Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(4): 3421-3425
Received: 10-05-2020
Accepted: 12-06-2020

Mohan I Naik
Professor and Scheme Head, All India Network Project (AINP) on Vertebrate Pest Management, GKVK, University of Agricultural Sciences (UAS), Bangalore, Karnataka, India

Basavadarshan AV
Senior Research Fellow, AINP on Vertebrate Pest Management, GKVK, UAS Bangalore, Karnataka, India

Boraiah B
Professor and Senior farm Superintendent, GKVK, University of Agricultural Sciences (UAS), Bangalore, Karnataka, India

Thippaiah M
Professor, Department of Agricultural Entomology, GKVK, University of Agricultural Sciences (UAS), Bangalore, Karnataka, India

Corresponding Author:
Mohan I Naik
Professor and Scheme Head, All India Network Project (AINP) on Vertebrate Pest Management, GKVK, University of Agricultural Sciences (UAS), Bangalore, Karnataka, India

Yield loss estimation and efficacy of biopesticides on the management of *Helicoverpa armigera* (Hubner) in vegetable soybean [*Glycine max* (L.) Merrill]

Mohan I Naik, Basavadarshan AV, Boraiah B and Thippaiah M

Abstract
The demand for vegetable soybean as a fresh or frozen vegetable is increasing worldwide. Successful production of vegetable soybean is hampered due to the incidence of several insect pests, particularly pod borer *Helicoverpa armigera* (Hubner). The pest represents a significant challenge to soybean production around the world. Through the chemical control measures are effective in combating the pest but not able to produce residue free grains. Hence, a study was taken up to estimate the loss caused by the pod borer and to evaluate the bio pesticides against it. The loss due to *H.armigera* in vegetable soybean varied from 38.49 to 45.04 per cent with an additional yield of 25.68 q to 37.56 q over untreated check. Among the biopesticides it was NSKE (4%) performed better followed by HaNPV. However, other bio pesticides *viz. Azadiractitin* (1.0%, 0.03%), *Bacillus thuringiensis*. Berliner and *Beauveria bassiana* (Bals-Criv.) Vuill. also performed better than control.

Keywords: Yield loss, *Helicoverpa armigera*, vegetable soybean, bio pesticides

1. Introduction
Soybean [*Glycine max* (L.) Merrill] is a unique crop with high nutritional value, providing 40 per cent of protein, 20 per cent edible oil, minerals, and vitamins [2, 8]. Vegetable soybean is similar to grain soybean, but harvested earlier, when pods are bright green, yielding higher and sweeter seeds. It has been cultivated thousands of years in East Asia and is a popular snack in Japan, China, Thailand, and Taiwan [24]. With short growth duration and high yield values, the demand for fresh or frozen vegetable soybean is increasing worldwide [16, 19]. Successful production of soybean is hampered by abiotic and biotic stresses such as drought, weeds, insect pests, and diseases. Among these, insect pests often pose a severe threat to soybean production by increasing the cost of cultivation and by impairing the quality of the produce [7]. Soybean crop attracts about 380 insect species in many parts of the world [11, 15]. Among these insect pest's pod borer, *Helicoverpa armigera*. Hubner represents a significant challenge to soybean production, preferably during the vegetative and pod development stage [5]. To minimize the losses caused by *H. armigera* the chemical control measures are recommended. However, due to indiscriminate use of insecticide led to the development of, resistant pest strains, mounting up of the cost of cultivation menace to natural enemies and other non-target organisms, the resurgence of pesticide-resistant insect populations and elevation of secondary pests to a status of primary importance, bio magnification of pesticide residues in food and upsetting the natural ecosystem [9, 21]. Because of the growing need for the production of residue free vegetable soybean by combating *H. armigera*, and to find out actual loss caused by this pest, an *investigation* was carried out.

2. Material and Methods
The present studies on the incidence, crop loss estimation and management of *Helicoverpa armigera* on vegetable soybean (*Glycine max*) were carried out during *Kharif* 2018 at the Zonal Agricultural Research Station, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru. Bengaluru is situated in hot semi-arid eco-region of Karnataka (agro-climatic zone 5) at 12058 North latitude and 77035 East longitude at an altitude of 930 MSL. The mean annual rainfall is about 950 mm, distributed over seven to eight months.

