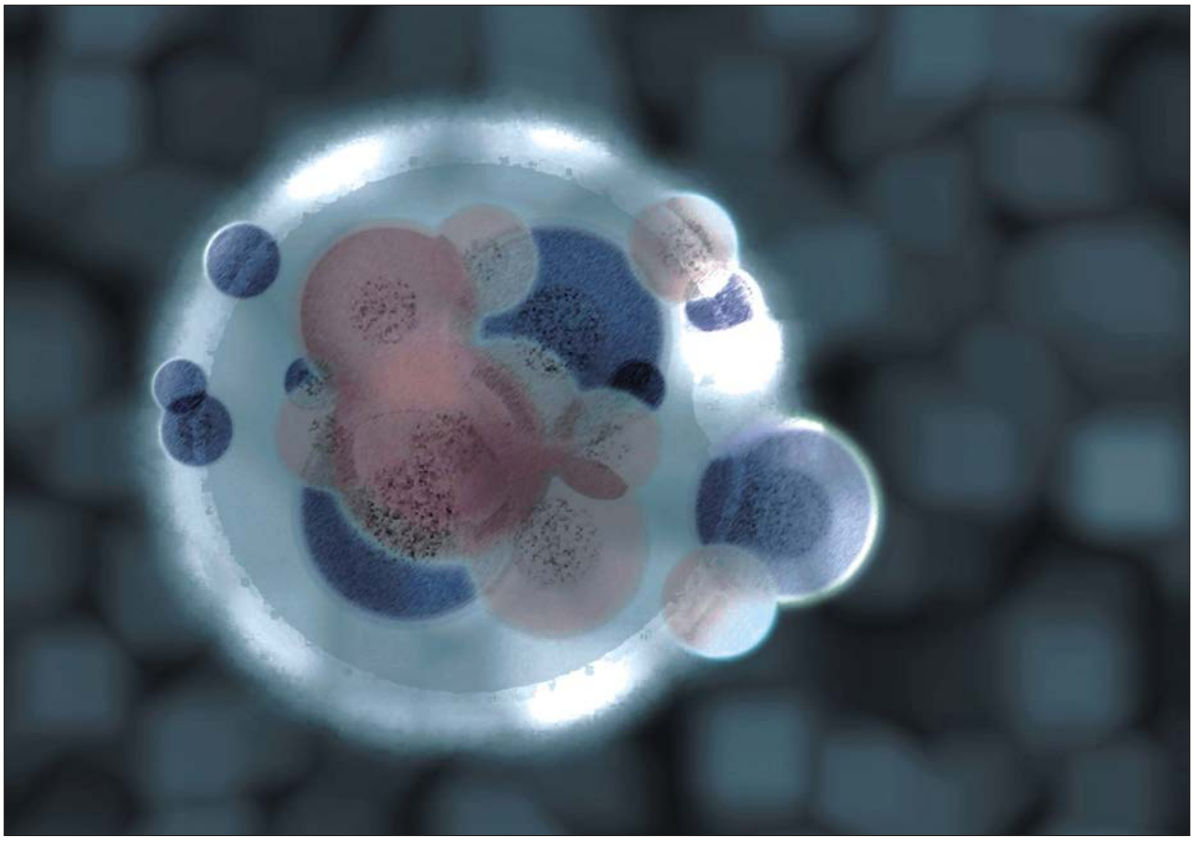

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Effects of Mulch from Four Agroforestry Species on the Moisture Content, Temperature and Microbial Population in a Humid Tropical Soil

D.O. Oke and I.T. Ologun
Department of Forestry and Wood Technology, Federal University of Technology, Akure

Abstract: This study evaluated the effect of leaf mulch of *Tithonia diversifolia, Cajanus cajan, Grevillea robusta* and *Acacia mangium* on the population of microorganisms in a humid tropical soil. The effects of the mulch materials on soil temperature and moisture were also evaluated. The study was carried out between April and August 2003. Microbial population was significantly affected by type of mulch. The highest population was observed under *T. diversifolia* mulch and the lowest under *A. mangium* mulch. The correlation between microbial population and soil moisture (0.18) and between microbial population and soil temperature (0.13) suggest that the changes in the measured soil physical characteristics did not result in corresponding changes in soil microbial population. Soil moisture was high under *A. mangium* mulch.

Key words: Mulch, microbial population, moisture, temperature

INTRODUCTION

There is increasing interest in the use of plant residues for improving soil productivity in agricultural systems in the tropics[1]. Although the roles of plant residues in regeneration of soil nutrients and amelioration of soil physical and biological processes are well known, little information is available on the role of residues from woody species used in agroforestry systems[2].

