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Population Dynamics of Chickpea Pod Borer And Their Management

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ABSTRACT:

A Field experiment carried out during Rabi season revealed that incidence of the chickpea pod borer *Helicoverpa armigera*. Population range of pod borer during different weather weeks varied between 0.30 and 1.89 larvae/mrl (April 2nd week and March 2nd week respectively). Peak larval population of *Helicoverpa armigera* was recorded in 2nd week of March (11 standard weeks). A weak negative correlation was observed with the maximum relative humidity and minimum relative humidity (r = -0.172, -0.595 respectively) and a weak positive correlation with maximum temperature, minimum temperature and rainfall. The experiment was laid out with 09 treatments (Chlorantraniliprole 18.5 SC @ 37 g a.i./ha, Fipronil 5% SC @ 50 g a.i./ha, Indoxacarb 15.8 EC @ 79 g a.i./ha, Spinosad 45 SC @ 90 g a.i./ha, Novaluron 10 EC @ 100 g a.i./ha, Emamectine benzoate 5 SG @ 10 g a.i./ha, Neem oil 0.15% , Bt.K. 3.5% and untreated check) and three replications. The crop was sprayed at 50% flowering stage of the crop and repeated after 15 days. First spray of insecticides over all mean analysis indicated that all the insecticidal treatments were significantly effective in reducing the larval population of pod borer as compared to untreated plots (1.56 larvae/plant) in the first and second spray(092 larva/plant) of insecticides over all mean larval population Indoxacarb 15.8 EC @ 79 g a.i./ha was effective in controlling the incidence of gram pod borer due to the first spray (0.59 larva/plant) and also the second spray (0.27 larva/plant) among all treatments. Resulting in the seed yield 1989.00 kg/ha with the highest cost: benefit ratio of 1:12.3, which was followed by the treatment of Emamectin benzoate 5 SG @ 10 g a.i./ha with cost benefit ratio of 1:10.83.

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INTRODUCTION:

Helicoverpa armigera [Hubner] is the most devastating chickpea pest responsible for substantial yield loss. Productivity losses by gram pod borer range from 20 to 90 percent depending upon the severity of insect attack (Akhtar et al., 2022). Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops cultivated in 89.28 Lakh hectares with a production of 83.65 Lakh tonnes in Madhya Pradesh comprising the Rewa Division with, 0.64 Lakh ha area producing 0.64 lakh metric tonnes and productivity of 999 kg/ha (Anonymous 2015). Chickpea crop is damaged by a large number of insect species, both under field conditions and in storage (Clement et al., 2000). Among them *Helicoverpa armigera* Hub. is known to be the key pest due to high reproduction rates and short life cycle (Kumar and Singh, 2014). Pod borer, *H. armigera* is a noxious and polyphagous pest of global importance ravaging more than 200 cultivated and wild hosts (Yadav et al., 2011) which is the major factor for low yield of chickpea damaging the crop from vegetative to podding stage (Dhingra et al.,2003). Among the biotic factors responsible for low yield the, damage due to insect pests is the major limiting factor. The major factor for low yield of chickpea is the damage caused by gram pod borer *Helicoverpa armigera* (Hubner) from vegetative to podding stage (Dhingra et al., 2003). Use of resistant plant material remains the most effective tool in integrated pest management which is compatible with other methods of control with no additional cost to growers (Naddem et al. 2010). Keeping the above facts in view, the present investigation was planned and carried out to establish a relationship between insect pests management and their natural enemies at different stages of the Chickpea crop. The pod borer management and inhabiting agro ecosystems play an important role in reducing the pest populations to help in increasing the yield.

