	1.0	7.0	16.0
	Leaf	5.0	0.0(1.0)	20.0(4.6)	0.0(1.0)	80.0(63.43)	0.0	7.0	15.0
	Root	5.0	0.0(1.0)	0.0(1.0)	10.0(3.3)	90.0(71.56)	1.3	7.3	17.0
	Stem	5.0	0.0(1.0)	0.0(1.0)	10.0(3.3)	90.0(71.56)	1.0	7.3	17.0
	Control	5.7	0.0(1.0)	0.0(1.0)	0.0(1.0)	100.0(89.09)	0.0	7.3	18.0
Petro-leum ether	Flower	5.0	10.0(3.3)	0.0(1.0)	30.0(5.6)	60.0(50.76)	1.0	7.0	10.0
	Leaf	5.0	0.0(1.0)	30.0(5.6)	10.0(3.3)	60.0(50.76)	0.0	7.3	17.0
	Root	5.0	0.0(1.0)	0.0(1.0)	10.0(3.3)	90.0(71.56)	0.0	7.3	18.0
	Stem	5.0	0.0(1.0)	10.0(3.3)	0.0(1.0)	90.0(71.56)	0.0	7.3	18.0
	Control	5.0	0.0(1.0)	0.0(1.0)	0.0(1.0)	100.00(89.09)	0.0	7.3	18.1
CD (0.05)		NS	2.5	2.7	3.0	12.62	NS	NS	NS

Figures in the parentheses are transformed values - $\text{Sin}^{-1}\sqrt{P}$ / $\sqrt{x+1}$.
NS Variations not statistically significant.

4.6.1 Effect of extracts of fresh plant parts of clerodendron on the last instar grubs of H. yigintioctopunctata

Results of the experiment and the results of statistical analysis of the data are presented in Table 6. Pupal duration in different treatments did not vary significantly and it ranged from 4.0 to 5.0 days.

Highest larval mortality was observed with benzene extract of leaf (20.0 per cent) and it was followed by water, acetone, ethanol and ether extracts of flower (10.0 per cent each). No mortality was observed in other treatments including control.

Thirty per cent of the grubs treated with acetone extract of leaf, benzene extract of leaf and flower and petroleum ether extract of leaf died as pupae. With ethanol extract of leaf and acetone extract of root 20.0 per cent pupal mortality was observed, while in water extract of leaf 16.6 per cent of treated grubs died as pupae. Water and benzene extract of stem and benzene extract of leaf caused 10.0 per cent mortality only. These treatments and the remaining extracts were on par with control having no pupal mortality.

The maximum of 30.0 per cent adult deformity was recorded in acetone extract of leaf and ether extract of flower which were on par with benzene and ethanol extract of flower and

acetone extract of root (20.0 per cent each). Remaining treatments were on par with control with no abnormal adult formation.

Percentage of normal adult emergence were on par and significantly less in acetone extract of leaf (40.0 per cent), benzene extracts of leaf (60.0 per cent), petroleum ether extract of leaf (60.0 per cent) and flower (60.0 per cent). In the remaining treatments adult emergence ranged from 70.0 to 100.0 per cent.

Longevity of abnormal adults did not vary significantly. They were short lived, survived for 1 to 2 days after emergence and failed to lay eggs.

Average survival period of normal adults ranged from 7.0 to 8.0 days in different treatments. The variation among treatments was statistically insignificant.

The number of eggs laid per female ranged from 10.0 to 18.0 and the variations were not statistically significant. The extracts of clerodendron did not reduce the hatchability of eggs.

4.6.2 Effect of extracts of shade-dried plant parts of clerodendron on the last instar grubs of *H. vigintioctopunctata*

Data relating to the experiments and the results of the statistical analysis are presented in Table 7. The mean pupal

Table 7. Hormonal effects of extracts of shade-dried plant parts of Clerodendron infortunatum (1 µl of 4% emulsion/insect) topically applied on the last instar grubs of Henosepilachna vigintioctopunctata

Solvents used	Plant parts used	Pupal duration	Mean percentage of grubs						
			Dying	Dying after pupation	Developing as abnormal adult	Developing as normal adult	Longevity of abnormal adult	Longevity of normal adult	Number of eggs laid per female
Water	Flower	5.0	0.0	3.3(2.1)	6.6(2.8)	90.0(71.56)	1.0	8.0	16.0
	Leaf	5.0	0.0	13.3(3.8)	6.6(2.8)	80.0(63.43)	2.0	7.0	17.0
	Root	4.0	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	2.0	7.3	16.0
	Stem	4.6	0.0	10.0(3.3)	0.0(1.0)	90.0(71.56)	0.0	7.6	18.0
	Control	5.0	0.0	0.0(1.0)	0.0(1.0)	100.0(89.09)	0.0	8.0	18.0
Acetone	Flower	5.0	0.0	13.3(3.8)	6.6(2.8)	80.0(63.43)	1.0	8.0	18.0
	Leaf	5.0	0.0	26.6(5.3)	3.3(2.1)	70.0(56.78)	2.0	8.0	17.3
	Root	5.0	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	0.0	7.6	17.6
	Stem	4.6	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	1.0	8.0	17.0
	Control	5.0	0.0	0.0(1.0)	0.0(1.0)	100.0(89.09)	0.0	8.0	18.0
Benzene	Flower	4.0	0.0	10.0(3.3)	10.0(3.3)	80.0(63.43)	3.0	7.3	16.6
	Leaf	5.3	0.0	20.0(4.6)	10.0(3.3)	70.0(56.78)	1.6	7.0	17.0
	Root	4.6	0.0	10.0(3.3)	0.0(1.0)	90.0(71.56)	2.3	7.0	17.3
	Stem	5.0	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	2.6	7.0	17.6
	Control	5.0	0.0	0.0(1.0)	0.0(1.0)	100.0(89.09)	0.0	8.0	18.0
Ethanol	Flower	5.0	0.0	10.0(3.3)	10.0(3.3)	80.0(63.43)	1.6	8.0	18.0
	Leaf	5.0	0.0	10.0(3.3)	10.0(3.3)	80.0(63.43)	1.3	8.0	17.3
	Root	5.0	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	2.0	7.6	17.6
	Stem	5.0	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	0.0	8.0	18.0
	Control	5.0	0.0	0.0(1.0)	0.0(1.0)	100.0(89.09)	0.0	8.3	18.3
Petroleum ether	Flower	5.0	0.0	20.0(4.6)	0.0(1.0)	80.0(63.43)	0.0	8.0	17.0
	Leaf	5.0	0.0	20.0(4.6)	0.0(1.0)	80.0(63.43)	0.0	8.3	18.3
	Root	5.0	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	1.6	8.0	18.3
	Stem	5.0	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	1.0	8.0	19.0
	Control	5.0	0.0	0.0(1.0)	0.0(1.0)	100.0(89.09)	0.0	8.0	20.0
CD (0.05)		NS	NS	2.0	NS	18.2	NS	NS	NS

Figures in the parentheses are transformed values - $\sin^{-1}\sqrt{P}$ / $\sqrt{x+1}$.
NS Variations not statistically significant.

duration in different treatments did not vary significantly and it varied between 4.0 to 5.0 days. There was no larval mortality in different treatments.

Pupal mortality was maximum with acetone extract of leaf (26.6 per cent) and it was followed by petroleum ether extract of flower and leaf (20.0 per cent each), water extract of leaf and acetone extract of flower (13.3 per cent each), all being on par. Ethanol extract of flower and leaf, benzene extract of flower and root and water extract of stem were significantly superior to control.

The percentage of grubs developed as abnormal adult ranged from 6.6 to 10.0. In the remaining treatments there was no abnormal adults. The variations among the treatments were statistically insignificant.

Acetone and benzene extracts of leaf were the treatments which produced significantly less number of normal adults (70.0 per cent). The remaining treatments were on par among themselves and with control. The percentage of normal adults was in the range of 80.0 to 100.0.

The longevity of malformed adults did not vary significantly. The average survival period ranged from 1.0 to 3.0 days and they failed to lay eggs. The longevity of normal

Table 8. Hormonal effects of extracts of sun-dried plant parts of Clerodendron infortunatum (1 µl of 4% emulsion/insect) topically applied on the last instar grubs of Henosepilachna vigintioctopunctata

Solvents used	Plant parts used	Pupal duration	Mean percentage of grubs						
			Dying	Dying after pupation	Developing as abnormal adult	Developing as normal adult	Longevity of abnormal adult	Longevity of normal adult	Number of eggs laid per female
Water	Flower	5.0	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	3.0	8.0	16.0
	Leaf	5.0	0.0	10.0(3.3)	10.0(3.3)	80.0(63.43)	2.3	7.0	16.3
	Root	5.0	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	1.3	8.3	15.0
	Stem	4.7	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	1.6	8.6	16.0
	Control	5.0	0.0	0.0(1.0)	0.0(1.0)	100.0(89.09)	0.0	9.0	18.0
Acetone	Flower	5.0	0.0	10.0(3.3)	0.0(1.0)	90.0(71.56)	0.0	7.0	16.0
	Leaf	4.0	0.0	20.0(4.6)	10.0(3.3)	70.0(56.78)	0.0	7.3	16.0
	Root	5.0	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	1.0	8.7	18.0
	Stem	5.0	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	1.0	9.0	18.0
	Control	5.0	0.0	0.0(1.0)	0.0(1.0)	100.0(89.09)	0.0	9.0	19.0
Benzene	Flower	4.0	0.0	10.0(3.3)	0.0(1.0)	90.0(71.56)	0.0	8.0	17.0
	Leaf	4.7	0.0	10.0(3.3)	10.0(3.3)	80.0(63.43)	1.3	8.3	18.0
	Root	4.7	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	1.6	8.6	18.0
	Stem	5.0	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	2.0	8.6	18.0
	Control	5.0	0.0	0.0(1.0)	0.0(1.0)	100.0(89.09)	0.0	9.0	18.0
Ethanol	Flower	5.0	0.0	10.0(3.3)	10.0(3.3)	80.0(63.43)	1.0	8.7	18.0
	Leaf	5.0	0.0	10.0(3.3)	10.0(3.3)	80.0(63.43)	2.0	8.7	18.0
	Root	5.0	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	1.6	8.3	18.3
	Stem	5.0	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	1.6	8.3	18.7
	Control	5.0	0.0	0.0(1.0)	0.0(1.0)	100.0(89.09)	0.0	9.0	18.7
Petro-leum ether	Flower	5.0	0.0	10.0(3.3)	10.0(3.3)	80.0(63.43)	1.6	8.3	19.7
	Leaf	5.0	0.0	20.0(4.6)	0.0(1.0)	80.0(63.43)	0.0	8.3	19.3
	Root	5.0	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	1.0	8.7	19.3
	Stem	5.0	0.0	0.0(1.0)	10.0(3.3)	90.0(71.56)	1.0	8.7	20.0
	Control	5.0	0.0	0.0(1.0)	0.0(1.0)	100.0(89.09)	0.0	8.7	20.0
CD (0.05)		NS	NS	2.4	NS	15.7	NS	NS	NS

Figures in the parentheses are transformed values - $\sin^{-1}\sqrt{P}$ / $\sqrt{x+1}$.
NS Variations not statistically significant.

adults also varied from 7.0 to 8.0 days. The number of eggs laid per female varied between 16.0 to 20.0. There was no significant variation among the treatments.

4.6.3 Effect of extracts of sun - dried plant parts of clerodendron on the last instar grubs of *H. vigintioctopunctata*

The data on the hormonal effects and the results of statistical analysis of the same are presented in Table 8. Acetone and ether extracts of leaf caused 20.0 per cent pupal mortality. The remaining treatments were on par with each other and control.

The percentage of abnormal insects ranged from zero to ten, the variation among the treatments being statistically insignificant.

The percentage of normal adults ranged from 70.0 to 100.0. The least percentage of normal adult was observed in acetone extract of leaf (70.0). This was followed by water, benzene, ethanol and ether extracts of leaf and ethanol and ether extracts of flower (80.0 per cent each). The remaining extracts were on par with control.

Table 9. Reduction in hormonal effect as shown by the increase in percentage of normal adult emergence caused by extracts of different plant parts of Clerodendron infortunatum plants, dried in sun and under shade, over the percentage caused by extract of fresh plant parts.

