East African Scholars Journal of Agriculture and Life Sciences
(An Open Access, International, Indexed, Peer-Reviewed Journal)
A Publication of East African Scholars Publisher, Kenya
www.easpublisher.com

Original Research Article

Assessment of the Potentials of *Chromolaena odorata* and Sawdust as Mulch in Soil Fertility Management of an Ultisol of Southeastern Nigeria

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Article History
Received: 08.11.2018 | Accepted: 20.11.2018 | Published: 30.11.2018 | DOI: 10.36349/easjals.2018.v01i02.003

Abstract: A pot experiment was conducted at the multi-purpose farm of Akanu Ibiam federal Polytechnic, Unwana, Afikpo, Ebonyi State of Nigeria, to investigate the effect of *chromolaena odorata* and sawdust as muclch materials on soil nutrient status indices such as soil pH, organic carbon, total nitrogen, available phosphorus as well as the effective cation exchange capacity. Soil samples were collected from 0-20cm depth from the polytechnic multi-purpose farm and the treatments comprised of five rates of *chromolaena odorata* (0, 1, 2, 3 and 4t/ha) and four rates of sawdust (0, 1, 2, and 3t/ha) applied as mulch. A completely randomized design (CRD) in factorial was used in three replications. Results showed that the mulch materials influenced the soil chemical properties ($P<0.05$) relative to control and the influence on these properties increased as the rate of application increased. Sawdust mulch material, was more effective in improving soil pH, available P, organic C, and ECEC compared to the *chromolaena odorata* mulch alone, while the application of *chromolaena odorata* showed greater improvement on the total N compared to the sawdust alone. With the exception of pH and total N, all treatments both as lone or combined showed significant difference ($P<0.05$) in influencing all the soil chemical properties. However, the mulch materials were only significant ($P<0.05$) in improving the soil pH and total N when applied as lone treatments, but their interactions showed no significant difference ($P<0.05$) in soil pH and total N.
Keywords: *chromolaena odorata*, Sawdust, Mulch

INTRODUCTION

In Nigeria, soil fertility restoration for improved agricultural production is a recurrent issue of immense importance mostly with her ever increasing population currently above 150 million. Therefore identifying sustainable ecological practice to improve soil fertility is one of the surest ways to enhance food security (Imiolemen *et al.,* 2012). Apart from the edaphic factors, climate and weather have longed being identified as major stakeholders in soil nutrient management. Extreme conditions of weather elements can impact negatively on the physiochemical and biological properties of the soil (Michael, 2009). Very high temperatures may induce dehydration and the consequent reduction the soil biological activities which will adversely affect the decomposition and mineralization of organic materials. On the other hand, very low temperatures inactivate soil microbes and may also induce physiological drought (Brady and Weil, 2006). Because of the variability of climatic elements (Nwagbara and Ibe, 2014) and their consequent roles on soil fertility, there have being concerted efforts geared towards providing various possible methods of moderating the harsh effects of extreme weather conditions and one of the most effective means of achieving this, is mulching.

The practice of mulching can be traced to the early history of agriculture when local farmers cover the soil surface around planted crops with plant leaves to reduce soil temperature and conserve moisture. Mulch in general, is a layer of material applied or spread over the soil surface (Bu *et al.,* 2002). Surface applied mulch is an effective method and widely used in recent years. Mulches provide several benefits to crop production through improving water content, heat energy and nutrient status in soil, preventing soil and water loss, preventing soil salinity and suppression of weed (Deng, *et al.,* 2006). According to Yang *et al.,* (2006), mulches serve as physical barriers that dissipate erosive energy from raindrops, thereby protecting the structure of the soil at the surface and reducing nutrient leaching. Many materials have being used as mulch and the choice of material as mulch depends on the availability, cost, appearance, effect on soil physiochemical and biological properties, durability, and the decomposition

rate (Tejedor*et al.*, 2002). Among the different mulch materials, organic mulches such as grass clippings, leaves, sawdust have proved to be effective in soil fertility maintenance because the increase biological activities leading to release of plant nutrients (Yang *et al.*, 2006). Organic mulches decay over time and release their nutrient content to the soil.

