ECOLOGICAL ROLE OF ANIMAL DIVERSITY IN SOIL SYSTEM (A CASE STUDY AT EL- RAWAKEEB DRY LAND RESEARCH STATION, SUDAN)

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Abstract:

Interest in soil biodiversity characterization and its function in soil ecosystem have come from the need to develop this ecosystem and manipulate soil biota to encourage a greater reliance on ecosystem self-regulation. Observations on the impacts of agricultural managements on populations and communities of soil fauna and their interactions confirm that high input, intensively managed systems tend to promote low diversity while lower input systems conserve diversity. Animal diversity contributes to soil ecology and functioning such as breakdown and cycling of nutrients in the soil. These animals are essential to the proper function of the soil ecosystem in different environments. In arid environment, the role of soil Collembola , mites and nematodes in decomposing plant litter was assessed and compared in El-Rawakeeb Dry land Research Station, (latitudes 15'' - 2° and 15''- 36° N and longitudes 32'' -0° and 32'' – 10° E) as affected by application of organic manure (bovine manure) or pesticide (neem leaf powder) over one year. Thirty litter bags each one contain 10 gm oven dried litter of *Cajanus, cajan* were buried into the treated and control plots. Six bags per plot along with their respective soil were retrieved four times the year. Mean mass loss in litter was correlated to population density of Collembola, mites and nematodes. Some soil properties eg. temperature, moisture , particle size distribution and organic matter contents were correlated to litter mass loss. Results showed that manuring enhanced role of decomposers in decomposing plant litter, while neem application mostly retarded it.

Key Words: Collembola, mites, nematodes organic manure, neem leaves powder, soil ecosystem

Introduction

Litter decomposition is a biological process by which plant litter is broken down and nutrients held in its combination are released (Deyer *et al*, 1990). It begins usually with large soil animals such as earthworms, arthropods and gastropde. These organisms breakdown plant litter into smaller fragments, which are further decomposed by bacteria and fungi (Pidwiry, 2001). Such decomposition takes several months to several years to complete depending on climatic and edaphic factors. Additionally, litter inherent decomposability are factors that can affect decomposition (Couleausae *et al*, 1995).

Animal decomposers are various groups of animals that feed on waste products produced within a food web. They contribute to the process of litter decomposition and to the maintenance of soil fertility. They also impose regulatory effect on decomposition through their tropic interactions with microorganisms and thus can enhance the primary production, (Setala and Huhta, 1991). Coleman and Crossaly (1996) illustrated that decomposers animals include protozoans, earthworms, micro arthropods such as mites and Collembolan and macro arthropods such as insects, arachnids, millipedes and centipedes. Seastedt (1984), illustrated that the presence of free living mites increases litter mass loss and primary productivity. These observations agreed to the recent findings of Khalil *et al* (1999) who added that soil mites could be used as bio indicators for ecotoxicolgical responses and environmental monitoring.

Nematodes are the most abundant soil decomposers animals. They are found in surprising numbers and usually classified according to their feeding habits, (Brady, 1990). Moreover, they represent major reserves of nutrients that upon their death returned to the cycle and used as food for other invertebrates. Nematodes affect decomposition directly as microbiovore feeding on primary decomposers. They can also affect decomposition as phytophages since they feed on the living protoplasm and plant which may facilitate their decay, (Yastes, 1979).

Soil decomposers animals are very important functional groups. They gain this importance through their contribution to different biological processes especially to organic matter decomposition and nutrients cycling. There is, therefore, a reason concerning the study of the potential role of decomposers in litter decomposition. The present study involves evaluation of the role of soil Collembola, mites and nematdes in litter decomposition in relation to manuring and application of neem leaf powder. It is also meant to clarify the impact of these animals in enhancing plant growth and productivity.

Materials and Methods

Study Site

Field experiments were conducted at El-Rawakeeb Research Station which lies in a El-Rawakeeb dry land which occupies the area southwestern Omdurman Governorate. It is located between latitudes 15" - 2° and 15"- 36° N and longitudes 32" -0° and 32" – 10° E. It thus lies within the tropical semi – arid region of the Sudan and its climate is characterized by a short rainy season that extends from July to October with peak in August as shown in Fig. (1).

According to El-Hag *et*, *al*. (1994), the average rainfall was 100 – 180 mm, and the evaporation potential was 1800 mm thus the relative humidity is low. The summer season usually, extends for a long period with a maximum temperature of 43 C° during May (Fig.2). The soil temperature was lower than the ambient temperature throughout the year. The geological formation of the area is mainly basement complex overlain by superficial deposits of the Nubian sand stone.

The soil is generally characterized by sandy texture, poor organic nitrogen and carbon, moderate bicarbonate and potassium and high sodium, calcium and chloride contents, El-Hag *et, al*. (1994).

