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Efficacy of Various Eco-Friendly Pesticides on Insect Pest Complex of Chilli (*Capsicum annum* L.)

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ABSTRACT

The population of insect pest complex on chilli and its damage upon the plant was monitored upon treatment with formulated *Beauveria bassiania* (0.5 ml L^{-1}), tobacco leaf extract (5 ml L^{-1}), neem oil (5 ml L^{-1}) and ginger garlic paste (50 g L^{-1}) by giving two sprays. The experiment was conducted at the experimental farm, New Colony, Ward 7, Chumukedima, Nagaland beginning from February 2021 to May 2021. The experiment was laid out in Randomized Block Design with four treatments and one control. A total of nine insect pests under seven orders and ten families were observed. The incidence of aphids, whitefly, thrips and fruit borer were major pests while others were non-significant. The results revealed that all biopesticides under study were superior and there was significant reduction over control against the insect pest complex of chilli. The most effective control was recorded in neem oil against aphids, whitefly, thrips and fruit borer with mean per cent reduction of 56.08%, 61.76%, 53.09% and 57.37%, respectively while the least was recorded in the treatment done with tobacco leaf extract.

Keywords Chilli, Insect pest, Management, Eco-friendly, Biopesticides.

INTRODUCTION

Chilli, *Capsicum annum* L. which belongs to Solanaceae family is an important spice crop grown in India. It was originated in Mexico and they are rich source of Vitamin C. Pungency in chilli is due to the presence of alkaloid called capsaicin and red color of chilli is due to the presence of capsanthin. Chillis are grown for the purposes of its spiciness and pungency and they are consumed both in green, ripe and latter dried form. Two species of chilli viz., *Capsicum annum* L. and *Capsicum frutescence* L. are well known in India, Karnataka has the highest chilli production i.e. 673.81 Metric Tonnes while in Nagaland, the production of chilli is 44.50 Metric Tonnes (Horticulture Statistics 2017-18). Regrettably, chilli is attacked by several insect pests right from sowing till harvesting which is one of the major limiting factor causing significant yield loss (Roopa and Kumar 2014). Gupta *et*

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al. (2016) reported infestation of whitefly (*Bemisia tabaci*), aphids (*Aphis gossypii*), on chilli *Capsicum annum* L. Similarly, Mousumi *et al.* (2018) observed chilli thrips (*Scirthothrips dorsalis*) and fruit borer (*Helicoverpa armigera*) infesting chilli plants. Chilli, being one of the important spice crop grown in India plays an important role in boosting the country's economy. However, because of the infestation caused by insect pests, it reduces the quality as well as quantity of chilli fruits and adversely affects its production. The infected fruits become unfit for human consumption and hence unmarketable. Therefore, proper insect pests management should be adopted in order to prevent the crop from economic loss. Over the years, farmers had been over dependent on chemical pesticides for controlling insect pests, which in return not only caused harm to environment and humans but also leads to various problems like soil depletion, soil erosion, pests resistance. Thus, keeping in view the severity and negative impacts of chemical pesticides and the need of the hour is to control insect pests in more efficient and sustainable way, the present study on effect of various eco-friendly pesticides on insect pests complex in chilli (*Capsicum annum* L.) was carried out.

