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Recovery Rate of Soil Microarthropods at Upper 0-5 cm After Treatment with Carbofuran Insecticide

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Abstract: The Recovery rate (Rr) of eight orders of soil microarthropods present in the soil during the period of the field experiment were investigated for a period of 90 days after the application of carbofuran insecticide at a depth of 0-5 cm. The Rr for Acarina (9.0×10^{-5} sec^{-1} for double treated plot and 1.02×10^{-5} sec^{-1} for single treated plot) and Coleopteran (5.0×10^{-6} sec^{-1} for double treated plot and 2.3×10^{-6} sec^{-1} for single treated plot) were the highest due to the nature of their exoskeletons and the effect of the carbofuran insecticide on other predators. The Recovery rate (Rr) of Hymenoptera (H) and Thysanoptera (TH) were the lowest observed during this period of investigation: HRr = 4.0×10^{-7} sec^{-1}, THRr = 3.0×10^{-7} sec^{-1}. There was no significant difference ($p>0.05$) in the Recovery rate (Rr) of soil microarthropod caught in the double treated plots to single treated plots. The correlation between the Total Hydrocarbon Content (THC) and the total number of soil microarthropods caught at both treatment were significant at 0.05 and 0.01 probability level with r = -0.96 for double treated plots and - 0.75 for the single treated plots. The implication of the above statement shows that the reductions of THC lead to the increase in the soil microarthropods.

Key words: Recovery rate (Rr), carbofuran insecticide, soil microarthropod, total hydrocarbon content, plots, Nigeria

INTRODUCTION

Pesticides are chemicals designed to combat the attack of various pests on agricultural and horticultural crops (Cremlyn, 1978). Applications of pesticides harm soil arthropods and change the food web structure in the ecosystem, some pesticides exert short term effects while others have long term effects on arthropod population (Prasse, 1985; Bamaszkiewicz, 1993; Larink, 1997). The persistence of carbaryl and methiodion in soil depend on its physical and chemical properties and also on the activities of the microorganisms (Hastily *et al*., 1998; Sandez *et al*., 2003; Ahmed *et al*., 2004).

In addition, different species are likely to be affected to different extend (Michaud and Grant, 2003), Collembolan abundance is generally not affected adversely by synthetic pyrethroid insecticides in field studies (Heungens and Daele, 1979; Hill, 1985; Shire, 1985; Inglesfield, 1989). Non-target effects of cypermethrin and pirimicarb on terrestrial arthropods population have been studied in detail for predatory microarthropods.

The abundance of microarthropods taxa was reduced by chlorpyrifos with delphalidae (Homoptera), parasitic hymenoptera and diptera the group affected most strongly. The total catch of macroarthropod and the overall taxonomic richness were reduced significantly by Chlorpyrifos on all post treatment sampling date (Frampton *et al*., 2006). Frampton *et al*. (2006) studied pesticides effects on invertebrate and recommended that Collembolan (*Folisoma canidida*) should also be tested routinely as a representative of soil arthropods because testing with oligochaetes alone does not identify all insecticides risks to soil invertebrate. Cypermethrin may act as a feeding repellent and has been found to temporary reduce prey consumption rates in spider and non-monitored predatory mite, independent of their abundance.

The aim of the investigation was to determine the Recovery rate (Rr) of soil arthropods after the treatment with carbofuran insecticide at a depth of 0-5 cm to compare the Rr of various soil microarthropod and succession in recolonization of the disturbed habitat from different plots and to ascertain if the number of treatment can affect the Recovery rate (Rr) of the present arthropods.

MATERIALS AND METHODS

Study area: The field study was conducted for 90 days after the application of carbofuran insecticides on

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grassland at the University of Benin (Ugbowo campus) 6°19'N, 60°36'E located on a sandy loamy soil with dominant grasses family Poacea and Guinea grass. The area measured 12×12 m and lies between the library and the biological museum with evidence of no previous pesticides application. The sampling site had one station with 3 sub-station marked plot A (doubled treatment), plot B (single treatment) and plot C (control no pesticide application). Three replicate stations were added to minimize experimental error. Each station measured 5×5 m and each plot 2×2 m except the control which measured 2×5 m and were all separated by a buffer zone of 1×1 m.

Spray/application: Carbofuran insecticide was in powered form and with the aid of hand protective cover, it was applied with hand.

