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Research Article

Efficacy of Neem Oil on Cardamom Thrips, *Sciothrips cardamomi* Ramk., and Organoleptic Studies

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The neem tree contains promising pest control substances which are effective against many pests. Oil extracted from neem seeds was used against cardamom thrips, *Sciothrips cardamomi*, a severe and economic pest of cardamom. Neem oil formulations, namely, Tamil Nadu Agricultural univeristy neem oil (TNAU NO) (acetic acid & citric acid), were found effective against the pest with a overall damage reduction of 30% after 14 days of treatment. The percent damage reduction in capsules over control after three consecutive sprays of TNAU NO(C) 2% and TNAU NO(A) 2% was 78.3 and 75.2 percent, respectively. The newly extracted and unformulated neem oil, though found inferior to the formulated one, still found to cause 50% and 70% reduction in damage caused by thrips at two and three rounds of sprays, making it useful in pest management. Organoleptic tests conducted on cardamom capsules sprayed with neem oil revealed no significant difference in taste, aroma, and overall acceptability of cow milk boiled with cardamom. Thus, TNAU NO (A and C) 2% was found effective against cardamom thrips with no adverse organoleptic properties and can be recommended.

1. Introduction

The backlash of synthetic pesticides because of the residual, resistance, and nontarget effects has led to the exploration of ecologically safe pest control alternatives in crop production. Among the different plant species with insecticidal properties, neem (*Azadirachta indica* A. Juss) is the well-studied and most commercially exploited one for pest management. Azadirachtin, a tetranortriterpenoid, was reported active over nearly 550 insect species [1]. Neem based insecticides especially those having azadirachtin are very much required for IPM programmes because they are selectively toxic, nonbioaccumulating, less persistent, and a natural source of insecticides [2]. Mode of action of neem on insect pests include direct effects on insect reproduction and secondary antifeedancy, and the physiological effects, measured as growth reduction, increased mortality and abnormal and delayed moults [3]. Neem seed kernel extract (NSKE), neem oil (NO) and neem cake (NC) are used in various field and horticultural crop pest managements. Neem oil cannot be used as such and has to be formulated to increase its efficacy and to decrease the potential phytotoxicity and to increase the storability. Neem oil per se is less systemic because it is insoluble in water. It should be formulated to make it systemic, to enhance its efficacy on sucking pests. To overcome these hurdles, better formulations are being developed [2]. Two neem oil formulations were made available by Tamil Nadu Agricultural University namely, TNAU NO(C) and TNAU NO(A) which are being tested for the efficacy on different insect pests. The neem product, TNAU NO(C) 30 mL/L, was reported effective against okra leaf hopper, *Amrasca devastans*, and reduced the population by 90% in one week period [4]. Both the formulations A and C at 3% were reported effective against sesame shoot webber and capsule borer, *Antigastra catalaunalis*, also [5]. TNAU NO is found effective against many other pests like *Liriomyza trifolii* on cotton [6], *Amrasca biguttula* and *Aphis gossypii* in okra [7], *Hypothenemus hampei* in coffee [8], *Pseudodendrothrips mori* in mulberry [9], and *Tetranychus urticae* in bhendi and brinjal [10].

Application of neem based formulations effectively checks insect pests of cardamom [11] and neem based IPM was also developed for cardamom borer and thrips [12].

Spraying neem oil 0.03% was found effective and caused 47% reduction in cardamom borer infestation [13]. Neem oil suspension at 0.5% sprayed on the lower surface of the leaf is very effective for the control of whitefly nymphs [11]. Margocide CK 0.1% effectively reduced root grubs in the field [14]. Neem cake 600 Kg acre^{-1} is also effective in controlling the grubs [15]. Moreover, neem cake was reported to significantly reduce the incidence of shoot fly of cardamom and also to enhance the production of side suckers [16]. The neem formulation under study is new, easy to make, cheap, and reported effective against many sucking pests of crops and thus needs to be evaluated against important pests of cardamom.