MATERIALS AND METHODS

Field experiment was carried out during February 2021 to May 2021, in the Experimental Farm, New Colony, Ward 7, Chumukedima, Nagaland. The population count for the insect pests was carried out throughout the cropping period i.e. appearance of pest till harvesting of crop. For sap sucking pests such as aphids, whitefly, pest population was counted from 3 shoots i.e. top, middle and bottom from 5 randomly selected plants in each plot. For fruit borer, pest count was made from fruits of 5 randomly selected plants in each plot at weekly interval. Leaf eating pests such as caterpillars, beetles, grasshoppers were collected in glass jars or entomological glass tubes with the help of forceps. Flower feeding pests such as thrips was counted from 5 infested flowers of 5 randomly selected plants per plot. The insect pests was counted and collected in weekly interval by shaking or opening the flower petal on a white blank paper. The experiment was laid out in Randomized Block Design (RBD) with three replications. There were five treatments viz., *Beauveria bassiania* (0.5 ml L^{-1} of water), tobacco leaf extract (5 ml L^{-1} of water), neem oil (5ml L^{-1} of water), ginger garlic paste (50g L^{-1} of water) and one untreated plot. The treatments were given after the appearance of the pest population and the second application was carried out after 15 days from first spray readings. The observation on the efficacy of different treatments was recorded as pre and post treatment at 3, 5, 7 and 9 days after spray. The pest population was recorded one day before application of treatments of each pest population as per the above described sampling methods. To assess the efficacy of each treatments, the mean percentage of reduction of the infestation was calculated from the following formula given by

$$\text{Per cent reduction} = \frac{\text{Pre treatment count} - \text{Post treatment count}}{\text{Pre treatment count}} \times 100$$

The data noted throughout the period of study were tabulated and tested adopting the procedure of two-way analysis of variance method as outlined by Gomez and Gomez (1984) and the treatment variance was tested against error mean square by applying Fisher Snedecor 'F' probability at 0.05 level of significance.

RESULTS AND DISCUSSION

Effect of different eco friendly pesticides or biopesticides against aphids (*Aphis gossypii*) on chilli crop

In the first spray, at 3, 5, 7 and 9 DAS, the highest percent reduction (49.79%, 62.80%, 56.37% and 54.29%) of the aphids population was observed in those plots which were treated with neem oil and the lowest percent reduction (33.55%, 55.42%, 44.16% and 42.70%) was recorded in tobacco leaf extract, respectively. In the second spray, similar results were observed at 3, 5, 7 and 9 DAS, the highest percent reduction (49.31%, 63.75%, 57.78% and 54.58%) was observed in neem oil treated plots whereas, the lowest per cent reduction (34.17%, 55.56%, 44.72% and 42.50%) was recorded in tobacco leaf extract, respectively. All the treatments were superior and

Table 1. Effect of different pesticides against aphids, *Aphis gossypii* on chilli. Note: Figures in the table are mean values and those in parenthesis are angular transformed values. NS: Non significant at 5% level of significance.

Treatments	First spray Percent reduction					Second spray Percent reduction					
	Pre-treatment count	3 DAS	5 DAS	7 DAS	9 DAS	Pre-treatment count	3 DAS	5 DAS	7 DAS	9 DAS	Mean
Beauveria bassiana @ 0.5 ml/lt of water: (T_1)	2.55	36.76 (37.26)	58.34 (49.87)	50.37 (45.19)	48.56 (44.17)	1.95	36.74 (37.26)	57.64 (49.40)	51.11 (45.64)	49.51 (44.71)	**48.63**
Tobacco leaf extract @ 5 ml/ lt of water: (T_2)	2.60	33.55 (35.39)	55.42 (48.12)	44.16 (41.64)	42.70 (40.72)	1.90	34.17 (35.74)	55.56 (48.23)	44.72 (41.96)	42.50 (40.39)	**44.10**
Neem oil @ 5ml/ lt of water: (T_3)	2.65	49.79 (44.88)	62.80 (52.45)	56.37 (48.67)	54.29 (47.47)	1.80	49.31 (44.60)	63.75 (53.00)	57.78 (49.54)	54.58 (47.64)	**56.08**
Ginger garlic paste @ 50 g/lt of water: (T_4)	3.05	36.38 (37.03)	57.89 (49.55)	46.80 (43.15)	42.39 (40.61)	2.05	37.32 (37.63)	57.77 (49.58)	45.51 (42.40)	43.24 (41.10)	**45.91**
Untreated control: (T_0)	3.20	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	2.60	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	**0.00**
SEm±	**0.18**	**1.42**	**1.34**	**1.57**	**1.43**	**0.18**	**1.34**	**2.14**	**1.93**	**2.39**	**-**
CD (p=0.05)	**NS**	**4.38**	**4.14**	**4.84**	**4.40**	**NS**	**4.12**	**6.61**	**5.94**	**7.36**	**-**

there was significant reduction over control (Table 1). A comparable study on solanaceous crop was conducted by Gandhi *et al.* (2006), the authors reported that the application of neem oil 60 EC recorded the maximum reduction in aphids (*Aphis gossypii* G.) population in okra.