Treatments	Solvents Used					
	Water	Acetone	Benzene	Ethanol	Petroleum ether	Mean
Shade-dried flower	12.5	60.0	60.0	14.2	33.3	36.0
Shade-dried leaf	0.0	75.0	16.6	0.0	33.3	24.9
Shade-dried root	0.0	12.5	28.5	0.0	0.0	8.2
Shade-dried stem	0.0	0.0	12.5	0.0	0.0	2.5
Mean	3.1	36.9	29.4	3.6	16.7	
Sun dried flower	12.5	80.0	80.0	14.2	33.3	44.0
Sun dried leaf	0.0	75.0	25.0	0.0	33.3	26.6
Sun dried root	0.0	12.5	28.5	0.0	0.0	8.2
Sun dried stem	0.0	0.0	12.5	0.0	0.0	2.5
Mean	3.1	41.9	36.5	3.6	16.7	

Longevity of abnormal adults did not vary significantly, they survived for one to three days after emergence and failed to lay eggs.

The normal adult emerged from treated grubs, survived for seven to nine days and the variations were not statistically significant. The fecundities of adult varied from 16.0 to 20.0 eggs per female and the variations also were not significant.

4.7 Effect of drying different parts of C. infortunatum plants, under shade and in sun, on the hormonal actions on H. vigintioctopunctata

The values of percentage increase in normal adult emergence compared to those in fresh plant parts are presented in Table 9. The means of the treatment revealed that the least increase in the normal adult emergence was in stem (2.5 per cent) and root (8.2 per cent). It was found to be much higher in leaf (24.9 per cent) and flower (36.0 per cent). The loss in activity when dried directly in sun and under shade was found to be almost same. The mean increase (in per cent) of the sundried plant parts ranged from 2.5 to 44.0. The relative ranking of the different plant parts was in the same order for shade-drying and drying in sun.

The percentage increase in normal adult emergence in shade-dried plant parts was less in the extract with water (3.1) and ethanol (3.6). It was found to be 16.7 per cent with

petroleum ether, 29.4 per cent with benzene and 36.9 per cent with acetone. In the case of sun dried materials the loss in activity among the solvents was found to be similar, ranging from 3.1 to 41.9 per cent and the percentage of normal adult emergence increased in the order of water (3.1), ethanol (3.6), ether (16.7), benzene (36.5) and acetone (41.9).

4.8 Screening of plant parts of clerodendron for sterilant action

Plant parts of clerodendron were bioassayed for assessing their sterilant activity on H. yigintioctopunctata.

4.8.1 Sterilant effect of extracts of fresh plant parts of clerodendron on H. yigintioctopunctata

The results of the experiments are presented in Table 10. Acetone extract of leaf and flower produced adults with least survival period of 7.00days. These were on par with all other plant parts but significantly different from that of control (11.00 days). Leaf (7.4 days) and flower (7.50 days) extracts were found to be significantly superior. Root (8.20 days) and stem extracts (8.50days) were inferior to the above treatments but superior to control.

The effects produced by solvents on average survival period were found to be similar. The average survival period was least in acetone (8.30days) which was followed by benzene

Table 10. Sterilant action of extracts of fresh plant parts of Clerodendron infortunatum on adults of Henosepilachna vigintioctopunctata, when fed on bittergourd leaves dipped in 4% emulsion

Observations	Plant parts used	Solvents Used					
		Water	Acetone	Benzene	Ethanol	Petroleum ether	Mean
Adult longevity	Flower	7.33	7.00	7.33	7.67	8.00	7.50
	Leaf	7.67	7.00	7.33	7.67	7.33	7.40
	Root	8.33	8.00	8.00	8.33	8.33	8.20
	Stem	8.33	8.33	8.33	8.67	8.67	8.50
	Control	11.00	11.00	11.00	11.00	11.00	11.00
	Mean	8.50	8.30	8.40	8.60	8.60	
Fecundity	Flower	21.30	23.00	23.00	23.00	22.60	22.58
	Leaf	22.00	22.60	23.60	23.00	23.00	22.84
	Root	22.30	23.30	24.00	23.30	23.60	23.30
	Stem	22.60	23.60	24.00	23.60	23.30	23.40
	Control	23.00	24.00	24.30	24.00	24.00	23.86
	Mean	22.20	23.30	23.70	23.40	23.30	
Hatching percentage	Flower	95.30 (77.40)	93.90 (75.67)	92.60 (74.10)	95.60 (77.86)	96.00 (78.49)	94.68 (76.70)
	Leaf	95.30 (77.40)	95.70 (78.00)	91.50 (73.00)	95.70 (78.00)	95.70 (78.00)	94.78 (77.18)
	Root	95.40 (77.50)	97.30 (80.50)	92.90 (74.50)	96.90 (79.80)	96.60 (79.34)	95.82 (78.00)
	Stem	95.30 (77.40)	97.40 (81.00)	94.10 (75.90)	97.40 (80.69)	96.90 (79.80)	96.22 (78.95)
	Control	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)
	Mean	96.26 (79.90)	96.86 (81.00)	94.22 (77.50)	97.12 (81.30)	97.04 (81.10)	
Sterility percentage	Flower	11.70 (3.56)	10.00 (3.31)	12.30 (3.64)	8.30 (3.04)	9.00 (3.16)	10.26 (3.34)
	Leaf	8.70 (3.11)	0.30 (3.04)	11.10 (3.47)	8.27 (3.04)	7.40 (2.89)	8.75 (3.11)
	Root	7.40 (2.89)	7.10 (2.84)	8.20 (3.03)	7.00 (2.82)	7.00 (2.82)	7.34 (2.87)
	Stem	6.10 (2.66)	4.20 (2.28)	7.10 (2.84)	4.20 (2.28)	5.90 (2.62)	5.50 (2.54)
	Control	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
	Mean	6.78 (2.64)	5.92 (2.49)	7.74 (2.78)	5.55 (2.43)	5.86 (2.49)	

CD(0.05)	Adult longevity	Fecundity	Hatching percentage	Sterility percentage
Plant parts	0.60	NS	0.64	0.42
Solvents	NS	NS	0.64	NS

Figures in the parentheses are transformed values - $\sin^{-1} \sqrt{P} / \sqrt{x+1}$

(8.40days), water (8.50days) and ethanol and petroleum ether (8.6 days). The variation among the treatments was statistically insignificant.

The fecundities did not vary significantly. There was no significant reduction in egg laying. All the treatments caused low suppression of fecundity when compared to control. The average number of eggs laid per female varied from 21.30 to 24.00.

Benzene extract of leaf reduced hatching of eggs (91.50 per cent) and it was significantly different from other treatments. This was followed by benzene extract of flower and leaf, the percentage of hatching were 92.60and 92.90respectively. Both were on par and significantly different from acetone extracts of flower (93.90per cent). The hatchability values ranged from 95.10to 100.00per cent.

Flower extract caused the least hatching percentage of 76.70 and it was followed by leaf extract (77.20). Both were on par. Root and stem extracts were on par, and inferior to the flower and leaf but was superior to control.

Least hatching percentage was observed in benzene extract (77.50) and it was significantly superior to all other solvents. It was followed by water (79.90 per cent). Water extract was on par with acetone (81.00per cent), petroleum ether (81.10per cent) and ethanol (81.30per cent).

Table 11. Sterilant action of extracts of shade-dried plant parts of Clerodendron infortunatum on Henosepilachna vigintioctopunctata, when fed on bittergourd leaves dipped in 4% emulsion

Observations	Plant parts used	Solvents used					
		Water	Acetone	Benzene	Ethanol	Petroleum ether	Mean
Adult longevity	Flower	8.00	8.00	7.67	7.67	8.33	7.93
	Leaf	8.00	7.67	8.00	8.00	8.33	8.00
	Root	8.33	8.00	8.33	8.67	8.67	8.67
	Stem	8.67	8.67	8.67	8.67	8.67	8.67
	Control	11.00	11.00	11.00	11.00	11.00	11.00
	Mean	8.80	8.67	8.70	8.80	9.00	
Fecundity	Flower	23.00	23.30	24.00	22.60	23.60	23.30
	Leaf	23.00	23.00	23.60	22.30	23.60	23.10
	Root	23.30	23.60	24.00	22.60	23.30	23.26
	Stem	23.60	22.00	24.30	22.60	23.60	23.22
	Control	24.00	22.00	23.60	23.00	24.00	23.52
	Mean	23.38	22.78	24.10	22.60	23.67	
Hatching Percentage	Flower	95.60 (77.86)	96.70 (79.50)	95.80 (78.10)	95.50 (77.70)	95.70 (78.00)	95.86 (78.23)
	Leaf	96.90 (79.80)	96.60 (79.30)	94.40 (76.2)	95.30 (77.40)	94.40 (76.26)	95.52 (77.79)
	Root	96.90 (79.80)	95.30 (77.40)	95.80 (78.1)	97.30 (80.5)	98.70 (83.40)	96.80 (79.84)
	Stem	97.40 (80.69)	96.80 (79.60)	97.10 (83.18)	98.60 (80.16)	98.70 (83.43)	97.72 (81.41)
	Control	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)
	Mean	97.36 (81.60)	97.08 (81.20)	96.62 (81.10)	97.30 (81.10)	97.5 (82.20)	
Sterility percentage	Flower	7.10 (2.84)	6.30 (2.70)	6.50 (2.73)	6.10 (2.66)	5.80 (2.60)	6.36 (2.70)
	Leaf	8.30 (3.04)	7.70 (2.94)	9.40 (3.22)	7.40 (2.89)	7.10 (2.84)	7.98 (2.99)
	Root	5.90 (2.62)	6.40 (2.72)	6.50 (2.73)	4.30 (2.30)	4.10 (2.26)	5.44 (2.53)
	Stem	4.20 (2.28)	3.20 (2.04)	4.10 (2.25)	3.10 (2.02)	3.00 (2.00)	3.52 (2.10)
	Control	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
	Mean	5.10 (2.35)	4.72 (2.28)	5.30 (2.39)	4.18 (2.17)	4.00 (2.14)	

CD(0.05)	Adult longevity	Fecundity	Hatching percentage	Sterility percentage
Plant parts	0.60	NS	0.64	0.42
Solvents	NS	NS	0.64	NS

Figures in the parentheses are transformed values - $\sin^{-1}\sqrt{P}$ / $\sqrt{x+1}$

Considering the fecundity and hatchability of eggs laid, the sterility percentages of adults were assessed. The highest percentage of sterility was observed in benzene extract of flower (12.30) and the other treatments came in the following descending order : water extract of flower, benzene extract of leaf, acetone extract of leaf, ether extract of flower, water extract of leaf, acetone extract of flower, ethanol extract of flower and leaf and benzene extract of root with sterility percentage of 11.70, 11.10, 10.00, 9.00, 8.70, 8.30, 8.30, 8.27 and 8.20 The above treatments were on par. The sterility percentage in the remaining extracts were in the range of 4.20to 7.10only.

Flower extract was found to be effective in causing sterility percentage (10.26) and it was followed by leaf (8.75) and root extracts (7.34). All were on par with each other and significantly superior to stem extract (5.50per cent). There was no significant difference among the solvents used.

4.8.2 Effect of extracts of shade-dried plant parts of clerodendron on reproduction on H. vigintioctopunctata

Data relating to the experiment and the results of the statistical analysis of the same are presented in Table 11. The average survival period in different treatments ranged from 7.67 to 8.67 days. The treatments were on par and significantly superior to control. Among the plant parts, flower (7.93 days)

and leaf (8.00days) had significantly higher effects compared to root (8.67 days) and stem extracts (8.67 days).

The fecundity of H. vigintioctopunctata in different treatments did not vary significantly. The number of eggs laid per female varied between 22.60to 24.00only.

Benzene and ethanol extracts of leaf gave 94.40per cent of eggs hatch. The remaining extracts caused more than 95.00 per cent of hatching.

The lowest hatching percentage was observed in leaf (95.52) and flower extract (95.86) and both were on par. It was followed by root extract (96.80 per cent) and it was significantly higher than stem extract (97.72 per cent).

The lowest percentage of hatching was observed in benzene (81.10) and ethanol (81.10) followed by acetone (81.20) and water (81.60). All were on par with each other and significantly less than the hatching percentage in petroleum ether treatment.

