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Contributions of Moringa (*Moringa Oleifera*) Tree Foliage for Enrichment of Soil Nutrient Status

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Abstract:
A study was carried out to determine the potentials of moringa (Moringa oleifera Lam) leaves for the enhancement of nutrient capacity of soils. The study specifically compared the rates of nutrient release by fresh and dry moringa leaves and monitored the rate of decomposition of the leaves for nutrient release into the soil over a period of six weeks of incubation. Three soil samples were taken at 0-30 cm depth from the Department of Crop Science, University of Nigeria, Nsukka (UNN) farm lands, put into 3 kg capacity plastic buckets, each containing 2kg of topsoil, and covered with lids. Thereafter, fresh and dry moringa leaves were incorporated into each of the plastic buckets at the rates of 50, 100 and 150 g. The experiment was laid out in a completely randomized design (CRD) with three replications. The effects of the treated soils on two growth characters: plant height and leaf area of maize (Zea mays) were monitored during four weeks of growth. The incorporation of fresh or dry moringa leaves increased the soil organic matter, nitrogen and phosphorus contents but reduced exchangeable aluminium and hydrogen ions. Nutrient release was higher in the dry than the fresh moringa leaves at all rates of incorporation. Maize performed generally well at the three levels of the fresh leaf treatment but the best result was obtained at the 100 g of fresh leaves per 2 kg of soil for leaf area and 150 g rate for plant height. For the dry leaf treatment, the plants responded best at 50 g rate.

Key words: *Moringa oleifera, Zea mays, farmers' plots, soil nutrients status, soil incubation*

1. Introduction

The soil is the main reservoir of water and nutrients and therefore controls the availability of most essential plant nutrients. It regulates nutrient availability by means of bio-physiochemical processes. The soil–plant system's capacity to supply or absorb nutrients is termed *soil nutrient bioavailability*, and it is the ability of the soil–plant system to supply essential plant nutrients to plants during a specific period of growth (Comerford, 1998). Nutrient uptake at the root surface is dependent on the amount of root–mycorrhizal surface and its uptake characteristics (Comerford, 1998). Nutrient release from the solid phase into the soil solution occurs biochemically (by mineralization and immobilization) or physiochemically (by adsorption and desorption, precipitation and dissolution). Mineralization and immobilization are transformations of nutrients from their organic to inorganic forms. These transformations are functions of the soil temperature, soil aeration, soil water regime, and the quality of the organic matter from which the nutrient is mineralizing – because these factors control the population and activity of soil organisms.

Moringa oleifera Lam, commonly called moringa, has probably been one of the most popular plants in seed bank of underutilised tropical crops. It belongs to an *Onogenic* family of shrubs and trees, *Moringaceae*. The tree is native to Agra and Oudh in the North West region of India, South of the Himalayan Mountains. It is planted around the world, especially in Pakistan, Asia Minor, Africa and Arabia (Mulghal et al., 1999). It was introduced into Eastern Africa from India at the beginning of 20th century. Amongst 13 species of the moringa family, *Moringa oleifera* is the most widely cultivated.

Moringa has valuable properties and characteristics which make it of great scientific interest. These include the high protein content of the leaves and stem, oil from seeds, the large number of unique polypeptides in seeds which can be bound to many moieties. Moringa's traditional, medicinal and industrial uses have been advocated for centuries. Different parts of the plant contain profiles of important minerals and they are good sources of protein, vitamin B, amino acids and various phenolic compounds (Foildl and Paul, 2008; Fuglie, 2005). The moringa plant provides a rich and rare combination of phyto-chemicals. Incorporation of moringa shoots as green manure increases the fertility level of agricultural lands. For this, moringa seeds are planted 1-2cm deep at a spacing of 10cm x 10cm in well prepared seed beds. The young plants are ploughed into the soil at 15cm depth after 25 days of planting (Fuglie, 2005). There are a few research studies to evaluate the use of *Moringa oleifera* foliage as green manure to improve the nutrient status of an impoverished soil in Nigeria. The main objective of this research was to

determine nutrient release from incorporated leaves of *Moringa oleifera* and their effects on the performance of maize (Zea mays L.).

2. Materials and Methods

2.1. Incubation Experiment

The incubation experiment was carried out in the Soil Science laboratory of the University of Nigeria, Nsukka. Nsukka is situated on altitude 447.2 above sea level with mean annual rainfall of 2500-3000 mm and temperature of 22-25^{o}C.

