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Effects of Flood Irrigation System on Abundance and Biodiversity of Soil Arthropods on Maize and Rice Farms in Gadau District, Bauchi State, Nigeria

Taofeeq Awwal Abiola* and Ismail Hassan

[1]Department of Biological Sciences, Faculty of Science, Bauchi state University Gadau, P.M.B. 65 Gadau, Nigeria.

*Correspondence Author: taofeeqawwalabiola@gmail.com

ABSTRACT

The human induced changes in the agricultural land (i.e., irrigation methods, tillage practices and land use changes) have profound impacts on the diversity and abundance of arthropods. Arthropods maintain soil ecosystem in variety of ways like breaking down the plant debris and dispersion of microorganisms. The present study was carried out to assess the effect of flood irrigation on the abundance and diversity of soil arthropods at two different randomly selected farms (maize and Rice farm) at Gadau, Itas/Gadau LGA, Bauchi state. Ten (10) pitfall traps fifteen (15) feet away was inserted in each farm for collection of soil arthropods. The arthropods were counted after seven two hours of installation and were taken to the laboratory for identification using physiological method. More also, the abundance of the arthropods was ssdetermined using Simpson index while their diversity was analyzed by Shannon-wiener index. The species abundance of soil arthropods were slightly higher in the old flood irrigation farm than the new flood irrigation farm. *Hymenoptera formicidae* constituted the highest and major proportion while others were detected in a low proportion in this decreasing order: spider, grasshopper and beetle. Although the richest soil arthropod was found in the newly constructed flood irrigation farm, this indicates that the soil arthropods diversity was not affected by the age of flood irrigation farm. Therefore, keeping in view the proven economic and easy irrigation with low energy input, the flood irrigation system can be adopted without harming soil arthropods diversity.

Keywords: Abundance, Biodiversity. Flooded Irrigation, Soil Arthropods, Gadau

INTRODUCTION

Soil biodiversity regulates the proper functioning of any terrestrial ecosystem (Shukla and Skea, 2019: Wolters, 2001). Arthropods are soil invertebrates that can be large or quite microscopic, have jointed legs, and perform particular functions in the the soil community. According to the body widths, they can be classified into two forms mesofauna and macrofauna, also termed microarthropod (0.2mm) and macroarthropod (2mm), they also include the class of insect. Arthropods comprise the major proportion (85%) of soil food web (Gonçalves and Pereira, 2012). In soil food web, arthropods convert plant debris into small fragments - deposited in their feces- which are further digested by microorganisms. This activity promotes the dissemination and propagation of micro-organism population. Moreover, arthropods make the soil porous and arable; improving plant root penetration, ameliorating water retaining capacity and averting erosion and crusting of soil (Culliney, 2013). They also serve as bio-indicators of environmental changes due to their high abundance and taxon richness (Ghiglieno and Simonetto, 2020).

The abundance and diversity of arthropods represent an equivalent variety of adaptations to variable environmental conditions. Aslam, M (2009). The physical and chemical properties of soil play a significant role in the

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abundance and dispersion of soil arthropods (Holmstrup and Maraldo, 2007). Soil biodiversity is significantly impacted by soil pH, organic matter content, texture and the concentration of heavy metals (Potapov and Goncharov, 2017). Due to the intensive agricultural practices, there is a notable loss of biodiversity in agricultural ecosystems (Onyeka and Alex, 2013). Frequent application of pesticides can alter soil microbial communities, reducing their diversity and abundance, and affecting ecosystem functioning Gao,X., et al. (2020). The agronomic practices change the soil micro-climate and influence on arthropods. It also changes the weed emergence, providing alternate habitat, rendering the arthropods prone to mortality by making them vulnerable to predators, dehydration and crushing (Sandhu and Cherry, 2014).

Flood irrigation can reduce water looses through evaporation, percolation, and run off, leading to more efficient water loose. (Kumar, R., & Singh D.K. 2020). Flood irrigation also known as surface or furrow irrigation, delivers water by the design and practice of the flowing of water over the surface to saturated the root zone, which can result in drier soil surface conditions compared to other irrigation methods like overhead sprinklers. This can reduce the abundance of arthropods that rely on moist environments, examples are beetles and spiders. It also altered the microclimate by creating a different microclimate around plants due to localized watering and this can affect the temperature, humidity, and plant physiology, potentially influencing the abundance and distribution of arthropods. Some arthropods may benefit from the modified microclimate while others may be negatively impacted. The composition of arthropod community changes with the change in temporal and spatial variability (Salmon, 2008). The biotic and abiotic factors affect the on-ground and underground spatial distribution of arthropod community. These factors also impact soil properties, plant community and climate (Briones, 2014). In most of the terrestrial ecosystems, seasonality is one of the salient features and soil invertebrate community varies with the changes in seasons (Pen-Mouratov, 2004). The present study was aimed at investigating the effect of flood irrigation on the abundance and diversity of soil arthropods.