The natural vegetation of El-Rawakeeb area is composed mainly of *Acacia sp*. (e.g. *Acacia tortilis*) and different grasses (e.g. *Aristida sp*.). This natural vegetation is replaced in the cultivated sites by some cereals (e.g. *sorghum bicolor*) and few legumes (e.g. *Cajanus cajan*). The system of land use is mainly pastoral except in low land where traditional agriculture is practiced. Within El-Rawakeeb Research Station, irrigated fodder, vegetables and cereal crops are grown.

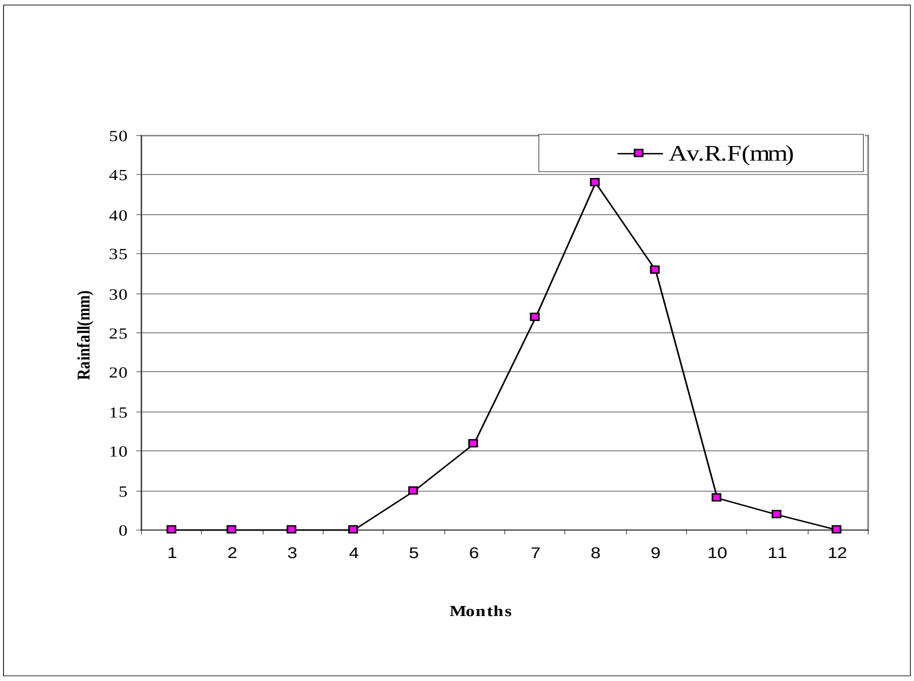

Fig.(1): Mean monthly rainfall in Khartoum state during the study period

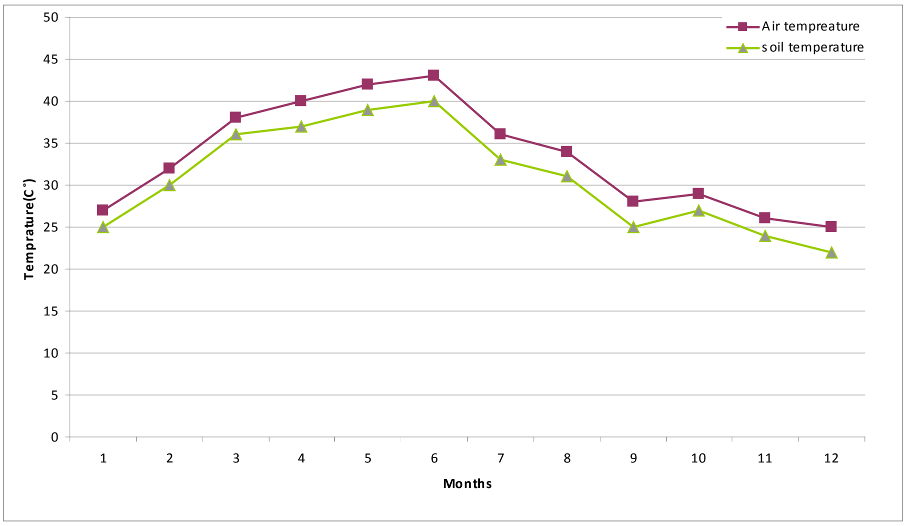

Fig.(2): Mean monthly air and soil temperature as recorded - El –Rawakeeb dry soil during the study period

Preparation and application of treatments

Fertilizers

Organic manure in the form of cattle manure was used as fertilizer. Fresh manure was collected from Shambat Dairy Production Unit, University of Sudan. It was then subjected to sunrays for 6 hrs to eliminate any possible faunal content and used as organic manure.

