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Insect-pests Management of Soybean and Their Natural Enemies in Rewa District

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ABSTRACT:

A Field experiment was carried out during *Kharif* season at Instructional Farm of JNKVV-College of Agriculture Rewa (M.P) in Soybean crop. The appearance of Girdle beetle from 4th week of July to 1st week of October with an initial population of 1.04 rings/mrl during the entire month of July. Thereafter, pest population continued to increasing and reached to maximum 4.10 rings/mrl in the 3rd week of August with an average weekly population of 3.42 rings/mrl in the month of August. The correlation of girdle beetle population with meteorological parameter viz., Temperature, relative humidity and rainfall had indicated a weak negative correlation with the minimum temperature, minimum relative humidity (r =-0.164, -0.255) and rainfall (r = –0.722). While positive correlation with maximum temperature and maximum relative humidity (r = 0.511 and 0.027) respectively, under the climatic condition of Rewa district. The White fly appearance in 3rd week of July and it's persistence up to 1th week of October. The initial average population of the pest was found 1.10 N&A / week besides an average number of 3.92 N&A /plant in the entire month of August. The highest population of white fly was recorded 13.40 N&A /plant in the 3rd week of August with an entire month average of 10.82 N&A /plant. The association of white fly population with temperature, relative humidity and rainfall had indicated a weak negative correlation with maximum and minimum relative humidity (r = -0.331, -0.497) and rainfall (r = –0.754) while a positive correlation with maximum & minimum temperature (r = 0.508 and 0.229). To evaluate the efficacy of new molecule of insecticides i.e. Triazophos 40% EC 800 ml a.i./ha, Indoxacarb 15.8% EC 333 ml a.i./ha, Thiacloprid 21.7% SC 650 ml a.i./ha, Profenophos 50% EC 1250 ml a.i./ha, Flubendiamide 39.35% SC 150 ml a.i./ha, Chlorantraniliprole 18.5% SC 160 ml a.i./ha, Betacyfluthrin 8.49%+ Imidacloprid 19.81% 300 OD 350 ml a.i./ha and Thiomethoxam 12.6%+ Lambda cyhalothrin 9.5% ZC 125 ml a.i./ha and compared with untreated control plot against the Girdle beetle, {*Obereopsis*

brevis (Swed.); and White fly, *Bemisia tabaci* Gennadius. Triazophos @ 320 g a.i. /ha and Chlorantraniliprole @ 30 g a.i./ha doses were observed as most effective insecticide with a suppression of 82 % and 81 % population, respectively. Thiacloprid @ 60 g a.i./ha and Triazophos @ 320 g a.i./ha doses were observed most effective treatments with suppression of 72 % and 64 % white fly population, respectively. The natural enemies were recorded from the Soybean cultivars during seedling to podding stage of the crop during Kharif season which indicated the incidence of nine species of insect pests and six species of natural enemies on the crop were observed. The highest yield of 1313.0 kg/ha, was recorded in the plot treated with Triazophos @ 320 g a.i. /ha followed by Thiomethoxam 12.6%+ Lambda cyhalothrin @ 27 g a.i./ha (1286.0 kg/ha) as against the yield of 813 Kg/ha in untreated control. .

KEYWORDS: Incidence, Soybean, insect-pests, correlation coefficient, insecticides, natural enemies

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INTRODUCTION:

Soybean [*Glycine max* (L.) Merrill] has established its recognition as both a pulse and an oilseed crop and ranks third among oilseed crops grown in India. Soybean has also been reported to have medicinal properties in combating diabetes, cancer, heart disease, etc. Another significance of this crop is its ability to fix atmospheric nitrogen. The major producer of soybean is USA, followed by Brazil, China and Argentina (Anonymous, 1991). The important Soybean producing states in India are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Andhra Pradesh and Gujarat. In India, cultivated area of soybean is 114.78 lakh ha with a production of 105.75 lakh metric tonne and productivity of 920 kg/ha. In Madhya Pradesh, it is being cultivated in about 54.01 lakh ha area with the production of 57.17 lakh metric tonne and productivity of 1059 kg/ha. In Rewa Division, 0.54 lakh ha area is under this crop and production is 0.38 lakh metric tonne and productivity is 715 kg/ha (SOPA, 2016).

The crop is infested by more than 275 insect pests on different plant parts throughout its growth stage and about a dozen of them have been reported causing serious damage to soybean from sowing to harvesting (Ramesh Babu, 2010). Amongst these, the girdle beetle *Obereopsis brevis* (Swed.) bore the main stem and branches. Girdle beetle, *Obereopsis brevis* (Swed.) (Coleoptera: Lamiidae) has been reported as a major stem borer pest in Madhya Pradesh, Rajasthan, Delhi, West Bengal, etc. It has been considered to be a cordinal insect pest. The pest infestation ranged from 19.5% to 26.5% (Kumawat et al., 2010). The White fly, *Bemisia tabaci* was first appeared on the crop in the last week of July with a mean population of 0.1 flies. Thereafter, the density of whitefly increased gradually with a peak of 3.2 flies in the last week of August (Ahirvar, 2013). Keeping this in view, study were under taken to know

the insect pests and their natural enemies in relation of abiotic factors and evaluate the insecticides against these pest in soybean.

