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## Efficacy of newer molecules and biorationals in managing pod borers in soybean ecosystem

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### Abstract

A field experiment was conducted to evaluate the efficacy of different insecticides against *Cydia ptychora* (Meyrick) and *Etiella zinckenella* (Treitschke) in Kharif 2021. Among all tested chemicals and biorationals, chlorantraniliprole proved very effective in controlling the *C. ptychora* larvae (80.95%) followed by indoxacarb 15.8 EC which controls 76.85 percent. While azadirachtin (41.93%) and NSKE (32.43%) were least in controlling the *C. ptychora* larvae, respectively. In case of *E. zinckenella* highest percent reduction, 89.54 was recorded in chlorantraniliprole treated plots, followed by indoxacarb (81.34%). NSKE was found to be the least effective by recording 68.87 percent when compared to untreated control. The higher cost-benefit ratio of 1:3.47 was recorded in chlorantraniliprole treated plot followed by indoxacarb (1:3.20).

**Keywords:** Insecticides, *Cydia ptychora*, *Etiella zinckenella*, chlorantraniliprole, indoxacarb

### Introduction

Soybean (*Glycine max* (L) Merrill) is a widely grown oil seed crop and also known as the "Golden Bean" or miracle crop of the 20<sup>th</sup> century. It is grown in different regions such as tropical, subtropical and temperate regions. Soybean oil and protein content account for about 20 and 40 percent of their weight, respectively. It is a highest source of edible vegetable protein when compared to any other pulse crop. Due to presence of significant amount of essential amino acids it is the world's foremost provider of oil and a good source of protein (Ankita *et al.*, 2012) [3]. A total area of 120.50 million hectares soybean cultivated in world soybean with the production 333.67 million tonnes in the year 2019-20 Brazil ranks first in soybean production with 114.27 million tonnes whereas, India ranks fourth in the area with 11.34 million hectares, accounting for 9.41 percent of the world area and fifth in production with 11.22 million tonnes. The major soybean-growing states are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and Telangana. In Karnataka, soybean occupies an area of 2.47 lakh hectare with the production of 3.00 lakh tonnes and productivity of 1215 kg/ha, majorly grown in Belagavi, Dharwad, Bidar, Bagalkote, Haveri and of late in, Davangere and Shivamogga districts of Karnataka (Parashuram and Patil, 2021) [7]. In the rainfed agro ecosystems of central and peninsular India, cultivation of soybean has played a pivotal role in improving the socio-economic conditions of large numbers of small and marginal farmers. This magical crop can potentially mitigate rampant protein energy malnutrition and be an excellent food for the country because of several nutraceutical and functional compounds. However, due to the continuous cultivation and a drastic increase in the area of cultivation, insect pests have negatively influenced the crop's economic yield as the pest complex threatens the soybean productivity from planting to harvesting.

The insect pests that infest the crop during and after flowering cause severe yield loss. The major ones are the *E. zinckenella* and *C. ptychora*.

The pod borer *C. ptychora* is a significant insect pest around the Shivamogga area and inflicts severe damage to the crop, leading to huge losses. The larvae bore into the seeds, producing whitish dry frass and making an exit hole on the pods. Larvae feeding holes and the production of frass and webbing within the pods result in seeds with severely reduced food value and poor germination capacity.

The percentage of damage from *C. ptychora* to soybean pods just before harvest ranged from 10.5 to 91.3 on the crop sown during October and July respectively (Adimani, 1976) [2].

To keep the pest population under economic injury level, newer molecules were evaluated

### Materials and Methods

The soybean crop was taken up during *Kharif* 2021 at Agriculture, Bavikere during for this experiment JS 335 variety of soybean was sown with a spacing of 45×10 cm in a gross plot size of 525 m<sup>2</sup> area of field by following the recommended package of practices except plant protection measures for pod borers in Randomized Completely Block Design (RCBD).

The field experiment was laid out in with seven treatments and three replications comprising of different newer molecules of insecticides along with an untreated control.

**Table 1:** Details of the insecticides tested against pod borer complex of soybean

| Sl. No. | Treatment                   | Dosage ml/l |
|---------|-----------------------------|-------------|
| 01      | Chlorpyrifos 20 EC          | 2.00        |
| 02      | Chlorantraniliprole 18.5 SC | 0.25        |
| 03      | Indoxacarb 15.8 EC          | 0.66        |
| 04      | Profenophos 50 EC           | 2.00        |
| 05      | NSKE 5%                     | -           |
| 06      | Azadirachtin 0.03%          | 5.00        |
| 07      | Control                     | -           |

**Treatment application:** A knapsack sprayer with a hollow cone nozzle was used for treatment imposition with the respective dosage mentioned in table 1. The first spray was given at 45 days after sowing and second spray was taken at 60 days after sowing.

**Observation:** The observations were recorded on five randomly selected plants on a day before spraying and 3, 7, 10 and 14 days after spraying by counting the number of larvae per plant and number of damaged pods per plant. Later, the damaged pods were cut open and checked for the presence of different species of larvae. Based on the larval characters larval species were identified. percent damage by different species of pod borers and percent reduction over control was calculated using the following formula.

$$\text{Percent pod damage} = \frac{\text{No. of damaged pods}}{\text{Total number of pods}} \times 100$$

### Economic analysis

#### Cost of plant protection

Based on prevailing market price of insecticides, wages of labour and cost of spray and cost of inputs, the cost of plant protection was worked out.

