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Impact of different insecticides on natural enemies in soybean (*Glycine max* L)

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Abstract
The experiment on, "Impact of different insecticides on natural enemies in soybean (*Glycin max* L)" was undertaken at Agricultural farm of Krishi Vigyan Kendra, Dhule and College of Agriculture, Dhule during 2020 -2021. The experiment was planned out in Randomized Block Design with seven treatments and three replications. The variety used for study was JSS-335.Total seven treatments were used in present investigation consisting of insecticides *viz.*, Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC @ 0.5 ml/l, Novaluron 5.25% + Emamectin benzoate 0.09% ww SC @ 1.75 ml/l, Lambda cyhalothrin 5% EC@ 0.05ml/l, Chlorantraniliprole 18.50% SC @ 0.3 ml/l, Emamectin benzoate 5% SG @ o.44 gm/l, Spinetoram 11.7% SC @ 0.9ml/l and untreated control. As regards the efficacy of different insecticides, all the insecticides were significantly superior over un-treated plot in terms to manage number of pests in soybean field. Moerever, while controlling pests its may harm the natural enemies present in soybean.

Keywords: Lady bird beetle, green lacewing, spider, soybean, infestation, insecticides

Introduction
The soybean is believed to have originated from China. In India is grown commercially in Maharashtra, Madhya Pradesh, Andhra Pradesh, Karnataka, Rajasthan etc. In Maharashtra-Ahmednagar, Dhule, Jalgaon, Akola, Parbhani, Osmanabad, Latur, Hingoli, Nanded districts are under soybean cultivation. It is a rich source of vitamins, minerals, poly unsaturated fats specially Omega 6 and Omega 5 fatty acids and well balanced in essential amino acids.

It contains 40% protein, 20% oil, 17-19% carbohydrates, 5-6% crude fibre and 6-7% total minerals, protein has several health benefits including soy protein and its isoflavones which has beneficial role in obesity, reduces body weight and fat mass in addition to lowering plasma cholesterol, triglyerides. Soybean and soy foods may reduce the risk of a range of cardiovascular disease, stroke, coronary heart disease (CHD), some cancers as well as improving bone health.

SOPA said "Estimated total production of soybean crop for all India for the year 2021 is 119.98 lakh tons, which is higher by 14.337 lakh tons (13.71 per cent) as compared to last year". The production stood at 104.55 lakh tonnes last year, the production in Madhya Pradesh and Maharashtra stood at 41.8 lakh tonnes and 45.44 lakh tonnes last year. The estimated production of soybean Madhya Pradesh occupy first rank with 55.68 lakh tonnes followed by Maharashtra (43.84 lakh tonnes), Rajasthan (9.25 lakh tonnes), Karnataka (3.82 lakh tonnes), Telangana (3.48 lakh tonnes), Gujarat (2.23 lakh tonnes) and others (1.12 lakh tonnes).

So as to raise production the obstacles have to take in note are abiotic and biotic factors like insect-pests plays role into reduce the yield of crop. Since, soybean is recently introduced in Maharashtra state and getting good monetary returns, the area under this crop is increasing with a tremendous scope particularly in Vidarbha, South Maharashtra and Marathwada. Improved variety of soybean are JS-335, JS-80-21, JS-95-60, JS 93-05, JS 80-21, NRC 2 (Ahilya1), NRC 37, NRC-12, NRC-7 have been introduced in Indian states.

Due to severe attack of pests on soybean crop, there is no certainty of harvesting the crop in good condition. Therefore, it is necessary to manage the pests effectively. Whereas there are many methods of pest control like cultural, physical, mechanical, chemical, biological, and legal method, chemical one is the best, which gives quick results. But harmful to natural enemies in somewhat level.

The natural enemies in soybean field like coccinellid beetles (*Cryptolaemus montrouzieri*), green lacewings (*Chrysoperla carnea*) and spiders (*Stegodyphus sarasinorum*) are common

which naturally keep control on pests like aphid, jassids and *Spodoptera litura*.

Depending upon wings, adult ladybirds range from a length of 1mm to 10 mm or slightly more. They also have wings and are oval in shape. Generally, males are smaller than females. Ladybird species chew using their mandibles. When there is insufficient prey for the adults' consumption, mature ladybird beetles feed on their eggs, larvae and pupae. Larva, which are characterized by a considerate level of mobility, are also protected by waxy secretions (Mohammed Albaaj, 2017) [3].

