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DIVERSITY OF INVERTEBRATES UNDER INSECTICIDE AND BIOPESTICIDE TREATMENTS IN BRINJAL AGROECOSYSTEM

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ABSTRACT

In an agroecosystem, knowledge of population ecology of invertebrates is of utmost importance to understand various relationships between crop plants, insects and its natural enemies. The present study was conducted to observe the effect of different biopesticides and insecticides on insect fauna in brinjal crop. Results revealed occurrence of 15 species of phytophagous arthropods belonging to five orders, Hemiptera, Coleoptera, Lepidoptera, Orthoptera and Succineidae, being highest from order Hemiptera. Similarly, 12 species of predators belonging to six orders (Araneae, Diptera, Dictyoptera, Neuroptera, Odonata and Coleoptera) were reported being highest in Coleoptera. Lower phytophagous population was recorded in insecticide treated fields as compared to biopesticides and control fields. However, higher predator population was recorded in biopesticide treated fields as compared to insecticide treatments as evidenced by calculation of diversity indices. Thus, the use of biopesticides is the best eco-friendly alternative that reduces phytophagous invertebrate population and encourages population of natural enemies.

Keywords: Biopesticides, Brinjal, Insecticides, Phytophagous, Predators

Brinjal (*Solanum melongena* L.) is a principal and vital vegetable crop widely grown throughout the world which contains different components belonging to different classes of alkaloid, flavonoid, palmitic, oleic and linoleic acids (Sathe *et al.,* 2016; Yadav *et al.,* 2010). India is third in production of brinjal after potato and tomato (Raza *et al.,* 2018). Total area under brinjal cultivation in India is 728 thousand hectares with an annual production of 12660 metric tons (Anonymous 2019a). In Punjab, the area under cultivation is 5.83 thousand hectares with an annual production of 126.57 metric tons (Anonymous, 2019b). Brinjal crop is attacked by many arthropod species, of which brinjal shoot and fruit borer, leafhopper, aphid, stem borer, epilachna beetle, white fly and green lacewing bug are the major phytophagous pests. Farmers over exploited the pesticides with an aim to get high yield but in return disturbed the ecological balance. It leads to the development of resistance by target pests and environmental problems (Pedigo, 2002). Biological control methods should be given more importance as these are more feasible, economical and environmentally safer and thus, a good alternative in sustainable agriculture. Among biological control agents of pests, coccinellids are of great economic importance as they are predaceous both in their larval and adult stages on various crop pests such as aphids, coccids and other soft bodied insects (Giorgi *et al.,* 2009, Navntoft *et al.,* 2006) accounted that non target arthropods were killed due to insecticides that affected population of both phytophagous arthropods and predators. Sathe (2014) reported that biological control is eco-friendly and safer to humans on edible crops hence, more emphasis should be given on natural and biological control. The present study was proposed to provide more detailed and consolidated account of invertebrate abundance and diversity present under both insecticides and biopesticides sprayed conditions. To accomplish this, the objectives of the present study were to study abundance and diversity of invertebrates on brinjal crop field under insecticides and biopesticides sprayed conditions.

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MATERIALS AND METHODS

Selection of site

The field experiment was conducted in randomized block design, replicated thrice with four insecticides and three biopesticide treatments along with control (untreated field).The brinjal (variety *Punjab Neelam*) was planted in a plot size of 3×4 m. To obtain well pulverized experimental field, the field was prepared by ploughing followed by harrowing and planking. The field was leveled and divided into plots as per layout plan, after which transplantation was done in mid July, 2019 with the recommended spacing of row to row (60 cm) and plant to plant (50 cm). All the recommended agronomic practices were followed to raise the brinjal crop.

Chemicals used

Different insecticides used in the study were quinalphos (1.75 ml/l), fenoprop (1 ml/l), indoxacarb (0.75 ml/l) and propoxur (0.4 ml/l). The biopesticides used were neem Baan (@ 10000 ppm), fungus *Beauveria bassiana* (@ 5 g/l) and delfin (@3 g/l (*Bt* formulation). Both insecticides and biopesticides were applied with the help of knapsack sprayer. Treatments were allocated to different plots on random basis. Spraying schedule for application of insecticides and biopesticides was as follows: 1st Spray: 2nd week of August 2019, biopesticide: Neembhan @10000ppm; insecticide: quinalphos @1.75ml/l, fenoprop @1 ml/l, 2nd Spray: 1st week of September 2019 Biopesticide: *Bt* (*Beauveria bassiana*) @5g/l and dolphin @3g/l; Insecticide: propoxur @ 0.4 ml/l, indoxacarb @0.75ml/l. Same schedule was followed for 3rd and 4th Spray of biopesticides and insecticides in 2nd week of October and 1st week of November, respectively.