2.1 Yield loss estimation due to *H. armigera*
Assessment of loss in yield due to pod borer infestation on vegetable soybean (Var: Karune) was studied by protecting the crop at different stages of growth. The plot size of 2.7 x 1.5 m

was maintained. The experiment was conducted as per the randomized block design consisting of six treatments and four replications with the recommended package of practices [3]. The treatments *viz.* covering with nylon net immediately after sowing till harvesting of the crop (T_1), spraying of Chlorpyriphos 20EC @ 2ml/ ltr (T_2), spraying of Quinalphos 25EC @ 2ml / ltr (T_3), Three sprays with Chlorpyriphos 20EC@ 2ml / l of water, Quinalphos 25 EC @ 2ml / l of water and Chlorpyriphos 20EC@ 2ml /l of water at 45, 55 and 65 days after germination, respectively (T_4) was taken up. In the supervisory control (T_5), the crop was sprayed with Chlorpyriphos @ 0.05% and Quinalphos based on Economic Threshold Level (ETL). However, the ETL is 1.54 larvae per plant [25]. In untreated check (T6), the crop was grown by following all the agronomic practices without any plant protection measures. Number of larvae per plant and pod damage per plant was recorded.

Green mature pods were harvested for estimating the yield. The per cent pod damage was noted based on the number of damaged pods out of total number of pods per plant. The probable loss due to *H. armigera* were computed by comparing the yield obtained from different plots that were exposed to various treatments.

2.2 Efficacy of the bio pesticides against *H. armigera*

The vegetable soybean (variety: Karune) was raised during *Kharif* 2018 following all the recommended package of practices except plant protection measures with eleven treatments and three replications in a randomized complete block design (RCBD). However, common foliar application of Chlorpyriphos @ 0.05 per cent was made on 10 and 25 days after germination as prophylactic spray for controlling sucking pests.

The treatments were imposed in respective plots (2.7m x 5 m) at pod initiation stage (45 days after germination) and the second application were imposed at pod development stage (55 days after germination). The treatment details are indicated below.

T_1-*Azadirachtin* 1% (Bioneem) @2 ml/ l of water
T_2 -*Azadirachtin* 0.03% (Azagro) @4 ml/ l of water
T_3-*Bacillus thuringiensis* (Dipel) @2 ml/ l of water
T_4-HaNPV (Flash) @500 LE/ha
T_5-NSKE (Freshly prepared) @ 4 per cent
T_6-*Beauveria bassiana* (Mycozaal) @ 2 ml/ l of water
T_7-Malathion dust 5% (Malathion) @ 10 kg / ha
T_8-Chlorpyriphos 20EC (Classic 20) @ 2 ml/ l of water
T_9-Chlorantroniliprole 18.5 SC (Ranaxypyr) @ 0.2 ml/ l of water
T_{10}-Quinalphos 25EC (Flash) @ 2 ml/ l of water
T_{11}-Untreated (Control)

Observations on the population of insects were recorded by standard method one day before treatment, and three and seven days after treatment each fifth plant in alternate row in each sub plot was selected for observation. The total numbers of larvae were recorded during pod formation stage and pod damage was also recorded. The per cent pod damage was noted based on the number of damaged pods out of total number pods per plant. The probable loss due to pod borer were computed by comparing the yield obtained from different plots which were exposed to different treatment. The cost of cultivation was calculated for different treatment which include both fixed and variable cost. Gross returns and net returns were calculated, and cost-benefit ratio was estimated.

2.3 Statistical analysis and interpretation

The data collected on different parameters during the investigation were subjected to Fisher's method of analysis variance for interpretation of the data as given by Panse and Sukhatme [17].