MATERIAL AND METHODS:

A field experiment was conducted at the entomology Instructional Farm, JNKVV College of Agriculture Rewa during *Rabi* 2018-19 on chickpea variety JG-16. District Rewa is situated at 24.31ºN latitude and 88.15ºE longitudes and climate is typically semi- humid and subtropical with winter and summer seasons. The average rainfall in this region is 1054.00 mm which is mostly received during monsoon season between mid June to end of October with little occasional showers in other seasons. The maximum temperature during the month of March and April reaches up to 35ºC, whereas minimum temperature goes below 6ºC in the month of December or January. Rewa traditionally comes under rice-wheat crop zone of Madhya Pradesh and is classified as "Kymore plateau and Satpura hills agro-climatic zone". The field was prepared following the recommended package of practices with plant spacing of 30 × 10 cm with plot size 3 m × 2.7 m. The incidence of *H. armigera* was observed from

five randomly selected plants from four middle rows of each plot at weekly interval. Meteorological parameters viz., temperature, humidity and rainfall were recorded at weekly interval. These data were subjected to statistical analysis to find out the correlation coefficients. The observations on insect pest populations and natural enemies will be recorded from one meter square area at weekly interval from the appearance of insect pests and natural enemies till harvesting of the crop. The spray of insecticides was applied as soon as the pest incidence is noted. The first spray was done by knapsac sprayer at 50% flowering stage of the crop and repeated after 15 days. Pre-treatment observation on pest population was undertaken one day before the application of the first spray by direct counting of *H. armigera* larvae per five randomly pre-selected plants in each plot. Similar procedure was followed for post-treatment observation which was recorded at 1, 3, 7, 10, 15 days after both the spray operations. The data were analyzed as per the experimental design to test the significant of the treatment by suitably transforming the larval population to square root ($\sqrt{x+0.5}$) for the statistical analysis. Pod damage and grain yield in different treatments recorded per plot.

Pod damage

Percent pod damage was calculated under different treatments as per formula

$$\text{Percent Pod Damage} = \frac{\text{Total damaged pod}}{\text{Total number of pods}} \text{ X } 100$$

Benefit Cost Ratio

Gross return was calculated by multiplying total yield with the market price of the produce. Cost of cultivation and cost of treatment imposition was deducted from the gross returns, to find out net returns and cost benefit ratio by following formula

$$B:C = \frac{\text{Gross returns}}{\text{Total cost of cultivation}} \text{ X } 100$$

Where, B: C = Benefit Cost Ratio

Grain yield

Yield was calculated under different treatments as per formula.

Yield / ha = Factor x grain yield / plot

RESULTS AND DISCUSSION:

The data related to population dynamics of pod borer is presented in Table 1. It is visual from these tables that pod borer infestation in the chickpea , all over Rabi 2018-19, prevail from 1st

standard week (1st week of Jan 2019) to 15th standard week (2nd week of April 2019) in diverse population during various standard weeks.

Population dynamics of pod borer- Population of pod borer in different standard weeks of Rabi 2018-19 is presented in Table 1, which shows the initiation of pest infestation in the 1st standard week (1st week of Jan 2019) with an average population of 0.4 larvae/mrl/week when average weekly maximum and minimum temperature of 24.97^{0}C and 6.42^{0}C was persisting during the week besides 72.85% relative humidity and 0.00 mm rainfall. The average monthly population of the pod borer was recorded; 0.46 larvae/mrl in the month of Jan.2019. An increase in the pest population was continuously noted up to 11th standard week (2nd week of March 2019) with an average population of 1.89 larvae/mrl. During this period, the average maximum & minimum temperature prevailed at 29.37^{0}C & 14.62^{0}C respectively, with an average 74.28% relative humidity and 0.00 mm rainfall.

The correlation of the pod borer population with maximum and minimum temperature, relative humidity and rainfall was worked out to find out relationship exist between them. A weak negative correlation was observed with the maximum relative humidity and minimum relative humidity and a weak positive correlation with maximum temperature, minimum temperature and rainfall.

