Research Article

iMedPub Journals
http://www.imedpub.com/

European Journal of Experimental Biology
ISSN 2248-9215

2017
Vol.7 No.1:2

DOI: 10.21767/2248-9215.100002

The Effects of Glyphosate and Multrazine on the Abundance and Diversity of Soil Microarthropods at the University Park, University of Port-Harcourt, Nigeria

Abdullahi M Mohammed, Odidikac Umeozor, Tambeken Gbarakoro

Department of Animal and Environmental Biology, University of Port- Harcourt, East west road, P.M.B 5323, Port-Harcourt, Nigeria

Corresponding Author: Mohammed AM. Department of Animal and Environmental Biology, Faculty of Science, University of Port- Harcourt. East west road, P.M.B 5323, Port-Harcourt, Nigeria, Tel: +234 08032243691; Email: mairiga.abdullahi.@yahoo.com

Received date: November 03, 2016; **Accepted date:** January 19, 2017; **Published date:** January 26, 2017

Copyright: © 2017 Mohammed AM, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Citation: Mohammed AM, Umeozor O, Gbarakoro T. The Effects of Glyphosate and Multrazine on the Abundance and Diversity of Soil Microarthropods at the University Park, University of Port-Harcourt, Nigeria. Eur J Exp Bio. 2017, 7:2.

Abstract

The effect of two herbicides, Glyphosate and Multrazine on the abundance and diversity of soil microarthropods (Mites and Collembolans) was assessed in a field experiment conducted from August to December, 2011 at the University of Port Harcourt, Nigeria. The herbicides were applied at varying doses of low (1.4 ml/m^2 active ingredient; a.i, standard (2.8 ml/m^2 a.i) and high (5.6 ml/m^2 a.i) for Glyphosate; and low (2.1 ml/m^2 a.i), standard (4.2 ml/m^2 a.i) and high (8.4 ml/m^2 a.i) for Multrazine; and control was included. The experiment was conducted in a split-plot design with six replicates arranged in a Randomized Complete Block Design. Moist soil samples were randomly collected from treated and control plots at the depths of 0-5 cm, 5-10 cm, 10-15 cm, and 15-20 cm, with an 8.5 cm^2 diameter bucket-type auger. A total of 1080 soil microarthropods comprising of 931 mites and 149 Collembola were recorded. Oribatid mites were the dominant group being present at each sampling period. Total soil micro arthropods collected were 554 Oribatid mites, 377 Mesostigmata and 149 Collembola. The highest number of soil micro arthropods was recorded from the control treatment although this was not significantly different from the numbers recorded from low and standard doses of Glyphosate. All the three levels of Multrazine treatments significantly reduced the population of micro arthropods compared with all the three levels of Glyphosate. Both herbicides completely eliminated Collembola from the treated plots. In all the treatments, fewer soil micro arthropods were recorded as soil depth increased.

Keywords: Herbicide; Soil micro arthropods; Abundance; Diversity mites; Collembola

Introduction

Arthropods are integral part of functional ecosystem and perform key roles as detritivores, herbivores, predators and prey. Micro arthropods, in particular the Oribatid mites and Collembolans are the most abundant and diverse arthropods living in soil and litter environments [1,2]. Different herbicides have different effects on the abundance and diversity of soil microarthropods. Stevenson [3] reported that micro arthropods populations were different under different types of herbicide treatments. Sarath and Gupta [4-6] also recorded variation in the abundance and diversity of microarthropods due to application of different herbicides.

Edwards [7] examined the effect of the herbicide, 2, 4-D sodium on soil micro arthropods and reported that no significant effect was recorded on mite populations. Prasse [8] recorded a significant decrease in the abundance of Oribatid populations due to the Simazine treatment while, 2, 4-D sodium did not produce any significant effect. It has been reported that long-term uses of herbicides significantly reduce the population of collembolans [9]. Also that community structure, abundance and diversity of soil micro arthropods are influenced by the availability of organic matter, substrate quality, concentration of macro-and micro-nutrients and age and biodiversity of rehabilitating habitat [10].