Effect of different pesticides against whitefly (*Bemisia tabaci*) on chilli

In first spray, at 3, 5, 7 and 9 DAS, the highest percent reduction (60.46%, 67.48%, 60.54% and 58.37%) of the whitefly population was observed in those plots

Table 2. Effect of different pesticides against whiteflies, *Bemisia tabaci* on chilli. Note: Figures in the table are mean values and those in parenthesis are angular transformed values. NS: Non significant at 5% level of significance.

Treatments	First spray Percent reduction					Second spray Percent reduction					
	Pre-treatment count	3 DAS	5 DAS	7 DAS	9 DAS	Pre-treatment count	3 DAS	5 DAS	7 DAS	9 DAS	Mean
Beauveria bassiana @ 0.5 ml/lt of water : (T_1)	3.85	40.13 39.29	46.40 42.91	39.91 39.16	37.05 37.43	2.20	40.87 39.73	45.44 42.33	38.60 38.33	38.60 38.33	**40.88**
Tobacco leaf extract @ 5 ml/ lt of water : (T_2)	3.40	45.66 42.50	51.48 45.85	48.61 44.20	45.67 42.51	1.80	47.22 43.41	52.78 46.59	48.61 44.20	45.66 42.51	**48.21**
Neem oil @ 5 ml/ lt of water : (T_3)	3.55	60.46 51.07	67.48 55.30	60.54 51.09	58.37 49.83	2.00	62.58 52.30	67.58 55.31	59.80 50.66	57.30 49.22	**61.76**
Ginger garlic paste @ 50 g/lt of water : (T_4)	3.50	38.52 38.35	41.55 40.13	35.48 36.47	32.62 34.77	2.00	38.96 38.55	42.53 40.69	36.69 37.22	34.42 35.89	**37.60**
Untreated control : (T_0)	4.00	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	2.60	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	**0.00**
SEm±	**0.15**	**1.62**	**1.73**	**1.54**	**1.35**	**0.17**	**1.28**	**1.59**	**1.56**	**1.42**	**-**
CD (p= 0.05)	**NS**	**5.00**	**5.33**	**4.73**	**4.18**	**NS**	**3.95**	**4.91**	**4.79**	**4.39**	**-**

Table 3. Effect of different pesticides against thrips, *Scirthothrips dorsalis* on chilli. Note: Figures in the table are mean values and those in parenthesis are angular transformed values. NS: Non significant at 5% level of significance.

Treatments	First spray Percent reduction					Second spray Percent reduction					
	Pre-treatment count	3 DAS	5 DAS	7 DAS	9 DAS	Pre-treatment count	3 DAS	5 DAS	7 DAS	9 DAS	Mean
Beauveria bassiana @ 0.5 ml/lt of water: (T_1)	2.55	35.07 36.20	56.78 48.92	48.90 44.36	42.81 40.80	2.00	36.36 36.96	36.36 36.96	47.66 43.64	42.53 40.64	**43.31**
Tobacco leaf extract @ 5 ml/lt of water: (T_2)	2.85	32.39 34.69	54.16 47.40	43.66 41.35	39.24 38.73	2.10	33.26 35.21	33.26 35.21	42.20 40.47	37.84 37.95	**39.50**
Neem oil @ 5 ml/lt of water: (T_3)	2.15	48.64 44.21	60.45 51.05	55.68 48.28	52.27 46.30	1.70	49.60 44.77	49.60 44.77	56.34 48.65	52.10 46.21	**53.09**
Ginger garlic paste @ 50 g/lt of water: (T_4)	2.65	35.67 36.64	54.53 47.60	46.96 43.25	40.57 39.56	1.75	36.53 37.16	53.87 47.23	45.09 42.16	40.18 39.31	**44.18**
Untreated control: (T_0)	2.75	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	2.60	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	**0.00**
SEm±	**0.15**	**1.35**	**1.50**	**1.53**	**1.50**	**0.21**	**1.54**	**1.34**	**1.53**	**1.70**	**-**
CD (p=0.05)	**NS**	**4.17**	**4.61**	**4.73**	**4.61**	NS	**4.73**	**4.14**	**4.72**	**5.25**	**-**

