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Toxicity of Conventional Insecticides against Southern Green Stink Bug, *Nezara viridula* L. in Greengram, *Vigna radiata* L.

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Southern green stink bug, *Nezara viridula* has slowly gained importance as a major pest in greengram. Conventional insecticides used in pulses ecosystem were tested against *N. viridula* under laboratory and field conditions. Under *in vitro* condition, out of three methods of insecticidal applications, the adult dip and feeding method was found to be more effective. At 1 Hour After Treatment (HAT), triazophos 40 EC (1.5 mL.L^{-1}) and dimethoate 30 EC (2.0 mL.L^{-1}) were highly effective against the adults of *N. viridula* with earliest (100%) mortality than other treatments. Under the field condition also, triazophos 40 EC (1.5 mL.L^{-1}) and dimethoate 30 EC (2.0 mL.L^{-1}) had 100 per cent population reduction over control and were found to be more effective than other insecticides *viz.,* chlorantraniliprole, thiamethoxam, neemazal and imidacloprid. Results of toxicity tests concluded that triazophos 40 EC @ 1.5 mL.L^{-1} and dimethoate 30 EC @ 2.0 mL.L^{-1} were highly effective against the adults of *N. viridula* with high mortality than other treatments under both laboratory and field conditions.

Key words: *Nezara viridula*, Greengram, Triazophos, Dimethoate.

Greengram is an important pulse crop in India. About 64 insect species attack green gram (Lal, 1985). The average loss due to the insect pests in *Vigna radiata* was estimated as 28.7 per cent (Singh *et al.*, 2015). The economically important pests of green gram include whitefly (*Bemisia tabaci* Gennadius), spotted borer (*Maruca vitrata* Fabricius), red hairy caterpillar (*Amasacta sp*), pod borer (*Helicoverpa armigera* Hubner), stem fly (*Ophiomyia phaseoli* Tryon), bruchids (*Callosobruchus sp*) and aphids (*Aphis craccivora* Koch.). In south India, southern green stink bug (*Nezara viridula* L.) has slowly gained importance as a major pest in greengram (Durairaj and Kumar, 2013). *N. viridula* is a polyphagous pest which is cosmopolitan in distribution. Nymphs and adults of stink bugs suck the sap from pods during pod formation stage resulting in chaffiness of grains. The management practices followed worldwide include sterile insect technique, biological control through release of biocontrol agents like predators, parasitoids and entomopathogens, trap crops, resistant varieties, conservation of natural enemies and usage of pesticides (Dhillon, 2007; Todd, 1989) of which pesticides play an important role in stink bugs control. Insecticides which are being used in pulse ecosystem *viz.*, triazophos, dimethoate, chlorantraniliprole, thiamethoxam, neemazal and imidacloprid were evaluated against *N. viridula* under laboratory and field condition.

Material and Methods

Laboratory and field experiments were conducted with conventionally used insecticides in greengram (Table 1) to evaluate their efficacy against *N. viridula* individually 3 to 5 days old adults obtained from mass culture using beans were used for the laboratory studies.

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Laboratory experiment

This experiment included three methods of application *viz.*, contact, feeding and feeding plus adult dip method. In the contact method, filter paper was dipped in different insecticidal solutions and allowed for shade drying. Adults of *N. viridula* were allowed to be in contact with insecticide dipped filter paper kept in petriplates. In the feeding method, immature green gram pods dipped in different insecticidal solutions were provided as food source in petriplates. In feeding plus adult dip method, adults were dipped in insecticidal solution for few seconds and allowed to feed on insecticides/ neem formulation treated green gram pods. For all the above experiments, prestarved adults of *N. viridula* were released at 10 per petriplate (9 cm dia.)/ plastic basin of size 10 x 10 cm. Adults released on water sprayed filter paper and green gram served as control. Each experimental setup was replicated thrice. Observations on mortality of adults were taken at 3,6,9,12,18 and 24 HAT for contact and feeding method. For feeding and adult dip method, observations on number of dead insects were made from 1, 2 and 3 HAT for 24 hours. The corrected per cent cumulative mortality was worked out for statistical analyses.

