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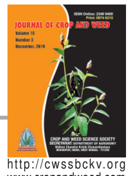

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# Seasonal incidence and management of Epilachna Beetle (*Henosepilachna vigintioctopunctata* Fab.) infesting potato in the plains of West Bengal

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## ABSTRACT

*A two-year field study was conducted during rabi season of 2016-17 and 2017-18 to investigate the seasonal incidence and management of epilachna beetles infesting potato. During the entire crop growth period, different meteorological data were observed and recorded.Various insecticides viz. Chlorantraniliprole 18.5% SC, Indoxacarb14.5% SC, Novaluron 10% EC, Imidacloprid 17.8% SL, Spinosad 2.5% SC, Flonicamid 50% WG and Spinetoram 11.7% SC were evaluated for best pesticidal management. First appearance of this beetle was observed during the 52 standard meterological week (last week of December) in both the years and the beetle was active till the maturity of the crop. Thereafter, the density of beetle increased steadily and reached to a peak in 7$^{th}$ SMW in 2017 and 8$^{th}$SMW in 2018 (February month) and then decreased. Among the various environmental factors, the population of epilachna beetle was positively correlated with maximum and average temperature and a negative correlation was found with relative humidity. The efficacy of Chlorantraniliprole 18.5% SC@30gm a.i.ha$^{-1}$(72-76%)was highest followed by Indoxacarb 14.5% SC@60gm a.i.ha$^{-1}$(62-71%)*

***Keywords:*** Bioefficacy, epilachna beetle, natural enemies, potato, seasonal incidence

Potato, *Solanum tuberosum* Linn. is an important starchy cash crop and can be successfully grown in sub-tropical and temperate regions.Under a single vegetable crop, potato occupies the largest area and yield more food per unit area than any cereals within a short span of time. Insect pests are major biotic factors affecting potato yield and tuber quality.Potato is attacked by wide range of insect pests due to its global geographical distribution (Kroschel *et al.,* 2020). Among these, *Henosepilachna vigintioctopuntata* Fab. (Coccinellidae: Coleoptera) is an important pest causing serious damage to potato. Though epilachna beetle is a serious pest of brinjal it also infests potato and cause serious damage (Ghosh and Chakraborty, 2012). The adults and grubs feed on the leaves and skeletonize them. Yield losses can be estimated up to 10-15% in normal years but in severe condition, the crop yield gets substantially reduced to 20-30% (Song *et al.,* 2008). Some time in severe condition complete destruction is also possible (Jackson, 2016). Thus, epilachna beetle may act as one of the limiting factor in the higher production of potato tubers, mainly in late planting potato crop (Konar and Mohasin, 2002).

Seasonal occurrence of any insect is an important phenomena of pest management to know the population pressure of the particular insect and its potential to damage the crop. Clear understanding about population fluctuation of the pest depending upon the biotic and abiotic factors is necessary for development of proper management guide.

The role of insecticides in pest management programs against various insect pests cannot be ignored totally. The newer insecticide molecules presently available have several advantages over conventional insecticides like high selectivity to target pests, excellent efficacy at low rates or dosage, cause less harm to natural enemies and environment (Kodandaram *et al*., 2010). Field experiment was conducted during *rabi* season of 2016-17 and 2017-18 at C-unit Research Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal, India to study the seasonal incidence and management of epilachna beetles infesting potato.

## MATERIALS AND METHODS

The present experiment was conducted at C-Unit Research Farm (Kalyani) of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal for consecutive two *rabi* seasons of 2016-17 and 2017-18 to study the seasonal incidence and management of epilachna beetle [*Henosepilachna vigintioctopunctata* (F.)] infesting potato. The crop was grown by following standard agronomic package of practice. During final land preparation well rotten farm yard manure (FYM) was applied in the field @ 5 t ha$^{-1}$ along with the recommended dose of fertilizer @ 200:150:150 kg N: P: K ha$^{[-1]}$. Half dose of nitrogen, full dose of phosphate and full dose of potash were applied as basal just before planting and rest of nitrogen were applied after one month of planting at the time of earthing up. The seasonal incidence study of epilachna beetle was

