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Evaluation of Insecticides Against Sucking Pests in Green Gram Grown During Summer

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ABSTRACT

Investigationswere carried out at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand during Summer, 2015for evaluation of various insecticidesagainst sucking pests *viz.,* aphids (*Aphis craccivora* Koch), jassids (*Empoasca kerri* Pruthi), whiteflies (*Bemisia tabaci* Gennadius), thrips (*Thrips palmi* Karny), flower thrips (*Megalurothrips usitatus* Bagnall) in green gram. Two sprays were given.Thiamethoxam 25 WG (0.01%) and imidacloprid 70 WG (0.014%) were found more effective against these sucking pests, yielded higher and economical followed by dimethoate 30 EC (0.03%) in green gram. Higher Incremental Cost Benefit Ratio (ICBR) was also obtained in these treatments. Next in order of effectiveness was diafenthiuron 50 WP @ 0.05% followed by flonicamid 50 WG @ 0.015%, acephate 75 SP @ 0.075% and profenophos 50 EC @ 0.05%. Clothianidin 50 WDG @ 0.02% and dinotefuran 20 SG @ 0.008% registered higher population of sucking pests andproved less effective.

Key words *Insecticides, aphids, jassids, whitefly, thrips, green gram.*

Pulse crops have a unique position in sustainable crop production as they provide highly nutritive food and keep the soil alive as well as productive and also in the agricultural economy of India being the major source of protein in Indian dietary. The General Assembly of the United Nations has recognised pulses as an essential source of protein and a part of improving nutrition globally and declared 2016 as "The International Year of Pulses" (IYP 2016) (Anon., 2016[a]). India is the world's largest producer (18.5 million tonnes), largest importer (3.5 million tonnes) and largest consumer (22.0 million tonnes) of pulses (Anon., 2016[b]).

The sucking pests like aphids, *Aphis craccivora* Koch; jassids, *Empoasca kerri* Pruthi; white flies, *Bemisia tabaci* Gennadius, thrips, *Thrips palmi* Karny andflower thrips, *Megalurothrips usitatus* Bagnall are known to cause significant damage to green gram crop. Whitefly, apotential vector of mung bean yellow mosaic virus (MYMV), can cause losses ranging from 30 – 70 per cent (Swaminathan,*et al.*, 2012) and 80 to 100 per cent in green gram and black gram (Naimuddin, 2001). Sreekanth (2002) reported that thrips cause at least 40 per cent yield loss in green gram. The annual yield loss due to the insect pests has been estimated to the tune of 30 per cent by Soundararajan and Chitra (2011) in green gram and Justin,*et al.* (2015) in urd bean and green gram. There is a need to investigate the tools for the sucking pests of green gram to develop an effective management strategy.Chemical insecticidesare used as the frontline defence sources against insect pests in India. However, their indiscriminate and continuous use creates a number of problems such as development of resistance, pest resurgence and environmental hazards including residue in soil, water and foods. Nowadays, the pest management was focused on the use of safer chemicals and pesticides.

MATERIALS AND METHODS

In order to evaluate the efficacy of various insecticides *viz.,* Flonicamid 50 WG @ 0.015%, Thiamethoxam 25 WG @ 0.01%, Imidacloprid 70 WG @ 0.014%, Clothianidin 50 WDG @ 0.02%, Diafenthiuron 50 WP @ 0.05%, Profenophos 50 EC @ 0.05%, Acephate 75 SP @ 0.075%, Dinotefuran 20 SG @ 0.008%, Dimethoate 30 EC @ 0.03% and Control (water spray)against sucking pests in green gram, the experiment was laid out in a Randomized Block Design with three replications having gross and net plot area 3.0 m × 2.7 m and 2.4 m × 1.8 m, respectively duringSummer, 2015 at College Agronomy Farm, B. A. College of Agriculture, AAU, Anand.Green gram cultivar, Meha was grown with spacing 45 cm × 15 cm under recommended agronomical practices.

