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EFFECTS OF SAWDUST AND ORGANOMINERAL FERTILIZER AND THEIR RESIDUAL EFFECT ON THE YIELD OF MAIZE ON DEGRADED SOIL

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Conventional mineral fertilizer alone cannot sustain arable crop production in soil which top layer has been eroded hence it is necessary to employ the application of organic base fertilizer. A greenhouse experiment was conducted to investigate the effects of sawdust, organomineral fertilizer and their residual effects on the growth and yield of maize. Organomineral fertilizer is the combination of organic manure and mineral fertilizer. Simulated degraded soil was used and the experimental design was a 2 x 2 x 3 factorial in a completely randomized design with three replicates. The factors investigated were: two levels of organomineral fertilizer (with and without), two levels of soil amendment (with and without sawdust) and three levels of application methods. The methods of organomineral fertilizer used were ring, subsurface and mixed methods. The amendment of soil to sawdust was ratio 1: 1 by volume. The growth and yield of maize was significantly ($p = 0.05$) higher in non–amended soil with OMF under different application methods compared to soil amended with sawdust with or without OMF application. Ring method of application of OMF in non–amended soil significantly increased the growth and yield of maize compared to other methods of OMF application. The residual effect of OMF and sawdust on the growth and yield of maize was significantly higher in non–amended soil with OMF under different application methods compared to soil amended with sawdust. Addition of sawdust to soil does not improve the growth and yield of maize with or without OMF and under different application methods. Organomineral fertilizer using ring and subsurface application methods has a beneficial effect in improving the growth and yield of maize in degraded soil where the top layer has been eroded.
Keywords: application methods, degraded soil, maize, organomineral fertilizer, sawdust.

INTRODUCTION

Land degradation is the reduction in the capacity of land to produce benefit from a particular land use under a specific form of land management (Eswaran *et al*., 2001). Land degradation is caused by biophysical, socio-economic and chemical factors and these factors have negative impact on the physiochemical properties of the soil. Erosion is the most devastating physical factor, causes loss of soil nutrient, organic matter and structural deterioration which results to low crop yield. Replenishment of the nutrient status of an eroded soil takes a lot of efforts which could be physical, chemical and biological. Agroforestry system is an effective method of controlling erosion, improved soil fertility and enhanced crop productivity (Hellin and Haigh, 2003). The practice of zero tillage, contour, strip and cover cropping control erosion and improve soil and crop productivity (Hudson, 1995).

Application of fertilizer to degraded soil is an effective means of improving soil fertility. The use of inorganic fertilizer to ameliorate degraded soil have gained wide acceptance in improving soil fertility and it has significantly increased the yield of crops such as maize. However, its scarcity and removal of government subsidies make its use unprofitable for crop production. The use of mineral fertilizer alone does not improve the organic matter content of soil and its continuous use results to decrease in the yield of maize. Also frequent uses of nitrogenous fertilizer increase the acidity of soil which adversely affect crops and microbiological properties of the soil (Kapkiyai *et al*., 1999). For better nutrient management in the tropics organomineral fertilizer (OMF) is a better alternative to inorganic fertilizer as it improves not only soil nutrient but also the organic matter content of the soil. The application organomineral fertilizer improves the physical, chemical and microbiological properties of the soil and also supply micronutrient; high amount of calcium and magnesium which reduces the hazard from the use of liming material (Ogazi and Omueti, 2000). The placement method of fertilizer most appropriate recommendation must be developed from considerations specific to crops and cropping systems, soil, crop management and environmental factors that influences crop response to nutrient placement (Havlin, 2008). The application of organomineral fertilizer has been found to increase the yield of maize over a long period (Adeoye *et al.,* 2008).

The use of organic waste such as plant residues, animal dung, mulch materials and sawdust improves the physiochemical properties of the soil and reduced environmental pollution (Nottidge *et al.*, 2005). It therefore the objective of this study to investigate the effect of sawdust and OMF on the growth and yield of maize in degraded (eroded) soil.

