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Effectiveness of biopesticides against *Spodoptera litura* infesting groundnut under field condition

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Abstract
Among the eight tested biopesticides, SlNPV 250 LE, *B. bassiana* 1% WP and aqueous bidi tobacco dust extract 2% found most effective and recorded minimum larval population of *S. litura* as well as per cent damaged groundnut plant. While, treatments of neem oil 1%, Btk 1% WP and *M. anisopliae* 1% WP were found moderately effective in reducing larval population and per cent damaged plant. Whereas, the treatments of azadirachtin 10000 ppm and *N. rileyi* 1% WP. Efficacy of biopesticides as reduction in *S. litura* population was SlNPV 250 LE > *B. bassiana* 1% WP > aqueous bidi tobacco dust extract 2% > neem oil 1% > Btk 1% WP > *M. anisopliae* 1% WP > azadirachtin 10000 ppm > *N. rileyi* 1% WP.

Keywords: SlNPV, *B. bassiana*, aqueous bidi tobacco dust extract, neem oil, *M. anisopliae and N. rileyi*

Introduction

Groundnut (*Arachis hypogea* Linnaeus) is the world's fourth most significant oilseed crop, as well as the world's largest source of edible oil and 13th most important food crop (Ramanathan, 2001) [8]. Gujarat, Rajasthan, Tamil Nadu, Andhra Pradesh, Karnataka, Madhya Pradesh, Telangana, Maharashtra, and West Bengal are the highest groundnut-growing states in India (Anon., 2021) [1]. There are a variety of biotic and abiotic factors responsible for low groundnut productivity; among them, insect pests are acknowledged as one of the greatest restrictions on groundnut production, resulting in significant losses in India (Singh, 1980) [9]. Only insect pest causes 10-20% crop loss and 10-25% post-harvest loss of groundnut output in India, with the greatest losses occurring during long-term storage. Due to the invasion of a diverse variety of insect-pests and diseases, the national average yield of groundnut sawn in the *kharif* season is lower than in the *rabi* season. Adoption of inappropriate management measures such as excessive application of pesticides, inadequate crop rotation and unfavorable storage conditions are among the key reasons that cause pest outbreaks (Joshi, 2020) [6]. Pests have a harmful influence on both crop output and human health (Tandi *et al*., 2014; Misca *et al*., 2014 and Datcu *et al*., 2019) [10, 7, 3]. At the seedling and flowering phases, one *S. litura* larva per groundnut plant might result in a considerable production loss. At the seedling stage, it devoured 54.70 per cent of the leaf area and decreased pod output by 25.80%. During flowering, it consumed 49.10% of the leaf area and lowered production by 19.00%. At pegging, it devoured 38.80% of the leaf area, resulting in a 5.7 per cent yield reduction (Dhir *et al*., 1992) [4].

Looking to the importance of groundnuts in agricultural economy and the impact of *Spodoptera litura* (F.) on groundnut production, it is an essential to develop pest management strategies by incorporating various IPM components such as use of botanicals. Keeping these points in view, detail investigations were undertaken.

Materials and Method

The experiment was laid out in a randomized block design with three replication and eight bio-pesticides along with control at Regional research station, Anand Agricultural University, Anand during *Kharif*, 2021. Groundnut *c.v.* GG34 were sown during June, 2021 with the spacing of 45 x 10 cm with the gross and net plot size of 3.6 x 4.5 m and 2.7 x 4.3 m, respectively. First spray was made at initiation of the pest and second spray was made after 10 days of first spray. The observations on pest population were recorded by counting number of larvae per plant and number of healthy and damaged plant(s) per 10 plants from ten randomly select plants from each treatment before 24 hrs of spraying and 3, 7, 10 days after spraying.