Field experiment

A field trial in green gram (CO 6) was laid out during Summer 2018 at TNAU in Coimbatore in a randomized block design with a plot size of 4 × 3 m with three replications. All agronomic practices were followed as per the TNAU recommendation except plant protection measures. The treatment details are as in the Table 4. Precount on *N. viridula* population was made before the initial spray by counting the number of nymphs and adults in 10 plants selected at random. First round of insecticidal spray was given at pod formation stage followed by another spray at 10 days interval. Population of *N. viridula* (both nymphs and adults) was assessed after each spray. Observations were made on 3 and 7 days after first and second spray.

Results and Discussion

Laboratory toxicity studies

Feeding method

The results of the experiment on toxicity of insecticides against *N. viridula* by feeding method were given in Table 1. At 12 HAT, the highest mortality was observed in triazophos 40 EC @1.5 mL.L^{-1} (90.00%) followed by dimethoate 30 EC @ 2.0 mL.L^{-1} (43.33%) and imidacloprid 17.8 SL @ 0.5 mL.L^{-1} (13.33%). At 24 HAT, population in triazophos 40 EC @ 1.5 mL.L^{-1} and dimethoate 30 EC @ 2.0 mL.L^{-1} treated green gram pods registered cent per cent mortality followed by 16.66, 92.2, 3.33 and 3.33 and 57.7 per cent in imidacloprid 17.8 SL @ 0.5 mL.L^{-1}, chlorantraniliprole 18.5 SC @ 0.2 mL.L^{-1} and thiamethoxam 25 WG @ 0.5 g.L^{-1} treated pods. Whereas, no mortality was observed in neemazal 1 EC @ 2.0 mL.L^{-1} treated pods. Hence, in feeding method, triazophos 40 EC @ 1.5 mL.L^{-1} was found to be highly effective against *N. viridula* adults with higher mortality when compared to other treatments.

Table 1. Toxicity of insecticides against *Nezara viridula* by feeding method

Insecticides	Dose (mL.L^{-1})	Adult mortality % 12 HAT	Adult mortality % 24 HAT	Mean
Imidacloprid 17.8 SL	0.5	13.33 ^{c}	16.66 ^{b}	14.99^{c}
		(21.14)	(23.35)	(22.24)
Dimethoate 30 EC	2.0	43.33 ^{b}	100.0 ^{a}	71.67^{b}
		(41.05)	(89.34)	(65.20)
Triazophos 40 EC	1.5	90.00 ^{a}	100.0 ^{a}	95.00^{a}
		(71.54)	(89.34)	(80.44)
Chlorantraniliprole 18.5 SC	0.2	6.66^{cd}	6.66^{bc}	6.66^{cd}
		(12.31)	(12.31)	(12.31)
Thiamethoxam 25 WG	0.5	3.33^{d}	3.3^{cd}	3.33^{de}
	(g/l)	(6.18)	(6.18)	(6.18)
Neemazal 1 EC	2.0	0.00 ^{d}	0.00 ^{d}	0.00 ^{e}
		(0.06)	(0.06)	(0.06)
Control	-	0.00 ^{d}	0.00 ^{d}	0.00 ^{e}
		(0.06)	(0.06)	(0.06)
SEd	-	6.41	5.32	5.46
CD (p= 0.05)	-	13.76**	11.42**	11.72**

All values are mean of three replications; HAT – Hours After Treatment;**Significant
Figures in the parentheses are arcsine transformed values
In a column, means followed by the common letter(s) are not significantly different by LSD (p < 0.05)

Contact method

In contact toxicity method, at 12 HAT, triazophos 40 EC @ 1.5 mL.L^{-1} recorded 83.33 per cent mortality. In all other insecticides, the mortality percentage ranged from 16.66 (dimethoate 30 EC @ 2.0 mL.L^{-1}) to 33.33 per cent (thiamethoxam 25 WG @ 0.5 g.L^{-1}). At 24 HAT, triazophos 40 EC @ 1.5 mL.L^{-1} recorded 90.00 per cent mortality followed by dimethoate 30 EC @ 2.0 mL.L^{-1} (63.33 %), imidacloprid 17.8 SL @ 0.5 mL.L^{-1} (43.33 %) and thiamethoxam 25 WG @ 0.5 g.L^{-1} (38.84 %) respectively. Whereas, there was no mortality of *N. viridula* in neemazal 1 EC at 12 and 24 HAT. Over all mean mortality showed that triazophos 40 EC @ 1.5 mL.L^{-1} was statistically significant and superior than other insecticides with 86.67 per cent mortality (Table 2).