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conducted by planting Kufri Jyoti variety in 6 nos. of plots with a plot size of 5m × 6m each. Ridges were made at 60 cm apart with a height of 15 cm. The seed tubers were planted maintaining a 60 cm row to row and 20 cm plant to plant spacing. Observations were recorded at weekly interval. The population of epilachna beetle was recorded by counting the grub and adult from each plant through visual count. Five plants were selected from each plot at random. The data were taken from randomly selected thirty plants and subsequently demarcated at the plot from December to March 2016-17 and 2017-18. Meteorological data was recorded throughout the crop growth period to work out the correlation between weather parameters and insect density.For bio-efficacy study the experiment was conducted in a Randomized Block Design (RBD) with 3 replications and 8 treatments in plot size of 3m x 3m. Some new generation insecticides *viz.* Chlorantraniliprole 18.5% SC(Coragen)@ 30gm a.i.ha$^{-1}$, Indoxacarb14.5% SC(Indocab)@60gm a.i.ha$^{-1}$, Novaluron 10% EC (Rimon)@75gm a.i.ha$^{-1}$, Imidacloprid 17.8% SL (Confidor)@30gm a.i.ha$^{-1}$,Spinosad 2.5% SC (Tracer)@17.5gm a.i.ha$^{-1}$,Flonicamid 50% WG (Ulala)@75gm a.i.ha$^{-1}$, Spinetoram 11.7% SC (Delegate)@60gm a.i.ha$^{-1}$ and control were considered in eight different treatments replicated three times.Two sprays at 10 days interval were done during both the crop season of 2016-17 and 2017-18 by using 500 liters of spray volume per hectare with high volume knapsack sprayer.The data of target pests were recorded from randomly selected five plants in each treatment. Observations of total number of epilachna beetles were recorded per plant per plot. First count was taken one day before first spray and post treatment counts were recorded on 1, 3, 5,7 and 10 days after the sprays. The data collected on insects count before and after the application of various insecticides at different doses were statistically analyzed after making necessary transformation to work out the corrected percent mortality over control using combination of Abbott's formula (1987). The correlation study and necessary transformation was done by using OPSTAT software.

$$\frac{x-y}{y}\times 100 = Corrected\,\%$$

Where, $x$ = % survival in the control plot (concentration of pesticide is = 0), y = % survival in the insecticide treated plot.

## RESULTS AND DISCUSSION

### *Seasonal incidence of epilachna beetle on potato*

The results in Table1 and 2 revealed that the population of epilachna beetle (grubs and adults) was ranged from 0.66 to 9.11 and 1.33 to 7.66 per plant in season I season II with seasonal mean of 3.35 and 3.17 respectively. It was first appeared on the crop during the 52$^{nd}$ standard meteorological week (SMW) in both the years and active till the maturity of the crop. The density of the beetle increased steadily and reached to a peak of 9.11 grub and adults per plant in 7$^{th}$ SMW during 2016-17when maximum and minimum temperature were 30.49$^0$C and 15.73$^0$C and morning and evening relative humidity were 89.9% and 44.4% respectively. In the next year *i.e* during 2017-18 the pest population reached its peak of 7.66 per plant in 8$^{th}$ SMW when maximum and minimum temperature were 33.39$^0$C and 17.64$^0$C and morning and evening relative humidity were 91.3% and 44.4% respectively. After that the population of the beetle started declining with the maturity of the crop. The present findings are in agreement with Roy (1999) who observed that the adult epilachna beetle and grub was first recorded on 3$^{rd}$ and 4$^{th}$ week of December during the year 1996 and 1997 respectively. The maximum population (both adult and grub) of this beetle was found during second fortnight of February. Anandhi and Varma (2008) revealed that in brinjal the incidence of epilachna beetle was first noticed from the 20$^{th}$ week after transplanting (3$^{rd}$ week of January) with an average population 0.27 epilachna beetle per plant and reached the peak in the 3$^{rd}$ week of February in 2004-05.