Benzene extract of flower exhibited maximum percentage of sterility (9.40) and it was followed by water extract of leaf (8.30). Acetone extract of leaf, ethanol extract of leaf, water extract of flower and ether extract of leaf caused 7.70, 7.40, 7.10 and 7.10per cent of sterility respectively. The above treatments were on par and significantly different from the remaining

Table 12. Sterilant action of extracts of sun-dried plant parts of Clerodendron infortunatum on Henosepilachna vigintioctopunctata, when fed on bittergourd leaves dipped in 4% emulsion

Observations	Plant parts used	Solvents used					
		Water	Acetone	Benzene	Ethanol	Petroleum ether	Mean
Adult longevity	Flower	8.33	8.00	8.00	8.00	8.33	8.10
	Leaf	8.33	8.00	8.33	8.33	8.33	8.33
	Root	8.33	8.33	8.67	8.67	8.67	8.50
	Stem	8.67	8.67	8.67	9.00	8.67	8.70
	Control	11.00	11.00	11.00	11.00	11.00	11.00
	Mean	8.93	8.80	8.93	9.00	9.00	
Fecundity	Flower	23.30	23.60	23.00	23.30	24.00	23.40
	Leaf	23.00	23.30	23.30	23.30	24.00	23.30
	Root	23.60	23.60	23.60	23.60	24.30	23.70
	Stem	23.30	23.60	23.60	23.60	24.30	23.60
	Control	24.00	24.30	24.00	24.00	24.60	24.10
	Mean	23.40	23.60	23.80	23.60	24.20	
Hatching percentage	Flower	96.70 (79.80)	95.50 (77.70)	98.70 (83.40)	96.90 (79.80)	97.00 (80.00)	96.96 (80.14)
	Leaf	95.60 (77.86)	95.30 (77.40)	95.70 (78.00)	95.70 (78.00)	95.80 (78.10)	95.62 (77.90)
	Root	95.70 (78.00)	98.60 (83.18)	97.40 (80.69)	97.40 (80.69)	97.10 (80.16)	97.24 (80.50)
	Stem	98.70 (83.40)	100.00 (89.96)	97.40 (80.69)	98.70 (83.43)	98.70 (83.43)	98.70 (84.10)
	Control	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)
	Mean	97.34 (81.80)	97.88 (83.64)	97.84 (82.50)	97.74 (82.30)	97.72 (82.30)	
Sterility percentage	Flower	5.90 (2.62)	6.10 (2.66)	5.30 (2.50)	5.90 (2.62)	5.30 (2.50)	5.70 (2.54)
	Leaf	7.10 (2.84)	7.40 (2.89)	7.00 (2.82)	7.00 (2.82)	6.50 (2.73)	7.00 (2.82)
	Root	5.80 (2.60)	3.10 (2.02)	5.40 (2.53)	4.20 (2.28)	4.10 (2.25)	4.52 (2.34)
	Stem	4.10 (2.26)	1.70 (1.64)	2.90 (1.97)	3.00 (2.00)	2.50 (1.87)	2.84 (1.95)
	Control	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
	Mean	4.58 (2.26)	3.66 (2.29)	4.12 (2.41)	4.02 (2.14)	3.68 (2.03)	

CD(0.05)	Adult longevity	Fecundity	Hatching percentage	Sterility percentage
Plant parts	0.60	NS	0.64	0.42
Solvents	NS	NS	0.64	NS

Figures in the parentheses are transformed values - $\sin^{-1}\sqrt{P}$ / $\sqrt{x+1}$

extracts. The sterility percentages in the remaining treatments ranged from 3.00to 6.50.

The highest sterility percentage was observed in leaf extract (7.98) and it was on par with flower extract (6.36) and these were significantly less than that of root extract (5.44). The lowest activity was observed in stem extract (3.52 per cent).

Among the solvents tested, benzene (2.39 per cent) had the highest activity and it was follwed by water (2.35 per cent), acetone (2.28 per cent), ethanol (2.17 per cent) and ether (2.14 per cent). The variation between solvents were statistically insignificant.

4.8.3 Sterilant effect of extracts of sun-dried plant parts of clerodendron on H. vigintioctopunctata

The results of the experiment on the sterilant effect of sun-dried clerodendron plant parts and the statistical analysis of the data are presented in Table 12. The average survival period of adults ranged from 8.30to 9.00days. All the treatments were on par and significantly less than that of control. Among the plant parts used, flower (8.10days) was most effective and it was followed by leaf (8.30days), root (8.50days) and stem extracts (8.70days). The above treatments were on par and significantly different from control (11.00 days). The variation between solvents were statistically insignificant.

Fecundity of treated females did not vary significantly. The fecundity varied from 23.00to 24.00eggs per female only.

The lowest percentage of hatching was observed in acetone extract of leaf (95.30). The hatching percentage of the remaining plant parts ranged from 95.50to 100.00. Leaf extract was found to be significantly superior to other plant parts (77.90 per cent). It was followed by flower extract (80.14 per cent) and it was on par with root extract (80.50 per cent). The hatching percentage of stem extract was 84.00 and it was significantly higher than the above treatments. The highest percentage of hatching was observed in control (89.96).

The lowest hatching percentage was observed in water (81.80) and it was followed by ethanol (82.30), petroleum ether (82.30) and benzene extracts (82.50). These treatments were on par with each other and significantly better than acetone extract (83.60per cent).

The highest percentage of sterility was observed in acetone extract of leaf (7.40). It was followed by water, benzene and ethanol extracts of leaf, the sterility percentages were 7.10, 7.00 and 7.00respectively. The remaining extracts caused less than 7.00per cent of sterility.

Table 13. Reduction in sterility percentage caused by different parts of Clerodendron infortunatum plants, dried in sun and undere shade, over the percentage caused by extracts of fresh plant parts.

Treatments	Water	Acetone	Benzene	Ethanol	Petroleum ether	Mean
Shade-dried flower	39.3	37.0	47.1	26.5	35.5	37.0
Shade-dried leaf	4.5	7.2	15.3	9.7	4.0	8.1
Shade-dried root	20.2	9.8	20.7	38.5	41.4	26.1
Shade dried stem	3.1	2.3	4.2	2.6	5.0	3.4
Mean	16.8	14.1	21.8	19.3	21.5	
Sun dried flower	49.5	39.0	43.3	28.9	41.1	40.4
Sun dried leaf	18.3	10.8	26.1	14.6	12.1	16.4
Sun dried root	21.6	56.3	34.1	40.0	41.4	38.6
Sun dried stem	3.2	5.9	5.9	2.8	5.7	4.7
Mean	23.2	28.0	27.4	21.6	25.1	

Leaf extract caused highest percentage of sterility (7.00) and it was followed by flower extract (5.70). Both were on par with each other. The flower extract was on par with root extract (4.50 per cent) but significantly different from stem extract (2.80per cent). All the plant parts were significantly superior to control. The variation among the solvents were statistically insignificant.

4.9 Effect of drying in different parts of *C. infortunatum* plants, under shade and in sun, on the sterilant action on *H. vigintioctopunctata*

The reduction in sterility percentage compared to the value in fresh plant parts are furnished in Table 13. The means of the treatment showed that the least reduction in the sterility percentage was in the stem (3.4) and it was followed by leaf (8.1), root (26.1) and flower (37.0). The loss in activity when dried directly in sun was significantly higher than when dried under shade. The mean reductions ranged from 3.4 to 37.0 per cent in the former, while in the latter the range was 4.7 to 40.4 per cent. The relative ranking of the different plant parts was the same for shade-drying and drying in sun.

The sterilant activity of the plant parts dried under shade suffered less loss with acetone (14.1 per cent) and it was followed by water (16.8 per cent), ethanol (19.3 per cent), ether

(21.5 per cent) and benzene (21.8 per cent). In the case of sun-dried materials the loss in activity among the different solvents ranged from 21.6 to 28.0 per cent.

4.10 Screening of plant parts of C. infortunatum for ovicidal action

Extracts of plant parts viz., flower, leaf, root and stem of clerodendron were tested on the eggs of H. vigintioctopunctata for ovicidal action. Data relating to the experiment and the results of statistical analysis of the same are presented in Table 14.

4.10.1 Fresh plant parts

The lowest percentage of hatching was observed in leaf extract (75.5) and it was followed by flower extract (76.3). Both were on par and significantly less than root (81.8 per cent) and stem (83.4 per cent) extracts. Root and stem extracts were inferior to the above treatments but was superior to the control (96.3 per cent).

Benzene (75.4 per cent) was found to be significantly superior to other solvents. It was followed by acetone extract (81.1 per cent), water (84.9 per cent), ethanol (85.0 per cent) and petroleum ether (86.2 per cent) extracts and were on par.

Table 14. Effect of extracts of different plantparts of Clerodendron infortunatum on hatching percentage of the eggs of Henosepilachna vigintopunctata

Treatments	Percentage of eggs hatched					
	Solvents Used					
	Water	Acetone	Benzene	Ethanol	Petroleum ether	Mean
Fresh Flower	82.0(64.80)	71.0(57.41)	66.5(54.61)	80.4(63.69)	81.5(64.49)	76.3(60.85)
Fresh Leaf	76.5(60.97)	73.2(58.79)	71.2(57.79)	79.2(62.84)	80.8(63.98)	75.5(60.35)
Fresh Root	85.0(67.19)	82.6(65.32)	73.3(58.20)	83.3(65.85)	85.5(67.50)	81.8(64.70)
Fresh Stem	84.7(66.90)	85.4(67.50)	75.2(60.10)	85.3(67.30)	86.2(68.10)	83.4(65.91)
Control	96.4(79.00)	96.0(78.49)	94.9(76.90)	97.2(80.22)	96.9(79.83)	96.3(78.87)
Mean	84.9(67.14)	81.1(64.20)	75.4(60.25)	85.1(67.26)	86.2(68.17)	
Shade dried Flower	83.4(65.90)	82.0(64.80)	73.4(58.90)	84.9(67.01)	84.5(66.70)	80.9(64.08)
Shade dried Leaf	80.0(63.40)	76.7(61.13)	71.3(57.50)	84.0(66.39)	82.0(64.38)	79.7(63.25)
Shade dried Root	86.6(68.49)	85.4(67.50)	82.0(64.80)	86.8(68.80)	86.8(68.66)	85.6(67.65)
Shade dried Stem	85.7(67.75)	86.6(68.50)	85.1(67.20)	89.6(71.10)	87.1(68.92)	86.8(68.69)
Control	97.7(81.20)	96.7(79.50)	95.4(77.50)	96.7(79.50)	97.7(81.20)	96.9(79.84)
Mean	86.7(68.59)	86.3(68.25)	81.4(64.48)	88.4(70.08)	87.4(69.27)	
Sun dried Flower	87.4(66.90)	85.4(67.50)	83.5(66.00)	85.1(67.26)	89.9(71.44)	85.7(67.82)
Sun dried Leaf	81.5(64.49)	80.3(63.72)	75.7(60.40)	85.7(67.75)	87.5(69.26)	82.3(65.12)
Sun dried Root	87.5(69.18)	86.6(68.50)	84.6(66.86)	87.3(69.09)	89.1(70.69)	81.0(68.86)
Sun dried Stem	88.6(70.20)	85.8(67.80)	86.3(68.20)	89.5(71.06)	90.3(71.80)	88.1(69.81)
Control	96.2(78.72)	95.8(78.10)	96.4(79.00)	96.6(79.30)	96.9(79.81)	96.6(79.36)
Mean	87.7(69.45)	86.7(68.67)	85.3(67.45)	88.8(70.48)	90.7(72.24)	

CD(0.05) Plant part : 1.25
Solvent : 1.25

Figures in the parentheses are transformed values - $\sin^{-1}\sqrt{P}$.

4.10.2 Shade-dried plant parts

Leaf extract was found to be more effective than other plant parts (79.7 per cent). It was followed by flower (80.9 per cent), root (85.6 per cent) and stem extract (86.8 per cent) which were on par and significantly higher than that of control (96.9 per cent).

Among the solvents, benzene (81.4 per cent) was found to be significantly superior to all other solvents, followed by acetone (86.3 per cent) and water (86.7 per cent) and both were on par. Highest hatching percentage among the extracts occurred in ethanol (88.4) and petroleum ether (87.4).

4.10.3 Sun-dried plant parts

Leaf extract was found to be significantly superior to other plant parts (82.3 per cent). It was followed by flower (85.7 per cent). Highest percentage of hatching was observed in root (86.0) and stem extracts (88.1), which were significantly superior to control (96.6).

Benzene was found to be significantly superior to all other solvents (85.3 per cent). It was followed by acetone (86.7 per cent) which was on par with water (87.7 per cent). The hatching percentage in ethanol extract was 88.8. The highest percentage of hatching was observed in petroleum ether (90.7).

Table 15. Reduction in sterlant effect as shown by the increase in percentage of hatching caused by extracts of different plant parts of Clerodendron infortunatum plants, dried in sun and under shade, over the percentage caused by extracts of fresh plant parts.

