Nigerian Journal of Soil Science

journal homepage:www.soilsjournalnigeria.com

EVALUATION OF MYCORRHIZA AND PIGEON PEA LEAVES COMPOST ON THE GROWTH, YIELD AND NUTRIENT UPTAKE OF MAIZE IN DEGRADED ULTISOL

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ABSTRACT

Soil nutrient and organic matter replenishment cannot be attained by the use of inorganic fertilizer alone hence, the advocation for the use of integrated fertility management method to improve soil fertility for continuous crop production. Two-season pot experiment was conducted at the Teaching and Research Farm, Ambrose Alli University, Ekpoma, Edo State to assess pigeon pea leaves compost and mycorrhiza on the growth, nutrient uptake and yield of maize in degraded ultisol. The experimental design was a Completely Randomized Design with four treatments replicated three times and the treatments were: pigeon pea leaves compost + mycorrhiza, pigeon pea leaves compost, mycorrhiza and control. The soil samples collected and pigeon pea green manure were analysed for essential nutrients. Data collected were analysed using descriptive statistics and ANOVA at $p = 0.05$. The compost of pigeon pea leaves + mycorrhiza significantly ($p \leq 0.05$) increased the growth of maize compared to other treatments. Also, the application of pigeon pea leaves compost and mycorrhizal inoculum significantly ($p \leq 0.05$) increased the growth of maize compared to control. The nutrient uptake in maize was significantly ($p \leq 0.05$) higher with the application of pigeon pea leaves compost + mycorrhiza compared to other treatments. Pigeon pea leaves compost + mycorrhiza significantly ($p \leq 0.05$) increased the grain and dry matter yield of maize compared to other treatments. Also, pigeon pea leaves compost and mycorrhizal inoculation significantly increased maize yield compared to the control. The result from the study showed that pigeon pea leaves compost + mycorrhizal inoculation significantly increased the growth, nutrient uptake and yield of maize in degraded soil compared to other treatments. Also, pigeon pea leaves compost + mycorrhiza, pigeon pea leaves compost and mycorrhizal inoculation can sustain and improve the growth and yield of maize in degraded soil.

Keywords: maize, nutrient uptake, yield, compost and mycorrhiza.

INTRODUCTION

Maize is one of the major staple food crops in Nigeria, where it is grown in all agroecological zones. Also, its ability to strive under different ecological condition in Nigeria has led to increase production (Adekunle and Nabinta, 2000). It was estimated that 1.5 million hectares of maize are cultivated in Nigeria with yield of about 1.9 million tonnes (FAO, 2005).

Ultisols are the tropical and subtropical soils of old landscapes that have a monsoon climate and are extremely weathered and leached. They have a red, brown or yellow argillic B horizon with a base saturation of less than 50 %. The soils have a low content of organic matter with ferric and hydromorphic properties. These soils are generally of low fertility and are susceptible to erosion (Fitzpatrick, 1986).

Soil fertility management is the major concern among tropical Africa farmers particularly with the high rate of nutrient depletion resulting from land degradation and the rapid growing population. The application of fertilizer organic, inorganic and combination of both has been used to improve soil nutrient and crop productivity. However, the use of mineral fertilizer among farmers is limited due to high cost, poverty, inadequate credit facilities and their unavailability at the right time. It is therefore, necessary to use organic and biological methods to improve soil fertility for increase crop production.