Chromolaena odorata which is considered as an invasive weed of field crops and natural environment has been reported to be the most problematic invasive species within protected rainforests in Africa (Schmidt and Schilling, 2000). The plant is sometimes grown for its medicinal and ornamental values (Tchonme, 1980). Recent studies, have shown that apart from it's medicinal values, *chromolaena odorata* can be used as fallow species and as soil fertility improvement plant in the slash and burn rotational system of agriculture (Schmidt and Schilling, 2000). The high production of biomass of *chromolaena odorata* contributes to its role in soil fertility and spread in Nigeria. Apart from its roles on soil chemistry, studies have also shown that using *chromolaena odorata* as mulch can equally improve the soil physical characteristics. Research carried out in ultisols of southeastern Nigeria shows that mulching with dry *chromolaena odorata* decreased soil bulk density and increased soil moisture retention for soil moisture tension between 0.05 and 15 bar.

Sawdust is very common mulch in areas where it is readily available. Although, it is often used as mulch, it's has the problem of inducing nitrogen deficiency when decomposed due to it's high C:N ration especially when fresh. Consequently, this research is set out to determine the interactive effect of *chromolaena odorata* and sawdust as mulch on the soil chemistry and nutrient status of southeastern Nigeria.

MATERIALS AND METHOD

The experiment was conducted in buckets placed within the multi-purpose farm of AkanuIbiam Federal Polytechnic, Unwana, Afikpo. This region is located within the tropical rainforest zone of Nigeria, latitude 5^{o} 48'N and longitude 7^{o} 55'E. The air temperature is generally high all year round. The current mean maximum temperature of this area is 32^{o}c while the mean minimum is 21^{o}c and a relatively very wet coastal area with an annual rainfall exceeding 3500mm (Njoko, 2006). The soils are largely a combination of hygromorphic soils, vertisols and ferrasol (Areroa, 1983).

Soil samples were collected at 0-20cm depth, air dried, sieved through a 2mm sieve after which 5kg of the soil were weighed into 10L plastic buckets perforated at the bottoms and appropriate weights of sawdust and fresh *chromolaena odorata* shoot were used to cover the surface of the soil of each bucket. The treatment comprised of five rates of *chromolaenaodorat* (0,1,2,3 and 4t/ha) and four rates of sawdust (0, 1, 2, and 3t/ha) arranged factorially in a completely randomized design with three replications, giving a total of sixty observational units.

The soils were incubated for three months, July to September, during which, the pots were watered to keep the soil at field capacity. Soil samples from each bucket was collected after incubation period for chemical analysis and the chemical properties analyzed in the laboratory include soil activity/soil pH, (Maclean, 1965), organic carbon (Walkley and Black, 1934), total nitrogen (Jackson, 1962), available phosphorus (Bray and Kurtz, 1945), effective cation exchange capacity (Kamprath, 1967) as modified by Eno*et al.*, (2009).

Data collected from soil analysis, were subjected to analysis of variance, (ANOVA) as outlined by steel and Torrie (1980), while the means were separated using F-$LSD_{0.05}$.

RESULT AND DISCUSSION

The physic-chemical properties of the soil used for the study are presented in table 1. The textural class was a sandy clay loam with sand, silt and clay content of 52.40%, 24.80% and 22.80% respectively. The soil reaction indicated acidity with pH value of 4.57 and 4.02 in water and $Cacl_2$ respectively which is similar to pH values of ultisols of southeastern Nigeria (Onwuku*et al.*, 2007). Organic carbon and organic matter were low (1.22 and 2.10 respectively) indicating a low soil fertility status (Woomer and Ingram, 1990). Total nitrogen was very low (0.09%) which is less than the critical level of 0.15% reported by Adeoye and Agboola, (1984) for soils of humic tropical region. This could be as a result of high mineralization and subsequent high rate of leaching that accompany the heavy rains associated with the forest zone of southeastern Nigeria as reported by Osodeke, (1996). The soil was moderate in available phosphorus (13.56) which is lower than the critical value of 15mg/kg for most tropical crops (Osodeke and Uba, 2005). The soil was low in exchangeable bases and hence, low in ECEC indicating the inability of the soil to support crop growth to obtain optimum yield.