Method of application

First spray application of respective insecticides was given on the initiation of the pests and subsequently another one spray was given after

Table 1. Efficacy of insecticides against different sucking pests in green gram in Summer (Pooled over periods and sprays)

Treatments		No. of sucking pests/ 3 leaves				No. of flower thrips/ 5 flowers
		Aphids	Jassids	Whiteflies	Thrips	
1		2	3	4	5	6
Flonicamid 50 WG 0.015%		1.63 b (2.16)	0.99 b (0.48)	1.19 b (0.92)	1.57 b (1.96)	1.10 b (0.71)
Thiamethoxam 25 WG 0.01%		1.01 a (0.52)	0.77 a (0.09)	0.85 a (0.22)	1.06 a (0.62)	0.80 a (0.14)
Imidacloprid 70 WG 0.014%		1.03 a (0.56)	0.78 a (0.11)	0.86 a (0.24)	1.08 a (0.67)	0.82 a (0.17)
Clothianidin 50 WDG 0.02%		2.45 d (5.50)	1.57 d (1.96)	1.51 c (1.78)	2.00 c (3.50)	1.72 d (2.46)
Diafenthiuron 50 WP 0.05%		1.59 b (2.03)	1.04 b (0.58)	1.19 b (0.92)	1.54 b (1.87)	1.07 b (0.64)
Profenophos 50 EC 0.05%		2.11 c (3.95)	1.34 c (1.30)	1.54 c (1.87)	1.97 c (3.38)	1.42 c (1.52)
Acephate 75 SP 0.075%		2.08 c (3.83)	1.30 c (1.19)	1.54 c (1.87)	1.95 c (3.30)	1.39 c (1.43)
Dinotefuran 20 SG 0.008%		2.48 d (5.65)	1.32 c (1.24)	1.82 d (2.81)	2.60 d (6.26)	1.74 d (2.53)
Dimethoate 30 EC 0.03%		1.55 b (1.90)	1.01 b (0.52)	1.50 c (1.75)	1.60 b (2.06)	1.13 b (0.78)
Control (water spray)		3.70 e (13.19)	2.09 e (3.87)	2.34 e (4.98)	3.55 e (12.10)	2.35 e (5.02)
	F – Test (T)	Sig	Sig	Sig	Sig	Sig
S.Em.±	Treatment (T)	0.05	0.03	0.05	0.05	0.05
	Period (P)	0.03	0.02	0.02	0.03	0.02
	T x P	0.11	0.07	0.06	0.09	0.06
C.D. at 5%	Treatment (T)	-	-	-	-	-
	Period (P)	Sig	Sig	Sig	Sig	Sig
	T x P	Sig	NS	NS	Sig	NS
	C.V.%	9.27	9.34	14.79	8.51	10.10

Notes: Figures in parentheses are retransformed values; those outside are $\sqrt{X+0.5}$ transformed values. Treatment mean with letter(s) in common are not significant by DNMRT at 5 % level of significance within a column; Non-Significant; S: Significant

25 days using manually operated knapsack sprayer having duromist nozzle with slight runoff stage. The required chemicals were collected from Department of Entomology and were sprayed.

Method of recording observations

For recording the observations, five plants were selected randomly and tagged in each net plot.The population of aphids, jassids, whiteflies and thrips was counted from three (upper, middle and lower leaves) from the same selected plants in each sector. The population of flower thrips per five flowers was counted from the same selected plants in each sector.The observations on sucking pests as well as coccinellids (grubs + adults) population were recorded prior to one day of first spray as well as after 3, 5 and 10 days after each spray.

Yield

Yield was recorded after threshing and separating of green gram seeds. Seed yield from each plot was weighed separately and converted into quintals per hectare for further statistical

Table 2. Impact of insecticides on coccinellids and seed yield of green gram

Treatments		No. of coccinellids (grubs + adults)/ plant	Seed yield (q/ ha)	Increase over control (%)
1		2	3	4
Flonicamid 50 WG 0.015%		1.14 (0.80)	8.95 bcd	27.60
Thiamethoxam 25 WG 0.01%		1.25 (1.06)	11.80 a	45.08
Imidacloprid 70 WG 0.014%		1.24 (1.04)	10.34 ab	37.33
Clothianidin 50 WDG 0.02%		1.08 (0.67)	8.41 cd	22.95
Diafenthiuron 50 WP 0.05%		1.13 (0.78)	9.26 bcd	30.02
Profenophos 50 EC 0.05%		1.06 (0.62)	8.80 cd	26.36
Acephate 75 SP 0.075%		1.16 (0.85)	8.87 cd	26.94
Dinotefuran 20 SG 0.008%		1.25 (1.06)	8.02 d	19.20
Dimethoate 30 EC 0.03%		1.11 (0.73)	9.49 bc	31.72
Control (water spray)		1.36 (1.35)	6.48 e	-
	F – Test (T)	NS	Sig	-
S.Em.±	Treatment (T)	0.08	0.43	-
	Period (P)	0.00	-	-
	T x P	0.01	-	-
C.D. at 5%	Treatment (T)	-	-	-
	Period (P)	Sig	-	-
	T x P	Sig	-	-
	C.V.%	19.62	8.31	-