Soil microarthropods perform several key roles in the soil which make them a vital part of all ecosystems, including agriculture. They are known to improve soil quality and productivity by decreasing bulk density, increasing soil pore space, soil horizon mixing, increasing aeration and drainage, increasing water holding capacity, litter decomposition and improving soil aggregate structure [11,12]. They can respond sensitively to land management practices, integrate ecosystem processes which can be used as bio-indicators to quantify environmental degradation [13-15].

Soil micro arthropds also play important role in fragmentation and commination (i.e. the reduction to small fine particles) which have very important consequences on decomposition and mineralization processes because they create new surface area for microbial colonization [16,17]. Glyphosate and Multrazine are herbicides mostly used by farmers in the study area, thus, it is pertinent to ascertain their effects on soil micro arthropods. The effects of herbicides on soil micro arthropods are likely to be influenced by the frequency of rainfall in the study area. The aim of the study was to assess the effects of Glyphosate and Multrazineon the abundance and diversity of soil microarthropods in the university environment located in the tropical rain forest zone of Nigeria.

Materials and Methods

The field experiment was conducted on natural soil with undisturbed animal communities between August and December 2011 to which two herbicides, Glyphosate and Multrazine, were applied by small volume hand sprayer with a capacity of 255 ml to compare their effects on the abundance and diversity of soil micro arthropod communities.

Study area

The research was conducted at the University Park, University of Port Harcourt, Nigeria. Port Harcourt city is situated on the southern part of Nigeria (6° 19'N, 6° 36'E), located in the rain forest zone of humid tropics. The prevailing climate is tropical monsoon with bimodal type of rainfall in a year. The rainy season starts from March and ends in October while the dry season lasts for four months, November to February with occasional rainfall. The heaviest precipitation in the city occurs during the month of September with an average of 370 mm of rain. Temperature shows little variation throughout the course of the year, with mean annual temperature of 35°C.

Experimental design

The study area was an expanse of land adjacent to Ofrima Complex at the University Park, University of Port Harcourt. Four plots (31 × 11 m^2) which had not previously been sprayed with herbicides were selected. The experiment was laid out in a simple Randomized Complete Block Design (RCBD) with herbicide as the main factor and application dose as the sub plot factor, and each treatment combination was fitted into plot size measuring 9 × 11 m^2. The doses were applied as low (1.4 ml/m^2 a.i), standard (2.8 ml/m^2 a.i) and high (5.6 ml/m^2 a.i) for Glyphosate and low (2.1 ml/m^2 a.i), standard (4.2 ml/m^2 a.i) and high (8.4 ml/m^2 a.i) for Multrazine and a control was included at a distance of 3 m from the experienenmental plots. The blocks were well delineated and marked out to prevent the interference of the herbicides.

Sample collection and processing

Soil microarthropods sampling procedure involved three main stages

- Collection of soil samples.
- Tullgren Funnel extraction.
- Sorting and identification of extracted organisms.

Collection of soil samples: To evaluate the effect of the various treatment combinations on soil microarthropod abundance, the first soil samples were collected 14 days after the herbicides were applied and further collections were made at the intervals of 21 days during the period of August to December, 2011.

Soil samples were collected at various depths of 0-5 cm, 5-10 cm, 10-15 cm and 15-20 cm from each of the treatment combinations using bucket-type auger (8.5 cm^2 diameter) between the hours of 8-10 am. The auger was pushed into the soil and rotated by vertical application of pressure in a clockwise direction at each depth. Each ring containing moist soil was gently placed in a plastic bag to avoid the loss of the micro arthropods and the samples were then transported in a cooler to the Entomology Laboratory of the University of Port Harcourt after each sampling period for extraction.

