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Efficacy of sunshine and neem-based organic fertilizer on performance and chemical constituents of *Aloe vera* in the southern guinea savanna ecology of Nigeria

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Abstract

The guaranteed premium prices of organic food, reduction and elimination of the adverse effects of synthetic fertilizers on human health and the environment and sustainability of organic agro ecosystem have continued to stimulate the interest of more people on the continent to grow and eat organic food. Organic materials applied in soil as fertilizers could play an important role in the establishment of sustainable agriculture. This study was carried out in Ladoke Akintola University of Technology Teaching and Research Farm, Ogbomoso to determine the effect of organic fertilizers on growth, yield and the mineral composition of Aloe vera. Field experiment was laid out in randomised complete block design with three replications. The treatments were nine treatments comprising of control at 0 kg P/ha, Sunshine and neem based fertilizer at 15, 30, 45 and 60 kg P/ha. Data on leaf (length, width, number, thickness) and suckers were collected and laboratory analyses of mineral composition were also determined. Application of organic fertilizer at the rate of 15 kg P/ha had better performance on leaf length, width, thickness, number of suckers and mineral composition of Aloe vera. The availability of nutrient elements like phosphorus in the fertilizers used seems to increase the absorption of nitrogen, which promotes vegetative production. P fertilizer is also important for Aloe vera production. Aloe vera growers should embark on the use of organic fertilizer for effective growth, yield and quality Aloe vera in the study area.

Keywords: *Aloe vera, mineral constituents, organic fertilizer. production*

Introduction

Aloe vera (L) Burn. F. (Liliaceae). is a perennial, succulent plant and produces secondary metabolites with numerous properties such as anti-bacterial, anti-inflammatory and antioxidant (Ghazanfar et al. 2012; Lopez et al. 2013). Aloe vera is a valuable medicinal herb that is used in the pharmaceutical, food industry and cosmetics (Ilbas et al. 2011) as pills, sprays, lotions, creams, jellies and drinks (Datta et al. 2012). Leaves are helpful in digestion and constipation. Cosmetic companies add sap or other derivative from Aloe vera to products such as makeup items, moisturizers, soaps, sunscreens, shaving cream and shampoos (Nandal & Bhardwaj, 2012).

Neem tree (Azadiracthta indica), Meliaceae family has been reported to acts as a soil enricher, bio-degradable, eco-friendly, excellent soil conditional and provides essential nutrients for plant growth (Lokanadhan et al. 2012). Azadirachta extracts has been reported to help soil to effectively maintain the soil nutrient level before the next season comes for plantation as it is sustainable organic matter in long run, increases water holding capacity, improves soil structure, keeps the soil aerated for root development, boost the rhizospheric flora that enhances soil health and fixes soil texture (Chauhan and Urooj, 2019). Sunshine organic fertilizer grade B are commercial organic fertilize developed by Ondo state Government of Nigeria.

Use of fertilizer in Aloe vera field has been reported to be one of the strategies for increasing the yield of Aloe vera (Saha et al., 2005). It has been reported that the application of N fertilizer enhanced the growth and yield of Aloe vera (Khandelwal et al., 2009, Van Schaik et al., 1997). Babatunde and Yongabi (2008) observed that the growth parameters of Aloe plants increased significantly, by increase in nitrogen levels. Organic manures are more effective in Aloe vera growth and yield which is comparable to chemical fertilizer (Saha et al., 2005). In addition, organic manures enhance good leaf quality. So, it may be necessary to find out a suitable recommendation for manuring in Aloe vera farming. According to Faryabi and Ghazanchi (2005), increasing N and P fertilizers applications rates increased leaf fresh weight and gel content. In another experiment, it was reported that application of higher rate of nitrogen fertilizers enhanced the number of leaves, leaf weight, leaf diameter and leaf length of Aloe vera (Luis, 2002). Hasanuzzaman et al. (2008) also found that the highest leaf yield, number of leaves, leaf fresh weight and leaf area index of Aloe vera were obtained when 50% organic manure was mixed with soil.

