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Management of major insect pests of black gram under dryland conditions

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Abstract
Field experiments were conducted during *rabi* 2011 and 2013 to evaluate the efficacy of different insecticidal treatments against aphid, *Aphis craccivora* Koch, leafhopper, *Empoasca kerri* Pruthi, defoliator, *Spodoptera litura* (Fab.) and pod borer, *Helicoverpa armigera* (Hub.) on black gram. The results showed that seed treatment with thiamethoxam 25 WG @ 3 g/ kg of seed + spray with thiamethoxam 25 WG @ 0.4 g/ l recorded the lowest population of aphids (1.60, 1.45 no. /plant) and leafhoppers (2.36, 2.12 no./ plant) followed by spraying of imidacloprid 17.8 SL @ 0.4 ml/ l with 83.96, 87.45 kg and 66.13, 71.61 per cent reduction over control, respectively after second round of spraying in the fields trials I and II. Indoxacarb 14.5 SC @ 1 ml/ l provided an effective control of *S. litura* and *H. armígera* which recorded 0.04, 0.00 and 0.09, 0.03 nos of larvae/plant at 7th day after the second application in the field trial I and II, respectively, which was at par, with sponsored 45 SC @ 0.4 ml/ l (0.08, 0.07 and 0.13, 0.13 at 7 DAT of second application) but was significantly better than the untreated control. Thus, seed treatment with thiamethoxam 25 WG @ 3 g/kg of seed + spray with thiamethoxam 25 WG @ 0.4 g/ l and indoxacarb 14.5 SC @ 1 ml/ l proved effective against sucking pests and borers of black gram, respectively and can be recommended for their use in black gram ecosystem.

Keywords: Insecticides, sucking pests, defoliator, pod borer, black gram

1. Introduction
Pulses are rich in proteins and it is the second important constituent of Indian diet after cereals. Undoubtedly, pulses have been considered as poor man's meat for the underprivileged people who cannot afford animal proteins. Among the different pulses, black gram is a rich source of protein which is one of the essential nutrients of human diet. Black gram (*Vigna mungo* L.) contributes 10% to the national pulse production from an area of 13%. The area under black gram in India is about 3.25 million ha with production of 1.81 million tonnes and productivity of 463 kg ha^{-1} [1]. In Tamil Nadu, black gram is cultivated in an area of 3.41 lakh ha with 1.21 lakh tonnes production and an average productivity of 354.84 kg ha^{-1} [2]. Black gram has many important insect pests that cause serious damage and reduction in yield. In India, quantitative avoidable losses (7-35%) caused by insect pest complex, both in black gram and green gram vary with different agro-climatic conditions [3]. On an average, 2.5 to 3.0 million tonnes of pulses are lost annually due to pest problems [4]. The annual yield loss due to the insect pests has been estimated at about 30 per cent in urd bean and mung bean. Farmers rely on insecticides for the management of insect pests in black gram. Hence, the present study was undertaken to identify an efficacious insecticide for the management of sucking pests as well as borers in black gram.

2. Materials and Methods
The field trials were conducted at the farm of Agricultural Research Station, Tamil Nadu Agricultural University, Kovilpatti, Tuticorin District, Tamil Nadu, India during *rabi* season of 2011-12 and 2013-14. The experimental sites are situated approximately 9˚10' N latitude, 77˚52' E longitude and 90 m above MSL. Eight treatments including control were evaluated and each treatment was replicated three times. The crop was grown with a package of practices recommended by TNAU [5]. The treatment against aphids and leafhoppers are presented in Table 1-8. Two sprays were conducted at 15 and 10 days interval in the case of sucking pests and borers starting with the initiation of insect pests by using Knapsack sprayer at 500 l of spray fluid/ ha. For aphids and leafhoppers, observation was recorded on ten randomly selected plants at three leaves/ plant (top, middle and bottom) and for borers, the number of

Larvae/plant was recorded on ten randomly selected plants of each replication and the mean number of aphids, leafhoppers, defoliator and pod borer were worked out.

The data thus obtained from field experiments in a Randomized Block Design were analyzed statistically by ANOVA using the package AGRES after converting it to square root value and arcsine percentage.

3. Results and Discussion

The results on the efficacy of insecticides against major insect pests of black gram are presented in Table 1-8.