Notes: Figures in parentheses are retransformed values; those outside are $\sqrt{X + 0.5}$ transformed values. Non- Significant; S: Significant; Treatment mean with letter(s) in common are not significant by DNMRT at 5 % level of significance within a column.

analysis. The per cent increase over control was also calculated by following formula:

$$\text{Per cent increase in over control} = \frac{\text{Yield of treatment} - \text{Yield of control}}{\text{Yield of treatment}} \times 100$$

Economics

The economics of the insecticides were worked out. In order to know the economics of different treatments evaluated against sucking pests infesting green gram, Incremental Cost Benefit Ratio (ICBR) was worked out. For the purpose, total cost of insecticides treatment per hectare was calculated for each treatment based on the prevailing market price. The net gain (yield) over control was calculated by subtracting the yield obtained in control treatment from the yield obtained in each insecticidal treatment. Then, the realization was worked out for each treatment based on increased yield (q/ha) over control. The net profit (Rs./ha) for each treatment was computed by deducting the cost of insecticides treatment from the value of realization over control. The ICBR *i.e.* net gain in rupees per rupee cost of insecticides treatment was calculated by dividing net profit with the cost of treatment. This gives value of gross ICBR. To calculate the value of net ICBR (NICBR) *i.e.* additional profit gained per rupee cost of treatment, 1 rupee was subtracted from ICBR obtained in each treatment.

RESULTS AND DISCUSSION

The efficacy of various tested synthetic insecticides was adjudged based on pooled over periods and sprays against the sucking pests. While, yield parameter was discussed based on recorded seed yield from each treatment and economic too.

Table 3. Economic of various synthetic insecticides used for control of sucking pestsinfesting green gram

Insecticides (%)	Conc. (%)	Total cost treatment (Rs./ha)	Yield of seed (q/ha)	Net gain over control (q/ha)	Realization (Rs./ha)	Net Realization (Rs./ha)	ICBR	NICBR
1	2	3	4	5	6	7	8	9
Flonicamid 50 WG	0.015	4094	8.95	2.47	14820	10726	1:2.62	1:1.62
Thiamethoxam 25 WG	0.01	2784	11.80	5.32	31920	29136	1:10.47	1:9.47
Imidacloprid 70 WG	0.014	2906	10.34	3.86	23160	20254	1:6.97	1:5.97
Clothianidin 50 WDG	0.02	7104	8.41	1.93	11580	4476	1:0.63	1:-0.37
Diafenthiuron 50 WP	0.05	5084	9.26	2.78	16680	11596	1:2.28	1:1.28
Profenophos 50 EC	0.05	2024	8.80	2.32	13920	11896	1:5.88	1:4.88
Acephate 75 SP	0.075	2288	8.87	2.39	14340	12052	1:5.27	1:4.27
Dinotefuran 20 SG	0.008	4784	8.02	1.54	9240	4456	1:0.93	1:-0.07
Dimethoate 30 EC	0.03	1648	9.49	3.01	18060	16412	1:9.96	1:8.96
Control (water spray)	-	-	6.48	-	-	-	-	

Market price of green gram grain : Rs. 60/ kg (Rs. 6000/ quintal)\

Labour charges : For spraying Rs. 296/labour/day

Two labour per hectare required for each spray, two sprays were given (500 litre spray solution is required for one spray for one hectare)