Awareness of and the demand for organic produce has increased tremendously in the last two decades in sub-Saharan Africa due to its potential to improve nutrition, income and livelihoods of smallholder farmers (Atungwu et al., 2009). In Nigeria, farmers realize the need for soil amendments by using available resources such as crop wastes, farmyard manure and poultry waste (Adediran et al. 2003). The use of organic fertilizer as source of nutrients to crops has recently received comprehensive review by Awodun, et al. 2007; Akanbi et al.(2003) and Ojetayo et al. (2011). The guaranteed premium prices of organic food and sustainability of organic agro ecosystem have continued to stimulate the interest of more people on the continent to grow and eat organic food. Reduction and elimination of the adverse effects of synthetic fertilizers and pesticides on human health and the environment is a strong indicator that organic agriculture is gaining worldwide attention [Aksoy, 2001, Chowdhurry, 2004]. Organic fertilizers are environmentally friendly, since they are from organic sources [Oyewole et al. 2012]. The current global scenario firmly emphasizes the need to adopt eco-friendly agricultural practices for sustainable food production. The cost of inorganic fertilizers is increasing enormously, to the extent that they are out of reach for small and marginal farmers. The organic fertilizers provide nutritional requirements, suppress plant pest populations, and increase the yield and quality of agricultural crops in ways similar to inorganic fertilizers [Arancon et al., 2004; Bulluck and Ristaino 2002; Bulluck et al., 2002; Heeb et al., 2006;; Liu et al., 2007; Maske et al., 2015; Tonfack, 2009].

However, use of chemical fertilizers alone may not be sufficient under intensive agricultural management. Over-reliance on the use of chemical fertilizers has been associated with declines in some soil properties and crop yields over time (Hepperly et al., 2009) and significant land problems, such as soil degradation due to over exploitation of land and soil pollution caused by high application rates of fertilizers (Singh, 2000). Therefore, this study was therefore conducted to compare the effects of rates of Sunshine and neem based organic fertilizers on growth, yield and chemical constituents of Aloe vera in Southern Guinea Savanna of Nigeria.

Materials and methods

Description of Experimental Site

The study was carried out at the experimental field of the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Oyo State (Latitude 8^0 10'N and Longitude 4^0 25'E) in the Southern guinea savanna ecology of Nigeria. The average annual precipitation is over 1000 mm with rain extended from March till November while later is warm and moist which start from April to October. Temperature ranges from 20^0 C to 33^0 C and humidity is high as 74% all year round except January when the dry wind blows from the North.

Land Preparation, Experimental Design and Treatments

The experimental plot was manually cleared, tilled and beds measuring 2 m x 2 m were constructed. Alleyways between blocks were 2 m while those between plots were 1 m. The experiment was laid out in a completely randomized block design with three replications. There were nine treatments as follows:

T1 fi Control (0 kg P/ha)
T2 fi Sunshine at 15 kg P/ha
T3 fi Sunshine at 30 kg P/ha
T4 - Sunshine at 45 kg P/ha
T5 fi Sunshine at 60 kg P/ha
T6 fi Neem at 15 kg P/ha
T7 fi Neem at 30 kg P/ha
T8 fi Neem at 45 kg P/ha
T9 fi Neem at 60 kg P/ha

The rate of application of the fertilizers was based on the phosphorus content on the fertilizer materials and applied on dry weight basis. The organic fertilizers was incorporated into the soil one week before planting to allow mineralisation of nutrients. The nutrient composition of the organic fertilizers are presented in Table 1.

Table 1 Proximate analysis for sunshine organic fertilizer Grade B and neem based organic fertilizer

Organic fertilizer	N%	P%	K%
Sunshine Grade B	3.5	1.0	2.5
Neem-based organic fertilizer	3.0	1.82	2.75

Planting and Weeding

The organic manures were evenly distributed and incorporated to specified plot using ring method one week before planting. One Aloe vera sucker was planted per stand on 2m x 2m bed at a spacing of 75m x 75m (0.563 m^2) giving a plant population of 243 plants/ha. The experimental plots were kept weed free throughout the period of the experiment.Weeding was done forthnightly and 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). Data collection commenced two weeks after transplanting till 6 months after transplanting (MAT) at two 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 callipers. Leaf width was determined at the centre of the longest leaf while count of leaves considered all fully opened leaves per plant.

