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EFFECTS OF ORGANIC AND INORGANIC NUTRIENT SOURCES ON PERFORMANCE OF ALOE VERA AND SOIL CHEMICAL PROPERTIES

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ABSTRACT

Research-based fertilizer recommendations for production of *Aloe vera* are scanty and it is essential to have an appropriate fertilizer recommendation for enhanced yield and nutrient composition. This study was carried out to determine the effects of organic and inorganic nutrient sources on performance of *Aloe vera* and soil chemical properties. The treatments which comprise control (Plot with no application of nutrient),inorganic N (Urea) + SSP + MOP, organic N (Alesinloye) + SSP +MOP, organic N (Poultry manure) + SSP + MOP were replicated thrice, monitored for two years and all applied at 125 kgN/ha, 30 kg P/ha and 90 kg K/ha recommendation. Data on number, length, width, thickness and volume of leaves and number of suckers were collected and soil chemical properties and textural composition were also determined. Application of inorganic (N) fertilizer and poultry manure improved the growth and yield parameters of *Aloe vera*. The soil P, Mg, Cu and pH were also significantly increased by Alesinloye organic fertilizer. *Aloe vera* farmers in general should embark on the use of commercial organic fertilizer and Poultry manure for effective growth, yield and soil fertility improvement in the study area.

Keywords: *Aloe vera*, alesinloye, sources, performance, fertilizer, composition.

INTRODUCTION

Aloe vera (*Aloe barbadensis* Miller) is tropical or subtropical plant widely use in folk medicine, cosmetic, supplement and food material (Eshun and He, 2004). *Aloe vera* has a wide range of medicinal applications such as wound healing effect, reduces blood sugar in diabetes, soothes burns, eases intestinal problems, reduces arthritic swelling, ulcer curative effect, stimulates immune response against cancer, etc. Many researchers had also reported *Aloe vera* to have broad range of pharmacological properties which includes, anti-inflammatory, antiviral, antioxidative actions, antibacterial, immuno-stimulant, antifungal, analgesic, antitumor, antidiabetic and inhibition of tumor cells activation and proliferation (Kammoun *et al*., 2011; Nejatzadeh-Barandozi, 2013 and Ray *et al*., 2013).

The rapid organic matter mineralization (Sanchez and Logan, 1992) and the presence of highly weathered secondary minerals Van Wambeke (1992) in tropical soil resulted in poor growth and low yield of crops. However, fertility can be successfully improved using both inorganic and organic fertilizers. The major drawbacks of inorganic fertilizers are low accessibility to resource-poor farmers (Garrity, 2004), environmental effects (Ojeniyi, 2000; Maritus and Vleic, 2001; Oyedeji *et al*., 2014), low efficiency in highly weathered soils (Baligar and Bonnett, 1996) and soil degradation (Khaim *et al*., 2003) as a result of continuous use of high level of inorganic fertilizers which is detrimental to crop production. Ipinmoroti *et al*. (2002) recommended combined use of organic and inorganic fertilizers for sustenance of long term cropping in the Tropics.Organic fertilizers have been proved to improve nutrient use efficiency under tropical conditions and improves soil physical attributes (El-Shakweer *et al*., 1998). Soil fertility and productivity, according to Iren *et al.* (2014) can only be maintained through the use of soil amendment under a system of continuous cropping which has become the characteristic feature of Nigerian farmers.

Despite the great potential of *Aloe vera*, there is, however very little information on the response of *Aloe vera* to combined use of organic and inorganic fertilizer in Southwestern zone of Nigeria. Therefore, this study was aimed at determining the effect of sole and complementary application of organic and inorganic manure on soil properties and yield of this medicinal plant *Aloe vera*.

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MATERIALS AND METHODS

Description of Experimental Site

The study was carried out in 2013 and 2014 at the experimental field of the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Oyo State (Latitude 8° 10'N and Longitude 4° 25'E) in the Derived savannah agro-ecological zone of Southwestern Nigeria. It has a bimodal pattern of rainfall distribution which is characterized by peaks around July and September. The day temperature ranges between 25.8°C in August and 30.50 °C in March, with mean annual temperature of 27°C. The soils of the sites belong to the USDA classification of Alfisol (Soil survey staff, 2006) which is moderately drained with a sandy loam texture. The experimental site was manually cleared, tilled and flat beds measuring 2 m x 2 m were constructed.