Result and Discussion

Based on larval population

First spray

From each treatment, the number of *S. litura* larvae per plant was recorded and presented in Table 1. According to the data of before spray, all the treatments had uniform populations of larvae that were non-significant, ranging from 1.76 to 2.02 larvae per plant. Third day after spray, the minimum larval population were recorded from treatment of SlNPV 250 LE (0.96 larva/plant) and it was at par with *B. bassiana* 1% WP (1.09 larvae/plant) and aqueous bidi tobacco dust extract 2% (1.40 larvae/plant). Seventh day after spray, treatments of SlNPV 250 LE and *B. bassiana* 1% WP proved to be most effective treatments and recorded the lowest larval population (0.75 and 0.85 larva/plant). However, it was at par with aqueous bidi tobacco dust extract 2% (0.87 larva/plant). Tenth day after spray, the data on larval population revealed that all the bio-pesticides treatments were found significantly superior over control. The data of pooled over periods presented in Table 1 showed that there was significant difference among various bio-pesticides treatments. The treatment of SlNPV 250 LE recorded lowest population (0.87 larva/plant) and it was at par with *B. bassiana* 1% WP (0.96 larva/plant) and aqueous bidi tobacco dust extract 2% (1.06 larvae/plant). While, treatments of Btk 1%WP (1.52 larvae/plant), *M. anisopliae* 1% WP (1.54 larvae/plant), neem oil 1% (1. 54 larvae/plant), azadirachtin 10000 ppm (1.69 larvae/plant) and *N. rileyi* 1% WP (1.75 larvae/plant) were found moderately effective in reducing larval population of *S. litura*.

Second Spray

From each treatment, the number of *S. litura* larvae per plant was recorded and presented in Table 1. Third day after spray, the data revealed that all the treatments were significantly superior over control. The treatment of SlNPV 250 LE maintained its superiority by recording lowest population (0.82 larva/plant). Seventh day after spray, the treatment of SlNPV 250 LE maintained its superiority by recording lowest population (0.69 larva/plant) and it was at par with *B. bassiana* 1% WP (0.75 larva/plant) and aqueous bidi tobacco dust extract 2% (0.80 larva/plant). Tenth day after second spray, the data revealed that all the treatments were significantly superior over control. The data of pooled over periods presented in Table 1 showed that there was significant difference among various bio-pesticides treatments. The treatment of SlNPV 250 LE found most effective and recorded lowest population (0.71 larva/plant) and it was at par with *B. bassiana* 1% WP (0.78 larva/plant) and aqueous bidi tobacco dust extract 2% (0.82 larva/plant) thus, all these treatments were found most effective than the rest of the treatments. However, treatments of neem oil 1% (1. 32 larvae/plant), Btk 1%WP (1.35 larvae/plant), *M. anisopliae* 1% WP (1.40 larvae/plant), azadirachtin 10000 ppm (1.57 larvae/plant) and *N. rileyi* 1% WP (1.66 larvae/plant) were found moderately effective in reducing larval population.

Over all pooled

The data on pooled over periods and sprays presented in Table 1 revealed that minimum larval population was recorded in treatment of SlNPV 250 LE (0.80 larva/plant) which was at par with *B. bassiana* 1% WP (0.87 larva/plant) and aqueous bidi tobacco dust extract 2% (0.94 larva/plant). While, treatments of neem oil 1% (1.43 larvae/plant), Btk 1% WP (1.43 larvae/plant) were found moderately effective and it was also at par with *M. anisopliae* 1% WP (1.49 larvae/plant) and azadirachtin 10000 ppm (1.60 larvae/plant).

Based on damaged plant (%)

First spray

From each treatment, the number of damaged plants (%) are recorded and presented in Table 2. According to the data of before spray, all the treatments found uniform damaged plants (%) that were non -significant, ranging from 66.71 to 80.65 per cent. Third day after spray, the minimum per cent damaged plant was recorded from treatment of SlNPV 250 LE (46.62%) and it was at par with *B. bassiana* 1% WP (49.97%) and aqueous bidi tobacco dust extract 2% (53.31%). Seventh day after spray, the data on per cent damaged plant revealed that all the bio-pesticides were found effective in reducing per cent damaged plant as compared to control. Tenth day after spray, the treatment of SlNPV 250 LE maintained its superiority by recording lowest per cent damaged plant (39.83%). However, it was at par with *B. bassiana* 1% WP (43.28%) and aqueous bidi tobacco dust extract 2% (46.62%). The data of pooled over periods presented in Table 2 showed that there was significant difference among various bio-pesticides treatments. The treatment of SlNPV 250 LE recorded lowest per cent damaged plant (40.87%) and it was at par with *B. bassiana* 1% WP (44.41%) and aqueous bidi tobacco dust extract 2% (47.73%) thus, all these treatments were found most effective than the rest of the treatments. The treatments of Btk 1%WP (60.05%) were found moderately effective. However, it was also at par with treatments of azadirachtin 10000 ppm (66.71%), *M. anisopliae* 1% WP (70.19%) and neem oil 1% (71.46%).