Efficacy of various synthetic insecticides on aphids, *A. craccivora*

The data on aphids population recorded periodically was also pooled and presented in Table 1 (Column 2). It clearly indicated that all insecticidal treatments were significantly different from control. Among the various insecticides, thiamethoxam 25 WG @ 0.01% and imidacloprid 70 WG @ 0.014% found significantly superior than rest of the insecticidal treatments and recorded the lower (0.52 and 0.56 aphids/ 3 leaves, respectively) population. Dimethoate 30 EC @ 0.03% (1.90), diafenthiuron 50 WP @ 0.05% (2.03) and flonicamid 50 WG @ 0.015% (2.16) were next in order on their effectiveness. Further, they all were at par with each other. There was no significant difference between acephate 75 SP @ 0.075% and profenophos 50 EC @ 0.05% and recorded somewhat higher aphids population (3.83 and 3.95, respectively). However, clothianidin 50 WDG @ 0.02% and dinotefuran 20 SG @ 0.008% proved to be less effective by recording higher (5.50 and 5.65, respectively) aphids population in green gram.However, all the insecticides were significantly more effective as compared to control (13.19). The interaction between treatments and periods (T x P) was found to be significant which indicated that treatment effect was inconsistent in its behaviour over the periods.

Justin,*et al.* (2015) in black gram and Kabir,*et al.* (2014) in green gram reported higher efficacy of thiamethoxam. Higher efficacy of imidacloprid was also reported in cowpea by Khade,*et al.* (2014) and Reddy,*et al.* (2014). Khutwad,*et al.* (2002) also reported higher efficacy of thiamethoxam and imidacloprid in green gram. Thus, the present findings are in close proximity with the earlier reports. While, Chandrasekaran and Balasubramanian (2002) reported higher efficacy of acephate in green gram. However, Parmar,*et al.* (2015) reported higher efficacy of clothianidin in black gram which was differed from the present findings. The variations in effectiveness of these insecticides might be due to different doses, climatic conditions of the location, pest species or variations in crop.

Efficacy of various synthetic insecticides on jassids, *E. kerri*

The data on jassids population recorded periodically was also pooled and depicted in Table 1 (Column 3). All the insecticidal treatments significantly differed from control. Among the various insecticides, thiamethoxam 25 WG @ 0.01% and imidacloprid 70 WG @ 0.014% found significantly superior than rest of the insecticidal treatments and recorded lower (0.09 and 0.11 jassids/ 3 leaves, respectively) population of jassids. Next in order was flonicamid 50 WG @ 0.015% (0.48), dimethoate 30 EC @ 0.03% (0.52) and diafenthiuron 50 WP @ 0.05% (0.58). Further, they all were at par with each other. Acephate 75 SP @ 0.075%, dinotefuran 20 SG @ 0.008% and profenophos 50 EC @ 0.05% recorded somewhat higher jassids population (1.19 to 1.30). Among the insecticides, clothianidin 50 WDG @ 0.02% proved to be least effective by recording significantly the highest (1.30) population in green gram. However, it was better than control (3.87), so far its effectiveness is concerned.The interaction between treatments and periods (T x P) was found to be non-significant which indicated that treatment effect was consistent in its behaviour over the periods.

While shifting the literatures, Khattak,*et al.* (2004) reported the highest reduction of jassids in the green gram plots treated with thiamethoxam followed by imidacloprid and diafenthiuron. Sutaria,*et al.* (2010) in soybean, Patel,*et al.* (2012) in cowpea, Sharma and Singh (2015) in urdbean, Iqbal,*et al.* (2013) and Ahirwar,*et al.* (2016) in green gram also reported higher efficacy of thiamethoxam and imidacloprid. Lower efficacy of acephate in green gram was reported by Iqbal,*et al.* (2013). Anusha,*et al.* (2014) in cowpea reported higher efficacy of imidacloprid and diafenthiuron and lower efficacy of profenophos. Justin,*et al.* (2015) reported the higher efficacy of thiamethoxam in black gram. Thus, the present findings are in close agreement with the earlier reports.

