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Effect of Malathion Application on Soil Microarthropods Population in Agroforestry: Relationship to Soil Temperature and Soil Moisture

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Abstract—*The widespread use of insecticides has greatly benefited agriculture, but has also led to many problems. One of the more important of these is that they may affect animals against which the chemicals are not directed, and which may be beneficial. Invertebrates that live in soil can be killed not only by chemicals applied directly to the soil, but also by those that reach the soil in drift from aerial sprays or are washed off foliage. The importance of the activities of some invertebrates such as Enchytraeidae, Pauropoda, Diplura and Protura in soil fertility is still not fully understood, but it is known that some soil animals are essential in the breakdown of some kinds of dead leaf material into its organic and inorganic constituents and in the incorporation of these materials into the soil structure (Stockli 1950, Mellanby 1960, Raw 1961).*

A small field study highlights the effectiveness of pesticide Malathion for the growth and development of soil microarthropods.This study was conducted during January 2010 to December 2010 at department of Zoology, Aligarh Muslim University, Aligarh (India).The main objective of this study is to evaluate the toxicity of malathion on the population density and diversity of soil microarthropods in the year 2010. The extraction of soil microarthropods was done by modified Tullegren funnel and analyses of edaphic factors such as- soil temperature, soil moisture, organic carbon, available nitrogen, phosphate were done by standard laboratory methods. This study clearly stated that Malathion have negative effect on soil mesofaunal population and edaphic factors also.

1. INTRODUCTION

Trehan (1945) was the earliest to work on Indian soil arthropods. Arthropods with in the soil and litter play vital role in maintaining soil. Fertility, health and productivity (Niwa Christine G., Peck Robert W. et. al 2001). Below ground communities have a key role in the process of humus formation in governing ecosystem functioning (Berdgett et. al 1988, Hopper et. al 2000 and Wardle et. al 2004). Microarthopods release nutrients held within fungal standing crops and contribute to soil structure and humus formation. (Wallwork 1983; Norton1985). The term pesticide covers a wide range of compounds including insecticides, Fungicides, Herbicides, Rodenticides, Molluscides, Nematicides, plant growth regulators. The intensive use of pesticides causes concern both to public and scientists all over the world.

Malathion is an organophosphorus insecticide used in public health, residential, and agricultural settings as early as 1950. Over 100 food crops can be treated with Malathion, and about half of total applications in the United States (U.S.) are on alfalfa, cotton, rice, sorghum, and wheat. Annual use of Malathion is over 16.7 million lbs active ingredient (A.I.) per year of which approximately 12.5 million lbs ai is used on food crops alone (ATSDR, 2003)**.** It is used for agricultural and non agricultural purposes that are released to the environment primarily through spraying on agricultural crops and at agricultural sites, spraying for home and garden use, and spraying for public health use in both urban/residential and non-residential areas; the insecticide is also released to the environment using fogging equipment**.** In modern agriculture, insecticides are frequently applied to the crop fields to increase the crop 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) where the maximum microbiological activities occur (Alexander1978). 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 effect of insecticides on the faunal population of the soil.

Although considerable research works have been done on the effect of various soil management practices on soil arthropods. In temperate agroecosystem, little is known to these aspects in tropical and subtropical agroecosystems. This work reports the effect of pesticides on soil microarthropods in areas which are used for agriculture.

2. MATERIAL AND METHODS

Sampling Site:

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 two plots each measuring3×4m² and separated by 4 m.wide space.

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 no2-** Another plot was served as control plot without any insecticide treatment.

All the three plots were applied with water. Other management practices such as-tilling, cropping, manuring were applied time to time. Weeds were removed manually and regularly.

Extraction of soil microarthropods:

In the present study mineral soil samples were collected from depth of 5cm with the help of a corer modified by Averbach and Crossly (1960). The soil samples were collected bimonthly for a period of three months. Extraction of microarthopods was done in a modified Tullegren-Funnel. The insects collected were 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. Temperature was measured by directly inserting 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 (water content) 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.

3. RESULTS AND DISCUSSION

The application of Malathion in an agroforestry showed that the applied dose of Malathion had direct effect on the population of soil mesofaunal population. during the study period. Results indicated that during the investigation period, Malathion applied at practical rates, had negative effect on total population of 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. This agrees with the result of kautz, (2005) who suggested that low humidity could result in migration, lower reproduction and higher mortality of soil microarthropod. The population density of the Malathion treated plot showed Dipterans on a higher side followed by Hymenopterans, Coleopterans and Mites.