### *Impact of abiotic factors on incidence of epilachna beetle*

The result obtained from the correlation studies has been presented in Table 3 and 4. The results revealed that the population of epilachna beetle had a significant positive correlation with maximum ($r = 0.729$, $p \le 0.01$) and average ($r = 0.607$, $p \le 0.05$) temperature and significant negative correlation with the morning relative humidity ($r = -0.780$, $p \le 0.01$), evening relative humidity ($r = -0.752 \le 0.05$) and average relative humidity ($r = -0.776$, $p \le 0.01$) during season I (Fig. 1). Among the different abiotic stresses, it was noticed that the maximum temperature was the most influencing factor for the population build up of this beetle with high regression coefficient ($R^2 = 0.5997$) followed by morning, average and evening relative humidity. Similarly in season II, the population of epilachna beetle had a significant positive correlation with maximum temperature ($r = 0.633$, $p \le 0.05$) and significant negative correlation with the morning ($r = -0.655$, $p \le 0.05$), evening ($r = -0.806$, $p \le 0.01$) and average ($r = -0.822$, $p \le 0.01$) relative humidity (Fig.2). Unlike season-I, the evening relative humidity was the most influencing factor with the highest regression coefficient value ($R^2 = 0.7844$) on the population of epilachna beetle followed by average and morning relative humidity.

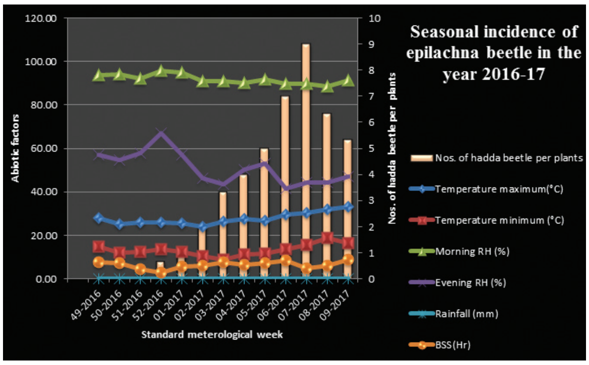


**Fig. 1: Effect of different weather factors on the population dynamics of epilachna beetle during *rabi* season of 2016-17**

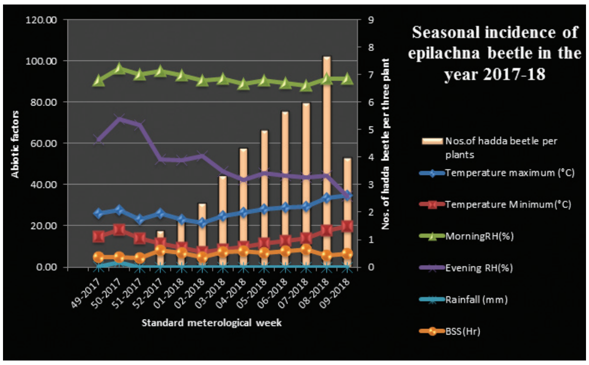


**Fig. 2: Effect of different weather factors on the population dynamics of epilachna beetle during *rabi* season of 2017-18**

