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Validation of IPM modules against insect-pests complex of soybean, *Glycine max* (L.) Merrill

Manish Kumar, Mahender Singh, Savita Kumari and AK Dixit

Manish Kumar
Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Krishi Vigyan Kendra, Dewas, Madhya Pradesh, India

Mahender Singh
Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Krishi Vigyan Kendra, Dewas, Madhya Pradesh, India

Savita Kumari
Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Krishi Vigyan Kendra, Dewas, Madhya Pradesh, India

AK Dixit
Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Krishi Vigyan Kendra, Dewas, Madhya Pradesh, India

Corresponding Author
Manish Kumar
Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Krishi Vigyan Kendra, Dewas, Madhya Pradesh, India

Abstract
Field experiments were conducted to evaluate IPM modules against major insect- pests of soybean at farmer's field in adopted village of RVSKVV, Krishi Vigyan Kendra, Dewas (M.P.) during kharif season of the year 2015and 2016. These revealed that IPM module M1 ((Deep ploughing and exposure of soil to hot summer to kill pupating larvae, Use of optimum seed rate @75Kg/ha, Seed treatment with Thimethoxam 70WS 3g/kg of seed, Installation of pheromone trap @ 10/ha, for tobacco caterpillar, Erection of bird perches @ 50/ha and Spraying of Chlorantraniliprole 18.5% SC @ 100 ml/ha at ETL level) proved to be most effective with lowest incidence of whitefly, blue beetle, green semilooper, tobacco caterpillar and pod borer and significantly superior module M2 (Deep ploughing and exposure of soil to hot summer to kill pupating larvae, Use of optimum seed rate @75Kg/ha, Seed treatment with Thimethoxam 70WS 3g/kg of seed, Installation of pheromone trap @ 10/ha, for tobacco caterpillar, Erection of bird perches @ 50/ha, Spraying of NSKE @ 800 ml/ha at ETL level and Spraying of Trizophos 40 EC @ 800 ml/ha at ETL level). Whereas IPM module M2 found most effective against girdle beetle, where 4.47% were recorded followed by M3 and at par with M4. The higher seed yield i.e. 1978 and 1612 kg/ha was found in the module M1 during both the years. The studied also showed that net return was also higher and maximum ICBR in module M1 (1:1.66).

Keywords: soybean, IPM modules, whitefly, girdle beetle, pod borer, semilopper

Introduction
Soybean, Glycine *max* (L.) Merrill is subjected to attack by about 275 species of insect right from vegetative stage to harvesting in India. Out of that species, 20 insect- pests have been observed on crop in area. Among them semilooper, *Chrysodeixis acuta* Walker (Noctuidae: Lepidoptera) in defoliators and girdle beetle, *Obereopsis brevis* Swed. (Lamiidae: Coleoptera) in borers are predominant and of economic significance can cause severe damage and consequent reduction in yield (Sharma, 1999) [17]. The girdle beetle infests the plants both in early and late phase. As a result of early infestation of plants, 75% plants die before maturity and 47.2 kg/ha grains weight loss caused at an average plant infestation of 8.7% (Gangrade and Singh, 1976.) [9]. The damage caused by individual insect- pests in crop is well documented (Chaudhary and Gopal, 2005) [6]. Among the various insect defoliators, sap sucking insects are the major constraints for low yield in the soybean, them only few are of economic importance (Raju *et al.*, 2013) [15]. At present, *Obereopsis brevis Swed.*, *Melanagromyza sojae Zehnt.*, *Cneorane* spp., *Spodoptera litura* Fabr., *Bemisia tabaci*, *Chrysodeixis acuta* Fabr., *Diachrysia orichalcea* Walker, *Mocis undata* Fab., *Helicoverpa armigera* Hub. and *Tetranychus telarius* are predominant and of economic significant can cause severe damage and consequent reduction in yield (Sharma, 1999) [17]. Due to problems like pest outbreak, development of resistance to insecticides, elimination of natural enemies, risk to human and animal health besides environmental pollution, integrated pest management (IPM) is perceived as the only alternative (Rao *et al.*,1999) [16]. Hence, it is very much necessary to adopt a holistic approach with IPM in order to avoid economic damage and to make soybean cultivation sustainable. Dependency on single control tactics using solely insecticides have resulted in many hazards and these are impediments to sustainable agriculture (Miller *et al*., 2010) [12]. Hence, integration of different control tactics like physical, cultural, chemical and biological is advocated in IPM (Kennedy and Sutton, 2000) [10]. The available tools for controlling insect pests involve a very wide range of techniques viz., cultural, mechanical, biological, chemical and regulatory methods of control and have been combined to form various IPM modules used in soybean. Plant protection in soybean during early as well as later stage of crop is very much essential to avoid the losses through protecting

from insect pests. In view of this adoption of integrated strategies for ecofriendly management incorporating selective, safer, modern pesticides and biopesticides seem to be the best alternative. Hence, evaluates multiple control tactics in the form of IPM modules on major pests of soybean at Dewas (Madhya Pradesh).