Within the ecosystems they inhabit, spiders play a vital role as predators, prey for other arthropods and vertebrates, and even contributors to decomposition. Although the vast majority of spiders are quite small, their impact on the insect population is quite significant. It has been estimated that the world spider population kills 400 – 800 million metric tons of prey per year and over 90% of that prey is insects. The majority of these insect prey belong to seven orders: Diptera (flies), Hemiptera (true bugs, aphids), Hymenoptera (bees, ants), Collembola (springtails), Coleoptera (beetles), Lepidoptera (butterflies and moths), and Orthoptera (grasshoppers and crickets). This is potentially significant since many insect pests of crops belong to the orders Lepidoptera, Hemiptera, and Coleoptera. In addition to their role as predators, spiders are also an important source of food for a variety of other arthropods as well as vertebrates. The ecology and behaviour of *S. albicosta* and *V. virgifera* in corn dictates which guilds of spiders may interact with and prey upon them in the field. Early instar western bean cutworm larvae are exposed on the top half of the corn plant and therefore may encounter ambush predators in the crop canopy. Crab spiders (Araneae: Thomisidae) are ambush predators commonly collected in corn agro-ecosystems that sit on leaves or blossoms to wait for prey and can perceive motion from up to 20 cm away. These characteristics give thomisids the potential to locate and subdue lepidopteran larvae that come within their reach (Samantha Daniel, 2021) [8].

Green lacewing, *Chrysoperla zastrowi* (Stephens) (Neuroptera: Chrysopidae) is also known as golden eyes and aphid lions, is a cosmopolitan polyphagous and efficient predator commonly found in a wide range of agricultural habitat. It is an example of one of these species that is not predacious in the adult stage. Adults feed only on pollen, nectar and aphid honeydew. Larval stage of green lacewing is predatory stage, while in some species adults are also predator in nature. It is considered a prominent general predator that feeds on a variety of insect pests of field crops, vegetables and fruit orchards. Because of its voracious feeding on soft bodied insects e.g., aphids, caterpillars, leafhoppers, psyllids, mealy bugs, white flies, thrips, insect eggs, spiders and mites, it constitutes a prominent group of predators due to their amenability to mass production and potential for their use in varied ecosystems. One larva may devour as many as five hundred aphids in its life and there is no doubt that they play an important part in the natural control of many small homopterous pests.

Materials and Methods

The field experiment was conducted during Kharif season of 2020-2021 at farm of Krishi Vigyan Kendra, Dhule and College of Agriculture, Dhule. The variety used for study was 'JSS-335' with spacing 5 × 4 m.

Method of Recording Observations of Natural enemies

The population ofnatural enemies (Lady bird beetle, spider and green lacewing) was recorded. The average larval and adult population per meter row length was recorded from randomly selected three locations of one meter row length, during early in the morning.

Treatment Details

Treatments	Name of Biopesticides / Insecticides	Dosage / ha (G/ml per l).
T_1	Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6%ZC	0.5
T_2	Novaluron 5.25% + Emamectin benzoate 0.09 ww% SC	1.75
T_3	Lambda cyhalothrin 5% EC	0.05
T_4	Chlorantraniliprole 18.50% SC	0.3
T_5	Emamectin benzoate 5% SG	0.44
T_6	Spinetoram 11.7% SC	0.9
T_7	Untreated control (water spray)	-

Results and Discussion

1) Influence of chemical insecticides on natural enemies

Effect of various treatments under investigation on natural enemies/mrl is illustrated through the data presented Table 1 to 3 and depicted in Fig 1 to 3. Effect of chemical insecticide on the abundance of natural enemies was studied by comparing the survival population of predatory lady bird beetle, spider, and green lacewing on treated and untreated plots of soybean. The population of natural enemies were recorded at 3, 7 and 14 days after spray.

1.1 Effect of insecticides on lady bird beetle population

Cumulative effect of chemical insecticides on lady bird beetle population (average of two sprays)

The average effect of all two sprays on the population of lady bird beetle on soybean is presented in Table 1 and depicted in Fig 1. The data revealed the significant difference among all treatments. The treatment without spray i.e., untreated control recorded significantly maximum number of 1.97, 2.14 and 1.83 natural enemies /mrl at 3, 7 and 14 days after spray, respectively.

