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RESEARCH ARTICLE

Effect of Pesticides on Spider Population in Cotton Agro-System of Vadodara (Gujarat)

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Abstract

Spiders are important bio-control agents. They limit insect pests due to their entomophagous nature. Inspite of the beneficial role they play most farmers are unaware of the spider's role in agro-ecosystems. The traditional farming practices were helpful in maintaining the population of bio-control agents like spiders but the current farming practices, which use a wide range of pesticides and inorganic fertilizers have affected the bio-control agents besides deteriorating the yield of the farming lands. Hence the main objective of the present research work is to study the effect of pesticides on the spider diversity, in the cotton agro-system in and around Vadodara (Gujarat). Spider population was assessed before and after the pesticide spray in cotton fields. Their population was sampled using visual and pitfall sampling method. Sampling was done 24 hours before and 24 hours after the spraying of pesticide in the cotton fields. The assessment of pre and post sprayed fields revealed that the practice of pesticide spray have reduced the spider diversity and density in the cotton fields. These results indicate that the use of pesticide is detrimental to the spider population and diversity. Assemblage of spider species is more effective in reducing a wide range of insect pests than a single species. Practices such as organic farming, Integrated Pest Management (IPM) and Good Agricultural Practices (GAP) are recommended to the farmers for maintaining and conserving the density and diversity of spiders in agro-ecosystems as well as to improve the crop productivity.

Keywords

Spiders, Cotton fields, Pesticides, GAP, IPM

Introduction

Agro-ecosystems harbor a variety of natural enemies which are involved in regulating several types of insect prey, one such social spider is *Stegodyphus sarasinorum* (Karsh), which feeds on insects several times larger than its own size (Kumar and Yashkamal, 2011). The role of spiders as generalist predator in an agro-ecosystem is well recognized (Samu, 2003). However, their role in pest control and crop protection has not been utilized properly in India. Spiders are the largest group of arachnids, comprising more than 43,678 species distributed over 112 families worldwide (Platnick, 2013). Till now 18 families of spiders in the fields of banana, 11 families in the field of cotton, 9 families in castor and 13 families of spiders in the fields of paddy and pigeon pea have been identified in and around the agricultural fields of Vadodara (Kumar, 2007). This shows that cotton which is one of the important cash crops of Gujarat harbors good diversity of spiders due to its structural complexity. Fortunately, the life cycle of cotton overlaps with the lifecycle of spiders i.e. from June to December this adds to the diversity of spiders in cotton fields. Various living organisms live in harmony and balance with each other in different ecosystems before the chemical control of pests came into picture. In India agricultural practices are changing and farmers have stopped using organic fertilizers. The current farming practices deal with extensive use of pesticides to control insect pests of crops. Every year tones of pesticides is been sprayed in the fields for pest suppression. The total reliance on chemical pesticides for pest suppression has taken its toll severely on health and environment (Kaaya, 1994). The pesticide spray not only kills the pests but it simultaneously affects the non target invertebrates like spiders. Agricultural fields that are frequently sprayed with pesticides often have lower spider populations (Amalin *et al*,, 2001). In general, spiders are more sensitive than many pests to some pesticides, such as the synthetic pyrethroids, organophosphates, carbamates, carbaryl and sulphur compounds. A decrease in spider populations as a result of pesticide use can result in an outbreak of pest populations. Thus the knowledge about the effect of

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chemical pesticides on spider population will result in broader acceptance of IPM and conservation biological control. The present study was undertaken to (1) Survey the spider fauna belonging to various families present in the cotton crops, (2) Collect the remnants of the dead insects, spiders feed upon and taxonomic identification of both spiders and insect pests and (3) Study the variation in density and diversity of the spiders in correlation with pesticide spray.

Materials and Method

The survey was conducted in the months of June- February for two years 2009 and 2010. Two cotton fields in and around Vadodara were sampled. The spider population was sampled using visual and pitfall sampling methods. Sampling was done 24 hours before and 24 hours after the spraying of pesticide in the cotton fields. The pesticides used by the farmers in these fields were synthetic pyrethroids, organophosphorous compounds, carbamates and sulphur compounds. The cotton field in and around Vadodara received six to eight applications of pesticides during the study period i.e. 2009 and 2010. The pesticide applications were increased in the month of July to August when the cotton was lush green with more number of pests.


Pardosa sp.


Oxyopes sp.


Neoscona sp.