Soil microorganisms play important roles in maintaining soil quality. Major amount of soil organic matter is derived from the vegetation that is either deposited on the soil surface as an organic layer or incorporated into the soil[3]. Litter decomposition is by the action of soil organism under the condition of high air temperature and soil moisture[4]. Taylor and Parkinson[5] reported that some environmental factors like soil, water content and air temperature affect the organic matter decomposition rate which is usually higher in tropical than in temperate regions.

Bacteria and fungi were reported to be the soil microorganism with the highest value of biomass and respiratory metabolism and they have greater participation in the organic matter process[6]. Agricultural management practices particularly inputs of manure, compost and cover crops can have serious impact on the size and activity of soil microbial communities[7-9]. It has been observed that there are differences in microbial communities in fields with different histories of soil amendment, irrigation tillage and plant community structure[10-12].

This study was carried out to determine the effects of the characteristics of organic mulch materials on soil temperature, moisture and microbial population in a humid tropical Alfisol.

MATERIALS AND METHODS

Experimental site: The study was carried out at the agroforestry site of the Teaching and Research farm, Federal University of Technology, Akure, Nigeria (latitude 7°17′ N, longitude 5°10′ E 350 m a.s.l.). The area has a bimodal rainfall pattern with an annual mean of 1500 mm and a mean annual temperature of 26°C. The main growing season is from April to August and a minor growing season is from August to October, followed by a long dry season from November to April. The experiment was conducted during the 2003 growing season. The soil of the experimental site is an Alfisol with the following surface (0-15 cm) soil properties; organic matter: 3.03%, total N: 0.17% and pH-H_2O (1:1) 5.9 and sandy loam texture[13]. Before the experiment the land was under natural fallow.

Experimental design: The experiment was laid out in a split-plot-in-time design. The main plot treatment was the sampling dates while the mulch materials constituted the sub-plot treatment. The whole experimental plot (6x6 m)

Corresponding Author: Dr. D.O. Oke, Department of Forestry and Wood Technology, Federal University of Technology, Akure
E-mail: davoke2003@yahoo.com

was partitioned into 20 micro-plots of 1x1 m in dimension. Adjacent micro-plots were separated from each other by a buffer 0.25 m wide. Each treatment including a control (without mulch) was replicated four times and treatments were randomly allocated to the micro-plots.

Based on the facts obtained from literature[14], the following plant materials which have contrasting chemical and physical characteristics were chosen for the field study: *Tithonia diversifolia, Cajanus cajan, Grevillea robusta* and *Acacia mangium*. The leaf and litter characteristics of the selected species is as presented in Table 1. Matured but not senescent leaves of the woody species were collected as mulch materials for the study. Fresh mulch materials were applied at the rate of 0.5 kg per micro-plot, an equivalent of 5000 kg ha^{-1}.

Soil sampling: Surface soil (0-15 cm) samples were collected with the aid of a 3.5 mm diameter soil auger. Three auger points were taken in each micro-plot. Soil samples from same micro-plot were bulked and homogenized and composite samples were taken to the laboratory for analyses. Soil samples were collected at 1, 2, 4, 6 and 8 weeks after mulching. The soil samples were kept in polythene bags. Fresh field moist sieved samples collected within 24 h were used for the microbiological analyses.

Measurement of soil temperature and moisture: Measurement of soil temperature and moisture were done at 2, 4, 6 and 8 weeks after mulching. Measurement was done at 9.00 am each day. Soil temperature was measured using a Liquid Crystal Display (LCD) thermoprobe set at 10 cm depth and soil moisture was measured using soil moisture meter also placed at 10 cm depth into the soil.

Soil microbiological analyses: Plate dilution method was used for the determination of microbial population (bacteria and fungi) in the soil. Ten gram of soil was shaken with 90 mL of distilled water. From this suspension, the serial solution (1:10) was prepared. Then 0.5 mL of the serially diluted solution was plated on nutrient agar by pour plate technique[15]. The plates were allowed to gel and incubated at 37°C for 24 h. The resultant colonies after incubation were counted using a Gallenkamp colony counter and expressed as colony forming units (cfu).

Statistical analysis of data: A split plot experimental design was used with the main plots being mulch type and the sub plots, the time soil of sampling. For the analysis of variance, values of microbial population were transformed into log (x+1) where, x = cfu g^{-1} dried soil. Mean comparison were made according to the Duncan's Multiple Range Test (p=0.05). Correlation between variables were also performed.