Soil Sampling, Preparation and Laboratory Analysis

Before the experiment, 9 auger point samples taken at 0fi 15 cm depth were randomly collected per plot, bulked to form a composite, air dried, crushed and sieved

through 2mm and 0.5 mm meshes for laboratory analysis. Representative samples were taken and air-dried, crushed and sieved through 2mm for the determination of particle size, pH (H20), available P, extractable micronutrients (Fe, Cu, Mn & Zn) and exchangeable cations (K, Mg, Ca & Na). Soil sieved through 2 mm and 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 hexametaphophate 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 macrofi Kjeldahl digestion (Bremner and Mulvaney, 1982) method followed by colorimetric determination using Technicon Auto analyser. 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 Potassium (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 (Heanes, 1984). The organic manure was analyzed using standard procedures (Juo, 1979).

Statistical Analysis

Data collected were subjected to statistical analysis using Genstat software and Duncan Multiple Range Test (DMRT) was used to compare the mean at 5% level of probability.

Results and Discussion

Physical and chemical analysis of the experimental soil

The physical and chemical properties of the experimental soil is presented in Tables 2. The soil is moderately acidic with pH (6.0). The organic carbon (0.61 gkg-1), total nitrogen (0.06 gkg-1) and Mehlich P (3.55 mgkg-1) were low. For most crops the critical levels of Nitrogen ranged between 0.15–0.2% (Adeoye. 1986). The total N value of 0.06 is more than critical level of 0.2% while the 5.73 mgkg-1 available for P is very low than critical level 10–16 mgkg-1 (Adeoye, 1986). The exchangeable Ca, Mg, K and Na are 1.92 cmol/kg, 0.71 cmol/kg, 0.36 cmol/kg and 0.09 cmol/kg respectively. The K status of the soil which is 0.36 cmol/kg is also less than the critical level of 9.00 cmol/kg (Adeoye, 1986). The textural class of the experimental soil was sandy loam. The implication here is that the soil is low in major elements and cannot support Aloe vera. Soil fertility will be improved by meaningful amendments while the soil pH, organic matter content as well as micro nutrient level are to be considered.

Table 2. Physical and chemical properties of the experimental soil

Properties	Soil values
pH (H_20) (1:1)	6.0
Organic carbon (g kg^{-1})	0.61
N (g kg^{-1})	0.06
Mehlich P (mg kg^{-1})	3.55
Exchangeable cations (cmol kg^{-1})	
Ca	1.92
Mg	0.71
K	0.36
N	0.09
Exchangeable acidity	0.00
ECEC (cmol kg^{-1})	3.07
Extractable micronutrient (mg kg^{-1})	
Zn	7.96
Cu	0.12
Mn	153.56
Fe	57.00
Soil texture (gkg^{-1})	
Sand	810
Salt	90
Clay	100
Textural class	Sandy-loam

Effects of Sunshine and Neem based fertilizer on growth of *Aloe vera*

Application of Sunshine and Neem based fertilizer improved the growth of Aloe vera across all stages of growth when compared with the control (Table 3). This in line with the work of (Sakakibara et al., 2006) that there is significant improvement in both quantity and quality of plant growth when appropriate fertilizers are added. Sunshine organic fertilizer produced the highest number of leaves at 30 kg P/ha level of application which was significantly different from control. According to Hoseini et al. (2013) reported that organic fertilizers increased length of Aloe vera leaf. Barandoxi et al. (2011) noted increase in leaf length of Aloe vera under N and P fertilizers which agree with the present findings. Neem based fertilizer application level at 60 kg P/ha produced the lowest number of leaves. Organic manures are more effective in Aloe vera growth and yield which is comparable to chemical fertilizer (Saha et al., 2005). Plots with applied sunshine organic fertilizer at 60 kg P/ha produced the highest leaf width compared with Neem application at 60 kg P/ha which had the lowest leaf. Hasanuzzaman et al. (2008) opined that the highest leaf yield, number of leaves, leaf fresh weight and leaf area index of Aloe vera were obtained when 50% organic manure was mixed with soil. From the result in Table 3, Sunshine organic fertilizer produced the highest leaf length at 30 kg P/ha level when compared with

