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Management of gram pod borer, *Helicoverpa armigera* (Hubner) by evaluating different IPM Modules in southern Rajasthan

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Abstract
The field experiment to evaluate suitable and ecofriendly IPM modules was conducted at Turgarh village of Jhadol block of Udaipur district during Rabi 2018-19 and 2019-20 using 10 different modules. Results revealed that mean larval population of gram pod borer, *Helicoverpa armigera* was considerably low after evaluating sprays in different modules. The lowest larval population of insect (2.98 larvae /MRL) was recorded in Module 7, consissing of spinosad 2.5 SC @ 0.5 ml/l of water as 1st spray and indoxacarb 14.5% SC @ 1 ml/l of water as 2nd spray followed by module 1, consisting of clorfluazuron 5.4% EC @ 3 ml/l of water as 1st spray and indoxacarb 14.5% SC @ 1 ml/l of water as 2nd spray and module 2 consisting of spinosad 2.5 SC @ 0.5 ml/l of water as 1st spray and profenofos 50 EC @ 1.5 ml/l of water as 2nd spray in Rabi 2018-19 as well as in Rabi 19-20. Based on the benefit cost ratio module 6 Consisting of indoxacarb 14.5% SC @ 1 ml/l of water as 1st spray and profenofos 50 EC @ 1.5 ml/l of water as 2nd spray gave maximum return *i.*e. 1:2.04 & 1:2.12 respectively during first and second year, which proved more viable due to lower cultivation cost in both the seasons than all other modules evaluated during Rabi 2018-19 and Rabi 2019-20.

Keywords: Bio-pestiticides, *Helicoverpa armigera*, IPM

Introduction
Chickpea, *Cicer arietinum* L. is a most important pulse crop,India accounts for more than 20 percent of world's pulse production and much of the world chickpea supply (80 to 90%). India is one of the important chickpea growing countries in Asia with an area of 9.01 mha and production of 7.58 mt with productivity of 841 kg ha^{-1} (Anon., 2012) [2]. Rajasthan contributes 16.70% area and 9.73% production to the nation under gram. During Rabi 2015-16 gram was grown in about 9.41 lakh hectare with an average annual production of 0.84 mt and the average productivity was 8.92 q/ha. The low yield of chickpea may be attributed to many reasons, among which damage by insect pests especially gram pod borer, *Helicoverpa armigera* is more pronounced (Bindra, 1968) [3]. This insect feeds voraciously from seedling stage to maturity and cause about 50 and 60 percent damage to the chickpea pods (Khare and Ujagir, 1977) [5]. In India, losses caused by *H. armigera* on chickpea and pigeonpea fields exceeded Rs.12, 000 million per year as per survey carried out by ICRISAT (Anon., 1996) [1]. Now this pest *H. armigera* has developed resistance to all the major insecticide classes and day by day it has become increasingly and difficult to manage its population in India. This pest alone accounts for consumption of half of the total pesticides used in India for protection of different crops (Suryavanshi *et al.*, 2008) [11]. However, the indiscriminate and continuous and over dependence of a particular group of chemical use has led to resistance, pest resurgence, environment pollution and deleterious effects on predators and parasites, therefore an attempt has been made to develop an ecofriendly pest management strategy or IPM modules for this more destructive pest (*Helicoverpa armigera)*.

Material and Methods
The field trial was conducted at farmers field at village Turgarh, Jhadol block of Udaipur district during two successive years i.e., Rabi 2018-19 and Rabi 2019-20. Gram variety GNG-1581 (Ganguar) was sown in randomized block design (RBD) having ten different pest management modules included two checks were evaluated, there were three replications and

