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Influence of Moringa Seed Powder and Liquid Gold on Available Phosphorus and Potassium Pools of a P-deficient Alfisol at Samaru, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author AIG designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author MAH conducted the research and drafted the paper. Author NA reviewed the draft. All authors read and approved the final manuscript.

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ABSTRACT

The low fertility constraint of the soils in the northern Guinea savannah of Nigeria necessitates the application of external nutrient supplements for sustainable crop production. An incubation study was undertaken to evaluate the effectiveness of Moringa Seed Powder (MSP) and Liquid Gold (LG) on available phosphorus (P) and potassium (K) pools of a P-deficient soil. Treatments consisted of four rates at 0, 5, 10 and 20 tons per hectare (tha^{-1}) of the MSP and four (0, 10, 15 and 20 tha^{-1}) of the LG. The treatments were laid out in a completely randomized design in a screen house. Significant (*P*<.0001) increase in the available P and K was observed. Treatment L_1M_4 had significantly improved P and K pools of the soil. Treatments L_1M_4 (0 ml LG+20 tha^{-1} MSP), L_2M_4 (10 ml LG+20 tha^{-1} MSP) and L_3M_4 (15 ml LG+20 tha^{-1} MSP) can, however, be used as fertilizer for leguminous crops as they contain substantial levels of P and K. Treatment L_1M_1 (0 ml LG+0 tha^{-1}

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MSP), however, recorded the least levels of the P and K in its nutrients pool, probably be due to absence of organic amendments. All the parameters, however, recorded significant (*P*<.0001) correlation with one another. This study, therefore, revealed that MSP and LG have substantial amount of nutrients and high residue quality that can be used as organic nutrient source. More research work on the impact of the treatments on other nutrients and soil properties will contribute to a sustainable soil fertility management program.

Keywords: Alfisol; liquid gold; Moringa seed powder; P-deficiency.

1. INTRODUCTION

The improvement of soil fertility is very crucial if agricultural productivity and environmental quality are to be sustained for continuous cropping [1]. Most soils of the Nigerian Savannah have low inherent fertility status due, mainly, to low levels of organic matter (OM), cation exchange capacity (CEC), total nitrogen (N), water infiltration capacity, low to moderate P. The soils are also characterized by poor internal drainage due to poor structure. This is mainly attributed to erosion, poor tillage practice, overgrazing, nutrient mining and leaching as well as bush burning. Heavy application of inorganic (chemical) fertilizers also causes depletion of certain nutrients in the soil and some become accumulated in excess resulting in nutrient imbalance [2], which negatively affects soil fertility and productivity [3]. However, the use of fertilizer (inorganic and organic) is recommended for the maintenance of soil fertility and productivity through improvement of soil nutrients [4].

Moringa oleifera Lam. is the most widely cultivated species of the genus moringa which is the only genus in the family moringaceae. English common names include moringa, drumstick tree (from the appearance of the long, slender, triangular seed pods), horseradish tree (from the taste of the roots which resembles horseradish), ben oil tree or benz oil tree (from the oil which is derived from the seeds). It is a fast growing, drought-resistant tree, native to the southern foothills of the Himalayas in Northwest India, and widely cultivated in tropical and subtropical areas where its young seed pods and leaves are used as vegetables [5,6].

Moringa oleifera is also known by diverse names in different parts of the world. In Nigeria, it is known as *Owe Ohio* among the Igbo; *Zogale*, among the Hausa; and *Ewe ile* among the Yoruba tribes. In English, *M. oleifera* is also variously called Miracle tree, Mother's best friend, Never die and Benz olive tree [5]. In a study, [7] observed that moringa seeds contain substantial levels of N, P and K putting their concentrations at 29.8 gkg^{-1}, $6.2x10^{-4}$ gkg^{-1}, and 0.73 gkg^{-1} respectively. Different parts of *Moringa oleifera* can be put into use for industrial and agricultural benefits. The industrial application involve its use in the production of; cosmetics, biogas/biofuel, butter, perfume, pharmaceuticals, food, pulp and paper [6].

In "Liquid Gold: The lore and logic of using urine to grow plants", [8] described human urine as a Liquid Gold because it contains nutrients which, when properly utilized, can be used as liquid fertilizer; hence preventing water bodies from pollution and saving fertilizer cost. Urine has been used as a valuable plant food for centuries in many parts of the world, particularly in the Far East. It is surprising therefore that nearly all the urine produced in the West and in Africa goes to waste and is lost to something else [9]. A liter of urine contains 11.0 g N, 0.8 g P and 2.0 g K, this makes a ratio of NPK of about 11:1:2. A 500-liter urine produced by each person per year, amounts to an equivalent 5.6 kg N, 0.4 kg P and 1.0 kg K, varying from one person to another, from country to country and depending on the national diet [10].

