

Research Article

Prospects for the Use of *Pongamia pinnata* Oil-Based Products against the Green Peach Aphid *Myzus persicae* (Sulzer) (Hemiptera: Aphididae)

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Received 31 January 2014; Accepted 14 March 2014; Published 7 April 2014

Academic Editor: Nawal Kishore Dubey

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This study is devoted to an estimation of the action of preparations based on *Pongamia pinnata* oil on the life cycle (survival, fecundity) of green peach aphid *Myzus persicae* (Sulzer) (Hemiptera: Aphididae). The *M. persicae* is a widespread pest and damages more than 100 species of plants. All test formulations had aphicidal activity for *M. persicae* adults and larvae. Moreover, they possess prolonged action, exerting a negative influence on the offspring. The preparations differed in speed of onset of mortality. The single treatment with these formulations provides significant reduction in the number of aphids during the observation period, because of the efficiency rising in time.

1. Introduction

A wide range of chemicals are used to protect plants from pests in modern agriculture. Most of them are not destroyed by enzyme systems of plants, or by external natural impacts, that is cause their accumulation in the crop, and as a result—in humans and animals. Regular treatments cause the occurrence of resistance in harmful objects and, at the same time, are dangerous for beneficial arthropods.

One possible solution to these problems is the search for new active substances—secondary plant metabolites. The ability of plants to produce antibiotic substances is well known [1, 2]. Currently, the list of known plant secondary metabolites continues to expand. Enough information to support the use of plant preparations for crop protection is already accumulated [3, 4].

Botanical insecticides are natural chemical substances isolated from plants. Such preparations may be considered as an alternative to synthetic chemical compounds, but they are not always less toxic to mammalian. But botanical insecticides are easily decomposed in the soil and will not be stored in the tissues of plants and animals.

Among the substances of plant origin, essential oils, which have well-known activity against various pests, occupy a special place. So, essential oils from plants of the *Mentha* genus, *Origanum vulgare* L., *Ocimum basilicum* L. (Lamiaceae), and *Carum carvi* L. (Umbelliferae) are highly toxic to *Trialeurodes vaporariorum*, *Tetranychus cinnabarinus*, *Acanthoscelides obtectus*, and *Meligethes aeneus* [5–8].

One of the most interesting objects of study in recent years is *Pongamia* oil, the use of which is widespread in various areas of activity. According to the literature and earlier results, this plant has insecticidal activity to some pest and synanthropic insects [9, 10].

Myzus persicae (Sulzer) (Hemiptera: Aphididae) is a widespread polyphagous aphid, which damages more than 100 species of plants. In greenhouses, there are forms with incomplete development cycle that can reproduce continuously throughout the year [11, 12]. Pesticide with broad spectrum is not effective enough due to the high resistance of *M. persicae* to organophosphate and pyrethroid insecticides [13].

With year-round growing season, the problem of the replacement of traditional pesticides with new means of pest

control is actual in greenhouse crop production, where there is a constant accumulation of harmful arthropods.

The aim of our work is to evaluate the action of preparations based on *Pongamia pinnata* (L.) Pierre oil on the life cycle (survival, fecundity) of green peach aphid.

2. Materials and Methods

2.1. Insects. The green peach aphid *Myzus persicae* (Sulzer) was reared on sprouting broad beans (*Vicia faba* L.), grown at $22 \pm 2^\circ\text{C}$, 16 : 8 LD, and 50 ± 10 RH.

2.2. Plant Material and Chemicals. Pongam is seed oil from *Pongamia pinnata* (Parker Group, India) emulsified using Tween 85. The oil was tested by HPLC to determine the Karanjan content that is over 22 000 ppm.

Cinnamomum verum oil was obtained from the bark of *Cinnamomum verum* J. Presl, which were collected from plants growing in distinct areas of commercial plantations in southern India. The essential oil was extracted by hydrodistillation using a modified Clevenger apparatus. The bark was pulverized and 20 g was distilled in 300 mL DH₂O in a 500 mL flask for 60 min. Oil samples were stored at 4°C until bioassays.