the plots size was 4x4 m^2 with spacing of row to row and plant to plant was 30x15 cm, respectively. Different biopesticides and ecofriendly pesticides *viz.,* HaNPV (Helicoverpa Nuclear Polyhedrosis Virus), spinosad, clorfluazuron, neem oil, pongamia leaf extract 5% and indoxacarb along with conventional synthetic organic insecticides such as Lambda-cyhalothrin, profenofos and cypermethrin were used in different combinations to prepare the modules (Table 1). Module 9 consisting of Lambda cyhalothrin 5% EC (1.25 ml/l) as 1st spray & Profenofos 50 EC (1.5 ml/l) as 2nd spray and Module 10 consisting of Cypermethrin 10% EC (2.0 ml/l) as 1st spray & Lambda cyhalothrin 5% EC (1.25 ml/l) as 2nd spray did not have any biorational insecticides in their schedule as they were used as Check. In each module, two foliar sprays of insecticides were taken in each season. First spray was done at the pod initiation stage while next spray was undertaken after 15 days of first spray. Observation on larval population of *H. armigera* was recorded one day before the first spraying as pretreatment count (PTC) while post treatment counts were recorded at 1, 3 and 7 days after each spray. Thereafter, post-treatment mean larval population was calculated. The calculation of insect population was based on shaking method in one meter row length (MRL) randomly at three locations in each plot. After discarding the border rows seed yield of chickpea was recorded from net plot area and computed on hectare basis. Benefit cost ratio was also computed using the following formula:

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Net monetary returns grain yield (₹)}}{\text{Cost of pest control operations and cost of inputs (₹)}}$$

The data thus, obtained on various aspects were analyzed statistically after making necessary transformation, whatever required.

Table 1: Details of Pest management modules against *Helicoverpa armigera* in chick pea during Rabi 2018-19 and Rabi 2019-20.

Treatments	Details of the spray (Spray 1st - Spray 2nd)
Module 1	Clorfluazuron 5.4% EC (3 ml/l) - Indoxacarb 14.5% SC (1ml/l)
Module 2	Spinosad 2.5 SC(0.5 ml/l) - Profenofos 50 EC (1.5 ml/l)
Module 3	Pongamia leaf extract 5% - Profenofos 50 EC (1.5 ml/l)
Module 4	Neem oil (5 ml/l) - Profenofos 50 EC (1.5 ml/l)
Module 5	Ha NPV 250 LE(1.5 ml/l)-Profenofos 50 EC (1.5 ml/l)
Module 6	Indoxacarb 14.5% SC (1ml/l) - Profenofos 50 EC (1.5 ml/l)
Module 7	Spinosad 2.5 SC(0.5 ml/l) - Indoxacarb 14.5% SC (1ml/l)
Module 8	Indoxacarb 14.5% SC (1ml/l) - Cypermethrin 10% EC (2.0 ml/l)
Module 9	Lambda cyhalothrin 5% EC (1.25 ml/l) - Profenofos 50 EC (1.5 ml/l)
Module 10	Cypermethrin 10% EC (2.0 ml/l) - Lambda cyhalothrin 5% EC (1.25 ml/l)

Results and Discussion

The efficiency of various IPM modules against *Helicoverpa armigera* was evaluated in chickpea during two years i.e. Rabi 2018-19 and Rabi 2019-20.

First year (Rabi 2018-19)