3. Results and discussion

3.1. Yield loss estimation by *Helicoverpa armigera* in vegetable soybean.

3.1.1 First spray

The larval population was significantly low (1.41± 0.02 larvae / plant) over other treatments at one day before treatment in T_1 (cover with nylon net) as the net was covered immediately after sowing. The incidence was only by moths emerged from pupae of that area and was significantly superior (1.41 ± 0.02larvae/ plant). Whereas, in other treatments larval population was uniform and there was no significant difference (Table 1). After a day and third day after the first spray the larval population (1.70 ± 0.02 and 1.87 ± 0.08 larvae per plant) was significantly less with other treatments. In chemical treatments (T_2, T_3, T4 and T_5) the larval population recorded was least compared to control. In control the larval population was 3.39 ± 0.12 and 3.21 ± 0.06 larvae per plant, after one and three days after the treatments, respectively.

3.1.2 Second spray

The larval population at one day before second treatment was least in T_2 (2.15 ± 0.02 larvae/plant) which was on par with T_1 (2.23 ± 0.04), T_3 (2.17 ± 0.02), and T_4 (2.18 ± 0.03). The highest population was recorded in untreated control (3.41 ± 0.15 larvae/plant) (Table 1). At one day and third day after second spray the larval population was least in T_4 (1.91 ± and 1.51 ± larvae per plant). In supervisory control 1.93 ± 0.1 and 1.87 ± 0.03 larvae per plant was recorded, a day after and three days after treatment which is on par with T_3 and T_4 (Table 1).

3.1.3 Third spray

There was a significant difference between the larval population one day before treatment. The crop that was covered with nylon net recorded population of 2.37± 0.02 larvae per plant (T_1) which was significantly lower than the untreated check, but the lowest population was recorded in T_3, T_4 and T_5 which were on par with each other (Table 1). One day after third spraying, the least larval population (1.07 ± 0.01 larvae/plant) was noticed in T_5 and which was followed by T_4 (1.34 ± 0.08 larvae/plant) and T_3 (1.53 ± 0.01 larvae/plant). The highest larval population was recorded in T_1 (2.33 ± 0.04 larvae/plant) and T_2 (2.29 ± 0.06 larvae/plant). Whereas after the three days after the third spray the larval population was least in T_5 (0.76 ± 0.04 larvae/plant) followed by T_4 (1.24 ± 0.03larvae/plant). However, the highest larval population was recorded in untreated check (3.73± 0.07 and 3.58 ± 0.12 larvae/plant) (Table 1).

3.1.4 Pod damage and yield

There was significant difference between the treatments with respect to pod damage and yield. Highest number of pod damage was recorded in control (18.46 ± 1.26%) and lowest pod damage was recorded in T_3 (7.82 ± 0.31%). However, the pod damage was on par in treatments T_1 (8.46 ± 0.72%), T2 (8.78 ± 0.65%) T_4 (8.25 ± 0.57%) and T_5 (8.32 ± 0.23%) which were superior to the untreated check (Table 2). Among the treatments (T_1, T_2, T_3, T4 and T_5) recorded highest yield

(61.07 to 68.34 q / ha) when compared to untreated check (37.56 q/ha). The additional yield obtained over control was highest in T_4 (30.78 q/ha) fallowed by T_3 (26.71 q/ha). Additional yield over control obtained by other treatments were T_1 (25.68 q/ha), T_2 (23.51 q/ha) and T_5 (24.81 q/ha).

The table 2 indicates that there is a significant loss in yield of vegetable soybean due to *H. armigera*. In control the yield per ha was 37.56 q per ha which is significantly less when compared to any other treatment (T_1 to T_5) with per cent increase in yield of 66.05 to 81.94. An additional yield of 23.51 q per ha (T_2) to 30.78 q per ha (T_4) indicates that there is a significant increase in yield due to the treatments. The data also shows (Table 2) the loss would have been varied from (T_2) 38.49 and (T_4) 45.04 per cent due to *H. armigera* incidence in soybean in the absence of control measures.

The above results as in confirm that the loss in yield caused by *H. armigera* was 42 to 56 per cent [10], 40 to 100 per cent [12], 36.4 per cent [13] and 24.6 per cent [14] and these reports emphasize that there is wide range of losses due to *H. armigera* in soybean. However, the variation in the present study may be due to change in the location and variety.