The reports of Jood et al. [17] stated that maize treated with neem oil, neem leaf, and kernel powder adversely affected the taste, aroma, and overall acceptability of Chapati rendering it unsuitable for consumption makes the necessity of organoleptic test especially for botanical pesticides. However, organoleptic tests conducted with broiler chicken fed with diets containing urea ammoniated neem seed kernel cake revealed no bitter taste in the cooked meat [18]. With these views, a study was carried out to find the efficacy of TNAU NO (A and C) along with unformulated neem oil and a commercial neem product (Vijay Neem) on cardamom thrips and organoleptic test on capsules collected from neem sprayed cardamom plants.

2. Materials and Methods

2.1. Efficacy Studies. Two field trials were laid out in cardamom plantations in Bodimettu, Bodi, during March to May, 2006, and Devarshola, Gudalur, Tamil Nadu, during September to November, 2006, to find out the efficacy of neem formulations on cardamom thrips. The trials were laid in randomized block design as per the treatments given in Tables 1 and 2 with three replications. The new neem formulations, TNAU NO (A and C), were made and standardized by Tamil Nadu Agricultural University, Coimbatore. The formulations are of 60% a.i and the first formulation contains acetic acid and thus is denoted as A and the other has citric acid and is denoted as C. The TNAU neem oil formulations A and C were tested at the rate of 2 and 3% each and compared with unformulated neem oil and a commercially available neem formulation (Vijay Neem).

Field trials were laid out in randomized block design (RBD) in the farmers' holdings in Bodimettu, Bodi and Devarshola, Gudalur, to test the efficacy of neem oil against thrips. Both the trials were conducted in a ruling variety of cardamom, namely, Njellani Green Gold, as per the treatments given in Tables 1 and 2 and replicated thrice. Spray treatment was given using backpacked knapsack sprayer with hollow cone nozzle at a rate of 750 L ha^{-1} (1500 cardamom clumps). Three sprays were given at 15 days interval and observations were made on the capsule damage. A control treatment was made by spraying only water.

The thrips incidence in cardamom was assessed on capsule basis and expressed as percent damage. Percent damage was assessed by counting total number of capsules per ten panicles in four clumps in a treatment and capsules showing scabs 3, 7 and 14 days after each application and also prior to the treatment. A clump consists of 5-6 cardamom plants planted/grown together, which covers an area of 0.8 to 1 m^2, demanding 0.5 L of spray fluid per clump. The percent damage thus recorded was subjected to statistical analysis adopting randomized block design using IRRISTAT version 3/93 after converting it to arcsine values. The mean values of treatments were then separated by Duncan's multiple range test (DMRT) after being transformed into arcsin values [19].

2.2. Organoleptic Test for Neem Sprayed Cardamom. Samples were collected 10 days after treatment from different treatments as given in Table 3 for TNAU neem oil sprayed plants from the field. Milk was boiled after putting these cardamom capsules separately for each treatment at 20 capsules per L of milk. To obtain unbiased scores each sample was coded. Organoleptic properties of milk for colour, aroma, taste, and overall acceptability were done by a panel of 10 judges. All are untrained panelists but well educated and most of them are agricultural professionals aged between 24 and 55 years. Using a well-structured questionnaire, the panelists independently assessed the samples for appearance (colour), taste, aroma/flavor, and overall acceptability employing 9.0 point hedonic scale [20] as given in Table 4.

3. Results

3.1. Field Trial I-Bodimettu. The mean damage by thrips prior to neem application ranged from 12.0 to 14.6 percent (Table 1). Three days after spraying, the capsule damage ranged between 11.5 and 13.3 percent in different treatments, while in the control it was 15.0 percent. The maximum mean reduction in capsule damage over check being 32.9 percent was recorded in TNAU NO(C) 3% followed by TNAU NO(A) 3% (31.5%) at the end of first spray. Ordinary neem oil 0.2% recorded the least reduction of damage over check (21.5%). Plots treated with TNAU NO(C) 3% and 2% registered a damage score of 10.8 and 9.6 percent and 10.7 and 9.6 percent 7 and 14 days after treatment, respectively, which were not significantly different from each other. The check, Vijay Neem at 2 mL L^{-1} recorded 11.8 7 days after treatment and 10.6 percent damage 14 days after treatment. Second spray was given fifteen days after the first spray when the damage ranged from 9.4 to 16.8 percent. At 7 days after treatment, TNAU NO(C) 3% and 2% recorded a damage of 7.8 to 8.1 percent which were on par with each other (Table 1). Though the reductions in capsule damage were low, the thrips population was reduced significantly in all the treatments after the sprays except untreated check. The same trend of efficacy was observed in the third spray also. TNAU NO(C) 3% recorded thrips damage to a level of 6.0, 4.9, and 3.8 percent 3, 7, and 14 days after treatment, respectively, and was found to be statistically superior to other treatments. TNAU NO(C) 3% was found superior in reducing the damage to a level of 80.1 percent at the end of three applications. The percent reduction over control after three sprays of TNAU NO(C) 2% and TNAU NO(A) 2% was 78.3 and 75.2 percent, respectively (Table 1).