For collection of spiders visual search of one meter row was conducted. Each plant was inspected carefully. After visual examination, the same plants were sampled by shaking them over a white cloth of one by one meter in length, which was rolled out in the furrow between two rows without disturbing the plants. Ten such one meter samples were taken at random. In addition to above methods, pitfall trap method was also used to collect the ground dwelling and nocturnal surface spiders. For which polycarbonate sampling containers of 250 ml with 48mm opening diameter were used. Opening of the sampling container was covered with a funnel, the stem of the funnel opened into a smaller container filled with 50 ml of 20% ethylene glycol. Pitfall traps were sunk into the soil so that the container opening was at level with the ground surface. The pitfall traps were placed both pre and post spraying of pesticides in the fields from the edge of the field and then every five rows on a diagonal line across the fields such that they were spread evenly on the study area. Pitfall traps were collected in a 24 hour period. Spiders collected were transferred into polypropylene vials containing 70% ethyl alcohol and brought to the laboratory for taxonomic identification. Spiders were identified using stereozoom microscope (Leica) MZ 16. For taxonomic identification references of Tikader (1980; 1982) were used and also while collecting, a note was made on their habitat and their web building ability. In case of web building spiders, their webs were searched for remnants of prey hanging from their webs. The remnants were collected and brought to the laboratory for further identification of the prey taxa to see the prey preference of these spiders. Also the total number of spiders from both the cotton fields was counted for calculating the percentage of more abundant families out of the total population.

Results and Discussion

In the cotton fields we have recorded 11 families, 22 genera and 29 species of spiders (Table 1).

Table 1. Checklist of spiders found in cotton agro-ecosystem

Family	Scientific name
Eresidae	*Stegodyphus sarasinorum*
Theridiidae	*Argyrodes sp.*
Theridiidae	*Theridion sp.*
Linyphiidae	*Labulla nepula*
Linyphiidae	*Stemonyphantes sp.*
Tetragnathidae	*Leucauge decorate*
Araneidae	*Argiope anasuja*
Araneidae	*Neoscona mukerjei*
Araneidae	*Neoscona theis*
Araneidae	*Neoscona sp.*
Araneidae	*Cyclosa sp.*
Araneidae	*Parawixia sp.*
Araneidae	*Zygiella sp.*
Lycosidae	*Hippasa sp.*
Lycosidae	*Pardosa sumatrana*
Lycosidae	*Pardosa birmanica*
Lycosidae	*Lycosa sp.*
Oxyopidae	*Oxyopes shweta*
Oxyopidae	*Oxyopes gujarati*
Oxyopidae	*Oxyopes sp.*
Miturgidae	*Cheiracanthium melanostomum*
Clubionidae	*Clubiona filicate*
Thomisidae	*Thomisus shivajiensis*
Thomisidae	*Thomisus pugilis*
Thomisidae	*Thomisus sp.*
Thomisidae	*Xysticus sp.*
Thomisidae	*Tibellus sp.*
Salticidae	*Phidippus punjabensis*
Salticidae	*Plexippus paykulli*

Table 2. List of bio-control spider species in cotton agro-ecosystem

Spider species	Prey	Pests of cotton
Phidippus punjabensis	Aphids, Whiteflies, Jassids, Spotted bollworm	Aphids, Whiteflies, Jassids, Spotted bollworm
Thomisus shivajiensis	Thrips, Whiteflies, Mosquitoes	Thrips, Whiteflies, Mosquitoes
Thomisus pugilis	Larvae of Butterflies & Moths, Thrips, Honeybees, Wasps	Larvae of Butterflies & Moths, Thrips
Thomisus sp.	Aphids, Whiteflies, Jassids, Thrips, Flies	Aphids, Whiteflies, Jassids, Thrips
Xysticus sp.	Whiteflies, Thrips, Fruitflies	Whiteflies, Thrips
Clubiona filicate	Larvae of Butterflies & Moths, Ants, Cottonflies	Larvae of Butterflies & Moths
Cheiracanthium melanostomum	Houseflies, Larvae of Butterflies & Moths, Ants	Larvae of Butterflies & Moths
Oxyopes shweta	Larvae of Butterflies & Moths, Red cotton bug, Thrips	Larvae of Butterflies & Moths, Red cotton bug, Thrips
Hippasa sp.	Plant hoppers, bugs, Grasshoppers, Beetles	Plant hoppers, bugs, Grasshoppers
Pardosa sumatrana	Whiteflies, Aphids, Jassids, bugs, Other spiders	Whiteflies, Aphids, Jassids
Pardosa birmanica	Fruitflies, Butterflies, Moths, Ants	Flies, Butterflies, Moths
Argiope anasuja	Cottonflies, Houseflies, Whiteflies, Aphids, Butterflies, Moths, Crickets	Whiteflies, Aphids, Butterflies, Moths, Crickets
Neoscona mukerjei	Aphids, Jassids, Cottonflies	Aphids, Jassids
Neoscona theis	Aphids, Houseflies, Jassids	Aphids, Jassids