Extracts from *Sapindus saponaria* L. and *Thymus vulgaris* L. were prepared from the seeds of *S. saponaria* or flowering plants of *T. vulgaris*, respectively, by pulverization and extracted using 100% pure methanol during 48 h at the laboratory temperature (ratio plants : methanol; 1 : 10).

Thymol (pure 99.9%) was obtained from Sigma-Aldrich, Czech Republic.

2.3. Formulations

RE: Pongam (emulsified using Tween 85—ratio Tween : Oil = 1 : 9).

REP: Pongam + thymol (emulsified using Tween 85—ratio Tween : Oil : thymol = 1 : 8 : 1).

REP3: Pongam + *Thymus vulgaris* extract (emulsified using Tween 85—ratio Tween : Oil : extract = 1 : 8 : 1).

REP4: Pongam + *Cinnamomum verum* oil (emulsified using Tween 85—ratio Tween : Oil : EO = 1 : 8 : 1).

REP5: Pongam + *Sapindus saponaria* extract (emulsified using Tween 85—ratio Tween : Oil : extract = 1 : 8 : 1).

NA: NeemAzal TS—The commercial insecticide NeemAzal-U (a.i. azadirachtin A 10 g/kg) (Trifolio-M GmbH, Lah-nau, Germany) was used for treatment.

2.4. Bioassays. To estimate insecticidal activity of the formulations in laboratory bioassays, filter paper discs impregnated with test solutions (0.25 mL/disc) were placed in the bottom and the lid of small Petri dishes (36 mm in diameter) (Corning Inc., USA); then a bean leaf treated with the same test solutions and 10 adult aphids were added. The control was treated with water. Twenty-four hours later, live and

dead aphids and their offspring were counted. There were 5 replicates for each treatment. Biological efficacy, inhibition of oviposition, and mortality of subsequent nymphs were corrected by Abbott's formula [14].

The effect of the treatments on aphid larvae mortality was determined as follows. The pepper plants (*Capsicum annuum* var. *annuum* L.) were grown particularly in the flowerpots at $23 \pm 2^\circ\text{C}$, 16 : 8 LD. The 15 aphid's first instar larvae were placed on each plant with two true leaves freshly treated with formulations or water (control). The number of live and dead aphids was counted 1, 2, 3, and 7 days after. This procedure was replicated 10 times for each formulation and the control. Efficacy was corrected by Abbott's formula [14].

Data were examined using analysis of variance (ANOVA), and means were separated using the Tukey honestly significant difference (HSD) multiple comparison test ($P < 0.05$). The LC_{50} and the 95% confidence limit of upper and lower confidence levels were calculated by using probit analysis [15].

3. Result and Discussion

At the maximum concentration (3%), almost all formulations, except REP5, resulted in 90% or above mortality of treated females (Table 1). With such a high mortality rate in tests NA, REP, REP3, and RE only a few larvae hatch and immediately died. On the other hand, after REP4 treatment, the fertility did not change significantly compared to the control, but the emergence of the next generation of individuals was not viable.

The gradual decrease in the concentration of working solutions in 2 times allowed us to determine the samples that retain their activity. In particular, even at a concentration of 0.75%, RE caused the death of more than 60% of females and inhibited the development of subsequent nymphs on 80%. After dilution to 0.375%, the efficacy (mortality of females) was 50%. The NA and REP4 somewhat inferior to RE in imagocidal activity.

When studying the influence of preparations on mortality of larvae of green peach aphid on vegetative plants, all samples showed high aphicidal activity at 3 and 1.5% (Table 2). There is a clearly expressed dynamic of aphid's death, which indicates the accumulation of toxins in the body of insects. The preparations differed in speed of onset of mortality.