3.1. Aphid, *A. craccivora*

In the field trial I, the pretreatment observation indicated that the aphid population varied between 10.66 and 12.66/ plant (Table 1). Seed treatment with thiamethoxam 25 WG @ 3 g/ kg of seed + spray with thiamethoxam 25 WG @ 0.4 g/ l recorded the minimum population of aphids (0.73/ plant) followed by spraying of imidacloprid 17.8 SL @ 0.4 ml/ l (1.03/ plant) on the first day after treatment (DAT). A similar trend was observed on 3, 7 and 14 DAT. The results of the second application revealed that aphid population was 0.60 aphids/ plant in the seed treatment with thiamethoxam 25 WG @ 3 g/ kg of seed + spray with thiamethoxam 25 WG @ 0.4 g/ l followed by spraying of imidacloprid 17.8 SL @ 0.4 ml/ l (0.87/ plant) on one DAT. Spraying of neem oil 3% was found to be less effective among all the treatments, however, found to be superior over the untreated check (Table 1).

Table 1: Effect of Insecticides on Aphids, *Aphis craccivora* in Black gram (Field Trial I)

Treatments	Aphids/ 3 leaves/ plant (no.)													
	Days after first application							Days after second application						
	PTC	1	3	7	14	Mean	% Redn	PTC	1	3	7	14	Mean	% Redn
Soil application of neem cake + spray with neem oil 3%	12.67	1.23 (1.11)	1.40 (1.18)	3.87 (1.97)	5.53 (2.35)	3.01	76.21	10.00	1.40 (1.18)	1.67 (1.29)	2.53 (1.59)	4.07 (2.01)	2.42	79.78
Seed treatment (ST) with thiamethoxam 25 WG @ 3g/kg of seed + spray with thiamethoxam 25 WG @ 0.4g/ l	12.67	0.73 (0.85)	0.80 (0.89)	1.53 (1.24)	3.60 (1.90)	1.67	86.80	10.67	0.60 (0.76)	0.67 (0.81)	1.80 (1.34)	3.33 (1.82)	1.60	86.63
ST with dimethoate 30 EC @ 5 ml/ kg of seed + spray with dimethoate 30 EC @ 2 ml/ l	12.00	0.90 (0.95)	1.13 (1.06)	1.93 (1.39)	4.07 (2.02)	2.01	84.11	12.00	0.83 (0.91)	1.00 (0.99)	2.27 (1.50)	3.93 (1.98)	2.01	83.21
Spraying of imidacloprid 17.8 SL @ 0.4 ml/ l	10.67	1.03 (1.01)	1.07 (1.03)	1.87 (1.36)	4.00 (2.00)	1.99	84.27	11.33	0.87 (0.93)	0.93 (0.96)	2.00 (1.41)	3.87 (1.97)	1.92	83.96
Spraying of triazophos 40 EC @1.5 ml/ l	11.33	0.80 (0.89)	1.27 (1.12)	2.07 (1.44)	4.20 (2.05)	2.09	83.48	9.33	0.93 (0.96)	1.20 (1.09)	2.40 (1.55)	4.20 (2.05)	2.18	81.79
Spraying of dimethoate 30 EC@ 2.0 ml/ l	12.00	0.97 (0.98)	1.20 (1.09)	2.00 (1.41)	4.13 (2.03)	2.08	83.56	11.50	1.00 (0.99)	1.13 (1.06)	2.20 (1.48)	4.07 (2.01)	2.10	82.46
Spray with Neem oil 3%	12.00	1.63 (1.28)	1.80 (1.34)	4.20 (2.05)	5.60 (2.37)	3.31	73.83	10.77	1.60 (1.26)	1.87 (1.36)	2.80 (1.67)	4.40 (2.10)	2.67	77.69
Untreated check	11.80	12.03 (3.47)	12.67 (3.56)	12.57 (3.54)	13.33 (3.65)	12.65	-	11.00	11.93 (3.46)	12.00 (3.46)	13.33 (3.65)	10.60 (3.26)	11.97	-
SE.D	0.160	0.066	0.046	0.069	0.049	-	-	0.072	0.089	0.070	0.051	0.051	-	-
CD (P = 0.05)	NS	0.141	0.098	0.148	0.105	-	-	0.154	0.191	0.149	0.111	0.107	-	-

PTC - Pretreatment count; DAT - Days after treatment; Figures in the parentheses are square root transformed values