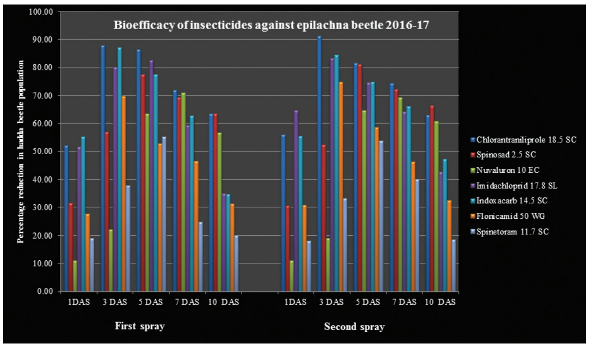


**Fig. 3: Bio-efficacy of insecticides against epilachna beetle in 2016-17**

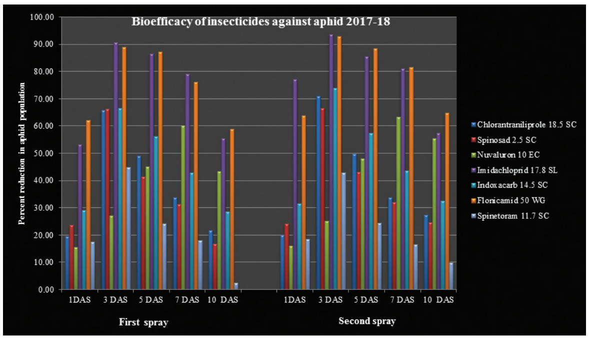


**Fig. 4: Bio-efficacy of insecticides against epilachna beetle in 2017-18**

**Table 1: Influence of various abiotic factors on the population dynamics of epilachna beetle in the year 2016-17.**

| Standard Met. Week | Temperature (°C) | | Relative humidity (%) | | Rainfall (mm) | Sunshine (Hours) | No. of epilachna beetle per plant |
|---|---|---|---|---|---|---|---|
| | Maximum | Minimum | Morning | Evening | | | |
| 49-2016 | 27.80 | 14.97 | 93.7 | 57.0 | 0 | 7.67 | 0.00 |
| 50-2016 | 25.30 | 11.80 | 94.1 | 54.7 | 0 | 7.30 | 0.00 |
| 51-2016 | 25.93 | 12.43 | 92.0 | 57.9 | 0 | 4.59 | 0.00 |
| 52-2016 | 25.93 | 13.41 | 95.9 | 67.0 | 0 | 2.89 | 0.67 |
| 01-2017 | 25.70 | 12.41 | 94.9 | 57.1 | 0 | 5.50 | 1.00 |
| 02-2017 | 24.13 | 10.50 | 91.0 | 46.4 | 0 | 5.94 | 2.00 |
| 03-2017 | 26.29 | 8.80 | 91.0 | 43.3 | 0 | 7.67 | 3.33 |
| 04-2017 | 27.66 | 11.31 | 90.0 | 50.4 | 0 | 6.59 | 4.28 |
| 05-2017 | 26.90 | 11.79 | 91.7 | 53.0 | 0 | 7.14 | 5.00 |
| 06-2017 | 29.64 | 13.43 | 89.6 | 41.4 | 0 | 8.36 | 7.00 |
| 07-2017 | 30.49 | 15.74 | 89.9 | 44.4 | 0 | 4.70 | 9.11 |
| 08-2017 | 31.86 | 18.59 | 88.6 | 44.3 | 0 | 5.87 | 6.33 |
| 09-2017 | 33.27 | 16.50 | 91.3 | 47.0 | 0 | 8.80 | 5.33 |
| 10-2017 | 34.07 | 18.27 | 90.4 | 46.7 | 0 | 8.57 | 0 |

**Table 2: Influence of various abiotic factors on the population dynamics of epilachna beetle in the year 2017-18**

| Standard Met. Week | Temperature (°C) | | Relative humidity (%) | | Rainfall (mm) | Sunshine (Hours) | No. of epilachna beetle per plant |
|---|---|---|---|---|---|---|---|
| | Maximum | Minimum | Morning | Evening | | | |
| 49-2017 | 25.97 | 14.86 | 90.4 | 62.0 | 0.37 | 4.73 | 0.00 |
| 50-2017 | 27.62 | 17.98 | 96.3 | 71.8 | 2.13 | 5.00 | 0.00 |
| 51-2017 | 22.98 | 13.85 | 93.7 | 68.8 | 0 | 4.22 | 0.00 |
| 52-2017 | 26.04 | 11.57 | 95.1 | 52.3 | 0 | 8.04 | 1.33 |
| 01-2018 | 23.26 | 9.34 | 93.3 | 51.9 | 0 | 6.90 | 1.67 |
| 02-2018 | 21.47 | 7.34 | 90.6 | 53.9 | 0 | 4.93 | 2.33 |
| 03-2018 | 24.97 | 8.54 | 91.3 | 46.4 | 0 | 7.09 | 3.33 |
| 04-2018 | 26.40 | 9.76 | 89.1 | 42.1 | 0 | 7.84 | 4.17 |
| 05-2018 | 28.29 | 11.29 | 90.7 | 45.4 | 0 | 6.83 | 5.11 |
| 06-2018 | 28.85 | 12.63 | 89.4 | 44.4 | 0 | 7.62 | 5.67 |
| 07-2018 | 29.41 | 13.96 | 88.1 | 43.4 | 0 | 8.40 | 6.00 |
| 08-2018 | 33.39 | 17.64 | 91.3 | 44.4 | 0 | 5.70 | 7.67 |
| 09-2018 | 34.77 | 19.90 | 91.4 | 34.6 | 0 | 6.31 | 4.00 |
| 10-2018 | 34.56 | 18.67 | 90.6 | 39.5 | 0 | 7.42 | 0 |

