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Non-Target Effects of Chemical and Biopesticides on Spiders

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Abstract: Spiders have significant role in ecosystem as biological pest control agent.The usage of chemical and biopesticides in agriculture effects the non-targeted organisms also.This study is to disclose the effects of synthetic and organic pesticides on spiders.Two spider species Crossopriza iyoni and Cyclosa hexatuberculatawere used for the experiment.Spiders were collected from agricultural field using hand picking method, sweep netting method and inverted umbrella method. Collected spiders were feeded and cared.Two spiders were exposed to three different concentrations (20, 30, 40 ppm) of Thiamethoxam (chemical pesticide) and Nimbecidine (biopesticide) along with control for 5 hours.Number of dead spiders counted at the end of experiment and % mortality calculated. LC 50 calculated using Microsoft Excel 2019. Both the pesticides adversely affect the population of spiders. Lethality of Nimbecidinewas less than Thiamethoxam.C. iyoni was more sensitive to both the pesticides.C. hexatuberculata was slightly tolerant to the pesticides. This study reveals that time is up to switch toimplement strategies for targeted pest control for conserving biodiversity.

Key words: 1. Crossopriza iyoni, 2. Cyclosa hexatuberculata,3.Thiamethoxam, 4. Nimbecidine,5. Toxicity, 6. Lethality.

Introduction

Spiders are the seventh largest group of animals belonging to phylum Arthropoda, class Arachnida and order Araneae. A total of 52,154 species of spiders belonging to 4,385 genera of 135 families have been described all over the world(WSC, 2024),out of which about 2,245 species have been reported from India(Singhetal,2023).

Spiders are terrestrial predators and the most successful venomous animals. Spiders are divided into two groups based on the predatory role as "Web-weavers" (Construct the web and hunt the prey caught in the web) and "Active hunter" (Hunts the prey by searching). Their remarkable success is due in large part to their ingenious exploitation of silk and the evolution of pharmacologically complex venoms that ensure rapid subjugation of prey(Saez et al, 2010). The spiders which are already present in all agroecosystems may have a profound influence on the pests of crops. All spiders are predators and most of them consume the agricultural pests of men they are very important in controlling the population of insect pests and thus act as bioindicators(Sharma et al, 2010).

Recently, many efforts have been made to combine various non-chemical control methods with insecticides in systems of Integrated Pest Management (IPM). One such effort is the use of natural enemies, like spiders to combat pest population. Spiders undoubtedly have a direct impact on human affairs because insects constitute their major source of prey, thus spiders regulate insect pest populations in natural and agricultural ecosystems. Spiders have a higher host finding ability and capacity to consume a greater number of prey than other fields inhabiting predators(Kamal et al, 1990).

Crossopriza iyoni and Cyclosa hexatuberculata were reported in several diversity studies in agricultural field(Guruswamy et al, 2023 and Shabnam et al, 2021). C. lyoni found as an important component of integrated control of Aedes aegypti and help reduce dengue transmission(Jenias et al, 2018).Spiders may be potential biocontrol agents because they are relatively long lived and are resistant to starvation and desiccation(Sarma et al, 2013).These beautiful and magnificent creatures are considered to be effective biological indicators of different habitats indulging agroecosystems(Rajashekhar et al, 2020).The present study is to compare the effect of two pesticides on two different species of spidersand also disclose the impact of unscientific usage of chemical andbiopesticides on non-target organisms like spiders.

Materials and methods

Study Area

The spider samples were collected from vellangallur (10.30 N and 76.20 E),28 km south of Thrissur.

