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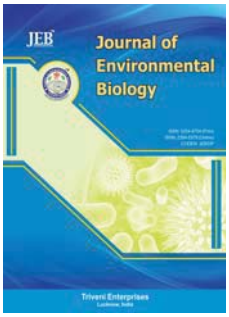

Evaluation of certain non-conventional plant based oils against red spider mite of tea

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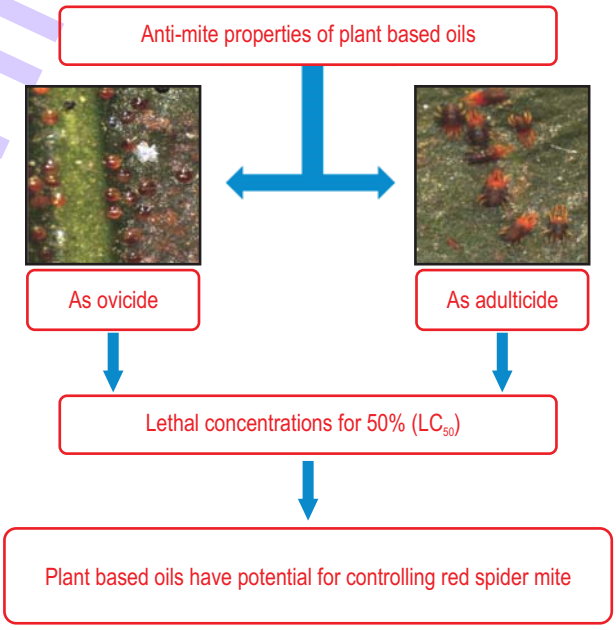
Abstract

Aim : Red spider mite, *Oligonychus coffeae* is considered as one of the most severe and persistent pest of tea. To limit the use of synthetic acaricides against the pest and to promote alternative pest control strategies using natural products, the present study aimed to determine the anti-mite properties of seven plant based oils *viz*., castor oil, sesame oil, rose oil, olive oil, mustard oil, groundnut oil and karanja oil against *O. coffeae*.

Methodology : Red spider mites were collected from a commercial tea garden of Jorhat, Assam, India. Bioassays were performed on adults and eggs of *O. coffeae* with 5 to 7 different concentrations of plant oils. Mortality data was expressed by Abbott's formula and lethal concentration of 50% mortality (LC_{50}) was calculated using Finney probit analysis and expressed in ppm.

Results : Among the plant oils, karanja oil was the most toxic adulticide followed by mustard oil and olive oil. The egg hatchability was significantly affected in all treatments with rose oil being most toxic ovicide among the plant oils followed by karanja oil and olive oil. Further, their bioefficacy was comparable to synthetic insecticide, ethion.

Interpretation : The data suggest that the selected plant oils have potential to control tea red spider mite, and therefore could be effectively utilized in integrated pest management programme envisaged for tea mite.



Introduction

Red spider mite, *Oligonychus coffeae* Nietner (Tetranychidae : Acarina), a worldwide polyphagous acari, is reported to be a severe pest of tea of many tea growing countries. Adults and nymphs of *O. coffeae* lacerate cells on the upper surface of mature tea leaves along the mid rib and veins leading to high defoliation and debilitation of tea bush, resulting in crop loss of 17% to 46% (Roy *et al*., 2014). To manage *O. coffeae*, application of synthetic acaricides has been widely adopted. Extensive use of chemicals against this pest has led to a number of problems like resistance development, environmental contamination, health hazards, increased cost of application *etc*. (Hazarika *et al*., 2009). Additionally, tea being an important export commodity has to be in compliance with the international regulations on pesticide usages (Roy *et al*., 2010).

These problems have necessitated the development of new chemicals with novel modes of action and effective biodegradable properties. There is a rising trend for use of natural pesticides which are derived from plants or micro-organisms, since they are considered safe than synthetic chemicals (Radhakrishnan and Prabhakaran, 2014). Among the natural pesticides, plant-derived oils are reported as potential alternative compounds for pest control. Several plant oils contain lipophilic compounds that have direct contact and fumigant actions (Rajendran and Sriranjini, 2008) and acetyl-cholinesterase (AChE) inhibitory activities (Owokotomo *et al*., 2015) against specific pests (Isman, 2000; Kostyukovsky *et al*., 2002; Mukesh *et al*., 2014). They are also considered to be relatively safe because they have minimal impact on human and animal health and act at multiple and novel target sites, resulting in reduced resistance development (Han *et al*., 2006).

Efficacies of plant based oils have been used to suppress mite pest populations, as well as some insects (Koul *et al*., 2008). However, the effect of plant based oils on *O. coffeae* has not been studied till date. In view of the above, a laboratory study was carried out to examine the effects of seven plant based oils *viz*., castor oil, sesame oil, rose oil, olive oil, mustard oil, groundnut oil and karanja oil against *O. coffeae* in terms of their acaricidal and ovicidal activities.

