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Influence of Atrazine on Soil Microarthropod Fauna, and the Performance of Maize *(Zea mays* L.) in a Humid Tropical Environment.

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Abstract

The influence of atrazine on soil microarthropods, and the growth and yield of maize during the late and early seasons of a humid tropical environment were investigated. Soil microarthropod populations were found to be extremely low in the maize plots where atrazine had been used to control weeds when compared with the adjoining regrowth forest both in the dry as well as the wet seasons. In the regrowth forest and the maize plots, microarthropods were more abundant during the early than the late season. In general, under maize plots microarthropods increased with period after planting due to increased shading effect on the soil afforded by the growing maize plants. Maize performed better during the early than the late season. Although atrazine suppressed the growth of weeds in the maize plots, it also provided unfavourable conditions for the soil microarthropods especially during the early growth of maize when there was no litter cover and the soil was exposed to direct solar radiation.

Introduction

The manual labour involved in the 'slash and burn' technique of preparing land for crop production has made it difficult for peasant farmers to produce enough food for the ever increasing human population. There is therefore a need to modernize our farming systems to allow for increased food production. The soil as a reservoir of nutrients for crops, is of utmost importance to the agriculturist. As a result, many workers have investigated the effects of various farming practices on the microflora, decomposition processes and nutrient status of the soil (Corbet 1934, Dommergues 1954a & b, Mieklejohn 1955, Dommergues 1956, Moore 1960, Egunjobi 1971, Brinkmann and Nascimento 1973, Seubert 1975). In the tropics, little information is available on how the modern farming practices affect the soil fauna, most especially the microarthropods whose role in decomposition processes is critical.

In Nigeria, Critchley *et al,* (1979), Lasebikan (1979) and Perfect *et al,* (1981) reported a selective influence of agricultural practices on soil microarthropods and identified pesticide application as being one of the major factors responsible for reduction in soil microarthropod numbers. They added that the deleterious effect of pesticides became more marked with successive years of repeated application. Badejo (1987) reported further that manual weeding which is the main method of controlling weeds in the tropics caused an increase in arthropod numbers. However, the effect of herbicides on the microarthropod fauna in the tropical ecosystem has not been reported.

This study was carried out to investigate the soil microarthropod fauna under maize, and the performance of maize where a pre-emergence application of atrazine (6-chloro-N-ethyl-N[1]-(1-menthyl ethyl)-1,3,5,-triazine-2,4-diamine) was used to control weeds.

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Materials and Methods

Study area:

A two-year-old fallow in the Teaching and Research farm of Obafemi Awolowo University, Ile-Ife was mechanically cleared and ploughed in June 1984. There had been an alternation of cropping and fallow periods on this piece of land for about 20 years. The prominent weeds in the fallow before clearing were: *Amaranthus hybridus* L., *Amaranthus spinosus* L., *Aspilia africana* (Pers.) C.D. Adams, *Ageratum conyzoides* L., *Cleome ciliata* Schum. and Thonn., *Imperata cylindrica* (L.) Beauv. and *Euphorbia heterophylla* L. The prepared land was divided into two strips of several adjacent plots, each plot being 10 m x 10 m. Plots were separated by strips about 50 cm wide. A 10 m x 10 m control plot was also marked out from the adjoining 20-year old fallow for microarthropod sampling.

The soil of the study area belongs to the *Iwo series* of the Iwo Association (Symth and Montgomery 1962), with a pH of 6.1 and organic matter content of 2% C.

Field Operations

During the late planting season, yellow maize (FARZ 7) was planted at a spacing of 1 m x 1 m in the first plot of the first strip of plots in August 1984. Subsequently, planting was done at monthly intervals on adjoining plots till December 1984. Another set of planting was carried out in the following early planting season between April and August 1985 on the adjoining strip of land. Immediately after planting in each season, the plots were sprayed with 3.0 kg a.i./ha atrazine for weed control using a Knapsack sprayer previously calibrated to deliver spray volume of 250 l/ha at a pressure of 2-3 kg/cm^2. Fertilizer application with NPK applied at the rate of 3.5 kg/plot was carried out 3 weeks after planting. The plots were irrigated twice a day on alternate days during the dry period using overhead sprinkler irrigation system. On each sampling occasion, five plants were randomly selected from each plot for measurement of plant height and number of leaves. The five plants represented five replicates.