MATERIAL AND METHODS:

The experiment was conducted at Instructional farm, College of Agriculture Rewa (M.P.). The research work was carried out during the *Kharif* season in the year 2017 -2018.The materials used and methodologies was adopted during the investigations on the population dynamics and efficacy of insecticides of Girdle beetle and White fly and the quality composition of insect pests and their natural enemies. Rewa district comes under the sub tropical zone of the north-eastern part of Madhya Pradesh, which is situated at 24º 31' and 88 º 15' longitudes in the north and east respectively, with an altitude of 306.6 m above the mean sea level (MSL). The average rain fall in the region varies between 1050 to1250 mm and the maximum and minimum temperature during *Kharif* season ranged between 34 to 38^0C and 23 to 24^0C respectively. The experimental field was prepared following the recommended package and practices for the crop (Table 1)

The observations on the grub population of Girdle Beetle, *Obereopsis brevis* will be recorded, as soon as their first appearance is noticed, at a weekly intervals, in per meter row length (mrl) of the crop by counting the ring on plant and the observations on the population of White fly, *Bemisia tabaci* Gennadius will be recorded at a weekly intervals starting from 20 days after sowing till the time of harvesting. The number of white flies nymph & adult counted from top 3 and 2 middle leaves of randomly selected five tagged plants in each plot. Meteorological parameter, Viz. temperature, humidity and rainfall will be recorded at weekly interval during the entire period of experiment. The observations on insect pest fortnightly and natural enemies were recorded from experiment field at fifteen day interval from the appearance of insect pests and natural enemies till harvesting of the crop (Table 1 & 2).

Correlation of insect population (Nymph and Adult) with temperature (maximum and minimum), humidity and rainfall was worked out to find out if any relationships exist between them.

The efficacy of insecticides i.e. Triazophos 40% EC, Indoxacarb 15.8% EC, Thiacloprid 21.7% SC, Profenofos 50% EC, Flubendiamide 39.35% SC, Chlorantraniliprole 18.5% SC, Betacyfluthrin 8.49%+ Imidacloprid 19.81% 300 OD, Thiomethoxam 12.6%+ Lambda cyhalothrin 9.5% ZC, will be compared with untreated control plot against the Girdle Beetle , *Obereopsis brevis* Swed. and White fly, *Bemisia tabaci* Gennadiu (Table 4 & 6).

Population of white fly was recorded separately from five tagged plants randomly selected in each plot and observation for Girdle beetle number of larvae/ring was counted in one meter row length (mrl) were counted one day before and 1,3,7 and 15 days after the treatments.

STATISTICAL ANALYSIS :

The data on the populations of different larvae were subjected to statistical analysis as per RBD after transforming the square root transformation by using the following formula :-

The square root transformation = $\sqrt{X + 0.5}$

Where: X = in the insect population count.

Economics of the different insecticide treatments was assessed on the basis of cost benefit ratio which was worked out by considering the cost of insecticide treatment and the market value of the produce saved by the treatment.

RESULTS AND DISCUSSION:

Population dynamics of Girdle beetle (*Obereopsis brevis* Swed.*)* and White fly (*Bemisia tabaci* Gennadius) were studied in Soybean crop during *kharif* 2017. The findings on the population fluctuation of Girdle beetle and White fly has indicated their appearance in the crop from 4th week of July (30th standard week) and 3rd week of July (29th standard week), respectively. Infestation of both the pest were continued up to harvest of the crop in the region and appeared to be a major pest in the area (Table 2 & 3). Severity of these pests on the crop has also been reported by Askey et al (2007), Netam et al (2013) and Yadu & Kumari (2017).

Population dynamics of Girdle Beetle (*Obereopsis brevis* Swed) :

The beginning of Girdle beetle infestation was recorded in the 4th week of July 2017 (30th standard week) with an average population of 0.75 rings/mrl with an average weekly population of 0 to 1.04 rings/mrl in the month of July 2017.

The higher numbers of Girdle beetle population was observed in the month of August 2017 with a record of peak population of 4.10 rings/mrl in the 3rd week of August (34th standard week) and the entire months average weekly population of 2.50 to 4.10 Rings/plant. The girdle beetle population in present climatic condition of Rewa district had indicated a decline in pest number from 1st week of September (36th standard week) and complete disappearance in the 1st week of October 2017 (Table 2). Khandwe and Chouhan (2016) also reported girdle beetle infestation initiation in the 2nd week of August (32nd SMW) during 2015 with peak population in the 1st week of September (36th SMW) during 2015 and 2nd week of September (37th SMW) during 2015 in Gwalior district of Madhya Pradesh state, which indicate variation in infestation level due to climatic condition.

The correlation of Girdle beetle population with the meteorological parameter viz., Temperature, relative humidity and rainfall had indicated a weak negative correlation was observed with the minimum

temperature, minimum relative humidity and rainfall (r = -0.164, - 0.255, -0.722 respectively) while a weak positive correlation with maximum temperature and maximum relative humidity. The respective r was found to be (0.511) and (0.027)**.** Ahirwar et al (2015) has also reported that high mean ambient temperature and relative humidity favoured the pest population build-up of Girdle beetle, while the minimum temperature showed a negative correlation.