Table 1: Physiochemical Properties of the soil used for the study

Characteristics	Value
Sand (%)	52.40
Silt (%)	24.80
Clay (%)	22.80
Textural class	sandy clay loa
pH (H_2O)	4.57
pH ($Cacl_2$)	4.02
Org. carbon (%)	1.22
Org. matter (%)	2.10
Total Nitrogen (%)	0.09
C:N ratio	13.56
Av. Phosphorus (mg/kg)	10.92
Ca (cmo1/kg)	1.99
Mg (cmo1/kg)	1.05
K (cmo1/kg)	0.09
Na (cmo1/kg)	0.01
E. A (cmo1/kg)	1.66
ECEC (cmo1/kg)	4.80
B.S (%)	65.42

Table 2: Chemical Characteristics of the Organic Mulch used for the study

Property	Chromolaena	Sawdust
pH (H2O)	8.99	11.20
pH (Cacl2)	8.17	10.70
Av. P. (mg/kg)	17.33	14.29
Total N. (%)	0.72	0.33
Org. C (%)	5.49	8.43
C:N ratio	7.63	25.55
Ca (%)	5.27	6.91
K (%)	0.55	0.64
Mg (%)	2.88	0.59
Na (%)	0.07	0.09

Nutrient composition of the two mulch materials is presented in table 2. Both materials had high pH values and nutrient compositions which can be attributed to the fact that plants are composed of nutrients absorbed from the soil. The high pH values indicate the potentials of these materials as improvers of acidic soils for better crop yield when they decompose into the soil. Similar observations have been made by several authors (e.g. Odelina *et al.,* 2003; Owolabi *et al.,* 2003; Awodun, 2007; Onwuka *et al.,* 2007; Ewulo *et al.,* 2009). Thus, it is expected that, the high nutrient content in both mulch materials will have the potentials of establishing greater improvement on both the physical and chemical conditions of the soil under study.

EFFECT OF MULCHING ON SOIL CHEMICAL PROPERTIES

The effect of the two mulch materials on soil chemical properties is presented in Table 3. Significant differences were observed. Generally, mulching with *chromolaena odorata* and sawdust both as lone or combined treatment improved the soil chemical conditions relative to the control and the improvements were proportional to the rate of mulch application. Soils mulched with sawdust showed greater improvement in soil pH, available P, organic C, exchangeable bases and ECEC ($P<0.05$) than those mulched with *chromolaena odorata.* The finding is in line with that of several other researchers (Patterson et al., 2004; Onwuka et al., 2007; Awodun, 2007) who reported the positive effects of sawdust ash and lime on cationic nutrients. The implication of the observation is that the nutrient

contained in the sawdust were mineralized by microbial activities (Baath and Arnebrant, 1994) and made available in soil solution for subsequent plant uptake.

On the other hand, soils mulched with *chromolaena odorata* showed greater improvement on the total N, the could be attributed to not only because of the high N content in *chromolaena odorata*, but due to the high production of biomass of the plant which contributes to it's role in soil fertility (Schmidt and Schilling, 2000).

Apart from the pH and total N, both mulch materials either as lone or combined applications were statistical significant ($P<0.05$) in influencing the soil nutrient indices. However, the mulch materials were only significant ($P<0.05$) in improving the soil pH and total N when applied as lone treatments, but their interactions showed no significant differences ($P<0.05$) in soil pH and total N.