Microarthropod sampling, extraction and counting

Late season sampling started in October 1984 when 3 maize plots had been established. Four soil cores were randomly taken from each of the 3 maize plots with a soil auger. Each soil core was 8.5 cm in diameter and 7.75 cm deep. Sampling was carried out thrice at monthly intervals such that on every sampling occasion, the maize on the 3 plots were 1 week, 5 weeks and 9 weeks old respectively.

Early season sampling was done between June and August 1985 using the same procedure as in the late season. On each sampling occasion, soil cores were also collected from the control plot in the adjoining regrowth forest. Microarthropods were extracted from the soil samples in the Berlese-Tullgren extractor. This extractor is made up of a battery of funnels below which are collecting tubes. A sample container with 2 cm wire mesh at the bottom rests

on each funnel. Heat and light were supplied to each soil core which was contained in each sample container from a 25W bulb. Extraction lasted for 8 days although it was observed that after the fifth day, very few microarthropods emerged. The extracted microarthropods were sorted into various taxonomic groups and simultaneously counted under a dissecting microscope.

Results

Table 1 shows the density of microarthropods under the maize plots and the adjoining forest on each sampling occasion and also the development and yield of the maize. Generally, microarthropod density was lower in the maize plots than in the adjoining 20-year-old fallow. Microarthropod density was highest 9 weeks after maize planting and least 1 week after planting in all sets of planting except in November 1984 when the density of microarthropods one week after planting was higher than 5 or 9 weeks after planting (Table 1). In all sets of planting, maize height and number of leaves increased steadily with time from planting up till the 9th week after planting when growth stopped. The height, number of leaves and dry grain yield of maize were more in the early season than the late season probably due to insufficient moisture in the late season as a result of inconsistent functioning of the irrigation pump during this period. However, the yield in the early season is within the range of figures reported for FARZ 7 in the rainforest zone of South Western Nigeria (Fakorede, Personal communication). There also was a progressive decline in yield with month of planting in each season.

The data obtained for the microarthropod groups from the maize plots were pooled into three groups to represent the different periods after planting and show the relative abundance of the microarthropod groups in both season (Table 2). At 1 week and 5 weeks after planting, densities were higher during the early season than during the late season although the species composition of the microarthropods during these two periods (1 week and 5 weeks) was more during the late season than during the early season. *Haplozetes* spp., *Tectocepheus* sp. and Psocoptera appear to be the dominant groups in the maize *Astigmata, Araneida, Pseudoscorpionida, Schizopeltida, Chilopoda, Pauropoda* and *Symphylla* plots. Arthropod groups like were ignored because their numbers were extremely low on the few occasions that they were recorded (Table 2).

Table 3 gives a list of microarthropods that were not encountered at all in the experimental maize plots but present in the adjoining regrowth forest.

Discussion

The higher maize grain yields and better crop development in the early season when compared with the late season was probably due to moisture stress which occurred more in the late season than the early season. Although water was supplied through irrigation in both seasons, evaporation rate was probably higher in the dry months of the late season than the wet months of the early season.

The abundant soil moisture in the early season was probably responsible for the higher numbers of microarthropods in the early season when compared

with the late season. The fact that late season planting was done immediately after the initial clearing and ploughing is probably responsible for the higher species composition of microarthropods in the late season when compared with the early season. Some species were eliminated before ploughing for early season and more species were probably eliminated when the plots were ploughed again and exposed to direct rays of the sun before maize planting.