MATERIALS AND METHODS

Study Area

The study was conducted in Itas Gadau L.G.A Bauchi State, Nigeria. The town of Gadau is located on $11^0$50’08’’N $10^0$10’02’’E / 11.835566^{0}N 10.16722^{0}E,with a land mass of 2,200 square kilometers with Jama’are and Kiyawa rivers bordering it north-western part, while Zaki Local Government bordered the to the north. Gamawa and Katagum Local Governments Areas bordered Gadau district from the east and south respectively.

The area has a population of about 4088,100 people at 2022 population projection.Gadau town is 15 km away from Azare city. The district is situated in the eastern part of the Local Government, cut-off from the rests of the Local Government by river Jama’are. Gadau is economically blessed with abundant natural resources including rich fertile soil for farming, grazing, reserves, forest, and clay sand and gum-arabic. The area has abundant water too. Based on the availability of abundant fertile land, water and grazing areas are also available; the main occupations of the people are farming, fishing (Wikipedia)

Soil Sample and Arthropods Collection

The research field work was carried out on flooded farms in Gadau in an area called Maiyashi, where two different farms were used for the study; maize and rice Farm. The

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data were collected for a period of two months, from the farms. (Sajjad *et al*., 2022). Ten (10) pitfall traps 15 feet away was inserted in each farm for collection of soil arthropods where the depth was 1feet and the diameter was 0.5 feet. The arthropods were counted after seven two (72) hours of installation and were taken to the laboratory for identification using physiological method.

Identification of Arthropods

For the convenience in analysis, Sajjad *et al*., 2022 method was used. Arthropods were classified into functional groups based on their feeding closely related species are morphotyped into one group habits and behavior. i.e ants (omnivores), spiders (sucking predators), ground beetles (scavengers), and field crickets and grasshopper (phytophagus). (Sajjad *et al*., 2022).

Data Analysis

Diversity and abundance of arthropods were assessed and analyzed using Shannon-Wiener Index and Simpson Index (1-D) (Hammel *et al*., 2001).

RESULTS

The species of arthropods collected in maize farm were spider, grasshopper, ants and beetle was not found (Table 1). Ant has the highest proportion (10) while each of spider and grasshopper was also found in appreciable quantity (8). On rice farm, each of beetle and grasshopper were collected in the same amount and were lowest (2), spider was found to be four (4), while ant has the highest population (5) (Figure 1). The percentage of spider, beetle, grasshopper and ant on the two farms was 30.8, 5.10, 26.6, 38.0 %, respectively. The diversity of the Arthropods in the maize and rice farm based on the Shannon Wiener index analysis were presented in Table 2 and 3. Moreover, Simpson diversity index (SDI) showed the abundance of soil arthropods in both farms (Table4).

Table 1: Number of Arthropods counted in the farms

Name of species	Specie in maize farm	Species in rice farm	% Arthropods
Spider	8	4	30.8%
Beetle	0	2	5.1%
Grasshopper	8	2	26.6%
Ant	10	5	38%
Total:	28	13	100%

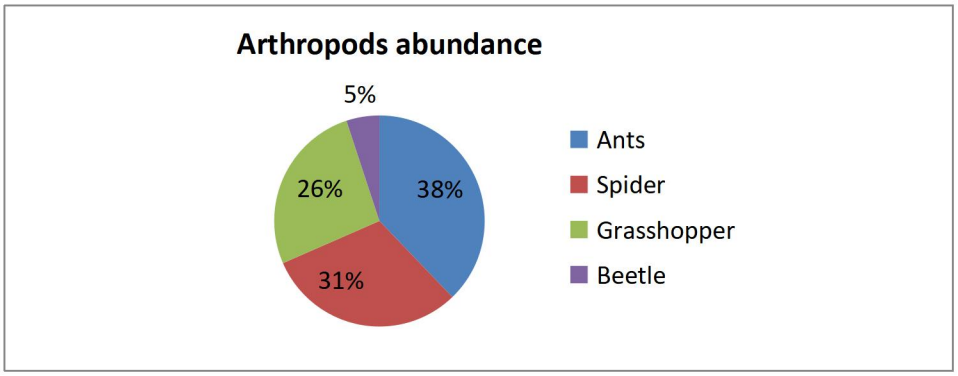

Figure 1: Chart showing the percentages of the arthropods

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Table 2: Shannon Wiener index showing the diversity of soil arthropods in maize farm