Collection of spiders

The collection of spiders was done from the agriculture field. It was six months study. Active searching and handpicking were the most important method adopted for collection. Active searching on the ground as well as on the plant was done. The whole plant was carefully examined for spiders. Occasionally sweep netting and inverted umbrella methods were also performed to collect spiders from the top of the leaves of banana plants.

a. Hand-picking method: The collection of most web building and surface-dwelling spiders was made by direct handpicking with the help of test tubes.

b. Sweep netting method: A sweep net is made with cotton fabric. It is rugged enough not to be torn by leaves and other vegetation while sweeping. We can drag it and after dragging we can get a good sample of spiders. Spiders that fell into the net were easily collected before they escaped. Some other Arthropods also fell into the net while sweeping was separated.

c. Inverted umbrella method: in this method an inverted umbrella is placed below the plant and when the plant is shaken, spiders along with insects fall into an inverted umbrella. Then spiders are transferred into collecting tubes. The selected spiders were transferred to plastic specimen vials and taken to the lab.

Photographs were taken, identified and scientific labelling of the specimen was done and kept in the lab for rearing.

Keeping of spiders

Crossopriza iyoni (Blackwall, 1867) and Cyclosa hexatuberculata(Tikader, 1982)were selected for the present study. The spiders collected were kept in a glass jar which corresponds to the size of the web they make. The bottom of the jar was provided with clean, sterilized and moist sand and the top of the jar was covered with a muslin cloth periodically water was sprayed over the cloth which helped to keep the sand moist and maintain proper humidity inside the jar.

Feeding of spiders

All spiders are carnivorous and they should feed exclusively with live moving prey. They should feed on a variety of insects for ensuring optimum growth. The main insects used as feed were odonates, larvae of beetles, grasshoppers. The live prey was introduced to the glass jar and the remaining after feeding was removed every day.

Study of the effect of pesticides

Two pesticides were selected for the study. The synthetic pesticide was Thiamethoxam. It is a neonicotinoid Insecticide used widely in agriculture to control a broad spectrum of chewing and sucking insect pests. It is a contact and systemic pesticide used against pests like stem Borer, Gall midge, Leaf Folder, es of crops like paddy, wheat, cotton and vegetables. The biopesticide used was Nimbecidine, which was Azadirachtin based organic pesticide used againstwhiteflies, aphids, thrips, mealy bugs, caterpillars, leafhoppers etc. Three different concentrations (20 ppm, 30 ppm, 40 ppm) of both the pesticides were prepared. Six spiders of the same size and sex are taken in four Petri plates. Each of the groups is exposed to one of the solutions of the pesticide prepared. One petri plate is kept as control and is sprayed with distilled water. The number of dead spiders in each Petri plate is counted after 5 hours of exposure to the pesticide. The same procedure was repeated for the second pesticide and second spider species also.

Calculation and Statistical analysis

$$\% \text{ Mortality} = \frac{\text{Number of deaths}}{\text{Total population}} \times 100$$

LC 50 is calculated using Microsoft Excel 2019.

Results and discussion

The present study reveals that when concentration increases mortality rate also increases.The mortality rate of synthetic pesticide was much more than organic pesticide in both the spider species.C.iyoniwas more sensitive(Table.3, 4., Figure. 3, 4) to both the chemical and biopesticides compared to C. hexatuberculata.The toxicity tolerance of C. hexatuberculata was slightly more thanC. iyoni (Table. 1, 2., Figure. 1, 2).

