Review Article

ROLE OF TERMITES IN IMPROVING SOIL PRODUCTIVITY: A review to arid environments

ABSTRACT

Termites have been considered as a major pest causing a significant reduction to crop productivity and it causes destruction to crop at any stage of development from the seedlings to the maturity Crops such grasslands, cotton, wheat and ground nuts, upper land rice and eucalyptus trees are highly susceptible to the activities of termite. However, some termite species are essential in maintaining long-term soil productivity and also in restoring barren soils. This review seeks to find out the contribution of termites activities influences on soil productivity. The result from the review shown that termite activities such as burrowing, excavation activities in search of food, and construction of storage chambers in the soil or above-ground leads to improved soil structure, soil aeration, water infiltration via soil porosity, plant nutrient (calcium, nitrogen, phosphorus, potassium, magnesium) and soil organic matter which will eventually result to improved yields of crops.

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"You can improve the writing not to repeat the word crop so often?"

Keywords: *soil, structure, porosity, infiltration, nutrient, termite and* burrows

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Introduction

Termites are insects of the order Isoptera.They spend most of their life cycle on the ground; together with their association with the soil, they have several effects on soil properties(Holt and Lepage, 2000).Termites are among the macrofauna that influence soil physical, chemical and biological properties. They are more active in the semi-arid and arid areas(Lal, 1988). According to Moe(2009), termite account for 40 to 60% of the total soil macrofauna biomass in many tropical ecosystems. Their estimated biomass in African savannas is estimated to be between 70 to 110kg/ha.Several research shown that termites are able mechanically to chew up plant material with their mandibles and grind it with their gizzard, thereby increasing the surface area accessible to soil microorganisms. However, some termite species are essential in maintaining long-term soil productivity and also in restoring barren soils(Kaiser et al., 2017). This review seeks to find out the contribution of termites through their physical, chemical and biological influence on soil and how it enhances soil productivity.

Functional activity of termite mound microorganisms

The importance of non-mutualistic microorganisms in termite mounds (as opposed to, or besides, termites) can be determined by the variety of organisms' present. The combination of mountain microorganisms and termite

s was thought to have a positive impact on decomposition of organic matter and nutrient cycling, particularly in more arid ecosystems (Abe et al., 2000). They further reported that more microbial activity studies showed that the microbial biomass present in mound soil exceeds that of the termite population and that the ratio of microbial biomass carbon to termite biomass carbon was approximately 20:31 in an average mound, suggesting a relatively large microbial community. Several studies have demonstrated that cellulose decomposers are the predominant group of bacteria found in termite mound soil, suggesting that cellulosic material degrades more quickly in mound soil than in surface soil unaffected by termites (Mohindra and Muketji, 1982). According to (Meiklejohn, (1965) there are also large numbers of nitrifying and denitrifying bacteria found in termite mound soils. The presence and activity of these organisms has also been determined indirectly by assaying end products of both the nitrifying and denitrifying process (nitrate and nitrous oxide respectively). Nitrate rates exceeding 100 ppm were measured in the mounds of some Australian termites, and significant N2O fluxes from termite mounds were also reported (Abe et al., 2000). In certain areas of some termite mounds, there are also some records of low microbial activity, and the possibility that termite excretions may have bacteriostatic properties. It was proposed that the extremely low microbial activity found in *Nasutitermes exitiosus* mounds was due in part to the presence in the mound of termite-derived, enzyme-inhibiting chemical substances (Abe et al., 2000).

Influence of termites on soil physical properties

Termite plays a major role in ecosystem which deals with soil loosening (reduction of bulk density) and both vertical and horizontal transport through bioturbation, and subsequent erosions of their constructions. Large amounts of soil are translocated from various depths of the profile to the soil surface during mound-, gallery- and sheeting constructions (Jouquet et al., 2011). Sako et al. (2009) reported that, considering rare earth element and the concentration of trace element, the nests of *Macrotermes* sp. Are produced through the accumulation of highly weathered soil originating from deeper layers. The magnitude and route of soil translocation resulting from termite activity is directly related to their specific dietary habits and the properties of the soil they use. Generally, soil transported by termites contains higher proportions of finer particles size and therefore typically demonstrates different clay mineral compositions than those predominating at the original surface (Abe and Wakatsuki, 2010; Jouquet et al., 2011).;~~Abe and Wakatsuki, 2010).~~