control. It was reported that application of higher rate of nitrogen fertilizers increased the number of leaves, leaf weight, leaf diameter and leaf length of Aloe vera (Luis, 2002). Sunshine organic fertilizer produced the highest number of sucker at 30 kg P/ha level of application when compared with the control. Furthermore, highest leaf thickness at 30 kg P/ha was recorded by Sunshine organic fertilizer when compared with the control. According to Faryabi and Ghazanchi (2005), increasing N and P fertilizers applications rates increased leaf fresh weight and gel content. Sunshine organic fertilizer produces the highest root length of Aloe vera at 30kg P/ha of application which was significantly different from control which produces the lowest root length. According to Boroomant et al. (2011) reported that the application of P fertilizer enhanced the growth attributes of Aloe vera plants. Harendra & Yadav (2007) also reported significant increase in the gel content in Aloe vera plants treated with phosphorus fertilizer. The highest root length was also produced at Neem application level of 15 kg P/ha which was not significantly different from other levels of application. Sunshine organic fertilizer produces the highest number of lateral root of Aloe vera at 15 kg P/ha level of application which was not significantly different from control. This could be as a result of higher rates of phosphorus application which leads to the enhancement in the number of leaves, leaf fresh weight, leaf root length and leaf diameter of Aloe vera plants. The lowest number of lateral root was produced at 60 kg P/ha level of application of Neem based fertilizer which was not significantly different from other levels of application.

Table 3. Effects of Sunshine and Neem based fertilizer growth of *Aloe vera*

Treatment (kg P/ha)	No. of Leaves	Leaf Width (cm)	Leaf Length (cm)	No. of suckers	Leaf thickness (cm)	Root length (cm)	Number of lateral root
Control	11.72bc	3.21bc	21.57d	16.00bc	2.51ab	15.33b	29.00ab
SS_{15}	12.61ab	3.39ab	25.59ab	17.39ab	2.44bc	19.77ab	36.67a
SS_{30}	13.44a	3.48ab	27.74a	19.67a	2.55a	21.23a	28.33ab
SS_{45}	11.67bc	3.18bc	24.90bc	11.83e	2.41cd	20.03a	30.33ab
SS_{60}	12.17bc	3.59a	25.74ab	16.67b	2.49abc	18.37ab	24.67ab
Nm_{15}	12.06bc	3.47ab	25.60ab	15.22bcd	2.48abc	21.23a	22.00ab
Nm_{30}	12.00bc	3.31abc	24.25bc	13.44cde	2.42bc	18.67ab	27.00ab
Nm_{45}	11.61bc	3.29abc	24.43c	15.56bc	2.45bc	18.23ab	25.33ab
Nm_{60}	11.56c	3.11c	22.63cd	12.39de	2.32d	19.10ab	21.33ab
LSD	1.03	0.32	2.37	2.95	0.10	4.83	17.02

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

Effects of Sunshine and Neem based fertilizer on the leaf volume and weight gained of *Aloe vera*

It was shown that Sunshine organic fertilizer produces the highest leaf volume at 30kg P/ha (61.27 cm3) level of application which was significantly different from control (44.89 cm3). This is in line with the work of Van Schaik et al. (1997) that growth rate of leaf breadth was higher with treatment where higher percentage of fertilizer was used. Khan et al. (2012) reported that availability of nutrients increased the biomass of plants. Neem application level at 60 kgP/ha (43.79 cm3) produces the lowest leaf volume. This could be as a result of reduction or absence on nitrogen fertilizer which does not fall in line with the work of Hossain et al. (2007) who reported that N fertilizers increased the plant height of Aloe vera. Sunshine organic fertilizer produces the highest weight of Aloe vera at 30kg P/ha. Hasanuzzaman et al. (2008) showed that organic fertilizers increased the fresh weight of Aloe vera. According to Jones (2005), the availability of nutrient elements like P in the fertilizers used seems to increase the absorption of N, which promotes vegetative production. Plants with no application of organic fertilizer produces lowest weight of Aloe vera.

Table 4. Effects of Sunshine and Neem based fertilizer on the leaf volume, initial weight, final weight and weight gained of *Aloe vera*

Treatment (kg P/ha)	Leaf volume (cm^3)	Initial weight	Final weight	Weight gained
			(kg)	
Control	44.89e	0.10a	0.50b	0.49b
SS_{15}	55.44ab	0.01a	1.07ab	1.06ab
SS_{30}	61.27a	0.01a	1.40a	1.39a
SS_{45}	47.32bcd	0.01a	0.70ab	0.69ab
SS_{60}	56.73ab	0.01a	1.40a	1.39a
Nm_{15}	55.17abc	0.01a	1.03ab	1.02ab
Nm_{30}	45.89cd	0.01a	0.63b	0.62b
Nm_{45}	51.62abcd	0.04a	0.83ab	0.69ab
Nm_{60}	43.79d	0.01a	0.67b	0.66b
LSD	10.12	0.01	0.70	0.70