which were treated with neem oil and the lowest per cent reduction (38.52%, 41.55%, 35.48% and 32.62%) was recorded in ginger garlic paste. The effect of all the treatments on the whitefly population was significantly superior to the untreated control. In the second spray, at 3, 5, 7 and 9 DAS, the highest per cent reduction (62.58%, 67.58%, 59.80% and 57.30%) of the whitefly population was observed in those plots which were treated with neem oil and the lowest per cent reduction (38.96%, 42.53%, 36.69%

Table 4. Effect of different pesticides against mealy bugs, *Phenacoccus solenopsis* on chilli. Note: Figures in the table are mean values and those in parenthesis are angular transformed values. NS: Non significant at 5% level of significance.

Treatments	First spray Percent reduction					Second spray Percent reduction					
	Pre-treatment count	3 DAS	5 DAS	7 DAS	9 DAS	Pre-treatment count	3 DAS	5 DAS	7 DAS	9 DAS	Mean
Beauveria bassiana @ 0.5 ml/lt of water: (T_1)	1.60	37.80 37.92	57.86 49.53	48.21 43.97	45.09 42.18	1.80	35.42 36.38	58.40 49.85	50.00 45.00	45.49 42.39	**47.28**
Tobacco leaf extract @ 5 ml/lt of water: (T_2)	1.45	34.38 35.82	54.91 47.84	44.64 41.92	42.86 40.87	1.70	35.42 36.51	55.90 48.40	45.66 42.51	42.36 40.58	**44.52**
Neem oil @ 5 ml/lt of water: (T_3)	1.65	48.61 44.20	60.76 51.23	54.17 47.43	50.69 45.40	1.65	50.00 45.00	62.29 52.19	55.45 48.14	52.95 46.70	**54.37**
Ginger garlic paste @ 50 g/lt of water: (T_4)	1.55	35.27 36.40	54.91 47.84	45.09 42.16	42.75 40.81	1.95	35.34 36.39	59.26 50.35	51.36 45.79	47.30 43.45	**46.41**
Untreated control: (T_0)	1.75	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	2.35	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	**0.00**
SEm±	**0.06**	**1.31**	**1.56**	**1.58**	**1.38**	**0.16**	**1.72**	**1.35**	**1.13**	**1.23**	**-**
CD (p=0.05)	**NS**	**4.04**	**4.80**	**4.86**	**4.26**	**NS**	**5.31**	**4.16**	**3.49**	**3.80**	**-**

Table 5. Effect of different pesticides against jassids, *Amrasca biguttula biguttula* on chilli. Note: Figures in the table are mean values and those in parenthesis are angular transformed values. NS: Non significant at 5% level of significance.