Materials and Methods

The investigation were carried out in twelve locations at farmers's fields of adopted villages in sonkachha and Dewas block near RVSKVV Krishi Vigyan Kendra, Dewas in kharif 2015-16 and 2016-17 to assess IPM modules. The IPM modules were evaluated based on insect-pests incidence at vegetative, flowering, pod initiation and up to harvesting. The recommended agronomical practices were followed. The location specific Sequential details of the IPM modules and the recommended insecticidal control schedule (non IPM) are furnished below.

Module -1(M_1)

- Deep ploughing and exposure of soil to hot summer to kill pupating larvae
- Use of optimum seed rate @75Kg/ha
- Seed treatment with Thimethoxam 70WS 3g/kg of seed
- Installation of pheromone trap @ 10/ha, for tobacco caterpillar
- Erection of bird perches @ 50/ha
- Spraying of Chlorantraniliprole 18.5% SC @ 100 ml/ha at ETL level

Module -2 (M_2)

- Deep ploughing and exposure of soil to hot summer to kill pupating larvae
- Use of optimum seed rate @75Kg/ha
- Seed treatment with Thimethoxam 70WS 3g/kg of seed
- Installation of pheromone trap @ 10/ha, for tobacco caterpillar
- Erection of bird perches @ 50/ha
- Spraying of NSKE @ 800 ml/ha at ETL level
- Spraying of Trizophos 40 EC @ 800 ml/ha at ETL level

Module -3 (M_2)

- Deep ploughing and exposure of soil to hot summer to kill pupating larvae
- Use of optimum seed rate @75Kg/ha
- Installation of pheromone trap @ 10/ha, for tobacco caterpillar
- Spraying of Trizophos 40 EC @ 800 ml/ha at ETL level

Module -4 (M_4) (Farmers practice module- chemical control)

The plant protection measures adopted by local farmers were mostly dependent on Indiscriminate application of insecticides i.e. Trizophos 40 EC @ 800 ml/ha & Profenofos 50% EC @ 1250 ml/ha. These insecticides were sprayed at 10-15 days interval.

The numbers of insects were counted as replication wise in from each modules. The observations on the population of the defoliators and stem borers viz., blue beetle, green semi lopper, tobacco caterpillar, girdle beetle and pod borer larvae of per meter row length (MRL) were recorded at fifteen days interval. The immature stage as well as mature stage of whitefly was recorded on 05 randomly selected plants from each 3 leaves/plants. The numbers of larvae, beetles ad whitefly were transformed to square root values and per cent infestation were transformed angularly for statistical analysis. Seed yield was recorded from each replication after the harvest of the crop and converted to Kg/ha before subjected to the statistical analysis. Both years pooled data were subjected analysis, component-wise were worked out insecticides cost, labourers wages and the other inputs cost and additional return in term of Rs and Incremental Benefit Cost Ratio (IBCR).

Results and Discussion

The data recorded on the insect-pests and the various economic parameters in IPM modules plots during 2015-16 and 2016-17 are presented in Tables 1, 2 and 3.