3.2 Evaluation of bio pesticides against *Helicoverpa armigera*

3.2.1 Effect of first spray

There was no significant difference between the treatments with respect to number of *H. armigera* larvae per plant before the imposition of the treatments. (Table 3). After three days after treatment there was a significant difference between the treatments. The chemical treatments Chlorantraniliprole 18.5 SC (1.53 ± 0.11) and Chlorpyriphos 20 EC (1.58 ± 0.21) per formed significantly better than other treatments. Among the bio rationales NSKE 4% and *Azadirachtin* 1% exhibited significant reduction in *H. armigera* population with 1.90 ± 0.23 and 1.91 ± 0.23 larvae per plant respectively when compared to other treatments.

However, after seven days after the first spray significant differences were recorded between the treatments with respect to the larval population which ranged from 1.15 ± 0.09 (Chlorpyriphos 20 EC) to 2.48 ± 0.06 (control) per plant. Among bio rationales NSKE 4 per cent recorded the lowest larval population of 1.25 ± 0.02 larvae per plant and all other bio rationales (HaNPV, *Beauveria bassiana*, *Bacillus thuringiensis* and *Azadirachtin*) were on par with each other. However, significantly lowest larval population was recorded in the recommended chemical control Chlorpyriphos (1.15 ± 0.09 larvae/plant) and Chlorantraniliprole (1.39 ± 0.01 larvae/plant).

3.2.2 Effect of second spray.

The treatment effects were significant at one day before the treatment, three and seven days after the treatment (Table 3). A day after second spray the larval population per plant between the treatments were significant. The larval population ranged from 0.81 ± 0.14 (NSKE 4) to 1.17 ± 0.03 (*Beauveria bassiana*) per plant, among the bio pesticides tested. Lowest larval populations were recorded in Azadirachtin 1% (0.82 ± 0.06 larvae / plant) followed by and *Ha*NPV (0.87 ± 0.03 larvae/plant) after 3DAS. At seven days after the treatment all the bio pesticides (0.45 to 0.71 larvae per plant) were on par with the chemicals (0.37 to 0.61 larvae / plant) except *Beauveria bassiana* (0.71 ±0.13 larvae / plant) which significantly differed with Chlorpyriphos (0.43 ± 0.09 larvae / plant).

3.2.3 Pod damage and yield

Among all bio pesticide treatments lowest pod damage was recorded in NSKE (5.73%) followed by HaNPV (6.2 per cent) with a yield of 50.75 ± 1.39, 49.96 ± 0.18 q per ha and cost benefit ratio of 1:1.19 and 1:1.15 and other bio rationales were non-significant with these treatments. The chemicals Chlorantraniliprole (18.5 SC) and Chlorpyriphos (20 EC) resulted with yield of 71.57 ± 2.73 q per ha and 71.19 ± 0.02 q per ha with C: B ratio of 1:2.84 and 1:2.80 respectively. In control the damage was 26.83 per cent with a yield of 50.75 per ha and 49.96 q per ha and C: B ratio of 1:1.19 and 1:1.15. Thus, it revealed that all the bio pesticides significantly enhanced the pod yield of vegetable soybean compared to control.

As per the study chemicals were more effective than bio-pesticides. Similar results and opinion were presented by Sarode *et al.*, [23], Byrappa *et al.*, [6], sultani [25] and Rambihari *et al.*, [18]. However, performance of Bt, NSKE and cow urine + NSKE in the present study is similar to the reports of Abedi *et al.*, [1], Bhat *et al.* [4] and Sachan and Lal [22], respectively. Thus, it was observed that most of the biopesticide treatments significantly enhanced the pod yield of vegetable soybean when compared with the chemicals. These findings are in agreement with Ravikumar [20], Sarode *et al.*, [23], Byrappa *et al.*, [6].