**Table 3: Correlation between epilachna beetle and weather parameters in the year 2016-17**

| Environmental factors | | Correlation co-efficient (r) | Co-efficient of determination ($R^2$) | Regression equation |
|---|---|---|---|---|
| **Temperature (°C)** | **Maximum** | 0.729** | $R^2 = 0.5997$ | y = 0.5635x + 22.329 |
| | **Minimum** | 0.421 | $R^2 = 0.1993$ | y = 0.2989x + 10.547 |
| | **Average** | 0.607* | $R^2 = 0.4207$ | y = 0.4321x + 16.033 |
| **Relative Humidity (%)** | **Morning** | (-) 0.780** | $R^2 = 0.5608$ | y = -0.4251x + 94.998 |
| | **Evening** | (-) 0.752** | $R^2 = 0.5015$ | y = -1.3538x + 62.017 |
| | **Average** | (-) 0.776** | $R^2 = 0.5339$ | y = -0.8798x + 78.617 |
| **Bright sunshine hour (hr)** | **Duration** | 0.213 | $R^2 = 0.0703$ | y = 0.1092x + 6.089 |

*Note: *Significant at 5% level of significance.**Significant at 1% level of significance*

**Table 4: Correlation between epilachna beetle and weather parameters in the year 2017-18**

| Environmental factors | | Correlation co-efficient (r) | Co-efficient of determination ($R^2$) | Regression equation |
|---|---|---|---|---|
| **Temperature (°C)** | **Maximum** | 0.633* | $R^2 = 0.5365$ | y = 0.7216x + 21.547 |
| | **Minimum** | 0.079 | $R^2 = 0.0513$ | y = 0.2093x + 10.983 |
| | **Average** | 0.378 | $R^2 = 0.2578$ | y = 0.516x + 15.969 |
| **Relative Humidity (%)** | **Morning** | (-) 0.655* | $R^2 = 0.5618$ | y = -0.3764x + 95.064 |
| | **Evening** | (-) 0.806** | $R^2 = 0.7844$ | y = -2.3997x + 71.028 |
| | **Average** | (-) 0.822** | $R^2 = 0.7698$ | y = -1.5213x + 81.992 |
| **Bright sunshine hour (hr)** | **Duration** | 0.525 | $R^2 = 0.2488$ | y = 0.1687x + 4.9587 |

*Note: *Significant at 5% level of significance.**Significant at 1% level of significance.*

From the result it was evident that there was a negative correlation between the pest population and the relative humidity in both the season which indicates that increase in morning, evening and average relative humidity was detrimental to this beetle population.

Similar kind of observations were recorded by Putta Raju in 2008 on brinjal crop which revealed that epilachna beetle was noticed during 3rd and 4th weeks of December and showed positive correlation with maximum temperature. Kalaiyarasi *et al.* (2017) also revealed that the different life stages of epilachna beetle were positively correlated with temperature (minimum, maximum and mean) and negatively

