Original Article

Decomposition of *Jatropha curcas* Linn. Litter

(A case study at El Rawakeeb Research Farm, Sudan)

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ABSTRACT

Decomposition is a biological process through which nutrients are released for plant use. The physic nut (*Jatropha curcas* Linn.), is a potential tropical plant that can be grown to improve the environment and enhance the quality of rural life. Since, knowledge about the decomposition of *Jatropha curcas* litter is not fully documented in Sudan, the objective of this study is to evaluate decomposition and factors affecting it. A completely randomized block design field experiment was conducted at El-Rawakeeb Research Farm. The study area was divided into three study sites according to plant spacing. These sites were: A: control barren site, B: planted site spaced at (2x270 m) and C: planted site spaced at (1x3m). Eight gram air dried *Jatropha curcas* litter was weighed into 0.1 x 1.5 m nylon litter decomposition bags of 2 mm mesh size. Litter bags were buried at 20 cm soil depth in the three sites. Random samples of these bags along with their soil contents were periodically retrieved monthly and for four months for analyses. Results obtained indicated significant variations in litter decomposition between the three study sites. Significant differences in soil temperature and pH values and insignificant variations in humidity, Ca, Mg and silt contents, Sat, Na and SAR, between the three study sites, (P≤0.05) were noticed. Significant differences in population density of the extracted decomposers fauna (i.e. Collembola, termites and mites) were obtained. (P≤0.05). These results emphasize that decomposition of *Jatropha curcas* litter is affected by plant spacing, site characteristics and population density of decomposers.


INTRODUCTION

Decomposition process is defined as "a biological process by which organic matter is broken down and nutrients held in its combinations are released for plant use", (Dyer *et al* 1990). Most of the above ground net primary production of terrestrial ecosystem is returned to the soil as plant litter. The products of complete decomposition are carbon dioxide, water, and inorganic ions (like ammonium, nitrate, phosphate, and sulfate). It is necessary to all ecosystems because it reincorporates nutrients in dead plants and animals and makes them accessible to plants (Magill, 1989).

Decomposition of this litter is influenced by substrate quality, environmental conditions and decomposers organisms. They added that although decomposition is mainly a result of microbial activity; soil fauna are important in conditioning the litter and stimulating the microbial actions, (Coleman and Crossley (1996). Shredding is done by fauna that feed on the detritus and thereby break it into smaller parts. These smaller parts have greater surface area for chemical decomposition, and leaching. The increased surface area allows more microbes to chemically decompose the detritus and exposes more detritus area to the processes of leaching (Magill, 1989). Culliney (2013) reported that mesofauna comprise the important middle links of soil food webs, serving, in their role as both predator and prey, to channel energy from the soil microflora and microfauna to the
macrofauna on higher trophic levels. The Acari of the soil includes members that feed on dead plant materials, as well as on the microflora (bacteria, fungi); in addition, species of Prostigmata and Mesostigmata may prey upon elements of the micro-and mesofauna.

Moreover, collembolan are extremely abundant in soil and leaf litter, with significant densities. Termites are said to dominate soil arthropod assemblages across much of the dry tropics and into dry temperate regions. They depend entirely on the partly decomposed plant matter in the soil, (Schuurman, 2012)

A comprehensive knowledge of the organic matter decomposition and nutrient release patterns from leaf litter maximizes soil sustainability and crop productivity (Mugendi et al., 2000). Planting tree species with high biomass production and rich in foliar and branch nutrient content can therefore play a major role in maintaining levels of soil organic matter, (Young, 1997).

The Jatropha curcas L. plant is currently receiving a great deal of attention. It has been recognized as a source for medium viscosity plant oil that is easily converted to biodiesel with good product properties (Agarwal, 2007).