Adult dip and Feeding method

After one HAT, triazophos 40 EC @ 1.5 mL.L^{-1} and dimethoate 30 EC @ 2.0 mL.L^{-1} recorded 100 per cent mortality followed by thiamethoxam 25 WG @ 0.5 g.L^{-1} (3.33 %). There was no mortality in imidacloprid 17.8 SL @ 0.5 mL.L^{-1} and neemazal 1 EC @ 2 mL.L^{-1} and chlorantraniliprole 18.5 SC @ 0.2 mL.L^{-1}. At 2 HAT, imidacloprid 17.8 SL @ 0.5 mL.L^{-1} caused 13.33 per cent mortality which was statistically on par with thiamethoxam 25 WG @ 0.5 g.L^{-1} (10 %) and chlorantraniliprole 18.5 SC @ 0.2

mL.L^{-1} (6.66 %). Same trend was seen at 3 HAT in which imidacloprid 17.8 SL @ 0.5 mL.L^{-1} caused 16.67 per cent mortality. Over all mean mortality represented that triazophos 40 EC @ 1.5 mL.L^{-1} and dimethoate 30 EC @ 2.0 mL.L^{-1} were highly effective against the adults of *N. viridula* with earliest mortality than other treatments (Table 3).

Table 2. Toxicity of insecticides against *Nezara viridula* by contact method

Insecticides	Dose (mL.L^{-1})	Adult mortality %		Mean
		12 HAT	24 HAT	
Imidacloprid 17.8 SL	0.5	26.66 ^{b}	43.33^{a}	29.99 ^{b}
		(30.28)	(41.14)	(35.71)
Dimethoate 30 EC	2.0	16.66 ^{b}	63.33 ^{a}	39.99 ^{b}
		(23.85)	(52.84)	(38.34)
Triazophos 40 EC	1.5	83.33 ^{a}	90.0 ^{a}	86.67 ^{a}
		(69.84)	(53.65)	(61.74)
Chlorantraniliprole 18.5 SC	0.2	0.0 ^{c}	0.0 ^{b}	0.0 ^{c}
		(0.06)	(6.26)	(0.06)
Thiamethoxam 25 WG	0.5	33.33 ^{b}	40.0 ^{a}	36.67^{b}
	(g/l)	(34.91)	(38.84)	(36.88)
Neemazal 1 EC	2.0	0.0 ^{c}	0.0 ^{b}	0.0 ^{c}
		(0.06)	(0.06)	(0.06)
Control	-	0.0 ^{c}	0.0 ^{b}	0.0 ^{c}
		(0.06)	(0.06)	(0.06)
SEd	-	7.04	15.23	10.44
CD (p= 0.05)	-	15.09**	32.67**	22.39**

All values are mean of three replications; HAT – Hours After Treatment;**Significant; Figures in the parentheses are arcsine transformed values
In a column, means followed by the common letter(s) are not significantly different by LSD ($p < 0.05$)

Field toxicity studies

Field spray of insecticides on *N. viridula* was carried out during 2017- 2018 in Department of Pulses, TNAU, Coimbatore. In the experimental plots, the population of *N. viridula* was found to be uniformily distributed (2-3 bugs/plant) before insecticidal sprays. Observation (first spray) on the mean population of *N. viridula* per ten plants (Table 4) on 3 and 7 Day After Spraying (DAS) ranged from 0.0 in dimethoate 30 EC @ 2.0 mL.L^{-1} and triazophos 40 EC @ 1.5 mL.L^{-1} to 29.10 in neemazal 1 EC @ 2.0 mL.L^{-1} against 29.8 in control respectively. However, during second spray, there was no population in dimethoate 30 EC @ 2.0 mL.L^{-1} and triazophos 40 EC @ 1.5 mL.L^{-1} sprayed plots. Mean population of *N. viridula* per ten plants on 3 and 7 DAS ranged from 0.0 in dimethoate 30 EC @ 2.0 mL.L^{-1} and triazophos 40 EC @ 1.5 mL.L^{-1} to 30.60 in control respectively.