Data collection

In each plot, five plants were selected randomly from all the four geographical sides as well as from the centre of the plot. The leaves as well as other parts of plant along with the soil were searched to record arthropods and non-arthropods in brinjal crop. The specimens were collected throughout the season at fortnightly intervals. The collection was done during morning hours (7:00 am–10:00 am). Different methods used for collection were visual searching and sweeping net method. Specimens were killed by using ethyl acetate in killing bottle and were mounted in insect boxes using standard procedure. In 70% ethanol, small and soft bodied arthropod specimens were preserved. Specimens were then identified by using identification keys (Choate, 2003; Nair, 1995, Rajendran *et al.,* 2018).

Measurement of diversity index: Shannon–Weiner diversity index

The Shannon-Weiner index for the samples was calculated by applying $H' = \sum P_i \ln P_i$

Here, P_i – the fraction of individual in the i^{th}

H'– it calculates the index with the help of natural logarithm

Relative abundance

The relative abundance was calculated by using formula: $RA = N_i/N \times 100$

Here, N_i is the number of arthropods and non arthropods of i^{th} species

N is total number of arthropods and non arthropods recorded

Statistical analysis

Data was represented as Mean ± SE. Significance of differences between arthropod and non-arthropod population in insecticides and biopesticides sprayed fields of brinjal crop in different months of season were assessed using one way ANOVA and Tukey HSD posthoc test.

RESULTS AND DISCUSSION

Phytophagous pests

Population count of invertebrates was recorded in both treated and control plots in the order control> biopesticide> insecticide). The results from survey revealed the occurrence of fifteen species of phytophagous arthropods belonging to five orders namely Hemiptera, Coleoptera, Lepidoptera, Orthoptera and Succineidae, being highest from order Hemiptera (Table 1). The data revealed that abundance of phytophagous arthropods and non-arthropods ranged between 0.04±0.09 to 12.95±14.47 in control fields; 0.02±0.03 to 8.67 ± 9.79 in biopesticide treated fields and 0.00±0.00 to 4.58 ± 7.04 in insecticide treated fields (Table 2). Among them, jassids showed the highest abundance in all the three selected fields while rice bug showed the lowest abundance. Shannon-Weiner diversity index of phytophagous insects calculated was maximum (1.40) in control field followed by biopesticide treated (1.39) fields and insecticide treated (1.10) fields (Table 3). Prasad and Devappa (2006) observed that application of biopesticide is an effective way in suppressing the larval population of jassids, fruit borers and other phytophagous insect pests infesting vegetable crops. Extracts of neem (*Azadirachta indica*), safeda (*Eucalyptus* sp.), hing (*Asfoetida* sp.) and dhatoora (thorn apple) are also very efficient for controlling the sucking pests. Among biopesticides, *Bacillus thuringiensis* was also found to be effective against the population of sucking insects (Borkakati 2019). Ursani *et al.* (2019) reported that the chemical control were highly effective to control the population of whitefly and jassid on brinjal crop.

Predators

The data revealed the occurrence of 12 species of predators belonging to six orders [Araneae, Diptera, Dictyoptera, Neuroptera, Odonata and Coleoptera] and eight families (Table 1). The abundance of predators ranged between 0.07±0.12 to 2.21±1.40 in control field, 0.04 ± 0.08 to 2.15 ±1.40 in biopesticide treated fields and 0.00±0.00 to 0.19±0.27 in insecticide treated fields. Among predators, maximum abundance was of lady bird beetle and spider was recorded while minimum abundance was of damselfly (Table 4). Shannon – Weiner diversity index of predators calculated was maximum (1.81) in control field followed by biopesticide treated (1.77) fields and in insecticide treated (1.67)