#### Gross return

The price of soybean prevailing in the market at the time of harvest was used for the calculation of gross return (Rs/ha).

$$\text{Gross return} = \text{Total yield (kg/ha)} \times \text{Market price (Rs/kg)}$$

#### Net return

Net return is calculated using the below mentioned formula

$$\text{Net return} = \text{Gross return} - \text{Cost of cultivation}$$

### Cost Benefit ratio

C: B ratio was calculated by dividing the gross returns by cost of cultivation.

$$\text{C: B ratio} = \frac{\text{Gross return}}{\text{Total cost of cultivation}}$$

### Statistical analysis

The statistical analysis of the data collected from management experiment was done using analysis of variance (ANOVA) using Web Agri Stat Package (WASP-2) developed by Indian Council of Agricultural Research, Research Complex, Goa. The interpretation of data was done by using the critical difference value calculated at 0.05 probability level. The level of significance was expressed at 0.05 probability.

### Results and Discussion

#### *Cydia ptychora*

##### First spray

The first spray of insecticides and biorationals were applied at the 50 percent blooming. The results indicated that the larvae population in all treatments was statistically uniform one day before spray imposition (DBS), as shown by non-significant variations between treatments. However, all the treatments were significantly superior to the untreated check (Table 2).

At 3 DAS, it was noticed that there were significant differences among the treatments. The lowest larval population per plant was observed in chlorantraniliprole (1.67), followed by indoxacarb (2.07 larvae/plant) and profenophos (2.47 larvae/plant) which were on par with each other. The subsequent next treatment was chlorpyrifos and azadirachtin, which were on par with each other, by recording the mean larvae of 3.67 and 3.47, respectively. NSKE was found to be least effective with a mean larval population of 4.13 per plant compared to other treatments. All the treatments recorded a lower number of larvae per plant over the untreated check (4.87) and were significantly superior to the control (Table 2).

At 7 DAS, chlorantraniliprole, which registered 1.17 larvae per plant, followed by indoxacarb, which recorded 1.53 larvae per plant and also which was on par with the profenophos by recording 1.92 larvae per plant, chlorpyrifos recorded with mean larvae of 2.38 per plant. Azadirachtin and NSKE, were on par with each other, by recording 2.93 and 3.53 larvae per plant, respectively. The highest larvae population of 4.96 per plant was observed in the untreated check (Table 2).

Similar results were noticed on the 10<sup>th</sup> DAS. All the treatments recorded a significantly lower mean larvae population than the untreated check. The lower mean larvae was noticed in chlorantraniliprole (0.21/per plant) and on par with the indoxacarb, which recorded 0.53 larvae per plant. The next best treatment was profenophos. It recorded 1.01 larvae per plant. The next succeeding best treatment was chlorpyrifos, Azadirachtin and NSKE which recorded 1.41, 1.75 and 1.97 larvae per plant. However, untreated control recorded the highest mean larvae of 5.09 per plant (Table 2).

At 14 DAS, there was slight increase in larvae population. However, the best treatment was chlorantraniliprole and indoxacarb, which registered 1.20 and 1.57 larvae per plant, which were on par with each other, the subsequent best

treatment was noticed in profenophos and chlorpyrifos, which recorded mean larvae of 2.30 and 2.85 per plant, which were on par with each other. Biorationals like Azadirachtin and NSKE, recorded 3.35 and 3.93 larvae per plant, respectively which were statistically on par with each other. Untreated check recorded a significantly higher larvae population of 5.48 per plant.

Overall mean efficacy of different insecticides and biorationals revealed that chlorantraniliprole, recorded the lower mean number of *C. ptychota* (1.06) larvae per plant, followed by indoxacarb 15.8 EC which recording 1.43 larvae per plant. Profenophos 50 EC, chlorpyrifos, azadirachtin and NSKE which recorded mean larvae of 1.92, 2.58, 2.87 and 3.39 per plant, respectively. However, all treatments were significantly superior to untreated control (Table 2).

Among all the treatments, chlorantraniliprole was most effective for controlling the *C. ptychota* larvae with reducing of 81.01 percent as compared to other treatments, followed by indoxacarb (74.49%). The subsequent best treatment was profenophos and chlorpyrifos, reducing the 65.50 and 53.76 percent, respectively. While in the case of biorationals like azadirachtin and NSKE, the least effective compared to insecticides which recorded the below 50 percent, 48.41 and 39.09 percent, respectively (Table 2).

### Second spray

The findings on the effectiveness of insecticides and biorationals on the population of *C. ptychota* larvae one day before treatment, three, seven and fifteen days following the second spray are presented in Table 3. The larvae population of *C. ptychota* was the same on the day before the second spray as it was fifteen days following the first spray since the second spray was initiated. Even though there was a substantial difference between the treatments 15 days after the initial spray, the number of larvae inside the treatments had already exceeded the threshold for economic impairment of 1 larvae/2 plants. A second spray was applied to bring the population below the level of economic harm.