Extraction of micro arthropods: Soil micro arthropods were extracted from the soil samples by a modified Berlese-Tullgren Funnel method [14,18,19]. The set of soil samples collected were removed from the nylon bags and placed over a fine wire mesh screen at the top of the funnels where they were immediately exposed to 60-watt light bulbs on the funnels for 7 days with periodic observation to ensure that dead bulbs were replaced. The brightness and heat generated from the bulbs dry out the soil from above and stimulate the soil animals (micro arthropods) to move downward (positive geotaxis in response to dryness). This downward movement eventually causes them to fall through the sieve into small vials of 70% alcohol attached to the base of each funnel. This method is the best technique for extracting soil micro arthropods with an efficiency of about 90% [18-20] and it also allows for an affordable and effective micro arthropods extraction at a low cost. The extractions were terminated seven days after each sampling throughout the period of the study and collection vials containing micro arthropods were removed for sorting and identification.

Sorting and identification of extracted organisms: After the soil micro arthropods were extracted, they were placed in a Petri-dish and observed under a binocular dissecting microscope at low magnification. Mites and Collembolans were carefully sorted to suborders. Species were individually placed in a separate specimen bottles containing 70% alcohol for preservation and later mounted on a temporary slides for taxonomic identification. Species identification was done in the Entomology Laboratory by the use of identification keys [21-25].

Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using SAS 9.0 at 95% level of significance. Comparisons between treatments were done at the species level or at the community level and means were separated using New Duncan's Multiple Range Test (NDMRT) at 0.05 error limit.

Results

A total of 1080 soil micro arthropods comprising 931 mites and 149 Collembolans were collected during the study.

Effects of herbicides on abundance

Effects of low concentrations of herbicides on the overall abundance of soil mites at the end of the study indicated that a total of 53 soil mites were recorded in the Multrazine treated plots while 191 occurred in the Glyphosate treated plots. At standard concentrations, 44 and 121 of mites were found in the Multrazine and Glyphosate treated plots, respectively. At high concentrations, 28 mites were recorded in the Multrazine treatments while a total of 140 were found in the Glyphosate plots. The control plots recorded the highest number with a total of 358 soil mites **(Table 1)**.

Table 1 Abundance of mites at Low, Standard and High Concentrations of Multrazine and Glyphosate herbicides.

Treatments	Low Conc.	Std. Conc.	High Conc.	Total
Control	-	-	-	358
Multrazine	53	44	24	121
Glyphosate	191	121	140	452
Total	244	165	164	931

Collembolans were not recorded at all levels of herbicide treatment (low, standard and high concentrations) throughout the period of the study but a total of 149 Collembolans were found exclusively in the control plots.

The effects of concentration of Multrazine and Glyphosate herbicides on the abundance of Cryptostigmatids and Mesostigmatids showed that at low concentration, a total of 46 Cryptostigmatids were recorded in the Multrazine treated plots and 182 occurred in the Glyphosate treated plots. At the standard concentration, 44 and 155 of Cryptostigmatids were recorded in Multrazine and Glyphosate treated plots, respectively, while at high concentration, 24 and 103 Cryptostigmatids occurred at Multrazine and Glyphosate treated plots, respectively.

For Mesostigmatids, 7 were recorded at low concentration of Multrazine while 61 were recorded in the Glyphosate treated plots. At standard and high concentrations, Mesostigmatids were not found while 18 and 5 Mesostigmatids were recorded in the standard and high concentrations of Glyphosate treated plots respectively **(Table 2)**.

Table 2 Effects of concentration of Multrazine and Glyphosate herbicides on the abundance of Cryptostigmatids and Mesostigmatids.