The average population of pod borer in the entire month was found at 1.69 larvae/mrl. The decline in the pod borer population on the crop was observed after the peak incidence in the 2nd week of March 2019 and population of the pod borer was found 0.30 larvae/mrl in 15th standard week (2nd week of April 2019). Zahid and Shahzad (2007) reported that *H. armigera* pest population was low during 49th to 6th standard weeks but increased from 7th standard week onwards and declined again during 14th standard week. A positive correlation between the eggs, larval instars and overall density of *H. armigera* and the maximum and minimum temperatures. However a negative correlation existed between the eggs, larval instars and overall density and the average morning percent relative humidity. A weak negative correlation was observed with the maximum relative humidity and minimum relative humidity (r = -0.172, -0.595 respectively) and a weak positive correlation with maximum temperature, minimum temperature and rainfall. The respective r were found to be 0.306, 0.391, 0.269.

Among seven species recorded in which one species belong to sucking pests, one species pod borer found chickpea pod borer, (*Helicoverpa armigera* Hubner) destroy buds, flowers and pods. If flowers and pods are not available, they feed upon leaflets, leaving the veins. On pods, conspicuous holes are made by the entry of larvae. Usually developing and partly matured seeds are eaten completely. One species of cutworm damaging symptom chickpea seedling are cut through at or below ground level. Chickpea leaves, inflorescence stalk and young pods covered with black aphid, Honey dew secretion with black ant movement. Termite species (*Odontoterms obesus*) attack standing crop of chickpea, termite

bores into the roots and stem. Due to the bore chickpea plant soon dry. Semilooper larvae feed on leaflets, tender pods and developing seeds. When pods are attacked, much of the pod wall is eaten and the damage is ragged and irregular. Dabhi and Patel (2004) found that the population peaks occurred during the first and fourth weeks of February and second week of May (2.1, 2.8 and 1.2 larvae per mrl, respectively). High temperature and relative humidity during the morning hours were negatively and positively correlated with *H. armigera* population increase on the chickpea.

Seasonal incidence of major insect pest of chickpea and their natural enemies-The diversity of seven insects pests associated with the chickpea (variety JG-16) was found belonging to four orders i.e. Lepidoptera (3 families), Hemiptera (1 family), Isoptera (1 family), Colioptera (1 family), Orthoptera (1 family) (Table 2). The family Noctuidae, Aphididae, Termitidae, Melontidae and Acrididae were represented each one species.

Seven natural enemies were recorded during observation of fields i.e. Lady bird beetle (*Chilomenes sexmaculata* Fab.) order- Coleoptera, Lady bird beetle (*Coccinella septempunctata* L.) order- Colioptera, Praying mantid (*Mantis religiosa*) order- Dictyoptera, Dragon fly (*Crocothemis servilia*) order- Odonata, Campoletis parasitoid (*Campoletis chlorideae*) order- Hymenoptera, Indian mynah (*Acridotheris tristis*) order- Passeriformes, King crow (*Dicrurus macrocercus*) order- Passeriformes (Table 3).

Seven natural enemies were recorded during observation of fields. Sunanda and Reena (2010) reported that the parasitoid, *Campoletis chloridae* made its presence felt throughout the cropping season, whereas *T. ayyari* and *B. lassus* were also seen parasitizing the pests. These parasitoids, if manipulated might prove to be a potential source of suppressing the population build of *Helicoverpa armigera.*

Pod borer (*H. armigera*) incidence

All insecticides were found very effective and significantly superior over untreated control. However, T_3 and T_6 (indoxacarb and emamectine benzoate) were the best among them. (Table 4). Over all mean analysis indicated that all the insecticidal treatments were significantly effective in reducing the larval population of *H. armigera* as compared to untreated plots (1.56 larvae/plant). Indoxacarb was the most effective in controlling the incidence of gram pod borer (0.59 larva/plant) among all treatments. Whereas efficacy of rest of the treatments were in the order of Emamectin benzoate @ 10 g a.i./ha (0.75 larva/plant), chlorantraniliprole @ 37 g a.i./ha (0.79 larva/plant), spinosad @ 90 g a.i./ha (0.80 larvae/plant), Fipronil @ 50 g a.i./ha (0.83 larva/plant), Bt.K. @ 35 g a.i./ha (0.89 larvae/plant), novalurone @ 100 g a.i./ha (0.95 larvae/plant) and neem oil @ 4.5 g a.i./ha (0.97 larvae/plant). In chickpea two sprays of Indoxacarb 14.5 SC @ 72 gram ai/ha first at 50% flowering and pod formation stage and second spray after 15 days applied were effective to reduced the pod borer population (Kumar et al., 2013).