In the field trial II, the mean aphid population was minimum in seed treatment with thiamethoxam 25 WG @ 3 g/ kg of seed + spray with thiamethoxam 25 WG @ 0.4 g/ l 14 days after application of insecticides (1.68 nos/ plant) and was found to be superior in controlling the aphids in black gram (Table 2). This treatment was followed by spraying of imidacloprid 17.8 SL @ 0.4 ml/ l (2.08). Among the treatments excluding untreated check, the least efficacy was recorded by name oil treatment at 3 percent (4.04). However, all the treatments were significantly superior to untreated control which exhibited mean aphid population of 14.23. The pre treatment observation prior to second application revealed that the population of aphids varied between 10.87 and 15.27/ 3 leaves/ plant. The data recorded on the first day after the second spraying showed that the seed treatment with thiamethoxam 25 WG @ 3 g/ kg of seed + spray with thiamethoxam 25 WG @ 0.4 g/ l recorded

0.80 aphids, / 3 leaves/ plant which was followed by spraying of imidacloprid 17.8 SL @ 0.4 ml/ l (1.03 aphids/ 3 leaves/ plant. But soil application of neem cake + spray with neem oil 3% and spraying with neem oil though recorded more number of aphids/ plant when compared to insecticides, they were significantly superior to untreated control. The observations made on the third day after the second application revealed that seed treatment with thiamethoxam 25 WG @ 3 g/ kg of seed + spray with thiamethoxam 25 WG @ 0.4 g/ l recorded 0.73 aphids/ plant followed by spraying of imidacloprid 17.8 SL @ 0.4 ml/l (0.97 aphids/ plant). The other insecticidal treatments *viz*., seed treatment with dimethoate 30 Ec @ 5 ml/ kg of seed + spray with dimethoate 30 EC @ 2 ml/ l, spraying of dimethoate 30 EC@ 2.0 ml/ l and spraying of triazophos 40 EC @1.5 ml/ l were found to be on par with each other. The observation recorded in 7 and 14 days showed a similar trend, whereas all the treatments of insecticides and botanicals were effective in reducing the population of aphids. The per cent reduction of aphids over control after second application indicated that seed treatment with thiamethoxam 25 WG @ 3 g/ kg of seed + spray with thiamethoxam 25 WG @ 0.4 g/ l exerted 90.32 per cent reduction of aphids followed by spraying of imidacloprid 17.8 SL @ 0.4 ml/ l (87.45 %), seed treatment with dimethoate 30 Ec @ 5 ml/ kg of seed + spray with dimethoate 30 EC @ 2 ml/ l (85.51 %), spraying of dimethoate 30 EC @ 2.0 ml/ l (84.58 %) and spraying of triazophos 40 EC @ 1.5 ml/ l (83.58 %). The botanical treatments like soil application of neem cake + spray with neem oil 3% and spray with neem oil 3% gave 77.70 and 77.04 per cent reduction, respectively (Table 2). This is in accordance with the previous findings that treatment of cotton seeds with thiamethoxam at 2.85 g/ kg appeared to be optimum for the control of early sucking pests [6]. Imidacloprid 17.8 SL @ 50 g a.i./ha was the effective insecticide against aphid and it was on par with thiamethoxam and acetamiprid [7].

Table 2: Effect of Insecticides on Aphids, *Aphis craccivora* in Black gram (Field trial II)

Treatments	Aphids/ 3 leaves/ plant (no.)													
	Days after first application							Days after second application						
	PTC	1	3	7	14	Mean	% Redn	PTC	1	3	7	14	Mean	% Redn
Soil application of neem cake + spray with neem oil 3%	12.60	1.90 (1.70)	2.10 (1.76)	3.63 (2.15)	6.17 (2.68)	3.45	75.76	13.60	2.17 (1.78)	2.20 (1.79)	3.37 (2.09)	5.60 (2.57)	3.34	77.70
Seed treatment (ST) with thiamethoxam 25 WG @ 3g/kg of seed + Spray with thiamethoxam 25 WG @ 0.4g/ l	12.97	0.93 (1.39)	0.80 (1.34)	1.53 (1.59)	3.47 (2.11)	1.68	88.19	10.87	0.80 (1.34)	0.73 (1.32)	1.40 (1.55)	2.87 (1.97)	1.45	90.32
ST with dimethoate 30 Ec @ 5 ml/ kg of seed + Spray with dimethoate 30 EC @ 2 ml/ l	13.27	1.47 (1.57)	1.33 (1.53)	2.17 (1.78)	4.23 (2.29)	2.30	83.84	12.07	1.33 (1.53)	1.30 (1.52)	2.20 (1.79)	3.83 (2.20)	2.17	85.51
Spraying of imidacloprid 17.8 SL @ 0.4 ml/ l	11.90	1.13 (1.46)	1.07 (1.44)	2.03 (1.74)	4.10 (2.26)	2.08	85.38	11.33	1.03 (1.43)	0.97 (1.40)	1.93 (1.71)	3.57 (2.14)	1.88	87.45
Spraying of triazophos 40 EC @1.5 ml/ l	12.67	1.60 (1.61)	1.47 (1.57)	2.30 (1.82)	4.50 (2.34)	2.47	82.64	11.33	1.53 (1.59)	1.50 (1.58)	2.47 (1.86)	4.33 (2.31)	2.46	83.58
Spraying of dimethoate 30 EC@ 2.0 ml/ l	12.20	1.53 (1.59)	1.43 (1.56)	2.23 (1.80)	4.37 (2.32)	2.39	83.20	11.60	1.40 (1.55)	1.43 (1.56)	2.33 (1.83)	4.07 (2.25)	2.31	84.58
Spray with Neem oil 3%	10.97	2.50 (1.87)	2.83 (1.96)	4.53 (2.35)	6.30 (2.70)	4.04	71.61	13.47	2.27 (1.81)	2.23 (1.80)	3.60 (2.14)	5.67 (2.58)	3.44	77.04
Untreated check	12.30	14.23 (3.89)	13.50 (3.80)	14.30 (3.91)	14.90 (3.99)	14.23	-	15.27	14.80 (3.98)	15.13 (4.02)	15.07 (4.01)	14.93 (3.99)	14.98	-
SE.D	0.130	0.141	0.105	0.088	0.090	-	-	0.052	0.060	0.063	0.056	0.058	-	-
CD (P = 0.05)	NS	0.305	0.228	0.190	0.194	-	-	NS	0.130	0.137	0.122	0.125	-	-