**Table 5: Bio-efficacy of various insecticides against epilachna beetle infesting potato during *rabi*, 2016-17**

| Treatment | Chemicals | Dosage (g a.i.ha$^{-1}$) | Pretreatment population plant$^{-1}$ | Reduction in the epilachna beetle (adult and grub) population after 1st round spray (%) | | | | | | Reduction in the epilachna beetle (adult and grub) population after 2nd round spray (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 DAS | 3 DAS | 5 DAS | 7 DAS | 10 DAS | Mean reduction (%) | 1 DAS | 3 DAS | 5 DAS | 7 DAS | 10 DAS | Mean reduction (%) |
| $T_1$ | Chlorantraniliprole 18.5 SC | 30 | 10.13 | 52.05 (46.15) | 87.98 (69.68) | 86.37 (68.29) | 71.98 (58.05) | 63.37 (52.74)* | 72.35 (58.28) | 55.91 (48.45) | 91.23 (72.90) | 81.57 (64.59) | 74.32 (59.73) | 63.07 (52.51) | 73.22 (58.83) |
| $T_2$ | Spinosad2.5 SC | 17.5 | 9.67 | 31.64 (34.29) | 56.84 (48.92) | 77.44 (61.47) | 69.18 (56.24) | 63.39 (52.75) | 59.70 (50.59) | 30.55 (33.54) | 52.44 (46.56) | 81.49 (64.47) | 72.15 (58.39) | 66.36 (54.47) | 60.53 (51.08) |
| $T_3$ | Nuvaluron10 EC | 75 | 9.47 | 11.11 (19.54) | 22.23 (28.45) | 63.37 (52.90) | 70.94 (56.74) | 56.58 (48.10) | 44.85 (42.04) | 11.10 (19.35) | 18.92 (26.01) | 61.25 (53.52) | 69.26 (56.46) | 60.70 (51.26) | 44.91 (42.08) |
| $T_4$ | Imidachloprid17.8 SL | 30 | 7.33 | 51.62 (45.90) | 80.06 (63.35) | 82.66 (65.50) | 59.29 (50.34) | 34.99 (36.29) | 61.72 (51.78) | 64.57 (53.47) | 83.19 (65.83) | 74.48 (59.64) | 64.13 (53.32) | 42.59 (40.92) | 65.80 (54.21) |
| $T_5$ | Indoxacarb14.5 SC | 60 | 9.20 | 55.23 (48.06) | 87.16 (68.97) | 77.47 (61.63) | 62.82 (52.32) | 34.62 (35.98) | 63.46 (52.81) | 55.40 (47.92) | 84.53 (66.84) | 74.81 (59.97) | 66.08 (54.42) | 47.26 (43.31) | 65.62 (54.10) |
| $T_6$ | Flonicamid50 WG | 75 | 10.27 | 27.79 (31.69) | 69.65 (56.65) | 52.82 (46.64) | 46.53 (43.07) | 31.29 (34.05) | 45.62 (42.48) | 30.94 (33.79) | 74.80 (59.78) | 58.65 (49.99) | 46.31 (43.04) | 32.42 (34.64) | 48.62 (44.21) |
| $T_7$ | Spinetoram11.7 SC | 60 | 8.73 | 18.95 (25.77) | 37.81 (37.91) | 55.23 (47.96) | 24.81 (29.83) | 20.00 (26.44) | 31.36 (34.06) | 18.10 (250.4) | 33.19 (35.45) | 47.31 (47.13) | 39.93 (39.18) | 18.44 (25.51) | 32.69 (34.87) |
| $T_8$ | Control | | 9.53 | 0.00 (4.05) | 0.00 (4.05) | 0.00 (4.05) | 0.00 (4.05) | 0.00 (4.05) | | 0.00 (4.05) | 0.00 (4.05) | 0.00 (4.05) | 0.00 (4.05) | 0.00 (4.05) | |
| **LSD (0.05)** | — | — | **NS** | **2.085** | **1.50** | **1.686** | **2.142** | **2.328** | **—** | **1.747** | **2.133** | **2.875** | **2.291** | **2.409** | **—** |
| **SEm(±)** | — | — | **—** | **0.687** | **0.551** | **0.556** | **0.706** | **0.768** | **—** | **0.576** | **0.703** | **0.948** | **0.755** | **0.794** | **—** |

*Values in the parentheses are angular transformed, DAS: Day(s) after spray, NS: Non-significant.