MATERIALS AND METHODS

A greenhouse experiment was conducted at the Department of Agronomy, University of Ibadan, Ibadan in 2004 and 2005. Subsoil was collected at Parry Road, University of Ibadan, the soil was sieved and used for the physical and chemical analysis. The sieved soil was also used to fill the 10 kg pots; the amendment of soil with sawdust was ratio 1: 1 by volume. The sawdust was obtained from sawmill and it was a mixture of Iroko and mahogany woods. The sawdust was mixed with soil in the pots, one litter of water was applied weekly and the mixture was left for three weeks to allow partial decomposition before the planting of maize and application of OMF. Three maize (Suwan- 1- SR) seeds were planted and later thinned to one plant per pot two weeks after planting. OMF was applied at 20 g per pot and the maize was later top dressed with NPK 15- 15- 15 at the rate of 0.5 g per pot. The residual experiment was carried out in 2005, after the first experiment when the soil was neither amended with sawdust nor OMF. A litter of water was applied to each pot after every three days and water was added intermittently to prevent it from draining. Organomineral fertilizer is the combination of organic manure and mineral fertilizer. The factors investigated were: two levels of organomineral fertilizer (with and without), two levels of soil amendment with sawdust (with and without sawdust) and three levels of application methods (ring, subsurface and mixed). Ring method is the placement of fertilizer in a circular shallow hole of 3 cm deep and the distance of application from the plant was 15cm radius to avoid scorching. This was carried out two weeks after planting. Subsurface application method; the organomineral fertilizer was buried 10 - 15 cm deep in the soil a week before planting maize. Mixed method of OMF application; the soil was thoroughly mixed the quantity of organomineral fertilizer and this was done a week before planting.

Particle size analysis was carried out using hydrometer method (Bouyoucous, 1962). The pH of the soil was determined in water (ratio1:1, soil: water). Organic carbon was determined according to the method described by Nelson and Sommers (1975) and Available phosphorus by Bray-1 extraction method (Anderson and Ingram, 1993). Total nitrogen was determined by Kjeldahl method. Exchangeable cations (potassium, calcium and magnesium) were extracted with ammonium acetate (Naeem *et al*., 2011). Potassium and sodium were determined by Jenway model of flame photometer while calcium and magnesium by 210VGP model of atomic absorption spectrophotometer (Aslam *et al*., 2011). Sodium Absorption Ratio (SAR) was determined.

Growth parameter measured were plant height, stem girth, number of leaves, leaf area and data were taken between three to eight weeks after planting. Leaf area of maize was determined by the method described by Remison and Lucas (1982); L x W x 0.75. The dry matter weight of stem, leaves, roots and cob weight of maize were determined. Data collected were analyzed using ANOVA (SAS, 1995) and Duncan's Multiple Range Test (DMRT) was used to separate the means.

RESULTS

The soil was moderately acidic, high in clay and deficient in essential nutrients such as nitrogen, phosphorus and potassium (Table 1).

Table 1. Pre planting chemical and physical soil analysis

Parameters	Units	Values
pH(water)		5.25
Organic carbon	g/kg	10.9
Nitrogen	g/kg	1.30
Phosphorus	mg/g	1.52
Potassium	cmol/kg	0.04
Magnesium	cmol/kg	0.04
Calcium	cmol/kg	0.05
Sodium	cmol/kg	0.04
SAR		2.67
Particle Size Analysis		
Sand	g/kg	704
Silt	g/kg	95
Clay	g/kg	201
Textural Class		sandy clay loam

The nutrient content of OMF were as follows; 44g/kg of nitrogen, 11 mg/kg of phosphorus, 6.80 cmol/kg of potassium, 0.80 cmol/kg of sodium, 10.80 cmol/kg of magnesium, 6.80 cmol/kg of calcium, 558.30 mg/kg of manganese, 8153 mg/kg of iron, 247.40 mg/kg of copper and 712.70 mg/kg of zinc (Table 2). The height of maize was significantly higher ($p< 0.05$) in non–amended soil with OMF without sawdust compared to other treatments. The height of maize in non- amended soil without OMF and sawdust was significantly higher compared to soil amended with sawdust. The height of maize in soil amended with sawdust with mixed OMF application was significantly higher compared to other treatments amended with sawdust. There was significant ($p<0.05$) interaction in plant height between soil * fertilizer, fertilizer * methods also between soil * fertilizer * methods of application (Table 3). Maize stem girth was significantly higher in non – amended soil with OMF subsurface, mixed and ring method of application in soil amended with sawdust compared to other treatments.