Experimental Design and Treatments

The experiment was laid out in a randomized complete block design with three replications. The rate of organic manure used was based on N equivalent and applied on dry weight basis. There were four treatments as follows:

T1 - Control
T2 - Inorganic N (Urea) + SSP + MOP
T3 - Organic N (Alesinloye) + SSP + MOP
T4 - Organic N (Poultry Manure) + SSP + MOP

All at 125 kg N/ha, 30 kg P/ha and 90 kg K/ha recommendations (Owoade, 2015).

Alesinloye Grade B (Unamended compost) is a commercial organic fertilizer products of Alesinloye fertilizer plant, Ibadan, Oyo State, Nigeria. The poultry manure was collected from animal farm at LAUTECH while Aloe vera suckers were collected from Ogbomoso.

Field Studies

Planting and collection of growth and yield data

The organic manures were evenly distributed and incorporated to specified plots one week before planting as recommended by (Iren *et al*., 2011). One *Aloe vera* sucker was planted per stand on 2m x 2m at a spacing of 75 m x 75 m (0.563 m^2) giving a plant population of 17778 plants/ha. Weeding was done manually with hoe and cutlass.

Data Collection on *Aloe vera*

Data were collected on growth (length, width and thickness of leaves) and indices of yield (number of leaves and suckers, leaf volume and weight gained).

Data collection commenced two weeks after transplanting till 13 MAT at four weeks interval. Leaf length was determined as the distance from the base to the tip of the longest leaf. Leaf thickness was determined using Veneer calipers. Leaf width was determined at the centre of the longest leaf while count of leaves considered all fully opened leaves per plant. Leaf volume was calculated based on the shape of the plant using the formular V = (Length / 12) x 3.142 x Weight x Thickness (Alagukannan *et al*., 2006, Hernandez-Cruz *et al*., 2002. Initial and final weights of the plants were determined.

Collection and preparation of soil samples

Before the experiment, 12 auger point samples taken at 0-15 cm depth were randomly collected, bulked and sub-sampled for analysis. At the end of the experiment, 8 soil auger point samples were taken per plot at the same depth, bulked and sub-sampled for analysis.

Laboratory Studies

The organic manure was analyzed using standard procedures (Juo, 1979). Representative samples were taken and air–dried, crushed and sieved through 2mm for the determination of particle size, pH (H_2O), available P, extractable micronutrients (Fe, Cu, Mn & Zn) and exchangeable cations (K, Mg, Ca & Na). Soil sieved through 0.5 mm mesh was used for both the determination of total nitrogen (N) and organic carbon. Particle size analysis was carried out according to Bouyoucous (1951) hydrometer method using sodium hexametaphosphate as the dispersant. Soil pH was determined in 1:1 soil water ratio (IITA, 1982; Black *et al*., 1965).

Total N was extracted by the macro–Kjeldahl digestion (Bremner and Mulvaney, 1982) method followed by colorimetric determination using Technicon Autoanalyser (Technicon Instrument Corporation, 1975). Melich 3 (a multipurpose extractant) was used to extract available phosphorus, exchangeable cations (Ca, Mg, K and Na) and extractable micronutrients (Mn, Fe, Cu and Zn) (Mclean, 1965). Phosphorus was determined colorimetrically using the Technicon AAII Auto-analyzer, while the concentrations of Calcium, Magnesium, Copper, Zinc, Iron and Manganese in the extract were determined by Atomic Absorption Spectrophotometer (AAS) (Model Buck, 200A).

Sodium (Na) and K were determined using Flame emission photometer. Exchangeable acidity was determined by KCl extraction method (Mehlich, 1984). Effective cation exchange capacity (ECEC) was determined by summation of Exchangeable bases (Ca, Mg, K and Na) and Exchangeable acidity. Organic carbon was determined by chromic acid digestion method (Heans, 1984).

Data Analysis
Data collected were analyzed by Analysis of Variance (ANOVA) and significant means obtained were separated by Duncan Multiple Range Test (DMRT) at 5% probability level.

RESULTS AND DISCUSSION

Properties of the Manure and Soil Used for the Experiment

The chemical composition of the poultry manures and Alesinloye organic fertilizer is presented in Table 1. From the analysis of the organic manures used for the study, Poultry manure had higher levels of CaO and N than Alesinloye organic fertilizer while P_2O_5 and K_2O were higher in Alesinloye.