Efficacy of various synthetic insecticides on whiteflies, *B. tabaci*

The data on whiteflies population recorded periodically was also pooled and presented in Table 1 (Column 4). All the insecticidal treatments significantly differed from control and recorded lower population than untreated plots. Thiamethoxam 25 WG @ 0.01% (0.22/ 3 leaves) and imidacloprid 70 WG @ 0.014%(0.24) were at par with each other and significantly differed from the rest of chemicals. Further, both these insecticides were found more effective against this pest. Diafenthiuron 50 WP @ 0.05% (0.92) was equally effective as flonicamid 50 WG @ 0.015% (0.92). Dimethoate 30 EC @ 0.03%, clothianidin 50 WDG @ 0.02%, acephate 75 SP @ 0.075% and profenophos 50 EC @ 0.05% were next in order and recorded higher (1.75 to 1.87) whiteflies population. Dinotefuran 20 SG @ 0.008% was found to be least effective and recorded the highest (2.81) population of whiteflies among the tested chemicals. The interaction between treatments and periods (T x P) was found to be non-significant which indicated that treatment effect was consistent in its behaviour over the periods.

As far as past findings is concerned, Ganapathy and Karuppiah (2004) in green gram, Patel,*et al.* (2012) in cowpea, Gotyal and Prasad (2013) in soybean and Yadav,*et al.* (2015) in black gram reported minimum population of whiteflies in thiamethoxam treated plots. Muhammad,*et al.* (2002), Sreekanth,*et al.* (2004), Khattak,*et al.* (2004) and Shah,*et al.* (2007) reported higher efficacy of imidacloprid to control whiteflies in green gram. Singh and Kumar (2011) from urdbean and Ahirwar,*et al.* (2016) from green gram reported that dimethoate recorded minimum population of whiteflies, however, it was less effective over thiamethoxam and imidacloprid. The higher effectiveness of diafenthiuron on whiteflies was reported by Gopalaswamy, *et al.* (2012). Mandal,*et al.* (2015) in green gram and Parmar,*et al.* (2015) in black gram also tested the clothianidin on this pest for its effectiveness. Thus, the present findings are in close agreement with the earlier reports.

Efficacy of various synthetic insecticides on thrips, *T. palmi*

The data on thrips population recorded periodically was pooled and presented in Table 1 (Column 5). The data revealed that all insecticidal treatments significantly differed from control. Among the various insecticides, thiamethoxam 25 WG @ 0.01% and imidacloprid 70 WG @ 0.014% found significantly superior than rest of the insecticidal treatments and recorded lower (0.62 and 0.67/ 3 leaves, respectively) population of thrips. Diafenthiuron 50 WP @ 0.05% (1.87) and flonicamid 50 WG @ 0.015% (1.96) were also found effective by remaining at par with dimethoate

30 EC @ 0.03% (2.06) against thrips in green gram. There was no significant difference among acephate 75 SP @ 0.075%, profenophos 50 EC @ 0.05% and clothianidin 50 WDG @ 0.02% and recorded somewhat higher thrips population (3.30 to 3.50). Among the tested insecticides, dinotefuran 20 SG @ 0.008% proved to be least effective by recording the highest (6.26) thrips population in green gram. Although, it was better than control (12.10).There was no incidence of thrips during second spray.The interaction between treatments and periods (T x P) was found to be significant which indicated that treatment effect was inconsistent in its behaviour over the periods.

While referring the past findings, Ahirwar,*et al.* (2016) reported the higher efficacy of thiamethoxam against thrips in green gram. Kaushik,*et al.* (2015) and Anusha,*et al.* (2014) in cowpea and Nataraja,*et al.* (2014) in groundnut also reported higher efficacy of thiamethoxam and imidacloprid followed by diafenthiuron. Damasia,*et al.* (2013) reported the higher effectiveness of dimethoate against thrips in green gram followed by thiamethoxam and imidacloprid. Thus, the present findings are in close agreement with the earlier reports.

Efficacy of various synthetic insecticides on flower thrips, *M. usitatus*

The data on flower thrips population recorded periodically was pooled and presented in Table 5. All the insecticidal treatments significantly differed from the control. Thiamethoxam 25 WG @ 0.01% (0.14) and imidacloprid 70 WG @ 0.014% (0.17/ 5 flowers) recorded significantly lower population and proved to be most effective chemicals against this pest. Diafenthiuron 50 WP @ 0.05% (0.64) was next in order followed by flonicamid 50 WG @ 0.015% (0.71) and dimethoate 30 EC @ 0.03% (0.78). Acephate 75 SP @ 0.075% and profenophos 50 EC @ 0.05% also found comparatively (1.43 and 1.52, respectively) effective. Although, clothianidin 50 WDG @ 0.02% (2.46) and dinotefuran 20 SG @ 0.008% (2.53) registered significantly higher flower thrips population and proved to be less effective chemicals. Although, they were significantly more effective as compared to control (5.02).The interaction between treatments and periods (T x P) was found to be non-significant which indicated that treatment effect was consistent in its behaviour over the periods.