Table 1: Bio-efficacy of biopesticides against larvae of *S. litura* in groundnut

Treatments	No. of larva(e)/ plant									
	Before spray	First Spray				Second Spray				Pooled over periods and sprays
		3DAS	7DAS	10 DAS	Pooled	3DAS	7DAS	10 DAS	Pooled	
Neem oil 1%	1.59 (2.02)	1.47 ^{bcd} (1.66)	1.37 ^{c} (1.38)	1.43 ^{bc} (1.54)	1.43 ^{b} (1.54)	1.41 ^{bc} (1.49)	1.34 ^{bcd} (1.30)	1.31 ^{bcd} (1.22)	1.35 ^{b} (1.32)	1.39 ^{b} (1.43)
Metarhizium anisopliae 1% WP	1.54 (1.89)	1.45 ^{bcd} (1.60)	1.38 ^{c} (1.40)	1.45 ^{c} (1.60)	1.43 ^{b} (1.54)	1.44 ^{c} (1.57)	1.36 ^{cd} (1.35)	1.33 ^{cd} (1.27)	1.38 ^{b} (1.40)	1.41 ^{bc} (1.49)
Bacillus thuringiensis var. *kurstaki* 1% WP	1.57 (1.96)	1.47 ^{bcd} (1.66)	1.36 ^{bc} (1.35)	1.44 ^{bc} (1.57)	1.42 ^{b} (1.52)	1.43 ^{c} (1.54)	1.34 ^{bcd} (1.30)	1.32 ^{bcd} (1.24)	1.36 ^{b} (1.35)	1.39 ^{b} (1.43)
Beauveria bassiana 1% WP	1.59 (2.01)	1.26 ^{ab} (1.09)	1.16 ^{a} (0.85)	1.20 ^{a} (0.94)	1.21 ^{a} (0.96)	1.18 ^{a} (0.89)	1.12 ^{ab} (0.75)	1.09 ^{ab} (0.69)	1.13 ^{a} (0.78)	1.17 ^{a} (0.87)
Nomuraea rileyi 1% WP	1.54 (1.87)	1.50 ^{cd} (1.75)	1.49 ^{c} (1.72)	1.49 ^{cd} (1.72)	1.50 ^{b} (1.75)	1.47 ^{c} (1.66)	1.48 ^{d} (1.69)	1.45 ^{d} (1.60)	1.47 ^{b} (1.66)	1.48 ^{c} (1.69)
SlNPV 250 LE	1.58 (1.96)	1.21 ^{a} (0.96)	1.12 ^{a} (0.75)	1.17 ^{a} (0.87)	1.17 ^{a} (0.87)	1.15 ^{a} (0.82)	1.09 ^{a} (0.69)	1.06 ^{a} (0.62)	1.10 ^{a} (0.71)	1.14 ^{a} (0.80)

Aqueous bidi tobacco dust extract 2%	1.50 (1.76)	1.38 ^{abc} (1.40)	1.17 ^{ab} (0.87)	1.21 ^{ab} (0.96)	1.25 ^{a} (1.06)	1.19 ^{ab} (0.92)	1.14 ^{abc} (0.80)	1.11 ^{abc} (0.73)	1.15 ^{a} (0.82)	1.20 ^{a} (0.94)
Azadirachtin 10000 ppm	1.52 (1.80)	1.47 ^{bcd} (1.66)	1.43 ^{c} (1.54)	1.50 ^{cd} (1.75)	1.48 ^{b} (1.69)	1.49 ^{c} (1.72)	1.42 ^{d} (1.52)	1.41 ^{d} (1.49)	1.44 ^{b} (1.57)	1.45 ^{bc} (1.60)
Control	1.59 (2.02)	1.65 ^{d} (2.22)	1.71 ^{d} (2.42)	1.72 ^{d} (2.46)	1.69 ^{c} (2.36)	1.74 ^{d} (2.53)	1.76 ^{e} (2.60)	1.79 ^{e} (2.70)	1.76 ^{c} (2.60)	1.73 ^{d} (2.49)
S. Em. ± Treatment (T)	0.08	0.07	0.06	0.07	0.037	0.07	0.07	0.07	0.04	0.027
Period (P)	-	-	-	-	0.02	-	-	-	0.02	0.016
S	-	-	-	-	-	-	-	-	-	0.013
T x P	-	-	-	-	0.07	-	-	-	0.07	0.047
T x S	-	-	-	-	-	-	-	-	-	0.038
P x S	-	-	-	-	-	-	-	-	-	0.022
T x P x S	-	-	-	-	-	-	-	-	-	0.066
C.D. at 5% T	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C.V. (%)	8.36	8.08	8.30	8.66	8.06	9.06	9.25	9.06	8.78	8.34