Pesticide information: Carbofuran insecticide recommended application rate by manufacturer, 1 skg/100 m^2. Carbofuran insecticides was active for 2 weeks (14 days) according to the manufacturer information.

Sampling (collection and extraction): Samples from all stations were collected with a core split sampler of diameter 7 cm and length 20 cm between 8-10 h local time. The soil samples were placed in labeled black cellophane on the site of collection, date and temperature were recorded. Samples were taken to the Berlese Tullgren extracting funnel immediately and extraction was carried out for 48 h with 70% alcohol in the collecting cans to preserve the collembolans. Berlese Tullgren extractor is best for extracting soil arthropod with an efficiency of 90% (Hopkins, 1997).

Sorting and identification: Sorting was done under binocular dissecting microscope where individual members of collembolans were counted as a result of their small sizes, Hopkins procedure under phase illuminant mount was adopted to mount collembolans in Canada balsam in xylene for identification and documentation. Collembolan identification was done using identification keys from the museum of the Department of Animal and Environmental Biology, University of Benin, Benin city.

Measurement of parameters: The various parameters were monitored during the period of this field investigation include: Soil pH, soil moisture content, soil temperature and Soil Total Hydrocarbon (THC).

According to Bate, standard pH procedure, 20 g of air dry soil from each station was put in a 50 mL beaker and 20 mL of distilled water was added and allowed to stand for 30 min. Then the partially settled suspension (mixture) and readings were taken from the meter scale. The pH meter was calibrated with pH 7.0, 4.0 before use.

Soil moisture content: About 50 g of soil samples were taken from each station and placed in the oven for 24 h till a constant weight was observed.

$$\text{Loss in weight}(X) = \text{Initial weight}(Y) - \text{Final weight}(Z)$$

$$\text{Soil moisture content}(\%) = \frac{\text{Loss in weight}(X)}{\text{Initial weight}(Y)} \times 100\%$$

Where:
Initial weight = Y
Final weight = Z

Soil temperature: Temperature of the soil was taken by digging a hole in the soil (area sampled) and the thermometer was inserted and left for 5 min before reading was taken.

Soil Total Hydrocarbon (THC): In the determination of THC in soil sample the following were used: 250 mL separating glass funnel, spectrophotometer, pipette, mechanical shaker and n-hexane. About 5 g weight of soil from each site was air dried and kept in a bottle container. About 25 mL of n-hexane was added to the soil in order to extract THC. The bottle was placed on the shaker for 10 min and left standing thereafter. A standard solution was prepared and used to zero the spectrophotometer before introducing the extract into the Instrument for absorbance Reading (IR). The THC concentration in parts per million (ppm) is then calculated thus: THC (ppm) = Instrument Reading (IR) × slope reciprocal × 25 mL/5 g. Where Instrument Reading (IR) is from the spectrophotometer.

Recovery rate (Rr): No. of soil microarthropod (Order)/Total number of soil microarthropod × No. of days × 24 h × 60 min × 60 sec.

RESULT AND DISCUSSION

A total number of 993 soil microarthropods were collected from all the stations during the 90 days period of the field investigation. Plot A had 22.56%, plot B, 25.78% and plot C 51.66% of the total population. The population of soil microarthropod increased from the month of treated upward May to June to July (243<273<467). The month of July had the highest catch of soil microarthropods with

47.08% of the total number caught. The increased soil moisture content increased the number of soil microarthropods in all stations and sub-plots during the field investigation.There was no significant difference ($p>0.05$) in the population of soil microarthropod caught in the double treated areas to the single treated areas. Carbofuran insecticides had no effect on the total population of soil microarthropods but on taxonomically specific orders at a depth of 0-5 cm after the treatment. The correlation between the total hydrocarbon content of soil and the total number of soil microarthropods for a period of 90 days after the treatment with carbofuran insecticide was significant at both 0.05 and 0.01 probability level (r 0.05 (2) 4 = 0.811 and r 0.01 (2) 4 = 0.608). It implies that 96% of the increased population of soil microarthropods was due to a decrease in the soil Total Hydrocarbon Content (THC) (Table 1-3).

