https://doi.org/10.33307/entomon.v45i2.518
ENTOMON 45(2): 107-114 (2020)
Article No. ent. 45203

Insecticidal activity of cashew nut shell liquid against sucking pests of cowpea, *Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdc.

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ABSTRACT: Cashew nut shell liquid (CNSL), an important agro waste from cashew nut processing factories, was emulsified in water and assayed for insecticidal activity at concentrations ranging from 0.05 to 0.2 % against aphid, *Aphis craccivora* and pod bug, *Riptortus pedestris* infesting cowpea, *Vigna unguiculata sesquipedalis* under laboratory conditions by topical application. CNSL at various concentrations was found to have insecticidal properties against *A. craccivora* and *R. pedestris* wherein the speed of kill and efficacy varied with concentration and test insect. CNSL @ 0.1 % with mortality ranging from 95.83 to 100 per cent at 48 hours after treatment (HAT) was found effective against *A. craccivora* whereas a concentration of 0.2% was required against *R. pedestris* to achieve similar mortality (96.67 to 100 %) at 72 HAT. CNSL derived from two cashew nut processing methods (drum roasting and steam boiling) did not differ significantly in their insecticidal action. At concentrations of 0.1 and 0.2 %, mortality produced by CNSL was comparable to that of chemical insecticide, thiamethoxam 0.03% and significantly superior to the widely used botanical neem oil @ 2% against *A. craccivora* and *R. pedestris* respectively. *R. pedestris* that survived exposure to CNSL treatments exhibited developmental abnormalities and formation of nymphal adult intermediary indicating its possible insect growth regulatory effect.

KEYWORDS: CNSL, plant derived insecticide, *Riptortus pedestris, Aphis craccivora*

INTRODUCTION

Cow pea (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdc), commonly known as yard long bean is one of the most widely cultivated commercial vegetable crops of Kerala. Green pods of the crop harvested at short intervals are a cherished vegetable, fetching high returns to the cultivators. But the quality of the produce is at risk because of the insecticide residue left subsequent to over use of insecticides to tackle the incidence of insect pests. Sucking pests *viz*., cowpea aphid, *Aphis craccivora* Koch (Homoptera: Aphididae) and pod bug, *Riptortus pedestris* (Fabricius) (Coreidae: Heteroptera) cause serious loss, affecting both quantity and quality of the produce forcing farmers to use synthetic insecticides at frequent intervals. Indiscriminate use of insecticides leads to ecological and health hazards necessitating exploration of alternatives. Plant derived insecticides being quickly biodegradable and safe to non target organisms are potential alternative to

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chemical pesticides. Plants synthesize and store many secondary metabolites capable of affecting insect development, reproduction and behavior. Characterization and use of such phytochemicals for pest control have yielded several botanical pesticides (Isman, 1994). Cashew plants, *Anacardium occidentale* produce and store phenolic secondary metabolites in the honey comb structure of its nut shell to ward off pests. This cashew nut shell liquid (CNSL) exude from the shells during cashew nut processing is a cheap by-product of cashew agro processing industry, available in plenty. CNSL possess insecticidal activity against termites (Asogwa *et al*., 2007), microorganisms (Lomonaco *et al*., 2009; Parasa *et al.,* 2011) and *Aedes aegypti* G. (Oliveira *et al*., 2011).

Anacardic acid, cardol and cardanol, the phenolic constituents of cashew nut shell was proved to have toxicity against sucking pests which was earlier indicated in the study of Oparaeke *et al*. (2005) wherein cashew nut shell extract found effective in reducing the pod sucking bugs. The toxicity of CNSL was earlier documented against chewing pests *viz*., coconut root grub (John *et al*., 2008), *Helicoverpa armigera* and *Spilarctia obliqua* (Mahapatro, 2011).The pesticidal efficacy of CNSL against chilli aphid, *Aphis gossypii* was reported earlier by Sundaran and Faizal (2018) where CNSL @ 0.2 % caused cent per cent mortality at 72 HAT. Andayanie *et al*. (2019) evaluated the efficacy of hexane extract of cashew nut shells against white fly, *Bemesia tabaci* wherein CNSL was reported to have antifeedant and anti oviposition activity besides causing mortality. In the present investigation the potential of CNSL as a natural insecticide against aphids and pod bugs of cowpea was evaluated with an aim to find a green alternative to synthetic insecticides.