PTC - Pretreatment count; DAT - Days after treatment; Figures in the parentheses are square root transformed values

3.2. Leafhopper, *E. kerri*

During first field trial, the incidence of leafhopper ranged from 7.33 to 7.80 plant^{-1} prior to first spray (Table 3). The seed treatment with thiamethoxam 25 WG @ 3 g/kg of seed + spray with thiamethoxam 25 WG @ 0.4 g/ l showed significantly less population (3.53/ plant) at 14 DAT followed by spraying of imidacloprid 17.8 SL @ 0.4 ml/ l (3.80/ plant). The spraying of neem oil at 3% was found to be less effective (4.80/plant) however superior over untreated check (7.86/ plant). Similar trend was observed after the second round of application also.

Based on the mean population, the order of efficacy of different treatments are given as follows: seed treatment with thiamethoxam 25 WG @ 3 g/ kg of seed + spray with thiamethoxam 25 WG @ 0.4 g/ l > spraying of imidacloprid 17.8 SL @ 0.4 ml/ l > spraying of triazophos 40 EC @ 1.5 ml/ l > ST with dimethoate 30 EC @ 5 ml/ kg of seed + spray with dimethoate 30 EC @ 2 ml/ l > spraying of dimethoate 30 EC@ 2.0 ml/ l > soil application of neem cake + spray with neem oil 3% > spraying of neem oil 3% > untreated check (Table 3).

Table 3: Effect of Insecticides on Leafhopper, *Empoasca kerri* in Black gram (Field trial I)