The result of the investigation demonstrates that soil microarthropods are not evenly distributed. Acarina and collembolan were the most abundant of the soil microarthropods present in the soil samples as a result of the important role they play in the food web (Peterson and Luxton, 1982). Soil temperature decreased from May to July as the moisture content of the soil had positive effect on the total number of soil microarthropod. The population increase may be due to

Table 1: Mean number of bi-weekly soil microarthropods in the order category and the physiochemical parameters for 0-30 days

	First week			Second week		
Plots	A	B	C	A	B	C
Collembolan	2.75±2.06	2.75±2.9	4.75±1.25	0.00±0.0	0.00±0.0	5.25±0.5
Hymenoptera	0.5±1.0	0.25±0.5	0.5±0.57	0.00±0.0	0.00±0.0	0.5±0.57
Coleoptera	1.5±1.0	1.25±0.95	1.25±0.95	0.5±5.0	0.75±0.5	2.25±1.89
Isoptera	0.5±1.0	0.25±0.5	1.25±1.29	0.00±0.0	0.00±0.0	1.75±1.25
Thysaunra	0.75±1.5	0.5±1.0	1.5±0.57	0.00±0.0	0.25±0.5	1.5±0.57
Thysanoptera	0.00±0.0	0.00±0.0	0.25±0.5	0.00±0.0	0.00±0.0	1.0±0.82
Acarina	4.5±2.51	3.75±1.26	4.25±2.63	0.25±0.5	0.75±0.95	7.75±1.5
Myriapoda	1.75±0.95	0.75±0.5	0.75±0.5	0.0±0.0	0.00±0.0	1.5±0.57
THC (mg kg^{-1})	0.51	0.31	0.03	1.46	0.69	0.03
Soil moisture	5.20	5.10	5.10	5.40	5.30	5.60
Soil temp.	27.00	27.20	27.10	27.10	27.00	27.00
Soil pH	6.17	6.18	6.20	6.18	6.18	6.20

Table 2: Mean number of bi-weekly soil microarthropods in the order category and the physiochemical parameters for 30-60 days

	First week			Second week		
Plots	A	B	C	A	B	C
Collembolan	0.75±0.95	0.25±0.5	3.25±1.35	0.5±0.57	2.2±1.5	4.75±0.90
Hymenoptera	1.0±1.40	0.00±0.0	0.75±0.95	0.00±0.0	0.25±0.5	1.0±0.82
Coleoptera	1.5±1.0	2.0±1.41	2.00±0.82	2.0±1.41	1.75±1.70	1.75±1.20
Isoptera	0.25±0.5	0.5±0.57	1.75±1.25	0.5±0.57	1.75±0.5	2.0±0.81
Thysaunra	0.25±0.5	0.5±0.57	1.25±0.95	0.5±0.57	1.75±0.5	1.5±0.57
Thysanoptera	0.00±0.0	0.00±0.0	1.25±0.95	0.00±0.0	0.5±0.57	0.75±0.9
Acarina	3.5±0.71	3.75±3.5	5.75±3.5	3.75±3.5	4.75±0.50	6.0±2.0
Myriapoda	0.00±0.0	0.25±0.5	2.0±0.82	0.25±0.5	1.00±1.41	2.5±3.78
THC (mg kg^{-1})	1.06	0.18	0.03	0.91	0.15	0.03
Soil moisture	6.00	6.10	6.10	6.30	6.30	6.20
Soil temp.	26.30	26.20	26.40	26.00	25.90	26.0
Soil pH	6.19	6.18	6.19	6.18	6.20	6.20

Table 3: Mean number of bi-weekly soil microarthropods in the order category and the physiochemical parameters for 60-90 days

	First week			Second week		
Plots	A	B	C	A	B	C
Collembolan	1.5±0.57	2.25±1.5	4.0±1.41	2.25±0.95	2.25±0.95	6.0±0.82
Hymenoptera	0.25±0.5	0.5±0.57	1.0±0.82	0.5±0.57	0.5±0.57	2.25±0.95
Coleoptera	2.75±1.25	2.75±1.25	2.5±1.29	3.25±1.25	3.0±0.82	4.25±2.98
Isoptera	1.75±1.71	2.25±2.06	3.5±0.57	2.0±1.41	2.25±2.62	5.0±1.15
Thysaunra	0.25±0.5	0.25±0.5	1.25±0.95	0.25±0.5	1.5±1.9	1.75±0.95
Thysanoptera	0.25±0.5	1±1.15	1±2	0.25±0.5	0.75±0.5	0.75±0.95
Acarina	5.75±2.21	6.5±0.75	6.75±4.03	4.5±1.91	6.25±1.5	9.5±4.20
Myriapoda	0.51±1	1.25±0.95	2.25±1.71	1.25±1.25	1.75±1.5	2.25±1.5
THC (mg kg^{-1})	0.70	0.80	0.03	0.52	0.06	0.03
Soil moisture	7.20	7.30	7.10	7.60	7.60	7.80
Soil temp	26.00	26.00	25.90	25.70	25.80	259.00
Soil pH	6.22	6.24	6.22	6.27	6.24	6.26