**Table 6: Bio-efficacy of Different insecticides against epilachna beetle infesting potato during rabi, 2017-18**

| Treatment | Chemicals | Dosage (g a.i. ha$^{-1}$) | Pretreatment population plant$^{-1}$ | Reduction in the epilachna beetle (adult and grub) population after 1st round spray (%) 1 DAS | 3 DAS | 5 DAS | 7 DAS | 10 DAS | Mean reduction (%) | Reduction in the epilachna beetle (adult and grub) population after 2nd round spray (%) 1 DAS | 3 DAS | 5 DAS | 7 DAS | 10 DAS | Mean reduction (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | Chlorantraniliprole 18.5 SC | 30 | 9.27 | 54.32 (47.50) | 90.45 (71.88) | 87.92 (69.61) | 72.30 (58.29) | 55.95 (48.31) | 72.19 (59.14) | 64.32 (53.30) | 93.11 (75.13) | 90.58 (71.58) | 67.67 (55.40) | 66.22 (54.25) | 76.38 (60.92) |
| $T_2$ | Spinosad 2.5 SC | 17.5 | 6.93 | 31.65 (34.21) | 55.53 (48.17) | 75.68 (60.16) | 65.11 (53.74) | 58.94 (50.09) | 57.38 (49.34) | 31.52 (34.09) | 51.27 (45.77) | 82.65 (65.93) | 73.55 (59.36) | 69.09 (56.11) | 61.61 (51.72) |
| $T_3$ | Nuvaluron10 EC | 75 | 7.93 | 11.19 (19.61) | 19.96 (26.89) | 61.45 (51.63) | 72.35 (58.01) | 49.15 (44.37) | 42.82 (40.08) | 11.25 (19.61) | 14.32 (22.10) | 66.11 (54.44) | 70.89 (57.35) | 63.33 (52.63) | 45.18 (42.23) |
| $T_4$ | Imidachloprid 17.8 SL | 30 | 8.00 | 54.63 (47.58) | 86.68 (68.64) | 78.39 (62.07) | 62.01 (51.79) | 35.94 (36.77) | 63.53 (53.45) | 66.38 (54.68) | 91.55 (73.10) | 80.75 (64.03) | 68.97 (56.21) | 46.07 (42.61) | 70.74 (57.25) |
| $T_5$ | Indoxacarb14.5 SC | 60 | 7.53 | 53.89 (47.23) | 86.66 (68.60) | 76.43 (60.93) | 60.02 (50.74) | 33.69 (35.19) | 62.14 (52.58) | 55.12 (47.73) | 90.45 (71.96) | 83.90 (66.45) | 74.30 (59.38) | 52.32 (46.26) | 71.22 (57.55) |
| $T_6$ | Flonicamid50 WG | 75 | 8.67 | 34.22 (35.83) | 62.77 (52.23) | 54.57 (47.58) | 38.15 (38.06) | 35.40 (36.44) | 45.02 (42.08) | 42.34 (40.59) | 67.92 (55.49) | 56.63 (48.66) | 41.51 (40.00) | 33.98 (35.57) | 48.48 (44.13) |
| $T_7$ | Spinetoram11.7 SC | 60 | 7.73 | 18.83 (25.70) | 35.97 (36.88) | 52.65 (46.52) | 33.65 (35.40) | 11.68 (19.86) | 30.56 (32.89) | 18.06 (25.23) | 29.19 (32.49) | 51.93 (46.21) | 40.04 (39.34) | 26.72 (30.96) | 33.19 (35.18) |
| $T_8$ | Control | — | 9.13 | 0.00 (4.05) | 0.00 (4.05) | 0.00 (4.05) | 0.00 (4.05) | 0.00 (4.05) | | 0.00 (4.05) | 0.00 (4.05) | 0.00 (4.05) | 0.00 (4.05) | 0.00 (4.05) | |
| **LSD(0.05)** | — | — | **NS** | **1.912** | **2.085** | **2.076** | **2.154** | **2.198** | **—** | **2.070** | **1.491** | **2.170** | **1.648** | **1.714** | — |
| **SEm(±)** | — | — | — | **0.624** | **0.681** | **0.678** | **0.703** | **0.718** | **—** | **0.681** | **0.490** | **0.711** | **0.543** | **0.565** | **—** |

*Values in the parentheses are angular transformed, DAS: Day(s) after spray, NS: Non-significant.

correlated with relative humidity (morning, evening and mean).