Thus, the larval mortality on day 3 was over 60% in the tests with REP and REP3, while in tests with other formulations—below 50%. After dilution of the working solution to 0.75%, the activity of all samples sharply reduced, except REP (40%). The test samples are inferior to standard NeemAzal TS (NA) in the speed of appearance of the effect and retention of activity at reducing the concentration of the working solution, but nevertheless have certain larvicidal action to this insect.

The main component in our experimental formulations—*P. pinnata* oil—was not chosen by chance. So, Pongam oil treatments reduced the number of whiteflies on the chrysanthemum plants [16]. Also, the Pongamia oil caused high mortality of *Spodoptera littoralis*, *M. persicae*, and *Tetranychus urticae* on greenhouse plants [10].

TABLE 1: Activity of plant preparations to green peach aphid female and to its offspring.

Treatment	Concentration %	Biological efficacy %*	LC ₅₀ (CI ₉₅)	Inhibition oviposition %	Corrected mortality of subsequent nymphs %*	LC ₅₀ (CI ₉₅)
REP	3.0	90.3 ^a		93.5	100.0 ^a	
	1.5	84.3 ^{ab}	0.86	81.5	92.9 ^b	0.59
	0.75	27.2 ^{cd}	(0.72–0.96)	60.9	54.4 ^c	(0.42–0.68)
	0.375	11.6 ^e		56.5	20.8	
REP3	3.0	90.6 ^a		89.8	100.0 ^a	
	1.5	97.9 ^a	0.93	100.0	—	N.D.
	0.75	28.6 ^d	(0.85–1.11)	64.1	0.0 ^e	
	0.375	16.7 ^{de}		47.8	0.0 ^e	
REP4	3.0	97.8 ^a		28.6	100.0 ^a	
	1.5	71.5 ^b	0.95	11.7	100.0 ^a	1.25
	0.75	42.8 ^{bc}	(0.78–1.05)	18.2	26.6 ^d	(1.18–1.35)
	0.375	35.3 ^c		158.6	24.1 ^d	
REP5	3.0	73.5 ^b		79.7	95.0 ^b	
	1.5	24.6 ^d	2.18	60.1	66.0 ^c	0.89
	0.75	27.7 ^d	(1.98–2.25)	75.7	42.7 ^d	(0.78–0.99)
	0.375	3.1 ^f		48.6	0.0 ^e	
RE	3.0	95.9 ^a		97.4	100.0 ^a	
	1.5	97.8 ^a	0.36	94.8	100.0 ^a	0.58
	0.75	60.4 ^b	(0.28–0.45)	67.5	78.9 ^{bc}	(0.39–0.65)
	0.375	50.0 ^{bc}		58.4	5.5 ^e	
NA	3.0	88.6 ^b		97.3	100.0 ^a	
	1.5	83.3 ^b	1.25	78.4	91.7 ^b	0.72
	0.75	36.3 ^c	(0.96–1.38)	53.8	63.4 ^c	(0.67–0.95)
	0.375	29.3 ^{cd}		36.5	45.3 ^{cd}	

*The values within columns with the same lowercase letter do not differ significantly (Turkey's HSD test, $P < 0.05$).

There is not enough information about insecticidal properties of *P. pinnata* oil. Considering that, it is similar to well-known neem oil by a number of properties.

Additional components of our experimental formulations have insecticidal activity *per se*.

The thymol is one of the main substances of *T. vulgaris*. The extract and oil of this plant were toxic for stored pests *Tribolium castaneum* (Herbst), *Callosobruchus maculatus*, and *Sitophilus granarius* [17, 18], *Sitotroga granarius*, *Acanthoscelides obtectus* [19], and phytophage *Trialeurodes vaporariorum* [20].