Suyal et al (2018) also reported the peak population of girdle beetle on Soybean in the fourth fortnight of September during Kharif season. The temperature and relative humidity have favourable impact for girdle beetle population with positive correlation. In the present investigation peak of girdle beetle population occurred in the 3rd week of August 2017 which indicate a changing pattern in its appearance and peaks, which is probably due to climate change.

Population dynamics of White fly (*Bemisia tabaci* Gennadius) :

The beginning of White fly infestation was recorded in the 3rd week of July 2017 (29th standard week) with an average population of 1.10 N&A /plant. However, during the month of July the average weekly population of the pest varied from 0 to 3.2 N&A /plant.

The higher numbers of White fly population was observed in the month of August 2017, with a record of peak population of 13.40 N&A /plant in the 3rd week of August (34th standard week). During the entire month of August 2017, the average weekly population of the pest was found changing between 9.14 to 13.40 N&A /plant. The White fly population under the present climatic condition of Rewa district, had indicated a decline in pest number from 2nd week of Sept. (37th standard week) and completely disappeared in the 1st week of October 2017 (Table 3). The findings of Alam and Patidar (2015) has also indicated it's appearance from 4th week of July and peak population; 13.40 N&A /plant in the month of September of *kharif* 2014.

The correlation of White fly population with the meteorological parameter viz., Temperature, relative humidity and rainfall had indicated a weak negative correlation was observed with the maximum and minimum relative humidity and rainfall (r = -0.331, - 0.497, -0.754 respectively) while a weak positive correlation with maximum and minimum temperature. The respective r was found to be (0.508) and (0.229)**.** Similarly Ahirwar et al (2015) has also reported a significant positive correlation with maximum and minimum temperature that favoured the pest population build-up of white fly and a significant negative correlation with relative humidity and rainfall.

The peak population of white fly on Soybean in the 3rd week of August during Kharif season. A significant positive correlation with maximum and minimum temperature. Suyal et al (2018)

Efficacy of new molecules of insecticides against Girdle beetle and White fly:

The efficacy of insecticides against Girdle beetle and White fly was studied under climatic condition of Rewa region (Table 4-7).

Against Girdle beetle (*Oberiopsis brevis*) :

Efficacy of eight insecticides namely i.e. Triazophos 40% EC, Indoxacarb 15.8% EC, Thiacloprid 21.7% SC, Profenofos 50% EC, Flubendiamide 39.35% SC, Chlorantraniliprole 18.5% SC, Betacyfluthrin 8.49%+ Imidacloprid 19.81% 300 OD and Thiomethoxam 12.6%+ Lambda cyhalothrin 9.5% ZC were evaluated after two spray done on 40 and 55 DAG against girdle beetle. The observation was recorded after one day, 3,7 & 15th day of the insecticide spray. All insecticide was found effective against the pest but variation in the degree of pest control was observed. The post treatment effect, after one day, indicated a significant reduction in the population of insect in the insecticide treated plot than untreated control. The average number of pest varied from 3.43 to 4.10 rings/mrl in insecticide treated plot as against (7.00 rings/mrl) of untreated control. A significance reduction in the pest population due to insecticide treatment was seen after 3rd and 7th day of the application with a record of 2.91 to 3.73 and 2.70 to 3.33 rings/mrl, respectively. However, the population in untreated control consequently, was found at 7.14 and 7.21 rings/mrl. Among the insecticides, Triazophos @ 320 g a.i. /ha was found superior over the rest of the insecticides with a percent reduction of 62 % in pest population after 1st spray and 7th day after the insecticide application followed by Chlorantraniliprole @ 30 g a.i./ha (61 %). However, after 15th day of insecticide application an increase in the pest population was again seen in all the treatment plots including check.

After second spray of insecticide, further reduction in girdle beetle population was seen in various treatments in comparison to untreated control. In the insecticide treated plots population of girdle beetle was observed between 2.56 to 3.80 rings/mrl as against 6.69 rings/plant in untreated control one day after the second spray. A significance influence of the insecticide was further seen after 3rd and 7th day of the treatment, with a record of 1.70 to 2.32 and 1.13 to 1.73 rings/mrl population, respectively. However, the respective population in untreated control were found at 6.33 and 6.73 rings/mrl. Among the insecticides, Triazophos @ 320 g a.i./ha was found superior over other insecticides with a record of 82% reduction in population followed by Chlorantraniliprole @ 30 g a,i./ha 81% after 7th day of spraying (Table 4 & 5). Similar findings regarding Triazophos efficacy against Soybean were also reported by Jain and Sharma (2011). Triazophos 40% EC at 40-45 days after sowing to reducing the pest population of girdle beetle and most economic, Kumar and Pandey (2017).