Name of species	Number of species	pi	ln(pi)	pi ln(p)	+pi ln(p)
Spider	8	0.308	-1.178	-0.363	0.363
Beetle	0	0	0	0	0
Grasshopper	8	0.308	-1.178	-0.363	0.363
Ants	10	0.384	-0.957	-0.367	0.367
Total	**26**				**1.1**

<1.5 (low diversity)

Pi= percentage in decimal form

Table 3: Shannon Wiener index showing the diversity of arthropods in rice farm.

Name of species	Number of species	pi	ln(pi)	pi ln(p)	+pi ln(p)
Spider	4	0.307	-1.178	-0.362	0.362
Beetle	2	0.154	-1.871	-0.288	0.288
Grasshopper	2	0.154	-1.871	-0.288	0.288
Ants	5	0.357	-1.030	-0.367	0.367
Total	13				1.3

<1.5(Low diversity)

Table 4: Simpson diversity index (SDI), showing the abundance of soil arthropods on both farm

Species richness	No of individual caught	(n-1)	n(n-1)
Spider	12	11	1.32
Beetle	2	1	2
Grasshopper	10	9	90
Ants	15	14	210

SDi-1- ∑n (n-1)/N (N-1)

Where:

n= the number of individual of a particular species

N=the total number of individuals in the sample

∑=the sum of the calculations for each species

DISCUSSION

Thirty nine (39), individual of four species of arthropods was caught using the Pit fall trap (Table 1). Ant had the highest number and diversity, followed by spiders, while beetle had the lowest number and diversity. Species of the arthropods were high in old flood irrigated farm than new flood irrigated farm. The value of Shannon-wiener index showed that diversity is more in old flood irrigated farm (Table 2), and the overall diversity of Arthropods on both farms is low that's < 1.3 (Table 3). According to Shannon- wiener, if the diversity is <1.5 there is low diversity, from 1.5-<2.5 the diversity is moderate while >2.5 means there is high diversity. The abundance of soil arthropods were more in old flood irrigated farm this showed that abundance had correlation to each other and there was more diversity at new flood irrigated farm this showed that abundance is different from diversity, there is a possibility that abundance can be increased by flooding the field that provide shelter and food to the

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arthropods community prior to farming. A study stated that flooding can lead to an increase in the number of ground beetles, as well change in overall composition of insect and beetle taxa (Muller, T., et al. 2015). The abundance of arthropods of species is high in long flood irrigated farm than the new flood irrigated farm. However, there is higher diversity of arthropods in new flood irrigated farm. This may indicate that the abundance of arthropods do not have any correlation with the diversity. Three species were common in both farms i.e., Rice, and maize. One species was found distinct in new flood irrigated farm (beetle). There are many factors that may contribute in the variation of diversity across two farms.

According to (Dalerum et al. (2017), of many factors, seasonal climate change is the chief element that affects the abundance of arthropods. Temperature and humidity are crucial environmental factors determing the distribution and dispersal of soil micro-arthropods across different topographical features (Badejo, M.A., et al 2015) Several studies observed that the genetic variation, and unsystematic distribution as well as the local factors such as temperature, geography and climate greatly influenced the assemblage and configuration of biological organisms (Alonso et al., 2006). Soil arthropods were likely to have significant adaptations to the conditions of soil, humidity and tolerance to other soil management practices that may have enhanced their richness and abundance. Several studies have shown the elevated abundance of arthropods in the cultivated soil due to their adaptations and tolerance to the soil condition and tolerance to the tillage practices (Kirichenko- Babko et al., 2020, Sajjad et al., 2022)

CONCLUSION

In this research, it was discovered that flood irrigation did not significantly affect the abundance and diversity of soil arthropod, because in each habitat the changes in the assemblage, diversity and abundance of soil micro arthropods were also affected by seasonal change. And more also it's concluded that temporary change impact on soil arthropods were that changes in habitat. The biotic and abiotic factors such as plant community, climate changes, geological elevation and soil properties impact the spatial distribution of soil arthropods.

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