Families of spiders identified include all types of spiders; Diurnal and Nocturnal; Weaver (Foliage and ground) and non- weaver or hunting spiders (Foliage and ground). They were found feeding on all types of insects namely sessile, jumping and flying (Table 2). The sessile insects were fed by spiders from families: Thomisidae, Salticidae, Oxyopidae, jumping insects were fed by spiders from families: Clubionidae, Araneidae, while flying insects were fed by spiders from families: Araneidae, Eresidae, Linyphiidae. Inspite of the spiders being most abundant and diversified natural enemies found in all agro-ecosystems, their populations in the fields are adversely affected by the spraying of pesticides. Agricultural fields of Vadodara are normally sprayed by Synthetic pyrethroids, Organophosphorous compounds, Carbamates and Sulphur compounds. Maximum population of spiders was recorded in the month of July and August when the cotton was lush green (Flowering and fruiting stage) with more numbers of insect pests. With the increase in population of insect pests the frequency of pesticide spray in the cotton fields also increases. The spray of pesticide controls the population of insect pests but affects the population of spiders in the cotton fields which otherwise would have controlled the insect pest population by feeding on them. Maloney *et al,* in 2003 from Maine Agricultural and Forest Experiment Station, University of Maine has emphasized that some broad-spectrum organophosphates are highly toxic to spiders. Pekar in 2013 also believed that pesticide applications in agro-ecosystems heavily affect the occurrence of spiders. He also found that insecticides and acaricides when applied at the recommended concentrations and doses cause acute toxicity whereas herbicides and fungicides are relatively harmless. Even in our studies conducted by using visual search and pitfall trap method, we found that there were significantly fewer spiders in the pesticide sprayed fields as compared to the unsprayed cotton fields (Fig. 1 and 2). Through visual search 9 families namely Eresidae, Theridiidae, Tetragnathidae, Araneidae, Oxyopidae, Miturgidae, Clubionidae, Thomisidae and Salticidae were collected and by means of pitfall method only two families namely

Linyphiidae and Lycosidae were collected. After the pesticide spray in the cotton fields pitfall traps and visual observations were again done. There was a decline in the numbers of the spiders.