Table 1: Effect of TNAU neem oil on thrips damage in cardamom-Bodimettu, Bodi (mean of three observations).

Treatments	PTC	First round of application					Second round of application					Third round of application				
		3 DAT	7 DAT	14 DAT	Mean	% Redn	3 DAT	7 DAT	14 DAT	Mean	% Redn	3 DAT	7 DAT	14 DAT	Mean	% Redn
TNAU neem oil (A) 2%	12.0	11.5^{a}	10.7^{a}	10.6^{b}	11.0	31.0	9.9^{b}	8.8^{b}	7.1^{b}	8.6	54.7	6.9^{ab}	6.1^{abc}	5.3^{bc}	6.1	75.2
TNAU neem oil (A) 3%	12.6	12.5^{bc}	10.4^{a}	9.4^{a}	10.9	31.5	9.0^{a}	8.9^{bc}	7.2^{b}	8.4	56.0	6.8^{ab}	6.0^{abc}	4.9^{abc}	5.9	76.0
TNAU neem oil (C) 2%	13.4	12.7^{bc}	10.7^{a}	9.6^{a}	11.0	30.5	9.0^{a}	8.1^{a}	6.9^{b}	8.0	57.9	6.4^{ab}	5.4^{ab}	4.3^{ab}	5.4	78.3
TNAU neem oil (C) 3%	12.0	11.5^{a}	10.8^{a}	9.6^{a}	10.7	32.9	9.0^{a}	7.8^{a}	6.4^{a}	7.7	59.5	6.0^{a}	4.9^{a}	3.8^{a}	4.9	80.1
Neem oil 2%	13.3	13.1^{c}	12.6^{c}	11.7^{c}	12.5	21.5	11.0^{c}	9.9^{d}	8.6^{d}	9.8	48.5	8.1^{b}	8.0^{d}	6.8^{d}	7.6	69.0
Neem oil 3%	12.4	12.0^{ab}	11.2^{ab}	10.7^{b}	12.0	24.5	10.1^{b}	9.4^{c}	8.0^{c}	9.2	51.9	7.7^{b}	6.9^{bcd}	5.7^{cd}	6.8	72.5
Vijay Neem 2 mL L^{-1}	14.0	13.3^{c}	11.8^{bc}	10.6^{b}	11.9	25.0	10.0^{b}	9.3^{bc}	8.1^{c}	9.2	51.9	7.9^{b}	7.0^{cd}	6.1^{cd}	7.0	71.5
Untreated check	14.4	15.0^{d}	15.8^{d}	16.8^{d}	15.9	—	17.3^{d}	18.2^{e}	21.6^{e}	19.1	—	22.0^{c}	24.7^{e}	27.2^{e}	24.6	—

Mean of three observations; PTC: pretreatment count.
In a column, means followed by a common letter(s) are not significantly different by DMRT ($P = 0.05$).

Table 2: Effect of TNAU neem oil on thrips damage in cardamom-Devarshola, Gudalur (mean of three observations).