Treatments	Leafhopper/ 3 leaves/ plant (no.)													
	Days after first application							Days after second application						
	PTC	1	3	7	14	Mean	% Redn	PTC	1	3	7	14	Mean	% Redn
Soil application of neem cake + Spray with Neem oil 3%	7.60	2.30 (1.18)	2.33 (1.53)	3.13 (1.77)	4.73 (2.18)	3.12	60.41	7.63	2.33 (1.52)	2.47 (1.57)	3.13 (1.77)	4.60 (2.14)	3.13	61.02
Seed treatment (ST) with thiamethoxam 25 WG @ 3g/kg of seed + spray with thiamethoxam 25 WG @ 0.4g/ l	7.60	1.53 (0.76)	1.47 (1.21)	2.20 (1.48)	3.53 (1.88)	2.18	72.34	7.53	1.70 (1.45)	1.67 (1.29)	2.47 (1.57)	3.60 (1.90)	2.36	70.61
ST with dimethoate 30 EC @ 5 ml/ kg of seed + Spray with dimethoate 30 EC @ 2 ml/ l	7.80	2.17 (0.91)	2.13 (1.46)	2.87 (1.69)	4.00 (2.00)	2.79	64.59	7.13	2.30 (1.46)	2.20 (1.48)	3.00 (1.73)	4.60 (2.14)	3.03	62.27
Spraying of imidacloprid 17.8 SL @ 0.4 ml/ l	7.73	1.93 (0.93)	1.87 (1.37)	2.60 (1.63)	3.80 (1.95)	2.55	67.64	7.80	1.97 (1.39)	1.93 (1.39)	2.83 (1.68)	4.13 (2.03)	2.72	66.13
Spraying of triazophos 40 EC @1.5 ml/ l	7.33	2.07 (0.96)	2.00 (1.41)	2.73 (1.65)	3.93 (1.98)	2.68	65.99	8.07	2.13 (1.44)	2.00 (1.41)	2.87 (1.69)	4.20 (2.05)	2.80	65.13
Spraying of dimethoate 30 EC@ 2.0 ml/ l	7.67	2.20 (0.99)	2.27 (1.51)	3.00 (1.73)	4.13 (2.03)	2.90	63.20	7.80	2.37 (1.48)	2.40 (1.55)	3.20 (1.79)	4.53 (2.13)	3.13	61.02
Spraying of Neem oil 3%	7.60	2.40 (1.26)	2.60 (1.61)	3.40 (1.84)	4.80 (2.19)	3.30	58.12	7.67	2.60 (1.54)	2.67 (1.63)	3.53 (1.88)	4.87 (2.20)	3.42	57.41
Untreated check	7.73	7.80 (3.46)	7.93 (2.82)	7.93 (2.82)	7.87 (2.80)	7.88	-	7.43	7.93 (2.79)	8.13 (2.85)	8.07 (2.84)	8.00 (2.83)	8.03	-
SE.D	0.040	0.089	0.051	0.035	0.028	-	-	0.020	0.091	0.043	0.045	0.041	-	-
CD (P = 0.05)	NS	0.191	0.110	0.075	0.061	-	-	NS	0.195	0.093	0.096	0.089	-	-

PTC - Pretreatment count; DAT - Days after treatment; Figures in the parentheses are square root transformed values

During the second field trial, the pre treatment count ranged between 7.57 and 8.40 leafhoppers/ 3 leaves/ plant (Table 4). Seed treatment with thiamethoxam 25 WG @ 3 g/ kg of seed + spray with thiamethoxam 25 WG @ 0.4 g/ l recorded the lowest incidence of 1.33, 0.93, 2.10 and 3.47 leafhopper/ 3 leaves/ plant in 1, 3, 7 and 14 days after treatment (DAT) than any other treated plots. Likewise, after second application also, seed treatment with thiamethoxam 25 WG @ 3 g/ kg of seed + spray with thiamethoxam 25 WG @ 0.4 g/ l proved the best by recording minimim leafhoppers than all other treatments (Table 4). Based on the per cent reduction of leafhopper over control after the second application, the order of efficacy of the treatments are as follows: seed treatment with thiamethoxam 25 WG @ 3 g/ kg of seed + spray with thiamethoxam 25 WG @ 0.4 g/ l > spraying of imidacloprid 17.8 SL @ 0.4 ml/ l > spraying of triazophos 40 EC @1.5 ml/ l > ST with dimethoate 30 Ec @ 5 ml/ kg of seed + spray with dimethoate 30 EC @ 2 ml/ l > spraying of dimethoate 30 EC@ 2.0 ml/ l > soil application of neem cake + spray with neem oil 3% > spray with neem oil 3% > untreated check. This is in agreement with the earlier findings that the efficacy of thiamethoxam (Cruiser 70 WS) at 2 or 3 g a.i./ kg cotton seed was compared with imidacloprid (Gaucho 70 WS) at 3.5 g a.i./ kg of seeds against jassids and the results revealed that thiamethoxam at 2 or 3 g a.i./ kg cotton seeds were as effective as imidacloprid at 3.5 g a.i./ kg of seeds in the reduction of pest population [8].

Table 4: Effect of Insecticides on Leafhopper, *Empoasca kerri* in Black gram (Field trial II)

Treatments	Leafhopper/ 3 leaves/ plant (no.)													
	Days after first application							Days after second application						
	PTC	1	3	7	14	Mean	% Redn	PTC	1	3	7	14	Mean	% Redn
Soil application of neem cake + Spray with Neem oil 3%	7.67	2.67 (1.91)	3.23 (2.06)	3.97 (2.23)	5.23 (2.50)	3.78	52.33	8.10	2.60 (1.90)	3.10 (2.02)	3.87 (2.21)	5.10 (2.47)	3.67	60.83
Seed treatment (ST) with thiamethoxam 25 WG @ 3 g/ kg of seed + spray with thiamethoxam	8.40	1.33 (1.53)	0.93 (1.39)	2.10 (1.76)	3.47 (2.11)	1.96	75.28	7.43	1.47 (1.57)	1.13 (1.46)	2.37 (1.84)	3.50 (2.12)	2.12	77.37