In case of second spray of insecticides also, the indoxacarb was superior over th rest of the treatments and all insecticides were found to be very effective and significantly superior over control. (Table 5). Over all mean analysis indicated that all the insecticidal treatments were significantly effective in reducing the larval population of *H. armigera* as compared to untreated plots (0.92 larva/plant) (Table 5). Indoxacarb was the most effective in controlling the incidence of gram pod borer (0.27 larva/plant) among all treatments, while the efficacy of rest of the treatments were in the order of Emamectin benzoate (0.44 larva/plant), chlorantraniliprole (0.47 larva/plant), spinosad (0.49 larva/plant), Fipronil (0.50 larva/plant), Bt.K. (0.52 larva/plant), novalurone (0.56 larva/plant) and neem oil (0.57 larva/ plant). In chickpea two sprays of Indoxacarb 14.5 SC @ 72 gram ai/ha first at 50% flowering and pod formation stage and second spray after 15 days applied were effective to reduced the pod borer population (Kumar et al., 2013).The highest grain yield was recorded with indoxacarb (1989.00 kg/ha) while the lowest grain yield was with neem oil (1414.00 kg/ha) which is accordance with the report of Gowda et. al. (2007) indicating that indoxacarb 14.5 SC @ 25 g a.i./ha. was found to be highly effective as compared to chlorpyriphos 20 EC @ 250 g a.i./ ha irrespective of spray equipment and offering maximum protection against pods which resulted in increased grain yield. Yogeeswarudu and Venkata Krishna (2014) also reported that indoxacarb 14.5 SC @ 0.5 ml/l was found the best treatment with the lowest population of *H. armigera,* (recording 1.53, 0.46 and 0.73 larva/five plants) and 89.45, 97.01and 95.83 percent reduction over control at 3 , 5 and 7 days after first spraying, respectively and (0.00, 0.26 and 0.00 larva/five plants) with 100, 98.74 and 100 percent reduction over control, at 3, 5 and 7 after second spray, respectively. The effectiveness of Spinosad, Indoxacarb and Fipronil insecticides treatment was in reducing larval population, pod damage and recorded higher good yield in comparison to untreated plot (Nitharwal et. al., 2017).

EFFECT ON GRAIN YIELD AND POD DAMAGE:

The result on the yield per plot (Table 6 and Table 7) shows a significant deference among the treatments. The highest yield of 1989.00 kg/ha, was recorded in the plot treated with Indoxacarb as against in the untreated control the yield of 1240.00 kg/ha.
The order of yield as influenced by insecticide was found in descending order Indoxacarb (1989.00 Kg/ha.) > Emamectin benzoate (1850.00 Kg/ha) > Chlorantraniliprole (1780.00 Kg/ha.) > Spinosad (1730.00 kg/ha) > Fipronil (1690.00 kg/ha) > Bt.K. (1642.00 kg/ha) > Novaluron (1530.00 kg/ha) > Neem oil (1414.00 kg/ha). Ghugal et al. (2013) reported that spinosad 45 SC @ 73 g a.i./ha was the most effective in controlling pod borer and resulting in the lowest pod damage (4.11%) and highest grain yield (2261.66 kg/ha) with CBR 1:7.37. Among biopesticides, *Beauveria bassiana*@ 1500 g/ha and NSKE 5% suffered 7.73 and 7.89 per cent pod damage producing 2011.66 kg/ha and 2001.66 kg/ha seed yield with CBR 1:12.6 & 1:5.78, respectively. Nitharwal et. al. (2017) reported that effectiveness of Spinosad, Indoxacarb and Fipronil insecticides was in reducing larval population, pod damage and recorded higher good yield in comparison to untreated plot.