Pesticides tend to disturb the spider population. Spiders play a main role in natural bio-pest control in agricultural fields. Sustenance of spider diversity and spider conservation is paramount to check the insect population, especially in agricultural fields or otherwise the pest would ruin the agricultural field. Spiders by instinct know the clever way of feeding on insects to control the insect population. Spiders are so diversified and have adapted to live in all sorts of habitats, including deserts, rain forests, and even urban areas. They are used as a model organism in ecology, behaviour, they provide silk for material research and venom. Spiders are natural predators that feed on insects, so they can help to control pests without the use of chemicals. Spiders work hand in hand with organic pesticides. Spiders that occur in agroecosystem are often heavily affected by pesticide applications. Insecticides and acaricides, when applied at the recommended concentration and dose, usually cause acute toxicity, while herbicides and fungicides are relatively harmless. Sublethal doses affect a number of life-history traits: movement, dispersal, predation rate, web building, mating, oviposition, fecundity, ontogenetic development, defence, and physiological processes such as enzymatic activities and water loss. Spiders are highly sensitive to different insecticides in laboratory conditions. Susceptibility of spider species (Crossopriza iyoni and Cyclosa hexatuberculata) against two pesticides (Thiomethaxam and Nimbecidene) was investigated in the laboratory. The pesticides are found to be having lethal effects on both species of spiders. The percentage mortality of the same species of the spider for the same concentration is found to be higher for Thiomethoxam than Nimbecidine. Approximately half concentrationof pesticide was enough to kill 50% population. Toxicity to spiders ranged from less mortality for herbicides to medium mortality for pyrethroid and organophosphate and to high mortality for cyclocompounds(Tietjen and Cady, 2007).To conserve and enhance spider populations, agricultural systems should be manipulated in ways beneficial to the needs of the spiders(Sarma et al, 2013).The results of the present study showed that residual toxicity of Thiamethoxam Nimbecidine was higher than Nimbecidine. The post spray exposure showed that reduction in mortality was much steeper in Nimbecidine than Thiamethoxam. The difference in mortality may be due to difference in the interaction of pesticides with the substrate and environment in the field. Toxicity of Thiamethoxam was higher than Nimbecidine in topical and residual toxicity. However, neonicotinoid was proved toxic for both species. The susceptibility of C. iyoni was more compared to other. The difference in the

susceptibility may be due to difference in the insecticide detoxifying enzymes. The C. iyoni is found to be more sensitive to both pesticides than C. hexatuberculata.

Table1. Effect of Thiomethoxam on C. hexatuberculata.

Concentration in ppm	% Mortality in set 1	% Mortality in set 2	% Mortality in set 3	Mean % Mortality
0	0	0	0	0
20	17	0	17	17
30	33	33	33	33
40	83	67	83	78

Figure 1. Graph showing toxicity of Thiomethoxam on C. hexatuberculata.