Pesticides

Leaves of neem tree (*Azadirachta indica* A. juss) were manually collected, air-dried and ground using a pestle and a mortar. Neem leaves powder was then used as pesticide.

Preparation of litterbags

Litter bags were prepared following Cepeda-Pizarro *et al.* (1992). Fresh leaves materials were collected from individuals of *Cajanus cajan* grown in the study area. Immediately after collection, the leaves were dried in sunlight for a week and then at 50 °C in an oven for 24 hrs. When dry, leaves were fragmented into large fragments using a mortar. Ten gm leaves' fragments were weighed and placed in bags made of cloth mosquito netting, of (10 X 5 cm) size.

Experimental layout

Litter bag experiment was conducted at El-Rawakeeb Dryland Research Station Prior to experimentation the study area was divided into 45 plots each plot is of 3 X 2 m in area in a complete randomized block design. The 45 plots were then grouped into three groups each group is of 15 plots, which were then kept as permanent sampling plots. The whole plots were cultivated with *Cajanus cajan* legume which is commonly known as pigeon peas in English or lubya Sudani in Arabic languages. According to the method described by Hafiz (1998), 12-kg of cattle manure were weighed and added to the first 15 plots. These were used as manure treatment plots.

Neem leaves powder was added to the soil as one gm/plant hole in the second 15 plots according to Siddig (Pers Comm). These plots were used as neem treatment plots. The rest 15 plots were kept as control.

A total of 90 litterbags were buried to a depth of 10 cm of each sampling plots. Sampling took place every 120-day. The sampling periods were winter, autumn and summer. Nine bags along with their respective soil were randomly retrieved from the field on each sampling event. The retrieved bags were reweighed and their mass loss was obtained. Soil samples were analysed for their some of physicochemical properties. Following methods described by the International Centre for Agricultural Research in Dry Areas (ICARDA).

Extraction of animal decomposers

Nine soil samples were weekly taken randomly from each sampling plot. They were then introduced into polyethylene bags and taken to laboratory for decomposers extraction as follows:

Extraction of nematodes

Nematodes were extracted from soils of the study using Baermann trays technique as described by Freckman and Baldwin (1986). A soil sample was spread evenly into a thin layer over a sieve lined with tissue paper. The sieve containing the sample was placed in plastic tray. Sustainable amount of water was added to saturate the soil sample. The nematodes became active, swam out of the soil, and sank on the bottom of the tray. The nematodes were collected in water and preserved in 75 % ethanol for further identification.

Extraction of mites and Collembola

Mites and Collembola were extracted using Tullgren funnel apparatus as described by Griffith (1996). This method is based on taking a soil sample and applying a physical or a chemical stimulus to drive the animal into a collecting fluid. Tullgren funnel apparatus consists of a metal funnel measuring 25 cm in diameter. A fine mesh screen of 0.2 mm size was fitted to the neck of the funnel to retain the soil sample. Since dividing 1 kg soil sample into sub samples produced no difference in the encountered fauna, the funnel was loaded with the whole1 kg soil. The funnel was then fitted to a beaker containing 70 % ethanol as a preservative medium. The soil sample was subjected to the direct illumination of a 60-watt light bulb placed 10 cm above soil surface for 24 hrs. The contents of the collecting beaker were transferred into a Petri dish and then examined under a binocular microscope. The fauna collected were further preserved in 75% ethanol for further identification.

Statistical analysis

Litter decomposition in EL-Rawakeeb treated soil were analyzed as affected by the application of cattle manure and Neem leaves powder using the Statistical package for social sciences (SPSS), (1997) under Windows.

Results and Discussion

Soil Properties

Effects of manuring and application of neem leaf powder were evaluated through the study period. Results shown in table (1) explained that manuring increased water content and decreased temperature value. It also decreased soil contents of silt and sand but increased clay content as compared to the control. Manuring decreased pH and increased organic C and N contents. These results could be ascribed to the fibrous content of cattle manure which may add to its cementing effect of manure to soil particles. These effects may improve soil texture and increase its ability to retain water content by improving its water holding capacity. Also, manuring may alter cations and anions contents and improve its organic matter content. These findings were in conformity with Hafiz (1994) who studied the impacts of cattle manure application on soil properties. He concluded that cattle manure has a significant positive effect on soil bulk density texture and water content:

Application of neem leaf powder to El-Rawakeeb soil induced varying impacts on its physicochemical properties as given in table (1). Physically, neem application increased water and clay contents but decreased temperature, sand and silt contents. Chemically, it increased soil organic contents and C and N while induced insignificant change on soil pH. These results might be due to the amendment effects and neem beside its biocidal effects Radwanski and Wickens (1981) evaluated the impacts of neem products on soil properties. They concluded that neem products added significant amounts of organic matter, improved soil texture and increased its cations contents.