A nutrient deficiency, a physiological disorder caused by shortage of one or more plant nutrients [11], reduces a plant's ability to complete its life cycle of producing flowers and fruits. Phosphorus deficiency is a plant disorder associated with the insufficient supply of P and can be corrected by application of P-based fertilizers [12]. Phosphorus in this context refers to salt of phosphates; monohydrogen phosphate (HPO^{2-}) or dihydrogen phosphate ($H_2PO_4^-$) [11]. The potential of organic amendments to improve soil fertility, increase crop yield and their nature as the safest and long lasting improviser [13] has shifted the attentions of soil scientists and farmers towards the use of organic fertilizers. This work was aimed at evaluating the effects of Moringa Seed Powder (MSP) and Liquid Gold (LG) on a P-deficient Alfisol at Samaru, Nigeria.

2. MATERIALS AND METHODS

2.1 Site Location and Description

The study was conducted in the screen house of soil microbiology unit of the Department of Soil Science, Ahmadu Bello University, Zaria. The pot soil was sampled from the research farm of the Institute for Agricultural Research (IAR) Samaru, Zaria (Lat. 11°10'N, Long. 7°36'E) with an altitude of 704 m above sea level in the Northern Guinea Savannah of Nigeria. The area is characterized by two seasons; dry season (November-April) and rainy season (May-October). It also has a mono-modal rainfall pattern ranging from 950-1270 mm with an annual mean of 1150 mm in the zone. Peaks of rainfall are observed between June and August. The rainfall period starts in May, but often stops in the month of September or early October. Dry season sets in by October and lasts into the month of May. Soil moisture and temperature regimes in the area are inferred to be ustic and isohyperthermic respectively. Mean air temperature in the zone ranges between 25°C and 28°C during the rainy season (June to September) and decreases to less than 20°C in the months between December and February [14,15].

2.2 Collection and Preparation of Treatments

The Moringa Seed Powder (MSP) is a by-product of ground moringa seeds. The seeds were obtained from Samaru market, Zaria, Nigeria. Foreign materials, such as uncrushed seeds, kernels, stones, leaves and straw, were initially removed from the powder and sub-sample was taken for laboratory preparations and analyses. The MSP was used for the screen house incubation study. Liquid Gold (LG) is the liquid human excretory product, and it was obtained from some students in the Division of Agricultural Colleges (DAC), Samaru, Zaria.

2.3 Soil Sampling and Preparation

A composite surface soil (0-15 cm) and sub-surface samples (15-30 cm) were taken from the experimental site. It was thoroughly mixed, air-dried, crushed and passed through 2 mm stainless sieve. The less than 2 mm soil fraction was used for laboratory analyses, while a 6 mm stainless sieve was used to sieve the soil used for the incubation study. Soil samples were also taken from the incubated soils for post-incubation soil analyses.

2.4 Treatments and Experimental Design

Treatments consisted of four levels (at 0, 5, 10 and 20 tha^{-1}) of MSP and four levels (at 0, 10, 15 and 20 ml) of LG. Ten (10) ml of chloroform was also applied to each pot, but for that of the control. The seventeen treatment combinations were as indicated in Table 1.

The treatments were laid down in a completely randomized design (CRD) in the screen house, and were repeated thrice.

Table 1. The treatment combinations used in the research work

Treatment	Treatment combinations
1	Control
2	L_1M_1 (0 ml of Liquid Gold+0 tha^{-1} of Moringa Seed Powder)
3	L_1M_2 (0 ml of Liquid Gold+5 tha^{-1} of Moringa Seed Powder)
4	L_1M_3 (0 ml of Liquid Gold+10 tha^{-1} of Moringa Seed Powder)
5	L_1M_4 (0 ml of Liquid Gold+20 tha^{-1} of Moringa Seed Powder)
6	L_2M_1 (10 ml of Liquid Gold+0 tha^{-1} of Moringa Seed Powder)
7	L_2M_2 (10 ml of Liquid Gold+5 tha^{-1} of Moringa Seed Powder)
8	L_2M_3 (10 ml of Liquid Gold+10 tha^{-1} of Moringa Seed Powder)
9	L_2M_4 (10 ml of Liquid Gold+20 tha^{-1} of Moringa Seed Powder)
10	L_3M_1 (15 ml of Liquid Gold+0 tha^{-1} of Moringa Seed Powder)
11	L_3M_2 (15 ml of Liquid Gold+5 tha^{-1} of Moringa Seed Powder)
12	L_3M_3 (15 ml of Liquid Gold+10 tha^{-1} of Moringa Seed Powder)
13	L_3M_4 (15 ml of Liquid Gold+20 tha^{-1} of Moringa Seed Powder)
14	L_4M_1 (20 ml of Liquid Gold+0 tha^{-1} of Moringa Seed Powder)
15	L_4M_2 (20 ml of Liquid Gold+5 tha^{-1} of Moringa Seed Powder)
16	L_4M_3 (20 ml of Liquid Gold+10 tha^{-1} of Moringa Seed Powder)
17	L_4M_4 (20 ml of Liquid Gold+20 tha^{-1} of Moringa Seed Powder)