Treatments	First spray Pre-treatment count	First spray Percent reduction 3 DAS	5 DAS	7 DAS	9 DAS	Second spray Pre-treatment count	Second spray Percent reduction 3 DAS	5 DAS	7 DAS	9 DAS	Mean
Beauveria bassiana @ 0.1 ml/lt of water: (T_1)	1.60	35.94 (36.82)	52.34 (46.35)	46.88 (43.20)	42.19 (40.48)	1.40	35.42 (36.51)	56.25 (48.62)	48.96 (44.40)	46.35 (42.90)	**45.54**
Tobacco leaf extract @ 68 g/lt of water: (T_2)	1.75	32.40 (34.62)	50.63 (45.37)	42.36 (40.58)	40.80 (39.64)	1.30	32.78 (34.73)	52.43 (46.39)	44.03 (41.56)	41.94 (40.36)	**42.17**
Neem oil @ 2%/lt of water: (T_3)	1.85	48.61 (44.20)	60.73 (51.22)	55.76 (48.32)	52.64 (46.51)	1.20	47.50 (43.56)	60.83 (51.31)	56.67 (48.88)	52.41 (46.38)	**54.39**
Ginger garlic paste @ 50 g/lt of water : (T_4)	1.80	35.42 (36.38)	57.15 (49.12)	44.10 (41.60)	42.53 (40.65)	1.25	36.19 (36.93)	56.07 (48.50)	47.50 (43.56)	43.63 (41.33)	**45.32**
Untreated control : (T_0)	1.70	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	1.85	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	**0.00**
SEm±	**0.07**	**1.72**	**1.65**	**1.58**	**1.50**	**0.15**	**1.65**	**1.48**	**1.58**	**1.45**	**-**
CD (p=0.05)	**NS**	**5.30**	**5.08**	**4.88**	**4.63**	**NS**	**5.10**	**4.55**	**4.86**	**4.46**	**-**

and 34.42%) was recorded in ginger garlic paste. All the treatments were superior and there was significant reduction over control (Table 2). A previous study conducted by Zeeshan and Kudada (2019) also reported that the application of botanicals insecticides viz., Neem Seed Kernel Extract (NSKE) and neem oil (0.03%) was found to be most effective in controlling whitefly ultimately reducing the leaf curl disease incidence upto 30.52%.

Effect of different pesticides against thrips (*Scirthothrips dorsalis*) on chilli crop

In the first spray, at 3, 5, 7 and 9 DAS, the highest

Table 6. Effect of different pesticides against mites, *Polyphagotarsonemus latus* on chilli. Note: Figures in the table are mean values and those in parenthesis are angular transformed values. NS : Non significant at 5% level of significance.

Treatments	First spray Pre-treatment count	First spray Percent reduction 3 DAS	5 DAS	7 DAS	9 DAS	Second spray Pre-treatment count	Second spray Percent reduction 3 DAS	5 DAS	7 DAS	9 DAS	Mean
Beauveria bassiana @ 0.1 ml/lt of water: (T_1)	1.60	46.83 (43.18)	52.28 (46.31)	50.27 (45.15)	47.23 (43.40)	1.45	47.17 (43.38)	54.91 (47.84)	52.57 (46.47)	50.48 (45.28)	**50.22**
Tobacco leaf extract @ 68 g/lt of water: (T_2)	1.45	34.43 (35.87)	42.76 (40.84)	39.64 (38.98)	36.62 (37.20)	1.40	34.67 (36.04)	44.72 (41.93)	40.59 (39.53)	40.59 (39.53)	**39.25**
Neem oil @ 2%/lt of water: (T_3)	1.20	53.57 (47.05)	60.27 (50.96)	55.13 (47.95)	50.00 (45.00)	1.30	54.61 (47.65)	62.35 (52.16)	58.33 (49.82)	54.46 (47.57)	**56.09**
Ginger garlic paste @ 50 g/lt of water: (T_4)	1.40	36.46 (37.11)	45.83 (42.57)	42.26 (40.51)	40.48 (39.46)	1.35	37.95 (37.96)	47.92 (43.80)	44.20 (41.65)	42.26 (40.52)	**42.17**
Untreated control : (T_0)	1.75	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	1.75	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	**0.00**
SEm±	**0.15**	**1.31**	**1.64**	**1.28**	**1.64**	**0.10**	**1.34**	**1.68**	**1.48**	**1.67**	**-**
CD (p=0.05)	**NS**	**4.05**	**5.06**	**3.95**	**5.06**	**NS**	**4.14**	**5.17**	**4.57**	**5.15**	**-**

Table 7. Effect of different pesticides against fruit borers, *Helicoverpa armigera* on chilli. Note: Figures in the table are mean values and those in parenthesis are angular transformed values. NS: Non significant at 5% level of significance.