At 3 DAS, all the insecticidal treatments were significantly superior to the untreated check. Chlorantraniliprole and indoxacarb recorded the least larval population of 1.15 and 1.49 per plant, respectively and they were on par with each other. Profenophos and chlorpyrifos, which recorded mean larvae of 2.14 and 2.60 per plant, were the subsequent best treatments. The rest of the treatments with azadirachtin and NSKE which recorded 3.26 and 3.86 larvae per plant, respectively, were on par with each other. Untreated check recorded a significantly higher population of 5.62 larvae per plant (Table 3).

Further, 7 DAS, chlorantraniliprole and indoxacarb recorded the least larvae population of 1.05 and 1.32 per plant, respectively and they were on par with each other. Profenophos and chlorpyrifos, which recorded mean larvae of 2.01 and 2.49 per plant, the subsequent best treatment and were on par with each other. The rest of the treatments *viz.* azadirachtin and NSKE, which recorded 3.25 and 3.75 larvae per plant, respectively, were on par with each other. Untreated check recorded a significantly higher population of 6.0 larvae per plant (Table 3).

At 10 DAS, the results showed a significant difference among the treatment where the lowest larvae population was seen in chlorantraniliprole and indoxacarb recorded the least larvae population of 0.96 and 1.14 per plant, respectively

and they were on par with each other. The subsequent best treatment was profenophos and chlorpyrifos, which recorded mean larvae of 1.87 and 2.22 per plant. Azadirachtin and NSKE, which recorded maximum mean larvae of 3.18 and 3.64 per plant, respectively, were on par with each other. Untreated checks recorded a significantly higher population of 6.17 larvae per plant (Table 3).

Similarly, on the 14<sup>th</sup> DAS, chlorantraniliprole, and indoxacarb recorded the least larval population of 1.09 and 1.22 per plant, respectively and they were on par with each other followed by profenophos and chlorpyrifos which recorded mean larvae of 2.05 and 2.32 per plant. Further azadirachtin and NSKE, recorded 3.28 and 3.85 larvae per plant, respectively. However, untreated control recorded a significantly higher population of 6.12 larvae per plant (Table 3).

After the second spray, the mean number of larvae indicated that chlorantraniliprole proved very effective in recording the lowest mean number of larvae, 1.06 per plant followed by indoxacarb with 1.29 larvae per plant. In the case of profenophos, and chlorpyrifos recording the mean larvae of 2.02 and 2.41 per plant. The following treatment, azadirachtin and NSKE recorded the highest mean larvae compared to other treatments, 3.24 and 3.77 per plant, respectively. In untreated control, there was highest mean of 5.58 larvae per plant.

Among all tested chemicals and biorationals, chlorantraniliprole proved very effective in controlling the *C. ptychota* larvae (80.95%) followed by indoxacarb 15.8 EC which controls 76.85 percent. The following chemical profenophos and chlorpyrifos which reduces 63.88 and 56.86 percent. While azadirachtin (41.93%) and NSKE (32.43%) were least in controlling the *C. ptychota* larvae, respectively (Table 3).

Observing the mean of the first and second spray indicated that all the insecticides proved their superiority over untreated control. But among those, chlorantraniliprole was found to be the most promising treatment, followed by indoxacarb, reducing the larvae population up to 81.01 and 76.85 percent, respectively. The lowest percent reduction was recorded in chlorpyrifos 56.86 percent, azadirachtin 41.93 percent and NSKE 32.42 percent.

The current results are same with Vinod and Patil (2015) [10], who reported that chlorantraniliprole 20 SC was significantly superior in reducing larvae populations, which indicated 80.85 percent population reduction over control, followed by flubendiamide 480 SC and novaluron 10 EC. The present findings are same with those (Umbarkar *et al.* 2010) [9] who reported that spinosad 0.009%, indoxacarb 0.0075%, cypermethrin 0.009%, or profenophos 0.05% were the most effective in reducing the pink pod borer population.

### First spray

Pre-treatment populations of the number of larvae per plant one day before pesticide spraying, were nearly similar across all treatments during the initial application, indicating no significant changes between treatments (Table 4).

At 3 DAS, it was observed that there were significant differences among the treatments. Chlorantraniliprole and indoxacarb, recorded the least larvae population of 1.17 and 1.21 larvae per plant, respectively. They were on par with each other, followed by profenophos and chlorpyrifos, which recorded the mean number of larvae 2.18 and 2.34

per plant and it is shown on par with each other. Further azadirachtin and NSKE recorded 2.74 and 2.58 larvae per plant, respectively. However, untreated check recorded a significantly higher population of 4.99 larvae per plant (Table 4).

At 7 DAS, all the treatments proved significantly superior in reducing the population of *E. zinckenella* in the field. The maximum reduction was noticed in chlorantraniliprole and indoxacarb, with the mean larvae of 1.07 and 1.09 per plant and which are on par with each other. Next effective treatment was profenophos and chlorpyrifos, which recorded mean larvae of 1.61 and 1.78 per plant and it is shown on par with each other. Azadirachtin and NSKE, which recorded 2.14 and 2.16 larvae per plant, respectively, were on par with each other. However, untreated check recorded a significantly higher population of 5.84 larvae per plant (Table 4).