Perusal of data revealed that during this experimental year, larval population in pretreatment observation was higher than post treatment in all the modules evaluated. However, before spraying no significant variation in larval population was found among the different modules (Table 2). Results further revealed that the pooled mean larval population of *H. armigera* was considerably low after spraying in different modules during the experimental period and lowest population of the insect (2.98 larvae/MRL) was recorded in module 7, consisting of spinosad 2.5SL @ 0.5ml/l of water as 1st spray and indoxacarb 14.5% SC @ 1ml/l of water as 2nd spray. Yadav (2009) [12]; Krishna *et al.* (2007) [6]; Kumar *et al.* (2014) [7] found out quite similar findings, these finding was followed by module1(3.23 larvae/MRL) consisting of 1st spray with clorfluazuron 5.4% EC @ 3 ml/l of water and indoxacarb 14.5% SC @ 1 ml/l of water as 2nd spray (El-Sayed *et al.,* 2013) [4] and module 2(3.40 larvae/MRL) consisting of spinosad 2.5SC @ 0.5 ml/l of water as 1st spray & profenofos 50EC 1.5 ml/l of water as 2nd spray. These all three treatment modules was followed by module 6(4.14 larvae/MRL) consisting of indoxacarb 14.5% SC 1ml/l of water as 1st spray & profenofos 50 EC 1.5 ml/l of water as 2nd spray, module 8 (4.43 larvae/MRL) consisting of indoxacarb 14.5% SC (1ml/l) as 1st spray & cypermethrinn 10% EC (2.0 ml/l) as 2nd spray, module 9(5.02 larvae/MRL) consisting of lambda cyhalothrin 5% EC (1.25 ml/l) as 1st spray & profenofos 50 EC (1.5 ml/l) as 2nd spray, module 10 (5.45 larvae/MRL) consisting of cypermethrinn 10% EC (2.0 ml/l) as 1st spray & lambda cyhalothrin 5% EC (1.25 ml/l) as 2nd spray, module 5(5.49 larvae/MRL) consisting of Ha NPV 250 LE(1.5 ml/l) as 1st spray & profenofos 50 EC (1.5 ml/l) as 2nd spray, module 4(5.79 larvae/MRL) consisting of neem oil (5 ml/l) as 1st spray & profenofos 50 EC (1.5 ml/l) as 2nd spray and module 3(6.10 larvae/MRL) which was least effective, consisting of Pongamia leaf extract 5% as 1st spray & profenofos 50 EC (1.5 ml/l) as 2nd spray, respectively (Kumar *et al.,* 2014) [7].

After 1st spray, significant difference in mean larval population was observed among the modules. module 7 (3.72 larvae/MRL) consisting of spinosad 2.5SL @ 0.5ml/l of water as 1st spray and indoxacarb 14.5% SC @ 1ml/l of water as 2nd spray proved most effective but was at par with module 1 (3.88 larvae/MRL) consisting of 1st spray with clorfluazuron 5.4% EC @ 3 ml/l of water and indoxacarb 14.5% SC @ 1 ml/l of water as 2nd spray, module 2 (3.97larvae /MRL) consisting of spinosad 2.5SC @ 0.5 ml/l of water as 1st spray & profenofos 50EC 1.5 ml/l of water as 2nd spray, module 6 (4.76 larvae/MRL) consisting of indoxacarb 14.5% SC (1ml/l) as 1st spray & profenofos 50 EC (1.5 ml/l) as 2nd spray and module 8 (4.93 larvae /MRL) consisting of indoxacarb 14.5% SC (1ml/l) as 1st spray & cypermethrinn 10% EC 2.0 ml/l of water as 2nd spray. Mean larval population of the insect further reduced after second spray and insect population was significantly low in module 7 (2.25larve/MRL) while in module 1 (2.58 larvae/MRL), module 2 (2.83 larvae/MRL), module 6 (3.52 larvae /MRL) and module 8 (3.94 larvae/MRL) remained on at par but proved effective than others in keeping the insect population at lower level. So

above results of first year shows the efficiency of different modules was in following descending order:
Module 7 > Module 1 > Module 2 > Module 6 > Module 8 > Module 9 > Module 10 > Module 5 > Module 4 > Module 3.