A methylene chloride extract of the *C. verum* was shown to be insecticidal to *T. castaneum* and *Sitophilus zeamais* Motsch [21]. Cinnamon oil provided >90% mortality of citrus mealybug *Planococcus citri* (Risso), but did not provide sufficient control of sweetpotato whitefly *Bemisia tabaci* (Gennadius) or green peach aphid *M. persicae* 7, 14, and 21 d after application [22].

A vast number of species showing great potential as anti-insect agents belong to *Sapindus* genus.

These plants are mostly known for being rich in saponins, which provide plant extracts with biological activities in medicine as well as in pest control [23].

Comparative evaluation of the activity of the tested formulations showed that the addition of various components to *P. pinnata* oil did not result in synergistic effects. Nevertheless, they all had aphicidal activity for *M. persicae* adults and larvae. Moreover, they possess prolonged action, exerting a negative influence on the offspring.

When preparations are recommended for pest management programs, besides the biological efficacy, the absence of side effects related to beneficial species (pollinators and insect predators) and protected plants plays a significant role.

In practice, the field treatment with 1% Pongamia oil did not have a negative influence on insect pollinators: Hymenopterans—*Apis florea*, *Apis dorsata*, and so forth, Dipterans—Muscidae, Syrphidae, and so forth, other orders—Lepidoptera, Hemiptera, and Coleoptera [24]. A high concentration of formulations we applied, (maximum 3%, at practical application, the most commonly used concentrations for formulations of plant insecticides are 0.5–1%) did not cause burns of plants (beans and peppers). In addition, the single treatment with these formulations provides significant reduction in the number of aphids during the observation period, because of the efficiency rising in time.

TABLE 2: Cumulating aphid mortality (mean \pm SE) at different times after treatment with plant preparations.

Treatment	Concentration, %	Days, after treatment							
		1		2		3		7	
		Mortality %*	Biological efficacy %						
REP	3.0	33.3 \pm 8.2 ^a	27.7	61.1 \pm 4.6 ^a	56.8	76.7 \pm 4.8 ^a	73.1	96.6 \pm 1.5 ^a	95.6
	1.5	41.1 \pm 4.9 ^a	36.1	52.2 \pm 6.3 ^{ab}	41.8	86.6 \pm 3.4 ^a	79.9	97.8 \pm 1.4 ^a	96.2
	0.75	13.3 \pm 2.4 ^c	10.3	36.7 \pm 2.8 ^{bc}	31.4	47.8 \pm 5.0 ^{bc}	39.1	57.8 \pm 6.8 ^c	41.9
REP3	3.0	29.9 \pm 5.1 ^{ab}	24.1	54.4 \pm 4.3 ^{ab}	49.4	71.1 \pm 3.7 ^{ab}	66.7	94.4 \pm 2.7 ^a	92.7
	1.5	26.7 \pm 4.8 ^b	23.3	56.7 \pm 5.1 ^{ab}	50.1	82.2 \pm 7.8 ^a	77.1	96.6 \pm 2.3 ^a	95.1
	0.75	2.2 \pm 2.2 ^d	0	21.7 \pm 3.4 ^d	15.2	40.9 \pm 3.4 ^c	31.0	48.9 \pm 4.1 ^c	29.6
REP4	3.0	4.4 \pm 2.2 ^d	0	35.5 \pm 4.7 ^{bc}	28.4	48.9 \pm 4.7 ^{bc}	41.1	88.9 \pm 3.3 ^a	85.5
	1.5	8.9 \pm 2.8 ^d	4.7	30.0 \pm 2.8 ^c	19.3	43.3 \pm 2.8 ^c	27.1	79.9 \pm 3.4 ^b	71.3
	0.75	3.3 \pm 1.5 ^d	0	17.6 \pm 3.7 ^d	10.7	37.3 \pm 3.9 ^c	26.8	45.0 \pm 2.9 ^{cd}	24.2
REP5	3.0	6.7 \pm 3.4 ^d	6.7	21.1 \pm 6.0 ^d	12.4	48.9 \pm 9.2 ^{bc}	41.4	84.4 \pm 4.1 ^{ab}	79.7
	1.5	15.6 \pm 3.2 ^c	8.5	34.4 \pm 3.1 ^{bc}	20.2	67.7 \pm 8.1 ^b	12.1	95.5 \pm 2.2 ^a	92.9
	3.0	31.1 \pm 6.5 ^a	25.3	51.1 \pm 7.4 ^{ab}	45.7	58.9 \pm 7.7 ^{bc}	52.6	84.4 \pm 5.6 ^{ab}	79.7
RE	1.5	10.0 \pm 2.8 ^d	2.3	44.4 \pm 7.4 ^b	32.3	62.7 \pm 12.3 ^b	44.1	94.4 \pm 2.1 ^a	91.2
	0.75	7.8 \pm 5.0 ^d	4.6	18.4 \pm 3.8 ^d	11.6	32.7 \pm 2.7 ^c	21.5	49.2 \pm 6.5 ^c	30.0
	3.0	20.0 \pm 4.8 ^{bc}	13.3	56.7 \pm 6.3 ^{ab}	51.9	78.9 \pm 2.1 ^a	75.7	100 ^a	100
NA	1.5	10.0 \pm 2.8 ^d	5.9	43.3 \pm 4.8 ^b	34.6	84.4 \pm 2.2 ^a	79.9	96.6 \pm 1.5 ^a	95.1
	0.75	4.4 \pm 2.2 ^d	1.1	36.7 \pm 2.8 ^{bc}	31.4	77.8 \pm 2.8 ^{ab}	74.1	97.8 \pm 2.2 ^a	96.7
	for 3%	7.7 \pm 2.7 ^d	—	9.9 \pm 2.3 ^c	—	13.3 \pm 3.8 ^d	—	23.3 \pm 6.8 ^d	—
Control	for 1.5%	4.4 \pm 3.3 ^d	—	13.3 \pm 4.2 ^{de}	—	22.2 \pm 4.4 ^d	—	30.0 \pm 4.1 ^d	—
	for 0.75%	7.7 \pm 4.4 ^d	—	17.8 \pm 6.4 ^d	—	33.3 \pm 7.3 ^c	—	36.6 \pm 6.4 ^d	—