The data recorded on third day after average of two sprays revealed that, all the treatments were significantly differ with each other. The average number of lady bird beetle/mrl ranged from 0.14 to 0.59 in the insecticidal treatments as against 1.97 in untreated control. The treatments with chemical insecticides *viz*., Lambda cyhalothrin 5% EC @ 25 ml/ha showed no predators after its spray. The Chlorantraniliprole 18.5% SC 150 ml/ha (0.16/mrl), Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC @ 250 ml/ha (0.19/mrl) and Novaluron 5.25%+ Emamectin benzoate 0.9% w/w @875 ml/ha (0.14/mrl) recorded on an

average number of lady bird beetle, while the Emamectin benzoate 5% SG @ 220 g/ha (0.59/mrl) and Spinetoram 11.7% SC @ 450 ml/ha (0.52/mrl) recorded highest number of lady bird beetles among all insecticides. It indicated the adverse effect of chemical insecticides on population build-up of natural enemies.

Table 1: Cumulative effect of different chemical insecticides on survival population of lady bird beetle (adult & grub) in soybean (average of two sprays)

Sr. No.	Treatment details	Dose formulated product g/ml/ha	Survival population of lady bird beetle (adult & grub) per meter row length at		
			3 DAS	7 DAS	14 DAS
T_1	Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC	250 ml	0.19 (1.08)	0.08 (1.03)	0.16 (1.17)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% w/w SC	875 ml	0.14 (1.07)	0.43 (1.18)	0.40 (1.07)
T_3	Lambda cyhalothrin 5% EC	25 ml	0.00 (1.17)	0.20 (1.09)	0.09 (1.04)
T_4	Chlorantraniliprole 18.5% SC	150 ml	0.16 (1.07)	0.10 (1.05)	0.27 (1.04)
T_5	Emamectin benzoate 5% SG	220 gm	0.59 (1.25)	0.52 (1.23)	0.58 (1.26)
T_6	Spinetoram 11.7% SC	450 ml	0.52 (1.22)	0.32 (1.14)	0.35 (1.12)
T_7	Untreated		1.97 (1.22)	2.14 (1.77)	1.83 (1.68)
	SE (d)+		0.11	0.11	0.11
	CD at 5%		0.29	0.27	0.28

DAS- Days after spray, Figures in parentheses indicate V_{n+1} transformed value,

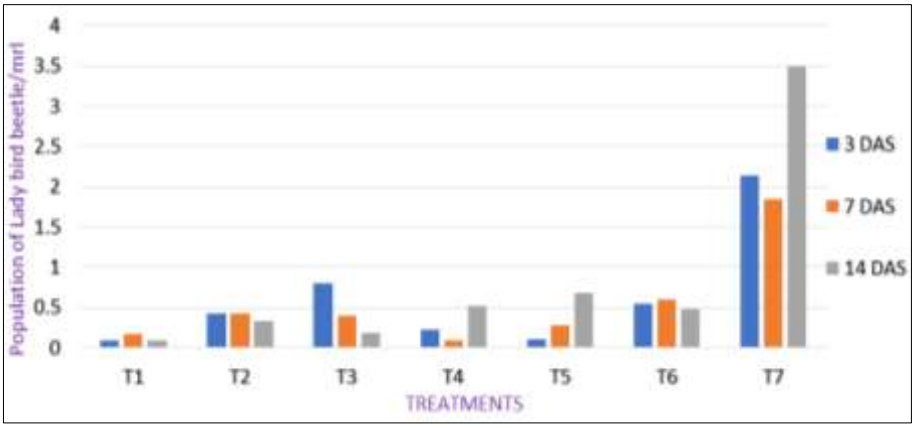

Fig 1: Survival population of lady bird beetle (grub & adult) on soybean (Average of two sprays)

The data recorded on seventh day after average of two sprays revealed that, the average number of coccinellid predators/mrl ranged from 0.10 to 0.52 in the insecticidal treatments as against 2.14 in untreated control. The treatments with chemical insecticides *viz.*, Chlorantraniliprole 18.5% SC 150 ml/ha, Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC @ 250 ml/ha and Lambda cyhalothrin 5% EC @ 25 ml/ha recorded very less (0.10, 0.08 and 0.20/mrl) count of lady bird beetle, respectively. And Novaluron 5.25% + Emamectin benzoate 0.9% w/w SC @ 875 ml/ha (0.43/mrl), Emamectin benzoate 5% SG @ 220 g/ha (0.52/mrl) and Spinetoram 11.7% SC @ 450 ml/ha (0.32/mrl) had maximum count of lady bird beetle among all insecticides.