Mycorrhiza has been found very useful in ecological restoration which enables the establishment of host plant on degraded soil and improve the quality and health of the soil (Jeffries *et al*., 2003). Arbuscular mycorrhizae (AM) are characterized by the formation of unique structure called arbuscules and vesicles by fungi of the phylum *Glomeromycota*. AM fungi help plants to capture nutrients such as phosphorus and micronutrients from the soil which are deficient in degraded soil. These organisms are beneficial to plants by improving its water and nutrients uptake, phosphorus transport, resistance to disease and drought (Wright, 2005; Fagbola *et al*., 1998). The hyphae of arbuscular mycorrhiza are considered to be primary soil aggregators and there is a high positive correlation between AM fungi hyphae and aggregate stability in natural system. Root and fungal hyphae are soil biota that contributes to soil aggregate stabilization, arbuscular mycorrhizal fungi produces glycoprotein substance called glomalin which cement soil particles together and help to resist the force of erosion (Fernando *et al.*, 2008).
Compost is rich in nutrients and it is used in garden, horticulture and agriculture. The compost itself is beneficial for the land in many ways, as soil. Conditional and fertilizer, addition of vital humus or humic acid, and as a natural pesticide for soil. In ecosystems, compost is useful for erosion control, land and stream reclamation, wetland construction and as landfill cover. It provides a rich growing medium, or a porous, absorbent material that holds moisture and soluble minerals, providing the support and nutrients in which plants can flourish, although it is rarely used alone, being primarily mixed with soil, sand, grit, bark chips, vermiculite, perlite, or clay granules to produce loam *(http://en.wikipedia.org/w/index.php*). The application of compost manure improve crop production and soil properties as reported by Ogbogodo *et al*. (2008)

Addition of mycorrhiza and compost have been found to be environmentally friendly and significantly improve the yield of crops such as maize and yam (Oyetunji *et al*., 2009). It is therefore, the objective this study to evaluate the effect of mycorrhiza and compost on the growth, yield and nutrient uptake of maize.

MATERIALS AND METHODS

Two-season pot experiment was conducted successively at Ambrose Alli University

Teaching and Research Farm, Ekpoma, Edo State in 2009. Top soils (0-15 cm) were collected from the site prior to planting season, the soils were air dried, sieved and the soil samples were analysed for both chemical and physical properties. Particle size analysis was carried out using hydrometer method (Bouyoucous, 1962). The pH was determined in water (ratio1:1, soil: water). Organic carbon was determined by wet dichromate method (Nelson and Sommer, 1975) and Available phosphorus by Bray extraction method (Anderson and Ingram, 1993). Total nitrogen was determined by Kjeldahl method. Exchangeable cations (potassium, calcium and magnesium) were extracted with ammonium acetate, potassium was determined by flame photometer while calcium and magnesium by atomic absorption spectrophotometer. The pigeon pea green manure was composted as follows; 600 g of air dried pigeon pea leaves was composted with 60 kg of soil. four litres of water was added and the materials were thoroughly mixed in a pit and covered for four weeks to allow decomposition. These composted materials were used to fill the 10 kg pots and 30 g of arbuscular mycorrhizal fungi (*Glomus clarum*) was used for inoculation. Three maize (Suwan- 1- SR) seeds were planted and later thinned to one plant per pot two weeks after planting. After planting, water was supplied to the potted maize at three days interval. The experimental design was a Completely Randomized Design with four treatments replicated three times. Weeding was carried out manually. Growth parameter measured were plant height, stem girth, 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 nutrient uptake, dry matter yield and grain weight of maize were determined. Data collected were analysed using ANOVA (SAS, 1995) and Duncan's Multiple Range Test (DMRT) was used to separate the means.

RESULTS

Soil Analysis

The pre-planting soil showed that the soil was low in nutrient; organic carbon (8.5 g/kg), nitrogen (0.30 g/kg), available phosphorus (5.71 mg/kg), potassium (0.67 cmol/kg), magnesium (0.37 cmol/kg) and calcium (0.10 cmol/kg). The soil was moderately acidic pH 6.20 and textural class was sandy loam (Table 1).

Analysis of pigeon pea compost

The leaves compost of pigeon pea was analysed to determine the nutrient content as shown below; nitrogen content was 30.2 g/kg; phosphorus, 8.5 kg/g; potassium, 1.2 cmol/kg; magnesium, 1.8 cmol/kg; calcium, 4.4 cmol/kg; manganese, 0.07 mg/g; iron, 0.04 mg/g,; zinc,0.03 mg/g and copper, 0.02 mg/g (Table 2).