The data recorded on whitefly per three leaves/plant during kharif 2015 presented in Table 1 revealed that population varied from 2.81 to 5.43 per three leaves/plant in different IPM modules and maximum 5.43 per three leaves/plant was recorded in farmer practices (M_4). All the IPM modules were significantly superior over farmer practices (M_4). The IPM module M1 (Deep ploughing and exposure of soil to hot summer to kill pupating larvae, Use of optimum seed rate @75Kg/ha+Seed treatment with Thimethoxam 70WS 3g/kg of seed, Installation of pheromone trap @ 10/ha, for tobacco caterpillar, Erection of bird perches @ 50/ha and Spraying of Chlorantraniliprole 18.5% SC @ 100 ml/ha at ETL level) found most effective against whitefly, whereas, 2.81 per three leaves/plant were recorded followed by M2 (Deep ploughing and exposure of soil to hot summer to kill pupating larvae, Use of optimum seed rate @75Kg/ha, Seed treatment with Thimethoxam 70WS 3g/kg of seed, Installation of pheromone trap @ 10/ha, for tobacco caterpillar, Erection of bird perches @ 50/ha, Spraying of NSKE @ 800 ml/ha at ETL level and Spraying of Trizophos 40 EC @ 800 ml/ha at ETL level) where 2.92 whitefly per three leaves/plant and at par with M3 (Deep ploughing and exposure of soil to hot summer to kill pupating larvae, Use of optimum seed rate @75Kg/ha, Installation of pheromone trap @ 10/ha, for tobacco caterpillar and Spraying of Trizophos 40 EC @ 800 ml/ha at ETL level) were recorded.

It is evident from Table 1, which the treatment of IPM module M1 was found most effective against whitefly (2.79 per three leaves/plant) during kharif 2016 followed by 3.20 whitefly per three leaves/plant in M2 and were significantly superior from rest of the modules. In farmer practices (M4) 5.24 whitefly per 3 leaves / plant were found.

The significantly lowest population of blue beetle were recorded in M1 plots (1.17 and 1.41 per MRL) while it was at par with M2 IPM module (1.40 and 1.66 per MRL) during kharif 2015 and 2016, respectively.

The pooled data on girdler beetle infestation during kharif 2015 and 2016 presented in Table 1 revealed that infestation varied from 4.47 to 8.03 per cent in different IPM modules, while 6.78 per cent was observed in farmer practices plot M4.The IPM module M2 (Deep ploughing and exposure of soil to hot summer to kill pupating larvae, Use of optimum seed rate @75Kg/ha, Seed treatment with Thimethoxam 70WS 3g/kg of seed, Installation of pheromone trap @ 10/ha, for tobacco caterpillar, Erection of bird perches @ 50/ha, Spraying of NSKE @ 800 ml/ha at ETL level and Spraying of Trizophos 40 EC @ 800 ml/ha at ETL level) found most effective against girdle beetle, where 4.47% were recorded followed by M3 and at par with M4. All the IPM modules were found lower damage of girdle beetle and statistically at par with each other except M1 (8.03%) during both the years.

The average larval population of green semilooper presented in Table 2 indicated that all the modules were statistically superior farmer practices plot (M4). The larval population of semilooper varied from 1.34 to 1.97 per MRL in different modules whereas, 2.25 per MRL was recorded in untreated control. The module (M1) was found significantly most effective where only 1.34 larva/ MRL was recorded followed by M2 (1.46 larva/MRL) and M3 (1.97 larva/MRL) were at par with each other during both the years. The present findings are in accordance with those of Chaudhary and Bajpai (2007) [8] on Triazophos.

The data pertaining to larval population of tobacco caterpillar are presented in Table 2, during Kharif 2015, all modules were significantly superior to farmer practices plot. Module (M1) recorded 1.44 larvae/MRL followed by M2 (1.62 larvae/MRL) and M3(2.02 larvae/MRL), which

were at par with each other. Farmer practices plot (M4) had recorded maximum (2.35 larvae/MRL) incidence of tobacco caterpillar. During Kharif 2016, significantly lowest incidence of tobacco caterpillar was observed in M1 module (1.47 larvae /MRL). The next best module was M2 (1.69 larvae/ MRL) followed by M3 (2.16 larvae/MRL) which were at par with each other. Significantly higher larval population was observed in untreated control (2.41 larvae/MRL). The pooled data (Table-2) showed a similar trend. Significantly lower larval population of tobacco caterpillar was recorded in module M1 (1.34 larvae /MRL), which was IPM Modules for tobacco caterpillar significantly superior to the rest of the modules. Significantly maximum incidence was observed in farmer practices plot (2.25 larvae /MRL).

The larval populations of Pod Borer (*H. armigera)* are presented in Table 2. During Kharif 2015, all modules were significantly superior to farmers practices plot (M4). Module M1 recorded 1.85 larvae/MRL followed by M2 (3.78 larvae/MRL) and M3 (4.55 larvae/MRL), which were at par with each other. Farmer practices plot M4 was found higher (4.73 larvae/MRL) incidence of *H. armigera*. During Kharif 2016, significantly lowest larval population of *H. armigera* was observed in M1 module (2.10 larvae /MRL). The next best module was M2 (3.78 larvae/ MRL) followed by M3 module (3.85 larvae/MRL) which were at par with each other. Significantly higher larval population was observed in farmer practices module M4 (4.55 larvae /MRL).