Subsurface application of OMF in non–amended soil with sawdust significantly increased leaf area of maize compared to other treatments. There was no significant difference in number of leaves of maize (Table 3). In the residual experiment; ring and subsurface methods of OMF application significantly increased the height of maize compared to other treatments. The ring, subsurface and mixed methods of OMF application on non-amended soil without sawdust significantly increased the leaf area of maize compared to soil amended with sawdust. There was no significant difference in the number of leaves. Also, there was significant ($p<0.05$) interaction on plant height between soil * fertilizer, fertilizer * methods of application and soil * fertilizer * methods (Table 4). Non–amended soil with OMF without sawdust ring and mixed application methods significantly increased the dry matter weight of root of maize compared to other treatments. The dry matter weight of maize stem was significantly ($p<0.05$) higher in ring method of OMF application compared to other treatments. Also the biomass of maize was significantly higher in non–amended soil with ring and subsurface methods of OMF application compared to soil amended with sawdust with or without sawdust and non–amended without OMF. The application of OMF to non–amended subsoil significantly increased the cob weight of maize compared to other treatments. There was significant ($p<0.05$) interaction in maize biomass and cob yield between soil * fertilizer * methods (Table 5). The residual effect of OMF on non–amended subsoil without sawdust was significantly higher in height, stem girth and leaf area of maize. There was no significant difference in the number of leaves of maize among the various treatments. Also the residual effect was significantly higher in non–amended soil with OMF application on the root weight, biomass and cob weight compared to amended soil with sawdust with or without OMF application. Ring method of OMF application in non–amended soil without sawdust significantly increased the growth and yield of maize compared to other methods of application. Significant ($p<0.05$) interaction occurs in maize biomass and cob yield between fertilizer * methods and soil * fertilizer * methods.

Table 2. The content of organomineral fertilizer grade A

Elements	Values
Total Nitrogen (g/kg)	44.0
Available phosphorus (mg/kg)	11.0
Exchangeable Bases (cmol/kg)	
K (cmol/kg)	6.8
Na (cmol/kg)	0.8
Mg (cmol/kg)	10.8
Ca (cmol/kg)	6.8
Extractable micronutrients	
Mn (mg/kg)	558.3
Fe (mg/kg)	8153.4
Cu (mg/kg)	247.4
Zn (mg/kg)	712.7

Source: Pacesetter Fertilizer Company, Bodija Ibadan, Nigeria

DISCUSSION

Erosion is the removal of top soil resulting to reduction of soil quality, nutrients and organic matter content. Subsoil is generally high in clay content and low in essential nutrient below critical value (Enwenzor *et al.*, 1989). Soil test interpretation for purposes of making nutrient recommendation is influenced by the mobility of the nutrient, with mobile interaction of nitrogen and sulphur crop yield is proportional to the total quantity of nutrient present in the root zone. In contrast yield response to immobile nutrients phosphorus and potassium is proportional to the concentration of the nutrients near the root surface because these nutrients strongly interacts with or are buffered by soil constitutions (IFA, 2008). Incorporation of sawdust to soil improved the physiochemical properties of soil and reduced environmental pollution. There was significant reduction in the growth and yield of maize when sawdust was incorporated without initial composting, this agreed with the earlier work done by Daramola *et al.* (2006). Also the reduction in the growth and yield of maize in amended soil with sawdust results from the direct incorporation of sawdust with high lignin content and this causes nitrogen immobilization and this confirmed the earlier work done by Olayinka and Adebayo (1989). Non–amended soil with or without OMF application in respective of methods of application were significantly higher in the height, stem girth and yield of maize compared to soil amended with sawdust with or without OMF. Non–amended soil with OMF application significantly increased the growth and yield of maize, these results confirmed the work done by Ogungbe and Fagbola (2008) and Adeoye *et al.* (2008). The application of organomineral fertilizer to soil not amended with sawdust with ring and subsurface placement significantly increased the growth and yield of maize in the residual experiment. Crop response to nutrient placement are strongly influenced by cropping system, residue management and other factors influencing nutrient availability (Havlin *et al.*, 2005). Ring and subsurface application methods of OMF significantly increased the yield of maize because these methods reduce fertilizer immobilization thereby increasing fertilizer (nitrogen) recovery (Maddux *et al.*, 1991). The various placement options can be characterized by a simple matrix of application placement relative to the soil surface or seed also specific application times refers to before, at or after planting while placement is characterized by surface or subsurface application of fertilizer. (Havlin, 2008).