The pre-planting chemical and physical characteristics of the experimental soil are presented in Table 2. The textural class of the soil used for the study was sandy loam. The soil is near neutral with pH value of 6.6. The soil was low in organic carbon content with the value of 0.55 g/kg lower than the critical level of 20 g/kg given by (Aduayi *et al*., 2002) for soils of the humid tropical region. The total nitrogen content in the soil was also low (0.45) as against the critical value of 1.5 g/kg given by (Aduayi *et al*., 2002).

The low nitrogen could be attributed to high rate of mineralization and subsequent high rate of leaching that accompany the heavy rains associated with the Southwestern Nigeria. The low amount of total N also reflects the amount of organic carbon in the soil. Available P value (3.54mg/kg) obtained in this study was very low compared to the moderate level range of 15-25 mg/kg and was therefore rated as very low.

The values for exchangeable bases (Ca, Mg, K and Na) and exchangeable acidity are very low, while effective cation exchange capacity is moderately low. The low soil contents of the macronutrients signify the need for improvement for optimal performance of *Aloe vera*.

The low ECEC and nutrient reserves of the study area have been attributed to the fact that soils of Southwestern Nigeria are strongly weathered, have little or no content of weatherable rock in their sand and silt fractions and have predominantly Kaolinite in their clay fraction (FPDD (Fertilizer Procurement Division, 1990). The soil had high Mn and Fe, while Zn and Cu are moderately low. The soil is inherently low in fertility and would therefore depend on soil amendments for sustainable agricultural productivity.

Table 1. Nutrient content of the organic fertilizer used for the experiment.

	Poultry manure	Alesinloye Grade B
N (%)	3	2
P_2O_5 (%)	3	5
CaO (%)	11	7
MgO (%)	0	0
K_2O (%)	2	3

Table 2. Pre-planting chemical and physical characteristics of the experimental soil.

Properties	Soil value
pH(H_20) (1:1)	6.6
Organic carbon (g kg^{-1})	0.55
Total N (g kg^{-1})	0.45
Available P (mg kg^{-1})	3.54
Exchangeable cations (cmol kg^{-1})	
Ca	2.62
Mg	0.43
K	0.24
Na	0.11
Exchangeable acidity (cmol kg^{-1})	0.00
ECEC (cmol kg^{-1})	3.40
Extractable micronutrient (mg kg^{-1})	
Zn	5.48
Cu	0.84
Mn	81
Fe	56
Soil Texture (gkg^{-1})	
Sand	82
Silt	6
Clay	12
Textural class	Sandy-loam

Properties of the soil after the experiment

Effects of the applied organic and inorganic fertilizer on the chemical properties of the soil are presented in Table 3. The results from the study showed that the application of the amendments significantly improved soil chemical properties (P, Mg, Cu and pH) with the application of Alesinloye giving the highest value for most of the parameters determined. Organic N (Alesinloye) + SSP + MOP reduced soil acidity $p \leq 0.05$ from slightly acidic level of 6.6 (Initial value before experiment) to neutral of 7.05 and also increased P from 3.54 mg/kg to 38.3mg/kg and Organic carbon from 0.55 g/kg to 0.66 g/kg. Eghball *et al*. (2004) and Chudhary *et al*. (2006) in their researches conducted using organic manure also reported increase in available P after application of organic fertilizer.

Generally, it was observed that addition of Alesinloye organic fertilizer combined with inorganic fertilizer increased most of the parameters determined. This may be due to enhanced release and mineralization of nutrients from native and added organic manure due to synergistic effects of the SSP and MOP (inorganic fertilizer) on organic matter (Adeniyan and Ojeniyi, 2005; Iren *et al*., 2011b). Organic matter shows a greater capacity to release and retain nutrients in forms that can be easily taken up by plants over a longer period of time. Conversely, nutrients released from inorganic fertilizer alone were of short period of time because of leaching losses. Hoffiman *et al.* (2001) also pointed out that if inorganic fertilizer, especially nitrogen carrier is combined with manure, the manure reduces soil acidification and improves the nutrients buffering capacity and release of nutrients.

Effects of organic and inorganic nutrient sources on growth and yield of *Aloe vera*

Application of inorganic fertilizer and organic manure in a single or in a combined form improved fresh yield and growth of *Aloe vera* across all stages of growth when compared with the control (Table 4). This is in support of (Sakakibara *et al*., 2006) that there is usually a significant improvement in both quantity and quality of plant growth when appropriate fertilizers are added.