Table 1. List of phytophagous arthropods recorded in brinjal crop

	Phytophagous arthropods			
S. No.	**Common Name**	**Scientific Name**	**Order**	**Family**
1.	Jassid	*Amrasca biguttula*	Hemiptera	Cicadellidae
2.	White fly	*Bemisia tabaci*	Hemiptera	Aleyrodidae
3.	Red cotton bug	*Dydercus cingulatus*	Hemiptera	Pyrrhocoridae
4.	Rice bug	*Leptocorisa acuta*	Hemiptera	Coniedae
5.	Green stink bug	*Nezara viridula*	Hemiptera	Pentatomidae
6.	Sugarcane planthopper	*Pyrilla perpusilla*	Hemiptera	Lophopidae
7.	Tree hopper	*Oxyrachis tarandus*	Hemiptera	Membracidae
8.	Hadda beetle	*Epilachna punctata*	Coleoptera	Coccinellidae
9.	Blister beetle	*Zonabrispha larata*	Coleoptera	Meloidae
10.	Chaffer beetle	*Oxycetonia versicolor*	Coleoptera	Scarabaeidae
11	Red pumpkin beetle	*Raphidopalpa foveicolis*	Lepidoptera	Chrysomelidae
12.	Brinjal fruit and shoot borer	*Leucinoides orbonalis*	Lepidoptera	Pyralidae
13.	Leaf roller	*Eublemma olivacea*	Lepidoptera	Crambidae
14.	Grasshopper	*Actractomorpha crenulata*	Orthoptera	Acrididae
15.	Snail	*Succinea putris*	Succineidae	Stylommatophora
Predators				
16.	Rove beetle	Paederusfuscipes	Coleoptera	Staphylinidae
17.	Syrphid fly	*Helophiluspendulus*	Diptera	Syrphidae
18.	Praying mantid	*Stagnomantiscarolina*	Dictyoptera	Mantidea
19.	Spider	*Neoscona theisi* *Oyyopes birmanicus*	Araneae	Oxypidae
20.	Green lacewing	*Chrysoperla carnea*	Neuroptera	Chrysopidae
21.	Damselfly	*Ischnura aurora*	Odonata	Coenagrionidae
22.	Dragonfly	*Crocothemis servilia*	Odonata	Libellulidae
23.	Lady bird beetle	Cheilomenes sexmaculata, *Coccinella septempunctata,* *Coccinella transversalis,* *Brumoides suturalis*	Coleoptera	Coccinellidae

fields (Table 3). The present study revealed that lady bird beetle, syrphid fly and spiders have good potential to control the pests of brinjal crop (Table 4). Arachnid and Coleoptera occupied 42.44% and 30.23% of the total plant dwelling predators, respectively (Latif *et al.,* 2009). The use of biopesticides is environmentally safe and also supported and maintained the population of predators in crop fields. Population of predators was not affected significantly by application of neem seed extract because predators are not phytophagous like other insects (Aziz *et al.,* 2019). The study revealed that plant based biopesticides is a good alternative to different insecticides like organophosphates and organochlorines which have ill effects on environment. Also *Bt* biopesticides do not have broad spectrum of activity, so they do not harm beneficial arthropods.

Population of predators was reduced significantly by application of insecticides (Table 4), this could be due to the use of broad spectrum action of insecticides which not only kill the target pests but also affected non-target invertebrate species, causing reduction in abundance and activity of natural enemies (predators). Grundy *et al.* (2000) also found that persistence of pesticides have serious negative impacts on natural enemies in the field crops.

Shannon Weiner diversity index of arthropods and non arthropods

Control field had diversity index of 36% and biopesticide treated field had diversity index of 35.90% whereas insecticide treated field had diversity index of 28.20% for phytophagous pests (Fig. 1). Diversity index for predators in control field was 34.48% whereas biopesticide treated field had diversity index of 33.71%

Table 2. **Mean population of different phytophagous arthropods under insecticide and biopesticide treatments in brinjal crop**