According to Carels, (2009), Jatropha curcas L. belongs to the family Euphorbiaceae and described as small tree or shrub which can reach the height of 5 m with branches containing latex. The plant is monoecious and flowers are unisexual, pollinated by insects. The lifespan of the plant is more than 50 years, and has a long history of medicinal uses where the leaves are used to relieve cough and as an antiseptic after birth. Additionally, it has environmental uses that include: boundary demarcation, since the plant is not browsed by animals and can live for long periods. It is also used for live fencing to protect gardens and fields. As Jatropha is known to be highly adaptable to harsh environment, drought tolerant and with lateral roots near the surface (Kaushik et al., 2007); it is used for anti-erosion measures, either in the form of plantation together with other species, or in the form of hedges to reduce wind speed and protect small earth dams or stone walls against run-off water. Kernels of Jatropha curcas L. containing 25-40% oil are used for the production of biodiesel chemically. The growing global biodiesel market has attracted investors and project developers to consider Jatropha curcas L. biodiesel as a substitute for fossil resources to reduce greenhouse gas emissions. By promoting the integrated utilization of Jatropha plant, the Jatropha system can provide direct financial benefits to rural economy.

Litter bags are usually used by scientists interested in decomposition studies and factors that speed or slow it. These bags contain a standard amount of detritus. They can be placed in different ecosystems, e.g. soil, stream, pond, etc. and then retrieved after a set amount of time and the fate of the detritus is determined. Bags can be buried in different places, treated in different ways and/or filled with different materials. They also can be crafted from screening with different sizes of holes to allow different kinds of organisms e.g soil fauna to get inside, (Harmon, et al 1999).

This study examines the influence of the soil fauna on Jatropha curcas litter decomposition under arid conditions. It also investigates the rates of Jatropha litter decomposition. Throw some light on the role of Jatropha curcas leaf litter in improving soil properties.

MATERIALS AND METHODS

Study Area
El-Rawakeeb dry land (Fig 1) 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 (July – October) with a peak in August (Fig. 2). According to El Hag et al. (1994) the average rainfall was 100 – 180 mm., and the evaporation potential was 1800 mm. and thus the relative humidity is low. The summer season usually extends from a long period with a maximum temperature 43.0°C during May, (Fig. 3). The soil temperature was lower than the ambient temperature through the year (El Hag et al. 1994).

Figure 1. Location map of El Rawakeeb area, (Source DRI An.Rep.2012)
Fig. 2 Mean monthly rainfall in Khartoum State during the study.

Fig. 3 Mean monthly air and soil temperature as recorded at El-Rawakeeb dry soil during the study.
The geological formation of the area is mainly basement complex overlain by superficial deposits of the Nubian Sandstone (El Hag et al. 1994). The soil, within the study area is generally characterized by its 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* spp. (e.g. *Acacia tortilis*) and different grasses (e.g. *Aristida* spp.). This natural vegetation is replaced in the cultivated sites with 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 Farm, irrigated fodder, vegetables and cereal crops are grown. *Jatropha curcas* L. is a wild plant originated in Central America from which it was introduced by Portuguese seafarers to Africa and Asia. Botanically, the genus *Jatropha* contains approximately 170 known species. The genus name *Jatropha* derives from the Greek jatrós (doctor), trophé (food), which implies medicinal uses. Curcas is the common name for physic nut in Malabar, India. The plant is planted as a hedge (living fence) by farmers all over the world, because it is not browsed by animals.

**Experimental layout:**
A complete block design was used to conduct a field experiment. The study area was divided into three study sites according to *Jatropha* presence and spacing of the plantation. These sites are:

1. A: control barren site,
2. B: planted site spaced at (2x270 m) and
3. C: planted site spaced at (1x3m)

Each of the cultivated sites (B and C) was regularly watered via surface irrigation system.

**Collection of *Jatropha curcas* L. leaf litter:**

Fresh leaves of *Jatropha curcas* plants were manually collected from EL- Rawakeeb Research Farm. These plants were planted by 1x1 m spacing, the collected leaves were subjected to air drying at room temperature.

**Preparation of litter bags:**
Eight gram air dried litter of *Jatropha curcas* were weighed into 0.1 x 1.5 m nylon litter decomposition bags with a 1-mm mesh size. Twenty seven litter bags were used to test for decomposition at each study site. Three litter bags per site were collected on days 30, 60 and 90. At each retrieval date, litter bags along with their soil contents were retrieved, placed in nylon bags and taken to laboratory for biological, physical and chemical investigations.

**Soil analysis:**
Soil samples were analyzed for their physical and chemical properties using the United States Department of Agriculture (USDA, 2014), manual for soil analysis.