At 10 DAS, all the treatments recorded a significantly lower larvae population than the untreated check. The lowest mean larvae population of 0.95 and 1.05 per plant were observed in chlorantraniliprole and indoxacarb, which were statistically on par with each other. The next succeeding treatment profenophos and chlorpyrifos, which recorded mean larvae populations of 1.09 and 1.78 per plant and they are on par with each other. In contrast, Azadirachtin and NSKE, which recorded 2.51 and 2.24 larvae per plant, respectively and on par with each other. However, untreated check recorded a significantly higher population of 5.98 larvae per plant (Table 4).

At 14 DAS, all the treatments recorded minimum larvae population than the untreated check. The lowest mean larvae population of 1.06 and 1.99 per plant was observed in chlorantraniliprole and indoxacarb, which were statistically on par with each other. The next succeeding treatment was profenophos and chlorpyrifos which recorded mean larvae populations of 2.09 and 2.51 per plant, which is on par with each other. Where Azadirachtin and NSKE recorded 2.76 and 3.19 larvae per plant, respectively and they are on par with each other. However, untreated check recorded a significantly higher population of 6.54 larvae per plant (Table 4).

The overall mean observations indicated that chlorantraniliprole and indoxacarb were superior by recording the mean number of larvae per plant 1.06 and 1.34, respectively. In case of profenophos recorded 1.77 larvae per plant, chlorpyrifos 2.10 larvae per plant, Azadirachtin and NSKE, recorded 2.45 and 2.54 larvae per plant, respectively. The maximum number of larvae was recorded in control (5.84/plant).

The best treatment among the tested chemicals chlorantraniliprole recorded the maximum percent reduction (81.81%) compared to all other treatments, followed by indoxacarb which reduced the 77.05 percent. while in case of profenophos and chlorpyrifos 70.16 and 64.03 percent. In case of Azadirachtin and NSKE recorded least control of 56.48 and 58.05 percent, respectively (Table 4).

### Second spray

The findings on the effectiveness of insecticides and biorationals on the population of *E. zinckenella* larvae one day before treatment, three, seven and fifteen days following the second treatment are presented in Table 18. The larvae population of *E. zinckenella* was the same on the day before the second spray as it was fifteen days following the first

spray since the second spray was initiated at that time. Even though there was a substantial difference between the treatments 15 days after the initial spray, the number of larvae inside the treatments had already exceeded the threshold for economic impairment of 1 larvae/2 plants. A second spray was applied to bring the population below the level of economic harm.

At 3 DAS, all the treatments were superior over the control but chlorantraniliprole and indoxacarb, recording the lowest 0.77 and 1.28, mean number larvae per plant, respectively and it is also on par with each other. The subsequent best treatment was profenophos, chlorpyrifos, azadirachtin and NSKE, recording the mean number of larvae 1.70, 1.84, 2.16 and 2.30 per plant, respectively and they are on par with each other. While in control, the highest mean larvae (6.59/plant) was recorded (Table 4).

At 7 DAS, the lowest mean larvae were seen in the treatment chlorantraniliprole, 0.84 per plant. The subsequent next best treatment was indoxacarb, profenophos, chlorpyrifos and azadirachtin, which recording the mean larvae of 1.28, 1.52, 1.79 and 2.06 per plant and they are on par with each other. Where NSKE showed the least effective treatment by recording the 2.20 mean larvae per plant. However, untreated check recorded a significantly higher population of 6.63 larvae per plant.

At 10 DAS, chlorantraniliprole recording the lowest larvae population of 0.53 per plant, followed by indoxacarb, profenophos, recording the mean larvae of 1.09 and 1.03 per plant. They are on par with each other. Chlorpyrifos, azadirachtin and NSKE, recording the mean number of larvae of 1.58, 1.43 and 1.87 per plant, respectively and they are on par with each other. In the control, the highest mean larvae were 6.70 per plant.

Similarly, on the 14<sup>th</sup> DAS, chlorantraniliprole and indoxacarb recorded the least larvae population of 0.64 and 1.16 per plant, respectively and they were on par with each other. The next treatment followed by profenophos, chlorpyrifos, azadirachtin and NSKE, recording the mean number of the larvae of 1.62, 1.69, 1.90 and 1.91 per plant, which are on par with each other. However, untreated check recorded a significantly higher population of 6.69 larvae per plant (Table 4).

The second spray observation indicated that chlorantraniliprole proved to be very effective by recording the lowest mean larvae of 0.70 per plant, followed by indoxacarb recorded the 1.24 larvae per plant and remaining treatments profenophos, chlorpyrifos, azadirachtin and NSKE, recording the mean larvae of 1.47, 1.73, 1.89 and 2.07 per plant. The highest larvae were observed in control, 6.65 larvae per plant (Table 4).

Among the treatments highest percent reduction, 89.54 was recording in chlorantraniliprole treated plots, followed by indoxacarb (81.34%). Profenophos, chlorpyrifos and azadirachtin, which recording the 77.94, 74.07 and 71.61 percent, respectively. NSKE was found to be the least effective by recording 68.87 percent when compared to untreated control (Table 4).