Month→ Treatment↓	July (2)	Aug (1)	Aug (2)	Sep (1)	Sep (2)	Oct (1)	Oct (2)	Nov (1)	Nov (2)	Dec (1)	Total mean population	% Reduction over control
Jassid												
Control	0.00	33.46	30.80	32.93	29.86	12.73	7.80	6.93	0.93	0.00	12.95± 14.47[a]	-
Biopesticide	0.00	29.60	19.40	14.06	17.06	11.93	6.80	5.13	0.00	0.00	8.67±9.79[a]	33.11
Insecticide	0.00	23.40	7.66	6.33	8.13	9.13	0.26	0.00	0.00	0.00	4.58±7.04[b]	64.67
Whitefly												
Control	7.53	9.46	11.13	12.66	18.25	8.73	7.93	9.06	0.53	0	7.11± 5.87[a]	-
Biopesticide	8.06	9	8.13	9.06	15.06	8.4	7.06	6.06	0.33	0	5.93± 4.83[ab]	16.56
Insecticide	2	7.06	2.46	3.86	0	6	2.53	0.13	0	0	2.00± 2.51[b]	71.81
Green stink bug												
Control	0	0.2	0.6	0.86	1.33	0.93	1.06	0.4	0	0	0.45±0.49[a]	-
Biopesticide	0	0	0.46	0.8	1.06	1	0.8	0.33	0	0	0.37±0.43[a]	17.29
Insecticide	0	0	0.13	0.2	0.46	0	0.13	0	0	0	0.08±0.14[a]	82.90
Red cotton bug												
Control	0	0	0	0.73	0.2	0.26	0	0.06	0	0	0.10± 0.22[a]	-
Biopesticide	0	0	0.13	0.13	0.26	0	0	0	0	0	0.04± 0.08[a]	58.40
Insecticide	0	0	0.33	0	0	0.06	0	0	0	0	0.03± 0.10[a]	68.80
Rice bug												
Control	0	0	0.26	0	0	0.2	0	0	0	0	0.04±0.09[a]	-
Biopesticide	0	0	0.06	0	0.06	0.06	0	0	0	0	0.02±0.03[a]	60.87
Insecticide	0	0	0	0	0	0	0	0	0	0	0.00±0.00[a]	100.00
Pyrilla												
Control	0	0.13	0.33	0.06	0	0.26	0	0	0	0	0.07±0.12[a]	-
Biopesticide	0	0.06	0	0.2	0.13	0	0	0	0	0	0.03±0.07[a]	50.00
Insecticide	0	0.06	0	0	0	0	0	0	0	0	0.01±0.02[a]	92.31
Tree hopper												
Control	0.26	0.93	1.33	1.53	1.8	1.33	0.33	0	0	0	0.63±0.70[a]	-
Biopesticide	0.13	0.8	1	1	1.53	0.33	0.26	0	0	0	0.42±0.53[ab]	32.76
Insecticide	0.2	0.6	0.13	0	0	0	0	0	0	0	0.08±0.18[b]	87.62
Hadda beetle												
Control	0	4.06	3.13	4.93	5.06	4.53	2.86	1.12	0.26	0.13	2.18± 2.12[a]	-
Biopesticide	0	4	2.93	3.06	2.13	3.06	2.06	1	0.2	0.06	1.54± 1.50[ab]	29.06
Insecticide	0	3.13	1.06	0	0	1	0.46	0.26	0	0	0.49± 0.92[b]	77.34
Blister beetle												
Control	0	0	0.46	0.66	0.4	0.2	0.26	0	0	0	0.17± 0.23[a]	-
Biopesticide	0	0	0.4	0.46	0.13	0.13	0.06	0	0	0	0.10±0.16[a]	40.40
Insecticide	0	0	0	0	0	0.06	0	0	0.06	0	0.01± 0.02[a]	93.94
Chaffer beetle												
Control	0	0.86	1.06	0.8	1.4	0.73	0.46	0.2	0.06	0	0.46±0.49[a]	-
Biopesticide	0	0.73	1	0.93	1.2	0	0.33	0.2	0	0	0.37±0.47[ab]	21.18
Insecticide	0	0.33	0.2	0	0	0	0	0	0	0	0.04± 0.11[b]	90.48
Brinjal shoot and fruit borer												
Control	0	0	0	0.26	0.26	0.13	0	0.13	0.13	0	0.08± 0.10[a]	-
Biopesticide	0	0	0.06	0.13	0.33	0.26	0.06	0	0	0	0.07± 0.11[a]	7.69
Insecticide	0	0	0.13	0	0	0.06	0.06	0	0	0	0.02± 0.04[a]	72.53
Leaf roller												
Control	0	0.33	0.8	0.46	1.13	0.26	0.4	0.53	0.2	0	0.34± 0.35[a]	-
Biopesticide	0	0.4	0.66	0.4	1	0.33	0.26	0.6	0.26	0	0.33± 0.31[a]	4.87
Insecticide	0	0.53	0.33	0	0	0.06	0	0	0	0	0.08± 0.17[a]	77.62
Red pumpkin beetle												
Control	0	0.46	0.2	0.33	1.06	1.46	0.86	0.13	0.2	0	0.39± 0.48[a]	-
Biopesticide	0	0.53	0.26	0.26	0.53	0.33	0.06	0	0	0	0.16± 0.21[ab]	58.09
Insecticide	0	0.13	0.13	0	0	0.26	0	0	0	0	0.04± 0.08[b]	88.94
Grasshopper												
Control	0	0	0.26	0.4	0.33	0.53	0.13	0.13	0.2	0	0.17± 0.18[a]	-
Biopesticide	0	0	0.2	0.53	0.2	0.06	0	0.13	0.13	0	0.10± 0.16[ab]	36.87
Insecticide	0	0	0	0.13	0	0.06	0	0	0	0	0.02± 0.04[b]	90.40
Snail												
Control	0	0.4	0.86	0.33	0.86	0.06	0	0	0	0	0.21 ±0.33[a]	-
Biopesticide	0	0	0.53	0.13	0.66	0	0	0	0	0	0.11±0.23[a]	47.41
Insecticide	0	0.06	0	0	0	0	0	0	0	0	0.01 ±0.02[a]	97.61