**Extraction of decomposers animals:**
The retrieved litter bags were used to extract their faunal content using Tullgren Funnel method. Litter was placed into the funnel for 24h after which fauna were isolated under a dissecting microscope (Model Ms 13). Collected fauna were classified to their possible taxonomic group using reference keys.

**Litter decomposition:**
Decomposition of *Jatropha curcas* L. leaf litter was assessed in terms of mass loss. Litter bags retrieved were re-weighed and the percentage of litter mass loss was obtained as decomposition indicator.

**Results:**
Generally, indicated that during the first sampling period, sites A and C are found to be alkaline, non saline non sodic sandy loam
where as site B: acidic, non saline non sodic sandy loam. During the second sampling period, site A is alkaline, non saline non sodic the three sites are noticed to be alkaline, non saline non sodic sandy clay loam. Furthermore, despite their vicinity to each other topographically, they are significantly varied in soil temperature and pH values. Table (1) also shows that the three sites were found to be insignificantly differed in humidity, Ca, Mg and silt contents. Sat, Na and SAR, insignificantly differ between sites A and B but significantly differed between each of these two sites and site C. Sand % insignificantly differ between sites A and C, whereas it significantly differs between each of the two sites and site B. The percent of clay content I loamy soil, whereas sites B and C are alkaline, non saline non sodic sandy clay loam soil. During the third sampling period, insignificantly differ between sites B and C, whereas, significantly differ between each of these sites and site A, (Table 1). The variations of these abiotic factors may modify habitat characteristics which in turn may affect organisms and their functional role. Table (1): characterization of soil as described in the three study sites. Muogalu, (2003), and Solly et al (2014) claims that certain abiotic factors such as temperature, moisture and some chemical elements affect soil as a site for decomposition and nutrient cycling into the ecosystem.

Table 1: Soil properties of the three study sites* at El Rawakeeb dry area

<table>
<thead>
<tr>
<th>Sampling events</th>
<th>Site</th>
<th>Humidity %a</th>
<th>Temp c</th>
<th>pH</th>
<th>Sat %a</th>
<th>EC</th>
<th>Ca meq/L</th>
<th>Mg meq/L</th>
<th>Na meq/L</th>
<th>SAR</th>
<th>Sand %b</th>
<th>Silt %</th>
<th>Clay %</th>
<th>Soil Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>7.78</td>
<td>37.7a</td>
<td>7.23c</td>
<td>25.50a</td>
<td>0.625a</td>
<td>0.119</td>
<td>0.92a</td>
<td>0.21b</td>
<td>0.24b</td>
<td>71.40a</td>
<td>7.44a</td>
<td>19.16b</td>
<td>SL</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>1*</td>
<td>37.3a</td>
<td>6.76c</td>
<td>24.00a</td>
<td>0.541a</td>
<td>0.21a</td>
<td>0.99a</td>
<td>0.68b</td>
<td>0.82b</td>
<td>58.40a</td>
<td>27.44a</td>
<td>20.16b</td>
<td>SL</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0.7a</td>
<td>37.7a</td>
<td>7.32c</td>
<td>25.50a</td>
<td>0.410a</td>
<td>0.04a</td>
<td>0.52a</td>
<td>0.49b</td>
<td>0.94b</td>
<td>69.40a</td>
<td>9.44a</td>
<td>21.16b</td>
<td>SCL</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
<td>1.34</td>
<td>29.7b</td>
<td>7.83b</td>
<td>40.00a</td>
<td>0.617a</td>
<td>0.117a</td>
<td>0.174a</td>
<td>0.140b</td>
<td>0.34b</td>
<td>30.56b</td>
<td>39.28a</td>
<td>22.16a</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.66</td>
<td>29b</td>
<td>7.79b</td>
<td>40.00a</td>
<td>0.914a</td>
<td>0.131a</td>
<td>0.248a</td>
<td>0.35b</td>
<td>0.31b</td>
<td>47.56b</td>
<td>20.28a</td>
<td>20.16b</td>
<td>SCL</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>1*</td>
<td>29b</td>
<td>7.83b</td>
<td>40.00a</td>
<td>1.213a</td>
<td>0.351a</td>
<td>2.119a</td>
<td>0.143b</td>
<td>0.13b</td>
<td>49.56b</td>
<td>26.28a</td>
<td>24.16b</td>
<td>SCL</td>
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<tr>
<td>3</td>
<td>A</td>
<td>1.46</td>
<td>26c</td>
<td>8.33a</td>
<td>30.00b</td>
<td>0.75a</td>
<td>0.042a</td>
<td>0.358a</td>
<td>7.11a</td>
<td>16.16a</td>
<td>69.84a</td>
<td>60.0a</td>
<td>24.16b</td>
<td>SCL</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>1.44</td>
<td>26.7c</td>
<td>8.62a</td>
<td>30.00b</td>
<td>0.64a</td>
<td>0.081a</td>
<td>0.804a</td>
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<td>69.84a</td>
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<tr>
<td></td>
<td>C</td>
<td>1.43</td>
<td>24c</td>
<td>8.34a</td>
<td>30.00b</td>
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<td>1.887a</td>
<td>11.966a</td>
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<td>3.58a</td>
<td>83.84a</td>
<td>9.00a</td>
<td>27.16b</td>
<td>SCL</td>
</tr>
</tbody>
</table>