Materials and Methods

Maintenance of *O. coffeae* : The mites were collected from the tea gardens of Tocklai Tea Research Institute, Jorhat, Assam, India. A culture of red spider mite was maintained in the laboratory following the detached leaf culture method of Helle and Sabelis (1985). From the stock, spider mites were transferred onto fresh tea leaf (6 cm^2) placed on moistened cotton pads in plastic trays (42 × 30 × 6.5 cm). Rearing trays were kept under controlled conditions where temperature was maintained at 25±2°C, 75±5% RH, and 16L: 8D photoperiod. Water was added to the rearing trays as and when necessary to keep the cotton moist. Withered leaves were replaced with new ones at regular interval.

Adulticidal bioefficacy : The assay was carried out by leaf disc method (Ebeling and Pence, 1953). Mature tea leaves of TV1 clone were collected from Tocklai experimental garden and brought to laboratory. The leaves were then washed with distilled water and air dried. Three leaf discs (2 cm diameter) each representing replicates of different treatments were placed over a wet cotton pad placed in a Petri plate (9 cm diameter) with its ventral surface down. Thirty adult mites were released on each disc with a camel hair brush and allowed to settle. A final count of mite population was taken after 4 hrs. Mites were initially exposed to a wide range of concentrations, and on the basis of the resulting mortality, a series of concentrations with narrower ranges were tested further. The second series was determined on the basis of the concentrations causing mite mortality above 20% and below 100%. The different concentrations of aqueous solutions of plant oils (purchased from local market) and control (distilled-water) were sprayed on the leaf using a glass atomizer (constant pressure 2.5 kg cm^{-2}). To all concentrations, 3 to 4 drops of teepol (Teepol- AG®, National Organic Chemical Industries Ltd., Mumbai, India) was added as an emulsifier. Synthetic acaricide, ethion 50 EC (Tafethion®, Rallis India Ltd., Mumbai, India) was used as a standard. The entire procedure was replicated three times. Final assessment was made after 48 hrs of application and expressed as per cent mortality of mites at each dose in relation to control mortality using Abbott's formula (Abbott, 1925). Lethal concentrations for 50% (LC_{50}) were calculated using statistical package for social (SPSS) version 10.0 (SPSS Inc., USA), based on Finney Probit Analysis (Finney, 1973) and expressed in ppm.

Ovicidal bioefficacy : For the assessment of ovicidal properties, leaf discs (20 mm diameter) were placed over water soaked cotton pad. Fifteen gravid female mites were introduced on the leaf discs and kept overnight for oviposition. After 24 hrs, the introduced mites were removed with the help of fine camel hair brush. The eggs laid on leaf discs were counted under microscope for bioassay. Thirty eggs per leaf was selected for treatment and subjected to spraying with different concentrations of plant oils using a glass atomizer (constant pressure 2.5 kg cm^{-2}) and control (water). After drying for 30 min, the discs were placed at 27°±2°C and 65±5% RH and examined daily for 12 successive days. Hatchability was recorded for both experimental and control batches of eggs. Those eggs which did not hatch after this period were regarded as non-viable. Each treatment was replicated three times and ethion was used as a standard to compare the results. Lethal concentrations for 50% (LC_{50}) were calculated using the statistical package for social (SPSS) version 10.0 (SPSS Inc., USA), based on Finney Probit Analysis (Finney, 1973) and expressed in ppm.

Results and Discussion

Botanical insecticide contain compounds that exhibit ovicidal, repellent, antifeedent and toxic effects in insects (Isman,

Table 1 : Relative toxicity of different oils against adult mite (*Oligonychus coffeae) population*

Treatment	n[a]	Slope ± SE	LC_{50} (ppm)	95%FL[b] of LC_{50} (Upper-Lower)	x^2
Karanja oil	90	0.71±0.005	117.241	250.211-54.930	0.543
Mustard oil	90	0.58±0.004	345.706	757.746-157.721	1.133
Olive oil	90	0.45±0.003	360.045	949.328-136.551	0.157
Sesame oil	90	0.90±0.007	386.186	689.472-216.310	0.943
Castor oil	90	0.79±0.005	1131.41	2006.420-637.999	0.844
Groundnut oil	90	0.80±0.003	1493.47	2600.963-857.550	0.747
Rose oil	90	1.30±0.004	2042.65	2936.530-1420.860	1.340
Ethion	90	1.76 ± 0.013	441.891	502.642-371.561	4.270

LC_{50}= lethal concentration for 50%; [b]FL= Fiducial limit

Table 2 : Ovicidal toxicity of different oils against eggs of adult mite (*Oligonychus coffeae*) population

