Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(3): 3703-3706
Received: 07-03-2018
Accepted: 12-04-2018

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Evaluation of different spray schedules of insecticides against fruit borer (*Helicoverpa armigera* H.) and leaf curl disease intensity of chilli (*Capsicum annum* L.)

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Abstract
Experiment was carried out under field condition at Horticulture Instructional Farm of Chamanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University Sardarkrushinagar during *kharif* 2016-17. To evaluate different spray schedules against fruit borer *Helicoverpa armigera* (Hubner) and leaf curl disease intensity of chilli. Among different spray schedules which was consist of different insecticides. The spray schedule fourth (clothianidin 50WP @ 20g/ 10 lit., thiamethoxam 25WG @ 3g/ 10 lit., propergite 57EC @ 10ml/ 10 lit., chlorantraniliprole 18.5SC @ 4 ml/ 10 lit.) was effective for the management of fruit borer, leaf curl disease intensity, higher benefit cost ratio (1:2.86) and higher yield of chilli fruit (5405 kg/ ha), respectively.

Keywords: Chilli, fruit borer, spray schedule, leaf curl

Introduction
Chilli is an important vegetable and condiment crop in India. The two cultivated species (*Capsicum annum* L. and *Capsicum frutescens* L.; family Solanaceae) are raised in the tropics and sub-tropics with a temperature range of 20-25 °C considered as ideal. The medicinal value of chilli is much realized because of its vitamin 'C' and capsaicin (C_{18} H_{27} O_3 N) [14]. It is widely used throughout the tropics as major ingredient of curry powder in the culinary production. Besides essential alkaloid, red colouring matter, which is non-pungent. India is the largest consumer and exporter of chilli in the world with a production of 3292 MT from an area of 238 thousand ha and productivity 10 MT per ha during 2016 (NHB 2016). The major chilli growing states are Andhra Pradesh, Maharashtra, Karnataka, Tamil Nadu and Rajasthan. In Gujarat, it is cultivated in an area of 6500 ha with the production of 6600 MT (Anonymous 2013) [1]. The major chilli growing districts of Gujarat include Anand, Banaskantha, Kheda, Vadodara, Navsari, Patan, Mehsana and Surat. A number of factors responsible for low yield include adverse climate, poor quality seeds, diseases, insect and mites significantly affect both the quality as well as production of chilli. The yield losses range between 50 to 90 per cent due to insect pests of chilli (Nelson and Natrajan 1994, Kumar, 1995) [10, 7]. Thrips (*Scirthothrips dorsalis* Hood), whiteflies (*Bemisia tabaci* Genn), aphids (*Aphis gossypii* Glover) and yellow mites (*Polyphagotarsonemus latus* Banks) are the important sucking pests which contributed to reduce the crop yield (Hosmani, 1993) [4]. The damage due to mites and thrips together had been estimated to the tune of 50 per cent (Kandasamy *et al*. 1990) [5]. Fruit borer, *H. armigera* feed and damage the floral buds and tender fruits. Due to this pest devastation was recorded up to 10-50 per cent of fruit (Ukey *et al.*, 1991) [13]. Reddy and Reddy (1999) [12] reported that the losses caused by the fruit borers is to the extent of 90 per cent.

Materials and Methods
A field experiment was conducted during *kharif* 2016-17 at Horticulture Instructional Farm of Chamanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University Sardarkrushinagar.
The experiment was consisted of five spray schedules which replicated fourth in Randomized Block Design (RBD). Gross plot size 3.60m X 6.00m and net plot size 2.40m X 2.80m, Seedling of chilli vatiety GCh 1 was used and transplanted during second week of july 2016, with spacing 60 cm X 60cm for evaluate different spray schedules of insecticides against fruit borer and leaf curl disease intensity in chilli. The spray schedules consisted the following: S_1 (diafenthiuron 50WP @ 10g/ 10 lit., imidacloprid 17.8SL @ 5ml / 10 lit., propergite 57 EC @ 10 ml/ 10 lit., profenophos 50 EC @ 10 ml/ 10 lit.,), S_2 (triazophos 40EC @ 20 ml/ 10 lit.,

acetamiprid 20SP @ 2g/ 10 lit., imidacloprid 17.8SL @ 5 ml / 10 lit., novaluron 10 EC @ 10 ml/ 10 lit.,), S_3 (acetamiprid 20SP @ 2 g/ 10 lit., thiamethoxam 25WP @ 3g/ 10 lit., thiacloprid 21.7SC @ 6 ml/ 10 lit., emamectin benzoate 5SG @ 5 g/ 10 litre), S_4 (clothianidin 50WP @ 20 g/ 10 lit., thiamethoxam 25WP @ 3g/ 10 lit., propergite 57EC @ 10 ml/ 10 lit., chlorantraniliprole 18.5SC @ 4 ml / 10 litre) and spray schedule S_5 (untreated control) were studied under present investigation. Foliar application of respective insecticides was given as per schedule using a manually operated knapsack sprayer. The first spray was made at 1 thrips / leaf and subsequent sprays were at an interval of ten days.