Against White fly (*Bemisia tabaci* Gennadius) :

Evaluation of efficacy of above mentioned insecticides against white fly have indicated effectiveness of all insecticide over the untreated control. The post treatment effect, after one day, indicated a significant

reduction in the population of insect in the insecticide treated plot than untreated control. The average number of insects varied from 5.23 to 6.80 N&A /plant in insecticide treated plot as against 10.50 N&A /plant of untreated control. A significance influence of the insecticide was further seen after 3rd and 7th day of the treatment with an average population ranging from 1.94 to 3.60 and 01.55 to 3.28 N&A /plant, respectively as against respective population of 9.80 and 9.60 N&A /plant in untreated control. Thiacloprid @ 60 g a.i. /ha was found superior with a percent reduction of 83 % in insect population after 7th day, followed by Triazophos @ 320 g a.i. /ha with a reduction of 82 % percent. After 15th day of insecticide treatment a slight increase in the pest population was seen in all the insecticide treated plots and untreated control.

After second spray of insecticide, no doubt, further reduction in white fly population was observed in various treatments with a count of 3.77 to 4.60 N&A /plant in comparison to untreated control (8.13 N&A /plant). One day after the second spray, a significance reduction in the pest population was further seen after 3rd and 7th day of the treatment. At this stage, the population varied between 1.83 to 3.60 and 1.28 to 2.21 N&A /plant respectively, as against of respective population of 6.03 and 4.57 N&A /plant in untreated control. Among the tested insecticides, Thiacloprid @ 60 g a.i. /ha was found superior over the rest of the insecticides with a percent reduction of 72 % in insect's population after 7 days which was followed by Triazophos @ 320 g a.i. /ha with a reduction of 63 % (Table 6 & 7). Similar findings regarding Thiacloprid efficacy against white fly were also reported by Kujur (2011). Triazophos @ 320 g a.i. /ha as the most effective in reducing the population of white fly, Alam and Patidar (2015) and Kushram et al., 2017).

Diversity of insect pests infesting Soybean crop field:

The diversity of insect pests on soybean crop in Rewa district during Kharif 2017 was studied which indicated the incidence of nine insect pests on the crop from germination to harvesting stages. The insects which appeared on the crop were from Lepidoptera, Hemiptera, Coleoptera and Diptera order and their incidence were noted from 3rd week of July (29th standard week) to harvesting of crop. Among infesting insects, three insect pests were from Lepidoptera order, two to Hemiptera, three to Coleoptera, and one each to Diptera order (Table 8). They were Girdle beetle, White fly, Stem fly, Tobacco caterpillar, Bihar hairy caterpillar, Green semilooper, Blu beetle, Jassid and Grey weevil, The composition of Soybean insect pests has been studied by various workers. The insect pests of economic importance have been recorded by various workers (Kumar et al. 2012, Singh et al. 2013, Ahirwar R. 2013 and Brahaman et al. 2018).

Diversity of natural enemies of insect pests in Soybean:

Soybean crop attracts large number of insect pests and their natural enemies. The natural enemies help in restricting the population of potential pests to non-damaging level. The natural enemies of insect pests associated with soybean cultivar JS-2029 were of diversified groups. The cultivar attracted six natural

enemies in which lady bird beetle found effectively on white flies and Jassids, Pentatomid bug and Bracon spp. found effectively on larvae of Bihar hairy caterpillar, Lacewing, Dragon fly and Yellow lynx spider (Table 9). The literature is available on the natural enemies of soybean insect pests (Kedar et al. 2014, Ahirwar. 2015, Kushram. 2016 and Rana and Meena. 2017).

Effect on grain yield:

The finding on the yield per plot (Table 10) shows a significant difference in yield among the treatments. The highest yield of 1313.0 kg/ha, was recorded in the plot treated with Triazophos @ 320 g a.i. /ha followed by Thiomethoxam 12.6%+ Lambda cyhalothrin @ 27 g a.i./ha (1286.0 kg/ha) as against the yield of 813 Kg/ha in untreated control. The order of yield as influenced by insecticide was found in descending order Triazophos 320 g a.i./ha, > Thiomethoxam + Lambda cyhalothrin 27 g a.i./ha, > Chlorantraniliprole 30 g a.i./ha, > Thiacloprid 60 g a.i./ha, > Profenofos 625 g a.i./ha, > Indoxacarb 60 g a.i./ha, > Betacyfluthrin + Imidacloprid 125 g a.i./ha, > Flubendiamide 60 g a.i/ha. Patil and Phadv (2014) found that significantly higher yield due to Triazophos 40 EC @ 800 ml/ha was found most superior in reducing the damage of both girdle beetle and stem fly and gave the highest yield (2061 kg/ha).

COST BENEFIT RATIO:

The C:B ratio of various insecticide treatments was calculated and presented in Table 15, which divulge that maximum C:B ratio (1:10.7) was recorded from Triazophos treatment followed by Thiomethoxam + Lambda cyhalothrin (1:10). However, the minimum CB ratio was noted in the plot treated with Flubendiamide (1:2). (Table 11).