MATERIALS AND METHODS

Laboratory bioassay studies were carried out at Department of Agricultural Entomology, College of Agriculture, Vellayani, Thiruvananthapuram during 2016-2019 to evaluate the insecticidal property of CNSL against major sucking pests of cowpea, *A. craccivora* and *R. pedestris*. *A. craccivora* was reared on sprouted green gram seeds maintained on wet cotton bed, kept in plastic containers. Gravid females were collected from the field and released to sprouted green gram seeds and the population thus maintained served as source culture. Second instar nymphs were collected from this source culture carefully, using a camel brush and used for experiments. Twenty numbers of aphids were used per treatment. The males and females of *R. pedestris* were collected from cowpea field and released on to the red gram pods maintained in the laboratory for egg laying. The nymphs that emerged from the eggs were transferred to fresh red gram pods. The second instar nymphs (10 numbers) from this source culture were used for each treatment.

Cashew nut shell liquid derived out of drum roasting method (CNSL-DR) of processing was purchased from Mahatma cashew exports, Kollam, Kerala and that derived from steam boiling technique (CNSL-SB) were collected from A.A nuts, Kollam. Seven different concentrations *viz*., 0.05, 0.06, 0. 07, 0.08, 0.09, 0.1 and 0.2 per cent of both CNSL- DR and SB were prepared using vegetable soap (0.6 %) as emulsifier and tested in the laboratory against *A. craccivora* and *R. pedestris* in completely randomized block design with three replications. Neem oil emulsion 2 % and thiamethoxam 25 WG 0.03% served as botanical and chemical check respectively.

The treatments were applied using potters precision spray tower @ 2 ml/replication ensuring uniform coverage of test insects and were subsequently transferred to treated pods kept in poly vinyl containers covered with muslin cloth. The insects sprayed with distilled water served as untreated check. The mortality of the test insects were observed at 24, 48 and 72 hours after treatment (HAT) for *A. craccivora;* 48, 72 and 96 HAT for *R. pedestris*. The treatment mortality was corrected with the mortality in untreated check (Abbot, 1925). The cumulative corrected percentage mortality was statistically analyzed after arcsine transformation. LC_{50} and LC_{90} was calculated using probit analysis in the statistical program, SPSS (Statistical Product and Service Solutions).

RESULTS AND DISCUSSION

Among the different treatments evaluated on the mortality of *A. craccivora*, thiamethoxam 25 WG 0.03% recorded cent per cent mortality and was superior to all other treatments at 24 HAT. This was followed by 0.2 % CNSL- DR, 0.2 % CNSL-SB and 0.1 % CNSL- DR with 76.67, 73.33 and 66.67 respectively which were on par with each other. The percentage mortality obtained in all other treatments including CNSL concentrations ranging from 0.05 to 0.09 were found to be inferior and on par with each other. At 48 hours after treatment also, the higher concentrations of CNSL *viz*, 0.2 % CNSL-SB, 0.1 % CNSL-SB and 0.2 % CNSL-DR were significantly superior (100 percent mortality) and their effect was equal to that of chemical check thiamethoxam 0.03%. Cent per cent mortality was observed at 72 HAT in all the treatments except neem oil emulsion 2 %, 0.6 % vegetable soap solution and untreated check (Table 1). CNSL emulsions caused mortality of *A. craccivora* at 24 HAT itself ranging from 30.00 per cent at 0.05 % to 76.67 per cent at 0.2 % and so LC_{50} and LC_{90} values were calculated by the probit analysis of dose-mortality responses at this level. The LC_{50} values obtained for the *A. craccivora* were 0.079 and 0.084 respectively for CNSL-DR and CNSL-SB with corresponding LC_{90} values of 0.250 and 0.275 (Table 2).