The data recorded on fourteenth day after average of two sprays revealed that, all the treatments were significantly differ with each other. The average number of coccinellid predators /mrl ranged from 0.09 to 0.58 in the insecticidal treatments as against 1.83 in untreated control. The treatments with chemical insecticides *viz.*, Chlorantraniliprole 18.5% SC 150 ml/ha, Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC @ 250 ml/ha and Lambda cyhalothrin5% EC @ 25 ml/ha recorded very less (0.27, 0.16 and 0.09/mrl) count of lady bird beetle, respectively, and Novaluron 5.25% + Emamectin benzoate 0.9% w/w SC @ 875 ml/ha (0.40/mrl), Emamectin benzoate 5% SG @ 220 g/ha (0.58/mrl) and Spinetoram 11.7%SC @ 450ml/ha (0.35/mrl) had highest count of lady bird beetle among all insecticides.

Effect of insecticides on spider population

Cumulative effect of chemical insecticides on Spider population (average of two sprays)

The average effect of all two sprays on the population of Spider on soybean is presented in Table 2 and depicted in Fig 2. The data revealed the significant difference among all treatments. The treatment without spray i.e., untreated control recorded significantly maximum number of 7.71, 8.73 and 8.81 Spider /mrl at 3, 7 and 14 days after spray, respectively.

The data recorded on third day after average of two sprays revealed that all the treatments were significantly differ with each other. The average number of Spider/mrl ranged from 0.10 to 5.88 in the insecticidal treatments as against 7.71 in untreated control. The treatments with chemical insecticides *viz.*, Lambda cyhalothrin 5% EC (0.13/mrl) and Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC @ 250 ml/ha (0.10/mrl) showed negative impact on spider, other treatments were not much harm to spiders as not have acaricidal properties like above two chemicals, so the Novaluron 5.25% + Emamectin benzoate 0.9% w/w SC @ 875 ml/ha (6.15/mrl), Emamectin benzoate 5% SG @ 220 g/ha(6.66), Chlorantraniliprole 18.5% SC 150 ml/ha (6.75) and Spinetoram 11.7% SC @ 450ml/ha (5.80) shown maximum number of spiders.

The data recorded on seventh day after average of two sprays revealed that the average number of Spiders/mrl ranged from 0.07 to 8.36/mrl in the insecticidal treatments as against 8.

73/mrl in untreated control. The Lambda cyhalothrin 5% EC (0.07/mrl) and Lambda cyhalothrin 4.6% ZC + Chlorantraniliprole 9.3% @ 250 ml/ha (0.37/mrl) shown a smaller number of spiders, while the Novaluron 5.25% + Emamectin benzoate 0.9% w/w SC @ 875 ml/ha (6.83/mrl), Chlorantraniliprole 18.5% SC 150 ml/ha (6.44/mrl), Emamectin benzoate 5% SG @ 220 g/ha (7.33/mrl), and Spinetoram 11.7% SC @ 450 ml/ha (8.36/mrl) shown maximum number of spiders.

The data recorded on fourteenth day after average of two sprays revealed that all the treatments were significantly differ with each other. The average number of Spider/mrl ranged from 0.22 to 7.76 in the insecticidal treatments as against 8.81 in untreated control. The treatments with chemical insecticides *viz.*, showed effect on spider as in such a way, The Lambda cyhalothrin 5% EC (0.59/mrl) and Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC @ 250 ml/ha (0.22/mrl) shown a smaller number of spiders, while the Novaluron 5.25% + Emamectin benzoate 0.9% w/w SC @ 875 ml/ha (5.21/mrl), Chlorantraniliprole 18.5% SC 150 ml/ha (6.5/mrl), Emamectin benzoate 5% SG @ 220 g/ha (7.26/mrl), and Spinetoram 11.7% SC @ 450 ml/ha (7.76/mrl) shown maximum number of spiders.