Second year (Rabi 2019-20)

During Rabi 2019-20, higher insect population was observed before application of any insecticides but after repeated spraying mean larval population of the insect remained consistently low throughout experimental period in different modules. In module 7 consisting of spinosad 2.5SL @ 0.5ml/l of water as 1st spray and indoxacarb 14.5% SC @ 1ml/l of water as 2nd spray, the mean larval population was 3.10 & 2.06 larvae/MRL after 1st and 2nd spray respectively, again proved most effective to manage larval population of *Helicoverpa*. This module followed with module 1 consisting of 1st spray with clorfluazuron 5.4% EC @ 3 ml/l of water and indoxacarb 14.5% SC @ 1 ml/l of water as 2nd spray (3.24 & 2.40 larve /MRL after 1st and 2nd spray respectively), module 2 (3.72 & 2.48/MRL after 1st and 2nd spray, respectively) and Module 6 (3.79 & 3.20/MRL after 1st and 2nd spray, respectively). A picture on pooled mean of larval population revealed that module 7 consisting of spinosad 2.5SL @ 0.5ml/l of water as 1st spray and indoxacarb 14.5% SC @ 1ml/l of water as 2nd spray found superior among others as lowest number of larvae (2.78/MRL) was recorded in this pest management module which was followed by module 1 (3.02 larvae/MRL) consisting as first spray with Clorfluazuron 5.4% EC @ 3ml/l of water and 2nd spray with Indoxacarb 14.5% SC @ 1ml/ of water. Similarly, finding was recorded on *Helicoverpa armigera* in chickpea by Moorthy *et al.* (2011) [8] and Kumar *et al.* (2014) [7]. So, overall the effectiveness of different modules against *H. armigera* in chickpea were found in below descending order:
Module 7 > Module 1 > Module 2 > Module 6 > Module 8 > Module 9 > Module 10 > Module 5 > Module 4 > Module 3.

Yield

The quantum of monetary benefit expected from insecticidal application depend on many factors like effectiveness of the compound against the pest, cost of the insecticides and the produce of the crop, labour, wage, etc. in the locality. There is every possibility of variations of these factors over place and time which led to the inference on monetary benefit from pest control operations. In the present investigation, the data on cost of production, net returns and benefit cost ratio (BCR) with respect to different treatment were presented in Table 3. During Rabi 2018-19, total cost of production per ha involved in different pest management modules varied from ₹14,700.00 to ₹23,700.00. Further highest net returns of ₹43,700.00 were obtained from application of module 7 consisting of spinosad 2.5SL @ 0.5ml/l of water as 1st spray and indoxacarb 14.5% SC @ 1ml/l of water as 2nd spray followed by module 1 (₹41,400.00) consisting of 1st spray with clorfluazuron 5.4% EC @ 3 ml/l of water and indoxacarb 14.5% SC @ 1 ml/l of water as 2nd spray and module 2 (₹39,880.00) consisting of Spinosad 2.5SC @ 0.5 ml/l of water as 1st spray & profenofos 50EC 1.5 ml/l of water as 2nd spray. Despite lower yield, better BCR was calculated in module 6 (1:2.04) consisting of indoxacarb 14.5% SC (1ml/l) as 1st spray & profenofos 50 EC (1.5 ml/l) as 2nd spray due to lower expenditure incurred to produce the crop as compared to module 7 (1:1.84) which got 5th rank. The BCR was more than the unit in all modules due to use of these modules in effective way. During second year (Rabi 2019-20), BCR improved in most of the modules especially in module 6 (1:2.12). it is at par with module 8 (1:1.96) consisting of indoxacarb 14.5% SC (1ml/l) as 1st spray & cypermethrinn 10% EC (2.0 ml/l) as 2nd spray also at par with module 1(1:1.93) and module 2(1:1.91). The present finding corroborated well with the earlier findings of Suganthy and Kumar (2002) [8]; Kumar *et al.* (2014) [7]. Thus integrated management using low doses of insecticides were found to be better options as reported by Nagmani *et al.* (2013) and Kumar *et al.* (2014) [7].

Table 2: Efficacy of Pest management modules against *Helicoverpa armigera* in chick pea during Rabi 2018-19 and 2019-20.