CNSL was comparatively slower in its action against heteropteran *R. pedestris* wherein a consistent mortality was observed only at 48 HAT, at which the chemical check thiamethoxam 0.03 % proved significantly superior (Table 1). 0.2 % CNSL-DR, 0.1% CNSL-SB and 0.2% CNSL-SB with per cent mortality of 73.33, 66.67, and 66.67 which were on par with each other and were significantly different from rest of the treatments. All other treatments containing CNSL emulsions were found to be inferior with values ranging from 26.67 to 50.00. At 72 HAT, cent per cent mortality was recorded in chemical check, 0.2% CNSL-DR and 0.1% CNSL-SB. These treatments along with CNSL-SB 0.2% with a mortality of 96.67 were significantly superior than rest of the treatments. The same trend continued at 96 HAT also. Apart from mortality developmental irregularities like nymphal adult intermediary formation was noticed in *R. pedestris* that survived exposure to CNSL.

At 48 HAT, 0.2 % concentration of CNSL emulsion caused only 73.33 per cent mortality, hence the LC_{50} and LC_{90} values were calculated by probit analysis of dose mortality responses studied at CNSL concentrations ranging from 0.05 to 0.5 %, the results of which are presented in Table 2. Mortality of *R. pedestris* increased with increase in concentration of CNSL. The LC_{50} values obtained for *R. pedestris* at 48 HAT were 0.095 and 0.102 per cent respectively for CNSL-DR and CNSL-SB. The corresponding LC_{90} values were 0.275 and 0.334 per cent respectively for CNSL-DR and CNSL-SB at 48 HAT.

CNSL at various concentrations was found to have insecticidal properties against *A. craccivora* and *R. pedestris* wherein the speed of kill and efficacy varied with concentration and test insect. *A. craccivora* succumbed to the treatments as early as 24 HAT where as *R. pedestris* took slightly more time to get killed. The mortality of the pest was found to increase with increase in concentration of CNSL. 0.2 % CNSL-DR and SB and 0.1 % CNSL-DR which produced 76.67, 73.33 and 66.67 per cent mortality respectively of *A. craccivora* at 24 HAT and was found to be superior over other concentrations of CNSL though inferior to chemical check (100 per cent). But at 48 HAT, higher concentrations of CNSL *ie*., 0.1 and 0.2 % recorded cent per cent mortality and was on par with chemical check thiamethoxam 0.03 %. Thiamethoxam was reported to be an effective chemical insecticide against the sucking pests in cotton (Nagger and Zidan, 2013), okra (Ghosh *et al.,* 2016) and green gram (Sujatha and Bharpoda, 2017). In the present study CNSL was found to be as effective as chemical pesticide thiamethoxam against *A. craccivora,* though it took slightly more time to kill the insects. The lower concentrations of CNSL also yielded cent percent mortality at 72 HAT confirming its efficacy comparable to thiamethoxam. No significant difference was observed in the insecticidal action of CNSL @ 0.1 and 0.2 % against *A. craccivora*, which indicates

Table 1. Effect of different concentrations of cashew nut shell liquid emulsion on *Aphis craccivora* and *Riptortus pedestris*