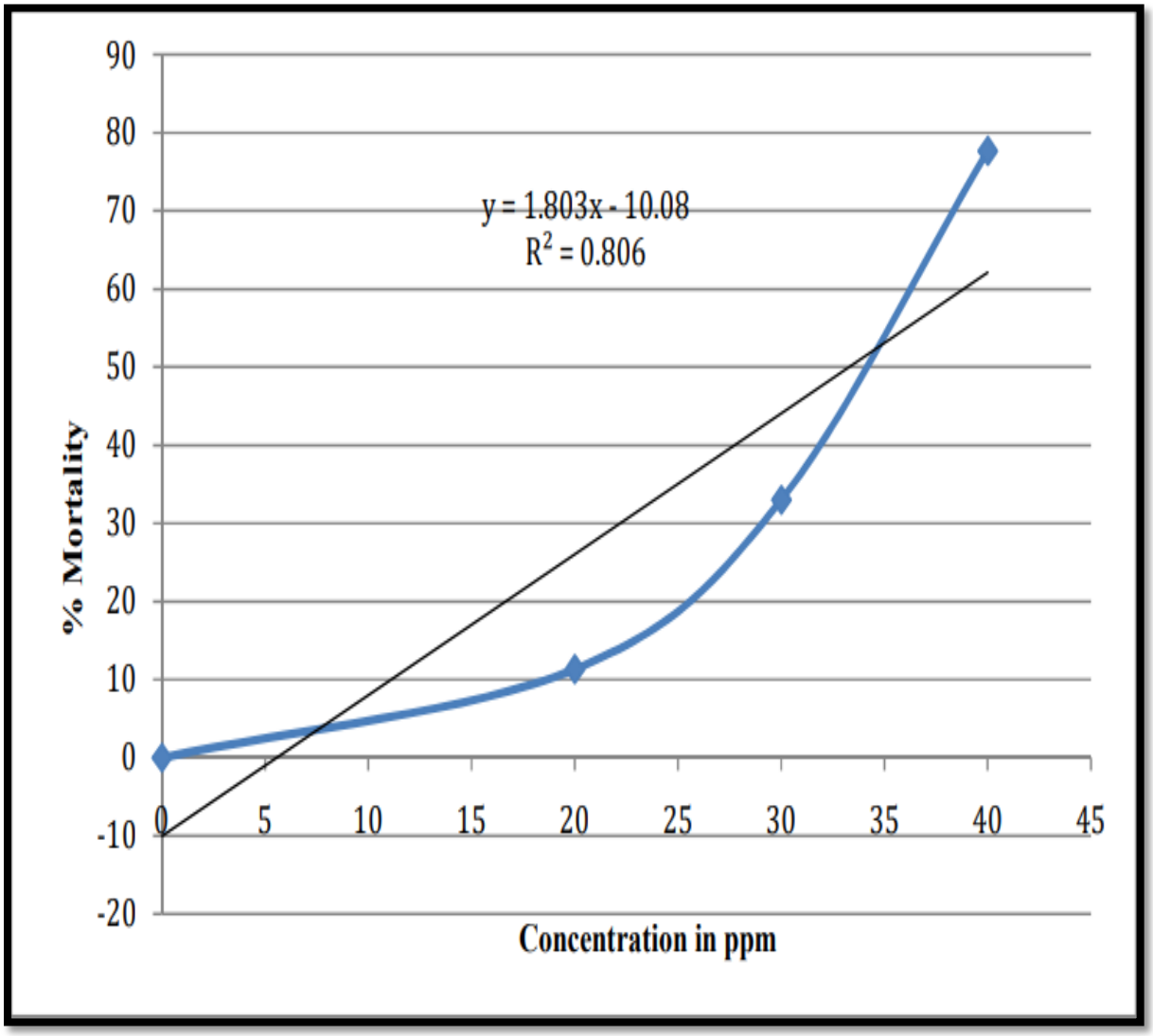


Table 2. Effect of Nimbecidine on C. hexatuberculata.

Concentration in ppm	% Mortality in set 1	% Mortality in set 2	% Mortality in set 3	Mean % Mortality
0	0	0	0	0
20	0	0	0	0
30	17	17	17	17
40	33	17	33	28

Figure 2. Graph showing toxicity of Nimbecidine on C. hexatuberculata.