Data on pooled mean population of *N. viridula* in 10 plants revealed that, after first spray the bug population per 10 plants ranged from 0.0 in dimethoate 30 EC @ 2.0 mL.L^{-1} and triazophos 40 EC @ 1.5 mL.L^{-1} to 19.37 bugs in neemazal 1 EC @ 2.0 mL.L^{-1} against 29.85 in control. Observation after second spray also recorded with the same trend. There was cent per cent reduction over control in triazophos 40 EC @ 1.5 mL.L^{-1} and dimethoate 30 EC @ 2.0 mL.L^{-1} compared to other treatments.

Insecticides which are being used in pulse ecosystem were evaluated against *N. viridula* under field condition. During 1980s and 1990s many workers have studied the effectiveness of pyrethroids against *N. viridula* in various crops (Corso and Gazzoni, 1998; Seymour *et al.*, 1995)1995. The effectiveness of insecticides depends on reach of insecticides to the target *N. viridula.* Hence, the insecticides were evaluated on the possible route of reach i.e., feeding, contact and feeding plus adult dip methods under laboratory condition against *N. viridula.*

In the present study, under *in vitro* condition, out of three methods of insecticidal applications, adult dip and feeding method was found to be more effective than other methods. In the present study, thiamethoxam 25 WG proved to be moderately toxic in all methods. This in accordance with the reports by Tillman (2006) who found that thiamethoxam were moderately toxic to *N. viridula* with 82.5 and 80 per cent mortality in residual toxicity and food toxicity studies. In all types of *invitro* toxicity study and field conditions, Neemazal (neem formulation) has no expected control but have some effect (reduction in population) due to antifeedant and repellant. In contrary to this result, Singha *et al.* (2007)A</

Table 3. Toxicity of insecticides against *Nezara viridula* by adult dip and feeding method

Insecticides	Dose ($mL.L^{-1}$)	Adult mortality % 1 HAT	Adult mortality % 2 HAT	Adult mortality % 3 HAT	Mean
Imidacloprid 17.8 SL	0.5	0.0 ^{b} (0.06)	13.33 ^{b} (21.41)	16.67 ^{b} (23.25)	30.65^{b} (14.85)
Dimethoate 30 EC	2.0	100.00 ^{a} (89.34)	100.00 ^{a} (89.34)	100.00 ^{a} (89.34)	100.00^{a} (89.34)
Triazophos 40 EC	1.5	100.00^{a} (89.34)	100.00 ^{a} (89.34)	100.00^{a} (89.34)	100.00^{a} (89.34)
Chlorantraniliprole 18.5 SC	0.2	0.0 ^{b} (0.06)	6.66^{b} (12.31)	6.66^{bc} (12.31)	6.66^{bc} (8.22)
Thiamethoxam 25 WG	0.5 (g/l)	3.33^{b} (6.18)	10.00 ^{b} (15.01)	10.00^{b} (15.01)	10.00^{b} (12.07)
Neemazal 1 EC	2.0	0.0 ^{b} (0.06)	0.0 ^{c} (0.06)	0.0 ^{c} (6.26)	0.0^{c} (0.06)
Control	-	0.0 ^{b} (0.06)	0.0 ^{c} (0.06)	0.0 ^{c} (6.26)	0.0^{c} (0.06)
SEd	-	3.27	5.50	5.93	4.48
CD (P= 0.05)	-	7.02**	11.81**	12.72**	9.61**