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

Effects of Sunshine and Neem based fertilizer on mineral composition of *Aloe vera*

Effects of the applied nutrient sources were significant on mineral composition of Aloe vera except N, Protein, Ca, Fat, Ash, Na, Cu and Zn (Table 5). Plot with no application of nutrient (Control) had the highest Mg, application of Neem at 30 kg P/ha level of application produces Aloe vera with highest protein, Sunshine at 45kg P/ha produces the highest P and Neem at 60 kg P/ha produces the highest Ca. Sunshine organic fertilizer produces highest Nitrogen and Protein at 15 kg P/ha level of application which was not significantly different from control. Akinyele et al. (2012) reported that organic fertilizers shows greater capacity than inorganic fertilizer in retaining nutrients in form that can easily be taken by plants over a long period. Neem based organic fertilizer produced highest Ash and Fe at 45 kg P/ha level of application which was not significantly different from other levels of application. Neem based fertilizer produces highest potassium at 45 kg P/ha level of application which is not significantly different from other levels of application and control produces the lowest potassium. Plot with application of Neem had the plant with highest Na at 15 kg/ha which was significantly different from other applications. Also, plot with applied Neem had the highest fat, Zn and Fe at 45 kg P/ha which is not significantly different from control. Applied sunshine organic fertilizers produces plants with highest Mn and Moisture content at 60 kg P/ha which is not significantly different from control.

Table 5. Effects of organic and inorganic nutrient sources on mineral composition of *Aloe vera*

Treatments	Protein	Ash	N	P	Ca	Mg	K	Na	Fat	Zn	Cu	Mn	Fe	Mc
	ppm		%	ppm	cmolkg^{-1}									
Control	6.90ab	15.01abc	1.10ab	0.24a	2.29b	0.66a	2.84a	32.92d	2.90ab	14.29a	3.26ab	392.76a	51.90a	13.69a
SS_{15}	6.90ab	14.28abc	1.10ab	0.24a	2.09b	0.57a	3.28a	31.26d	2.42ab	9.11b	5.58ab	303.60a	40.99a	14.14a
SS_{30}	6.58ab	14.98abc	1.05ab	0.29a	2.22b	0.59a	3.14a	34.38d	1.95ab	12.15ab	4.35ab	387.04a	65.44a	13.04a
SS_{45}	6.61ab	15.60abc	1.06ab	0.23a	1.82b	0.45a	3.13a	32.43d	1.89b	12.88ab	4.35ab	342.54a	51.69a	15.86a
SS_{60}	6.42ab	11.83c	1.08ab	0.22a	1.91b	0.53a	3.08a	37.18cd	2.08ab	12.82ab	2.180b	428.51a	48.90a	16.04a
Nm_{15}	6.21a	17.40abc	0.99b	0.25a	1.87b	0.51a	3.29a	50.62a	1.93ab	12.07ab	4.707ab	354.31a	63.36a	12.06a
Nm_{30}	7.63a	12.91bc	1.22a	0.26a	1.85b	0.55a	3.24a	43.87abc	2.37bc	13.14ab	3.28ab	352.45a	58.37a	12.19a
Nm_{45}	6.50ab	19.00a	1.03ab	0.24a	1.93b	0.61a	3.55a	46.10ab	3.30a	15.04a	2.88ab	348.33a	75.68a	13.97a
Nm_{60}	6.65ab	17.27ab	1.06ab	0.25a	55.26a	0.59a	3.14a	38.97bcd	2.63ab	2.63ab	2.167b	358.19a	66.83a	14.37a
LSD	1.34	5.06	0.20	0.10	52.72	0.27	0.73	8.29	1.41	1.41	4.36	144.1	35.17	5.19

Conclusion

This study has examined the effect of organic fertilizer on the growth, yield and mineral constituents of Aloe vera in the Southern guinea savanna ecology of Nigeria. Observation showed that sunshine organic fertilizer produces highest at 30 kg P/ha level of application and lowest at 45 kg P/ha level of application. Also, Neem based organic fertilizer produces highest at 15 kg P/ha and produced lowest at 60 kg P/ha level of application. The rate mentioned above also affected the mineral composition of Aloe vera. It is however recommended for farmers that any organic fertilizer should be applied at the rate of 15 fi 30 kg P/ha level of application for optimum growth and good mineral composition for Aloe vera production.

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