Table 1. Weekly meteorological data during the experimentation period at Rewa

Standard wseeks /name week of month	**Max.temp. (^{0}C)**	**Min.temp(^{0}C)**	**Max.RH (%)**	**Min.RH (%)**	**Rainfall (mm)**
25(June 3rd week)	40.08	25.11	53.14	47.14	21.60
26(June 4th week)	36.55	23.56	71.11	55.55	79.80
Average	**38.31**	**24.33**	**62.12**	**51.345**	**Total 101.40**
27(July 1st week)	31.36	23.86	81.80	63.00	98.10
28(July 2nd week)	29.37	23.90	86.14	76.28	198.60
29(July 3rd week)	32.30	23.79	76.28	61.85	115.20
30(July 4th week)	32.03	23.34	84.23	76.59	95.60
31(July 5th week)	32.30	24.35	78.50	63.50	34.20
Average	**31.47**	**23.84**	**81.39**	**68.24**	**Total 541.70**
32(Aug. 1st week)	32.25	24.12	84.14	67.71	24.60

33(Aug. 2nd week)	31.72	24.08	80.85	67.00	-
34(Aug. 3rd week)	33.67	24.72	73.14	61.85	-
35(Aug. 4th week)	32.48	24.31	89.10	65.01	65.80
Average	**32.53**	**24.30**	**81.80**	**65.39**	**Total 90.40**
36(Sept. 1st week)	34.11	23.20	74.85	58.28	23.40
37(Sept. 2st week)	34.80	23.08	75.42	65.00	21.80
38(Sept. 3rd week)	33.40	20.10	84.14	69.42	49.20
39(Sept. 4th week)	33.79	22.22	80.30	64.23	-
Average	**34.02**	**22.15**	**78.67**	**64.23**	**Total 94.40**
40(Oct. 1st week)	34.46	20.93	73.66	49.40	-
41(Oct. 2nd week)	34.65	21.42	80.85	55.14	-
Average	**34.55**	**21.17**	**77.25**	**52.27**	
Total					**856.90****

*Total of the month **Cumulative rainfall during the season

Table 2. Population of Girdle beetle in relation to temperature, relative humidity and rainfall during *kharif* season 2017-18

Standard weeks /name week of month	**Population mrl**	**Max.temp. (^{0}C)**	**Min.temp. (^{0}C)**	**Max.RH (%)**	**Min.RH (%)**	**Rainfall (mm)**
25(June 3th week)	**0.00**	40.08	25.11	53.14	47.14	21.60
26(June 4th week)	**0.00**	36.55	23.56	71.11	55.55	79.80
Average	**0.00**	**38.31**	**24.33**	**62.12**	**51.345**	**101.40**
27(July 1st week)	**0.00**	31.36	23.86	81.80	63.00	98.10
28(July 2nd week)	**0.00**	29.37	23.90	86.14	76.28	198.60
29(July 3rd week)	**0.00**	32.30	23.79	76.28	61.85	115.20
30(July 4th week)	**0.75**	32.03	23.34	84.23	76.59	95.60
31(July 5th week)	**1.34**	32.30	24.35	78.50	63.50	34.20
Average	**1.04**	**31.47**	**23.84**	**81.39**	**68.24**	**541.70***
32(Aug. 1st week)	**2.50**	32.25	24.12	84.14	67.71	24.60
33(Aug. 2nd week)	**3.28**	31.72	24.08	80.85	67.00	0.00
34(Aug. 3rd week)	**4.10**	33.67	24.72	73.14	61.85	0.00
35(Aug. 4th week)	**3.82**	32.48	24.31	22.60	65.01	65.80
Average	**3.42**	**32.53**	**24.30**	81.80	**65.39**	**90.40***
36(Sept. 1st week)	**3.40**	34.11	23.20	21.60	58.28	23.40
37(Sept. 2nd week)	**3.26**	34.80	23.08	79.80	65.00	21.80

38(Sept. 3rd week)	**3.61**	33.40	20.10	84.14	69.42	49.20
39(Sept. 4th week)	**3.10**	33.79	22.22	80.30	64.23	0.00
Average	**3.34**	**34.02**	**22.15**	**78.67**	**64.23**	**94.40***
40(Oct. 1st week)	**0.00**	34.46	20.93	73.66	49.40	0.00
41(Oct. 2nd week)	**0.00**	34.65	21.42	80.85	55.14	0.00
Average	**0.00**	**34.55**	**21.17**	**77.25**	**52.27**	**0.00***
Total						**826.90****
Correlation coefficient (r value)	**1.00**	**0.511**	**-0.164**	**0.027**	**-0.255**	**-0.722**

***Total of the month** ****Cumulative rainfall during the season**

Table 3. Population of White flies in relation to temperature, relative humidity and rainfall during *kharif* season 2017-18