(1) - First fortnight (2) - Second fortnight. Values followed by different superscripts are significantly different ($p<0.05$)

Table 3. Shannon Weiner diversity index of phytophagous arthropods at different fields of brinjal crop

Phytophagous arthropods	
Field	**Shannon Weiner diversity index**
Control	1.40
Biopesticide	1.39
Insecticide	1.10
Predators	
Control	1.81
Biopesticide	1.77
Insecticide	1.67

Table 4. Mean population count of different predators under insecticides and biopesticides sprayed conditions in brinjal crop

Month→ Treatment↓	July (2)	Aug (1)	Aug (2)	Sep (1)	Sep (2)	Oct (1)	Oct (2)	Nov (1)	Nov (2)	Dec (1)	Total mean population
Lady bird beetle											
Control	0.00	0.00	0.80	0.33	0.53	1.80	2.20	3.93	3.20	2.40	1.34±1.34 [a]
Biopesticide	0.00	0.00	0.73	2.13	2.06	1.93	2.33	4.13	2.46	1.80	1.50±1.28 [a]
Chemical	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.03±0.06 [b]
Rove beetle											
Control	0.00	0.00	0.33	0.86	1.13	1.06	0.66	0.26	0.00	0.00	0.36±0.45 [a]
Biopesticide	0.00	0.13	0.13	0.56	0.80	0.33	0.40	0.20	0.00	0.00	0.21±0.26 [ab]
Chemical	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02±0.06 [b]
Syrphid fly											
Control	0.73	0.93	1.33	1.46	2.13	0.00	0.46	0.73	0.66	0.46	0.74±0.65 [a]
Biopesticide	0.53	0.46	1.40	1.33	2.06	0.06	0.53	0.66	0.53	0.20	0.65±0.64 [a]
Chemical	0.33	0.46	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08±0.16 [b]
Drangonfly											
Control	0.86	1.46	0.93	1.73	1.06	0.40	0.00	0.00	0.00	0.00	0.54±0.64 [a]
Biopesticide	0.80	1.40	1.00	1.93	1.73	0.33	0.13	0.00	0.00	0.00	0.61±0.74 [a]
Chemical	0.66	0.40	0.66	0.40	0.20	0.00	0.00	0.00	0.00	0.00	0.19±0.27 [a]
Damselfly											
Control	0.00	0.00	0.06	0.06	0.20	0.40	0.13	0.00	0.00	0.00	0.07±0.12 [a]
Biopesticide	0.00	0.00	0.00	0.13	0.06	0.26	0.00	0.00	0.00	0.00	0.04±0.08 [a]
Chemical	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00±0.00 [a]
Spider											
Control	0.53	1.13	2.33	2.73	2.06	3.00	3.66	3.86	3.33	3.20	2.21±1.32 [a]
Biopesticide	0.40	0.86	2.20	2.93	2.13	3.46	3.73	4.06	3.20	2.26	2.15±1.40 [a]
Chemical	0.20	0.20	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07±0.14 [b]
Praying mantid											
Control	0.00	0.00	0.06	0.13	0.26	0.20	0.33	0.00	0.06	0.00	0.09±0.12 [ab]
Biopesticide	0.00	0.00	0.00	0.20	0.33	0.26	0.46	0.13	0.13	0.00	0.13±0.16 [a]
Chemical	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01±0.02 [b]
Green lacewing											
Control	0.00	0.00	0.00	0.26	0.66	1.06	0.73	0.40	0.66	0.00	0.31±0.38 [ab]
Biopesticide	0.00	0.00	0.06	0.93	1.06	1.00	0.80	0.53	0.46	0.13	0.41±0.44 [a]
Chemical	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01±0.04 [b]