Assessment of per cent damage of *H. armigera* and leaf curl disease intensity in chilli

Five plants were selected randomly in each plot.The per cent fruit damage was worked out by counting total number of fruit per plant and number of damaged fruits per plant on five randomly selected plants in each treatment at every picking by adapting following formula.

$$\text{Per cent fruit damage} = \frac{\text{Number of fruit damaged}}{\text{Total number of fruit}} \times 100$$

Number of plants showing the symptoms of leaf curl disease/ plot were also be recorded at 50, 75 and 100 days after transplanting and leaf curl disease intensity were worked out. Green chilli yield (marketable) were recorded at each picking converted into kg per hectare. Economics of different treatments were computed.

Estimation of avoidable losses in chilli crop due to pest complex

From the yield data, per cent avoidable loss was calculated for each treatment using following formula suggested by Khosla (1977).

$$\text{Avoidable loss (\%)} = \frac{\text{Highest yield in treated plot} - \text{Yield in treatment}}{\text{Highest yield in treated plot}} \times 100$$

Increase in yield over control due to various treatments

Increase in yield over control due to various treatments was worked out using following formula suggested by Khosla (1977).

$$\text{Increase in yield over control} = \frac{\text{Yield in treatment} - \text{Yield in control}}{\text{Yield in control}} \times 100$$

Statistical analysis of data

Data on the damage due to chilli fruit borer was analyzed after transforming into angular transformation.

Economics

In order to know the economics of different treatments evaluated against insect pests of chilli, Incremental Cost Benefit Ratio (ICBR) was worked out. For this purpose, total cost of insecticidal treatment per hectare was calculated for each treatment based on the prevailing market price. The increased yield over control was calculated by subtracting the yield obtained in control treatment from the yield obtained each insecticidal treatment. Then, the gross realization over control was worked out for each treatment based on the increased yield of green fruit (kg/ ha) over control. The net green fruit yield (₹ / ha) for each treatment was computed by deducting the cost of insecticidal treatment from the values of gross realization over control. The ICBR *i.e.*, net green fruit in rupee (₹) per rupee cost of insecticidal treatment was calculated by dividing net green fruit with the cost of treatment.

Results and Discussion

Fruit borer (*Helicoverpa armigera* H.)

The results on fruit borer infestation in chilli showed that different spray schedules vary significantly in their impact on fruit infestation (Table 1). The results further indicated significantly the lowest fruit damage found in (S_4) (3.60%) which was at par with (4.11%) in S_3. The fruit damage in (S_2 and S_1) was 5.09 and 5.70%, respectively whereas, maximum fruit borer infestation observed in S_5 (12.09%).

Table 1: Fruit damage due to fruit borer (*Helicoverpa armigera)*

Sr. No.	Treatments	Fruit borer damage (%)
1.	S_1	13.81(5.70)^{b}
2.	S_2	13.03(5.09)^{bc}
3.	S_3	11.69 (4.11)^{cd}
4.	S_4	10.94 (3.60)^{d}
5.	S_5	20.35(12.09)^{a}
S. Em.±		0.31
C.V. %		10.05

*Figures outside parentheses are arc sin transformed values

The present findings are in confirmity with the results of Chowdary *et al.* (2010) [2] who evaluated new insecticide against okra fruit borer, rynaxypyr 20 SC @ 30 g a.i. / ha and rynaxypyr 20 SC @ 20g a.i./ ha were superior in recording less larval populations, lower fruit damage and higher fruit yield, followed by spinosad @ 56g a.i/ ha, emamectin benzoate @ 15g a.i/ ha and flubendiamide @ 45g a.i/ ha. These results are also supported by the work of Ghulam *et al.* (2015) [3].

In past, Prajapati and Agalodiya (2011) evaluated spray schedule S_1 (comprising triazophos 40EC @ 25ml/10 lit., wettable sulphur 50 WP @40g/10lit., imidacloprid 17.8 SL @ 5ml/10lit., wettable sulphur 50 WP @ 40g/10lit and acephate 75 SP @ 15g/ 10lit.of water) who observed the minimum fruit borer damage.

Leaf curl disease intensity

The results presented in table 2 revealed that all spray schedules were significantly superior in reducing the leaf curl disease at 50, 75 and 100 days after transplanting (DATP). The minimum leaf curl was observed in S_4 (3.02%, 3.10% and 3.44% at 50, 75 and 100, days after transplanting), which was at par with S_3 (3.37%, 4.11% and 4.44% at 50, 75and 100 days after transplanting). It was followed by S_2 and S_1, respectively.

Table 2: Leaf curl disease intensity in chilli (%)

S. No	Treatments	50 DATP	75 DATP	100 DATP
1.	S_1	13.96 (5.82)^{b}	14.47 (6.25)^{b}	15.06 (6.75)^{b}
2.	S_2	13.00 (5.06)^{b}	14.35 (6.14)^{b}	14.80 (6.53)^{b}
3.	S_3	10.58 (3.37)^{c}	11.70 (4.11)^{c}	12.16 (4.44)^{c}
4.	S_4	10.01 (3.02)^{c}	10.14 (3.10)^{c}	10.69 (3.44)^{c}
5.	S_5	17.28 (8.83)^{a}	16.65 (8.21)^{a}	26.59 (20.03)^{a}
S. Em.±		0.29	0.38	0.54
C.V. %		11.05	13.50	13.20

*Figures outside parentheses are arc sin transformed values

The results of present investigation are in agreement with the results of Nagaraj *et al.* (2007) who revealed that the mean leaf curl index (LCI) recorded in chilli was minimum in

thiamethoxam 25 WG (35g a.i./ ha) treated plots which was followed by imidacloprid 17.8 SL (35g a.i./ ha), thiacloprid 21.7 SC and clothianidin 50 WG.