***Evaluation of some new generation insecticides against epilachna beetle under field condition***

The bio-efficacy of some new generation insecticide molecules were evaluated against epilachna beetle infesting potato and the result has been depicted in Table 5 and Table 6. After first round spray in season I there was percent reduction in epilachna beetle population ranged between 11.11% and 87.98% compared to that of control plot. Highest percentage of reduction in population of epilachna beetle was seen in the plot treated with chlorantraniliprole 18.5% SC ($T_1$) @ 30gm a.i.ha.$^{-1}$ with 87.98% population reduction after 3days of the spray. Overall efficacy of chlorantraniliprole 18.5% SC was highest with 72.35% mean reduction in this beetle population followed by Indoxacarb14.5% SC@60 gm a.i.ha.$^{-1}$ ($T_5$) to the tune of 63.46% reduction though it was statistically at par with that of imidacloprid 17.8 SL@30gm a.i.ha.$^{-1}$at 7days after spray. Among the other treatments spinosad 2.5% SC @ 17.5 gm ai.ha$^{1}$, flonicamid 50% WG @ 75 gm a.i.ha$^{1}$, novaluron 10% EC @ 75 gm a.i.ha$^{1}$gave considerable control to the tune of almost 45% to 60%. Spinetoram 11.7% SC @60gm a.i.ha.$^{-1}$ was found least effective against epilachna beetle with overall efficacy of 31.36% reduction in the population. Like the first spray in second spray also Chlorantraniliprole 18.5% SC was found most effective in reducing the beetle population accounting for 91.23% mean reduction. Indoxacarb 14.5% SC @ 60 g a.i.ha$^{-1}$ was next to follow, which was statistically at par with imidacloprid 17.8 SL after 3 days of spraying. Spinetoram 11.7% SC was found least effective against epilachna beetle.

Similarly in 2017-18 chlorantraniliprole 18.5% SC was found most effective with overall efficacy of 72.19% and 76.38% and spinetoram 11.7% SC was found least effective with 30.56% and 26.72% reduction in epilachna beetle population after first round and second round spray respectively. Indoxacarb14.5% SC and imidacloprid 17.8 SL were next to follow chlorantraniliprole 18.5% SC but here also, like the previous year, these two treatments were statistically at par with each other at 3 days after spray in both the round. Among other treatments spinosad 2.5% SC rendered satisfactory result with overall efficacy of 57.38% and 61.61% after first round and second round spray respectively followed by flonicamid 50 WG and novaluron 10% EC.These results are in agreement with Kodandaram *et al.* (2014) who found that chlorantraniliprole 18.5 SC @ 150 g a.i.ha$^{-1}$ was most effective against eggs of epilachna beetle with lowest per cent hatching. Further, they also found that against grubs, chlorantraniliprole 18.5 SC @ 250 g a.i.ha$^{-1}$ and indoxacarb 14.5 SC @ 50 g a.i.ha$^{-1}$ registered 65, 63.3 per cent mortality respectively. Mahato (2017) concluded that chlorantraniliprole 18.5 % SC @ 30.83 g a.i.ha$^{-1}$ was proved superior in suppressing epilachna beetle population by 75.86 to 84.53% over control during *kharif*, 2016 and *rabi*, 2016- 17.

## CONCLUSION

The population of epilachna beetle was influenced with abiotic factors like temperature and relative humidity. High temperature and low relative humidity favoured the population build up. Chlorantraniliprole 18.5% SC @ 30 g a.i.ha$^{-1}$ was found the best. Indoxacarb 14.5 SC@ 60 g a.i.ha$^{-1}$ and imidacloprid 17.8 SL @30 g a.i.ha$^{-1}$ also gave good result over control in managing epilachna beetle in potato crop.

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