The results of the two sprays data indicated that out of six insecticides and biorationals on the *E. zinckenella*, the highest reduction of 89.54 percent was recorded in chlorantraniliprole treated plots, followed by indoxacarb (81.34%), profenophos (77.94%) and chlorpyrifos (74.07%). Biorationals like azadirachtin (71.61%) and NSKE (68.87%) were least effective with percent reduction

over control.

These results are associated with the bioefficacy of some new insecticides and their combinations against pod borer *E. zinckenella* infesting pigeon pea (Swami *et al.*, 2017). Among the various insecticides, lowest population of larvae with a mean of 3.65, 4.16, 2.25 and 2.16 larvae per 10 plants was recorded in Chlorantraniliprole 9.6% + Lambda-cyhalothrin 4.6% at 300 ml/ha as against 35.10, 37.0, 39.55 and

38.47 larvae per 10 plants, Chlorantraniliprole 9.6% + Lambda-cyhalothrin 4.6% at 200, and 250 ml/ha. Kambrekar *et al.* 2017. The field experiment was designed to evaluate the efficacy of a new diamide insecticide against the defoliators and pod bore of soybean under field conditions. Tetraniliprole @ 0.6 ml/l has recorded a lower incidence of defoliators. All the dosages of tetraniliprole have excelled in recording a smaller number of defoliators and were equally effective to the standard check (chlorantraniliprole).

### Yield and cost economics

The data on yield of soybean revealed that, the significantly higher grain yield of 2389 kg/ha was recorded in chlorantraniliprole, followed by indoxacarb (2119 kg/ha), profenophos (1987 kg/ha), chlorpyriphos (1801 kg/ha), azadirachtin (1787 kg/ha) and NSKE (1643 kg/ha). The untreated control recorded a significantly lower yield of 1136 kg/ha (Table 6).

The higher cost-benefit ratio of 1:3.47 was recorded in chlorantraniliprole applied plot followed by indoxacarb

(1:3.20), profenophos (1:3.20), chlorpyriphos (1:2.86), azadirachtin (1:2.27) and NSKE (1:2.58). However, a lower benefit-cost ratio of 1:1.91 was recorded in the untreated check (Table 6).

The cost-benefit ratio was estimated under the economics of insecticides against the pod borer complex of soybean. The higher cost-benefit ratio of 1:3.47 was recorded in chlorantraniliprole applied plot followed by indoxacarb 0.66 ml/l (1:3.20), profenophos (1:3.05), chlorpyriphos (1:2.86), azadirachtin (1:2.72) and NSKE (1:2.58). However, a lower benefit-cost ratio of 1:1.91 was recorded in the untreated check.

The present findings are in line with findings of Madhurima and Patil 2015. The highest B: C ratio was obtained in chlorantraniliprole (2.32), followed by flubendiamide 480 SC (0.5 ml/l) (2.12), emamectin benzoate 5SG (0.2 g/l) (2.08), indoxacarb 14.5 SC (0.3 ml/l) (2.00) and chlorpyriphos 20 EC (2 ml/l) (1.99). However, novaluron 10 EC (1 ml/l) recorded the highest cost-benefit ratio of 1.89 among the biorationals. It was followed by cimetidine 3000 ppm (3 ml/l)

The current findings are consistent with Abhilash and Patil (2006) [1], who indicated that nimbecidine and NSKE had comparable grain yields among the eco-friendly treatments. According to Remya (2010), novaluron 10 EC (0.1 ml/l) had the greatest pod yield of 21.33 q/ha, which was comparable to emamectin benzoate 5 SG (0.2 g/l) (20.66 q/ha), spinosad 45 SC (0.1 ml/l) (19.89 q/ha), and flubendiamide 20 SC (0.2 g/l) (19.77 q/ha). Novaluron 10 EC had the highest cost-benefit ratio (1:2.67), followed by endosulfan 35 EC (1:2.64).

**Table 2:** Bio efficacy of different insecticides and biorationals against pink pod borer, *Cydia pythor* infesting soybean during Kharif-2021 (First spray)