Treatments		Corrected mortality per cent*							
		24 HAT		48 HAT		72 HAT		96 HAT	
		Aphis craccivora	*Riptortus pedestris*	*Aphis craccivora*	*Riptortus pedestris*	*Aphis craccivora*	*Riptortus pedestris*	*Aphis craccivora*	*Riptortus pedestris*
T1	0.05 % CNSL – DR	30.00 (32.99)^{h}	0.00 (0.00)^{c}	54.17 (47.39)^{c}	26.67 (30.98)^{fg}	100.00 (90.00)^{a}	65.56 (54.08)^{cd}	100.00 (90.00)^{a}	74.07 (59.47)^{de}
T2	0.06 % CNSL - DR	43.33 (41.05)^{fg}	0.00 (0.00)^{c}	70.83 (57.90)^{bc}	30.00 (33.20)^{efg}	100.00 (90.00)^{a}	68.89 (56.08)^{bcd}	100.00 (90.00)^{a}	77.78 (61.85)^{cde}
T3	0.07 % CNSL - DR	46.67 (43.06)^{fg}	0.00 (0.00)^{c}	70.83 (58.08)^{bc}	33.33 (35.20)^{def}	100.00 (90.00)^{a}	72.22 (58.30)^{bcd}	100.00 (90.00)^{a}	77.78 (61.85)^{cde}
T4	0.08 % CNSL - DR	43.33 (41.14)^{fg}	0.00 (0.00)^{c}	66.67 (55.49)^{bc}	40.00 (39.22)^{cde}	100.00 (90.00)^{a}	75.93 (60.68)^{bc}	100.00 (90.00)^{a}	81.48 (64.73)^{cd}
T5	0.09 % CNSL - DR	53.33 (46.90)^{def}	0.00 (0.00)^{c}	66.67 (54.80)^{bc}	50.00 (44.98)^{c}	100.00 (90.00)^{a}	75.93 (60.68)^{bc}	100.00 (90.00)^{a}	85.19 (67.62)^{c}
T6	0.1 % CNSL - DR	66.67 (54.76)^{bcd}	0.00 (0.00)^{c}	95.83 (83.09)^{a}	50.00 (44.98)^{c}	100.00 (90.00)^{a}	79.26 (62.89)^{b}	100.00 (90.00)^{a}	92.59 (77.00)^{b}
T7	0.2 % CNSL - DR	76.67 (61.20)^{b}	0.00 (0.00)^{c}	100.00 (90.00)^{a}	73.33 (58.98)^{b}	100.00 (90.00)^{a}	100.00 (90.00)^{a}	100.00 (90.00)^{a}	100.00 (90.00)^{a}
T8	0.05 % CNSL - SB	30.00 (32.99)^{h}	0.00 (0.00)^{c}	54.17 (47.39)^{c}	20.00 (26.55)^{g}	100.00 (90.00)^{a}	61.85 (51.90)^{d}	100.00 (90.00)^{a}	70.37 (57.09)^{e}
T9	0.06 % CNSL - SB	33.33 (35.20)^{gh}	0.00 (0.00)^{c}	58.33 (49.81)^{c}	26.67 (30.98)^{fg}	100.00 (90.00)^{a}	68.89 (56.08)^{bcd}	100.00 (90.00)^{a}	77.78 (61.85)^{cde}
T10	0.07 % CNSL - SB	46.67 (43.06)^{fg}	0.00 (0.00)^{c}	79.17 (63.07)^{b}	33.33 (35.20)^{def}	100.00 (90.00)^{a}	70.00 (56.98)^{bcd}	100.00 (90.00)^{a}	77.78 (61.85)^{cde}
T11	0.08 % CNSL - SB	46.67 (43.06)^{fg}	0.00 (0.00)^{c}	70.83 (57.39)^{bc}	36.67 (37.21)^{def}	100.00 (90.00)^{a}	75.93 (60.68)^{bc}	100.00 (90.00)^{a}	85.19 (67.62)^{c}
T12	0.09 % CNSL - SB	50.00 (44.98)^{ef}	0.00 (0.00)^{c}	83.33 (66.17)^{b}	43.33 (41.14)^{cd}	100.00 (90.00)^{a}	75.93 (60.68)^{bc}	100.00 (90.00)^{a}	85.19 (67.62)^{c}
T13	0.1 % CNSL – SB	63.33 (52.75)^{cde}	0.00 (0.00)^{c}	100.00 (90.00)^{a}	66.67 (54.97)^{b}	100.00 (90.00)^{a}	100.00 (90.00)^{a}	100.00 (90.00)^{a}	100.00 (90.00)^{a}
T14	0.2 % CNSL - SB	73.33 (58.98)^{bc}	13.33 (21.14)^{b}	100.00 (90.00)^{a}	66.67 (54.76)^{b}	100.00 (90.00)^{a}	96.67 (83.85)^{a}	100.00 (90.00)^{a}	100.00 (90.00)^{a}
T15	0.6% soap solution (emulsifier)	3.33 (6.14)^{j}	0.00 (0.00)^{c}	29.17 (32.57)^{d}	0.00 (0.00)^{h}	70.83 (57.39)^{b}	0.00 (0.00)^{f}	100.00 (90.00)^{b}	11.11 (19.46)^{g}
T16	2 % Neem oil emulsion	10.00 (18.43)^{i}	0.00 (0.00)^{c}	29.17 (32.57)^{d}	3.33 (6.14)^{h}	75.00 (60.49)^{b}	7.04 (12.63)^{e}	100.00 (90.00)^{b}	22.22 (27.61)^{f}
T17	Thiamethoxam 25 WG 0.03 %	100.00 (90.00)^{a}	63.33 (52.75)^{a}	100.00 (90.00)^{a}	86.67 (68.83)^{a}	100.00 (90.00)^{a}	100.00 (90.00)^{a}	100.00 (90.00)^{a}	100.00 (90.00)^{a}
	C.D.(0.05)	**(8.023)**	**(2.360)**	**(12.865)**	**(7.654)**	**(3.896)**	**(7.827)**	**NS**	**(7.264)**
	SE(m)	2.779	0.818	4.457	2.652	1.350	2.712	-	2.503