Treatments	PTC	First round of application					Second round of application					Third round of application				
		3 DAT	7 DAT	14 DAT	Mean	% Redn	3 DAT	7 DAT	14 DAT	Mean	% Redn	3 DAT	7 DAT	14 DAT	Mean	% Redn
TNAU neem oil (A) 2%	31.0	28.6^{bc}	26.8^{b}	24.6^{b}	26.7	23.0	22.7^{bc}	20.3^{bc}	18.8^{cd}	20.6	47.0	15.3^{b}	12.8^{de}	10.9^{c}	13.0	70.6
TNAU neem oil (A) 3%	30.8	28.9^{ab}	25.1^{ab}	23.3^{ab}	25.8	25.7	21.7^{bc}	19.6^{bc}	17.9^{bcd}	19.7	49.3	13.7^{b}	8.5^{ab}	6.5^{a}	9.6	78.3
TNAU neem oil (C) 2%	29.6	27.4^{ab}	25.6^{ab}	23.2^{ab}	25.4	26.8	21.5^{bc}	19.4^{bc}	17.2^{bc}	19.4	50.2	14.3^{b}	10.2^{bc}	7.4^{ab}	10.6	75.9
TNAU neem oil (C) 3%	29.1	25.6^{a}	23.8^{a}	21.0^{a}	23.5	32.3	17.5^{a}	15.8^{a}	14.0^{a}	15.8	59.3	11.6^{a}	7.7^{a}	5.3^{a}	8.2	81.5
Neem oil 2%	29.3	29.0^{b}	27.2^{ab}	25.4^{b}	27.2	21.6	25.0^{c}	22.8^{c}	21.0^{d}	22.9	41.0	17.9^{c}	14.2^{e}	11.4^{c}	14.5	67.2
Neem oil 3%	29.9	28.3^{ab}	26.9^{ab}	24.7^{b}	26.7	23.2	22.8^{bc}	20.5^{bc}	18.9^{cd}	20.7	46.7	15.1^{b}	11.3^{cd}	9.5^{bc}	12.0	72.8
Vijay Neem 2 mL L^{-1}	30.3	27.4^{ab}	25.4^{ab}	22.9^{ab}	25.2	27.3	19.8^{ab}	17.7^{ab}	15.3^{ab}	17.6	54.7	13.8^{b}	10.9^{cd}	7.3^{ab}	10.7	75.8
Untreated check	29.3	32.7^{c}	34.7^{c}	36.7^{c}	34.7	—	37.7^{d}	38.6^{d}	40.3^{e}	38.9	—	41.7^{d}	44.2^{f}	46.4^{d}	44.1	—

Mean of three observations; PTC: pretreatment count.
In a column, means followed by a common letter(s) are not significantly different by DMRT ($P = 0.05$).

Table 3: Organoleptic evaluation of TNAU NO sprayed cardamom capsules (mean of ten scores).

Treatments	Mean scores			
	Colour	Taste	Aroma	Overall acceptability
T_1—TNAU NO (A) 3%	8.7	8.6	8.5	8.5
T_2—TNAU NO (C) 3%	8.6	8.6	8.3	8.6
T_3—control (water spray)	8.9	8.7	8.8	8.9
SED	0.200	0.226	0.206	0.207
CD (0.05)	0.410	0.464	0.422*	0.425

*Significant at 95 percent level.
SED: standard error of a difference between 2 means; CD: critical difference.

Table 4

Category	Scale
Like extremely	9
Like very much	8
Like slightly	7
Neither like nor dislike	6
Dislike slightly	5
Dislike moderately	4
Dislike very much	2
Dislike extremely	1

The data collected were subjected to analysis of variance (ANOVA) using completely randomized block design (CRD) using AGRES Version 7.01.

3.2. Field Trial II-Devarshola. The mean damage of thrips to cardamom capsules was high prior to spraying which ranged from 29.1 to 31.0 percent (Table 2). Three days after spraying, the capsule damage ranged between 25.6 and 28.9 percent in different treatments. Plots treated with TNAU NO(C) 3% registered a damage of 23.8 and 21.0 percent 7 and 14 days after treatment against 34.7 and 36.7 percent in control, respectively, and were found to be the best but not statistically superior to TNAU NO(C) 2% and TNAU NO(A) 3%. The thrips damage in TNAU NO(A) 3% treatment was on par with TNAU NO(C) 2% in all the days of observations. The maximum mean reduction in capsule damage over check of 32.3 percent was recorded in TNAU neem oil (C) at 3% followed by Vijay Neem at 2 mL L^{-1} (27.3%) at the end of first spray. Second spray was given 15 days after the first spray. Seven and 14 days after treatment, the thrips damage was found to be 15.8 and 14.0 percent in TNAU NO(C) 3% treatment, respectively, while the standard check Vijay Neem registered 17.7 and 15.3 percent, respectively. Ordinary neem oil was also somewhat effective by reducing the thrips damage, namely, from 24.7 percent before spray down to 18.9 percent, 14 days after treatment. After the third application, the thrips damage was 7.7 and 10.2 in TNAU NO(C) 3 and 2% treatments 7 days after treatment, respectively. TNAU NO(A) 3% registered 6.5 percent thrip damage 14 days after treatment while that in the standard check, Vijay Neem, was 7.3 percent. The mean reduction of thrips damage was 81.5 and 75.9 percent in TNAU NO(C) 3 and 2% sprays, respectively (Table 2). Vijay Neem registered 75.8 percent mean reduction in thrips damage when compared to control at the end of three applications.