A: control barren site,
B: planted site spaced at (2x270 m) and
C: planted site spaced at (1x3m)

Litter decomposition:
Litter decomposition of Jatropha curcas L. was assessed in relation to site characteristics and animal decomposers’ individual numbers. Results are shown in Fig. (4). This figure indicated that litter decomposition differed significantly between study sites. It also illustrated that, litter mass loss rate in site C was observed to be higher than that in site, B as compared to the control A. This result could be attributed to the effect of site characteristics on decomposition. Similar results have been obtained in other experiments dealing with the spatial variability in litter mass loss and decomposition rates, such as those of Laura and Yolanda (2007), and Abugre et al (2011). Veen
et al. (2015), indicated that site properties exerts a significant impact on litter decomposition as measured in terms of litter mass loss. Yang and Zhu (2015), illustrated that plant litter decomposition is regulated by both biotic and abiotic factors.

![Graph showing litter mass loss measured during the study](image)

**Fig.4: litter mass loss measured during the study**

A: control site without Jatropha plantation  B: cultivated with Jatropha spaced at (2x270 m)  C: cultivated with Jatropha spaced at (1x3m)

*Jatropha curcas* L. litter decomposition was evaluated in relation to population density of the retrieved decomposers fauna. These fauna were identified as Collembola, mites and termites. Their population density was noticed to exert a significant impact on litter mass loss as shown in Table (2). This result could be ascribed to the regulatory effect of decomposers fauna. García-Palacios et al., (2013), indicated that soil fauna consistently enhanced litter decomposition at both global and biome scales.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type iii Sm of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sign.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study sites</td>
<td>64.535</td>
<td>2</td>
<td>21.512</td>
<td>4.275</td>
<td>0.020*</td>
</tr>
<tr>
<td>Decomposers fauna</td>
<td>82.417</td>
<td>2</td>
<td>41.208</td>
<td>5.058</td>
<td>0.019*</td>
</tr>
<tr>
<td>Study sites * Decomposers fauna</td>
<td>221.162</td>
<td>2</td>
<td>73.721</td>
<td>5.533</td>
<td>.008**</td>
</tr>
</tbody>
</table>

- Significant at (P≤0.05).
Variation in individual number of decomposers fauna was studied throughout the study period. The results given in Fig. (5), showed that decomposers fauna differed in individual number during the three sampling periods. This trend of succession might be due to the recognition of fauna to litter that represent a food source for them to utilize and flourish. Li et al. (2014), noticed a similar trend upon studying the Interaction between decomposing litter and soil fauna in a Chinese forest ecosystem.

![Graph showing individual number of decomposers fauna extracted from the study sites during the three sampling events (S₁-S₃)](image)

**Fig. (5).** individual number of decomposers fauna extracted from the study sites during the three sampling events (S₁-S₃)

A: control site without Jatropha plantation
B: cultivated with Jatropha spaced at (2x270 m)
C: cultivated with Jatropha spaced at (1x3m)

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