Table 3. Vegetative growth of maize as affected by sawdust and different methods of OMF application under greenhouse conditions at eight weeks after planting

Soil	Fertilizer application	Application methods	Eight weeks after planting			
			Height (cm)	Girth (cm)	Number of leaves	Leaf area (cm^2)
Amended	With	ring	48.3 d	4.6 b	12.0 a	327.0 c
		subsurface	50.3 d	4.1 b	12.0a	278.9 d
		mixed	66.3 c	4.6 b	12.0 a	328.9 c
	Without	ring	52.2 d	3.7 c	12.0 a	312.0 c
		subsurface	43.4 d	3.9 c	12.0 a	250.3 d
		mixed	36.6 d	3.4 c	12.0 a	251.1d
Non- amended	With	ring	92.1 ab	5.6 a	13.0 a	368.4 b
		Subsurface	112.3 a	5.9 a	13.0 a	436.1 a
		Mixed	107.2 a	5.3 a	13.0 a	383.8 b
	Without	ring	87.8 b	4.8 b	12.0 a	342.1 b
		Subsurface	93.1 ab	4.5 b	12.0 a	418.5 a
		Mixed	48.6 d	4.1 b	12.0 a	372.4 b
		ANOVA				
		Soil (S)	***	***	***	***
		Fertlizer (F)	***	**	ns	ns
		Methods (M)	*	ns	ns	ns
		Interactions				
		S x F	*	ns	ns	ns
		S x M	ns	ns	ns	ns
		F x M	*	ns	ns	ns
		S x F x M	*	ns	ns	ns

**p≤ 0.05, ** p≤ 0.01, ***p≤ 0.001, ns= not significant. Values followed by the same letters are not significantly different according to Duncans Multiple Range Test*

Table 4. Residual effects of sawdust and different methods of OMF application on the vegetative growth of maize under greenhouse conditions at eight weeks after planting

Soil	Fertilizer application	Application methods	Eight weeks after planting			
			Height (cm)	Girth (cm)	Number of leaves	Leaf area (cm^2)
Amended	With	ring	41.7 b	4.40b	12.0 a	145.8 c
		Subsurface	36.2 c	4.20b	12.0 a	141.6 c
		mixed	52.0 a	4.00b	12.0 a	123.8 c
	Without	ring	47.8 b	5.10a	12.0 a	126.0 c
		subsurface	36.4 c	4.10b	12.0 a	123.5 c
		mixed	34.6 c	4.20b	12.0 a	126.0 c
Non- amended	With	ring	65.2 a	4.60b	12.0 a	267.0 a
		Subsurface	59.5 a	4.90a	12.0 a	259.9 a
		Mixed	62.3 a	4.90a	12.0 a	238.7 a
	Without	ring	59.5 a	4.50b	12.0 a	228.0 b
		Subsurface	53.1 a	4.00b	12.0 a	233.0 b
		Mixed	43.8 b	4.20b	12.0 a	232.0 b
		ANOVA				
		Soil (S)	***	***	***	***
		Fertlizer (F)	***	**	ns	ns
		Methods (M)	*	ns	ns	ns
		Interactions				
		S x F	*	ns	ns	ns
		S x M	ns	ns	ns	ns
		F x M	*	ns	ns	ns
		S x F x M	*	ns	ns	ns

**p≤ 0.05, ** p≤ 0.01, ***p≤ 0.001, ns= not significant. Values followed by the same letters are not significantly different according to Duncans Multiple Range Test*