Journal of Science and Research Innovations

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Differences in pod damage among insecticidal treatments were found significant CD value 0.573 and the pod damage ranged between 7.33 percent in Indoxacarb to 26.74 percent in untreated control.

Table 1. Population dynamics of chickpea pod borer (*Helicoverpa armigera*) in relation to temperature, relative humidity and rain fall during Rabi season

Standard weeks /name week of month	Population (Larva/plant)	Max.temp. (ºC)	Min.temp. (ºC)	Max.RH %	Min.RH %	Rainfall (mm)
46 (Nov 2nd week)	0.00	31.50	11.91	59.00	45.57	0.00
47 (Nov 3th week)	0.00	30.05	9.94	66.28	55.85	0.00
48 (Nov 4th week)	0.00	27.42	9.74	71.28	59.57	0.00
Average	0.00	29.65	10.53	65.52	53.66	0.00
49 (Dec 1th week)	0.00	25.20	8.60	75.00	58.57	0.00
50 (Dec 2th week)	0.00	24.78	7.70	75.28	56.28	0.00
51(Dec 3th week)	0.00	23.45	5.92	70.57	47.57	0.00
52(Dec 4th week)	0.00	22.44	4.22	70.57	41.28	0.00
Average	0.00	23.96	6.61	72.85	50.92	0.00
1(Jan1th week)	0.40	24.97	6.42	72.85	43.28	0.00
2(Jan 2ndWeek)	0.33	22.88	6.72	79.42	52.57	0.00
3(Jan 3rd week)	0.60	22.85	4.82	72.57	40.00	0.00
4(Jan 4th week)	0.33	25.81	10.87	84.28	64.14	2.54
5(Jan 5thweek)	0.66	23.88	6.44	76.00	45.57	0.00
Average	0.46	24.07	7.05	77.02	49.11	0.50
6(Fab 1st week)	0.33	26.02	9.47	73.42	50.00	0.00
7(Fab 2ndweek)	0.64	25.07	9.14	81.85	52.85	2.24
8(Fab3rd week)	0.80	28.68	11.65	76.71	42.57	7.60
9(Fab 4thweek)	0.91	25.84	9.61	69.42	46.14	4.14
Average	0.67	26.40	9.96	75.35	47.89	3.49
10(March 1stweek)	1.80	28.81	10.82	63.85	34.71	0.42
11(March 2ndweek)	1.89	29.37	14.62	74.28	42.28	0.00
12(March 3rd week)	1.70	32.61	13.18	62.42	31.14	3.17
13(March 4thweek)	1.40	36.98	16.08	54.00	34.42	0.00
Average	1.69	31.94	13.67	63.63	35.63	0.89
14(April 1stweek)	0.60	39.22	17.85	56.00	32.42	0.42
15(April 2nd week)	0.30	39.82	20.25	46.50	33.00	0.00
Total	0.45	39.22	19.05	51.25	32.71	0.21
Correlation coefficient (r value)	1	0.306	0.391	-0.172	-0.595	0.269

Journal of Science and Research Innovations

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Table 2. Qualitative composition of insect pests of chickpea during Rabi season

Common name	Scientific name	Family	Order	Crop Stage	Damaging stage	Status
Termite	*Odontotermes obesus* (Ram.)	Termitidae	Isoptera	Seedling stage	Nymphs	Minor
White grub	*Holotrichia consanguinea* (Bl.)	Melonthidae	Coleoptera	Seedling stage	Grubs	Minor
Black aphid	*Aphid craccivora* (C.L. Koch)	Aphididae	Hemiptera	Flowering stage	Nymph & adult	Minor
Grass hopper	*Chrotogonus trachypterus* (Blan.)	Acrididae	Orthoptera	Vegetative stage	Nymph & adult	Minor
Semi looper	*Autographa nigrisigna* (L)	Noctuidae	Lepidoptera	Flowering & podding stage	Larvae	Minor
Cut worm	*Agrotis ipsilon* (Huf.)	Noctuidae	Lepidoptera	Seedling stage	Larvae	Minor
Gram pod borer	*Helicoverpa armigera* (Hub.)	Noctuidae	Lepidoptera	Flowering & podding stage	Larvae	Major