| Treatments                  | Dosage (ml/l) | Number of larvae per plant |                             |                              |                              |                              | Mean | Percent reduction |
|-----------------------------|---------------|----------------------------|-----------------------------|------------------------------|------------------------------|------------------------------|------|-------------------|
|                             |               | DBS                        | 3 DAS                       | 7 DAS                        | 10 DAS                       | 14 DAS                       |      |                   |
| Chlorpyriphos 20 EC         | 2.00          | 4.03<br>(2.13)             | 3.67<br>(2.03) <sup>c</sup> | 2.38<br>(1.70) <sup>cd</sup> | 1.41<br>(1.38) <sup>bc</sup> | 2.85<br>(1.83) <sup>cd</sup> | 2.58 | 53.76             |
| Chlorantraniliprole 18.5 SC | 0.25          | 4.27<br>(2.18)             | 1.67<br>(1.47) <sup>e</sup> | 1.17<br>(1.29) <sup>f</sup>  | 0.20<br>(0.83) <sup>e</sup>  | 1.20<br>(1.30) <sup>e</sup>  | 1.06 | 81.01             |
| Indoxacarb 15.8 EC          | 0.66          | 4.67<br>(2.27)             | 2.07<br>(1.60) <sup>d</sup> | 1.53<br>(1.43) <sup>ef</sup> | 0.53<br>(1.02) <sup>de</sup> | 1.57<br>(1.43) <sup>e</sup>  | 1.43 | 74.49             |
| Profenophos 50 EC           | 2.00          | 4.08<br>(2.14)             | 2.47<br>(1.71) <sup>d</sup> | 1.92<br>(1.55) <sup>de</sup> | 1.01<br>(1.23) <sup>cd</sup> | 2.30<br>(1.67) <sup>d</sup>  | 1.92 | 65.50             |
| NSKE 5%                     | -             | 4.27<br>(2.18)             | 4.13<br>(2.15) <sup>b</sup> | 3.53<br>(2.00) <sup>b</sup>  | 1.97<br>(1.57) <sup>b</sup>  | 3.93<br>(2.10) <sup>b</sup>  | 3.39 | 39.09             |
| Azadirachtin 0.03%          | 5.00          | 3.80<br>(2.07)             | 3.47<br>(1.99) <sup>c</sup> | 2.93<br>(1.85) <sup>bc</sup> | 1.75<br>(1.48) <sup>b</sup>  | 3.35<br>(1.96) <sup>bc</sup> | 2.87 | 48.41             |
| Control                     | -             | 4.80<br>(2.30)             | 4.87<br>(2.32) <sup>a</sup> | 4.96<br>(2.34) <sup>a</sup>  | 5.09<br>(2.36) <sup>a</sup>  | 5.48<br>(2.44) <sup>a</sup>  | 5.10 | 0.00              |
| SEm.±                       |               | -                          | 0.08                        | 0.07                         | 0.08                         | 0.07                         | -    | -                 |
| CD @ 5%                     |               | NS                         | 0.24                        | 0.21                         | 0.24                         | 0.22                         | -    | -                 |
| CV (%)                      |               | 6.93                       | 7.31                        | 6.94                         | 9.72                         | 7.07                         | -    | -                 |

Note: DBS-Day Before Spray, DAS-Day After Spray; figures in parentheses are  $\sqrt{X} + 0.5$  transformed values; Means in the columns followed by the same alphabet do not differ significantly by DMRT (P=0.05)

**Table 3:** Bio efficacy of different insecticides and biorationals against pink pod borer, *Cydia ptychora* infesting soybean during *Kharif-2021* (Second spray)

| Treatments                  | Dosage (ml/l) | Number of larvae per plant   |                              |                             |                             |                             | Mean | Percent reduction |
|-----------------------------|---------------|------------------------------|------------------------------|-----------------------------|-----------------------------|-----------------------------|------|-------------------|
|                             |               | DBS                          | 3 DAS                        | 7 DAS                       | 10 DAS                      | 14 DAS                      |      |                   |
| Chlorpyrifos 20 EC          | 2.00          | 2.85<br>(1.83) <sup>cd</sup> | 2.60<br>(1.76) <sup>cd</sup> | 2.49<br>(1.73) <sup>c</sup> | 2.22<br>(1.65) <sup>c</sup> | 2.32<br>(1.68) <sup>c</sup> | 2.41 | 56.86             |
| Chlorantraniliprole 18.5 SC | 0.25          | 1.20<br>(1.30) <sup>e</sup>  | 1.15<br>(1.28) <sup>e</sup>  | 1.05<br>(1.24) <sup>d</sup> | 0.96<br>(1.21) <sup>d</sup> | 1.09<br>(1.26) <sup>d</sup> | 1.06 | 80.95             |
| Indoxacarb 15.8 EC          | 0.66          | 1.57<br>(1.43) <sup>e</sup>  | 1.49<br>(1.40) <sup>e</sup>  | 1.32<br>(1.34) <sup>d</sup> | 1.14<br>(1.28) <sup>d</sup> | 1.22<br>(1.31) <sup>d</sup> | 1.29 | 76.85             |
| Profenophos 50 EC           | 2.00          | 2.30<br>(1.67) <sup>d</sup>  | 2.14<br>(1.62) <sup>d</sup>  | 2.01<br>(1.58) <sup>c</sup> | 1.87<br>(1.53) <sup>c</sup> | 2.05<br>(1.59) <sup>c</sup> | 2.02 | 63.88             |
| NSKE 5%                     | -             | 3.93<br>(2.10) <sup>b</sup>  | 3.86<br>(2.09) <sup>b</sup>  | 3.75<br>(2.60) <sup>b</sup> | 3.64<br>(2.03) <sup>b</sup> | 3.85<br>(2.08) <sup>b</sup> | 3.77 | 32.42             |
| Azadirachtin 0.03%          | 5.00          | 3.35<br>(1.96) <sup>bc</sup> | 3.26<br>(1.94) <sup>bc</sup> | 3.25<br>(1.94) <sup>b</sup> | 3.18<br>(1.92) <sup>b</sup> | 3.28<br>(1.94) <sup>b</sup> | 3.24 | 41.93             |
| Control                     | -             | 5.48<br>(2.44) <sup>a</sup>  | 5.62<br>(2.49) <sup>a</sup>  | 6.00<br>(2.55) <sup>a</sup> | 6.17<br>(2.58) <sup>a</sup> | 6.12<br>(2.57) <sup>a</sup> | 5.58 | 0.00              |
| SEm.±                       |               | 0.07                         | 0.04                         | 0.24                        | 0.19                        | 0.20                        | -    | -                 |
| CD @ 5%                     |               | 0.22                         | 0.12                         | 0.74                        | 0.59                        | 0.62                        | -    | -                 |
| CV (%)                      |               | 7.07                         | 5.59                         | 10.57                       | 12.06                       | 12.13                       | -    | -                 |