*Corrected with Abbot's formula over control, Mean of 3 replication comprising 20 aphids and 10 *Riptortus pedestris* nymphs each (Values in the parentheses are arcsine transformed values).
DR- Drum roasting SB- Steam boiling HAT-Hours after treatment.

Table 2. Median Lethal concentration of cashew nut shell liquid emulsions against *Aphis craccivora* and *Riptortus pedestris*

CNSL	Lethal Dose	Estimate (Per cent)		Fiducial limits (per cent)				Chi square value	
				Lower bound		Upper bound			
		Aphis craccivora	*Riptortus pedestris*	*Aphis craccivora*	*Riptortus pedestris*	*Aphis craccivora*	*Riptortus pedestris*	*Aphis craccivora*	*Riptortus pedestris*
CNSL-DR	LC_{50}	0.079	0.095	0.066	0.082	0.091	0.109	5.325	2.849
	LC_{90}	0.250	0.275	0.198	0.221	0.356	0.381		
CNSL-SB	LC_{50}	0.084	0.102	0.071	0.088	0.098	0.119	5.898	7.530
	LC_{90}	0.275	0.334	0.216	0.261	0.394	0.479		

*CNSL- cashew nut shell liquid, DR- Drum roasting, SB- Steam boiling

the suitability of the lower dose (0.1 per cent) for management of *A. craccivora*. The pesticidal efficacy of CNSL against chilli aphid, *Aphis gossypii* was reported earlier by Sundaran and Faizal (2018) where CNSL @ 0.2 % caused cent per cent mortality at 72 HAT.

The bioefficacy of CNSL against *R. pedestris* indicated that at 48 HAT, the higher concentrations of CNSL tried *viz*., 0.2 % of both CNSL-DR and SB and 0.1 % CNSL-SB produced significantly higher mortality of 73.33, 66.67 and 66.67 respectively, though inferior to chemical check (86.67 per cent). Lower concentrations registered a mortality ranging from 20 to 50 per cent. But at 72 HAT, the mortality obtained in 0.1 and 0.2 % CNSL-DR and CNSL-SB (96.67 to 100 per cent respectively) was comparable with that of chemical check thiamethoxam. Similar trend was noticed at 96 HAT also, wherein cent per cent mortality was noticed in 0.1 and 0.2 % emulsions of both CNSL-DR and CNSL-SB as against a much low mortality of 22.22 per cent observed in conventional botanical pesticide neem oil. The results indicate the suitability of CNSL as plant derived insecticide against heteropteran sucking pests.