Numbers of individuals and species of microarthropods are generally low in cultivated plots (Murphy 1952, Olivier and Ryke 1969, Prabhoo 1976, Critchley *et al.* 1979, Lasebikan 1979). However, the numbers of microarthropods encountered in the maize plots were low when compared with the numbers recorded by Lasebikan (1979) and Badejo (1987) who both worked previously in the same location but on different sites. Lasebikan (1979) carried out his investigation in 1975 when most plots on the farm had not been intensively cultivated and therefore supported a richer soil microarthropod fauna. On the other hand, Badejo (1987) located his plot on a 20-year-old fallow which was opened up manually and cultivated with cassava for a one-year period. The plot was also hand weeded. The persistent use of herbicides in the plots under study is therefore probably responsible for the near-elimination of the soil microarthropod fauna. Apart from the fact that maize does not shed its leaves to provide litter, accumulation of litter on the soil surface was prevented by the use of atrazine, a pre-emergence herbicide during this investigation. Microarthropods of the surface soil were therefore denied food and shelter which a litter cover would have provided. Decomposition and nutrient replenishment would therefore be expected to be low in the maize plots. The absence of litter cover was probably one of the reasons why the numbers and species composition of Collembola were low in the maize plots. Fertilizer (NPK) application could also be responsible for the low number of Collembola because Nakamura (1974) reported a reduction in Collembola numbers after application of phosphorous fertilizer. The continued exposure of the bare surface of these plots to solar radiation during the better part of the 20 years of intensive farming might also have created a low moisture regime as a result of evaporation of water from the soil. This situation probably discouraged the growth of microarthropod populations whose survival depended to a large extent on high relative humidity and moisture content of the soil (Butcher *et al.* 1971).

The increase in numbers of microarthropods with the age of maize indicates a population build-up in the maize plots. While this increase may be attributed to availability of moisture due to reduced soil evapotranspirational losses, it is also likely that this trend will continue if the plots are left to fallow after harvest. Darlong and Alfred (1982) and Badejo (1987) have reported that soil microarthropods increase in numbers during the fallow periods.

There is an indication of a difference in the community structure of soil microarthropods of the maize plots and regrowth forest. This is because of the dominance shift observed in the arthropod populations. *Annectacarus* sp., *Carabodes* sp., *Oppia* sp., *Polyaspidae, Rhagidiidae, Trombidiidae, Isotomodes* sp., *Dicranocentrus* spp., *Lepidocyrtus* spp. and *Dicyrtoma* sp. which were dominant in the regrowth forest were completely absent in the maize plots. On the other hand, *Tectocepheus* sp. and *Psocoptera* which were not dominant in the regrowth forest were dominant in the maize plots

although *Tectocepheus* sp. appeared to be more favoured in the maize plots in the early planting season than in the late planting season. *Psocoptera* appeared to have benefited from the application of atrazine and other conditions in the maize plots right from the first week after planting. The only exception to this dominance shift is *Haplozetes* sp. which was both dominant in the undisturbed forest and the maize plot.

These results confirm that cultivation has a selective influence on soil arthropods as already reported by several workers (Critchley et al., 1979 and Badejo, 1987. Furthermore, it can be concluded that intensive mechanized farming accompanied with the use of pesticides will result in a notoriously impoverished soil.

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TABLE 1: MICROARTHROPOD DENSITY UNDER MAIZE AND ADJOINING REGROWTH FOREST, AND MAIZE PERFORMANCE

Month of Sampling	Month of Planting	Period after Planting (weeks)	Mi roarthropod density (N m^2)	Maize plots Regrowth forest	Maize Height at Sampling cm)	No. of Maize Leaves at Sampling	Maize Yield at Harvest Kg/ha
Late season 84							
October (26)	August (15)	9	6,416	17,708	165.4	14	0.64 x 10^3
	September (15)	5	583 (2,569)*		8.2	9	
	October (15)	1	708		2.0	0	
November (27)	September (15)	9	542	10,896	6.0	15	0.58 x 10^3
	October (15)	5	500 (736)		30.4	10	
	November (15)	1	1,166		1.5	0	
December (26)	Oc er (15)	9	2,083	8,896	167.8		0.54 x 10^3
	Nov ber (15)	5	917 (1,194)		8.6		
	Dec ber (15)	1	583		1.5		
Early season 1985							
June (27)	April (15)	9	3,406	32,708	225.0		1.32 x 10^3
	May (15)	5	2,720 (2,794)		32.3		
	June (17)	1	2,256		2.5		
July (30)	May (15)	9	3,333	22,917	2 .2	16	1.4 x 10^3
	June (17)	5	2,292 (2,542)		.0	10	
	July (22)	1	2,000		.4	0	
August (26)	June (17)	9	2,299	28,812	198.0	16	1.01 x 10^3
	July (22)	5	2,010 (2,422)		30.5	10	
	August (16)	1	1,987		2.0	0	