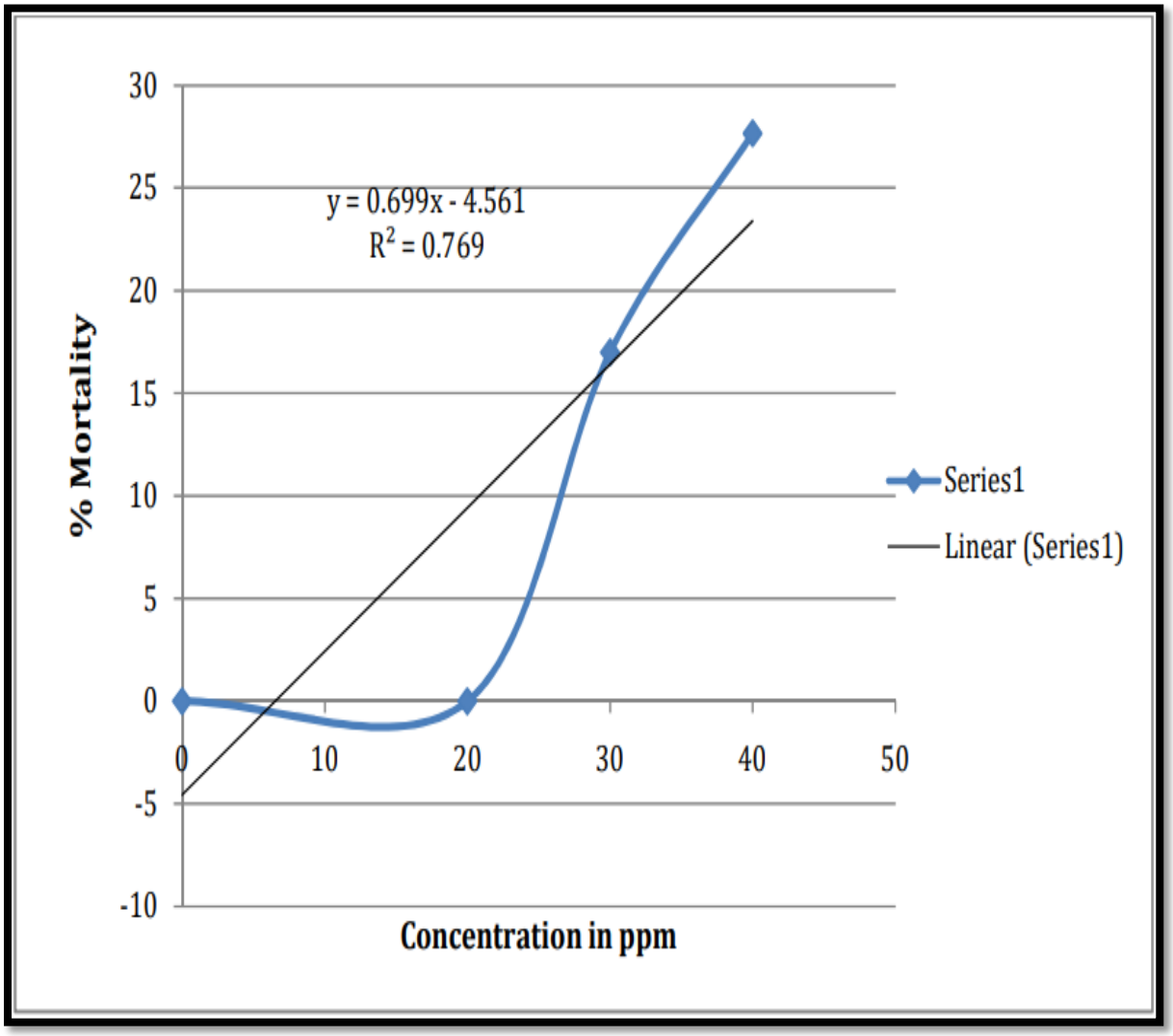


Table 3. Effect of Thiomethoxam on C. iyoni.

Concentration in ppm	% Mortality in set 1	% Mortality in set 2	% Mortality in set 3	Mean % Mortality
0	0	0	0	0
20	17	0	17	17
30	33	33	33	33
40	83	67	83	78

Figure 3. Graph showing toxicity of Nimbecidine on C. iyoni.