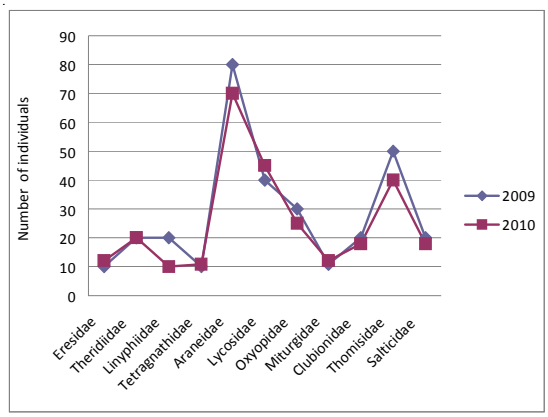

Fig.1. Spider density before spraying of pesticides in cotton fields

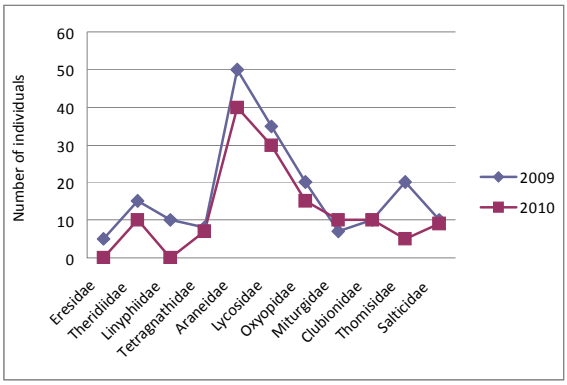

Fig.2. Spider density after spraying of pesticides in cotton fields

During visual search the foliage spiders belonging to families Oxyopidae, Miturgidae, Clubionidae, Thomisidae and Salticidae were observed to hide under the leaves to minimize their exposure from residues of pesticide spray. In case of web building spiders belonging to families Eresidae, Theridiidae, Tetragnathidae and Araneidae, it was observed that the droplets of the pesticides spray remains on the web which forces the spiders like *Stegodyphus sarasinorum* (Eresidae); *Argyrodes sp.* and *Theridion sp.* (Theridiidae); *Leucauge decorate* (Tetragnathidae) , *Argiope anasuja, Neoscona theis* (Araneidae) etc to leave the web. The two families collected through pitfall traps showed decline in numbers (Fig. 2). Spiders like *Pardosa sp.* (Lycosiade), *Labulla nepula* (Linyphiidae) prefer moving towards the field margins to avoid the pesticide percolated in the soil therefore the number of spiders in the pitfall declines. As soon as the effect of pesticide is over they once again start moving towards the fields. Such observations were made continuously till the cotton crops were in the field. Similar observations were made by Fountain *et al,* in 2007 during his research in the sprayed and unsprayed grasslands of Bowmont valley, in the Scottish Borders of UK by means of pitfall traps found a strong impact of chlorpyrifos on the spider communities. They found that there were significantly fewer spiders in the insecticide treated grasslands compared to the control plots of grasslands, mainly attributing to the lower numbers of *Tiso vagans* and *Pardosa palustris* belonging to family Linyphiidae and Lycosiade respectively. When it comes to density of spiders the families most affected were Eresidae and Linyphiidae followed by Araneidae and Thomisidae. The sprayed fields drastically brought down the population of the families Eresidae and Linyphiidae (Fig. 2). It was becoming difficult to sight members of these two families. Whereas when it comes to diversity of spiders the families most affected were Lycosidae and Oxyopidae followed by Thomisidae and Araneidae (Fig. 3 and 4).

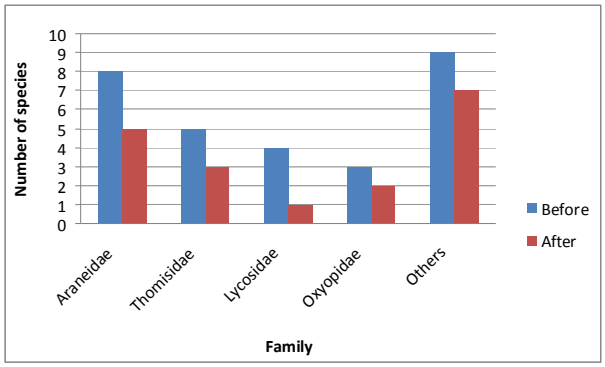

Fig.3. Spider diversity before and after spraying of pesticides in cotton fields (2009)

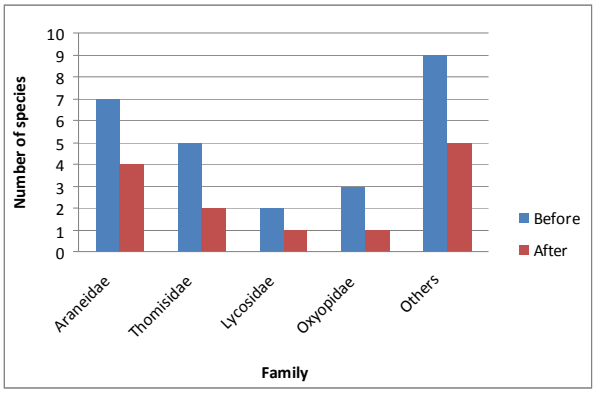

Fig.4. Spider diversity before and after spraying of pesticides in cotton fields (2010)

Studies conducted by Nyffeler *et al,* in 1994 showed that the hunting spiders, (Lycosidae, Oxyopidae, Thomisidae, and Salticidae) frequently capture Orthoptera, Homoptera, Hemiptera, Lepidoptera, Thysanoptera, Diptera, Hymenoptera and some Coleoptera. Mansour in 1987 also believed that spider played important role in

suppressing larvae of *Spodoptera littoralis* (Boisd.) and also helps in delaying pest outbreaks early in the cotton growing seasons. Studies conducted by Tahir *et al,* in 2011 also reported the adverse effect of carbofuran on ground spiders like Lycosidae which is one of the important groups of biological control agents and found that carbofuran is a serious threat to the ground spiders and suggested that its use in agricultural fields should be minimized. In a review regarding spider eco-toxicology by Pekar in 2012, he concluded that the side effects of pesticides on spiders can be very strong which can damage their normal life cycle. Hence in order to conserve and increase the density and diversity of spiders in agro-ecosystems practices such as organic farming, Integrated Pest Management (IPM) and Good Agricultural Practices (GAP) are recommended to the farmers and for that awareness to the farmers about IPM and GAP is in need. Kumar and Shivakumar in 2004 surveyed agricultural fields of Gujarat and found that IPM practices varied from partial to total unawareness, not only the information about IPM but there was unavailability of complete IPM packages to control the insect pests of various crops. Even in our studies we found that early spraying of pesticides like Synthetic Pyrethroids, Organophosphorous compounds which are generally used in the agricultural fields of Vadodara should be avoided.

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