Note: 1. Figures outside the parentheses are $\sqrt{X+0.5}$ transformed values and those inside are retransformed values.
2. Treatment means followed by the same letter are not significantly different by Duncan's New Multiple Range Test (DNMRT) at 5% level of significance.

Table 2: Bio-efficacy of biopesticides against *S. litura* damage on groundnut

Treatments	**Plant damaged (%)**									
	Before spray	**First Spray**				**Second Spray**				**Pooled over periods and sprays**
		3 DAS	**7 DAS**	**10 DAS**	**Pooled**	**3DAS**	**7DAS**	**10 DAS**	**Pooled**	
Neem oil 1%	63.90 (80.65)	61.20 ^{c} (76.79)	54.97 ^{cd} (67.05)	57.00 ^{cd} (70.34)	57.71 ^{c} (71.46)	54.76 ^{c} (66.71)	50.75 ^{c} (59.97)	48.83 ^{c} (56.66)	51.44 ^{bc} (61.15)	54.58 ^{de} (66.41)
Metarhizium anisopliae 1% WP	62.68 (78.94)	58.98 ^{c} (73.44)	54.76 ^{c} (66.71)	57.00 ^{cd} (70.34)	56.91 ^{c} (70.19)	54.97 ^{c} (67.05)	50.30 ^{c} (59.20)	46.90 ^{bc} (53.31)	50.90 ^{bc} (60.22)	53.90 ^{de} (65.28)
Bacillus thuringiensis var. *kurstaki* 1% WP	56.98 (70.30)	52.75 ^{bc} (63.36)	48.83 ^{bc} (56.66)	50.83 ^{bc} (60.11)	50.80 ^{b} (60.05)	48.83 ^{bc} (56.66)	45.07 ^{abc} (50.12)	41.05 ^{abc} (43.13)	44.98 ^{b} (49.97)	47.89 ^{c} (55.04)
Beauveria bassiana 1% WP	54.76 (66.71)	44.98 ^{ab} (49.97)	39.22 ^{a} (39.98)	41.14 ^{a} (43.28)	41.79 ^{a} (44.41)	39.13 ^{a} (39.83)	35.20 ^{a} (33.23)	33.20 ^{a} (29.98)	35.84 ^{a} (34.28)	38.81 ^{ab} (39.28)
Nomuraea rileyi 1% WP	63.90 (80.65)	61.20 ^{c} (76.79)	56.98 ^{cd} (70.30)	58.98 ^{cd} (73.44)	59.05 ^{cd} (73.55)	57.00 ^{c} (70.34)	54.76 ^{c} (66.71)	53.13 ^{c} (64.00)	54.96 ^{c} (67.04)	57.00 ^{e} (70.34)
SlNPV 250 LE	54.76 (66.71)	43.06 ^{a} (46.62)	37.21 ^{a} (36.57)	39.13 ^{a} (39.83)	39.80 ^{a} (40.97)	37.22 ^{a} (36.59)	32.99 ^{a} (29.65)	30.98 ^{a} (26.50)	33.73 ^{a} (30.83)	36.76 ^{a} (35.82)
Aqueous bidi tobacco dust extract 2%	58.98 (73.44)	46.90 ^{ab} (53.31)	41.14 ^{ab} (43.28)	43.06 ^{ab} (46.62)	43.70 ^{a} (47.73)	41.14 ^{ab} (43.28)	37.21 ^{ab} (36.57)	35.20 ^{ab} (33.23)	37.85 ^{a} (37.65)	40.78 ^{ab} (42.66)
Azadirachtin 10000 ppm	58.98 (73.44)	56.77 ^{c} (69.97)	52.75 ^{c} (63.36)	54.76 ^{c} (66.71)	54.78 ^{bc} (66.71)	52.75 ^{c} (63.36)	48.83 ^{bc} (56.66)	46.90 ^{bc} (53.31)	49.49 ^{bc} (57.80)	52.13 ^{d} (62.32)
Control	54.76 (66.71)	61.20 ^{c} (76.79)	63.41 ^{d} (79.97)	66.12 ^{d} (83.61)	63.57 ^{d} (80.19)	68.83 ^{d} (86.96)	74.40 ^{d} (92.77)	77.11 ^{d} (95.02)	73.44 ^{d} (91.88)	68.51 ^{f} (86.58)
S. Em. ± Treatment (T)	3.77	2.92	2.50	2.90	1.56	2.72	3.80	3.86	2.00	1.29
Period (P)	-	-	-	-	0.90	-	-	-	1.15	0.74
S	-	-	-	-	-	-	-	-	-	0.60
T x P	-	-	-	-	2.71	-	-	-	3.46	2.21
T x S	-	-	-	-	-	-	-	-	-	1.81
P x S	-	-	-	-	-	-	-	-	-	1.04
T x P x S	-	-	-	-	-	-	-	-	-	3.13
C.D. at 5% T	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C.V. (%)	11.10	9.36	8.68	9.67	9.02	9.33	13.78	14.56	12.45	10.83