*mean density in the

TABLE 2: MICROARTHROPOD GROUPS AND MEAN NUMBERS PER SAMPLE (± s.e.) IN MAIZE PLOTS IN LATE PLANTING SEASON (1984) AND EARLY PLANTING SEASON (1985)

Microarthropod	Late Season (weeks after planting)			Early Season (weeks after planting)		
	1	5	9	1	5	9
ACARINA						
CRYPTOSTIGMATA						
Nothrus sp.	+	+	1.50 ± 0.38			
Basilobelba sp.	—	—	—	—	—	+
Haplozetes spp.	+	+	5.83 ± 0.85	1.50 ± 0.32	2.00 ± 1.00	5.25 ± 1.55
Scheloribates spp.	+	+	+	—	—	1.00 ± 0.50
Tectocepheus sp.	—	—	+	2.25 ± 0.72	1.25 ± 0.38	2.00 ± 0.71
Galumnidae	—	—	—	—	—	+
Juveniles	+	—	1.50 ± 0.16	—	+	+
MESOSTIGMATA						
Rhodacarus sp.	—	2	1.42 ± 0.20	—	+	—
Uropodidae	—	—	+	—	—	1.00 ± 0.35
Parasitidae	+	+	2.00 ± 0.17	+	—	+
Macrochelidae	—	—	—	1.75 ± 0.38	—	—
PROSTIGMATA						
Cunaxidae	+	—	+		—	—
Bdellidae	—	+	—	—	—	—
INSECTA						
COLLEMBOLA*	+	+	+	+	—	+
PSOCOPTERA	1.83 ± 0.18	+	+	2.25 ± 0.55	8.75 ± 2.59	1.25 ± 0.63
HYMENOPTERA (Formicidae)	+	+	+	+	+	3.00 ± 1.34
COLEOPTERA		+	+	+	—	+
COLEOP. LARVA	+	—	1.42 + 0.14	+	—	1.25 ± 0.24

\+ = Present but represented by less than 4 individuals per plot.
\- = Not Present.
* = Represented by only 4 genera — *Cryptophygus* sp., *Rhodanella* sp., *Paronella* spp. and *Sminthurinus* sp.

TABLE 3: MICROARTHROPOD GROUPS THAT WERE COMPLETELY ABSENT FROM THE EXPERIMENTAL MAIZE PLOTS BUT PRESENT IN THE ADJOINING REGROWTH FOREST

CRYPTOSTIGMATA
- **Annectacarus sp.*
- *Epilohmania sp.*
- *Belba sp.*
- **Carabodes* sp.
- **Oppia* sp.
- *Ceratoppia* sp.
- *Mesoplophora* sp.
- *Rhysotritia* sp.
- *Indotritia* sp.
- *Pthiracarus* sp.

MESOSTIGMATA
- Trachyuropodidae
- Dinichidae
- Ascidae
- *Polyaspidae

PROSTIGMATA
- *Rhagidiidae
- Eupodidae
- Pachygnathidae
- Smaridiidae
- *Trombidiidae
- Anystidae

ISOPODA

DIPLOPODA

THYSANURA

DIPLURA

PROTURA

COLLEMBOLA
- *Ceratrimeria* sp.
- *Pseudachorutes* sp
- *Tullbergia* sp.
- **Isotomodes* sp.
- *Isotomiella* sp.
- *Cyphoderus* sp.
- **Dicranocentrus* spp
- **Lepidocyrtus* spp.
- *Seira sp.*
- *Lepidoseira sp.*
- **Dicyrtoma* sp.
- *Songhaica* sp.
- *Stenognathriopes* sp.

ORTHOPTERA

ISOPTERA

HETEROPTERA

THYSANOPTRA

LEPIDOPTERAN LARVA

DIPTERAN LARVA

*Groups that were very abundant in the regrowth forest.

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