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IMPACT OF PESTICIDES ON SOIL MESOFAUNAL POPULATION IN AN AGROFORESTRY HABITAT.

Entomology

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ABSTRACT

The widespread use of pesticides in agroforestry is most common in India. Despite their benefits, they have many problems also. The economy of agricultural production is depending on the soil productivity which is directly affected by soil mesofauna. Soil mesofauna play a vital role in the process of decomposition, nutrient cycling, and organic matter decomposition. Therefore it is important to maintain the population of soil mesofauna in the soil through different soil management practices such as- use of pesticides. This study summarizes the impact of two different pesticides (Malathion and Carbofuran) on soil microorganisms and non-target invertebrates during January to December 2013 at department of Zoology, Aligarh Muslim University, Aligarh (India). Pesticides applied on soil at recommended levels had a detrimental effect on soil mesofaunal population and their activities. The extraction of soil microarthropods were done by modified Tullegren funnel. Physical parameters such as-soil temperature, soil moisture, electrical conductivity etc. and chemical factors such as organic carbon content, phosphate, potassium, nitrogen etc. were also analyzed according to standard laboratory techniques during this period. They were also affected due to the application of these pesticides and resulting the disturbed population of soil mesofauna. This study strongly suggests that the continuous use of pesticides on soil is harmful to soil mesofauna as well as the soil health.

KEYWORDS:

Soil mesofauna, Pesticides, Malathion, Carbofuran, Agroforestry.

Introduction

The term pesticide covers a wide range of compounds including insecticides, Fungicides, Herbicides, Rodenticides, Molluscides, Nematicides, plant growth regulators. The use of Pesticide in India dates back to the year 1948 when Dichloro Di Phenyl Tri chloro Ethane (DDT) and Benzene Hexa Chloride (BHC) were imported for Malaria and Locust control. Today, India is the leading manufacturer of basic pesticides in Asia and ranks 12th globally. In advanced agriculture techniques, insecticides are frequently used to increase the production. Besides combating insects a significant amount of the insecticides eventually reaches the soil in the form of "insecticidal fall-out" and is accumulated in the top soil (0-10cm). Maximum microbiological activities occur in this portion (Alexander1978). As microorganisms are scavengers in soil and contain physiological variability, they degrade a great variety of chemical substances including the insecticides to derive energy and other nutrients for their metabolism (Stadnyk et al. 1971; Bhuyan et al. 1993) with the resulting increase in the biomass of the insecticide utilizes which may favorably influence nutrient transformation in soil (Agnihotri et al.1981; Das and Mukherjee 1994). On the other hand, there are some insecticides which exert adverse effect on the proliferation of microorganism and their associated transformations of nutrients are very specific since individual members within a group vary in toxicity (Simon-Sylnestre and Fournier 1979) Therefore to sustain the fertility status of the soil, it becomes all the more important to assess the impact of insecticides on the mesofaunal population.

In temperate agroecosystem, little is known to these aspects in tropical and subtropical agroecosystems. This work reports the impact of soil management practice mainly the application of pesticides in areas which are used for Agroforestry habitat.

Materials and Method

Geographical position of Aligarh:

Aligarh lies towards north of the Ganga-Yamuna doab within the parallels 20˚29' and 28˚1' north latitude and 77˚29' and 78˚38'east latitude. The district spreads over 4023 square kilometers and this area varies slightly from the year to year due to the changing courses of river Ganga and Yamuna.

Description of the Sites:

The experimental site was selected a stretch of land behind the zoology department. This patch of land is maintained by land and garden department by planting seasonal plants but mostly used by research scholars as the experimental site. A large area was selected then divided into three plots (control and treated plots), each measuring 3×4m² and separated by 4 m.wide space.

These three experimental plots were surrounded by variety of plants such as-Sun flower (*Helianthus annuus*), Makoi (*Solanum nigrum*), Sadabahar flowers (*catharanthus roseus*) etc. The experimental area was surrounded by mulberry trees along the road side. This area was undisturbed and only visited by birds, snakes, mangole during hot weather.

1. **Plot no.1-** A plot was first sprayed with Malathion at recommended rate (40 lbs/hectare) Starting from day 1 after showing and re-sprayed every 15 days namely Malathion treated plot.