Journal of Science and Research Innovations

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Table 3: Natural enemies recorded in chickpea during Rabi season.

Common name	Scientific name	Family	Order	Host
Lady bird beetle	*Chilomenes sexmaculata* (Fab.)	Coccinellidae	Coleoptera	Aphid
Lady bird beetle	*Crocothemis servilia* (Drury)	Coccinellidae	Coleoptera	Larvae of pod borer
Praying mantid	*Mantis religiosa* (L.)	Mantidae	Dictyoptera	Larvae of pod borer
Dragon fly	*Crocothemis servilia* (Drury)	Libellulidae	Odonata	Larvae of pod borer
Campoletis	*Campoletis chlorideae* (Uch.)	Ichneumonidae	Hymenoptera	Larvae of Parasitoid
Indian mynah	*Acridotheris tristis* (L.)	pod borer Sturnidae	Passeriformes	Pod borer Larvae
King crow	*Dicrurus macrocercus* (Vie.)	Dicruridae	Passeriformes	Pod borer Larvae

Journal of Science and Research Innovations

Volume - 1, Issue - 2, 2023, ISSN: 2583-9004 (ONLINE)

Table 4. Efficacy of insecticides treatment against Chickpea pod borer first spray during Rabi 2018-19

Treatments	Name of Insecticides	Doses in g a.i. /ha	Trade Name	Pod borer per plants						All over mean
				One day Before	First spray After Treatment					
					1 DAT	3 DAT	7 DAT	10 DAT	15 DAT	
T_1	Chlorantranilipr ole 18.5 SC	37	Coragen	1.73 (1.65)	1.20 (1.48)	0.73 (1.31)	0.63 (1.27)	0.65 (1.28)	0.75 (1.32)	0.79 (1.33)
T_2	Fipronil 5% SC	50	Ruler(KR)	1.76 (1.66)	1.13 (1.45)	0.86 (1.36)	0.66 (1.29)	0.80 (1.34)	0.73 (1.31)	0.83 (1.35)
T_3	Indoxacarb 15.8 EC	79	Avaunt	1.76 (1.66)	0.90 (1.37)	0.58 (1.25)	0.46 (1.20)	0.50 (1.22)	0.53 (1.23)	**0.59** (1.25)
T_4	Spinosad 45 SC	90	ONEUP	1.73 (1.65)	1.18 (1.47)	0.76 (1.32)	0.66 (1.29)	0.74 (1.31)	0.70 (1.30)	0.80 (1.33)
T_5	Novaluron 10 EC	100	Rimon	1.70 (1.64)	1.50 (1.58)	1.00 (1.41)	0.70 (1.30)	0.66 (1.28)	0.90 (1.37)	0.95 (1.38)
T_6	Emamectin ben oate 5 SG	10	Proclaim	1.76 (1.66)	1.00 (1.41)	0.80 (1.34)	0.60 (1.26)	0.65 (1.28)	0.70 (1.30)	0.75 (1.31)
T_7	Neem oil 0.15%	4.5	AZADIRACTINE	1.76 (1.66)	1.50 (1.58)	1.00 (1.41)	0.73 (1.31)	0.63 (1.27)	1.00 (1.41)	0.97 (1.39)
T_8	Bt.K.8L 3.5 % ES	35	ABTECABTEC	1.70 (1.64)	1.43 (1.55)	0.95 (1.39)	0.68 (1.29)	0.60 (1.26)	0.80 (1.34)	0.89 (1.36)
T_9	Untreated check	-	-	1.80 (1.67)	1.93 (1.71)	1.71 (1.64)	1.53 (1.59)	1.35 (1.53)	1.30 (1.51)	1.56 (1.59)
	SEm±			0.032	0.045	0.029	0.016	0.033	0.033	
	CD at 5%			N/S	0.136	0.088	0.048	0.099	0.1	