25 WG @ 0.4g/ l														
ST with dimethoate 30 Ec @ 5 ml/ kg of seed + spray with dimethoate 30 EC @ 2 ml/ l	8.13	2.20 (1.79)	1.93 (1.71)	2.87 (1.97)	4.13 (2.27)	2.78	64.94	7.90	2.30 (1.82)	2.23 (1.80)	2.97 (1.99)	4.70 (2.39)	3.05	67.45
Spraying of imidacloprid 17.8 SL @ 0.4 ml/ l	7.60	1.77 (1.66)	1.53 (1.59)	2.50 (1.87)	3.97 (2.23)	2.44	69.23	7.40	1.90 (1.70)	1.73 (1.65)	2.77 (1.94)	4.23 (2.29)	2.66	71.61
Spraying of triazophos 40 EC @1.5 ml/ l	7.57	1.90 (1.70)	1.63 (1.62)	2.67 (1.91)	4.07 (2.25)	2.57	67.59	7.73	2.03 (1.74)	1.97 (1.72)	2.80 (1.95)	4.40 (2.32)	2.80	70.12
Spraying of dimethoate 30 EC@ 2.0 ml/ l	8.33	2.23 (1.80)	2.03 (1.74)	3.07 (2.02)	4.20 (2.28)	2.88	63.68	7.90	2.37 (1.83)	2.30 (1.82)	3.10 (2.02)	4.67 (2.38)	3.11	66.81
Spraying of Neem oil 3%	7.90	2.53 (1.88)	3.40 (2.10)	4.10 (2.26)	5.40 (2.53)	3.86	51.32	8.00	2.47 (1.86)	2.93 (1.98)	4.00 (2.24)	5.37 (2.52)	3.69	60.62
Untreated check	7.73	7.93 (2.99)	8.10 (3.02)	7.90 (2.98)	7.80 (2.97)	7.93	-	8.50	8.87 (3.14)	9.03 (3.17)	9.60 (3.26)	9.97 (3.31)	9.37	-
SE.D	0.06	0.071	0.054	0.058	0.050	-	-	0.029	0.048	0.047	0.038	0.060	-	-
CD (P = 0.05)	NS	0.154	0.117	0.125	0.109	-	-	NS	0.104	0.102	0.083	0.130	-	-

PTC - Pre treatment count; DAT - Days after treatment; Figures in the parentheses are square root transformed values

3.3. Defoliator, *S. litura*

The incidence of *S. litura* during *rabi* 2011 and 2013 was significantly low in all insecticidal treatments when compared to untreated control plots, after each of first and second insecticidal application (Table 5 and 6). In both the field trials, indoxacarb 14.5 SC @ 1 ml/ l registered low or nil incidence of *S. litura* after imposing insecticidal treatments. This was followed by spinosad 45 SC @ 0.4 ml/ l and emamectin benzoate 5 WG @ 0.4 g/ l which recorded 0.10 larva/ plant at 7 DAT of first application and 0.08 and 0.11 larva/ plant at 7 DAT of second application in the field trial I and 0.1 and 0.07 larva/ plant at 7 DAT of first and the second application, respectively and were found to be on par with each other. The other insecticidal doses were also found to be significantly superior over untreated check. The efficacy of spinosad and emamectin benzoate in the present investigation was in line with the findings that among nine insecticides evaluated against *S. littoralis*, chlorantraniliprole (0.006%), spinosad (0.018%) and emamectin benzoate (0.002%) were noticed higher effective and statistically at par with each other [9].

Table 5: Effect of Insecticides on Defoliator, *Spodoptera litura* in Black gram (Field trial I**)**

Treatments	**Mean larvae/ plant (no.)**					
	Days after first application			**Days after second application**		
	PTC	**3 DAT**	**7 DAT**	**PTC**	**3 DAT**	**7 DAT**
Indoxacarb 14.5 SC @ 1 ml/ l	1.53	0.06	0.00	0.33	0.09	0.04
Thiodicarb 75 WP @ 1 g/ l	1.66	0.58	0.41	1.40	0.61	0.41
Spinosad 45 SC @ 0.4 ml/ l	1.60	0.12	0.10	0.47	0.13	0.08
Emamectin Benzoate 5 WG @ 0.4 g/ l	1.52	0.15	0.10	0.57	0.17	0.11
Quinalphos 25 EC @ 2 ml/ l	1.47	0.86	0.50	1.40	0.80	0.30
Chlorpyriphos 20 EC @ 2.5 ml/ l	1.43	0.58	0.46	1.30	0.56	0.49
Carbaryl 50 WP @ 2 g/ l	1.54	1.06	0.70	1.43	0.91	0.79
Untreated Check	1.54	1.78	1.80	1.53	1.06	1.20
SE.D	0.07	0.08	0.08	0.06	0.09	0.05
CD (P = 0.05)	NS	0.20	0.17	NS	0.24	0.16