Effect of Malathion application on the diversity of soil mesofauna in the experimental plots:

We have classified all the mesofauna in three groups which facilitated statistical analysis of the data collected. The groups include:

1. Pterygote (Diptera, Hymenaptera, Coleoptera etc.).

2. Apterygote (Diplura, Collembola, Protura)

3. Acarina (Astigmata, Prostigmata, Mesostigmata and Cryptostigmata)

Though, the soil fauna is large assemblage of insects from microscopic Springtails (0.2 mm-2.0 mm) to Coleopterans and their larval forms to Dipterans and Isopterans. But the above mentioned orders are those which were sampled from the sampling site throughout the investigation period. In both control and Malathion treated plot, among Pterygotes, Dipterans were most abundant in the soil (Figure1,2) and among Apterygotes, Springtails (order: Collembola) dominated throughout the investigation period. Carter (1993) also reported that about 90% of a microarthropod community in nature is composed of these two groups'i.e. Dipteran and Collembolan while the remainder includes Protura, Diplura and Pauropoda. Amoung Acarina, Prostigmata was dominated throughout the investigation period. These results are in conformity with Seastedt (1984) who reported that collembolan (springtails) and Acari (Mites) usually account for up to 95% of total numbers of microarthropod.

Nematodes were also observed during the investigation. They were not dominant during the experimental period. Yeates (1982) applied traditional population indices to pasture nematodes population and concluded that nematode fauna represents the sum of numerous populations being neither a community of interacting species nor a guild of species exploiting a resources. Nematodes are very abundant in grassland soils where population densities can be as high as 10 million m-² in highly productive grasslands.

Effect of Edaphic factors on the Soil mesofaunal population of the three experimental plots:

Soil mesofaunal communities are influenced by some selected factors which also influence above and below ground animals. We believe that differences in dispersal rates of soil faunal species are likely to be strongly correlated with the differences in their populations' response and with other factors such as soil temperature, soil moisture content and organic matter content of soil. Soil organisms are subjected to a variety of selective edaphic factors in the soil environment. However the effect of these factors on the density of soil mesofauna and their interaction is difficult to predict because of the dynamic nature of their diversity in an ecosystem environment. The effects of edaphic factors on mesofaunal population may be more subtle but equally significant from the stand point of long term ecosystem structure and functioning.

Laboratory analysis showed that the **soil temperature** of Malathion treated plots was (39˚c) in 2010 compare to that of control plot (34.5˚c). The mesofaunal population was also lower than control plot throughout the experimental period. In the present investigation, it may be noted that the direct influence of soil temperature on the population density and diversity in the mesofaunal population. The soil mesofauna collected belong to different orders and phyla and each group may have different temperature preferences. Webb (1970) observed that hot dry months population density and diversity are low and could be attributed to a direct effect causing inactivity and death of mites. Similarly, Ashraf (1971) reported that 30˚c temperature was the optimum for the species of Collembola to breed.

Observing the effect of pesticides on soil temperature and population dynamics and diversity, it is clear that when soil temperature decreases the adsorption of pesticides by soil increases. This may result in lower concentrations of pesticides dissolved in soil solution and flood water and this slower disappreance (Grezi and Beard 1976). Kardol et al. (2008) showed that soil temperature has a greater effect on overall microarthropod population.

The **Soil moisture** was also almost low at treated plot. It is well known that low humidly results in migration lower reproduction and higher mortality of soil micro arthropods. (Butcher et al. 1971). Therefore, drought stress may reduce abundance and diversity of Collembolans (Pflug and Wolters 2001). It means the moisture content and relative humidity of soil is directly dependent on rainfall. The influence of rainfall as a single entity on the oribatid mite was studies by Bhattacharya and Ray Choudhary (1979) and they opined that rainfall has a positive correlation with this group of mites. Hatter et al. (1998) and Chiutrapati (2002) also reported maximum population of Acarina during rainy season and observed decreasing trend with the onset of winter. Similar findings were reported in our earlier studies (Parwez H. and Sharma N.2014). Nutrient availability is a crucial soil property. It influences plant productivity, water quality and can serve as an indicator of soil health. (De Rauw and Rajot 2004a and De Rauw and Rajot 2004b). Nitrogen (N) is an essential plant nutrient and significantly influences agricultural productivity (Picone et al. 2002). In most soil, a significant ratio of available N is derived from mineralization of the soil organic matter (Cabrera et al. 1994, kerek et al. 2003).