Table 5. Dry matter yield and cob weight of maize as affected by sawdust and different methods of OMF application under greenhouse conditions

Soil	Fertilizer application	Methods	Root wt. (g)	Stem wt. (g)	Leaf wt. (g)	Biomass (g)	Cob wt. (g)
Amended	With	ring	3.10e	17.1 c	8.30b	28.5 c	14.2 c
		Subsurface	4.70d	10.2 d	5.00c	19.9 d	15.0 c
		mixed	2.90e	17.9 c	6.90b	27.5 c	17.5 c
	Without	ring	4.00d	13.6 c	7.70b	25.3 c	13.3 c
		Subsurface	5.00d	18.8 c	6.10b	29.9 c	14.6 c
		mixed	4.10d	8.9 e	4.20c	17.2 d	16.0 c
Non-amended	With	ring	10.20 a	36.1 a	14.30a	60.6 a	34.0 a
		Subsurface	7.30b	25.2 b	11.20a	43.7 b	32.4 a
		Mixed	10.10a	20.4 b	13.10a	43.6 b	32.2 a
	Without	ring	7.30b	15.1 c	8.70b	31.1 c	30.4 a
		Subsurface	6.10c	12.7 c	7.30b	26.1 c	29.9 ab
		Mixed	4.00d	15.7 c	8.70b	29.5 c	28.7 ab
		ANOVA					
		Soil (S)	*	*	ns	***	***
		Fertlizer (F)	ns	*	ns	ns	*
		Methods (M)	ns	ns	ns	ns	*
		Interactions					
		S x F	ns	ns	ns	ns	ns
		S x M	ns	ns	ns	ns	ns
		F x M	ns	ns	ns	ns	ns
		S x F x M	ns	ns	ns	*	*

**p≤ 0.05, ** p≤ 0.01, ***p≤ 0.001, ns= not significant. Values followed by the same letters are not significantly different according to Duncans Multiple Range Test*

Table 6. Residual effects of sawdust and different methods of OMF application on dry matter yield and cob weight of maize under greenhouse conditions

Soil	Fertilizer application	Methods	Root wt. (g)	Stem wt. (g)	Leaf wt. (g)	Biomass (g)	Cob wt. (g)
Amended	With	ring	2.10d	8.70c	4.20c	15.00c	1.20c
		Subsurface	2.70d	8.60c	2.60d	13.90c	2.70c
		mixed	2.00d	8.80c	3.50c	14.30c	1.90c
	Without	ring	2.30d	7.80c	3.80c	13.90c	2.30c
		Subsurface	3.10c	9.40c	3.20c	15.70c	1.70c
		mixed	2.30d	8.80c	2.80d	13.90c	2.20c
Non-amended	With	ring	9.10a	18.90a	8.90a	36.90a	13.30a
		Subsurface	8.20a	13.20b	6.20b	27.60a	12.30a
		Mixed	8.70a	16.30ab	6.60b	31.60a	11.50a
	Without	ring	6.80b	7.60c	4.60c	19.00c	8.50b
		Subsurface	4.80c	8.80c	3.80c	17.40c	10.00b
		Mixed	3.80c	8.60c	3.90c	16.30c	10.10b
		ANOVA					
		Soil (S)	*	*	ns	***	*
		Fertlizer (F)	ns	*	ns	ns	*
		Methods (M)	ns	ns	ns	ns	*
		Interactions					
		S x F	ns	ns	ns	ns	ns
		S x M	ns	ns	ns	ns	ns
		F x M	ns	ns	ns	*	*
		S x F x M	ns	ns	ns	*	*

**p≤ 0.05, ** p≤ 0.01, ***p≤ 0.001, ns= not significant. Values followed by the same letters are not significantly different according to Duncans Multiple Range Test*

CONCLUSION

Amendment of degraded soil with lignified material such sawdust without initial composting will impede the growth and yield of maize. The application of OMF using ring, subsurface and mixed application methods significantly increased the growth and the yield of maize. Ring and subsurface methods of OMF application significantly ($p< 0.05$) increased the growth and yield of maize in simulated eroded soil.

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