Treatments	Solvents Used					
	Water	Acetone	Benzene	Ethanol	Petroleum ether	Mean
Shade-dried flower	1.4	11.0	6.9	4.5	3.0	5.4
Shade-dried leaf	3.5	3.5	2.1	4.8	1.2	3.0
Shade-dried root	1.6	2.8	8.7	3.5	1.3	3.6
Shade-dried stem	1.0	1.2	9.9	4.3	0.9	3.5
Mean	1.9	4.6	6.9	4.3	1.6	
Sun dried flower	5.4	14.4	17.0	4.7	8.4	9.9
Sun dried leaf	5.0	7.1	4.3	6.5	6.7	5.9
Sun dried root	2.5	4.0	11.3	4.6	3.6	5.2
Sun dried stem	3.9	0.4	11.1	4.2	4.1	4.7
Mean	4.2	6.5	10.9	5.0	5.7	

4.10.4 Effect of drying in different parts of C. infortunatum plants, under shade and in sun, on the ovicidal action

The comparative values of the hatching percentage of sun and shade dried plant parts with that of fresh plant parts are presented in Table 15. The means of the treatment showed that the hatching percentage was minimum in leaf (3.0) followed by stem (3.5) and root (3.6). The flower extract showed 5.4 per cent increase. The loss in activity when dried directly in sun was slightly higher than when dried under shade. The mean increase in percentage ranged from 3.5 to 5.4 in the former, while in the latter, the range was 4.7 to 9.9. The hatching percentage of the sun-dried plant parts was in the following ascending order : Stem (4.7), root (5.2), leaf (5.9) and flower (9.9).

The increase in hatching percentage of plant parts dried under shade, was found to be less with ether (1.3) and water (1.8) as solvents, while in the case of ethanol and acetone it was found to be 3.5 and 3.8 respectively. In the case of sun dried materials the increase in hatching percentage using different solvents ranged from 3.3 to 9.0. Water and ethanol extracts showed comparatively less increase in hatching percentage (3.3 and 3.9 respectively). It was followed by ether (4.6 per cent) and acetone (5.1 per cent). The increase in hatching percentage was high in benzene extract (9.0).

Table 16. Contact toxicity of clerodendron extracts (1 ml. of 4 percent emulsion) to the adults of Chrysocharis johnsoni

Treatments	Corrected percentage mortality	
Water extract of leaf	15.0	(3.87)
Water extract of flower	10.0	(3.16)
Acetone extract of leaf	25.0	(5.0)
Acetone extract of flower	30.0	(5.47)
CD		1.2

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

4.11 Effect of clerodendron extracts on the C. johnsoni.

The selected plant extracts viz., water and acetone extracts of leaf and flower were tested against the parasite C. johnsoni.

4.11.1 Contact toxicity of clerodendron extracts

Data relating to the study are presented in Table 16. Insecticidal action observed on C. johnsoni. was very negligible. Water extract of flower caused the least mortality (10.0 per cent). It was followed by water (15.0 per cent) and acetone (25.0 per cent) extracts of leaf and both were on par with each other. Acetone extract of flower caused the maximum mortality (30.0 per cent) and it was significantly different from the above treatments.

4.11.2 Parasitization by C. johnsoni on epilachna grubs, treated with clerodendron extracts

The results obtained on the effect of clerodendron extracts on the parasitization of epilachna grubs and the statistical analysis of the data are given in Table 17. Epilachna grubs exposed to parasites immediately after the treatment showed significantly less parasitization in all the treatments. The highest percentage of parasitization was

Table 17. Parasitization of Epilachna grubs, treated with clerodendron extracts, (1 ml. of 4 percent emulsion) by Chrysocharis johnsoni when exposed at different intervals after treatment.

Treatments	Mean percentage parasitization of grubs			
	Treated and exposed after 12 hr		Treated and exposed after 24 hr	
Water extract of leaf	50.0	(45.00)	88.6	(70.26)
Water extract of flower	57.6	(49.37)	90.0	(71.57)
Water alone	60.0	(50.76)	93.3	(74.99)
Acetone extract of leaf	43.3	(41.10)	80.0	(63.43)
Acetone extract of flower	46.6	(43.05)	85.0	(67.21)
Acetone alone	58.3	(49.77)	86.6	(68.67)
CD (0.05)		1.33		1.57

Figures in the parentheses are transformed values - $Sin^{-1}\sqrt{P}$.

observed in control (60.0) and it was on par with water extract of flower (57.6). The least percentage of parasitization was observed in water extract of leaf (50.0). A similar trend was observed in acetone extract also. The highest percentage of parasitization was observed in control (58.3). It was followed by flower (46.6 per cent) and leaf (43.3 per cent).

Exposure done 24 hours after treatment resulted in higher parasitization. The mean percentage of parasitization in water extract of flower was 90.0 and it was on par with leaf extract (88.6). The maximum percentage of parasitization was observed in control (93.3). Parasitization in acetone extract of flower and leaf were 85.0 and 80.0 per cent respectively.

4.11.3 Effect of clerodendron extracts on parasitized epilachna grubs.

Results of the experiment and the statistical analysis of the data are given in Table 18. The lowest percentage of parasitized grubs (from which parasite emerged) was observed in the water extract of leaf 87.5 and it was followed by flower (89.0). Both were on par and significantly lower than that in control (100 per cent). In the case of acetone extracts, the flower extract permitted 87.5 per cent and leaf extract 86.0 per cent of grubs to release the parasite without any malformations. They were on par and significantly different from control (100 per cent).

Table 18. Development of Chrysocharis johnsoni in Epilachna treated with clerodenron extracts (1 ml. of 4 percent emulsion) after parasitization

Treatments	Mean percentage of grubs from which parasites emerged		Mean number of parasites emerged per grub
Water extract of leaf	87.5	(69.29)	18.50
Water extract of flower	89.0	(70.6)	18.00
Water alone	100.0	(84.26)	18.75
Acetone extract of leaf	86.0	(68.02)	17.75
Acetone extract of flower	87.5	(69.29)	17.75
Acetone alone	100.0	(84.26)	17.75
CD (0.05)		1.51	NS

Figures in the parentheses are transformed values - $\sin^{-1}\sqrt{P}$.
NS Variations not statistically significant.

The lowest number of parasite emergence was observed with acetone extract of flower and leaf, with a mean number of 17.75 and it was followed by water extract of flower (18.00), water extract of leaf (18.50) and water alone (18.75), the variation among the treatments being statistically insignificant.

4.12 Efficacy of the extracts of clerodendron in controlling H. vigintioctopunctata of bittergourd in field

The water extract of leaf, water extract of leaf with teepol, acetone extract of leaf, acetone extract of leaf with teepol, along with carbaryl as check, were tested against H. vigintioctopunctata.

4.12.1 Effect of clerodendron extracts on the population of H. vigintioctopunctata

The data relating to the experiment and the results of the statistical analysis of the same are presented in Table 19.

The pretreatment counts of the grubs in various treatments were statistically insignificant. Two days after treatment the least population was observed in carbaryl treated plot (20.0) and it was followed by acetone extract of leaf with teepol (24.0). Both were on par with water extract of leaf with teepol (24.5). Acetone extract of leaf with mean population of (26.0) was less effective and on par with water extract of leaf. All the treatments were significantly superior to control.

On the fourth day after spraying also, carbaryl had the least population (3.0) and it was followed by acetone extract of leaf with teepol (6.0), the variation among the treatments being insignificant. This was followed by water extract of leaf + teepol (10.0) and acetone extract of leaf (10.0). The mean number of epilachna grubs in water extract of leaf varied significantly from that of the above treatments. A rapid increase in epilachna population was observed in control plots which reached a level of 53.0 per plant.

On the 8th day after spraying, the population in different treatments showed a conspicuous rise. Carbaryl had the least population of 10.5. This was followed by acetone extract of leaf + teepol (22.0). The mean population of grubs in water extract of leaf and teepol (25.0), acetone extract of leaf (26.0) and water extract of leaf (33.0) came on par with each other and significantly less than the population in control (70.0).

4.12.2 Effect of clerodendron extracts on the extent of leaf damage

Counts of leaves damaged prior to and at different intervals after treatment and the results of the statistical analysis of the data are presented in Table 19. The effect of plant extracts were evident two days after treatment. The mean number of leaves damaged in different treatments ranged from 39.0 to 47.0. The least damage was observed on plants treated with

Table 19. Effect of applying 4 per cent leaf and flower extracts of Clerodendron infortunatum on Henosepilachna vigintioctopunctata in field

Treatments	Dose	Pre treatment count	No.of Epilachna grubs observed per plant at diferent intervals after spraying(days)			Pre treatment count	Mean number of leaves damaged observed at different intervals after spraying(days)			Mean yield Kg/plot
			2	4	8		2	4	8	
Acetone extract of leaf	4%	29.00 (5.38)	26.00 (5.29)	10.00 (3.13)	26.00 (5.29)	34.50 (5.87)	39.50 (6.29)	42.50 (6.51)	51.00 (7.14)	5.0
Acetone extract of leaf + teepol	4%	33.50 (5.79)	24.00 (4.89)	6.00 (2.62)	22.00 (4.49)	36.00 (6.00)	39.00 (6.23)	40.00 (6.33)	46.00 (6.77)	6.5
Water extract of leaf	4%	33.30 (5.77)	27.30 (5.13)	16.00 (4.00)	33.00 (5.56)	40.00 (6.33)	46.00 (6.74)	51.00 (7.14)	58.00 (7.60)	5.3
Water extract of leaf + teepol	4%	38.00 (6.16)	24.50 (4.97)	10.00 (3.13)	25.00 (5.10)	35.00 (5.91)	40.00 (6.33)	43.00 (6.55)	49.00 (7.03)	6.0
Carbaryl	0.15%	38.0 (6.16)	20.00 (4.54)	3.00 (1.52)	10.50 (3.24)	36.00 (6.00)	38.00 (6.15)	38.00 (6.16)	43.00 (6.55)	8.0
Control		30.00 (5.47)	33.00 (5.56)	53.00 (7.28)	70.00 (8.65)	34.00 (5.83)	47.00 (6.82)	58.00 (7.60)	69.00 (8.30)	3.0
CD		NS	0.48	1.15	0.65	NS	NS	0.51	1.12	1.51

Figures in parentheses are transformed values - $\sqrt{x}$.
NS Variations not statistically significant.

carbaryl (38.0) and it was followed by acetone extract of leaf (39.0). The mean number of leaves damaged in different treatments were acetone extract of leaf (39.5), water extract of leaf with teepol (40.0), water extract of leaf (46.0) and control (47.0). The variation between treatments was statistically insignificant.

The leaf damage observed on the 4th day after treatment showed highly significant effect. The mean number of leaves damaged was least in carbaryl with 38.0 and the other treatments came in the following ascending order : acetone extract of leaf with teepol, acetone extract of leaf, and water extract of leaf with teepol, with the mean number of 40.0, 42.5 and 43.0 respectively. This was followed by water extract of leaf (51.0) and it was inferior to the other treatments but significantly superior to control (58.0).

Observations made on the 8th day after spraying showed that there was an increase in the number of leaves damaged. However the mean number of leaves in all the treatments were significantly lower than that of control. The mean number of leaves damaged in treatments ranged from 43.0 to 56.0 while the mean leaves damaged in control was 69.0 per plant.

4.12.3 Effect of clerodendron extracts and carbaryl on the yield of bittergourd

The yield obtained from the various plots and the results of statistical analysis are presented in Table 19. The

yield obtained from the plots treated with 0.15 per cent of carbaryl was the highest (8.0 kg) and it was on par with acetone extract of leaf + teepol (6.5 kg). This treatment was followed by water extract of leaf + teepol (6.0 kg), water extract of leaf (5.3 kg) and acetone extract of leaf (5.0 kg). These were on par with each other and significantly superior to control. The yield was the least in control plots (3.0 kg).

4.12.4 Effect of clerodendron extracts on the predators

Count of the predators prior to and at different intervals after treatment and the results of statistical analysis of the data are presented in Table 20. The observation made before spraying did not vary significantly. The population observed two days after spraying ranged from 0.0 to 3.25 while in control the population was 4.25. The predators were absent in carbaryl treated plots.

On the fourth day, there was a rise in population except in carbaryl treated plots. It was on par with water extract of leaf (2.0) and significantly different from other treatments. These treatments were followed by acetone extract of leaf (2.25), water extract of leaf + teepol (3.0) and acetone extract of leaf + teepol (3.5). All these treatments came on par with each other and control also.

Table 20. Occurence of predators in bittergourd sprayed with 4 per cent clerodendron extracts observed at different intervals after spraying.