Table 1: Efficacy of different treatments against *Helicoverpa armigera in* field on vegetable soybean

Treatments	Larval population per plant								
	First spray			Second spray			Third spray		
	1 DBT	1 DAT	3 DAT	1 DBT	1 DAT	3 DAT	1 DBT	1 DAT	3 DAT
T_1- Covered with nylon net	1.41±0.02a	1.70±0.02a	1.87±0.08a	2.23±0.04ab	2.32±0.04bc	2.34±0.04cd	2.37±0.02b	2.33±0.04c	2.12±0.01c
T_2- Spray with Chlorpyriphos (one spray)	3.51±0.09b	2.59±0.33b	2.15±0.02c	2.15±0.02a	2.17±0.06b	2.21±0.01c	2.29±0.02b	2.29±0.06c	2.30±0.06c
T_3- Spray with Chlorpyriphos and Quinalphos (two spray)	3.47±0.07b	2.37±0.02b	2.22±0.03bc	2.17±0.02a	1.92±0.03a	1.53±0.04ab	1.46±0.01a	1.53±0.01b	1.51±0.02b
T_4 - Spray with Chlorpyriphos and Quinalphos and Chlorpyriphos (Three spray)	3.53±0.06b	2.45±0.04b	2.29±0.02bc	2.18±0.03a	1.91±0.03a	1.51±0.03a	1.48±0.04a	1.34±0.08b	1.24±0.03b
T_5- Supervisory (ETL based two sprays)	3.62±0.06b	2.30±0.05b	2.11 ±0.02b	2.51±0.02b	1.93±0.10a	1.87±0.03bc	1.54±0.07a	1.07±0.01a	0.76±0.04a
T_6- Untreated check	3.35±0.05b	3.39±0.12c	3.21±0.06d	3.41±0.15c	3.48±0.04c	3.51±0.02d	3.67±0.05c	3.73±0.07d	3.58±0.12d
F test	*	*	*	*	*	*	*	*	*
SEm (±)	0.06	0.10	0.07	0.0454	0.045	0.033	0.038	0.025	0.044
CD (P≤0.05)	0.19	0.43	0.25	0.616	0.167	0.115	0.126	0.111	0.178
CV (%)	4.11	11.60	6.96	19.06	4.84	3.52	3.92	3.58	5.96

(Mean ± standard error), * Significant at (P≤0.05), DBT- Day before treatment, DAT- Day after treatment

Table 2: Efficacy of spray schedule on pod damage and yield in vegetable soybean

Treatment	Healthy pods per plant	Pod damage (%)	Yield (q/ha)	Additional yield over control (q/ha)	Per cent increase over control	Per cent loss in yield
T_1- Covered with nylon net	34.15±4.43a	8.46±0.72a	63.24±0.81b	25.68	68.37	40.41
T_2- Spray with Chlorpyriphos (one spray)	38.59±1.50a	8.78±0.65a	61.07±1.32b	23.51	62.59	38.49
T_3- Spray with Chlorpyriphos and Quinalphos (two spray)	36.17±1.79a	7.82±0.31a	64.27±0.80 ab	26.71	71.11	41.56
T_4 - Spray with Chlorpyriphos and Quinalphos and Chlorpyriphos (Three spray)	35.39±2.35a	8.25±0.57a	68.34±2.38a	30.78	81.94	45.04
T_5- Supervisory (ETL based two sprays)	33.77±3.80a	8.32±0.23a	62.37±1.44b	24.81	66.05	39.77
T6-Untrreated check	27.32±1.50b	18.46±1.26b	37.56±1.60c	-	-	-
F test	*	*	*	-	-	-
SEm (±)	1.93	0.62	1.39	-	-	-
CD (P≤0.05)	6.42	3.65	4.38	-	-	-
CV (%)	12.53	19.38	4.89	-	-	-

(Mean ± standard error), * Significant at (P≤0.05),

Table 3: Efficacy of bio-rationales and insecticides against *Helicoverpa armigera* on vegetable soybean under field condition.