At 13 months after transplanting (MAT), all the amendments ($P \leq 0.05$) increased the yield and growth of *Aloe vera* except number of suckers. Plots with applied poultry manure and urea as source of N produce plants with longer leaf and volume which was 26% and 44% higher than control. Application of inorganic N source (urea) increase leaf thickness of *Aloe vera* plants by 23% while number of leaves was 18% higher than the plots without fertilizer and plots with applied Alesinloye organic fertilizer nitrogen source. Ved *et al*. (2002) has also recommended the application of 15 tons FYM and 50 kg each of nitrogen, phosphorus and potassium to *Aloe vera* for growth. It is also consistent with the findings of (Ji-Dong *et al.*, 2006) that nitrogen application increased leaf fresh weight and total biomass of *Aloe vera* plant. In the arable soil, the significant response of growth parameters and number of offshoot production to increasing N rates demonstrated the high demand for this element. This result corroborates the earlier findings of (Van Schaik and Struik, 1997; Ved *et al*., 2002; Hossain *et al*., 2007; Owoade *et al.*, 2008; Owoade, 2015; Khandelwal *et al*., 2009) that *Aloe vera* plants responded positively to applied N rates through increased growth and leaf yield. Furthermore, the significant increase in yield parameters may be because nitrogen is often regarded as limiting for biomass production in most plants (Babatunde and Yongabi, 2008).

Table 3. Effects of organic and inorganic nutrient sources on soil chemical properties.

Treatments	pH	OC	N	P	Ca	Mg	K	Na	ECEC	Zn	Cu	Mn	Fe
		g/kg		mg/kg		cmolkg^{-1}					mg/kg		
Control	6.65b	0.61	0.05	6.22d	2.44	0.39ab	0.30	0.70	3.19	11.77	6.58b	84.70	186.92
Poultry manure	6.72b	0.68	0.06	27.96b	2.66	0.37ab	0.24	0.07	3.33	11.26	3.61b	52.93	187.11
NPK	6.60b	0.59	0.05	12.23c	2.45	0.35b	0.23	0.06	3.10	11.15	4.05b	82.84	193.13
Alesinloye	7.05a	0.66	0.06	38.31a	2.86	0.43a	0.25	0.06	3.60	12.34	13.19a	50.94	160.93
		NS	NS		NS		NS	NS	NS	NS		NS	NS

Means having the same letters within the same column are not significantly different using Duncan Multiple Range test at 5% probability level.

Table 4. Effects of organic and inorganic nutrient sources on growth and yield of *Aloe vera*.

Treatment	Leaf Length (cm)	Leaf Thickness (cm)	Leaf Volume (cm^3)	Leaf Width (cm)	No. of Leaves	No. of Suckers
Control	14.50c	3.61c	3.30c	1.46c	8.56c	3.60a
Poultry manure	19.66a	4.33b	49.61a	1.91a	9.83b	3.26a
N P K	19.33a	4.69a	53.70a	1.78b	10.46a	3.80a
Alesinloye	16.26b	4.51b	39.75 b	1.52c	8.60c	3.40a

Means having the same letters within the same column are not significantly different using Duncan Multiple Range test at 5% probability level.

CONCLUSION

This study has investigated the effect of organic and inorganic nutrient sources on performance of *Aloe vera* and soil chemical properties in the Derived savannah agro-ecological zone of Southwest Nigeria. Observation showed that the addition of organic manure such as poultry manure or Alesinloye in combination with SSP and MOP fertilizer improved the chemical properties of the soil as well as *Aloe vera* plant growth and yield relative to the control and plot with urea combined with SSP and MOP. Applications of Alesinloye organic fertilizer neutralize the acidity of the soil while ensuring balanced plant nutrition and improved soil fertility. Application of Urea with combination of SSP and MOP also significantly improved growth parameters of *Aloe vera* plant. The observation suggests that due to high cost of fertilizers in the market, *Aloe vera* growers can combine the organic and inorganic fertilizers to reduce cost. Furthermore, since organic manure releases both major and minor nutrients, *Aloe vera* farmers in general should embark on the use of available manure and Poultry manure for effective growth, yield and soil fertility improvement in the study area since they are found in their localities.

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