Treatments	Mean larval population No./MRL								Pooled#
	2018-19				2019-20				
	PTC	I spray	II spray	Mean (I+II)	PTC	I spray	II spray	Mean (I+II)	
Module 1	6.85 (2.71)	3.88 (2.09)	2.58 (1.75)	3.23 (1.93)	7.26 (2.79)	3.24 (1.93)	2.40 (1.70)	2.82 (1.82)	3.02 (1.88)
Module 2	6.35 (2.62)	3.97 (2.11)	2.83 (1.85)	3.40 (1.97)	7.52 (2.83)	3.72 (2.05)	2.48 (1.73)	3.10 (1.90)	3.25 (1.94)
Module 3	7.13 (2.76)	6.20 (2.59)	6.01 (2.55)	6.10 (2.57)	8.19 (2.95)	5.85 (2.52)	5.71 (2.49)	5.78 (2.51)	5.94 (2.54)
Module 4	7.02 (2.74)	5.94 (2.54)	5.65 (2.48)	5.79 (2.51)	8.14 (2.94)	5.78 (2.51)	5.42 (2.43)	5.60 (2.47)	5.69 (2.49)
Module 5	6.87 (2.71)	5.76 (2.50)	5.23 (2.39)	5.49 (2.45)	7.51 (2.83)	5.70 (2.49)	5.30 (2.41)	5.50 (2.45)	5.49 (2.45)
Module 6	7.14 (2.76)	4.76 (2.29)	3.52 (2.00)	4.14 (2.16)	8.35 (2.97)	3.79 (2.07)	3.20 (1.92)	3.49 (2.00)	3.81 (2.08)
Module 7	7.11 (2.76)	3.72 (2.05)	2.25 (1.66)	2.98 (1.87)	7.75 (2.87)	3.10 (1.90)	2.06 (1.60)	3.58 (1.75)	2.78 (1.81)
Module 8	7.01 (2.74)	4.93 (2.33)	3.94 (2.11)	4.43 (2.22)	7.80 (2.88)	5.57 (2.46)	5.07 (2.36)	5.32 (2.41)	4.87 (2.32)
Module 9	6.31 (2.61)	5.03 (2.35)	5.01 (2.35)	5.02 (2.35)	7.43 (2.82)	5.58 (2.47)	5.10 (2.37)	5.35 (2.42)	5.18 (2.38)
Module 10	7.38 (2.81)	5.72 (2.49)	5.18 (2.38)	5.45 (2.44)	7.14 (2.76)	5.62 (2.47)	5.20 (2.39)	5.41 (2.43)	5.43 (2.44)
SEm±	0.354	0.073	0.634	0.135	0.313	0.032	0.039	0.122	0.091
CD at 5%(P=0.05)	1.052	0.224	0.102	0.402	0.930	0.095	0.117	0.364	0.262
CV (%)	8.87	2.62	1.41	5.09	7.03	1.15	1.63	4.72	4.91

PTC = Pretreatment count; # = Pooled mean population of two years (2018-19 & 2019-20); Figures in parentheses are square root transformed values.

Module 1= Clorfluazuron 5.4% EC (3 ml/l) - Indoxacarb 14.5% SC (1ml/l); Module 2 = Spinosad 2.5 SC (0.5 ml/l) - Profenofos 50 EC (1.5 ml/l)

Module 3 = Pongamia leaf extract 5% - Profenofos 50 EC (1.5 ml/l); Module 4 = Neem oil (5 ml/l) - Profenofos 50 EC (1.5 ml/l)

Module 5 = Ha NPV 250 LE (1.5 ml/l)-Profenofos 50 EC (1.5 ml/l); Module 6 = Indoxacarb 14.5% SC (1ml/l) - Profenofos 50 EC (1.5 ml/l)

Module 7 = Spinosad 2.5 SC(0.5 ml/l) - Indoxacarb 14.5% SC (1ml/l); Module 8 = Indoxacarb 14.5% SC (1ml/l) - Cypermethrin 10% EC (2.0 ml/l)

Module 9 = Lambda cyhalothrin 5% EC (1.25 ml/l) - Profenofos 50 EC (1.5 ml/l); Module 10 = Cypermethrin 10% EC (2.0 ml/l) - Lambda cyhalothrin 5% EC (1.25 ml/l).