* Figure in parenthesis are $\sqrt{X + 0.5}$ values

DAT = Day after treatment, NS = Non Significant

Journal of Science and Research Innovations

Volume - 1, Issue - 2, 2023, ISSN: 2583-9004 (ONLINE)

Table 5. Efficacy of insecticides treatment against Chickpea pod borer second spray during Rabi 2018-19

Treatments	Name of Insecticides	Doses in g a.i. /ha	Trade Name	Pod borer per plants After second spray Treatment					Over all mean
				1 DAT	3 DAT	7 DAT	10 DAT	15 DAT	
T_1	Chlorantraniliprole 18.5 SC	37	Coragen	0.63 (1.27)	0.48 (1.21)	0.38 (1.17)	0.33 (1.15)	0.53 (1.23)	0.47 (1.20)
T_2	Fipronil 5% SC	50	Ruler(KR)	0.66 (1.29)	0.51 (1.23)	0.41 (1.19)	0.36 (1.16)	0.56 (1.25)	0.50 (1.22)
T_3	Indoxacarb 15.8 EC	79	Avaunt	0.43 (1.19)	0.28 (1.13)	0.18 (1.08)	0.20 (1.09)	0.26 (1.12)	**0.27** (1.12)
T_4	Spinosad 45 SC	90	ONEUP	0.66 (1.29)	0.51 (1.23)	0.39 (1.17)	0.36 (1.16)	0.55 (1.24)	0.49 (1.21)
T_5	Novaluron 10 EC	100	Rimon	0.73 (1.31)	0.55 (1.24)	0.48 (1.21)	0.49 (1.22)	0.55 (1.24)	0.56 (1.24)
T_6	Emamectin benzoate5 SG	10	Proclaim	0.60 (1.26)	0.45 (1.20)	0.35 (1.16)	0.30 (1.14)	0.50 (1.22)	0.44 (1.19)
T_7	Neem oil 0.15%	4.5	AZADIRACTINE	0.73 (1.31)	0.58 (1.25)	0.48 (1.21)	0.43 (1.19)	0.63 (1.27)	0.57 (1.24)
T_8	Bt.K.8L 3.5 % ES	35	ABTECABTEC	0.68 (1.29)	0.53 (1.23)	0.43 (1.19)	0.38 (1.17)	0.58 (1.25)	0.52 (1.22)
T_9	Untreated check	-		1.15 (1.46)	1.00 (1.41)	0.9 (1.37)	0.80 (1.34)	0.75 (1.32)	0.92 (1.38)
	SEm±			0.024	0.018	0.015	0.015	0.012	
	CD at 5%			0.072	0.055	0.045	0.045	0.038	

* Figure in parenthesis are $\sqrt{X + 0.5}$ values

DAT = Day after treatment, NS = Non Significant

Table 6. Effect of insecticide on grain yield of Chickpea, Rabi 2018-19

Treatment	Name of Treatments	Doses in g a.i. /ha	Yield (kg/plot)	Average yield (kg/ha)	Additional yield over control (kg/ha)	% Yield increased
T_1	Chlorantraniliprole 18.5 SC	37	1.44	1780.00	540.00	43.54
T_2	Fipronil 5% SC	50	1.36	1690.00	450.00	36.29
T_3	Indoxacarb 15.8 EC	79	1.61	1989.00	749.00	**60.40**
T_4	Spinosad 45 SC	90	1.40	1730.00	490.00	39.51