(1) - First fortnight (2) - Second fortnight. Values followed by different superscripts are significantly different ($p<0.05$)

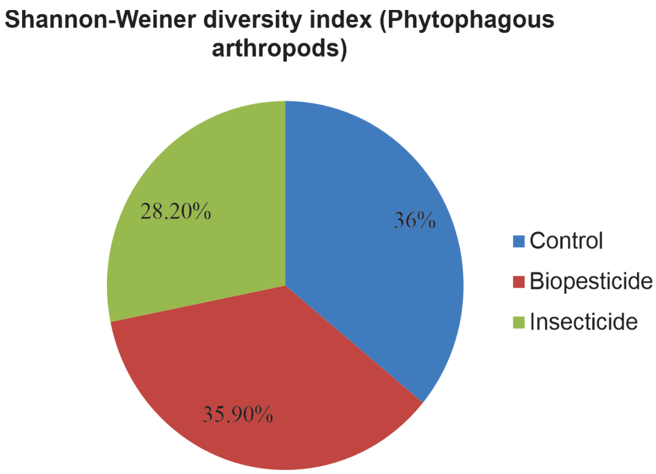

Fig. 1. Shannon Weiner diversity index of phytophagous arthropods at different treated fields of brinjal crop

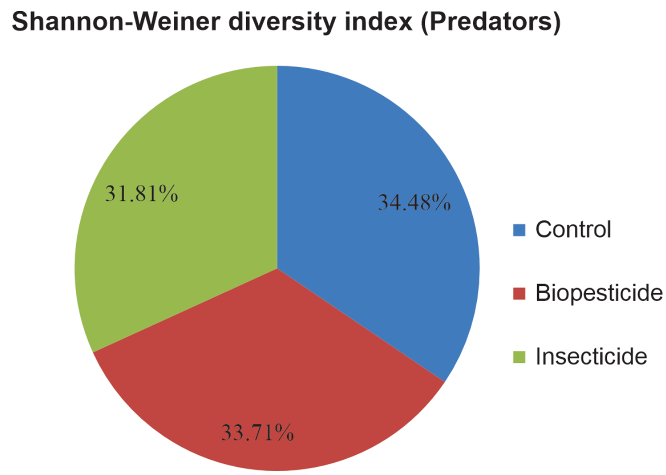

Fig. 2. Shannon-Weiner diversity index of predators at different treated fields of brinjal crop

(Fig. 2). Shannon Weiner diversity index revealed that higher invertebrates (arthropod and non-arthropod) diversity was recorded in the unsprayed field than the sprayed field. Our findings are in accordance with Anbalagan *et al.* (2015). Kousika and Kuttalam (2020) also found that insecticides reduce the population of natural enemies.

Lower population of phytophagous arthropods and predators were recorded in insecticide treated field as compared to biopesticide and unsprayed fields. The biopesticides showed moderate efficacy against target phytophagous arthropods as compared to insecticide treated field, but it maintained predatory population. Thus, population of phytophagous arthropods can be minimized or controlled by the use of biopesticide spray programme, which is safe for environment as well for natural predators.

Authors' contribution

Conceptualization of research work and designing of experiments (RKA, RS); Execution of field/lab experiments and data collection (RK); Data analysis and interpretation of results (RK, RKA, RS); Preparation of manuscript (RK, RKA)

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