Scanty information is available on the efficacy of insecticides on flower thrips in green gram. However, higher efficacy of imidacloprid and dimethoate against flower thrips in cowpea was reported by Oyewale,*et al.* (2014).

Effect of various synthetic insecticides on population of coccinellids

Coccinellids (grubs and adults):

The data on coccinellids recorded periodically was pooled and summarized in Table 1 (Column 6). The chronological order of various synthetic insecticides in comparison to control based on population of coccinellids (grubs and adults) per plant (in bracket) was: control (1.35) > dinotefuran 20 SG @ 0.008% and thiamethoxam 25 WG @ 0.01% (1.06) > imidacloprid 70 WG @ 0.014% (1.04) > acephate 75 SP @ 0.075% (0.85) > flonicamid 50 WG @ 0.015% (0.80) > diafenthiuron 50 WP @ 0.05% (0.78) > dimethoate 30 EC @ 0.03% (0.73) > clothianidin 50 WDG @ 0.02% (0.67)> profenophos 50 EC @ 0.05% (0.62). Pooled data over periods on the population of coccinellids (grubs and adults) revealed that there was no significant difference among the treatments. It can be said that none of the tested synthetic insecticides exerted any significant adverse effect on the activity of this predator. Further, all the tested chemicals were comparatively safer to this natural enemy. However, tested insecticides recorded comparatively lower (0.62 to 1.06/ plant) population of coccinellids than that of control (1.35).The interaction between treatments and periods (T x P) was found to be significant which indicated that treatment effect was inconsistent in its behaviour over the periods.

While shifting the literatures, Mithu,*et al.* (2015) in cowpea and green gram, Bharpoda,*et al.* (2014) in *Bt* cotton, Chakraborty,*et al.* (2013) in pulse crops as well as Sitaramaraju,*et al.* (2010) in cotton reported less toxicity of thiamethoxam and imidacloprid against coccinellids. Pawar and Bharpoda (2013) reported the less toxicity of flonicamid against coccinellids in safflower. Thus, the present findings are in conformity with the earlier reports.

Impact of various synthetic insecticides on seed yield, per cent increase in yield over control and economics

Yield:

The data on seed yield of green gram are presented in Table 2 (Column 3).

The efficacy of various chemicals against sucking pests also reflected on seed yield. Plots treated with different insecticides yielded significantly higher seed yield (8.02 to 11.80 q/ ha) than control (6.48). The chronological order of various insecticidal treatments in comparison to control based on seed yield (q/ ha) given in bracket was: thiamethoxam 25 WG @ 0.01% (11.80)> imidacloprid 70 WG @ 0.014% (10.34) > dimethoate 30 EC @ 0.03% (9.49) > diafenthiuron 50 WP @ 0.05% (9.26) > flonicamid 50 WG @ 0.015% (8.95) > acephate 75 SP @ 0.075% (8.87) > profenophos 50 EC @ 0.05% (8.80) > clothianidin 50 WDG @ 0.02% (8.41) > dinotefuran 20 SG @ 0.008% (8.02) > control (6.48). Significantly the highest seed yield was harvested from the plots treated with thiamethoxam 25 WG @ 0.01% and was at par with imidacloprid 70 WG @ 0.014%. Dimethoate 30 EC @ 0.03% also yielded higher followed by diafenthiuron 50 WP @ 0.05% and flonicamid 50 WG @ 0.015%. Further, they were at par with each other. Rest of the insecticides *i.e.* acephate 75 SP @ 0.075%, profenophos 50 EC @ 0.05%, clothianidin 50 WDG @ 0.02% and dinotefuran 20 SG @ 0.008% were at par with each other and recorded 8.87, 8.80, 8.41 and 8.02 q/ ha seed yield.