Standard weeks /name week of month	Population per plant	Max.temp (^{0}C)	Min.temp. (^{0}C)	Max.RH (%)	Min.RH (%)	Rainfall (mm)
25(June 3rd week)	**0.00**	40.08	25.11	53.14	47.14	21.60
26(June 4th week)	**0.00**	36.55	23.56	71.11	55.55	79.80
Average	**0.00**	**38.31**	**24.33**	**62.12**	**51.345**	**101.40**
27(July 1st week)	**0.00**	31.36	23.86	81.80	63.00	98.10
28(July 2nd week)	**0.00**	29.37	23.90	86.14	76.28	198.60
29(July 3rd week)	**1.10**	32.30	23.79	76.28	61.85	115.20
30(July 4th week)	**4.12**	32.03	23.34	84.23	76.59	95.60
31(July 5th week)	**6.54**	32.30	24.35	78.50	63.50	34.20
Average	**3.92**	**31.47**	**23.84**	**81.39**	**68.24**	**541.70***
32(Aug. 1st week)	**9.39**	32.25	24.12	84.14	67.71	24.60
33(Aug. 2nd week)	**11.36**	31.72	24.08	80.85	67.00	0.00
34(Aug. 3rd week)	**13.40**	33.67	24.72	73.14	61.85	0.00
35(Aug. 4th week)	**9.14**	32.48	24.31	89.10	65.01	65.80
Average	**10.82**	**32.53**	**24.30**	**81.80**	**65.39**	**90.40***
36(Sept. 1st week)	**11.57**	34.11	23.20	74.85	58.28	23.40
37(Sept. 2nd week)	**8.75**	34.80	23.08	75.42	65.00	21.80
38(Sept. 3rd week)	**6.52**	33.40	20.10	84.14	69.42	49.20
39(Sept. 4th week)	**3.23**	33.79	22.22	80.30	64.23	0.00
Average	**7.47**	**34.02**	**22.15**	**78.67**	**64.23**	**94.40***
40(Oct. 1st week)	**0.00**	34.46	20.93	73.66	49.40	0.00
41(Oct. 2nd week)	**0.00**	34.65	21.42	80.85	55.14	0.00
Average	**1.62**	**34.55**	**21.17**	**77.25**	**52.27**	**0.00***
Total						**826.90****
Correlation coefficient (r value)	**1.00**	**0.508**	**0.229**	**-0.331**	**-0.497**	**-0.754**

***Total of the month** ****Cumulative rainfall during the season**

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Table 4: Efficacy of insecticides against Girdle beetle in soybean crop after second spray

S. No.	Treatment	Treatment name	Trade name	Dosage g a.i. /ha	Population of Girdle beetle /mrl				
					Before	After Treatment			
						1DAT	3DAT	7DAT	15 DAT
1.	T_1	Triazophos 40% EC	Trifos-40	320	4.71 (2.26)	2.56 (1.74)	1.70 (1.43)	1.13 (1.20)	1.11 (1.26)
2.	T_2	Indoxacarb 15.8% EC	Avaunt EC	60	5.01 (2.34)	3.33 (1.95)	2.10 (1.60)	1.51 (1.35)	1.33 (1.33)
3.	T_3	Chlorantraniliprole 18.5% SC	Coragen	30	4.63 (2.25)	2.59 (1.73)	1.84 (1.49)	1.26 (1.28)	1.22 (1.31)
4.	T_4	Profenofos 50% EC	Curacron	625	4.93 (2.30)	3.13 (1.90)	2.00 (1.53)	1.46 (1.32)	1.29 (1.32)
5.	T_5	Thiacloprid 21.7% SC	Splendour	60	5.10 (2.38)	3.53 (1.99)	2.28 (1.61)	1.73 (1.46)	1.66 (1.44)
6.	T_6	Flubendiamide 39.35% SC	Fame	60	5.12 (2.36)	3.40 (1.97)	2.14 (1.60)	1.54 (1.41)	1.44 (1.38)
7	T_7	Betacyfluthrin 8.49% + Imidachloprid 19.81% 300 OD	Solomen	100	5.34 (2.40)	3.80 (2.07)	2.32 (1.64)	1.73 (1.43)	1.88 (1.52)
8	T_8	Thiomethoxam 12.6%+Lambda cyhalothrin 9.5% ZC	Alika	27	4.83 (2.30)	2.86 (1.83)	1.94 (1.55)	1.33 (1.34)	1.25 (1.30)
9	T_9	Untreated (Control)		-	7.17 (2.76)	6.69 (2.68)	6.33 (2.61)	6.73 (2.68)	6.92 (2.72)
		SEm±			0.188	0.160	0.223	0.191	0.192
		CD at 5 %			**NS**	**0.350**	**0.486**	**0.417**	**0.418**

* Figures in parentheses are $x+0.5$ transformed values.

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Table 5. Percentage reduction of Girdle beetle population in soybean crop after second spray of insecticide

S. No.	Treatment	Treatment name	Trade name	Dosage g a.i. /ha	Percentage of Population reduction after treatment	
					7 DAT	15 DAT
1.	T_1	Triazophos 40% EC	Trifos-40	320	82	84
2.	T_2	Indoxacarb 15.8% EC	Avaunt EC	60	77	80
3.	T_3	Chlorantraniliprole 18.5% SC	Coragen	30	81	82
4.	T_4	Profenofos 50% EC	Curacron	625	78	81
5.	T_5	Thiacloprid 21.7% SC	Splendour	60	74	76
6.	T_6	Flubendiamide 39.35% SC	Fame	60	77	79
7	T_7	Betacyfluthrin 8.49% + Imidachloprid 19.81% 300 OD	Solomen	100	74	72
8	T_8	Thiomethoxam 12.6% +Lambda cyhalothrin 9.5% ZC	Alika	27	80	81
9	T_9	Untreated (Control)		-		