3.3. Phytotoxicity. The treatments irrespective of the doses given did not inflict any phytotoxicity symptoms like epinasty, hyponasty, leaf injury, wilting, vein clearing, and necrosis on cardamom.

3.4. Organoleptic Tests. The mean scores graded based on the sensory perception are furnished in Table 3. There was no significant variation in the quality parameters assessed, namely, colour, aroma, taste, and overall acceptability. The standard error differences between two means of all the parameters assessed are approximately 0.2 and none of the treatments in any of the parameters evaluated are found to be statistically significant from each other.

4. Discussion

Though many chemical insecticides were reported to be effective for the management of cardamom pests [21, 22], it cannot be recommended for spraying continuously all the year. At the same time, control measures cannot be stopped because thrips will begin to infest the crop as soon as the treatment is stopped. So an effective botanical pesticide for thrips to be sprayed in between the chemical sprays can minimize the pesticide load. Particularly in the mountain ecosystem where cardamom is grown, the dislodgeable pesticides will be washed off from the plants, soil, and so forth and collected in the ponds and rivers contaminating the elixir of life—the "water." Moreover, cardamom is an export oriented crop and needs to be free of pesticide residues, and if a botanical pesticide is found to be effective, it will be an added advantage to the cardamom producers and exporters.

The extent of reduction in the thrips damage in TNAU NO(A) 3% was 31.5–76.0 percent and that of TNAU NO(C) 3% was 32.9–80.1 percent. TNAU NO(C) 2% was on par with its higher dose 3% in all the days of observations. So the two formulations were found to have no significant difference in reducing the thrips damage in cardamom. Generally, the percent reduction was low initially since the reduction of scabs in the capsules cannot be realized at once but in due course. This is evident from the continuous reduction in percent damage counts. TNAU NO(C) 3% is the best of the treatments imposed in terms of reduction in damage. The unformulated neem oil was also found effective against the thrips since it was used immediately after extraction. An overall reduction of 21% in cardamom thrips damage was reported by spraying neem oil 0.03% [16].

The reduced infestation of the cardamom pest in neem formulations sprayed field might be due to antifeedant, ovipositional deterrent or growth disturbing actions and also repellency effect. It is evident from the results that TNAU NO(C) when evaluated against different insect pests like *Cnaphalocrocis medinalis* is found to reduce the food consumption, pupal weight, adult emergence, pupation rate, and egg hatchability and to increase larval mortality [23]. The diverse biological effects of neem are also reported as it poses repellency, phagodeterrence, growth inhibition, abnormal development [24], and ovipositional suppression [25]. TNAU NO is reported as a potent ovipositional deterrent and it was found up to 90.81 percent in the laboratory. TNAU NO 0.3% causes a reduction up to 60.38 percent of thrips damage in cardamom capsules [26].

The neem sprays which were given to reduce the thrips damage and thereby to reduce the quality deterioration by the pest should not deteriorate the quality of the capsules by itself through its characteristic bitter taste or smell. Thus organoleptic test was carried out to know if there is any unacceptability for the cardamom harvested from neem sprayed field and blended with milk. Milk was taken as the medium so that any slight change in taste, aroma, or colour can be easily detected. Table 3 depicts that the scores given by the judges were between 8 and 9 which implies that the product is accepted by the consumers. This finding is in accordance with the reports of Shivashankar et al. [27], who reported no change in taste in tender coconuts harvested from soluneem (water soluble neem formulation) treated palms for the control of coconut black headed caterpillar. The present investigation clearly indicated that there are no disagreeable attributes in the harvested product of cardamom due to the application of neem which is effective in reducing the thrips and thus can be recommended for spray since it will not hamper the export also.

Conflict of Interests

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

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