While shifting the literatures, Chandrasekaran and Balasubramanian (2002) reported higher yield of green gram in plots treated with acephate. Sreekanth,*et al.* (2003), Shah,*et al.* (2007) and Hossain,*et al.* (2013) from green gram and Gopalaswamy,*et al.* (2012) in black gram reported higher yield in the plots treated with imidacloprid. Panickar,*et al.* (2013) reported higher yield of green gram in imidacloprid followed by profenophos. Mandal,*et al.* (2015) reported higher yield of green gram in thiamethoxam followed by dimethoate and clothianidin. Ahirwar,*et al.* (2016) reported higher yield of green gram in thiamethoxam followed by imidacloprid, dimethoate and acephate. Hence, the reports are in conformity with present findings. Bairwa,*et al.* (2006) reported higher yield in plots treated with dimethoate followed by acephate and imidacloprid in moth bean. Yasa,*et al.* (2010) reported that pod yield in groundnut increased in the plots treated with neonicotinoids. Sutaria,*et al.* (2010) reported highest seed yield in soybean plots treated with thiamethoxam followed by imidacloprid. Sharma and Singh (2015) reported higher yield in plots treated with imidacloprid followed by thiamethoxam in urdbean.

Per cent increase in yield over control

The per cent increase in yield over control in green gram was worked out and presented in Table 2 (Column 4). The chronological order of various treatments based on per cent increase in yield over control given in bracket was: thiamethoxam 25 WG @ 0.01% (45.08%)> imidacloprid 70 WG @ 0.014% (37.33%) > dimethoate 30 EC @ 0.03% (31.72%) > diafenthiuron 50 WP @ 0.05% (30.02%) > flonicamid 50 WG @ 0.015% (27.60%) > acephate 75 SP @ 0.075% (26.94%) > profenophos 50 EC @ 0.05% (26.36%) > clothianidin 50 WDG @ 0.02% (22.95%) > dinotefuran 20 SG @ 0.008% (19.20%). Maximum yield loss could be avoided with spray application of thiamethoxam 25 WG @ 0.01%, imidacloprid 70 WG @ 0.014%, dimethoate 30 EC @ 0.03% and diafenthiuron 50 WP @ 0.05%.

Economics

The economics of various synthetic insecticides (Table 3) revealed that the highest (31,920.00 Rs./ ha) realization was obtained from the treatment thiamethoxam 25 WG @ 0.01% followed by imidacloprid 70 WG @ 0.014% (23,160.00 Rs./ ha), dimethoate 30 EC @ 0.03% (18,060.00 Rs./ ha) and diafenthiuron 50 WP @ 0.05% (16,680.00 Rs./ ha). The highest Incremental Cost Benefit ratio (ICBR) was calculated from the plots treated with thiamethoxam 25 WG @ 0.01% (1:10.47). Dimethoate 30 EC @ 0.03% (1: 9.96), imidacloprid 70 WG @ 0.014% (1:6.97), profenophos 50 EC @ 0.05% (1:5.88) and acephate 75 SP @ 0.075% (1:5.27) also recorded higher ICBR. Dinotefuran 20 SG @ 0.008% (1:0.93) and clothianidin 50 WDG @ 0.02% (1:0.63) recorded lower ICBR and found not much economical insecticidal treatments. The highest (9.47) Net Insecticidal Cost Benefit Ratio (NICBR) was calculated from the plots treated with thiamethoxam 25 WG @ 0.01%. Dimethoate 30 EC @ 0.03% (8.96) and imidacloprid 70 WG @ 0.014% (5.97) also recorded higher NICBR. Dinotefuran 20 SG @ 0.008% (0.93) and clothianidin 50 WDG @ 0.02% (0.63) recorded lower NICBR and found not much economical insecticidal treatments.

While shifting the literatures, Sreekanth,*et al.* (2003) and Hossain,*et al.* (2013) reported higher cost benefit ratio in green gram plots treated with imidacloprid. Mandal,*et al.* (2015) reported higher net return in thiamethoxam followed by dimethoate and clothianidin in green gram. Hence, the reports are in conformity with present findings. Bairwa,*et* *al.* (2006) reported higher ICBR in plots treated with dimethoate followed by acephate and imidacloprid in moth bean. Kumar,*et al.* (2007) reported that dimethoate in black gram was more effective and economical. Sutaria,*et al.*(2010) reported highest net return in soybean plots treated with thiamethoxam followed by imidacloprid.

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