Table (1): Physicochemical properties of El-Rawakeeb soil as affected by application of cattle manure or neem leaf powder

Soil properties	Treatments		
	Cattle manure	Neem leaf Powder	Control
Water content	0.251a	0.158b	0.107c
Temperature	30.40a	31.04a	34.68b
Sand	68.30a	70.20a	72.70b
Silt	17.60a	18.30a	21.20b
Clay	14.10a	11.50b	6.10c
pH	7.17a	7.05b	7.06b
Organic N	0.10a	0.08a	0.02b
Organic C	1.54a	1.45a	0.013b

Means with same letter do not significantly differ, otherwise they do according to Duncan's multiple range test.

Litter decomposition in treated soil

Litter decomposition was measured as mean litter molasses over four sampling periods in response to manuring or neem application. Results shown in table (2) indicated that mean litter mass loss varied between treatments. Manuring increased litter mass loss during the first, second and fourth sampling periods but induced insignificant change in litter mass loss for the third sampling period as compared to the control. Increase in mean litter mass loss could be due to the possible effects of manuring on soil properties which in turn may enhance litter breakdown. Tester (1990) observed that manuring improved soil properties and altered litter decomposition consequently.

Application of neem leaf powder to El-Rawakeeb soil induced significant decreases in mean litter mass loss during the first, second and fourth sampling periods as given in table (2). These results could ascribe to neem toxicity which may reduce soil biological activity and reducing litter decomposition accordingly. Similar results were given by Parker *et al* (1984).

Maunring or neem application induced insignificant change in litter decomposition during the third sampling period as compared to the control (table 2). These results might be due to the effect of the rainy season which may mask the effects of treatments. Also, the rainy season flavoured decomposers to flourish and enhance the rate of litter mass loss. Christensen (1985) studied litter decomposition under field conditions. He observed that the percentage of litter mass loss was significantly higher during the rainy season than the other seasons of the experimentation year. Moreover, Reddy *et al* (1989) added that seasonal fluctuation of decomposers greatly affected litter decomposition.

Table (2): Litter decomposition in treated soil as recorded for four sampling periods.

Sampling periods	SS	MS	df	F-Values	
				F-calculated	F-tabulated
Period I	3.28	1.64	2	4.16*	3.17
Period II	21.59	10.79	2	3.59*	3.17
Period III	8.01	4.00	2	0.92Ns	3.17
Period IV	200.94	100.47	2	228.11**	3.17

* Significantly difference at P = 0.05 ** Significantly difference P = 0.01 Ns = insignificant difference.

Impact of decomposers animals on litter decomposition

Impact of Collembola, mites or nematodes on litter decomposition was assessed in El-Rawakeeb soil treated with cattle manure or neem leaf powder. Results shown in table (3) indicated that the three faunal groups were significantly positively correlated to mean litter mass loss upon manuring. These results could be ascribed to the substantial effect of manuring on decomposers animals which may in turn intensify their decomposing activity. Wenner and Dindal (1990) evaluated the impact of manuring on the functional role decomposers fauna. They found that manuring significantly increased population densities of fauna and intensified their ecological role in soil processes. Chiagnon *et al* (2000) noticed that decomposers animals responded to manuring interms of population density and functional role.

Table (3) showed that only Collembola correlated positively to litter mass loss upon neem application than the other two groups (mites or nematodes). This might be due to the ability of Collembol to resist neem toxicity by increasing its population density.

Moriarty (1978) explained that Collembola showed adaptive response to biocides application by increasing individual chances of survival and reproduction rate.

The insignificant correlation to litter of mites or nematodes to litter mean mass loss upon neem application could be attributed to neem toxicity which may retard ecological role of these animals. Wright and Coleman (1988) revealed that neem application reduced mites population density and reduced their biological activities as decomposers. Similarly, Brady (1990) observed negative effects of neem products on nematodes under normal conditions (control soil), mean population density of each of Collembola, mites and nematodes exhibited significantly positive correlation to litter mass loss as shown in table (3). This could be due to the direct effect of these animals as decomposers. Lussenhop (1980) indicated soil arthropods affected litter mass loss significantly due to their small sizes and great abundance in soil ecosystem. Paker *et al* (1986) observed positive correlation between arthropods or nematodes and litter mass loss under normal (untreated) soil.

Table (3): Correlation between decomposers animals and litter mean loss in El-Rawakeeb soil treated with cattle manure or neem leaf powder.

Taxon	Treatments		
	Cattle manure	**Neem leaf powder**	**Control**
Collembola	0.904**	0.831*	0.821
Mites	0.884**	0.693	0.810*
Nemastodes	0.814**	0.502	0.809*

* Significant at P = 0.05 ** Significant at P = 0.01

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