Treatments	Dose	Pre treatment count	Mean number of predators per plant observed at different intervals after spraying (days)		
			2	4	8
Acetone extract of leaf	4%	2.25 (1.80)	2.00 (1.73)	2.25 (1.89)	2.75 (1.93)
Acetone extract of leaf + teepol	4%	3.50 (2.12)	3.00 (2.00)	3.50 (2.02)	4.00 (2.24)
Water extract of leaf	4%	2.00 (1.73)	2.00 (1.73)	2.00 (1.73)	3.25 (2.29)
Water extract of leaf + teepol	4%	4.00 (2.24)	3.25 (2.06)	3.00 (2.00)	4.00 (2.24)
Carbaryl	0.15%	3.25 (2.06)	0.00 (1.00)	0.00 (1.00)	2.00 (1.73)
Control		4.25 (2.29)	4.25 (2.29)	4.25 (2.15)	4.75 (2.40)
	CD	NS	NS	0.80	NS

Figures in the parentheses are transformed values - $\sqrt{x+1}$
NS Variations not statistically significant.

The data collected on eighth day after spraying, showed further increase in predator population in all the treatments. Highest population of predators was observed in control with a mean number of 4.75 per plant and it was followed by acetone and water extract of leaf with teepol (4.0), water extract of leaf (3.3) and acetone extract of leaf (2.8). The variation among the treatments was statistically insignificant.

DISCUSSION

DISCUSSION

5.1.1 Antifeedant activity of the different parts of C. infortunatum plants to the grubs of H. vigintioctopunctata

When different parts of fresh C. infortunatum plants were extracted with different solvents and bioassayed against third instar grubs of H. vigintioctopunctata in the laboratory, it was seen that the whole plant contained substances with antifeedant activity. But there were significant variations in the bioactivity of different extracts (Para 4.1.1). Based on mean leaf protection of different solvents, leaf and flower portions of the plants were on par and significantly superior to root portion and the latter was followed by stem. When the different extracts of the leaf and flower were separately considered except in benzene extract flower showed slightly higher activity than leaf. Leaf areas protected by leaf and flower extracts were nearly double the areas protected by stem extract while the root extract gave 50 per cent more protection than the stem extract. With reference to larval starvation also, flower and leaves were on par and significantly superior to root and the least active one was the stem extract. For the control of H. vigintioctopunctata though the leaves and flowers possess higher antifeedant activity than the stem and root, the latter also gave around 50 per cent leaf protection at 4 per cent

concentration of the extract and the mean larval starvation in different treatments varied from 56.0 to 79.0 per cent. Hence the whole plant can be used for extracting antifeedants for controlling H. vigintioctopunctata. But it may be preferable to cut and use the aerial portions of the plant leaving the roots for producing fresh shoots for subsequent collections. The cost for collection can thus be reduced and the need for raising fresh plants with repeated sowing/planting can be avoided. C. infortunatum being a wild plant growing in all types of waste and marginal lands, retention of the roots will facilitate binding of soil particle and avoidance of soil erosion in the ecosystem.

Literature on antifeedant activity of products of C. infortunatum is rather meagre. One of the first clerodanes was isolated from C. infortunatum in 1937. More than 500 clerodanes are now known to exist in several species of plants in many plant families. Though antimicrobial, pesticidal and medicinal properties have been attributed to these diterpene compounds, their best known and well established bioactivity is the insect antifeedant activity (Devakumar and Parmar, 1993). Decalin unit of clerodendrin was reported effective against P. brassicae (Geuskens et al., 1983). Clerodendrin A and B and Clerodin obtained from C. infortunatum were found effective against S. litura (Antonius and Saito, 1981). Extracts of C. infortunatum were reported effective against S. litura (Van Beek

and de Groot, 1980; Saradamma, 1989), D. cingulatus and H. vigintioctopunctata (Saradamma, 1989). Antifeedant activity of clerodendrin and crude extract from other species of clerodendron also were found effective against S. litura (Wada and Munakata, 1968; Kato et al., 1972; Hosozawa et al., 1974; Munakata, 1977 and Jha and Roychowdhury, 1987) and D. obliqua (Tripathi and Rizvi, 1985). From a detailed bioassay of the leaf extracts of 20 plant species Saradamma (1989) concluded that C. infortunatum can be ranked above A. indica, the only plant from which commercially viable products, containing azadirachtin, salanin and related compounds, have been formulated for pest control so far. Present studies also reveal that C. infortunatum contained active antifeedant fractions in the leaf, flower and root portions of the plant.

The broad agreement in the relative performance of different solvents as well as plant parts on the basis of leaf protection and larval starvation respectively, revealed that the adverse effect on the larvae due to the treatments was caused by feeding deterrence only. Flowers which were on par with leaves when used as fresh material ranked significantly below when the flower is used after shade drying or sundrying. This indicated the probable presence of some volatile components in flowers, in addition to the antifeedant molecules commonly present in leaf and flower which get lost on drying.

The antifeedant activity of leaf extracts of C. infortunatum against H. vigintioctopunctata using benzene, acetone, petroleum ether and water was reported by Saradamma (1989). The availability of these phytochemicals in different parts of the plant was being studied for the first time. Accumulation of feeding deterrents in different plant parts reported earlier showed wide variability. Leaves and flowers of Eupatorium maculatum were reported effective against Popillia japonica (Metzger and Grant, 1982). The leaf and flower extracts of C. gigantea contained phagostimulants while phagodeterrents of the plant were present in the fruit and root bark (Rao, 1982). It is hence necessary to decide the distribution of the allelochemicals in the plant parts for effective utilisation of any species of plant in plant protection technology.

The second aspect covered in the study was a comparative assessment of five solvents for extracting the antifeedants from different plant parts. Taking leaf protection as the criterion, acetone and benzene extracts were found to be on par and significantly superior to other solvents. Benzene was followed by ethanol, water and petroleum ether. Based on larval starvation acetone was found to be the best extractant and it was followed by water, benzene, ethanol and ether. Acetone has been reported to be an efficient extractant for antifeedants by earlier workers (Ascher, 1980; Sachauer and Schmutterer, 1980; and Sutherdand, 1980). Saradamma (1989) reported benzene as the

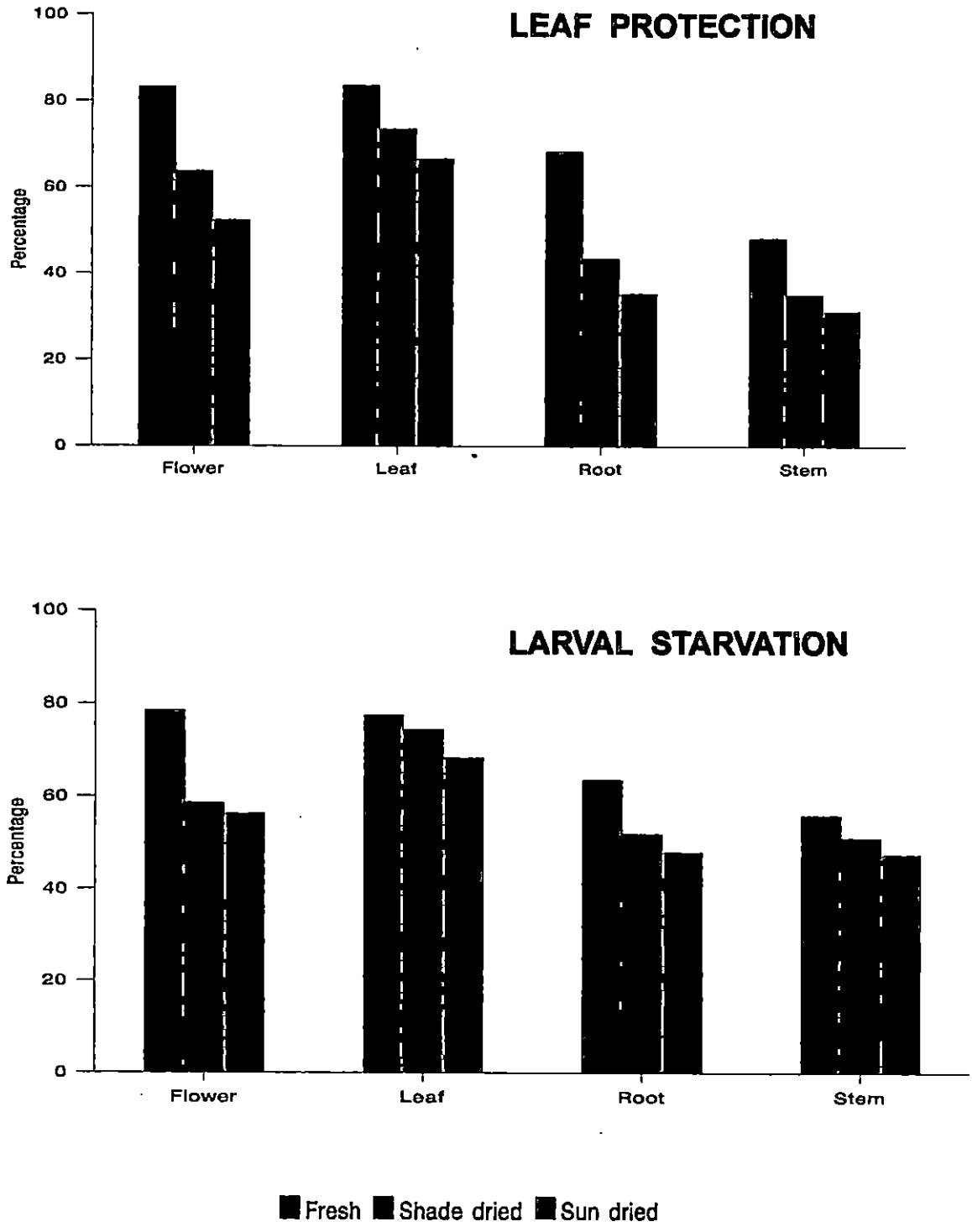
best extractant for the antifeedant component of leaves of C. infortunatum and she ranked acetone, ether and water below the same.

The data in Table 2 showed that though the statistically significant differences in the variations of the mean percentage of leaf protection caused by different extracts justify the ranking of acetone and benzene above water, the difference in the leaf protection between water and the better treatments was around 12 per cent and with reference to larval starvation it was around 5 per cent only. These benefits can probably be achieved by a marginal increase in the dosage of the extractant. While choosing the solvents for preparing crude extract of plants for plant protection, cost factor should be an important criterion and on this score water has an edge over the costly organic solvents and it may be chosen for extracting antifeedants in C. infortunatum for H. vigintioctopunctata control on bittergourd.

5.1.2 Effect of drying on the antifeedant activity of different parts of C. infortunatum plants

The results presented in para (4.4) showed that when shade dried parts of C. infortunatum plants were used as the source of antifeedant, the leaf had the highest bioactivity and it was followed by flower, root and stem. When the leaves and

Fig. 1. Mean percentage of leaf protection and larval starvation caused by different parts of Clerodendron infortunatum plants on Henosepilachna vigintioctopunctata