T_5	Novaluron 10 EC	100	1.23	1530.00	290.00	23.38
T_6	Emamectin benzoate5 SG	10	1.49	1850.00	610.00	49.19
T_7	Neem oil 0.15%	4.5	1.14	1414.00	174.00	14.03
T_8	Bt.K.8L 3.5 % ES	35	1.33	1642.00	402.00	32.41
T_9	Untreated check	37	1.00	1240.00	-	-
	SEm±	-	0.013	-	-	-
	CD at 5%	-	0.038	-	-	-

Table 7. Pod damage and grain yield at harvest under different treatments

Treatments	Name of Insecticides	Doses in g a.i. /ha	Pod Damage (%)	Yield (q/ha)
T_1	Chlorantraniliprole 18.5 SC	37	10.25 (18.64)	17.30
T_2	Fipronil 5% SC	50	12.3 (20.50)	16.90
T_3	Indoxacarb 15.8 EC	79	**7.33** (15.69)	**19.89**
T_4	Spinosad 45 SC	90	11.1 (19.43)	17.80
T_5	Novaluron 10 EC	100	16.25 (23.75)	16.42
T_6	Emamectin benzoate5 SG	10	9.2 (17.62)	18.50
T_7	Neem oil 0.15%	4.5	18.35 (25.34)	14.14
T_8	Bt.K.8L 3.5 % ES	35	14.5 (22.36)	15.30
T_9	Untreated check	-	26.74 (31.12)	12.40
SEm±	-	-	0.189	0.009
CD at 5%	-	-	0.573	0.026

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Table 8. The economics of pests control by insecticides on chickpea, Rabi 2018-19

Treatment	Name of Treatments	Price of insecticide (Rs./liter)	Cost of insecticides Rs/ha (2 spray)	Protection cost for Rs./ha (2 spray)	Yield (Kg/ha)	Additional yield over control (Kg/ha)	Additional income over control	Net return (Rs./ha)	C:B ratio
T_1	Chlorantraniliprole 18.5 SC	13500	5400	6000	1780	540	24948	18948	1:4.1
T_2	Fipronil 5% SC	1200	2400	3000	1690	450	20790	17790	1:6.9
T_3	Indoxacarb 15.8 EC	2200	2200	2800	**1989**	749	34603.8	31803.8	**1:12.3**
T_4	Spinosad 45 SC	20000	8000	8600	1730	490	22638	14038	1:2.6
T_5	Novaluron 10 EC	1050	2100	2700	1530	290	13398	10698	1:4.9
T_6	Emamectin benzoate5 SG	5000	2000	2600	1850	610	28182	25582	1:10.83
T_7	Neem oil 0.15%	700	4200	4800	1414	174	8038.8	3238.8	1:1.6
T_8	Bt.K.8L 3.5 % ES	1110	2220	2820	1642	402	18572.4	15752.4	1:6.5
T_9	Untreated check	-	-	-	1240	-	-	-	-

CONCLUSION:

The C:B ratio of various insecticide treatments was calculated and presented in table 8 which divulge that maximum C:B ratio (1:12.3) was recorded from Indoxacarb treatment followed by Emamectin benzoate (1:10.83), Fipronil (1:6.9), Bt.K. (1:6.5), Novaluron (1:4.9), Chlorantraniliprole (1:4.1), Spinosad (1:2.6), and Neem oil (1:1.6). However, the minimum

CB ratio was noted in the plot treated with The order of C:B ratio due to different insecticide treatments is given below.

Indoxacarb (T3) > Emamectin benzoate (T6) > Fipronil (T2) > Bt.K. (T8) > Novaluron (T5) > Chlorantraniliprole (T1) > Spinosad (T4) > Neem oil (T7).

Highest cost: benefit ratio of 1:12.3 was observed in the treatment of Indoxacarb 15.8 EC @ 79 g a.i./ha , followed by the treatment of Emamectin benzoate 5 SG @ 10 g a.i./ha with cost benefit ratio was 1:10.83.

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