N O T E

Toxicity of Three Plant-Based Oils Against *Oligonychus coffeae* (Acari: Tetranychidae)[1]

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There has been an increasing trend to reduce the dependence on conventional chemical insecticides with the implementation of the Plant Protection Code (PPC) for tea production by the government of India. Naturally derived plant products or botanicals are viable alternatives for pest management in tea plantations (Roy et al. 2016, Appl. Microbiol. Biotech. 100: 4831–4844). However, preparation of such botanicals is time consuming as well as labor intensive in terms of collection and drying of such plant materials. Thus, use of commercially available plant-based oils may represent a novel class of crop protectants which are readily available in the market as their preparation is reasonably easy and less time consuming. The effectiveness of plant-derived oils in control of arthropod pests in different crops is well established (Isman 2006, Annu. Rev. Entomol. 51: 45–66) and many have been documented to be effective against insect and acarine pests (Isman 2000, Crop Prot. 19: 603–608). They are also selective in having little to no impact on natural enemies and pollinators, which does not occur among conventional insecticides (Digilio et al. 2008, J. Plant Interact. 3: 17–23).

The advantage of plant-based oils is that they contain complex mixtures of monoterpenes, phenols, and sesquiterpenes which not only repel insects and mites but also have fumigant and contact toxicity (Koul et al. 2008, Biopest. Int. 4: 63–84). In tea production, a few plant-derived oils have demonstrated promising results against crop pests, primarily the red spider mite, *Oligonychus coffeae* Nietner (Barua et al. 2015, Proc. Zool. Soc. doi: 10.1007/s12595-015-0147-6; Roy et al. 2015, Acta Phytopath. Entomol. Hungarica 50: 127–138; Roy et al. 2016, Proc. Nat. Acad. Sci. India Sec. B: Biol. Sci. doi: 10.1007/s40011-016-0734-y). Identification and evaluation of such natural insecticides is necessary so that tea producers may have a variety of choices of products for effective pest management. Hence, the

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Table 1. Concentration-mortality response (LC_{50}) of *O. coffeae* adults to plant-based oils and conventional acaricides.*

Treatment	*n***	LC_{50} (ppm)	95% fiducial limits	Slope ($\pm$SE)	RT†	χ^2
Pongamia oil	630	194.20	141.50–266.54	1.40 $\pm$ 0.001	7.56	3.35
Nirgundi oil	540	78.40	68.48–89.74	3.67 $\pm$ 0.003	18.74	4.30
Neem oil	540	1469.88	1,334.06–1,619.51	3.01 $\pm$ 0.002	1.00	6.47
Ethion	540	997.60	932.38–1,067.30	6.80 $\pm$ 0.004	1.47	1.92
Fenazaquin	540	2.80	2.21–3.55	1.76 $\pm$ 0.001	524.95	4.01

* LC_{50} = median lethal concentration; ppm = parts per million; RT = relative toxicity.
** Number of adults tested.
† RT = LC_{50} of neem oil/LC_{50} of treatment.

present study was conducted to assess the acaricidal activity of three commercially available plant-based oils (e.g., pongamia oil derived from *Pongamia pinnata* [L.] Pierre, nirgundi oil derived from *Vitex negundo* L., and citronella oil derived from *Cymbopogon nardus* [L.] Rendle) in comparison to a standard neem oil derived from *Azadirachta indica* A. Juss and the chemical acaricides ethion and fenazaquin against *O. coffeae*.

Oligonychus coffeae were collected from a commercial planting of tea in Jorhat, Assam, India, and maintained as a stock culture in the laboratory following the detached leaf culture method described by Roy et al. (2010, Int. J. Acarol. 38: 74–78). Toxicity assays were conducted by following the "leaf-dipped method" recommended by the Insecticide Resistance Action Committee. Ovicidal properties were assessed by introducing 20 gravid female mites onto tea leaves and allowing them to lay eggs for 24 h, after which the female mites were removed using a fine brush. The numbers of eggs laid on the leaf surface were counted using a dissection microscope. The number of eggs per leaf disc was adjusted to 30 per disc. The discs with eggs were sprayed with the solutions using a glass atomizer. Egg hatching was observed daily and continued up to 15 d. A treatment with water served as the control. Mortality data were corrected for control mortality using Abbott's (1925, J. Econ. Entomol. 18: 265–267) correction formula, and median lethal concentrations were calculated using Finney's (1973, Probit Analysis, Cambridge Univ. Press, Cambridge, U.K.) probit analysis and expressed in parts per million.

These bioassays found that the nirgundi and pongamia oils were better adulticides against *O. coffeae* than neem oil or synthetic acaricides (Table 1) with relative toxicity, greater to lesser, being nirgundi oil $>$ pongamia oil $>$ dicofol $>$ ethion $>$ citronella oil $>$ neem. Nirgundi oil was the most toxic ovicide, followed by ethion, pongamia oil, and dicofol (Table 2). Citronella oil failed to demonstrate any ovicidal activity. Although neem oil and citronella oil are reported to have insecticidal properties (Maia and Moore 2011, Malar J. 10: S11; Silva et al. 2013, Chilean J. Agric. Res. 3: http://dx.doi.org/10.4067/S0718-58392013000300016),

Table 2. Concentration-mortality response (LC_{50}) of *O. coffeae* eggs to selected plant-based oils and conventional acaricides.

Treatment	*n***	LC_{50} (ppm)	95% fiducial limits	Slope (±SE)	RT†	χ^2
Pongamia oil	540	385.73	306.10–486.07	2.00 ± 0.001	12.73	2.32
Nirgundi oil	540	6.55	3.62–11.85	0.82 ± 0.007	750.11	1.55
Neem oil	540	4913.23	4,291.87–5,624.53	2.16 ± 0.003	1.00	4.15
Ethion	540	172.44	122.32–243.09	1.19 ± 0.005	28.49	1.94
Fenazaquin	540	7.86	5.45–11.33	1.17 ± 0.006	625.09	1.88

* LC_{50} = median lethal concentration; ppm = parts per million; RT = relative toxicity.
** Number of eggs tested.
† RT = LC_{50} of neem oil/LC_{50} of each treatment.

they were the least toxic to adults and eggs of *O. coffeae* in our bioassays. The moderate performance of ethion and dicofol as adulticides in our study likely reflects their extensive use for controlling *O. coffeae* in northeastern India for more than 50 yr, which has facilitated resistance development (Roy et al. 2016). Based on the results presented herein, nirgundi and pongamia oils can be used as alternatives to conventional acaricides in *O. coffeae* management programs.