Cryptostigmatids Mesostigmatids						
Treatments	Low Conc.	Std. Conc.	High Conc.	Low Conc.	Std. Conc.	High Conc.
Multrazine	46	44	24	7	-	-
Glyphosate	182	155	103	61	18	5
Total	228	199	127	68	18	5

Table 3 shows that the highest number of micro arthropods was collected from the control treatment although this was not significantly different from the numbers collected from low and standard concentrations of Glyphosate. All the three levels of Multrazine treatments significantly reduced the population of micro arthropods compared with all the three levels of Glyphosate.

Discussion

The application of the two herbicides had direct effect on micro arthropods abundance since their number varied among the treated and control plots. The results of the study indicated that Oribatid mites were the most abundant and diverse suborder encountered during the study. They were consistently present in all the treated and control sites. Within the Oribatida, *Scheloribates sp*., *Galumna sp*., and *Bicrythermania sp*. were the most abundant species recorded; their number tends to be stable as well.

Table 3 Effect of different concentrations of Glyphosate and Multrazine herbicides on soil microarthropods.

Treatments	Mean number of soil microarthropods (± SD)
Control	60.8 ± 24.54
Glyphosate Low conc.	52.5 ± 49.49*
Glyphosate Standard conc.	33.7 ± 29.65*
GlyphosateHigsh conc.	26.3 ± 18.42*
MultrazineLow conc.	16.5 ± 13.68
MultrazineStandard conc.	7.2 ± 6.68
Multrazine High conc.	5.0 ± 4.86
*The values are not significantly different (P ≤ 0.05, Duncan's MRT).	

Behan-Pelletier [26] reported that many species in this genus, especially Scheloribates sp. are drought tolerant and ubiquitous. To this effect, they have a worldwide distribution. *Scheloribates sp*., *Galumna sp*. and *Bicrythermania nigeriana* were resistant to both the Glyphosate and Multrazine treatments because they survived the effect of the herbicides. Based on their ability to withstand stress, they are regarded as monitors species [27,28].

Lower number of mites was recorded in Multrazine treated plots compared with Glyphosate treated plots. At low concentrations, higher number of soil mites was recorded than in the high and standard concentrations of the same treatment. The activity of soil mites in the control was maximum which recorded the highest abundance. The variation in abundance of soil mites may be due to the pronounced toxic effect of Multrazine treated plots. The Collembolan populations were completely eliminated by Glyphosate and Multrazine from the treated plots. Therefore, their abundance was highly influenced by the herbicides.

The application of these herbicides particularly Multrazine affected soil mites and collembolans due to contact with and consumption of contaminated soil. The Multrazine immobilized nutrients and also affected the soil structure and led to reduction of the soil oxygen level and soil water. This can lead to the death of some of these soils micro arthropods and subsequently decrease their abundance. In contrast, Glyphosate had less significant effect on these animals which is in line with the results obtained [4] which did not observed adverse effect of this agrochemical on soil micro arthropods probably due the fast Glyphosate inactivation and degradation in the soil [29-31]. The

© Under License of Creative Commons Attribution 3.0 License

results of this study support the hypothesis that different herbicides have different effects on the population densities of soil micro arthropods. This assertion is also supported by the findings of [2] who reported that micro arthropods populations were different under different types of herbicide treatments. Similarly [4,26,28] also recorded variation in soil faunal populations due to application of various agrochemicals.

The dominance of Oribatida recorded among soil micro arthropods has also been extensively recorded by [2,8,26] that their high numbers may be associated with wide range of their feeding habits. They feed on both living and dead organic materials [5,32] made the same observation which was also affirmed by the observations of [33] that oribatid mites are among the most numerically abundant and diverse soil mesofaunal species.

Three species of Collembolans - *Cryptophagus sp*., *Dicyrtoma sp*., and *Tomocerus sp*. were only recorded in the control but completely absent in all the herbicide treated plots. *Cryptophagus* was the dominant species recorded while *Dicyrtomasp* was the least abundant. The absence of the species of Collembola from the treated plots may be attributed to the toxic effect of the herbicides on them including negative impacts on their reproductive rates or indirectly on their food source [34].