Table 2: Cumulative effect of different chemical insecticides on survival population of Spiders on soybean (average of two sprays)

Sr. No.	Treatment details	Dose formulated product g/ml/ha	Survival population of Spiders per meter row length at		
			3 DAS	7 DAS	14 DAS
T_1	Lambda cyhalothrin 4.6% + hlorantraniliprole 9.3% ZC	250 ml	0.10 (1.05)	0.37 (1.16)	0.22 (1.10)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% w/w SC	875 ml	6.15 (2.67)	6.83 (2.79)	5.21 (2.49)
T_3	Lambda cyhalothrin 5% EC	25 ml	0.13 (1.06)	0.07 (1.03)	0.59 (1.26)
T_4	Chlorantraniliprole 18.5% SC	150 ml	6.75 (2.78)	6.44 (2.72)	6.5 (2.73)
T_5	Emamectin benzoate 5% SG	220 gm	6.66 (2.76)	7.33 (2.88)	7.26 (2.87)
T_6	Spinetoram 11.7% SC	450 ml	5.80 (2.60)	8.36 (3.06)	7.76 (2.95)
T_7	Untreated	--	7.71 (2.95)	8.73 (3.11)	8.81 (3.13)
	SE +		0.32	0.44	0.30
	CD at 5%		0.98	1.36	0.92

DAS- Days after spray, Figures in parentheses indicate V_{n+1} transformed value,

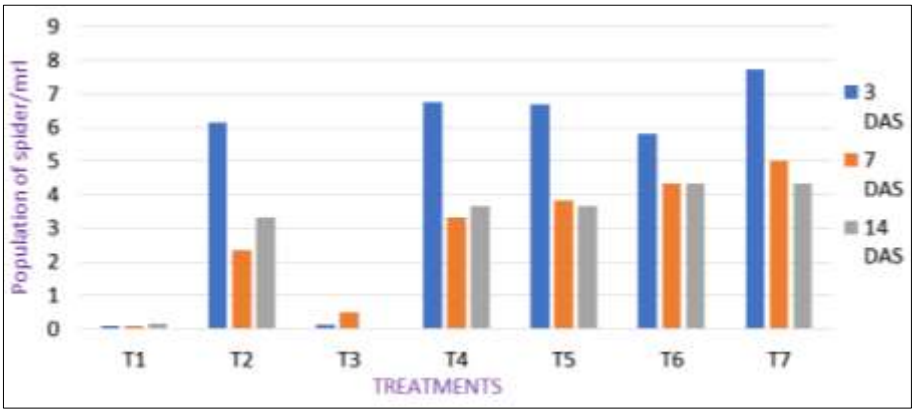

Fig 2: Survival population of spider per meter row length on soybean (Average of two spray)

Effect of insecticides on green lacewing population

Cumulative effect of chemical insecticides on green lacewing population (average of two sprays)

The average effect of all two sprays on the population of green lacewing on soybean is presented in Table 3 and depicted in Fig 3. The data revealed the significant difference among all treatments. The treatment without spray i.e., untreated control recorded significantly maximum number of 3.99, 4.00 and 3.00 green lacewing /mrl at 3, 7 and 14 days after spray, respectively.

Table 3: Cumulative effect of different chemical insecticides on survival population of green lacewing on soybean (average of two sprays)

Sr. No.	Treatment details	Dose formulated product g/ml/ha	Survival population of green lacewing per meter row length at		
			3DAS	7DAS	14DAS
T_1	Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC	250 ml	0.88 (1.37)	0.38 (1.17)	0.75 (1.32)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% w/w SC	875 ml	0.79 (1.33)	0.36 (1.16)	0.62 (1.27)
T_3	Lambda cyhalothrin 5% EC	25 ml	0.72 (1.31)	0.45 (1.20)	0.66 (1.28)
T_4	Chlorantraniliprole 18.5% SC	150 ml	0.45 (1.20)	0.42 (1.19)	0.55 (1.24)
T_5	Emamectin benzoate 5% SG	220 gm	0.99 (1.41)	0.88 (1.37)	0.94 (1.39)
T_6	Spinetoram 11.7% SC	450 ml	1.00 (1.41)	0.99 (1.41)	0.99 (1.41)
T_7	Untreated		3.99 (2.23)	4.00 (2.23)	3.50 (2.11)
	SE +		0.24	0.07	0.18
	CD at 5%		0.85	0.25	0.65