Note: 1. Figures outside the parentheses are $\sqrt{X+0.5}$ transformed values and those inside are retransformed values.
2. Treatment means followed by the same letter are not significantly different by Duncan's New Multiple Range Test (DNMRT) at 5% level of significance.

Second spray

From each treatment, the number of damaged plants (%) is recorded and presented in Table 2. Third day after spray, the treatment of SlNPV 250 LE maintained its superiority by recording lowest per cent damaged plant (36.59%) and it was at par with treatments of *B. bassiana* 1% WP (39.83%) and aqueous bidi tobacco dust extract 2% (43.28%) Seventh day after spray, the data revealed that all the treatments were significantly superior to control. Tenth day after second spray, the treatment of SlNPV 250 LE recorded the lowest per cent damaged plant (26.50%) and it was at par with *B. bassiana* 1% WP (29.98%) and aqueous bidi tobacco dust extract 2% (33.23%). The data of pooled over periods presented in Table 2 showed that there was significant difference among various bio-pesticides treatments. The treatment of SlNPV 250 LE recorded lowest per cent damaged plant (30.83%) and it was at par with *B. bassiana* 1% WP (34.28%) and aqueous bidi tobacco dust extract 2% (37.65%) thus, all these treatments were found most effective than the rest of the treatments.

Over all pooled

The data on pooled over periods and sprays presented in Table 2 and Fig. 1 revealed that minimum per cent damaged plant was recorded in treatment of SlNPV 250 LE (35.82%)

which was at par with *B. bassiana* 1% WP (39.28%) and aqueous bidi tobacco dust extract 2% (42.66%). The treatments of Btk 1% WP (55.04%) were found moderately effective. However, treatments of azadirachtin 10000 ppm (62.32%), *M. anisopliae* 1% WP (65.28%), neem oil 1% (66.41%) and *N. rileyi* 1% WP (70.34%) were found least effective in reducing per cent damaged plant and at par each other's. Symptoms of infected larvae with different biopesticides in Plate 1.

Chaudhari *et al.* (2020) [2] reported that SlNPV 1 x 10^9 POB/ml was found significantly effective for control of tobacco leaf eating caterpillar population followed by *Bt* var. *kurstaki* 0.5% WP and neem seed extract 5%. Yasin *et al.* (2020) [12] revealed that the application of NPV effective against populations of *S. litura in vitro* conditions. According to Vimala Devi *et al.* (2021) [11] that the Bt-127 WDG formulation was effective against early as well as older instar larvae *S. litura*. Gadhiya (2012) [5] revealed that the SlNPV @ 250 LE/ha, azadiractin @ 0.4 per cent, neem oil @ 0.3 per cent and neem seed kernel extract @ 5 per cent gave effective control of *S. litura* on groundnut crop. All these reports are in confirmation with the present finding.