Table 6. Efficacy of insecticides against White flies in soybean crop after second spray

S. No.	Treatment	Treatment name	Trade name	Dosage g a.i. /ha	Population of white flies /five leaves/plant				
					Before	After Treatment			
						1DAT	3DAT	7DAT	15 DAT
1.	T_1	Triazophos 40% EC	Trifos-40	320	7.47 (2.82)	3.98 (2.11)	2.07 (1.60)	1.62 (1.45)	0.72 (1.08)
2.	T_2	Indoxacarb 15.8% EC	Avaunt EC	60	8.37 (2.97)	4.45 (2.22)	2.83 (1.82)	2.18 (1.63)	1.53 (1.42)
3.	T_3	Chlorantraniliprole 18.5% SC	Coragen	30	7.75 (2.87)	4.37 (2.20)	2.32 (1.67)	1.94 (1.56)	1.25 (1.32)
4.	T_4	Profenofos 50% EC	Curacron	625	7.97 (2.91)	4.42 (2.21)	2.58 (1.75)	2.00 (1.58)	1.41 (1.38)
5.	T_5	Thiacloprid 21.7% SC	Splendour	60	7.32	3.77	1.83	1.28	0.64

					(2.79)	(2.06)	(1.51)	(1.32)	(1.06)
6.	T_6	Flubendiamide 39.35% SC	Fame	60	8.45 (2.99)	4.60 (2.25)	3.60 (2.02)	2.21 (1.64)	1.66 (1.46)
7	T_7	Betacyfluthrin 8.49% + Imidachloprid 19.81% 300 OD	Solomen	100	7.71 (2.86)	4.18 (2.16)	2.16 (1.60)	1.86 (1.53)	0.97 (1.21)
8	T_8	Thiomethoxam 12.6%+Lambda cyhalothrin 9.5% ZC	Alika	27	7.51 (2.83)	4.14 (2.15)	2.16 (1.62)	1.69 (1.42)	0.86 (1.15)
9	T_9	Untreated (Control)	-	-	9.10 (3.08)	8.13 (2.93)	6.03 (2.55)	4.57 (2.25)	4.00 (2.12)
		SEm±			0.097	0.086	0.109	0.081	0.096
		CD at 5 %			**NS**	**0.188**	**0.238**	**0.175**	**0.208**

* Figures in parentheses are $\sqrt{x+0.5}$ transformed values

Table 7. Percentage reduction of White flies population in soybean crop after second spray of insecticide

S. No.	**Treatment**	**Treatment name**	**Trade name**	**Dosage g a.i. /ha**	**Percentage of Population reduction after treatment**	
					7 DAT	**15 DAT**
1.	T_1	Triazophos 40% EC	Trifos-40	320	64	82
2.	T_2	Indoxacarb 15.8% EC	Avaunt EC	60	56	64
3.	T_3	Chlorantraniliprole 18.5% SC	Coragen	30	57	68
4.	T_4	Profenofos 50% EC	Curacron	625	52	61
5.	T_5	Thiacloprid 21.7% SC	Splendour	60	72	84
6.	T_6	Flubendiamide 39.35% SC	Fame	60	51	58
7	T_7	Betacyfluthrin 8.49% + Imidachloprid 19.81% 300 OD	Solomen	100	59	75
8	T_8	Thiomethoxam 12.6% +Lambda cyhalothrin 9.5% ZC	Alika	27	63	78

9	T_9	Untreated (Control)		-		

Table 8. Qualitative composition of insect pest of soybean during Kharif season 2017-18

S.No.	Common name	Scientific name	Family	Order	Damaging stage	Crop stage
1.	Girdle beetle	*Obereopsis brevis* Swed.	Cerambycidae	Coleoptera	Grub	Vegetative, Flowering & Podding
2.	Tobacco caterpillar	*Spodoptera litura* Fabricius	Noctuidae	Lepidoptera	Caterpillar	Foliage, Flowering & Podding
3.	White fly	*Bemisia tabaci* Gennadius	Aleyrodidae	Hemiptera	Nymph and adult	Vegetative, Flowering & Podding
4.	Stem fly	*Melanagromyza sojae* Zehntner	Agromyzidae	Diptera	Maggot	Seeling
5 .	Blue beetle	*Cneorane spp*. Jacoby	Chrysomelidae	Coleoptera	Nymph and Adult	Seeling
6.	Grey weevil	*Myllocerus maculosus* Desb.	Curculionidae	Coleoptera	Nymph and Adult	Vegetative
7.	Bihar hairy caterpillar	*Spilosoma oblique* Walker	Arctiidae	Lepidoptera	Caterpillar	Foliage, Flowering, Podding
8.	Green Semilooper	*Chrysodeixis acuta* Walker	Noctuidae	Lepidoptera	Caterpillar	Vegetative
9.	Jassid	*Empoasca kerri* Pruthi	Cicadellidae	Hemiptera	Nymph and Adult	Foliage, Flowering, Podding