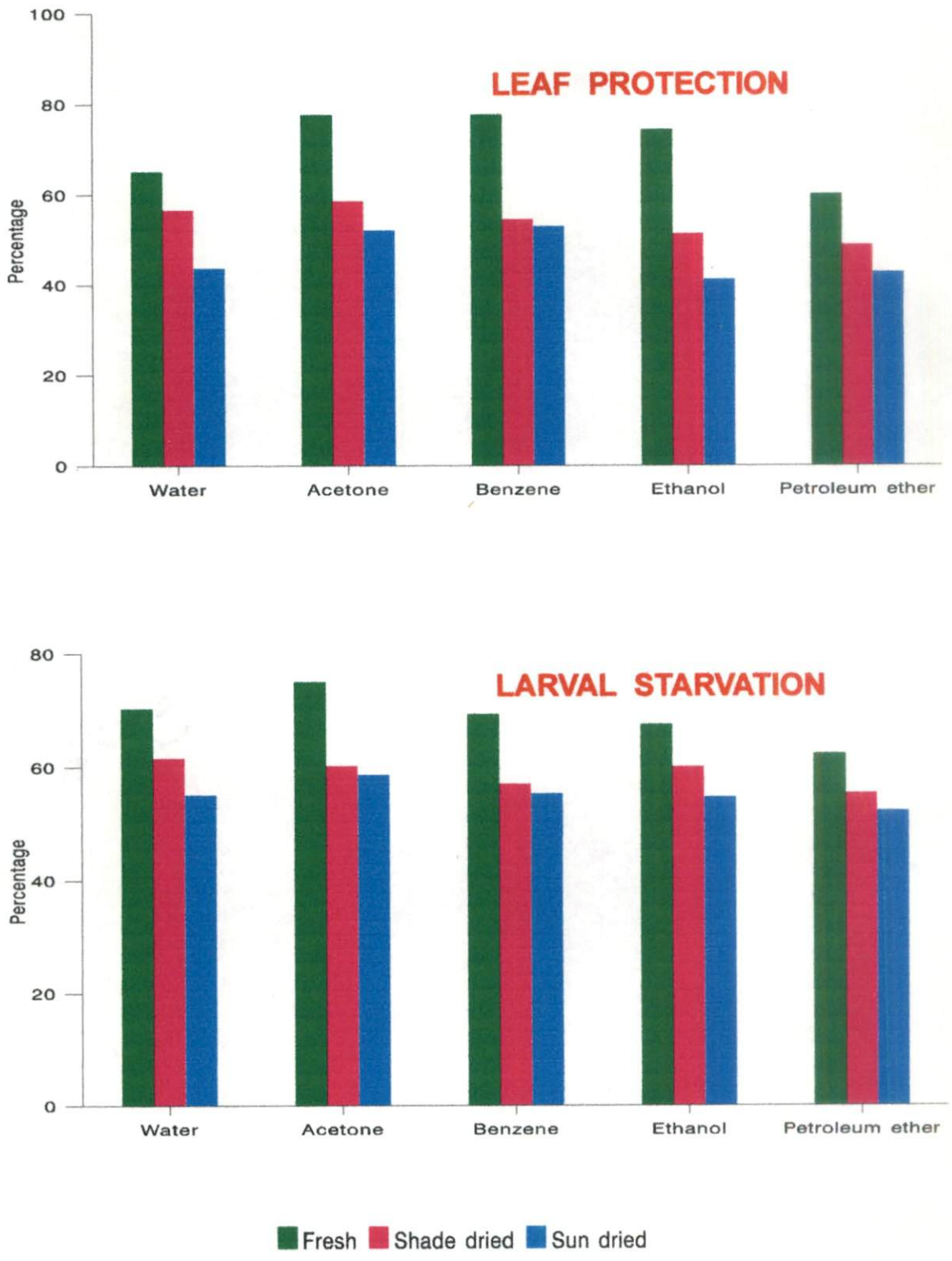
flowers gave the mean leaf protection of 74.0 and 64.0 percentages, the root and stem gave 43.5 and 35.1 per cent protection respetively. Similarly the larval starvation in leaf and flower was 74.0 and 59.0 per cent respectively as against 52.0 and 51.0 per cent starvation with root and stem respectively. As in the case of fresh plant parts, flower and leaf may be chosen as the better parts of the plant for extracting antifeedants while the exclusion of the root and stem is not warranted. Even when dried and used it will be advantageous to cut the aerial portion of the plant as a whole, leaving the root system for continous regeneration. For extracting shade-dried leaves and flowers of C. infortunatum water was seen most effective and for stem, ethanol and water were found to be on par and best. For extracting root, however water was at a low rank. Obviously for extracting dried aerial parts of the plant, water will be the most desirable extractant.

The comparison of the extracts of sun-dried plant parts (para 4.3) also showed that leaf was the best plant part to be chosen and it was followed by flower, root and stem and the data in Table 3 do not justify the elimination of any portions from the materials to be processed for extraction. For sun-dried leaf and stem extractions, water was found to be in the second or third position in the ranking of solvents and though not the best it has to be chosen on the basis of cost benefit ratio.

The effect of shade-drying and sun-drying on the loss of antifeedant activity of the different parts of C. infortunatum plant is represented in Figures 1 and 2. It is quite evident that there was significant loss in the antifeedant activity of all plant parts when dried and this loss is greater for sun-drying than for shade-drying. As shown in para 4.4 among the different parts least reduction in activity under shade - drying compared to those of fresh plant parts, was observed in leaf followed by root, flower and stem. When water, the chosen solvent, was used, the loss in leaf protection for leaf, flower and stem were 8.7, 21.2 and 21.9 per cent respectively. Corresponding loss for sun-drying of the plant parts were 12.5, 52.0 and 43.1 per cent respectively. With reference to larval starvation also, losses due to shade drying were 2.2, 14.7 and 25.4 per cent for leaf, flower and stem respectively and corresponding figures for sun-drying were 13.7, 24.7 and 24.8 per cent respectively. The results highlight the desirability of using fresh materials for extraction and shade - drying in preference to sun - drying for minimising the reduction of antifeedant activity in processed and preserved material.

The effect of drying on the antifeedant activity of plant clerodendron is being studied in detail for the first time. Sudhakar et al. (1978) reported that feeding deterrence of fresh leaves of A. barbadensis to A. proxima was much higher than dry leaf extract. Meisner et al. (1981) observed that the extract of

Fig. 2. Mean percentage of leaf protection and larval starvation caused by Clerodendron infortunatum plant extracts, using different solvents, on Henosepilachna vigintioctopunctata



fresh leaves of C. roseus was more effective than the dried leaves against S. littoralis.

5.2 Insecticidal activity of different extracts of C. infortunatum on third instar grubs of H. vigintioctopunctata

Results in para 4.5 showed that the maximum mortality of the grub was only 13.3 per cent when sprayed with an extract at 4 per cent concentration. When shade-dried and sun-dried parts were used, the mortality got reduced to 6.6 and 3.3 per cent respectively. Saradamma (1989) studied the insecticidal activity of different extracts of C. infortunatum leaves to A. craccivora, D. cingulatus, S. litura and H. vigintioctopunctata and concluded that the toxicity was too low among D. cingulatus and S. litura and the toxicity to A. craccivora was high, the LC 50 was too high and showed that field control of the pest with C. infortunatum extract won't be viable. H. vigintioctopunctata did not show any mortality even in 25 per cent extract used. The present studies also revealed the inefficacy of C. infortunatum extract as contact insecticide against the pest. No other report on the insecticidal activity of C. infortunatum is available in literature.

5.3 Hormonal effect of C. infortunatum on H. vigintioctopunctata

The results in para 4.6.1 reveal the hormonal effect of the extracts of all the fresh parts of C. infortunatum plants on

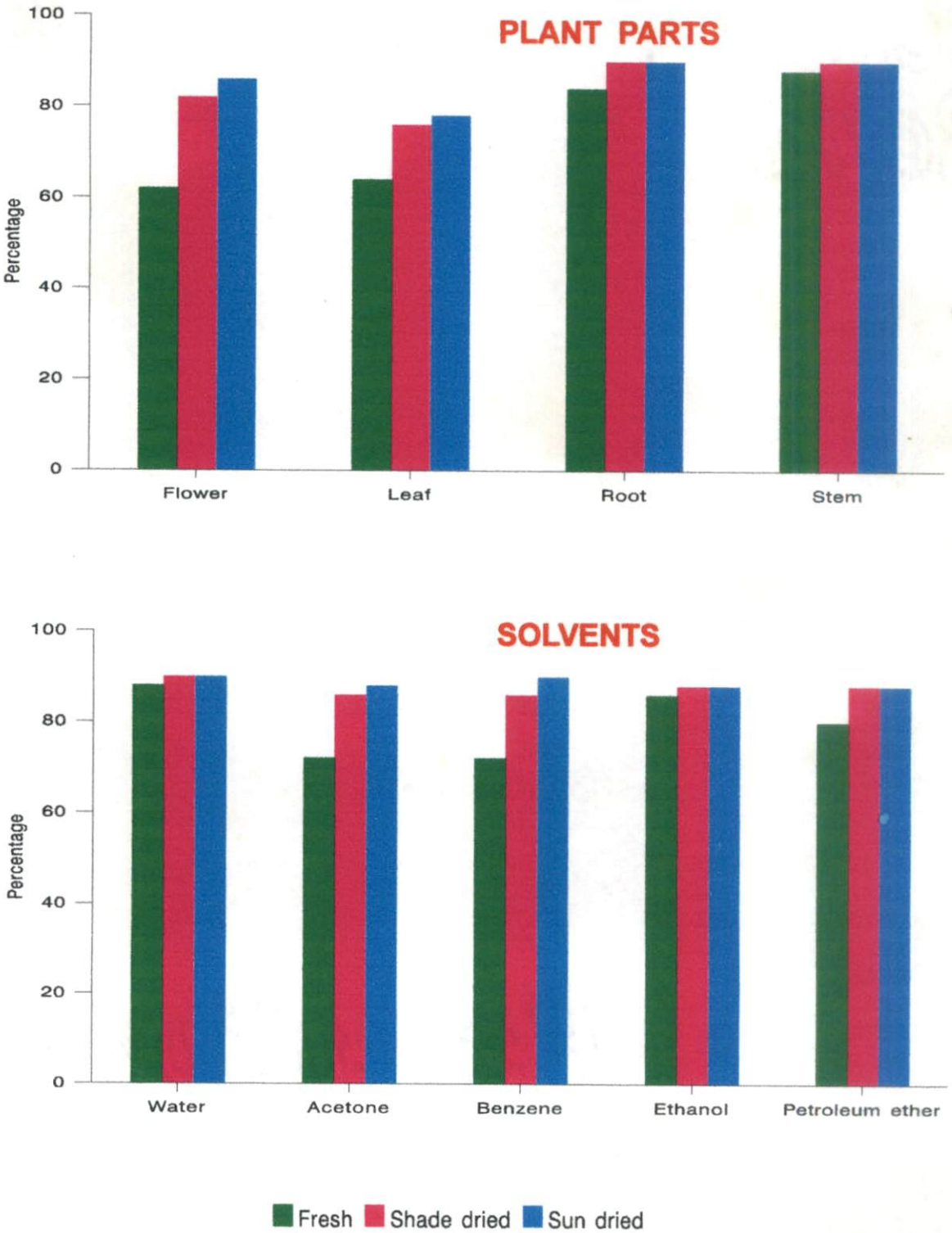
H. vigintioctopunctata. Benzene extract of leaf alone gave 20 per cent mortality of treated grubs while with other solvents, mortality was ten per cent only. This mortality can only be attributed to the low contact toxicity noted with the extracts (para 4.6) since a higher action as to produce larval pupal mosaics were not noted in the treatments. Post treatment duration of the test insect was not significantly influenced by the treatments. The adult longevity and their fecundity also were not seen significantly altered by the extracts. In several treatments pupal mortality was observed. It was largely due to the inability of the insects to emerge from the pupal skin. According to Outram (1973), the major mechanism involved in the use of juvenoids is the disruption of normal mechanism of emergence and the adult deformities noted also can largely be attributed to this factor and not to the normal process of metamorphosis. Mordue and Blackwell (1993) after a comprehensive review of the available information on the mode of action of azadirachtin concludes that the reduction or delay in the ecdysteroid titres of the haemolymph due to the blockage of prothoracicotrophic hormone from the brain corpus cardiacum complex in combination with allatotropic and juvenile hormones cause both growth and moulting aberrations and reproductive defects. The abnormal adult emergence was also noted in treatments with flower and leaf extracts using water as solvent and in all plant parts when extracted with benzene and acetone.

In petroleum ether and ethanol extracts, abnormal adult emergence was lacking in stem and leaf extracts. The data thus indicated the existence of hormonal activity of the extracts interferring with growth and causing mortality of the life stages of H. vigintioctopunctata. Based on the criterion of normal adult emergence, the flowers and leaves ranked higher than root and stem in all the treatments and with reference to the solvents, benzene and acetone came on par and significantly superior to petroleum ether which was followed by ethanol which in turn came on par with water.

When shade-dried materials were used for the extraction, leaves were found significantly superior to all other plant parts and it was followed by flower, root and stem. Among the extracts, water was the least effective and the others were on par and significantly superior to water. The relative performance of different plant parts and solvents was the same when sun - dried materials were used for extraction.

The loss in hormonal activity due to the drying of the plant parts under shade or in the sun is represented in Fig. 3 and the results have been described in para 4.7. The loss in hormonal activity of the extract of different plant parts under shade and in sun, came in the following descending order: stem, root, leaf and flower. Regarding solvents used for extraction, least loss of activity was in water extract and it was followed by ethanol, petroleum ether, benzene and acetone.

Fig. 3. Mean percentage of normal adults emerging from last instar grubs of Henosepilachna vigintioctopunctata treated with different extracts of Clerodendron infortunatum



Saradamma (1989) studied the hormonal effect of C. infortunatum leaf extract on S. litura and found 100 per cent emergence of normal adults in water extract while the emergence in benzene, ether, and acetone extracts were 70.0, 70.0 and 90.6 per cent respectively. In D. cingulatus, adult emergence in the four solvents were 47.72, 5.8, 50.0 and 45.0 per cent respectively. These results showed that though benzene was the best solvent, water, ether and acetone were not too inferior for extraction. In the screening trial, benzene was found to be followed by water in bioactivity and others were concluded to be less effective. In most of the earlier reports relating to the IGR activity of plant extracts, aromatic solvents and alcohol were seen used. Low ranking of water observed in the hormonal effect of C. infortunatum can be compensated with increased dosage of the extract for field application. The use of water in extracting these components from plant tissue will make the processing of plant materials easier and more economic at farm level.