Note: DBS-Day Before Spray, DAS-Day After Spray; figures in parentheses are  $\sqrt{X} + 0.5$  transformed values; Means in the columns followed by the same alphabet do not differ significantly by DMRT (P=0.05)

**Table 4:** Bio efficacy of different insecticides and biorationals against pod borer, *Etiella zinckenella* infesting soybean during *Kharif-2021* (First spray)

| Treatments                  | Dosage (ml/l) | Number of larvae per plant |                              |                             |                             |                             | Mean | Percent reduction |
|-----------------------------|---------------|----------------------------|------------------------------|-----------------------------|-----------------------------|-----------------------------|------|-------------------|
|                             |               | DBS                        | 3 DAS                        | 7 DAS                       | 10 DAS                      | 14 DAS                      |      |                   |
| Chlorpyrifos 20 EC          | 2.00          | 2.42<br>(1.70)             | 2.34<br>(1.68) <sup>cd</sup> | 1.78<br>(1.50) <sup>c</sup> | 1.78<br>(1.50) <sup>c</sup> | 2.51<br>(1.73) <sup>c</sup> | 2.10 | 64.03             |
| Chlorantraniliprole 18.5 SC | 0.25          | 2.83<br>(1.83)             | 1.17<br>(1.29) <sup>e</sup>  | 1.07<br>(1.25) <sup>d</sup> | 0.95<br>(1.20) <sup>d</sup> | 1.06<br>(1.23) <sup>d</sup> | 1.06 | 81.81             |
| Indoxacarb 15.8 EC          | 0.66          | 2.92<br>(1.85)             | 1.21<br>(1.29) <sup>e</sup>  | 1.09<br>(1.26) <sup>d</sup> | 1.05<br>(1.24) <sup>d</sup> | 1.99<br>(1.58) <sup>d</sup> | 1.34 | 77.05             |
| Profenophos 50 EC           | 2.00          | 2.93<br>(1.85)             | 2.18<br>(1.63) <sup>d</sup>  | 1.61<br>(1.45) <sup>c</sup> | 1.09<br>(1.26) <sup>c</sup> | 2.09<br>(1.61) <sup>c</sup> | 1.74 | 70.16             |
| NSKE 5%                     | -             | 2.81<br>(1.81)             | 2.58<br>(1.75) <sup>b</sup>  | 2.16<br>(1.63) <sup>b</sup> | 2.24<br>(1.66) <sup>b</sup> | 3.19<br>(1.92) <sup>b</sup> | 2.54 | 56.48             |
| Azadirachtin 0.03%          | 5.00          | 2.90<br>(1.84)             | 2.74<br>(1.80) <sup>bc</sup> | 2.14<br>(1.62) <sup>b</sup> | 2.15<br>(1.63) <sup>b</sup> | 2.76<br>(1.80) <sup>b</sup> | 2.45 | 58.05             |
| Control                     | -             | 2.93<br>(1.85)             | 4.99<br>(2.34) <sup>a</sup>  | 5.84<br>(2.52) <sup>a</sup> | 5.98<br>(2.54) <sup>a</sup> | 6.54<br>(2.65) <sup>a</sup> | 5.84 | 0.00              |
| SEm.±                       |               |                            | 0.06                         | 0.06                        | 0.04                        | 0.08                        | -    | -                 |
| CD @ 5%                     |               | NS                         | 0.20                         | 0.19                        | 0.135                       | 0.247                       | -    | -                 |
| CV (%)                      |               | 6.09                       | 6.77                         | 6.70                        | 9.96                        | 7.75                        | -    | -                 |

Note: DBS-Day Before Spray, DAS-Day After Spray; figures in parentheses are  $\sqrt{X} + 0.5$  transformed values; Means in the columns followed by the same alphabet do not differ significantly by DMRT (P=0.05)

**Table 5:** Bio efficacy of different insecticides and biorationals against pod borer, *Etiella zinckenella* infesting soybean during *Kharif-2021* (second spray)