Table 1: Leaf and litter characteristics of selected agroforestry species. A higher number of crosses (+) indicates a higher relative value

Species	N_2 fixer	C to N ratio	Lignin content	Polyphenol content
Acacia spp.	Yes	18-20	+++	+++
Cajanus cajan	Yes	10-15	+ to ++	+ to ++
Grevillea robusta	No	32	+++	++
Tithonia diversifolia	No	14	ND	+

ND – not determined Source: Mafongoya *et al.*[14]

RESULTS AND DISCUSSION

During the eight week period of this study, all the measured variables (soil moisture, soil temperature and microbial population) showed fluctuations over time. This could possibly be due to variations in the climatic variables (rainfall, solar radiation, humidity. The highest soil moisture content observed under *A. mangium* mulch was maintained until week 6. This could be due to the broader nature of *A. mangium* leaves and its slow decomposition rate which might have resulted in reduced evaporation of water from the soil surface. The soil moisture measurement for week 8 was taken shortly after a heavy rainfall and this explains the high values recorded for control and *T. diversifolia* mulch variations in the soil microbial population did not follow the trends of either the soil temperature or soil moisture. A correlation coefficient (r) of 0.13 between soil microbial population and temperature and 0.18 between soil microbial population and soil moisture are clear indication of the poor relationship. The poor relationship between soil moisture/temperature and microbial population observed in this study could be attributed to the overwhelming influence of nutrient input from decomposing plant material and the absence prolonged extreme variation in temperature and moisture conditions throughout the period of study.

A general increase was observed in soil microbial population under the various mulch materials between the time of mulch application and two weeks after mulching (Fig. 1). After two weeks there was again a general decline in soil microbial population under the mulch materials. The upsurge in the population of soil microbes after mulch application may be attributed to the availability of nutrient for these organisms following the decomposition of the mulch materials. Merkx *et al.*[15] stated that the input

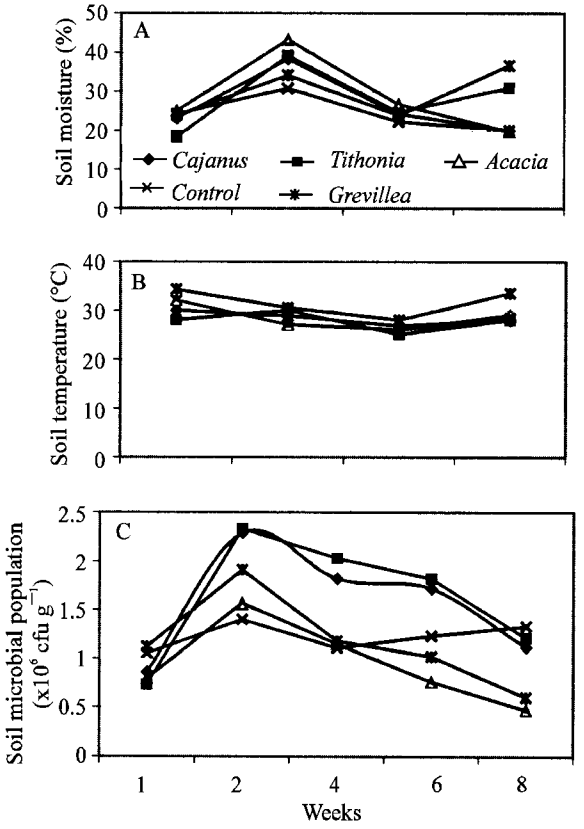

Fig. 1: Variation in soil moisture (A), soil temperature (B) and microbial population after application of leaf mulches of *Cajanus cajan, Tithonia diversifolia, Acacia mangium* and *Grevillea robusta*

of nutrients into the soil are of considerable importance in stimulating the growth of soil microorganisms.

The type of mulch material had a significant influence on the population of soil microorganisms. The highest population of soil microbes was observed under *T. diversifolia* mulch. This was followed closely by that of *C. cajan* with the least under *A. mangium* (Table 2). These results indicate that quality of litter has a significant effect on the microbial population in the soil. Tian *et al.*[17] made similar observations for soil macroorganisms. They attributed the increased soil faunal activity observed after application of residues from *Sesbania sesban* to the high quality of *S. sesban* litter.

Table 2: Effects of mulch type on soil microbial population

	(log cfu g^{-1}+1)1				
Week	*Grevillea*	*Cajanus*	*Tithonia*	*Acacia*	Control
1	6.00[a]	5.93[a]	5.98[a]	5.89[a]	6.01[a]
2	6.28[a]	6.36[a]	6.34[a]	6.20[b]	6.13[b]
4	6.07[b]	6.26[a]	6.30[a]	6.05[b]	6.04[b]
6	6.00[b]	6.23[a]	6.21[a]	5.87[c]	6.03[b]
8	5.77[b]	6.06[a]	6.05[a]	5.63[b]	6.09[a]

Means on the same row followed by different superscripts are significantly different ($p<0.05$)

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