Growth parameters of Maize

During the first planting season, it was observed that at five weeks after planting, application of mycorrhiza + compost significantly ($p \leq 0.05$) increased the stem girth of maize compared to other treatments. At six weeks after planting, the control was significantly lower in stem girth compared to other treatments. In the second experiment, at five and six weeks after planting, mycorrhiza + pigeon pea compost significantly increased the stem girth of maize compared to other treatments. Also, at seven and eight weeks after planting, mycorrhizal maize and the control were significantly lower in stem girth compared to other treatments (Table 3). The application of pigeon pea compost + mycorrhiza significantly ($p \leq 0.05$) increased the leaf area of maize compared to other treatments. Application of pigeon pea compost alone had higher leaf area than the treatments with mycorrhiza and control. Also, mycorrhizal maize had higher leaf area than the control (Table 4). The application of pigeon pea compost + mycorrhiza significantly ($p \leq 0.05$) increased the height of maize compared to other

treatments during the first cropping season. During the second planting season, the height of maize was significantly ($p \leq 0.05$) higher with the application of pigeon pea compost + mycorrhiza and pigeon pea compost alone at four and seven weeks after planting compared to other treatments. At five, six and eight weeks planting pigeon pea compost + mycorrhiza significantly ($p \leq 0.05$) increased the height of maize (Table 5).

Yield of Maize

The yield of maize was significantly increased with the application of pigeon pea compost + mycorrhiza compared to other treatments. The yield of maize with the application of pigeon pea + mycorrhiza was 3,055.7 kg/ha and 3,178.0 kg/ha in both seasons respectively. The yield of maize with the application of pigeon pea compost was 2, 445.7 kg/ha and 2,578.5 kg/ha at both season. Mycorrhizal maize yield was 1,475.6 kg/ha and 1,381.0 kg/ha at both cropping seasons respectively. The yield in the control was 679.8 kg/ha and 709.5 kg/ha at both planting seasons. The control had the lowest yield of maize during the experiment. The matter yield of maize was significantly ($p \leq 0.05$) higher under the application of pigeon pea compost + mycorrhiza. The application of pigeon pea compost to maize significantly increased the dry matter yield of maize compared to mycorrhizal maize and the control. Also the mycorrhizal maize was 30 % higher in dry matter yield than the control (Table 6).

Nutrient uptake

The integration of mycorrhiza and pigeon pea compost significantly ($p \leq 0.05$) increased the uptake of nitrogen, phosphorus, potassium, magnesium and calcium in maize compared to other treatments both in first and second experiments (Table 7). The application of pigeon pea compost significantly ($p \leq 0.05$) increased the nutrient uptake in maize compared to that of mycorrhizal inoculum and control. It was also observed that mycorrhizal inoculum had a significant higher nutrient uptake compared to the control both in experiment 1 and 2 (Table 7).

DISCUSSION

The major constraint to crop production among tropical farmers is the excessive loss of soil nutrient and pressure on land use for non agricultural purposes. This forced farmers to cultivate marginal or degraded land. The use fertilizer has become very imperative to improve crop production. In soil ecological environment for plant–microbe interactions involving colonization of different microorganisms in and around growing roots takes place in the plant rhizosphere. This result in associative, symbiotic, neutralistic, or parasitic interactions depending upon plant nutrient status in soil, soil environment, plant defence mechanism, and the type of microorganism proliferating in the rhizosphere zone. Associative action of mycorrhizal fungi in legumes has a great impact on root and shoot development and phosphorous uptake which results in the enhancement of nodulation and nitrogen fixation (Adholeya and Johri 1986; Albrecht *et al.*,1999).

The application of compost + mycorrhiza increased the growth and yield of maize significantly. This result confirmed the earlier work done by Rousseau *et al*. (1994). He observed similar result on the application of compost and mycorrhiza on pine. Adetunji and Okeleye (2001), reported that incorporation of legume pruning increased soil organic matter and plant growth while mycorrhizal inoculation has been known to improve crop yield (Dare *et al*., 2008). AM fungi + compost manure was found to enhance maize and yam production due to the role of manure in nutrient enrichment which was complimented by AM fungi that increased the absorbing surface area of the roots and its hyphae bridged the depletion zone by

supplying adequate amount nutrient mostly phosphorus.