DAS- Days after spray, Figures in parentheses indicate V_{n+1} transformed value,

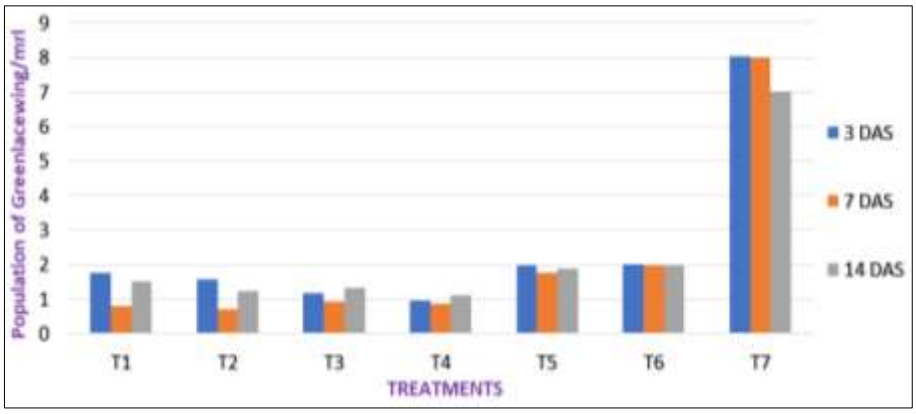

Fig 3: Survival population of green lacewing (grub & adult) per meter row (Average of two spray)

The data recorded on third day after average of two sprays revealed that, all the treatments were significantly differ with each other. The average number of green lacewing /mrl ranged from 0.45 to 1.00 and in the insecticidal treatments as against 3.99/mrl in untreated control. The treatments with chemical insecticides *viz*, were recorded number of green lacewings likewise., Chlorantraniliprole 18.5% SC @ 150 ml /ha, Lambda cyhalothrin 5% EC@ 25 ml/ha, Novaluron 5.25% + Emamectin benzoate 0.9% w/w SC @875 ml/ha, Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC @ 250 ml/ha, Emamectin benzoate 5% SG @ 220 g/ha (0.52/mrl) and Spinetoram 11.7%SC @ 450 ml/ha (0.45, 0.72, 0.79, 0.88, 0.79, 0.99 and 1.00/mrl), respectively.

The data recorded on seventh day after average of two sprays revealed that, the average number of green lacewing /mrl ranged from 0.36 to 0.99 in the insecticidal treatments as against 4.00 in untreated control. The treatments with chemical insecticides were recorded number of green lacewings likewise, Novaluron 5.25% + Emamectin benzoate 0.9% w/w SC @ 875 ml/ha, N Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC @ 250 ml/ha, Chlorantraniliprole 18.5% SC @ 150 ml /ha, Lambda cyhalothrin 5% EC @ 25 ml/ha, Emamectin benzoate 5% SG @ 220 g/ha (0.52/mrl) and Spinetoram 11.7% SC @ 450 ml/ha (0.36, 0.38, 0.42, 0.45, 0.99 &1.00), respectively.

The data recorded on fourteenth day after average of two sprays revealed that, all the treatments were significantly differ with each other. The average number of green lacewing /mrl ranged from 0.55 to 0.99 in the insecticidal treatments as against 3.50 in untreated control. The treatments with chemical insecticides showed effect on green lacewing as in such a way, Chlorantraniliprole 18.5% SC @ 150 ml /ha (0.55/mrl), Novaluron 5.25% + Emamectin benzoate 0.9% w/w SC @ 875 ml/ha (0.62/mrl),Lambda cyhalothrin 5% EC@ 25ml/ha (0.66/mrl), Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC @ 250 ml/ha (0.75/mrl), Emamectin benzoate 5% SG @ 220 g/ha (0.94 /mrl) and Spinetoram 11.7% SC @ 450 ml/ha (0.99/mrl).

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