| Treatments                  | Dosage (ml/l) | Number of larvae per plant   |                              |                               |                              |                              | Mean | Percent reduction |
|-----------------------------|---------------|------------------------------|------------------------------|-------------------------------|------------------------------|------------------------------|------|-------------------|
|                             |               | DBS                          | 3 DAS                        | 7 DAS                         | 10 DAS                       | 14 DAS                       |      |                   |
| Chlorpyrifos 20 EC          | 2.00          | 2.51<br>(1.73) <sup>bc</sup> | 1.84<br>(1.51) <sup>b</sup>  | 1.79<br>(1.50) <sup>bc</sup>  | 1.58<br>(1.43) <sup>b</sup>  | 1.69<br>(1.47) <sup>b</sup>  | 1.73 | 74.07             |
| Chlorantraniliprole 18.5 SC | 0.25          | 1.06<br>(1.23) <sup>d</sup>  | 0.77<br>(1.11) <sup>c</sup>  | 0.84<br>(1.13) <sup>d</sup>   | 0.53<br>(0.99) <sup>c</sup>  | 0.64<br>(1.04) <sup>c</sup>  | 0.70 | 89.54             |
| Indoxacarb 15.8 EC          | 0.66          | 1.99<br>(1.58) <sup>c</sup>  | 1.43<br>(1.38) <sup>bc</sup> | 1.28<br>(1.33) <sup>cd</sup>  | 1.09<br>(1.25) <sup>bc</sup> | 1.16<br>(1.28) <sup>bc</sup> | 1.24 | 81.34             |
| Profenophos 50 EC           | 2.00          | 2.09<br>(1.61) <sup>c</sup>  | 1.70<br>(1.48) <sup>b</sup>  | 1.52<br>(1.41) <sup>bcd</sup> | 1.03<br>(1.23) <sup>bc</sup> | 1.62<br>(1.44) <sup>b</sup>  | 1.47 | 77.94             |
| NSKE 5%                     | -             | 2.76<br>(1.80) <sup>bc</sup> | 2.30<br>(1.67) <sup>b</sup>  | 2.20<br>(1.64) <sup>b</sup>   | 1.87<br>(1.53) <sup>b</sup>  | 1.90<br>(1.54) <sup>b</sup>  | 2.07 | 68.87             |
| Azadirachtin 0.03%          | 5.00          | 3.19<br>(1.92) <sup>b</sup>  | 2.16<br>(1.63) <sup>b</sup>  | 2.06<br>(1.60) <sup>bc</sup>  | 1.43<br>(1.38) <sup>b</sup>  | 1.91<br>(1.55) <sup>b</sup>  | 1.89 | 71.61             |
| Control                     | -             | 6.54<br>(2.65) <sup>a</sup>  | 6.59<br>(2.66) <sup>a</sup>  | 6.63<br>(2.67) <sup>a</sup>   | 6.70<br>(2.68) <sup>a</sup>  | 6.69<br>(2.68) <sup>a</sup>  | 6.65 | 0.00              |
| SEm.±                       |               | 0.08                         | 0.10                         | 0.13                          | 0.10                         | 0.09                         | -    | -                 |
| CD @ 5%                     |               | 0.24                         | 0.31                         | 0.39                          | 0.31                         | 0.29                         | -    | -                 |
| CV (%)                      |               | 7.70                         | 10.8                         | 10.76                         | 11.74                        | 10.39                        | -    | -                 |

Note: DBS-Day Before Spray, DAS-Day After Spray; figures in parentheses are  $\sqrt{X} + 0.5$  transformed values; Means in the columns followed by the same alphabet do not differ significantly by DMRT (P=0.05)

**Table 6:** Cost benefit ratio of different insecticides and biorationals against pod borer complex of soybean

| Treatments                  | Dosage (ml/l) | Seed yield (kg/ha) | Cost of crop Protection (Rs/ha) | Cost of cultivation (Rs/ha) | Total cost of Cultivation (Rs/ha) | Gross income (Rs/ha) | Net returns (Rs/ha) | C:B ratio |
|-----------------------------|---------------|--------------------|---------------------------------|-----------------------------|-----------------------------------|----------------------|---------------------|-----------|
| Chlorpyrifos 20 EC          | 2.00          | 1801               | 1720                            | 29737                       | 31457                             | 90050                | 585930              | 1:2.86    |
| Chlorantraniliprole 18.5 SC | 0.25          | 2389               | 4646                            | 29737                       | 34383                             | 119450               | 85067               | 1:3.47    |
| Indoxacarb 15.8 EC          | 0.66          | 2119               | 3276                            | 29737                       | 33013                             | 105950               | 72937               | 1:3.20    |
| Profenofos 50 EC            | 2.00          | 1987               | 2820                            | 29737                       | 32557                             | 99350                | 66793               | 1:3.05    |
| NSKE 5%                     | -             | 1643               | 2000                            | 29737                       | 31737                             | 82150                | 50413               | 1:2.58    |
| Azadirachtin 0.03%          | 5.00          | 1786               | 3100                            | 29737                       | 32837                             | 89350                | 56513               | 1:2.72    |
| Control                     |               | 1136               | -                               | 29737                       | 29737                             | 56800                | 27063               | 1:1.91    |

Note: Market price of soybean – Rs. 50 Kg

Cost of cultivation – Rs. 29737/ha (Excluding plant protection cost)

(Chlorpyrifos 20 EC 500 ml – 240, Chlorantraniliprole 18.5 SC 60 ml-750, Indoxacarb 15.8 EC 100 ml-460, Profenofos 50 EC 500 ml-525 Neem seeds 1 kg-100, Azadirachtin 0.03% 500 ml-300)

## Conclusion

The spraying of chlorantraniliprole 18.5 SC @ 0.25 ml/liter at 60 and 75 days after sowing effectively reduced pink pod borer in soybean with a highest grain yield and C: B ratio.

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