Treatment	n[a]	Slope ± SE	LC_{50} (ppm)	95%FL[b] of LC_{50} (Upper-Lower)	x^2
Rose oil	90	0.89 ± 0.004	5622.5	9125.77-3464.03	0.5694
Karanja oil	90	0.98 ± 0.005	6927.6	10760.00-4460.21	0.9999
Olive oil	90	0.57 ± 0.007	7403.5	15559.12-3522.78	4.83
Castor oil	90	1.18 ± 0.003	10124	14727.93-6950.31	0.3301
Groundnut oil	90	0.97 ± 0.004	11881	18732.41-7536.06	2.5441
Mustard oil	90	1.05 ± 0.005	12133	18490.33-7961.44	2.1814
Sesame oil	90	0.68 ± 0.006	18216	34538.73-9607.18	0.2243
Ethion	90	1.33 ± 0.005	2270	5916.92-2080.13	0.114

LC_{50}, lethal concentration for 50%; [a]n= Number of individuals; [b]FL= Fiducial limit

2006) and have long been recommended as alternative to chemical pesticides for pest management. Insecticidal constituents of many plant oils are monoterpenoids that defend plants against plant directed pathogens, herbivores or competing plant species (Ahn *et al*., 1998). Adulticide bioassay of different oil concentrations on red spider mites (Table 1) showed lowest LC_{50} value (117.24 ppm) in case of karanja oil followed by mustard oil (345.70 ppm), olive oil (360.04 ppm), sesame oil (386.18 ppm), ethion (441.891 ppm), castor oil (1131.41 ppm) and groundnut oil (1493.47 ppm), while the highest LC_{50} value was observed in case of rose oil (2042.65 ppm). Roy *et al.* (2016) reported potential anti-mite properties of jatropha oil and garlic oil against the same pest with LC_{50} values of 118.54 ppm and 312.40 ppm, respectively. In this study, karanja oil, mustard oil, olive oil and sesame oil also exhibited similar type of toxicities in the mite population. The toxic effect of these oils may be due to their fumigant (Rajendran and Sriranjini, 2008; Ayvaz *et al*., 2010) and/or contact toxicities (Kim *et al*., 2003) of the major components of these oils or by inhibition of AChE activitites. Some authors also report that monoterpenoids present in oils cause insect mortality by inhibiting acetylcholinesterase enzyme activity (Sertkaya *et al*., 2010) possibly by activation of octopaminergic receptors (Kostyukovsky *et al*., 2002). As this target site is not shared with mammals, most essential oil chemicals are relatively non-toxic to mammals and fish and meet the criteria for “reduced risk” pesticides (Koul *et al*., 2008).

The results of the present study on ovicidal action on eggs of *O. coffeae* indicated significant reduction in adult emergence and the bioassay results showed that rose oil had the lowest LC_{50} value (5622.5 ppm) which was followed by karanja oil (6927.6 ppm) < olive oil (7403.5ppm) < castor oil (10124 ppm) < groundnut oil (11881 ppm) < mustard oil (12133 ppm) < sesame oil (18216 ppm). LC_{50} values registered for egg stage of red spider mite against ethion was 2270 ppm (Table 2). Plant based oils, in general, possess excellent ovicidal properties and found to be effective even at few parts per million (Benelli, 2015) as demonstrated against eggs of Mediterranean flour moth and red spider mite wherein oils of *Ziziphora clinopodioides, Jatropha curcas* and *Allium sativum* showed outstanding oviposition deterrence and ovicidal activity even at low concentrations (Kheirkhah *et al*., 2015; Roy *et al*., 2016), confirming the current findings.

The present investigation indicated that, among all the plant oils tested, karanja oil showed the lowest LC_{50} value against the adult mites of *O. coffeae*, thereby representing high toxicity of the components. The oil possess an active flavone compound 'karanjin' which has anti-insect activities (Perumalsamy *et al*., 2015). It also showed ovicidal action against the eggs of *O. coffeae*, which is in agreement with the report of Pavela (2009) where 100% mortality was observed on using 1% and 3% of karanja oil against *Tetranychus urticae*. It was observed that oil, methanolic seed extract, acetone leaf extract, aqueous seed

extract, chloroform seed extract and petroleum ether seed extract of *Pongamia pinnata* acted as oviposition deterrents, antifeedants and larvicides against a wide range of insect pests (Pavela, 2007). Also, sesame and rose oil showed high acaricidal, ovicidal and oviposition deterrence activities against red spider mite in the present study.

The results of the present investigation suggest that plant based oils have potential for controlling *O. coffeae.* Further, determination of chemical compositions of plant oils and field studies are needed for the development of new class of compounds in developing an eco-friendly and environmentally safe method for the management of red spider mite.

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