L=Liquid Gold, M=Moringa Seed Powder, Numbers 1-4=Varying levels of moringa seed power and Liquid Gold. All treatments, except control, received 10 ml chloroform 100gsoil^{-1}. 10 ml LG 100gsoil^{-1}, 15 ml LG 100gsoil^{-1} and 20 ml LG 100gsoil^{-1} were respectively equivalent to 200, 000l LGha^{-1} (52, 834 galha^{-1}), 300, 000l LGha^{-1} (79252 galha^{-1}) and 400, 000l LGha^{-1} (105669 galha^{-1})

2.5 Incubation Study

One hundred grams of soil was mixed with appropriate amounts of MSP and LG in cylindrical plastic containers, 9.5 cm both in height and diameter. The mixture was moistened with water and 10 ml of chloroform was added to suppress microbial activities. The incubated soil was left for four weeks at field capacity before post-incubation laboratory analyses.

2.6 Laboratory Analyses

The primary macronutrients (N, P and K) of the LG and MSP were determined following standard procedures. Total N was by the micro-Kjeldahl procedure based on procedure by [16]. The total P was determined using wet digestion method according to [17]. The LG and MSP were digested in triple acid (H_2SO_4-HNO_3-$HClO_4$) mixture; and the K content was determined by flame photometry, as described by [18].

The soil samples collected from the experimental site were analyzed for the following physicochemical parameters: Particle size distribution using hydrometer method [19]; soil pH in 1:2.5 soil to water and 0.01 M $CaCl_2$ ratio suspension with the glass electrode pH meter. The organic carbon was determined using the modified Walkley-Black method while total N was also determined by the micro-Kjeldahl method and available P by Bray 1 method according to [20]. The Exchangeable bases (Na, K, Ca and Mg) were, however, determined by the ammonium acetate (NH_4OAc) saturation method as described by [17]. Soil organic matter was determined by computation from the organic carbon content according to [18]. Soil samples from the incubated soils were, also on the other hand, analyzed. The Available P was determined using Bray 1 method [20], and K; following the Ammonium acetate (NH_4OAc) [17].

2.7 Statistical Analysis

All data generated were subjected to Analysis of Variance (ANOVA) using Generalized Linear Model (GLM) procedure, and Pearson's correlation analysis using Statistical Analysis System (SAS) statistical computer package [21]. Where F-ratios were found to be significant at 5% level of probability, treatment means were separated using Duncan's multiple range test (DMRT).

3. RESULTS AND DISCUSSION

3.1 Pre-incubation Soil Analyses

The physicochemical properties of the soil, from 2 depths (0-15 cm and 15-30 cm), were determined before incubation. The result on pre-incubation soil analyses is as shown in Table 2.

Table 2. Soil characterization before incubation

Parameter	Depth (0-15 cm)	Depth (15-30 cm)
Particle sizes (gkg^{-1})		
Sand	560.00	600.00
Silt	200.00	140.00
Clay	240.00	260.00
Textural class	Sandy clay loam	Sandy clay loam
pH (water)	6.10	6.00
pH ($CaCl_2$)	4.90	4.80
Organic C (gkg^{-1})	3.90	4.10
Total N (gkg^{-1})	0.69	0.49
Available P ($mgkg^{-1}$)	0.003	0.005
Exchangeable cations (gkg^{-1})		
K	0.20	0.07
Na	0.12	0.02
Ca	0.52	0.48
Mg	0.09	0.09
CEC ($cmolkg^{-1}$)	7.50	10.70
Organic matter (gkg^{-1})*	6.74	7.10

**OC (gkg^{-1}) x 1.729 [18]*

3.2 Moringa Seed Powder and Liquid Gold Chemical Analyses

The results obtained from the analyses of MSP and LG for primary nutrients were as shown in Tables 3 and 4 respectively as thus.