Table 9. Natural enemies recorded in soybean crop during Kharif season 2017-18

S. No.	Common name	Scientific name	Family	Order	Host
1.	Lacewing	*Chrysoperla carnea* Stephen	Chrysopidae	Neuroptera	Aphid, Thrips, White flies
2.	Dragon fly	*Ictinogoophus rapus*	Gomphidae	Odonata	Larvae of Bihar hairy caterpillar
3.	Lady bird beetle	*Chilomenes sexamaculata* Fabricius	Coccinellidae	Coleoptera	Aphids and white flies
4.	Yellow lynx spider	*Oxyopes satticus*	Oxyopidae	Araneae	Lepidopterous caterpillars, white flies and jassids
5.	Pentatomid bug	*Eocanthecona furcellata*	Pentatomidae	Hemiptera	Lepidopterous caterpillars
6.	Bracon spp.	*Bracon greeni* Ashmed	Bracconidae	Hemiptera	Larvae of Bihar hairy caterpillar

Table 10. Influence of insecticides on Yield of Soybean, *Kharif* 2017-18

S. No.	Treatments	Dosage ml or g/ha	Dosage g a.i./ha	Yield (Kg/plot)	Average Yield (Kg/ha)	Additional yield over control (Kg/ha)	%Yield increased
1.	Triazophos 40% EC	800 ml/ha	320	1.96	1313.0	500.0	61.0
2.	Indoxacarb 15.8% EC	333 ml/ha	60	1.75	1173.0	360.0	44.0
3.	Chlorantraniliprole 18.5% SC	160 ml/ha	30	1.87	1253.0	440.0	54.0
4.	Profenofos 50% EC	1250 ml/ha	625	1.78	1190.0	377.0	46.0
5.	Thiacloprid 21.7% SC	650 ml/ha	60	1.81	1210.0	397.0	48.0
6.	Flubendiamide 39.35% SC	150 ml/ha	60	1.74	1162.0	349.0	42.0
7.	Betacyfluthrin 8.49% + Imidachloprid 19.81% 300 OD	350 ml/ha	125	1.72	1149.0	336.0	41.0

8.	Thiomethoxam 12.6% +Lambda cyhalothrin 9.5% ZC	125 ml/ha	27	1.92	1286.0	473.0	58.0
9.	Untreated (Control)		-	1.21	813.0	0.00	0.00
	SEm±			0.027			
	CD at 5 %			0.060			

Table 11. Effect of different insecticide treatment on the economics of the crop

S. No.	Treatments	Dosage ml or g/ha	Average Yield (Kg/ha)	Additional yield over control (Kg/ha)	Gross monetary return due to treatment(Rs./ha)	Protection cost for 2 spray (Rs./ha)	Net return due to treatments (Rs./ha)	C:B ratio
1.	Triazophos 40% EC	320	1313.0	500.0	15250	1420	13830	1:10
2.	Indoxacarb 15.8% EC	60	1173.0	360.0	10980	2165	8815	1:5
3.	Chlorantraniliprole 18.5% SC	30	1253.0	440.0	13420	5020	8400	1:2.6
4.	Profenofos 50% EC	625	1190.0	377.0	11498	3350	8148	1:3.4
5.	Thiacloprid 21.7% SC	60	1210.0	397.0	12108	3820	8200	1:3
6.	Flubendiamide 39.35% SC	60	1162.0	349.0	10644	5740	4904	1:2
7.	Betacyfluthrin 8.49% + Imidachloprid 19.81% 300 OD	125	1149.0	336.0	10248	2590	7658	1:4
8.	Thiomethoxam 12.6%+Lambda cyhalothrin 9.5% ZC	27	1286.0	473.0	14226	1400	12826	1:10
9.	Untreated (Control)	-	813.0	0.00				
	SEm±		0.027					
	CD at 5 %		0.060					

CONCLUSIONS:

The appearance of Girdle beetle pest population continued to increasing and reached to maximum 4.10 rings/mrl in the 3rd week of August with an average weekly population of 3.42 rings/mrl in the month of August. The correlation of girdle beetle population with meteorological parameter had indicated a weak negative correlation with the minimum temperature, minimum relative humidity (r = -0.164, -0.255) and rainfall (r = –0.722). While positive correlation with maximum temperature and maximum relative humidity (r = 0.511 and 0.027) respectively. The highest population of white fly was recorded 13.40 N&A /plant in the 3rd week of August with an entire month average of 10.82 N&A /plant. The association of white fly population with abiotic had indicated a weak negative correlation with maximum and minimum relative humidity (r = -0.331, -0.497) and rainfall (r = –0.754) while a positive correlation with maximum & minimum temperature (r = 0.508 and 0.229). To evaluate the efficacy of molecule of insecticides compared with untreated control plot against the Girdle beetle and White fly, Triazophos @ 320 g a.i. /ha and Chlorantraniliprole @ 30 g a.i./ha doses were observed as most effective insecticide. The natural enemies were recorded from the Soybean cultivars during seedling to podding stage of the crop during Kharif season which indicated the incidence of nine species of insect pests and six species of natural enemies on the crop were observed. The highest yield of 1313.0 kg/ha, was recorded in the plot treated with Triazophos @ 320 g a.i. /ha. The maximum C:B ratio (1:10.7) was recorded from Triazophos treatment followed by Thiomethoxam + Lambda cyhalothrin (1:10).

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