Effect of termite activities on soil physical properties ranges from micromorphological to soil profile structure and evolution(Holt and Lepage, 2000).Termites are known to be major contributor to soil turnover and amount of biomass produced. Theyinfluence the alteration of the soil profile through of soil turnover and physical disturbance, decomposition of litter and biomass and creating deep galleries and burrows (Mando et al., 1996). Termites affect the soil through their activities search as:burrowing and excavation activities in search of food, or the construction of living spaces, or storage chambers in the soil or above-ground (Mando et al., 1997).The burrows in the soil increases soil porosity resulting to high infiltration of the soil and bulk density.Watsonthe (1977) perform an experiments on the use of mounds of the termite

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Macrotermes falciger (Gerstacker) as a soil amendment. The results obtained shows that termite mound had a lowest bulk density as compared to the nearby Ah and Ap horizons. Moreover, termites increase water infiltration via porosity and soil structure improvement (de Bruyn and Conacher, 1990). Termite increase water infiltration via porosity through creating tunnels. This tunnels find in the soil improved soil aeration, soil water availability through the macropores and soil turnover (Kaiser, 2017). Mando et al. (1996) found out that the termite restored the infiltration capacity of crusted soil through increased porosity, soil water content and less bulk density. Termite also increase soil aggregation by the secretion of substances that aid in biding of the soil particles Also, termite tunnels in the soil allow rainwater to percolate deep hence, reduce run- off and consequent soil erosion, through bioturbation, or biological mixing (Nyeko, 2008).

***Figure 1**. Effect of termites on soil water infiltration (cm) and infiltration efficiency (IE, %).*

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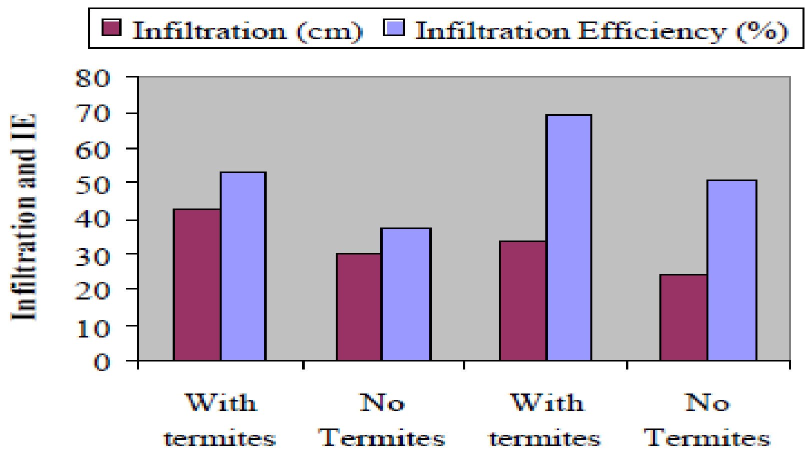

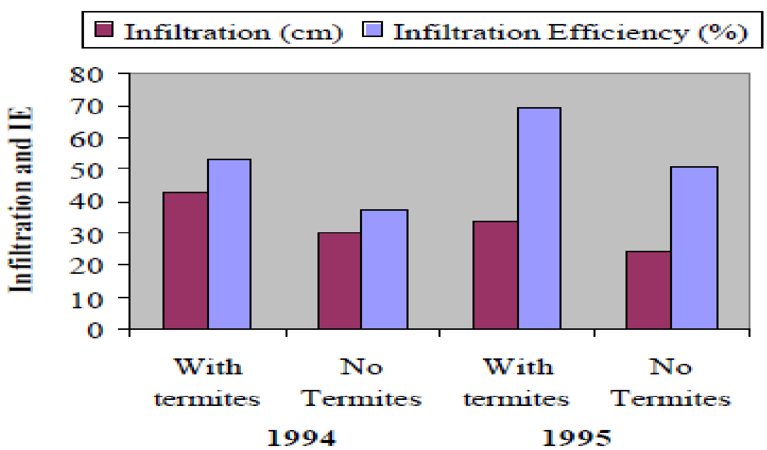

Termite with mulch had high infiltration rate and efficiency percentage as compared to mulch without termite