Marketable fruit yield of chilli

The data recorded on marketable yield of green chilli during *kharif* 2016 -17 have been presented in table 3. The S_4 gave the highest marketable yield (5405 kg/ ha) followed by S_3 (3350 kg/ ha) and found effective to protect the crop. The S_2 and S_1 gave the 3130 and 3070 kg/ ha yield, respectively. The minimum yield was recorded in S_5 (2750 kg/ ha).

Avoidable losses due to major insect pests of chilli

The percentage of avoidable losses in fruit yield of chilli due to major insect pests after applying various spray schedules was presented in table 3. It can be seen from the results that the maximum fruit yield of chilli was found in the S_4. The avoidable yield losses in chilli due to major insect pests varied from 38.02 to 49.12 per cent. The avoidable losses in chilli yield were minimum in S_3 (38.02 %) followed by S_2 (42.09 %). On other hand, the highest percentage of avoidable losses in chilli yield was observed in the untreated control S_5 (49.12 %).

Table 3: Yield, avoidable losses and increase in yield over control due to major insect pests of chilli

Sr. No.	Treatments	Yield (kg/ ha)	Avoidable losses (%)	Increase in yield over control (%)
1.	S_1	3070^{bc}	43.20	11.63
2.	S_2	3130^{bc}	42.09	13.81
3.	S_3	3350^{b}	38.02	21.81
4.	S_4	5405^{a}	0.00	96.54
5.	S_5	2750^{c}	49.12	--
S. Em.±		147	--	--
C.V. %		8.29	--	--

Increased in yield over control

Per cent increase in chilli yield over control due to various spray schedules was worked out and presented in table 3. Results showed that the highest per cent increased in yield over control was observed in the S_4 (96.54 %) and it was followed by S_3 (21.81 %) and S_2 (13.81 %). However, lowest per cent increase in yield of chilli over control was recorded in S_1 (11.63 %).

Economics of different treatments

In order to know the economics of different insecticidal treatments, Incremental Cost Benefit Ratio (ICBR) was worked out based on the marketable fruit yield of chilli, its prevailing market price and cost of respective insecticides/ acaricide. The details of ICBR calculated for different treatments under study are presented in table 4.

Data revealed that maximum net realization (39825 ₹/ ha) was found in the S_4, which was followed by S_3 (5880 ₹/ ha), S_2 (5700 ₹/ ha), S_1 (4800 ₹/ ha). (Table 4)

Perusal of data presented in table 4 indicated that maximum cost benefit ratio (1:2.86) was obtained with S_4 and it was followed by S_3 (1:1.88), S_2 (1:0.59), S_1 (1:0.06).

Thus, looking to the economics of different spray schedules, it can be concluded that S_4 was most economical. It was followed by S_3, S_2 and S_1 according to the economics of different spray schedules against major insect pests of chilli.

Table 4: Economics of different spray schedules against major insect pests of chilli

Treatments	Labour charge (₹)	Cost of material (₹)	Cost of treatment (₹)	Yield (kg/ha)	Total income (₹)	Net realization (₹)	Net gain (₹)	ICBR
S_1	720	3793	4513	3070	46050	4800	287	1:0.06
S_2	720	2864	3584	3130	46950	5700	2119	1:0.59
S_3	720	2400	3120	3350	50250	9000	5880	1:1.88
S_4	720	9585	10305	5405	81075	39825	29520	1:2.86
S_5	-	-	-	2750	41250	-	-	-

Labour Charges: ₹ 180/ day; Price of green chilli fruit ₹ 15/ kg; Diafenthiuron 50WP ₹3840 / kg; Imidacloprid 17.8 SL ₹ 1400/ kg; Propergite 57 EC ₹ 1380/ lit.; Profenophos 50 EC ₹ 600/ lit.; Triazophos 40 EC ₹ 640/ lit.; Acetamiprid 20 SP ₹ 1400 / kg; Novaluron 10 EC ₹ 3490/ lit.; Thiamethoxam 25WG ₹ 1750/ kg; Emamectin benzoate 5 SG ₹ 6000/ kg; Clothianidin 50 WP ₹ 12500/ kg; chlorantraniliprole 18.5 SC ₹16000 / lit.; Thiacloprid 21.7 SC ₹ 2520 / ha.

Acknowledgment

Authors are grateful to Dr. B.G. Prajapti and Dr. P.S. Patel (Department of Agriculture Entomology, C.P. College of Agriculture Gujarat) for providing necessary laboratory and other facilities to carry out this research work.

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