PTC - Pretreatment count; DAT - Days after treatment

Table 6: Effect of Insecticides on Defoliator, *Spodoptera litura* in Black gram (Field trial II)

Treatments	**Mean larvae/ plant (no.)**					
	Days after first application			**Days after second application**		
	PTC	3 DAT	7 DAT	PTC	3 DAT	7 DAT
Indoxacarb 14.5 SC @ 1 ml/ l	1.23	0.03	0.00	0.23	0.00	0.00
Thiodicarb 75 WP @ 1 g/ l	1.33	0.07	0.53	1.07	0.63	0.40
Spinosad 45 SC @ 0.4 ml/ l	1.40	0.13	0.10	0.53	0.10	0.07
Emamectin Benzoate 5 WG @ 0.4 g/ l	1.23	0.17	0.10	0.60	0.13	0.07
Quinalphos 25 EC @ 2 ml/ l	1.20	0.80	0.90	1.30	0.73	0.60
Chlorpyriphos 20 EC @ 2.5 ml/ l	1.33	0.63	0.60	1.23	0.60	0.47
Carbaryl 50 WP @ 2 g/ l	1.30	0.97	0.67	1.40	0.90	0.70
Untreated Check	1.27	1.80	2.00	2.83	2.80	2.97
SE.D	0.60	0.05	0.03	0.05	0.04	0.03
CD (P = 0.05)	NS	0.10	0.07	NS	0.08	0.08

PTC - Pretreatment count; DAT - Days after treatment

3.4. Pod borer, *H. armigera*

During 2011, the population of pod borer, *H. armigera* was reduced significantly in plots treated with indoxacarb 14.5 SC @ 1 ml/ l (0.09 larva/ plant) and spinosad 45 SC @ 0.4 ml/ l (0.13 larva/ plant) at 7 DAT of second application when compared to untreated control (1.79 larva/ plant) (Table 7). Indoxacarb 14.5 SC @ 1 ml/ l maintained its superiority during 2013 too, with 0.07 and 0.03 larva/ plant at 7 DAT after first and second spraying, respectively (Table 8). The effectiveness of indoxacarb 14.5 SC @ 1 ml/ l was followed by spinosad 45 SC @ 0.4 ml/ l and emamectin benzoate 5 WG @ 0.4 g/ l which recorded 0.10 and 0.13 larva/ plant at 7 DAT of I and II application. The efficacy of indoxacarb and spinosad against *H. armigera* has been reported earlier [10], [11].

Table 7: Effect of Insecticides on Pod borer, *Helicoverpa armigera* in Black gram (Field Trial I)

Treatments	Mean larvae/ plant (no.)					
	Days after first application			Days after second application		
	PTC	3 DAT	7 DAT	PTC	3 DAT	7 DAT
Indoxacarb 14.5 SC @ 1 ml/ l	1.59	0.12	0.07	0.40	0.15	0.09
Thiodicarb 75 WP @ 1 g/ l	1.45	0.21	0.14	0.53	0.33	0.16
Spinosad 45 SC @ 0.4 ml/ l	1.49	0.12	0.09	0.47	0.14	0.13
Emamectin Benzoate 5 WG @ 0.4 g/ l	1.70	0.13	0.10	0.53	0.23	0.21
Quinalphos 25 EC @ 2 ml/ l	1.60	0.76	0.56	1.40	0.46	0.39
Chlorpyriphos 20 EC @ 2.5 ml/ l	1.43	0.22	0.14	1.30	0.20	0.16
Carbaryl 50 WP @ 2 g/ l	1.51	0.71	0.62	1.43	0.67	0.75
Untreated Check	1.53	1.37	1.68	1.70	1.73	1.79
SE.D	0.08	0.10	0.09	0.07	0.08	0.06
CD (P = 0.05)	NS	0.30	0.27	NS	0.24	0.18

PTC - Pre treatment count; DAT - Days after treatment

Table 8: Effect of Insecticides on Pod borer, *Helicoverpa armigera* in Black gram (Field Trial II)