2.**Plot no.2-**Another plot was designed to sprayed with Carbofuran3G at recommended rate (1kg/hectare) starting from day 1 after showing and re-sprayed every 15 days like upper one plot, the Carbofuran treated plot.

3. **Plot no3-** The third plot served as a control plot without any insecticide treatment.

During the investigation period, the soil samples were collected from depth of 5cm with the help of a corer modified by Averbach and crossley (1960) The soil samples were collected twice in a month for a period of twelve months. Modified Tullegren-Funnel was used for the extraction of soil mesofauna. The collected mesofauna was preserved in 70% alcohol and identified in a steriozoom microscope. Analysis of edaphic factors such as soil temperature, soil moisture, pH, content of organic carbon, nitrate and phosphate were done by standard laboratory methods. Soil temperature was measured by directly inciating the soil thermometer into the soil up to the required depth, Relative humidity by a Dial Hydrometer, pH by electric pH meter and soil moisture by Dowdeswell's (1959) method. Organic carbon was estimated by rapid titration method as described by Walkey and Black (1934), Nitrogen content (N) by Jackson (1966) method, Phosphorus content (P) by Molybdenum blue test and Potash content (K) by Jackson (1966) method.

Results and Discussion

At the start of this treatment, soil mesofauna was collected for a period of 12 months from a depth of 5 cm throughout the sampling period from the three plots i.e. The Malathion treated plot, the Carbofuran treated plot and the Control plot. The Mesofaunal population thus collected day one and 14 days after the use of insecticide. A total of 24 collections were made for each site. Then we preserved, identified, counted and finally we calculated their diversity and density. The observations are based on the density individual orders.

Malathion treated plot:

The total population density of this plot was almost higher from the

carbofuran treated plot, during the investigation period i.e. (Jan 2013 to Dec.2013). In Malathion treated plot, the residue after day 1 was significantly higher than those after day 14. This is because of the half-life of Malathion in soil which is 1-25 days (EXTOX 1996). In addition, the degradation of Malathion in soil is rapid and related to the degree of soil binding. Breakdown occurs by a combination of biological degradation and non-biological reactions (beyond pesticides), Washington DC 2003. The population density of the Malathion treated plot showed Dipterans on a higher side followed by Hymenopterans, Coleopterans and Mites. Among Apterygotes, Springtails (order: collembola) was dominant during the investigation period (table 1).

Results indicated that during the investigation period, Malathion applied at practical rates, had negative effect on total population of mesofauna. The insecticide contamination in the ecosystem may produce secondary ill effects especially when the amount of chemical is below the lethal limits of the organism (Badji, 2007). The other reason may lie in the differences in physical properties of soil. Results showed that the soil moisture content was lower in treated plot than in control plot. These results are in agrees with Klironomos and Kendrick (1995) ,they reported on the most important variable that influenced microarthropod community structure as soil temperature, moisture content, soil pH and microbial community. Relative humidity observed in treated plot not in high proportion so it could be another reason for lowering the mesofaunal population.

Carbofuran treated plot:

The density of total mesofaunal population was lower than control plot except the beetles (order: Coleoptera) and Proturans (Order: Protura). A 50-81% reduction in activity, density for carabids (Order: Coleopteran and formicides combined was found over a 30 year period in Germany (Heydemann and Meyer 1983). This period was too long but our investigation period was not so long. So it could be the reason for maximum existence of beetles (order- Coleoptera). The toxic effects of most insecticides to Carabids are well documented e.g. Kromp B.(1999), LoboJ.M.et al.(2002), Luff M.L.(2007), Traugotti et al. (2015) and only the avoidance or use of lower than recommended application rates will ensure their survival.

It should be noted that the total number of mesofauna after day 1 of Carbofuran application was lower than those after day 14 because Carbofuran dehydrates in sunlight and it becomes degraded day by day. This crossponds with declining the level of Carbofuran residues in the soil from day 1 to day14. There are negative correlations between the concentration of residues and the total density of mesofauna.