3.3 Results of Incubation Study

3.3.1 Effect of moringa seed powder and liquid gold on available P and K contents of the soil

The treatments L_1M_4 (0.187 gkg^{-1}), L_2M_4 (0.178 gkg^{-1}), L_3M_4 (0.143 gkg^{-1}) and L_4M_4 (0.190 gkg^{-1})

significantly (*P*<.0001) contributed to the available P pool of the soil. In those, treatments L_1M_4, L_2M_4, L_3M_4 and L_4M_4 were statistically similar. However, L_4M_4 contributed the highest available P (Fig. 1a). This result may be attributed to the possible synergistic effect of LG and MSP as also observed by [22] and [23]. The result also showed significant (*P*<.0001) effect of the treatments on the soil K content. Treatment L_2M_4 recorded the highest (2960.00 gkg^{-1}) K value, and was statistically at par with treatments L_1M_4 (2693.33 gkg^{-1}) and L_3M_4 (2520.00 gkg^{-1}) (Fig. 1b), indicating the ability of organic amendments to improve the K pool in the soil (C Daudu, Ahmadu Bello University, Zaria, Nigeria. Unpublished PhD Thesis). The treatment L_1M_4 was generally the best in terms of contribution to both primary nutrients (P and K)'s pools of the incubated soil. Treatments L_1M_4, L_2M_4 and L_3M_4 can, therefore, be used as fertilizers, especially, for leguminous crops as they contain substantial quantities of P and K (Table 4). Treatment L_1M_1, on the other hand, recorded the least levels of both primary nutrients (0.003 gkg^{-1} P and 29.64 gkg^{-1} K), as respectively indicated in Figs. 1a and Fig. 1b. This is an indication of the treatment's poor potential as a good soil organic amendment.

Table 3. Nitrogen, phosphorus and potassium contents of the moringa seed

Parameter	Result
Total N (gkg^{-1})	
Husk	23.10
Dehusked seed	93.80
Husked seed	59.50
Total P ($mgkg^{-1}$)	
Husk	1.90
Dehusked seed	6.70
Husked seed	5.00
Total K (gkg^{-1})	
Husk	5.90
Dehusked seed	5.40
Husked seed	5.40

Table 4. Nitrogen, phosphorus and potassium contents of the liquid gold

Parameter	Unit	Results
N	gkg^{-1}	78.10
P	gkg^{-1}	0.60
K	gkg^{-1}	0.59

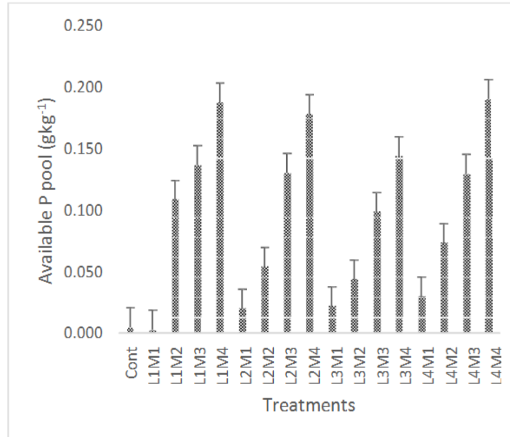

Fig. 1a. Effects of moringa seed powder and liquid gold on soil P

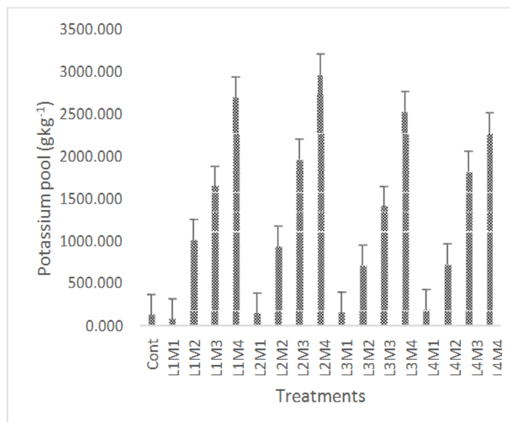

Fig. 1b. Effects of moringa seed powder and liquid gold on soil K

3.3.2 Pearson correlation analysis for the soil parameters

The relationship between the P and K, as determined from the incubated soil samples is presented in Table 5. There was a significant (*P*<.0001) correlation between P and K (r= 0.786**), implying that the evident increase in P content of the soil, as a result of the treatments, lead to an increase in the soil K pool.

Table 5. Correlation coefficients relating the incubated soil parameters

Parameters	P	K
P	1	
K	0.786**	1

***= Significant at 1% level probability*

4. CONCLUSION

The results obtained in this study, indicated that the Moringa Seed Powder and Liquid Gold have substantial P and K contents, as well as high residue quality, to be used as soil organic nutrient sources for improvement of the fertility of savannah Alfisols. It can also be deduced that physicochemical properties of the soil can readily be improved if Moringa Seed Powder and Liquid Gold are used on P-deficient soils. Further studies would be required in order to validate the result obtained from this study. Verifying role of the treatments on other nutrients availability; and physical and biochemical properties of soils would also be paramount.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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