Treatments	No. of *H. armigera* larvae per plant						Pod Damage (%)	Average yield (q/ha)	C:B ratio
	First spray			Second spray					
	1 DBS	3 DAS	7 DAS	1 DBS	3 DAS	7 DAS			
T1 - Azadirachtin 1%	2.06±0.13	1.91±0.23c	1.34±0.06bc	1.23±0.15c	0.82±0.06cd	0.57±0.04bc	8.92	45.15±0.22 d	1: 0.66
T2 - Azadirachtin 0.03%	2.39±0.30	2.28±0.04b	1.59±0.19bc	1.51±0.12bc	0.99±0.06bc	0.66±0.16bc	8.46	45.77±0.34 d	1:0.81
T3 - *Bacillus thurnigiensis*	2.25±0.10	2.34±0.22b	1.48±0.04 bc	1.33±0.06bc	0.96±0.01bc	0.60±0.05bc	11.40	39.22±0.05 d	1:0.07
T4 - HaNPV	2.37±0.07	2.30±0.16b	1.42±0.03 bc	1.35±0.01bc	0.87±0.03c	0.48±0.03bc	6.20	49.96±0.18 cd	1:1.15
T5 - NSKE 4%	2.03±0.10	1.90±0.23c	1.25±0.02 c	1.29±0.10bc	0.81±0.14cd	0.45±0.02bc	5.73	50.75±1.39bc	1:1.19
T6 - *Beauveria bassiana*	2.31±0.28	2.35±0.18b	1.40±0.15 bc	1.57±0.10bc	1.17±0.03b	0.71±0.13b	11.50	40.78±0.03 e	1:0.04
T7 - Malathion 5% dust	2.10±0.11	1.83±0.21c	1.23±0.02 bc	1.56±0.11bc	1.05±0.07bc	0.61±0.18bc	5.21	49.42±0.88 cd	1:1.21
T8 - Chlorpyriphos 20 EC	2.12±0.09	1.58±0.21d	1.15±0.09a	1.30±0.21a	0.61±0.04d	0.43±0.09c	3.73	71.19±0.02 a	1:2.80
T9 - Chlorantroniliprole 18.5 SC	2.56±0.14	1.53±0.11d	1.39±0.01a	1.66±0.24b	0.74±0.09cd	0.37±0.09bc	3.71	71.57±2.73 a	1:2.59
T10 - Quinalphos 25 EC	2.29±0.13	1.84±0.09c	1.35±0.24 bc	1.38±0.22bc	0.88±0.02c	0.53±0.10bc	5.10	62.16±0.39 b	1:2.26
T11 - Untreated control	2.18±0.30	2.47±0.07a	2.48±0.06d	2.50±0.02a	2.67±0.15a	2.89±0.06a	26.80	29.17±1.89 f	1: 0.66
F test	NS	*	*	*	*	*	-	*	-
SEm (±)	0.24	0.03	0.15	0.21	0.18	0.16	-	0.74	-
CD (P≤0.05)	NS	0.09	0.03	0.41	0.24	0.22	-	2.98	-
CV (%)	10.15	2.65	13.65	15.99	13.48	12.32	-	3.48	-

(Mean ± standard error), * Significant at (P≤0.05), DBS- Day before spray, DAS- Day after spray

4. Conclusion

The study indicated that there is a significant loss of yield in vegetable soybean due to pod borer *H. armigera*. The study suggested that that the chemical treatments were superior in yield-related parameters, which also reflected in the larval load of *H. armigera*. However, among the various biopesticides, it was NSKE 4% that stood out as the best followed by HaNPV against pod borer.