All values are mean of three replications; HAT – Hours After Treatment;**Significant
Figures in the parentheses are arcsine transformed values
In a column, means followed by the common letter(s) are not significantly different by LSD ($p < 0.05$)

author><author>Thareja, V</author><author>Singh, AK</author></authors></contributors><titles><title >Application of neem seed kernel extracts result in mouthpart deformities and subsequent mortality in Nezara viridula (L. reported that Neem seed kernel extracted using hexane (2.5 %) caused 100 per cent mortality and Neem seed kernel aqueous suspension caused 70 per cent mortality on fourth instar nymphs of *N. viridula.* Similarly, Riba *et al.* (2003) found that 95 per cent azadirachtin (neem formulation) caused cent

Table 4. Effect of insecticides against *Nezara viridula* on greengram under field condition

Insecticides	Dose ($mL.L^{-1}$)	PTC	Population of *N. viridula** (Nos. /10 plants) I Spray 3 DAS	I Spray 7 DAS	Mean	II Spray 3 DAS	II Spray 7 DAS	II Spray Mean	Pooled mean of 2 sprays	Reduction over control # (%)
Imidacloprid 17.8 SL	0.5	20	17.70^{c} (4.27)	19.67^{d} (4.27)	18.68^{cd} (4.44)	18.68^{cd} (4.38)	13.77^{b} (3.78)	16.23^{b} (4.03)	17.45^{bc} (4.23)	41.33^{bc} (39.97)
Dimethoate 30 EC	2.0	22	0.00^{a} (0.71)	0.00^{a} (0.71)	0.00^{a} (0.71)	0.00^{a} (0.71)	0.00^{a} (0.71)	0.00^{a} (0.71)	0.00^{a} (0.71)	100.00^{a} (89.34)
Triazophos 40 EC	1.5	24	0.00^{a} (0.71)	0.00^{a} (0.71)	0.00^{a} (0.71)	0.00^{a} (0.71)	0.00^{a} (0.71)	0.00^{a} (0.71)	0.00^{a} (0.71)	100.00^{a} (89.34)
Chlorantraniliprole 18.5 SC	0.2	25	19.60^{d} (4.48)	13.72^{b} (3.77)	16.66^{b} (4.20)	16.66^{bc} (4.14)	22.54^{d} (4.80)	19.60^{c} (4.48)	18.13^{bc} (4.30)	39.13^{bc} (38.67)
Thiamethoxam 25 WG	0.5 (g/l)	24	15.52^{b} (4.00)	17.46^{c} (4.24)	16.49^{bc} (4.18)	16.49^{b} (4.12)	17.46^{c} (4.24)	16.98^{c} (4.18)	16.73^{b} (4.15)	43.96^{b} (41.52)
Neemazal 1 EC	2.0	22	18.12^{c} (4.31)	20.18^{d} (4.54)	19.13^{d} (4.48)	19.13^{d} (4.43)	20.13^{d} (4.54)	19.63^{b} (4.48)	19.37^{c} (4.45)	34.85^{c} (36.08)
Control	-	26	26.00^{d} (5.16)	32.11^{e} (5.71)	29.10^{e} (5.48)	29.10^{e} (5.44)	32.00^{e} (5.71)	30.60^{d} (5.58)	29.85^{d} (5.50)	-
SEd	-		0.113	0.113	0.113	0.113	0.119	0.116	0.115	2.07
CD (P = 0.05)	-		0.246**	0.248**	0.246**	0.247**	0.260**	0.254**	0.251**	4.51**

Mean of three replications. DAS – Days after spray. **Significant
*Figures in Parentheses are square root) values; #Figures in Parentheses are arc sine transformed values.
In a column means followed by the same letter (s) are not significant by LSD ($p < 0.05$)

per cent mortality at 200ng dose/fifth instar nymph. Though chlorantraniliprole 18.5 SC @ 0.2 $mL.L^{-1}$ was highly effective for pests in pulse ecosystem (Patange and Chiranjeevi, 2017; Sambathkumar *et al.*, 2015), present study results showed no expected control to stink bugs. Triazophos 40 EC @ 1.5 $mL.L^{-1}$ and dimethoate 30 EC @ 2.0 $mL.L^{-1}$ were highly effective against *N. viridula* with greater reduction in population than control under field conditions.

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