Treatments	Mean larvae/ plant (no.)					
	Days after first application			Days after second application		
	PTC	3 DAT	7 DAT	PTC	3 DAT	7 DAT
Indoxacarb 14.5 SC @ 1 ml/ l	2.80	0.13	0.07	1.43	0.10	0.03
Thiodicarb 75 WP @ 1 g/ l	2.57	0.27	0.17	1.53	0.23	0.20
Spinosad 45 SC @ 0.4 ml/ l	2.63	0.13	0.10	1.50	0.17	0.13
Emamectin Benzoate 5 WG @ 0.4 g/ l	2.70	0.17	0.10	1.50	0.30	0.13
Quinalphos 25 EC @ 2 ml/ l	2.57	0.93	0.87	1.63	0.77	0.70
Chlorpyriphos 20 EC @ 2.5 ml/ l	2.47	0.30	0.23	1.60	0.30	0.27
Carbaryl 50 WP @ 2 g/ l	2.80	0.87	0.80	1.70	0.70	0.63
Untreated Check	2.63	2.7	2.93	3.13	2.97	3.03
SE.D	0.04	0.04	0.03	0.06	0.05	0.05
CD (P = 0.05)	NS	0.08	0.07	NS	0.10	0.10

PTC - Pre treatment count; DAT - Days after treatment

3.5. Yield

Data on the yield of black gram (2011-12 and 2013-14) showed that seed treatment with thiamethoxam 25WG @ 3 g/ kg of seed + spray with thiamethoxam @ 0.4 g/ l (465.7 and 481.0 kg/ ha exhibited significantly higher yield over rest of the treatments which was followed by spraying imidacloprid @ 0.4 ml/ l (447.3 and 466.67 kg/ ha) (Table 9). All the treatments were superior over untreated check (345.7 and 356.67 kg/ ha).

The data presented in Table 10 on the effect of insecticides against defoliator and pod borer on the yield of black gram during *rabi* 2011 and 2013 revealed that indoxacarb 14.5 SC @ 1.0 ml/ l recorded significantly higher yield (466.7 and 496.33 kg/ ha) followed by spinosad 45SC @ 0.4 ml/ l (448.3 and 485.0 kg/ ha) and emamectin benzoate 5WG @ 0.4 g/ l (456.0 and 477.0 kg/ ha) (Table 10). All the treatments were superior over untreated check (350.3 and 360.0 kg/ ha).

Table 9: Effect of insecticides against sucking pests on the yield of black gram

Treatments	Yield (kg/ ha) 2011-12	Yield (kg/ ha) 2013-14
Soil application of neem cake + spray with neem oil 3%	396.3	408.3
Seed treatment (ST) with thiamethoxam 25 WG @ 3 g/ kg of seed + spray with thiamethoxam 25 WG @ 0.4 g/ l	465.7	481.0
ST with dimethoate 30 EC@ 5 ml/ kg of seed + Spray with dimethoate 30 EC @ 2 ml/	427.7	448.3
Spraying of imidacloprid 17.8 SL @ 0.4 ml/ l	447.3	466.7
Spraying of triazophos 40 EC @1.5 ml/ l	440.0	460.0
Spraying of dimethoate 30 EC@ 2.0 ml/ l	418.3	438.3
Spraying of neem oil 3%	390.3	401.7
Untreated check	345.7	356.7
SE.D	0.13	0.23
CD (P = 0.05)	0.28	0.51

Table 10: Effect of insecticides against defoliator and pod borer on the yield of black gram

Treatments	Yield (kg/ ha) 2011-12	Yield (kg/ ha) 2013-14
Indoxacarb 14.5 SC @ 1 ml/ l	466.7	494.3
Thiodicarb 75 WP @ 1 g/ l	440.0	465.7
Spinosad 45 SC @ 0.4 ml/ l	448.3	485.0
Emamectin Benzoate 5 WG @ 0.4 g/ l	456.0	477.0
Quinalphos 25 EC @ 2 ml/ l	435.0	450.3
Chlorpyriphos 20 EC @ 2.5 ml/ l	420.0	435.7
Carbaryl 50 WP @ 2 g/ l	412.7	415.0
Untreated Check	350.3	360.0
SE.D	0.10	0.32
CD (P = 0.05)	0.21	1.82

4. Conclusion

Thus, from the present study it is evident that the seed treatment with thiamethoxam 25 WG @ 3 g/ kg of seed + spray with thiamethoxam 25 WG @ 0.4g/ l was found to be effective against black gram aphid and leafhopper and indoxacarb 14.5 SC @ 1 ml/ l was the efficacious insecticide against *S. litura* and *H. armigera.*

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