*The values within columns with the same lowercase letter do not differ significantly (Turkey's HSD test, $P < 0.05$).

Thus, the high activity of the formulations with *Pongamia pinnata* oil against the green peach aphid, absence of negative effects on pollinators, and phytotoxicity may be used as a basis for the study of their effects on complex arthropods, damaging crops in greenhouses, for inclusion in the integrated pest management program.

Conflict of Interests

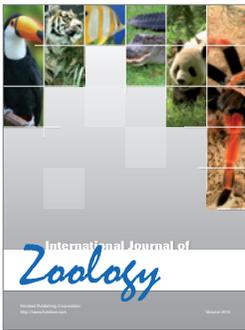
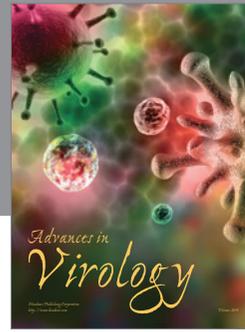
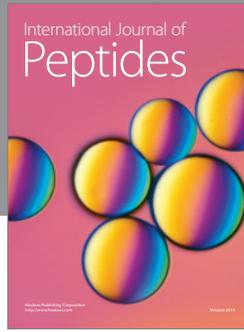
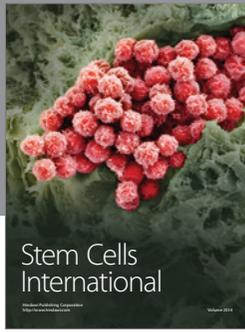
The authors declare that there is no conflict of interests regarding the publication of this paper.

Acknowledgment

This study was supported by Grants from the Czech Republic Ministry of Education, Youth and Sports (LH11133).

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