The different orders of mesofaunal population that are affected in term of density. Carbofuran may have effects on the density of springtails and mites indirectly. Some predators that were not affected by the pesticide application might have been profited from competition with other affected predators and from reduced Collembolan and Acari densities. Furthermore the density of competitors for food resources might have increased and cause a further decline in springtail and mite numbers (Endlweber et al. 2009). These two arthropod groups are sensitive to many insecticides (Joy and Chakervorty 1990) and have been used to asses show potential as bio indicators in the soil ecosystem.

Comparison of Mesofaunal population between Malathion treated plot, Carbofuran treated plot and controlled plot:

When the comparisons are made between Malathion, Carbofuran and Control plot, it becomes clear that the population of soil mesofauna was the highest, Malathion treated plot was higher than Carbofuran treated plot since the dominant order of both treated plots and control plot was same i.e. Diptera in pterygotes and Collembola among Apterygotes (Figure: 1 to 3) But only the number of Mesofauna was relatively low than Malathion treated plot. It may be perhaps due to the toxic nature of Carbofuran. It may be inferred that Carbofuran may be more toxic than Malathion for mesofaunal population and for soil properties also.

Conclusion

The results from the three experimental plots suggest that the soil mesofauna and many others co-exist in the community of the soil. They cooperate and compete, and they interact with each other to form an integrated system which functions in a manner as to affect the breakdown of organic material. In this way the recycling of plant nutrients in promoted. The majority of soil animals are microscopic in size and their diversity is quite remarkable. The soil fauna are active partners of the soil flora. To sum up it has been observed that the diversity of soil mesofauna was more or less same in the control and malathion treated plots but significantly lower in carbofuran treated plot. The lesser population observed in carbofuran treated plot may be due to the harmful effect of pesticides and normal population in the two plots i.e. control plot and malathion treated plot can be attributed to the defensive role of soil as a healthy environment, where the process of degradation of xenobiotics are relatively fast Sundaram 1991, Hanumantha raju and Awasthi 2004). It may be concluded that Carbofuran may be more toxic than Malathion for mesofaunal population and for soil properties also.

Table 1: Population density of soil mesofauna at experimental plots during the investigation period.

Orders	Population Density/m²		
	0-5 cm		
	Malathion treated plot	Carbofuran treated plot	Control plot
1. Diptera	24.0	17.5	29.5
2. Coleoptera	5.5	15.5	5.5
3. Hymenoptera	10.0	5.5	9.5
4. Isoptera	3.5	3.0	4.5
5. Hemiptera	16.0	4.0	9.5
6. Thysanoptera	2.0	1.5	2.5
7. Psocoptera	0.5	1.5	1.5
8. Zoraptera	0.5	2.0	3.0
9. Embioptera	0.5	3.0	1.0
10. Diplura	2.5	1.0	1.0
11. Collembola	2.5	4.0	13.5
12. Protura	1.0	1.0	0.5
13. Prostigmeta	8.5	3.5	1.5
14. Mesostigmata	4.0	6.0	5.5
15. Astigmata	1.5	8.5	4.5
16. Cryptostigmata	4.0	2.0	1.0
17. Nematode	2.5	1.0	1.0

Table 2: Pearson Correlation between mesofaunal population and edaphic factors at Malathion and Carbofuran treated plots during the experimental period.

Soil Mesofauna / Edaphic factors	Pterygote		Apterygote		Acari	
	Malathion treated plot	Carbofuran treated plot	Malathion treated plot	Carbofuran treated plot	Malathion treated plot	Carbofuran treated plot
Soil Temperature	-0.100	0.389	0.158	0.465	-0.532	**-0.668***
Soil Moisture	**0.646***	0.072	-0.125	**0.776****	0.290	0.268
Relative Humidity	-0.223	-0.107	0.282	-0.094	-0.329	-0.423
Ph	-0.255	-0.324	0.241	0.000	0.180	0.236
Organic Carbon	-0.258	**0.630***	0.295	-0.133	-0.379	-0.284
Organic Matter	-0.231	**0.620***	0.299	-0.122	-0.375	-0.276
Electrical Conductivity	-0.213	0.374	0.188	-0.221	**-0.579***	-0.482
Available Nitrogen	0.304	0.081	0-.188	0.174	-0.480	**-0.594***
Phosphate	0.000	-0.473	**-0.752****	-0.057	-0.219	-0.128
Potassium	0.147	-0.124	**0.577***	-0.077	-0.230	-0.402

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

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