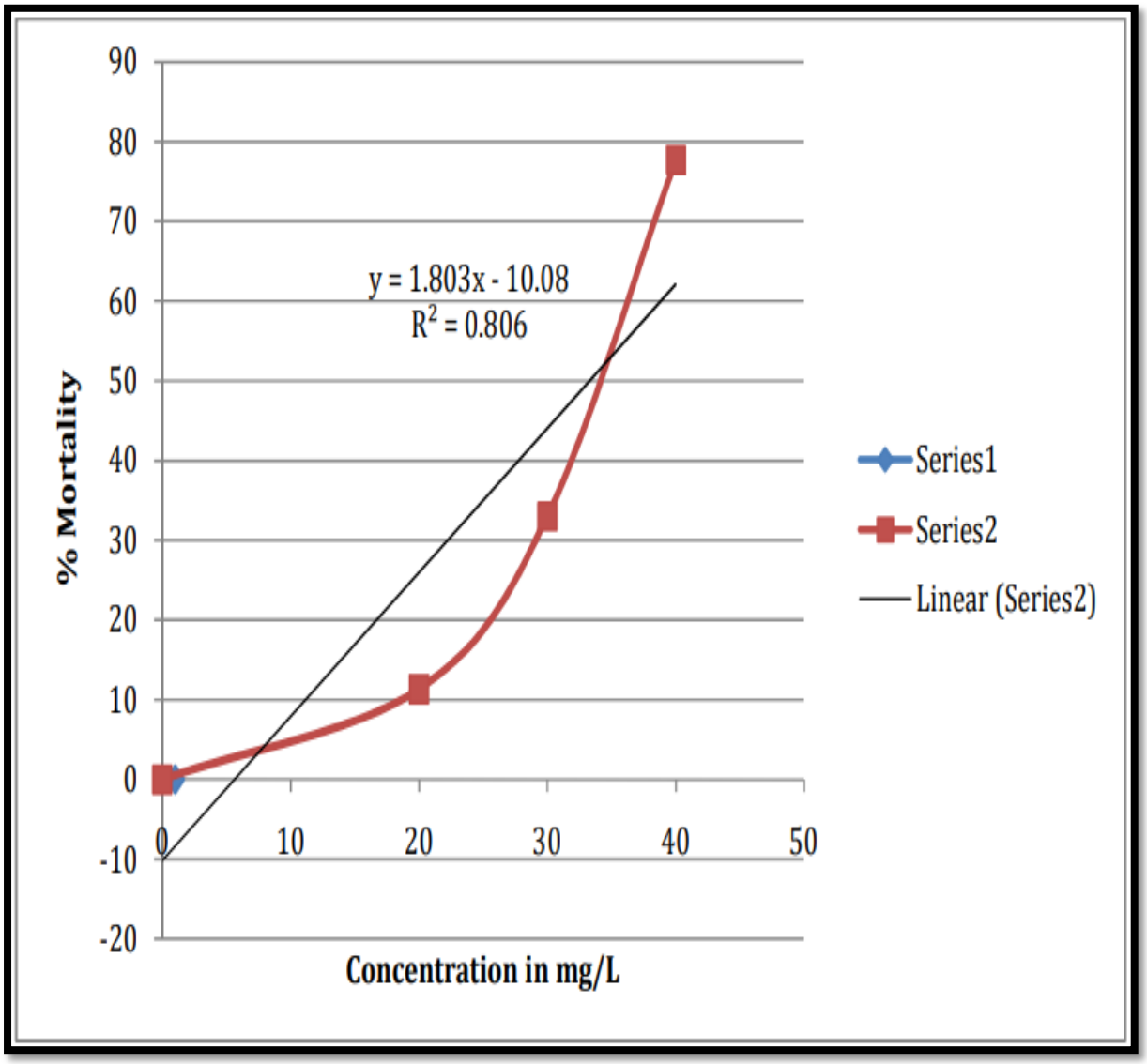
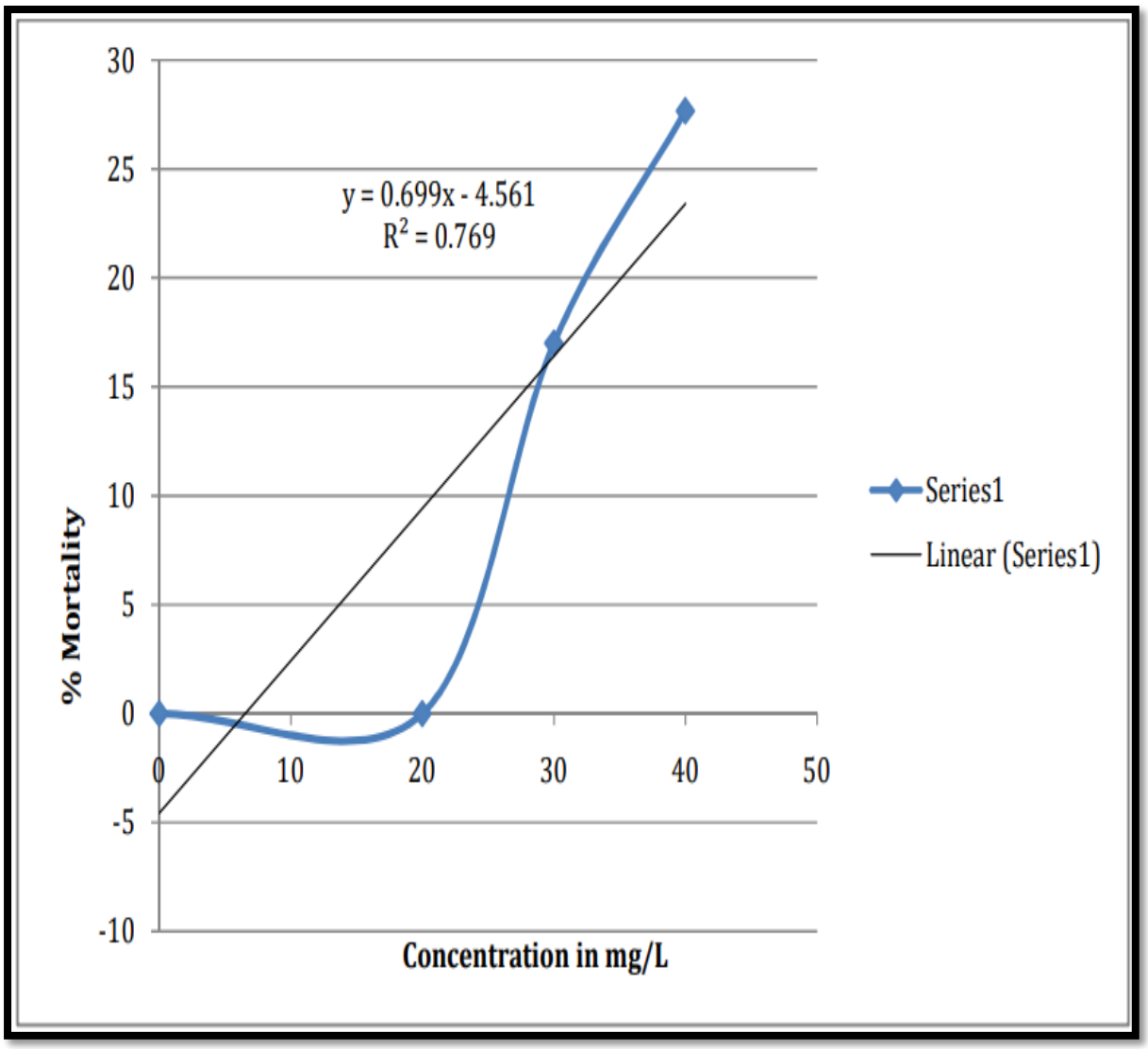


Table 4. Effect of Nimbecidine on C. iyoni.

Concentration in ppm	% Mortality in set 1	% Mortality in set 2	% Mortality in set 3	Mean % Mortality
0	0	0	0	0
20	0	0	0	0
30	17	17	17	17
40	33	17	33	28

Figure 4. Graph showing toxicity of Nimbecidine on C. iyoni.



Conclusion

Spiders are effective predators of herbivorous insect pests. Use of insecticides in fields results in a negative effect on the population densities of spiders. It shows that most insecticide reduces the density of spiders by direct lethal action, and by poisoning their food chain. They have a negative effect on population and species diversity. Biopesticides adverselyaffect the non-target and beneficial fauna of our croplands. Even the severity of the effect is less compared to the synthetic pesticides. In general, spiders are more sensitive to pesticides. They are biological pest control agents in nature. So, it is the time to think about alternate strategies for pest management to conserve our biodiversity.

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