It was also possible that the herbicides might have killed many of the Collembolans by adversely affecting their respiration. Their absence may be taken to indicate a significant level of contamination [4]. In this regard, they are considered to be good indicators of soil health. It has also been pointed out that distinct alterations in the population of mites and Collembolans which persisted for some time occurred [35].

The alterations were proportional to Multrazine concentrations. Almeida and Rodrinques [36] studied the effect of the herbicides 2,4-D, and reported a contrary view that species of Collembolans were minimally affected even with successive applications in the following year while [37] reported that the application of herbicide, Glyphosate in a culture of transgenic soy had no deleterious effect on Collembolans. Their studies showed that when herbicides were applied to the soil, mites and collembolans were able to use them thereby increasing their population density until the decomposition of the product occurs. After the reduction of the source (residue of herbicides), the population returned to normal.

Conclusion

This study has demonstrated the deleterious effects of herbicides on soil micro arthropods in the tropical rainforest zone. It indicated that all the three levels of Multrazine herbicide significantly reduced the population of soil micro arthropods, while that Glyphosate herbicide did not show such significant reduction as they were not significantly different from that of the control.

Acknowledgement

The authors wish to thank Mr. J. Hammazani of Petroleum Technology Development Fund (PTDF) for funding the work and Dr. C. Emmanuel of the Department of Environmental Parasitology, University of Port Harcourt who performed the Statistical analysis.

Reference

1. Brussaard L, Behan-Pelletier VM, Bignell DE, Brown DK, Didden W, et al. (1997) Biodiversity and ecosystem functioning in soil. Ambio 26: 563-570.
2. Santos-Roch IM, Andreazze R, Bullini BC (2011) Registros de Collembola (Arthropopd,Hexapoda) no Estado do Rio Grande do Norte, Brazil. Biota Neotropica 11: 167-170.
3. Stevenson FJ (1994) Humus chemistry Genesis, Composition, Reactions: Wiley Interscience. New York 2nd Edition. Stores Inc. Corvallis.
4. Sarath BB, Gupta GP (1986) Effect of systemic insecticides on the population of soil arthropods in cotton field. J Soil Biol Ecol 6: 32-41.
5. Srinivasareddy KM (2002) Impact of agro-chemicals and cropping systems on the abundance and diversity of soil invertebrates. Ph.D Thesis Univ Agric Sci, India.
6. Cockfield SD, Potter DA (1983) Short-term effect insecticidal applications on predaceous arthropods and oribatid mites in Kentucky 12: 1260-1264.
7. Edwards CA (1972) Effect of herbicides on the soil fauna. In: Proceedings of The Tenth British Weed Control Conference 1052-1062.
8. Prasse I (1973) Indications of structural changes in the communities of Microarthropods of the soil in an agro-ecosystem after applying Herbicides. Agr Ecosyst Environ 13: 205-215.
9. Mitra SK, Dutta AL, Mandl SB, Sengupta D (1983) Prelimnary Observations on the effects of rotation of crops and fertilizers on Collembola 657-663.
10. Loranger G, Ponge JF, Blanchart E, Lavelle P (1988) Influence of agricultural practices on arthropod communities in a vertisol. Eur J Soil Biol 34: 157-165.
11. Abbott I (1989) The influence of fauna on soil structure. In: Majer, JD(ed.), Animals in Primary Succession: The Role of Fauna in Reclaimed Lands. Cambridge University Press, 39-50.
12. Palacious-Vargas JG, Castano-Meneses G, Gomez-Anaya JA, Martinez- Yrizar A, Meja-recamier BE, et al. (2007) Litter and soil arthropods diversity and density in a tropical dry forest ecosystem in western maxico. Biodiversity and conservation 13: 703-717.
13. Larson WE, Pierce FJ (1994) The dynamics of soil quality as a measure of sustainable management.
14. Parisi V, Mentac Gardic C, Jacomini C, Mozzaini E (2005) Microarthropods community as a tools to assess soil quality and biodoversity: a new approach in Ially, Agriculture ecosystems and Environment 105: 323-333.