Compost manure from pigeon pea applied to maize significantly increased the growth and yield of maize. This research was in agreement with the previous report by Okonufua *et al*. (2009), Nottidge *et al*. (2008) and Adejumo *et al*. (2010). They reported that the application of pigeon pea or legumes residues/ compost increased the growth and yield of maize, yam and other crops. Compost does not only improve crop yield but also the organic matter content of the soil (Wakene *et al*., 2001). Inoculation of mycorrhiza has been reported to increase the yield and nutrient uptake of cassava (Fagbola *et al*., 2005). It has also been reported that a rotation with pigeon peas helped to reduce bulk density, increase the root volume and root weight of the following crop in the rotation specially cereals (Singh *et al.,* 2005).

The integration of mycorrhiza and pigeon pea compost significantly ($p \leq 0.05$) increased the nutrients uptake in maize compared to other treatments. This confirmed the earlier work done by Dalpe and Monrel (2004). Ogungbe and Fagbola (2008), observed increase in nutrient uptake when mycorrhiza and organomineral fertilizer were applied to maize. Application of pigeon pea compost increased the nutrients uptake in maize and this was in agreement with the earlier work carried out by Ogbogodo *et al*., (2008). Mycorrhizal inoculum also significantly increased the nitrogen, phosphorus, magnesium and calcium uptake compared to the control. A similar result was obtained by Fagbola *et al*. (2005) while working with cassava. In this research, mycorrhizal inoculation improved the yield and nutrient uptake of maize. Also the integrated application of pigeon pea compost + mycorrhizal inoculum significantly ($p \leq 0.05$) increased the growth and yield of maize.

CONCLUSION

Integration of mycorrhiza and compost increased the growth, yield and nutrient uptake of maize significantly compared to either the application of compost or mycorrhiza. The separate application of compost and mycorrhizal inoculum also significantly increased the growth, yield and nutrient uptake of maize compared to the control. The results of this experiment showed that the integration of pigeon pea compost and mycorrhizal inoculum (*Glomus clarum*) significantly ($p \leq 0.05$) increased the soil nutrient content for enhance crop production.

Table 1: Pre-planting Chemical and Physical Properties of soil

PARAMETER	Units	VALUE
pH (H_2O)	g/kg	6.20
Organic Carbon	g/kg	8.50
Total nitrogen	g/kg	0.30
Available p	mg/kg	5.31
Exchangeable Cations		
K	cmol/kg	0.67
Mg	cmol/kg	0.37
Ca	cmol/kg	0.10
Particle Size Analysis		
Sand	g/kg	812
Silt	g/kg	94
Clay	g/kg	94
Textural class		Loamy soil
pH of soil		Slightly acidic.

Table 2: Analysis of Nutrient content of pigeon pea leaves compost

PARAMETER	Units	VALUE
Total nitrogen	g/kg	30.2
Available p	mg/kg	8.00
K	c mol/kg	1.18
Mg	c mol/kg	1.77
Ca	c mol/kg	4.42
Na	c mol/kg	0.02
Mn	mg/g	0.07
Fe	mg/g	0.04
Zn	mg/g	0.03
Cu	mg/g	0.02

Table 3: Effects on Mycorrhizal inoculum and Pigeon pea compost on stem girth (cm) of maize

	Weeks after planting												
Experiment 1: Treatments	**3**	**4**	**5**	**6**	**7**	**8**	**Experiment 2:**	**3**	**4**	**5**	**6**	**7**	**8**
M + PPLC	2.90a	4.03a	5.08a	5.48a	5.76a	5.98a		2.80a	4.00a	5.00a	5.34a	5.67a	5.70a
PPLC	3.06a	3.80a	4.36b	5.16a	5.71a	6.11a		2.81a	3.11a	3.87b	4.10b	5.06a	5.44a
M +	2.66a	3.61a	4.51b	5.01a	5.63a	5.86a		2.61a	3.01a	3.74b	3.87b	4.24b	4.47b
CO	2.63a	3.5a	3.96c	3.74b	5.06a	5.28a		2.54a	2.81a	3.51b	3.74b	3.94b	4.11b

Mean values followed by different letters under the same column are significantly different according to Duncan multiple range (P<0.05).

M+PPLC = mycorrhiza + pigeon pea compost, PPLC = pigeon pea leaves compost, M+ = mycorrhiza, CO = control.