Table 3: Cost- benefit analysis of different management modules against *Helicoverpa armigera* in chick pea during Rabi 2018-19 and 2019-20.

Treatments	First year Rabi 2018-19					First year Rabi 2019-20				
	Yield (q ha^{-1})	Total cost (CP+PP) (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	BCR	Yield (q ha^{-1})	Total cost (CP+PP) (₹ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	BCR
Module 1	15.65	21200	62600	41400	1:1.95	15.95	21780	63800	42020	1:1.93
Module 2	15.17	20800	60680	39880	1:1.92	15.47	21300	61880	40580	1:1.91
Module 3	7.75	14700	31000	16300	1:1.11	8.10	15300	32400	17100	1:1.12
Module 4	8.49	15880	33960	18080	1:1.14	8.59	16500	34360	17860	1:1.08
Module 5	11.34	16300	45360	29060	1:1.78	11.67	17050	46680	29630	1:1.74
Module 6	14.61	19250	58440	39190	1:2.04	14.88	19100	59520	40420	1:2.12
Module 7	16.85	23700	67400	43700	1:1.84	17.13	24200	68520	44320	1:1.83
Module 8	13.34	18450	53360	34910	1:1.89	13.48	18200	53920	35720	1:1.96
Module 9	11.57	16700	46280	29580	1:1.77	11.70	17110	46800	29690	1:1.74
Module 10	11.12	16300	44480	28180	1:1.73	11.36	16800	45440	28640	1:1.70

CP: Cost of crop production; PP: Cost of plant protection

Module 1= Clorfluazuron 5.4% EC (3 ml/l) - Indoxacarb 14.5% SC (1ml/l); Module 2 = Spinosad 2.5 SC (0.5 ml/l) - Profenofos 50 EC (1.5 ml/l)

Module 3 = Pongamia leaf extract 5% - Profenofos 50 EC (1.5 ml/l); Module 4 = Neem oil (5 ml/l) - Profenofos 50 EC (1.5 ml/l)

Module 5 = Ha NPV 250 LE (1.5 ml/l)-Profenofos 50 EC (1.5 ml/l); Module 6 = Indoxacarb 14.5% SC (1ml/l) - Profenofos 50 EC (1.5 ml/l)

Module 7 = Spinosad 2.5 SC(0.5 ml/l) - Indoxacarb 14.5% SC (1ml/l); Module 8 = Indoxacarb 14.5% SC (1ml/l) - Cypermethrin 10% EC (2.0 ml/l)

Module 9 = Lambda cyhalothrin 5% EC (1.25 ml/l) - Profenofos 50 EC (1.5 ml/l); Module 10 = Cypermethrin 10% EC (2.0 ml/l) - Lambda cyhalothrin 5% EC (1.25 ml/l)

Conclusion

Field experiment to evaluate efficacy of IPM modules was conducted at Turgarh village of Jhadol block of Udaipur district during Rabi 2018-19 and 2019-20 using 10 different modules. The data revealed that mean larval population of gram pod borer, Helicoverpa armigera was considerably low (2.98 larvae /MRL) was recorded in Module 7, consissing of spinosad 2.5 SC @ 0.5 ml/l of water as 1st spray and indoxacarb 14.5% SC @ 1 ml/l of water as 2nd spray followed by module 1, consisting of clorfluazuron 5.4% EC @ 3 ml/l of water as 1st spray and indoxacarb 14.5% SC @ 1 ml/l of water as 2nd spray in Rabi 2018-19 as well as in Rabi 19-20. Based on the benefit cost ratio module 6 Consisting of indoxacarb 14.5% SC @ 1 ml/l of water as 1st spray and profenofos 50 EC @ 1.5 ml/l of water as 2nd spray gave maximum return i.e. 1:2.04 & 1:2.12 respectively during first and second year.

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