The pooled data (Table 2) showed a similar trend. Significantly lower larval population of *H. armigera* was recorded in module M1 (1.98 larvae /MRL) as comparison to other IPM modules. The similar trends were observed in pod damage. Bharpoda *et al.*, (2000) [2], who observed that IPM module proved significantly effective for management of *H. armigera* in comparison to the crop protected with recommended insecticide schedule and unprotected condition. Brar *et al*. (2002) [5] also reported the lowest incidence of *H. armigera* in IPM modules. Bhute (2010) [4] reported significantly lowest population of H. armigera larvae (0.02/5 plants) in MAU IPM module followed by chemical control.

Seed yield data of kharif 2015 presented in Table 3 reveal that the entire module are statistically superior over module M4. Module M1 was found the most effective with maximum seed yield (1978 kg/ha) followed by M2 (1867 kg/ha) and M3 (1625 kg/ha). The data of kharif 2016 show that all the modules were statistically superior compared to module M4. The modules M1 was found maximum seed yield (1612kg/ha) followed by M2 (1485 kg/ha) and at par with M3 (1540 kg/ha). Pooled data of two years further confirmed that all modules are significantly superior over M4. However, all were found statistically at par except module M1 (1795 kg/ha) gave maximum seed yield followed by M2 (1676 kg/ha). H. R. Chaudhary and H. P. Meghwal 2012 was also reported that the maximum seed yield of soybean Rynaxypyr 20 SC @ 100 ml/ha and Triazophos 40 EC @ 800 ml/ha. Kumar and Ram (2002) [11] also observed comparatively higher yield with two spray of chemical insecticide against insect pests in soybean.

Data on cost benefit ratio presented in Table 3 reveal that maximum additional seed yield over farmer practices (kg/ha), grass return (Rs./ha) and net return (Rs./ha) module M1. This is followed by Module M2 and M3 during both the years. The mean cost of protection (Rs 4525/ha) was higher in module M1 followed by module M4 (Rs. 5440/ha) and module M3 (Rs.3920/ha) however the mean gross return was found higher in the M1(Rs.56733.63) followed by module M2 and M3 modules during both the years. Maximum net return was obtained in both these. The higher IBCR (1:1.66) was observed module M1 followed by M3(1:1.56) and M2 (1:1.57) that was only due to lower cost of protection as compare to the most effective module (Deep ploughing and exposure of soil to hot summer to kill pupating larvae +Use of optimum seed rate @75Kg/ha+Seed treatment with Thimethoxam 70WS 3g/kg of seed +Installation of pheromone trap @ 10/ha, for tobacco caterpillar + Erection of bird perches @ 50/ha+ Spraying of Chlorantraniliprole 18.5% SC @ 100 ml/ha at ETL level). The present findings are more or less parallel to Sabir *et al* (2008) [13], who observed the cost benefit ratio of 1:4.27 in IPM conditions over non-IPM one. Chaudhary and Meghwal 2012 [12] was also reported that the maximum net return with highest IBCR (19.82) was obtained with Triazophos 40 EC @ 800 ml/ha. Existing conventional extension approach consists mainly of the centrally guided transfer of technology with readymade packages which unfortunately are not validated under location specific field condition (Bhosle *et al.* 2009) [3]. These findings are in tune with the reports of [Panduranga *et al*., 2011 [14], Anonumous, 2012 [1] and Singh and singh, 2015) [18] were reported that cost: benefit ratio higher in IPM plots compared to farmers' practice.

Table 1: Effect of IPM modules against incidence of whitefly, blue beetle and girdle beetle during kharif 2015 and 2016.