Table 3. Mean effect of *Chromolaena odorata* and sawdust mulch materials on soil chemical properties

C +SD (t/ha)	pH H_2O	pH $CaCl_2$	Aval. P (mg/kg)	Org. C (%)	Total N (%)	Exc. Bases (cmo1/kg)	Exc. Acidit (cmo1/kg)	ECEC (cmo1/kg)
Control	4.45	3.99	8.75	1.13	0.05	4.11	1.69	5.79
0 + 1	5.42	5.00	11.56	1.27	0.12	5.42	1.06	6.48
0 + 2	5.58	5.06	19.12	1.39	0.21	8.84	0.53	9.37
0 + 3	5.99	5.14	32.68	1.42	0.57	13.26	0.38	13.64
1 + 0	5.21	4.96	12.93	1.16	0.18	4.93	1.33	6.26
1 + 1	5.71	5.17	16.49	1.33	0.30	8.35	0.77	9.12
1 + 2	5.99	5.20	32.05	1.67	0.36	12.77	0.42	13.19
1 + 3	6.04	5.33	42.61	1.80	0.78	15.19	0.33	15.52
2 + 0	5.66	5.02	14.71	1.31	0.23	6.86	1.03	7.89
2 + 1	5.83	5.28	23.20	1.45	0.38	12.28	0.59	12.87
2 + 2	6.18	5.64	33.83	1.86	0.51	15.70	0.38	16.08
2 + 3	6.27	5.79	44.39	2.00	0.86	18.12	0.25	18.37
3 + 0	5.72	5.00	17.79	1.40	0.55	9.79	0.65	10.44
3+1	5.92	5.46	27.17	1.62	0.62	14.21	0.41	14.62
3 + 2	6.31	5.77	37.10	1.88	0.72	18.63	0.32	18.95
3 + 3	6.68	5.86	48.65	2.16	1.13	23.05	0.20	23.25
4 + 0	5.83	5.10	22.23	1.42	0.69	11.72	0.40	12.12
4 + 1	5.99	5.48	33.79	1.74	0.78	15.14	0.37	15.51
4 + 2	6.72	5.83	41.35	1.92	0.80	20.56	0.27	20.83
4 + 3	6.88	5.92	52.91	2.20	1.22	24.82	0.20	25.02
LSD(0.05)								
C.	0.0145	0.0067	0.0438	0.269	0.00048	0.00362	0.003	0.036
SD	0.0116	0.0109	0.0351	0.0351	0.241	0.00038	0.00021	0.029
(C XSD)	N5	N5	0.1753	0.012	N5	0.1448	0.012	0.143

Where C is chromolaena odorata, SD is sawdust

The highest values of soil nutrient indices were obtained from soils mulched with 4t/ha *chromolaena odorata* and 3t/ha sawdust and it is therefore recommended for soil fertility management in southeastern Nigeria.

CONCLUSION

Of all primary economic activities pursued throughout world, agriculture is the most important and it is also highly dependent on the weather. It has been amply demonstrated that agriculture being our outdoor activity is very sensitive to weather conditions (Ayoade, 2002). The weather has direct influence on the soil fertility and hence, crop production. Because of the variability of climatic elements (Nwagbara and Ibe, 2012) and their consequent roles in soil fertility, there is the need to identify sustainable ecological practices that will help moderate the harsh effects of weather and improve soil fertility. Mulching has become a popular practice in moderating the adverse effects of extreme weather conditions and also improves the soil physical and chemical conditions. This study has led to the conclusion that soils mulched with *chromolaena odorata* and sawdust as lone treatments and interactively gave appreciable higher improvement on soil fertility properties. The observations therefore emphasized the importance of *chromolaena odorata* especially when combined with sawdust as mulch in the maintenance of soil fertility status of tropical soils. It is therefore recommended that to reduce the residual adverse effects resulting from extreme weather conditions, soil fertility management strategy of mulching with *chromolaena odorata* with appropriate quantity of sawdust should be adopted. This will be a sure way of maintaining soil fertility and enhance food security.

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