Treatments	First spray Percent reduction					Second spray Percent reduction					
	Pre-treatment count	3 DAS	5 DAS	7 DAS	9 DAS	Pre-treatment count	3 DAS	5 DAS	7 DAS	9 DAS	Mean
Beauveria bassiana @ 0.1 ml/lt of water: (T_1)	0.00	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	1.50	42.52 40.69	47.32 43.46	44.87 42.05	40.63 39.58	**43.84**
Tobacco leaf extract @ 68 g/lt of water: (T_2)	0.00	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	1.40	56.25 48.62	50.00 45.00	47.40 43.46	43.75 41.37	**49.35**
Neem oil @ 2%/ lt of water: (T_3)	0.00	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	1.30	60.57 51.11	63.24 52.70	55.65 48.25	50.00 45.00	**57.37**
Ginger garlic paste @ 50 g/lt of water: (T_4)	0.00	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	1.50	49.55 44.76	45.65 42.50	42.41 40.63	38.39 38.28	**44.00**
Untreated control: (T_0)	0.00	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00	1.65	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	**0.00**
SEm±	-	-	-	-	-	**0.09**	**1.44**	**1.52**	**1.50**	**1.54**	-
CD (p=0.05)	-	-	-	-	-	**NS**	**4.45**	**4.68**	**4.63**	**4.74**	-

per cent reduction (48.64%, 60.45%, 55.68% and 52.27%) of the thrips population was observed in those plots which were treated with neem oil and the lowest per cent reduction (32.39%, 54.16%, 43.66% and 39.24%) was recorded in tobacco leaf extract. The effect of all the treatments on the thrips population was significantly superior over the untreated control. In the second spray, at 3, 5, 7 and 9 DAS, the highest per cent reduction (49.60%, 49.60%, 56.34% and 52.20%) of the thrips population was observed in those plots which were treated with neem oil and the lowest per cent reduction (33.26%, 33.26%, 42.20% and 37.84%) was recorded in tobacco leaf extract. All the treatments were superior and there was significant reduction over control (Table 3). Patel and Kumar (2017) also revealed that among different botanical treatments, application of neem oil 2.5ml L^{-1} was found to be most effective against chilli thrips, *Scirthothrips dorsalis* which reduces the thrips population up to a mean percent reduction of 53.22% followed by NSKE 5% which reduces up to 48.11% mean per cent reduction.

Effect of different pesticides against mealy bugs (*Phenacoccus solenopsis*) on chilli crop

In first spray at 3, 5, 7 and 9 DAS, the highest percent reduction (48.61%, 60.76%, 54.17% and 50.69%) of the mealy bugs population was observed in those plots which were treated with neem oil and the lowest per cent reduction (34.38%, 54.91%, 44.64% and 42.86%) was recorded in tobacco leaf extract. In the second spray, at 3, 5, 7 and 9 DAS, the highest per cent reduction (50.00%, 62.29%, 55.45% and 52.95%) of the mealy bugs population was observed in those plots which were treated with neem oil and the lowest per cent reduction (35.42%, 55.90%, 45.66% and 42.36%) was recorded in tobacco leaf extract. All the treatments were superior and there was significant reduction over control (Table 4). Halder *et al.* (2013) studied the compatibility of different entomopathogenic microorganisms viz., *Beauveria bassiana*, *Metarhizium fluorescens*, *Verticillium lecanii, Pseudomonas fluorescens* and plant origin insecticides viz., neem oil on sucking pests of vegetables including mealy bugs, *Phenacoccus solenopsis* and revealed that the application of neem oil was found to be most effective in controlling the sucking pest and mealy bugs compared to entomopathogenic microorganisms.