4. CONCLUSION

The results from the experimental plots suggest that the soil mesofauna and many others co-exest 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. . The lesser population observed in malathion treated plot may be due to the harmful effect of pestisides and normal population in. control plot plot can be attributed to the protective role of soil as a dynamic environment, where the process of degradation of xenobiotics are relatively fast (Sundaram 1991, Hanumantha raju and Awasthi 2004), involving both physical degradation and biodegradation. It may be concluded that malathion may be toxic for mesofaunal population and for soil properties also.

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Table 1: Population density of mesofaunal population at Malathion and Control plot during experimental year

Orders	Population density/ m²	
	Malathion treated plot	Control plot
1. Diptera	24.0	34.5
2. Coleoptera	5.5	7.5
3. Hymenoptera	10.0	12.5
4. Isoptera	3.5	4.5
5. Hemiptera	16.0	19.5
6. Thysanoptera	2.0	4.5
7. Psocoptera	0.5	1.5
8. Zoraptera	0.5	3.0
9. Embioptera	0.5	1.0
10. Diplura	2.5	2.0
11. Collembola	2.5	13.5
12. Protura	1.0	0.5
13. Prostigmeta	8.5	1.5
14. Mesostigmata	4.0	5.5
15. Astigmata	1.5	4.5
16. Cryptostigmata	4.0	1.0
17. Nematode	2.5	2.5

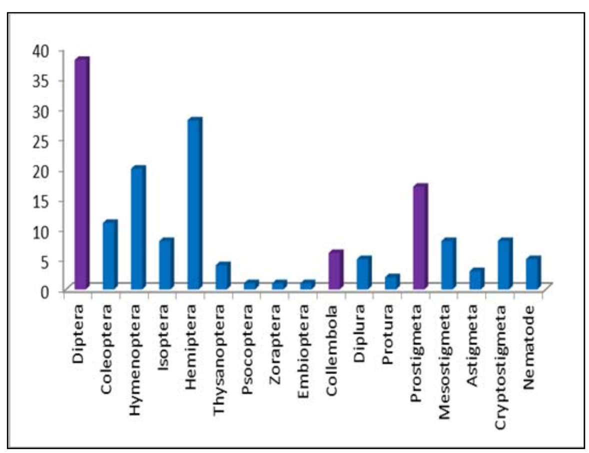

Figure 1: Dominant orders of Soil mesofauna at Malathion treated plot during 2010.

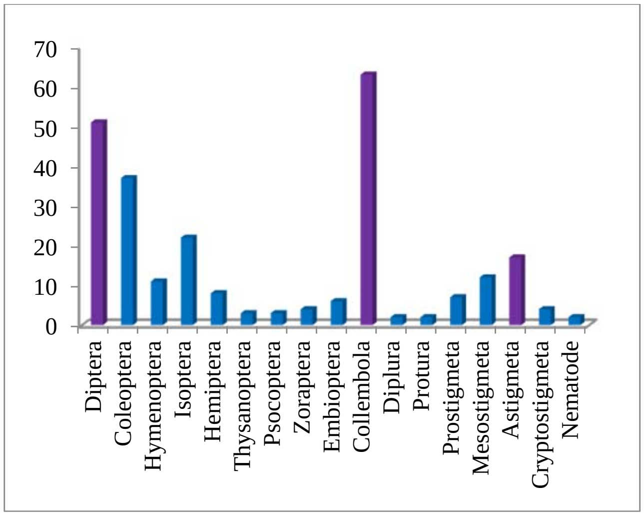

Figure 2: Dominant orders of Soil mesofauna at Control plot during 2010.

Table 2: Seasonal variation in edaphic factors at Malathion and Control plot during 2010.

Months	Malathion treated plot				Control plot			
	Soil temperature (˚C)	Soil Moisture (%)	Relative Humidity (%)	Organic Carbon (%)	Soil temperature (˚C)	Soil Moisture (%)	Relative Humidity (%)	Organic Carbon (%)
January	18	2.75	55	0.53	21	2.40	61	0.88
February	23	2.35	75	0.55	18	2.15	59	0.82
March	24	1.65	59	0.58	28	2.15	55	0.69
April	28	1.34	78	0.61	31	1.15	85	0.75
May	32	1.83	81	0.55	29	3.75	60	0.81
June	39	o.9	73	0.68	33	1.25	79	0.81
July	33	2.15	93	0.72	29.5	3.15	77	0.86
August	32.5	2.25	81	0.69	34.5	2.89	98	0.78
September	30	1.85	74	0.69	27	1.85	78	0.77
October	25.5	2.40	52	0.73	26.5	2.40	66	0.77
November	22	3.0	55	0.59	20	2.75	48	0.81
December	19	2.50	61	0.57	21	1.15	81	0.78

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