5.4 Sterilant action of different extracts of different parts of C. infortunatum plants on H. vigintioctopunctata

Results presented in para 4.7 showed that the adult longevity of treated insects was significantly lower in flower and leaf extracts than root and stem extracts. It was so with shade dried and sun-dried materials. Fecundity was not varying

significantly under all the three conditions. Hatching percentage showed significant variation. But the variability among treatments was within a range of 4.0 per cent and the total suppression was less than 10.0 per cent in all the treatments compared to control. Sterility percentages also ranged between 3 and 10 only and hence not of high significance in reducing the populations.

Saradamma (1989) found that acetone, benzene, ether and water extracts of C. infortunatum caused 75.0, 14.59, 60.0 and 47.0 per cent sterility on S. litura and corresponding figures for D. cingulatus were 100.0, 100.0, 76.47 and 100.0 respectively. Low levels of sterility obtained in the present study may be due to the low dosages of the extracts used and also the species variation in response of different species of insects. Even at the low level, relative superiority of the leaf and flowers as source of the sterility factors was indicated.

Loss of chemosterilant action due to the drying of materials under shade and in sun was evident in the results. Least loss of sterilant activity was in stem extract and it was followed by leaf, root and flower in the ascending order when dried under shade or sun. Regarding solvents, least loss was in acetone followed by water under shade and in sun respectively, while other treatments were inferior.

El Ghar and El Sheikh (1987) reported reduction in fecundity of adult pulse beetles emerging from pulses treated with C. infortunatum. Reduced fecundity caused by juvenoids and plant extracts other than C. infortunatum have been extensively reported on various insect species (Outram, 1973; Prabhu, et al., 1973; Kumuda Sukumar and Osmani, 1981; Jacobson et al., 1978, Fagoonee, 1980; and Velusamy et al., 1987). The results obtained with C. infortunatum extracts was in agreement with the observations of Slama (1974) that the sterility caused by juvenoids was not by the reduction in fecundity but because the eggs laid had a significantly low hatchability. The suppression of hatchability and the sterility percentage were much lower than those recorded for D. cingulatus and S. litura by Saradamma (1989). The variation can be attributed to the low dose at which the treatmens were made in the present studies or due to the difference in the sensibility to the sterilant effect of different species of test insects involved.

5.5 Mortality caused by different plant extracts of C. infortunatum on the eggs of H. vigintioctopunctata.

Results presented in para 4.10 showed that different treatments reduced the hatching percentage of treated eggs significantly compared to control. The hatching percentages were between 75.5 to 96.3 per cent with fresh materials and the corresponding range for shade dried and sun dried materials were

79.7 to 96.9 and 82.3 to 96.6 respectively. Assessment of the direct ovicidal effects of clerodendron extracts was done by Saradamma (1989) and she found the loss in hatching was 1.7 times more than that of A. indica extract. Comparative activity in the plant parts also remained in the general pattern, ... leaf and flower topping in rank followed by root and stem. Regarding the solvents ,benzene and acetone were better and they were closely followed by water when used as fresh or dried materials. The reductions in ovicidal activity, due to drying, was in general below 10.0 per cent and hence not very significant.

5.6 Effect of water and acetone extracts of C.infortunatum leaf and flower to C. johnsoni a parasite of H. vigintioctopunctata

Data presented in para 4.11.1 showed that water extract of flower and leaf were on par and significantly safer than acetone extract of leaf and flower which were again on par. When grubs were exposed for parasitization after treatment with extracts, water extract of flower was the safest and it was followed by water extract of leaf and acetone extract of flower and leaf. Compared to control, percentage parasitization was less by 10.0 and 5.0 per cent when exposed 12 and 24 h after treatment and corresponding figures for acetone extracts were 15.0 and 6.0 per cent respectively. These were rather low since under

field situations, it will be far below these levels. When parasitized grubs were sprayed, the grubs from which parasites emerged fell by 12.0 to 15.0 per cent compared to control but the treatments did not vary significantly. The number of parasites emerging from each host did not show significant variation among treatments including control. The above data revealed the safety of C. infortunatum extracts to the parasitie C. johnsoni. which is the most dominant parasite of H. vigintioctopunctata in Kerala.

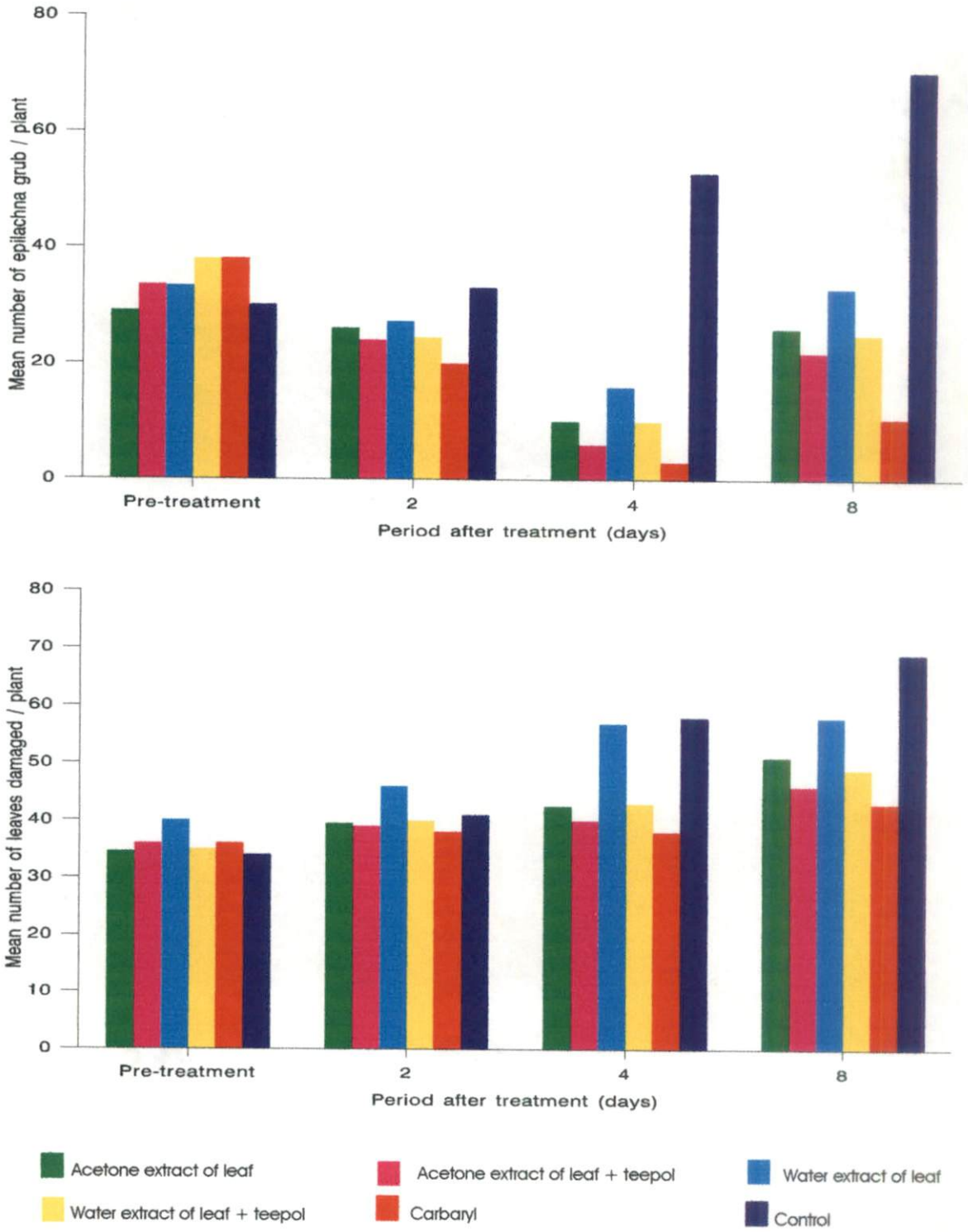
Botanicals, though not fully safe to natural enemies, are much safer than synthetic organic chemicals. The safety of neem and neem products to parasites and predators of major crop pests has been reported extensively (Saxena et al., 1980; 1983, Joshi et al. 1982; Wu, 1986; Mansour et al., 1987; TNAU, 1992; Patel and Yadav, 1993; Osman and Bradly, 1993 and Bandara and Kudagamage, 1993). Extracts of Eucalyptus sp; Catharanthus sp; Tagetes erecta and A. calamus were also reported safe against major parasites and predators of different crop pests (Tewari and Krishnamoorthy, 1985; Shanthi and Janarthanan, 1991; Mahimashanthi and Mohanasundaram, 1992 and Srinivasababu et al., 1993).

5.7 Field evaluation of water and acetone extracts of C. infortunatum leaf, with and without teepol, for the control of H. vigintioctopunctata

An overall assessment of various experiments showed that the leaf extract had the highest antifeedant activity. Among the different solvents tried, acetone was consistently maintaining a higher rank while water came close to it with reference to leaf protection and larval starvation. Though water ranked low as a solvent of C. infortunatum for causing disruption of growth and moulting processes of H. vigintioctopunctata, on cost criteria, it has to be preferred over other solvents. Hence acetone and water were used as solvents in the field experiment. Field persistence of botanical pesticides is known to be low and an attempt was made to evaluate the improvement in efficacy when teepol was used as an additive in some treatments.

Results of the experiment are presented in para 4.12.1 and 4.12.2 and Fig. 4. As is evident, significant reduction in pest population was achieved in all the treatments. The water and acetone mixed with teepol came on par with carbaryl on the second and fourth days after treatment. The population remained lower than that of control on the 8th day also but in C. infortunatum treated plots, it was significantly higher than the population in carbaryl treated plots. With reference to the leaf

Fig. 4. Effect of spraying water and acetone extracts of the leaves of Clerodendron infortunatum on Henosepilachna vigintioctopunctata infesting bittergourd



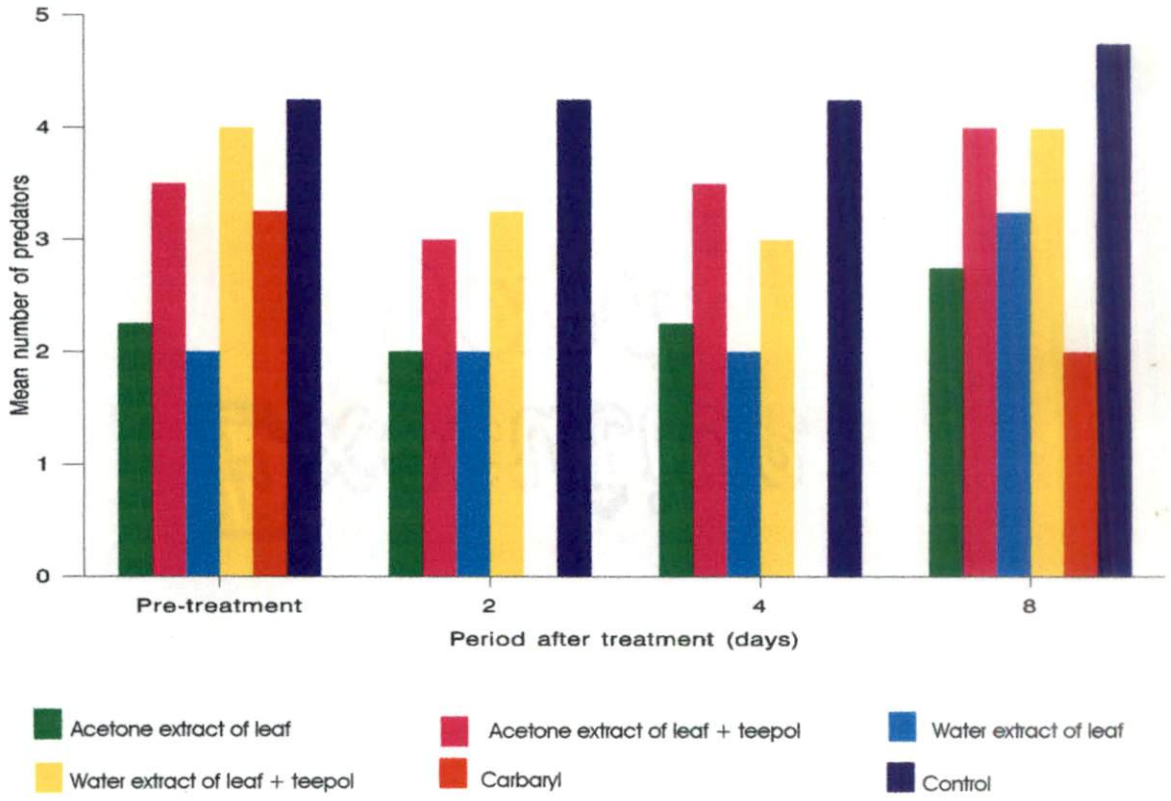
damage also acetone and water extract of leaves mixed with teepol ranked with carbaryl. Based on yield enhancement all the treatments were found to be better than control and the yield in acetone extract of leaf and teepol treated plots came on par with that of carbaryl treated plot and the former came on par with other treatments. Thus the results clearly showed that C. infortunatum leaf extract, using acetone or water as solvent, mixed with teepol controls H. vigintioctopunctata as best as carbaryl 0.15 per cent spray and significantly enhanced the yield of the crop. The results obtained from the field experiments conducted by Saradamma (1989) were in full agreement with the present finding. She also reported effective control of H. vigintioctopunctata population on brinjal and bittergourd for one week after treatment. Srinath (1990) reported that 4 per cent leaf extract of C. infortunatum effectively controlled amaranthus pests, A. crenulata and P. basalis and bhindi pest A. crenulata and A. biguttula biguttala. The extracts increased the yield also significantly over control.