Effect of different pesticides against jassids (*Amrasca biguttula*) on chilli crop

At 3, 5, 7 and 9 DAS, the highest per cent reduction (48.61%, 60.37%, 55.76% and 52.64%) of the jassids

population was observed in those plots which were treated with neem oil and the lowest per cent reduction (32.40%, 50.63%, 42.36% and 40.80%) was recorded in tobacco leaf extract. In the second spray, at 3, 5, 7 and 9 DAS, the highest per cent reduction (47.50%, 60.83%, 56.67% and 52.41%) of the jassids population was observed in those plots which were treated with neem oil and the lowest per cent reduction (32.78%, 52.43%, 44.03% and 41.94%) was recorded in tobacco leaf extract. All the treatments were superior and there was significant reduction over control (Table 5). Dhiloo *et al.* (2016) reported that the application of neem oil at 3% concentration was found to be most effective against jassids on egg plant with the total mean population reduction of jassids upto 59.74%.

Effect of different pesticides against mites (*Polyphagotarsonemus latus*) on chilli crop

In the first spray, at 3, 5, 7 and 9 DAS, the highest per cent reduction (53.57%, 60.27%, 55.13% and 50.00%) of the mites population was observed in those plots which were treated with neem oil and the lowest per cent reduction (34.67%, 44.72%, 40.59% and 40.59%) was recorded in tobacco leaf extract. In the second spray, at 3, 5, 7 and 9 DAS, the highest per cent reduction (54.61%, 62.35%, 58.33% and 54.46%) of the mites population was observed in those plots which were treated with neem oil and the lowest per cent reduction (34.67%, 44.72%, 40.95% and 40.59%) was recorded in tobacco leaf extract. All the treatments were superior and there was significant reduction over control (Table 6). A previous study conducted by Prasad *et al.* (2017) also revealed that foliar application of neem oil were found to be significantly effective against chilli mites, Polyphagotarsonemus latus causing 71.50% mortality or mean per cent reduction of mites population resulting in higher yield of chilli ranging from 96.80 q ha^{-1}.

Effect of different pesticides against fruit borers (*Helicoverpa armigera*) on chilli crop

The efficacy of different pesticidal treatments for fruit borers was recorded from second spray since there was no infestation of fruit borer during the first spray. In the second spray, at 3, 5, 7 and 9 DAS, the highest per cent reduction (60.57%, 63.24%, 55.65% and 50.00%) of the fruit borers population was observed in those plots which were treated with neem oil and the lowest per cent reduction (49.55%, 45.65%, 42.41% and 38.39%) was recorded in ginger garlic paste. All the treatments were superior and there was significant reduction over control (Table 7). Mustafiz *et al.* (2015) studied the efficacy of some botanicals viz., neem oil, neem leaf extract, garlic extract and marsh pepper extract against tomato fruit borer and reported that application of neem oil @ 3.0 ml L^{-1} of water showed better performance in controlling tomato fruit borer at different stages of pant growth compared to other treatments. Neem leaf extract, garlic extract were found less effective in controlling tomato fruit borer. The number of healthy fruit per plant (32.44) as well as the lowest number of infested fruit (0.17) was also obtained when the crop is treated with neem oil @ 3.0 ml L^{-1}.

CONCLUSION

The present study can be concluded that chilli crops are attacked by different pests right from transplanting up to the harvesting stage that leads to severe damage to the crops. Therefore, it draws a serious attention of the researchers in the related field as no detail study has been done on the pests of chilli. Among all the insect pests aphids, whitefly, thrips and fruit borers were found to be the major pests. Minimum temperature and rainfall had mostly negative and highly non- significant effect on the incidence of aphids, whiteflies and thrips. For ecofriendly pests management, application of neem oil (T_3) was observed to be most effective in the percent pest reduction. The finding of the present investigation provides important information about the pest complex and natural enemies of chilli, their incidence and correlation with abiotic factor and their management. The finding of this present study also provides information on ecofriendly and sustainable management of the pests of chilli using available botanicals and microbial agents. This information will be useful in conducting future research on this particular crop as well as in the management of the insect pests on local chilli found in India.

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