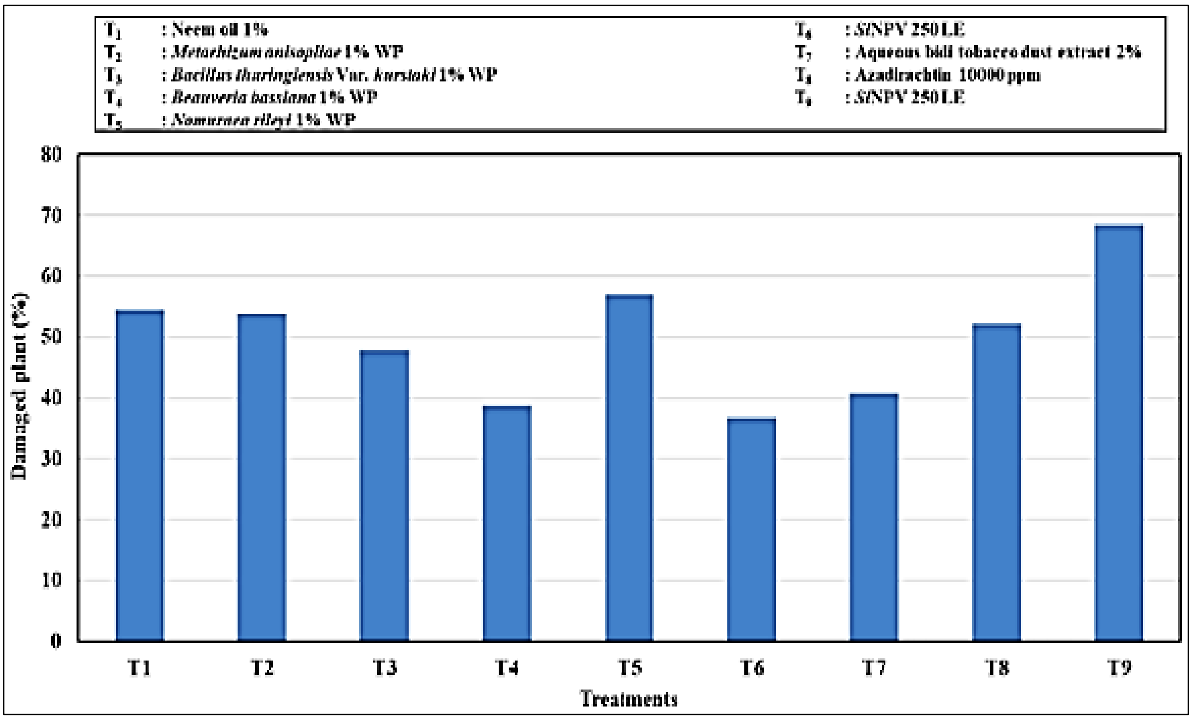

Fig 1: Efficacy of biopesticides against tobacco leaf eating caterpillar, *S. litura* infesting groundnut

Healthy larva of *Spodoptera litura* | *Metarhizium anisopliae* infected larva | *B.t. Var kurstaki* infected larva | SlNPV infected larva | Occlusion body of SlNPV

Plate 1: Healthy and biopesticide infected larvae of *Spodoptera litura* feeding on groundnut

Conclusion

Among the eight tested biopesticides, SlNPV 250 LE, *B. bassiana* 1% WP and aqueous bidi tobacco dust extract 2% were found most effective by showing minimum larval population and per cent damaged plants with groundnut pod and haulm yield 2765 kg/ha and 4147 kg/ha, 2705 kg/ha and 4057 kg/ha and 2701 kg/ha and 4052 kg/ha, respectively. Looking to the ICBR, the highest (1:21.60) returned was obtained with the treatment of aqueous bidi tobacco dust extract 2% followed by *B. bassiana* 1% WP (1:12.39), SlNPV 250 LE (1:12.35). On the basis of ranking, the treatments of SlNPV 250 LE, *B. bassiana* 1% WP and aqueous bidi tobacco dust extract 2% were found effective as well as economic against *S. litura* infesting groundnut. Efficacy of biopesticides as reduction in *S. litura* population was SlNPV 250 LE > *B. bassiana* 1% WP > aqueous bidi tobacco dust extract 2% > neem oil 1% > Btk 1%WP > *M. anisopliae* 1% WP > azadirachtin 10000 ppm > *N. rileyi* 1% WP.

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