Table 4: Effects on Mycorrhizal inoculum and Pigeon pea compost on leaf area (cm) of Maize

	Weeks after planting												
Experiment 1: Treatments	**3**	**4**	**5**	**6**	**7**	**8**	**Experiment 2:**	**3**	**4**	**5**	**6**	**7**	**8**
M + PPLC	46.00a	120.40a	246.70a	291..80a	357.00a	456.90s		46.84a	142.00a	275.25a	319.64a	401.67a	430.78a
PPLC	43.52a	84.57b	101.04b	144.50b	214.70b	414.33a		42.44a	66.97b	114.50b	159.75b	207.77b	233.43b
M +	42.78a	68.94c	105.84b	118.37	163.23c	208.03b		40.64a	73.60b	112.27b	141.17c	173.44b	180.25c
CO	40.87a	57.47d	107.74b	120.50c	149.87c	208.70b		45.40a	58.74b	99.90c	122.24c	150.24c	175.85c

Mean values followed by different letters under the same column are significantly different according to Duncan multiple range (P<0.05).

M+PPLC = mycorrhiza + pigeon pea compost, PPLC = pigeon pea leaves compost, M+ = mycorrhiza, CO = control.

Table 5: Effects on Mycorrhizal inoculum and Pigeon pea compost on the height (cm) of Maize

	Weeks after planting												
Experiment 1: Treatments	**3**	**4**	**5**	**6**	**7**	**8**	**Experiment 2:**	**3**	**4**	**5**	**6**	**7**	**8**
M + PPLC	18.14a	26.66a	38.44a	45.40a	54.24a	45.14b		17.14a	24.20a	44.20a	45.30a	52.10a	72.08a
PPLC	18.40a	26.96a	41.03a	50.78a	58.08a	64.10a		13.74a	19.67a	26.17b	33.60b	58.08a	42.84b
M +	18.28a	24.68a	29.18b	35.96b	39.20b	50.03b		12.27a	16.24b	21.34b	23.64c	39.20b	50.03b
CO	16.10a	23.56a	29.10b	33.60b	37.48b	47.80b		11.44a	13.94b	33.60b	34.80b	37.48b	48.80b

Mean values followed by different letters under the same column are significantly different according to Duncan multiple range (P<0.05).

M+PPLC = mycorrhiza + pigeon pea compost, PPLC = pigeon pea leaves compost, M+ = mycorrhiza, CO = control.

Table 6: Effects on Mycorrhizal inoculum and Pigeon pea compost on grain yield (kg/ha) and dry matter yield (kg/ha) of maize

Treatment	Experiment 1	2	Experiment: 1	2
	Grain yield (kg/ha)		Dry matter yield (kg/ha)	
M + PPLC	3,055.56a	3,178.40a	3,700.23a	3,333.00a
PPLC	2,045.65b	2,178.52b	2,673.00b	2,265.20b
M +	1,175..58c	1,251.43c	1,293.50c	1,494.85c
CO	679.80d	709.50d	906.85d	1,038.70d

Mean values followed by different letters under the same column are significantly different according to Duncan multiple range (P<0.05). M+PPLC = mycorrhiza + pigeon pea compost, PPLC = pigeon pea leaves compost, M+ = mycorrhiza, CO = control.

Table 7: Effects on mycorrhizal inoculum and Pigeon pea compost on nutrient uptake (Tonnes/ hectares) of maize

	Weeks after planting										
Experiment 1:	**N**	**P**	**K**	**Mg**	**Ca**	**Experiment 2**	**N**	**P**	**K**	**Mg**	**Ca**
M + PPLC	11.62a	0.27a	0.29a	6.06a	9.36a		10.46a	0.25a	0.26a	5.46a	8.43a
PPLC	6.52b	0.19b	0.20b	3.48b	5.45b		6.25b	0.18b	0.19b	3.33b	5.23b
M +	3.26c	0.06c	0.05c	1.93c	2.47c		3.76c	0.08c	0.06c	2.23c	2.85c
CO	2.03d	0.02d	0.03c	1.13c	1.21d		2.32d	0.03d	0.03d	1.39d	1.38d

Mean values followed by different letters under the same column are significantly different according to Duncan multiple range (P<0.05). M+PPLC = mycorrhiza + pigeon pea compost, PPLC = pigeon pea leaves compost, M+ = mycorrhiza, CO = control.

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