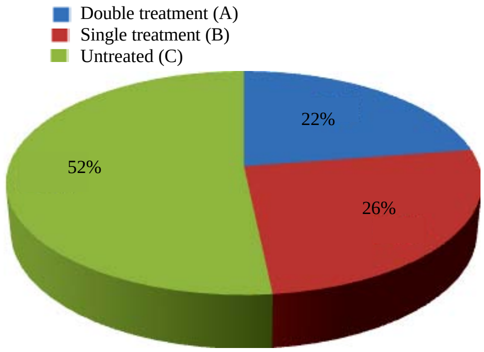

Fig. 1: The percentage distribution of soil microarthropod in the various plots with different treatments

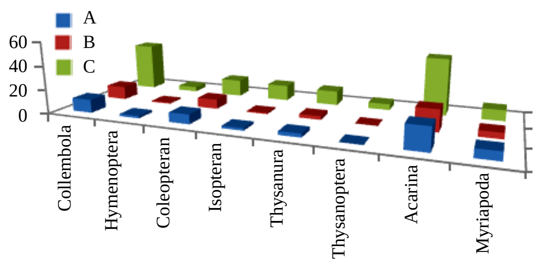

Fig. 2: The distribution of soil microarthropod 0-30 days

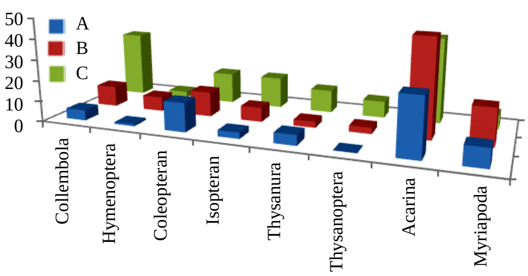

Fig. 3: The distribution of soil microarthropods after the apllication of carbofuran insecticide 31-60 days

hormonligis (stimulation of reproduction) of some classes of soil microarthropods. The Rr of acarina in the double treated plot 9.0×10^{-5} sec^{-1} and the single treatment 1.20×10^{-5} sec^{-1} was as a result of the hard exoskeleton which prevented the absorption of the applied carbofuran insecticide while Rr for coleopterans for double treatment 2.6×0^{-6} sec^{-1} and single treatment 2.3×10^{-6} sec^{-1}, respectively as they had same hard exoskeleton and were non-resident predators (Fig. 1-6). Hymenoptera (H) and Thysanoptera (TH) had the slowest Recovery rates (Rr)

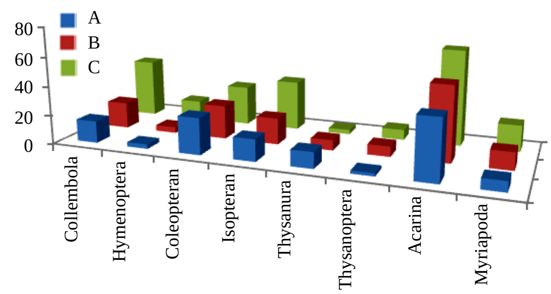

Fig. 4: The distribution of soil microarthropod after the application of carbofuran insecticides 61-90 days

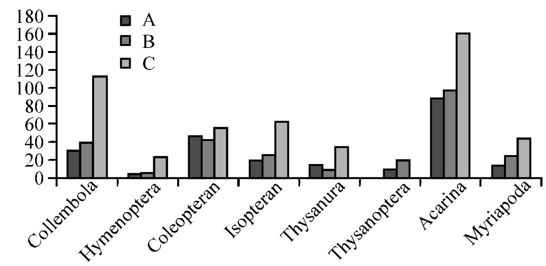

Fig. 5: The distribution of Soil microarthropod throughout the sampling period in the various plots