15. Costello MJ, May RM, Stork NE (2013) Can we name Earth's species before they go extinct? Science 339: 413-416.

16. Elkins NZ, Whitford WG (1982) The role of microarthropodsand nematodes in decomposition in semi-arid ecosystem. Oecologia 55: 303-310.

17. Webb DP (1977) Regulation of deciduous forest litter decomposition by soil arthropod faeces. The Role of Arthropods in Forest Ecosystems: Proceedings in Life Sciences 22: 57-69.

18. Edwards CA (1991) The assessment of populations of soil-inhabiting invertebrates. Agric Ecosyst Environ 34: 145-176.

19. McSorely R, Walter DE (1991) Comparison of soil extraction methods for nematodes and microarthropods. Agric Ecosyst Environ 34: 201-207.

20. Lasebikan BA (1994) Preliminary communication on microarthropods from a tropical rainforest in Nigeria. Pedobiologia 14: 402-411.

21. McDaniel B (1979) How to know mites and ticks. Wm C. Brown Company Publisher, Dubuque, Iowa, USA.

22. Norton RA (1990) Acarina: Oribatida. In:Dindal, DL (ed.), Soil Biology Guide. John Wiley, New York 779-803.

23. Wooley TA (1990) Acarology: mites and human welfare. New York 175-202.

24. Krantz GW (1978) A Manual of Acarology. Oregon State University Book Stores Inc. Corvallis 509.

25. Krantz GW, Walter A (2009) Manual of Acarology. Third (edn). Texas Tech University Press: Lubbock, Texas 207.

26. Behan-Pelletier VM, Walter DE (2013) Phylogenetic relationships of Tectoribates: nymphal characters of new North American species place the genus in Tegoribatidae (Acari, Oribatida). Zootaxa 3741: 459-489.

27. Beeby A (1993) Applying Ecology. Chapman and Hall, London 441.

28. Finnamore AT, Winchester NN, Behan-Pelletier VM (2002) Protocol for measuring biodiversity: arthropod monitoring in terrestrial ecosystems. WorldCat.

29. Feng JC, Thompson DG (1990) Fate of glyphosate in a canadian forest watershed.2. Persistence in foliage and soils. J Agric Food Chem 384: 1118-1125.

30. Wallwork JA (1976) The Distribution and Diversity of Soil Fauna Academic Press, London.

31. Wallwork JA (1983) Oribatidae in forest ecosystem. Annu Rev Entomol 28: 109-130.

32. Badejo MA, Akinwole PO (2000) Micro- environmental preferences of oribatid mite species on the floor of tropical rainforest. Experimental and Applied Acarology 40: 145-156.

33. Norton RA (1985) Aspects of the biology and systematics of soil arachnids, particularly saprophygous and mycophagous mites. Quaestiones Entomologicae 21: 523-541.

34. Iloba BN, Ekrakene T (2002) Soil arthropods recovery rates from 5 – 10 cm depth within 5 months period following dichlorov (an organophosphate) pesticide treatment in designated plots in Benin City, Nigeria. Journal of Entomology and Nematology 14: 43-49.

35. Popovici IG, Stan V, Stefan R, Tomescu A, Dumea A, et al. (1977) The influence of atrazine on soil fauna. Pedobiol 17: 209-215.

36. Almeida FS, Rodrigues BN (1989) Herbicide Guide: Recommendations for the proper use of the right and convention all. Ambio 27: 70-77.

37. Bitzer RJ, Buckcclew LO, Eediga LP (2002) Effects of transgenic herbicide-resistant SoyabeansVariteis and systems on surface-active Springtails (Entognatha:Collembola). Entomol Soc 31: 449-461.

© Under License of Creative Commons Attribution 3.0 License