Influence of termites on soil chemical properties

Termite alter the chemical properties of the soil by collect and transport live and dead, plant and animal materials, to their dwellings.The effects of termite activities depend on soil properties, age of the termite mound, termite species, vegetation and land use(Lal, 1988).Termite accumulate organic matter in their hills. This lead to the increase of plant macronutrient such as nitrogen, phosphorus and potassium in the soil as compared to the adjacent soil. to De Bruynand Conacher(1990) stated that, the capacity of termites to increase nutrient levels such as nitrogen, phosphorus potassium, calcium and magnesium are dependent on the rate of organic material incorporation and the type of artificial hills made by the termites. Termites generally modify the availability of nutrients either directly or indirectly for other organisms in the soil. (Moe et al., 2009) In an experiment performed by Watson(1977), termite mounds were combined with soil. The result shown high percentages of plant nutrient such as calcium 95%, mineral nitrogen 81%, extractable potassium 69% and available phosphorus 69%. The activities of termite to improve soil nutrient aid in increasing the crops' biomass and grain yield. According to Arshad(1982), the proximity of vegetation's growth and species structure to termites' mounds in semi-arid Savannahecosystem showed that the mounds influence nutrient and water availability, drainage of the soil, which in turn contribute to increased biomass.In addition, termites have also been considered as weathering agents due to their ability to transform minerals chemically (Sako et al., 2009) it can be hypothesized that the grinding of soil particles by termite mandibles in the saliva-rich environment of the buccal cavity increases the surface area exposed to the surrounding solution and then releases interlayer K and adsorption of hydrated or polar ions between the layers (Jouquet et al., 2011).

Influence of termites on soil biological properties

Termite mound is similar to the soil from which it is made from, because it normally includes large numbers of micro-organisms. These micro-organisms, mainly fungi and bacteria, have different functions within the process of decomposition of organic matter (Abe et al., 2000). The termite-fungal relationship can be divided into two groups, non-mutualistic and mutualistic. There are usually non-mutualistic interactions between dry wood termites and certain wood rotting pillows, with evidence suggesting that wood previously attacked by pillows is more favorable to these termites (Becker, 1975; Arshad, 1981~~; Becker, 1975~~). According to Abe et al. (2000) mutualistic relationships between termites and fungi are restricted to termites in the Macrotermitinae and the fungus *Termitomyces*, and have been particularly well studied. They further stated that the primary role of this fungus appears to be colony nutrition, which forms an extensive sporulating mycelium on aggregated, partially digested faecal pellets (forming characteristic structures within the mounds known as combs), the fungus has been attributed to other more specific functions. These include the provision of synergistic cellulolytic enzymes to facilitate digestion, decomposition of lignin and the provision of a nitrogen-enriched substrate for termites ingestion **(**Abe et al., 2000).Certain studies of termite mound soil microbiology have indicated the existence of large numbers of free-living bacteria and fungi not directly related to termite feeding. The found out that bacteria and fungi were more numerous in soil made from mound than in adjacent surface soils (Mohindra and Muketji, 1982). According to Jouquet et al. (2011) many studies suggest that termites and sheets could be microbial diversity sites with a different assembly structure from the parent soil. They stated that, increasing evidence suggests that termites are capable of controlling the numbers of microorganisms and probably diversity in selected parts of their mounds, such that the higher abundance of substrates, the nutrient content and the amounts of moisture available promote the growth of a selected and possibly specialized population of commensal bacteria and fungiin selected parts of their mounds.

Conclusion

Termites are among the macrofauna that influence soil physical, chemical and biological properties through their functional activities, can be considered as an ecosystem engineer. **Termite activities** aid in improvement of soil porosity, organic matter through decomposition, water infiltration, availability of soil water, soil aggregation, nitrogen, potassium, calcium, magnesium and phosphorus availability

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