The predator population in treated field was not seen affected significantly at 2 and 8 days after spraying while on 4th day population in treatments were significantly lesser than that of control (Fig. 5). In carbaryl treatment it was totally absent on 2nd and 4th days after spraying and very less on 8th day. The results indicated the safety of C. infortunatum extract to the non-target organisms in the ecosystem.

The results obtained from the present investigations clearly established the prospects of using aqueous extract of C. infortunatum plants (the aerial portions) for controlling H. vigintioctopunctata with less adverse effect on the non-target organisms in the ecosystem. The scope and desirability of botanical pesticides as a component in the integrated pest management strategy envisaged for the 20th century is now well accepted. Very intensive researches have been carried out on the extracts and products of neem in the last two decades and enormous data have been generated on the feeding deterrency, growth disruptive factors, insecticidal activity and bio efficacy on insect pests belonging to different orders and families occuring on various crops, stored products and aquatic arthropods and also on the safety aspects of these products. The results have been exhaustively reviewed in a number of recent publications (Schmutterer et al., 1981; Schmutterer and Ascher, 1984, 1987; Jacobson, 1986, 1988; Schmutterer, 1988; Arnasan et al., 1989; Warthen et al., 1989; Locke and Lawson, 1990; Schmutterer, 1990; Subrahmanyam, 1990; Ahmed, 1993 and Ascher, 1993). Azadirachtin and neem products are now accepted as environmentally sound insecticides for worldwide use in integrated pest management schedules.

In the production and use of botanical pesticides, several constraints have also been identified. The compounds identified are not often amenable for synthesis due to the

Fig. 5. Occurrence of predators on bittergourd at different intervals of spraying with water and acetone extracts of leaves of Clerodendron infortunatum



expensive steps involved. When plants are used as the source of pesticide , avaialbility of raw materials in bulk for the industry, proper machinery for harvesting, standardising the quality of materials from different sources etc. emerge as serious constraints. Obviously a single plant species like neem, a slow growing tree, is not likely to meet the world requirement of pesticides. Other sources of botanical pesticides and their use have to be given stress in plant protection research. Numerous substances with pesticidal properties were identified from plant sources and they have been covered in several reviews (Gilbert et al., 1967; Mansingh et al., 1970; Kim et al., 1976; Kubo et al., 1977; El Naggar et al., 1980, Joshi, 1980; Alfaro et al., 1981) on botanical pesticides now available. The resources of phytochemicals available in nature are very enormous. But most of the studies carried out so far, with reference to plants other than neem, end with reporting of the bioactivity of phytochemicals and their safety in the ecosystem. Against H. vigintioctopunctata also extracts of A. calamus (Tewari and Krishnamoorthy, 1985), A. indica, A. squamosa (Venkataramireddy et al., 1990), A. squamosa, A. mexicana, R. communis (Rao et al., 1990) have been reported as potential feeding inhibitors or growth disruptors. These are yet to be evaluated for their field performance and to be standardised for the field use.

Among the plants identified as source of potent botanical pesticide for integrated pest management, C. infortunatum will have an important place in the future. A serious limitation pointed out for the industrial exploitation of botanicals is the narrow selective action on pest species. C. infortunatum has already shown to be a potential antifeedant/insect growth disruptor against S. litura (Antonious and Saito, 1981; Van Beek and de Groot, 1986 and Saradamma, 1989). P. brassicae (Geuskens, 1983) S. exempta (Cooper et al., 1980) and D. cingulatus (Saradamma, 1989), thus indicating activity in a broad spectrum of pest species. The plant grows as a weed in many neglected farms and in marginal lands and hence is available in plenty for collection. If maintained along the boundaries or in waste lands also, it can be a perennial source for preparing extracts to be used for tackling pest problems faced by farmers. Information available on the human hazards from botanicals (other than neem) is very meagre. Since the root of C. infortunatum plants were being used for medicinal purposes during the past without adverse effects, in quite heavy doses, it can be presumed to be significantly safe to human beings and surely much safer than many of the so called safe synthetic pesticides now in extensive use. Though much more studies are

essential for full exploitation of C. infortunatum as a source of pesticide, particularly for substituting poisonous synthetic organics in the integrated pest management strategies of the twentieth century, aqueous extracts of this plant can be safely recommended for the control of vegetable pests like H. vigintioctopunctata, a technology that can be directly adopted by the farmers at farm level without any infrastructural facilities and at a low cost.

SUMMARY

SUMMARY

C. infortunatum is one of the plants identified recently as potent source of botanical pesticides from Kerala. Different parts of this plant viz., flower, leaf, root and stem were extracted with different solvents (Water, acetone, benzene, ethanol and petroleum ether) and assayed for their antifeedant, insecticidal, growth inhibitory, sterilant and ovicidal action on H. vigintioctopunctata. The ultimate aim was to assess the possibilities of using the promising crude extracts of C. infortunatum in the field for pest control purposes.

The experiments on the antifeedant activities of the extracts led to the following major conclusions:

1. All the plant parts exhibited antifeedant activity on H. vigintioctopunctata but there were significant variations among them. Based on mean leaf protection and larval starvation of different solvents, leaf and flower portions were on par and significantly superior to root and the least effective one was the stem extract.

2. Among the five solvents tried for their antifeedant activity against H. vigintioctopunctata, acetone and benzene gave higher leaf protection. With reference to larval starvation, acetone was the best followed by water, benzene, ethanol and ether.

3. When the shade dried parts of C. infortunatum plants were used as the source of antifeedant, the leaf had the highest bioactivity and it was followed by flower, root and stem.

4. For extracting shade-dried leaves and flowers of C. infortunatum, water was most effective.

5. In the case of sun-dried plant parts also, leaf was the best plant part to be chosen and it was followed by flower, root and stem. Water was found to be the most effective solvent.

6. The least reduction in activity under shade-drying compared to those of fresh plant parts was observed in leaf, followed by root, flower and stem. The losses due to sun-drying was also found to be in the same order.

7. Fresh plant parts were found to be superior to shade and sun - dried plant material for antifeedant activity.

Insecticidal action observed with extracts of different parts of C. infortunatum plant was very low. The maximum mortality observed was just 13.3 per cent with leaf extracts.

Effect of extracts of different plant parts were assayed for their growth inhibitory activity. The important findings were

1. The post treatment mortality observed on third instar grubs was very low.

2. Pupal duration of test insect did not vary significantly in different treatments.

3. In several treatments, pupal mortality was observed. It was largely due to the inability of the insects to emerge from the pupal skin.

4. The abnormal adult emergence was noted in treatments with flower and leaf extracts using water as solvent and with all plant parts extracted using benzene and acetone as solvents.

5. Based on the normal adult emergence, the flowers and leaves rank higher than root and stem and with reference to the solvents, benzene and acetone came on par and significantly superior to petroleum ether.

6. The adult longevity and fecundity were not seen significantly altered by the extracts.

7. When shade-dried materials were used for the extraction, leaf was found significantly suprior to all other plant parts in producing less number of normal adults and it was followed by flower, root and stem.

8. Among the extractants, water was the least effective one and others were on par and significantly superior. A similar trend was observed in sun-dried materials also.

9. Based on the reduction in hormonal activity of the extracts due to shade and sun drying, the plant parts came in the following descending order of ranking: stem, root, leaf and flower.

10. Regarding solvents used for extraction, the least loss of activity was in water extract and it was followed by ethanol, petroleum ether, benzene and acetone.

Different parts of C. infortunatum tested failed to show significant sterilant activity. This may be due to the low dosage of the extracts used.

The hatching percentage of treated eggs was reduced significantly by different treatments when compared to control. Among the different plant parts, leaf and flower ranked high followed by root and stem.

Water and acetone extracts of leaves and flowers were tested against the parasite C. johnsoni. The toxicity of the different extracts to the parasite was negligible. Water extracts were safer than acetone extracts of leaf and flower. The treatments did not affect the extent of parasitization of the grub. The progeny emerging from parasitized treated grubs also did not vary significantly from control, revealing the safety of clerodendron extracts to the parasite C. johnsoni.

In the field experiment, acetone and water extract mixed with teepol came on par with carbaryl in reducing pest population. The effect persisted upto eighth day after screening. With regard to leaf damage and yield also acetone and water extract of leaves mixed with teepol ranked with carbaryl.

The natural enemies population in treated field was not significantly affected by the application of clerodendron extracts while in carbaryl treatment it was totally absent after spraying. The results indicated the safety of clerodendron extracts to the target organisms in the ecosystem.

The study revealed the possibility and safety in using crude aqueous extract of different parts of C. infortunatum plant for the control of H. vigintioctopunctata, a serious pest of solanaceous and cucurbitaceous plants in Kerala.

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EFFECTS OF EXTRACTS OF *Clerodendron infortunatum* ON THE EPILACHNA BEETLE *Henosepilachna vigintioctopunctata* F. WITH RELATION TO SAFETY OF ITS NATURAL ENEMIES

By

LILY, B.

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ABSTRACT

Flower, leaf, root and stem extracts of Clerodendron infortunatum were screened for their antifeedant activity against grubs of Henosepilachna vigintioctopunctata using water, acetone, benzene, ethanol and petroleum ether as extractants.

Based on mean leaf protection and larval starvation of different plant parts, leaf and flower portions were found to be more effective than root and stem. Among the solvents, acetone and benzene gave higher leaf protection. High larval starvation was caused by acetone followed by water, benzene, ethanol and petroleum ether.

Fresh plant parts were found to be more effective than shade and sun-dried material. Shade - and sun - dried leaves and flowers showed high activity in water extract. The least reduction in antifeedant activity under shade and sun drying was observed in leaf.

Different parts of C. infortunatum did not cause significant insecticidal action against H. vigintioctopunctata.

Regarding growth inhibitory activity, flower and leaf were found to be more effective when they were used as fresh materials. Shade - and sun - dried leaves were found

significantly superior to all other plant parts in producing less number of normal adults. When the different parts of C. infortunatum were ranked on the basis of the percentage of normal adult emergence, acetone and benzene topped. The least reduction in hormonal activity of the extracts of different plant parts dried under shade and in sun was observed in the case of stem, followed by root, leaf and flower. Water was found to be the most effective solvent for extracting dried plant parts.

The sterility percentages observed in different treatments were found to be very low. In the bioassay of the C. infortunatum extracts using freshly laid eggs of H. vigintioctopunctata, it was observed that the hatchability of eggs was reduced significantly by different treatments, compared to control.

The mortality observed on the parasite C. johnsoni when treated with water and acetone extracts of leaf and flower was very low. Water extracts were safer than acetone extracts of leaf and flower. The treatments did not affect the extent of parasitization and the progeny emerging from the parasitized treated grubs.

In the field experiment, acetone and water extracts of leaf mixed with teepol reduced the population of H. vigintioctopunctata on bittergourd significantly. These treatments were on par with the insecticide check carbaryl 0.15 per cent. The clerodendron extracts did not affect the predator population in the treated plots, whereas it was totally absent in carbaryl - treated plot.

The results of the present investigation clearly indicate the safety of clerodendron extracts to the non- target organisms and the possibility of utilizing crude extracts of C. infortunatum as a potential pesticide for ecologically and economically sound insect pest management.