5. References

1. Abedi Z, Saberb M, Vojoudi S, Mahdavi V, Parsaeyane E. Acute, sublethal, and combination effects of azadirachtin and *Bacillus thuringiensis* on the cotton bollworm, Helicoverpa armigera. J Insect. Sci. 2014; 14(30):1-9.
2. Alexander MW. Soybean production in Virginia experimentation Division, Virginia Polytech, Inst. State Univ, 1974, 44.
3. Anonymous. Package of practices, UAS, Bangalore, 2014, 252.
4. Bhat NS, Raju GT, Manjunatha M, Nagabhushana GG, Deshpande VP. Chemical control of cowpea pod borer. Indian J Pl. Prot. 1988; 16:197-200.
5. Brahman SK, Awasthi AK, Singh S. Studies on insect-pests of soybean (*Glycine max*) with special reference to seasonal incidence of lepidopteran defoliators. J Pharmacognosy and Phytochemistry. 2018; 7(1):1808-1811.
6. Byrappa AM, Kumar NG, Divya M. Impact of biopesticides application on pod borer complex in organically grown field bean ecosystem. J Biopest. 2012; 5(2):148-160.
7. Chung G, Singh RJ. Broadening the Genetic Base of Soybean: A multidisciplinary approach, Critical Reviews in Plant Sciences. 2008; 27(5):295-341.
8. Delate K, Friedrich H, Burcham B, Fehr W, Wilson L. Edamame (Vegetable soybean) variety trial: IDALS specialty grant program- 2002, Annual Research Reports-2002. Armstrong research and demonstration farm, Iowa State University, Ames, IA, 2003, 1p.
9. Dhaliwal GS, Arora R. Integrated pest management: concepts and approaches. Kalyani Publishers, New Delhi, 2001, 427.
10. Gubbaiah, Rajanna TV, Kulkarni KA, *Cydia ptychora* M. as a pest of cowpea (*Vigna sinensis* Savi.). Curr. Res. 1975; 4:46.
11. Kamala NV. Development of IPM modules for soybean (*Glycine max* (L.) (Merrill). M.Sc. (Agri.) Thesis, Univ. Agric. Sci., Bangalore, India, 2000.
12. Lal SS, Yadav CP, Dias CAR. Insect pests of pulse crops and their management. Pesticides Annual Report, 1981, 66-67.
13. Lateef SS, Reed W. Survey of insect pest damage in farmer's field in India, Int. pigeonpea Newsle. 1981; 1:29-30.
14. Lal R. Diagnostic symptoms and loss assessment due to insect-pests in pulses. In: Saini R K, Sharma S S, Mrig K K. (Eds.) Advances in diagnosis of arthropod pests' damage and assessment of losses, September 6 to 26, 2011, CCS Haryana Agricultural University, Hisar, 2011, 78-80.

15. Luckmann WH. The insect pests of soybean. World Farm. 1971; 13(5):18-19. 22.
16. Mentreddy SR, Mohamed AI, Joshee N Yadav. Edamame: A nutritious vegetable crop. In: Janick J, Whipkey A. (eds.), Trends in new crops and new uses, 2002, 432-438.
17. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers, Indian Council of Agricultural Research, New Delhi, 1967, 243.
18. Rambihari A, Payal D, Rajeev G. Seasonal incidence of major insect- pests and their biocontrol agents of soybean crop (*Glycine max* L. Merrill). Academic J, 2015; 10(12):402-406.
19. Rao MS, Raman GV, Srimannarayana G, Venkateshawaralu B. Evaluation of some IPM packages in the management of pod borer complex of pigeon pea. Pestology. 1999; 23(8):41-43.
20. Ravikumar. Evaluation of organics and indigenous products for the management of *Helicoverpa armigera* (Hubner) in chilli. M.Sc. (Agri.) Thesis, Uni. Agric. Sci., Dharwad, India, 2004.
21. Reddy MRS, Reddy GS. An ecofriendly method to combat *Helicoverpa armigera* (Hub.) on sweet orange (*Citrus sinensis* L.). Insect Environ. 2000; 4(4):143-144.
22. Sachan JN, Lal SS. Role of botanical insecticides in *Helicoverpa armigera* management in pulses. In: Proceedings of Symposium Botanical Pesticides in IPM. Rajahmundry, Andhra Pradesh, 1990, 261-269.
23. Sarode SV, Deotale RO, Patil PP. Performance of *Helicoverpa* nuclear polyhedrosis virus (HNPV) combined with neem seed kernel extract (NSKE) against the pod borer on chickpea. Int. Chickpea and Pigeonpea Newslet. 1995; 2:35-37.
24. Shanmugasundaram S. Vegetable soybean - a multipurpose crop. AVRDC, the vegetable center, Taiwan, 1996, 427-430.
25. Sultani MS. Studies on the potentiality of the pod borer *Helicoverpa armigera* (Hubner) (lepidoptera: noctuidae) on soybean and its management, M.Sc. (Agri.) Thesis, Univ. Agric. Sci., Bangalore, India, 2015.