The main constituents of nut shell liquid of cashew are anacardic acid (60-65 %), cardol (15-20%), cardanol (10%) and traces of methyl cardol (Tyman *et al*., 1987). Since high temperature during processing is likely to decarboxylate thermally unstable anacardic acid, the composition of technical CNSL vary depending up on the processing conditions (Trevisan *et al*., 2005). Hence CNSL obtained from two widely employed processing methods *viz*., drum roasting and steam boiling (CNSL-DR and CNSL-SB), which vary considerably in the processing temperature was tested in this study to document difference if any in their insecticidal property. No significant difference was observed between the same concentrations of CNSL-DR and SB against the test insects indicating that insecticidal property of CNSL was unaffected by the difference in processing of cashew nuts. Cashew industry in Kerala mainly employs drum roasting method of processing and CNSL- DR is available in plenty at a cheaper rate.

Several malformations, possibly related to defective molting like nymphal adult intermediary formation was observed in *R. pedestris* that survived CNSL treatments. This point to the possible insect growth regulatory action of CNSL. Similar insect growth regulatory action was earlier reported by Zanuncio *et al*. (2016) for botanicals like neem oil at higher doses against predatory stink bug, *Podisus nigrispinus*. Dorn *et al*. (1986) reported insect growth regulatory action of azadirachtin on *Oncopeltus fasciatus* Dallas (Hemiptera: Lygaeidae) due to its effect on JH biosynthesis and catabolism.

The present study indicates the suitability of CNSL as a plant derived insecticide for the management of heteropteran, *R. pedestris* also, wherein a

comparatively higher dose was required and took slightly more time to achieve significant mortality than the homopteran, *A. craccivora.* CNSL @ 0.2 % was required to get an effect comparable to chemical pesticide against *R. pedestris* as against a dose requirement of 0.1 % against *A. craccivora*. The LC_{90} values of CNSL- DR against *A. craccivora* and *R. pedestris* was computed as 0.25 and 0.275 respectively in the dose mortality response studies. Since the field dose is normally fixed above LC_{90} value, CNSL @ 0.275 % or above need to be fixed for the field management of sucking pests complex. The toxicity of cashew nut shell extract against sucking pests was earlier indicated in the study of Oparaeke *et al*. (2005), where extracts of cashew nut shell + garlic bulb and cashew nutshell + African pepper mixed in the ratio of 10:10 % w/w were found effective in reducing the pod sucking bugs. Andayanie *et al*., 2019 evaluated the efficacy of hexane extract of cashew nut shells against white fly, *Bemesia tabaci* wherein a concentration of 0.75 % was reported to have antifeedant and anti oviposition activity besides causing mortality. CNSL up to 3.00 % did not cause any phytotoxic effect. Though the highest mortality of *B. tabaci* was obtained with 6.00 % CNSL, it caused phytotoxic symptoms on soybean leaves.

CNSL irrespective of concentration tested produced significantly superior mortality against both homopteran and heteropteran pests than the widely exploited botanical pesticide neem oil 2% indicating the potential of CNSL as an alternative plant derived insecticide for the management of sucking pests. Olotuah and Ofuya (2010) based on a screen house standardisation fixed a dose of 1% ethanolic extract of CNSL which when evaluated in the field conditions were found to yield more pod protection of cowpea than cypermethrin treatment from the attack of *A. craccivora* and *Maruca testulalis*. Present study reveals the possibility of utilising the technical CNSL obtained from cashew processing industry at a much lower dose of 0.2 % for the management of sucking pests of cowpea. Hence further field investigations on the effectiveness of CNSL need to be explored considering the phytotoxicity aspects. The toxicity of CNSL was earlier documented against chewing pests *viz*., coconut root grub (John *et al*., 2008), *Helicoverpa armigera* and *Spilarctia obliqua* (Mahapatro, 2011). The pesticidal property of CNSL is attributed to the presence of the phenolic compounds; cardanol and cardol (Venmalar and Nagaveni, 2005).

ACKNOWLEDGEMENTS

The authors are thankful to Kerala Agricultural University for providing the financial assistance and facilities for the conduct of research as part of PhD programme and Mahatma Cashew Exports, Kollam for providing Cashew Nut Shell Liquid.

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(Received February 14, 2020; revised ms accepted April 15, 2020; printed June 30, 2020)