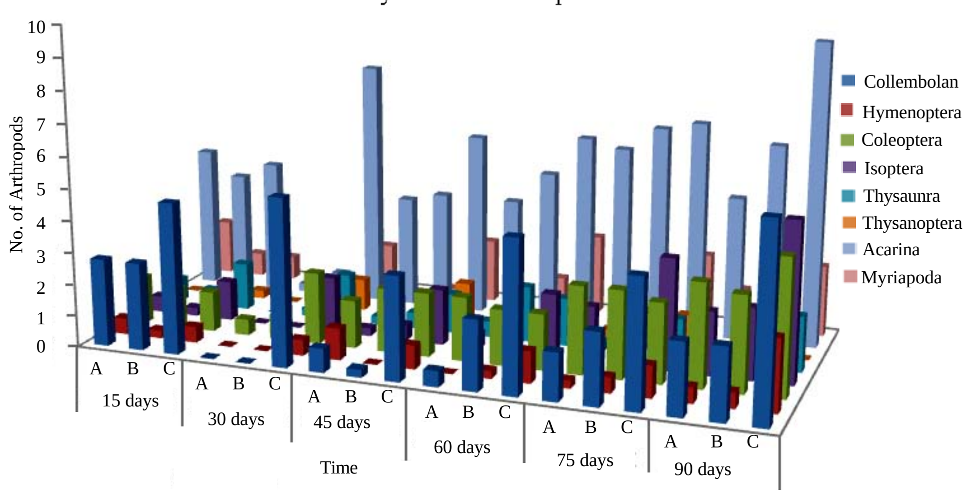

Fig. 6: The distribution of soil microarthropod and their recovery rates for 90 days period

from both treated plots: Rr for double treatment Hrr 4.0×10^{-7} sec^{-1}, THRr 3.0×10^{-7} sec^{-1} and for single treatment Hrr 6.0×10^{-6} sec^{-1}, THRr 1.3×10^{-6} sec^{-1} to carbofuran insecticide at a depth of 0-5 cm suggest their use as indicators of adverse pesticide effect.

CONCLUSION

Carbofuran insecticide is likely not to pose a risk to coleoptera and acarina but to hymenoptera, myriapoda and thysanoptera in uncultivated grassland in the tropics at depth of 0-5 cm in the single and double treatment. The rapid recovery rates of coleoptera and acarina may be due to the presence of hard exoskeleton.

RECOMMENDATION

In further studies hymenoptera, myriapoda and thysanoptera should be used to monitor the effect of pesticides on non-target organisms as their recovery rate were slow.

APPENDIX

Recovery rates (Rr) of insects in plots with double treatment (90 days):

Rr of Collembola	=	$20/90\times24\times60\times60 = 2.6\times10^{-6}$ sec^{-1}
Rr of Hymenoptera	=	$3/90\times24\times60\times60 = 4.0\times10^{-7}$ sec^{-1}
Rr of Coleoptera	=	$39/90\times24\times60\times60 = 5.0\times10^{-6}$ sec^{-1}
Rr of Isoptera	=	$18/90\times24\times60\times60 = 2.3\times10^{-6}$ sec^{-1}
Rr of Thysaunra	=	$18/90\times24\times60\times60 = 2.3\times10^{-6}$ sec^{-1}
Rr of Thysanoptera	=	$2/90\times24\times60\times60 = 3.0\times10^{-7}$ sec^{-1}
Rr of Acarina	=	$70/90\times24\times60\times60 = 9.0\times10^{-5}$ sec^{-1}
Rr of Myriapod	=	$8/90\times24\times60\times60 = 1.0\times10^{-6}$ sec^{-1}

Recovery rates (Rr) of insects in plots with single treatment (90 days):

Rr of Collembola	=	$28/90\times24\times60\times60 = 3.6\times10^{-6}$ sec^{-1}
Rr of Hymenoptera	=	$5/90\times24\times60\times60 = 6.0\times10^{-7}$ sec^{-1}
Rr of Coleoptera	=	$18/90\times24\times60\times60 = 2.3\times10^{-6}$ sec^{-1}
Rr of Isoptera	=	$18/90\times24\times60\times60 = 2.3\times10^{-6}$ sec^{-1}
Rr of Thysaunra	=	$18/90\times24\times60\times60 = 2.3\times10^{-6}$ sec^{-1}
Rr of Thysanoptera	=	$10/90\times24\times60\times60 = 1.3\times10^{-7}$ sec^{-1}
Rrof Acarina	=	$79/90\times24\times60\times60 = 1.02\times10^{-5}$ sec^{-1}
Rr of Myriapod	=	$21/90\times24\times60\times60= 2.7\times10^{-6}$ sec^{-1}

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