Treatments	*Whitefly (per three leaves/plant)			*Blue beetle (adult/MRL)			#Girdle beetle (%)		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
IPM Module-M1	2.81 (3.16)	2.79 (2.97)	2.80 (1.82)	1.17 (2.24)	1.41 (2.46)	1.29 (1.33)	8.43 (18.93)	7.63 (16.33)	8.03 (16.37)
IPM Module-M2	2.92 (3.27)	3.20 (3.21)	3.06 (1.89)	1.40 (2.26)	1.66 (2.47)	1.53 (1.42)	4.63 (11.71)	4.30 (12.82)	4.47 (12.10)
IPM Module-M3	4.80 (4.03)	4.91 (4.03)	4.85 (2.31)	1.90 (2.58)	2.24 (2.77)	2.07 (1.60)	5.20 (13.64)	5.73 (14.29)	5.47 (13.47)
IPM Module-M4	5.43 (4.25)	5.24 (3.97)	5.34 (2.41)	2.19 (2.68)	2.57 (2.93)	2.38 (1.69)	7.25 (18.28)	6.30 (15.17)	6.78 (14.99)

SEM±	0.07	0.08	0.04	0.03	0.04	0.03	1.0	0.49	0.57
CD 5%	0.16	0.16	0.09	0.07	0.07	0.07	2.04	0.99	1.17

* Figures in parentheses are square root transformed values.# Figures in parentheses are angular transformed values. MRL= meter row length

Table 2: Effect of IPM modules against incidence of green semilooper, tobacco caterpillar, pod borer and seed yield during kharif 2015 and 2016.

Treatments	Green Semilooper (larvae/MRL)			Tobacco Caterpillar (larvae/MRL)			*H. armigera* (larvae/MRL)			Seed Yield (Kg/ha)		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
IPM Module-**M1**	1.44 (2.37)	1.47 (2.54)	1.34 (1.35)	1.44 (2.85)	1.47 (2.14)	1.34 (1.40)	1.85 (2.91)	2.10 (2.68)	1.98 (1.57)	1978	1612	1795
IPM Module-**M2**	1.62 (2.47)	1.69 (2.64)	1.46 (1.39)	1.62 (3.11)	1.69 (2.43)	1.46 (1.56)	3.78 (3.65)	3.02 (3.16)	3.40 (1.97)	1867	1485	1676
IPM Module-**M3**	2.02 (2.60)	2.16 (2.90)	1.97 (1.57)	2.02 (3.34)	2.16 (2.75)	1.97 (1.69)	4.55 (3.94)	3.85 (3.44)	4.20 (2.17)	1625	1455	1540
IPM Module-**M4**	2.35 (2.85)	2.41 (2.87)	2.25 (1.66)	2.35 (3.57)	2.41 (3.05)	2.25 (1.82)	4.73 (3.71)	4.55 (3.69)	4.64 (2.26)	1516	1383	1450
SEM±	0.03	0.03	0.03	0.03	0.03	0.03	0.07	0.07	0.04	56.00	26.35	27.96
CD 5%	0.07	0.06	0.05	0.07	0.06	0.05	0.14	0.14	0.08	113.94	53.60	56.89

*Figures in parentheses square root transformed values; MRL=meter row length

Table 3: Effect of IPM modules on Economics of soybean (Pooled data during kharif 2015 and 2016)

Treatments	Pooled grain Yield (Kg/ha)	Additional yield over Farmer practices (Kg/ha)	Number of chemical spray	Cost of IPM protection measure/ ha*	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	Cost: benefit ratio
IPM Module-M1	1795.00	346.00	1.40	4525.00	34077.5	56733.63	22656.13	1:1.66
IPM Module-M2	1676.00	227.00	2.27	3920.00	33575	52992.13	19417.13	1:1.57
IPM Module-M3	1540.00	90.00	2.64	2750.00	32050	50065.88	18438.38	1:1.56
IPM Module-M4	1450.00	-	3.55	5440.00	34920	46922.25	12002.25	1:1.34

*Cost of IPM protection included (insecticides cost+ labour cost +sprayer rent cost)

Conclusion

Thus integration of Deep ploughing, Use of optimum seed rate @75Kg/ha, Seed treatment with Thimethoxam 70WS 3g/kg of seed, Installation of pheromone trap @ 10/ha, for tobacco caterpillar, Erection of bird perches @ 50/ha and Spraying of Chlorantraniliprole 18.5% SC @ 100 ml/ha at ETL have most promising results with significant reduction of blue beetle, green semi lopper, tobacco caterpillar, girdle beetle and pod borer larvae. These increased the yield considerably. The IPM technology used was not only directly environment friendly but also more sustainable vide increase in (natural enemies, soil flora and fauna) biodiversity and reduced use of pesticides with less load on environment. Several problems related to calendar based approach have limited the effectiveness and impact on further improving the intensive smallholder farming systems.

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