Auger soil samples were collected from different locations of the farm at a depth of 0 – 30cm. The soil samples were mixed to form a composite sample which was air dried and sieved via a 2mm mesh to remove coarse particles such as gravels. The soil samples were analysed for physical and chemical properties before incubation. Fresh Moringa leaves were collected from Nsukka town; half of the leaves were air-dried to a moisture content of 7%.Thirty blue plastic buckets (with lids), each containing 2 kg of soil were arranged in the laboratory in the batches of ten buckets per replicate. The experiment was laid out in a completely randomised design (CRD) with three replications. The fresh and dry Moringa leaves were incorporated into the potted soil at the rates of 0, 50, 100 and 150 g, moistened and covered loosely with the lids to allow aeration. Treated soils were constantly kept moist, but not waterlogged, throughout the experimental period which lasted for six weeks. Moistening was done once a week with 10 cl of water. The incubation was done at room temperature under aerobic condition. The physical and chemical properties of the soil and the nutrient status of the dry and fresh moringa leaves were determined before the incubation process. Samples of the mixture (topsoil and moringa leaves) were taken every two weeks to determine the amount of nutrient released into the soil. After the six weeks of incubation, the different soil media with the different levels of Moringa leaf incorporation were used to grow maize (*Zea mays* L.) in a screen house.

2.2. Analysis of the Soil and Moringa Leaves (before incubation) and the Collected Samples (during incubation)

The topsoil and collected samples of the mixture (i.e. topsoil and moringa leaves) were air-dried and analyzed in the Soil Science laboratory for physical and chemical properties (Table 1). The particle size distribution was determined using the hydrometer method (AOAC, 1990). The rate of nutrient release was determined by monitoring the release of total N, available phosphorus (P) and exchangeable potassium (K), calcium (Ca), magnesium (Mg) and sodium (Na). Other chemical properties included soil pH, organic carbon and cation exchange capacity (CEC). The total nitrogen of the soil was determined using the Microkjedahl apparatus (Bremner and Mulvaney, 1982). Available phosphorus was determined by the Bray I method using colorimetric assessment according to Association of Official Analytical Chemists (AOAC, 1990). The determination of Ca, Mg, K, Na and CEC was done using ammonium acetate method (Thomas 1982). The pH of the soil (before incubation) and the sample mixture (during incubation) was determined with a pH meter. The organic carbon content was determined by wet dichromate acid oxidation method (Nelson and Sommers, 1982) while the percentage organic matter (OM) was obtained by multiplying the % carbon (C) by 1.724, i.e. % OM = % C x 1.724. The exchangeable acidity (EA) was determined using the conventional Van Bernmeller method i.e. leaching the soil with 1N KCl and titrating with 0.05N sodium hydroxide. The exchangeable aluminium was determined by adding one drop of 0.05N HCl to make the soil solution colourless, then 10ml of 4% sodium fluoride to return the pinkish colour, and titrating with 0.05N HCl till the solution becomes colourless again. Table 2 shows the nutrient status of the dry and fresh moringa leaves before incubation.

Farmers' Plots	% Clay	% Silt	% F.sand	% C.sand	pH H_2O	pH KCL	% C	% O.m	% N	Meq/ 100g Na	Meq/ 100g K	Meq/ 100g Ca	Meq/ 100g Mg	Meq/ 100g C.E.C	%B.sat	Meq/ 100g Al	AvailP ppm
1	10	8	57	25	5.3	3.9	0.82	1.414	0.070	0.142	0.045	1.8	2.8	6.9	33.03	0.2	26.11
2	12	8	55	25	5.2	3.7	0.91	1.569	0.084	0.222	0.039	2	3.2	7.4	46.3	0.1	25.18
3	10	8	56	26	4.7	4	0.91	1.569	0.084	0.142	0.023	2	2.6	7.6	62.7	0.2	24.25
Average	10.7	8	56	25.7	5.1	3.9	0.88	1.517	0.079	0.169	0.036	1.9	2.9	7.3	47.34	0.17	25.18
FLSD 0.05	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	4.45	ns	ns

Table 1: Physical and chemical properties of soils of the farmers' plots before incubation
F. sand= Fine sand; C. sand= Coarse sand; O.m= Organic matter; B.sat= Base saturation; Avail= Available

Treatment (Moringa)	%N	% Ca	% Mg	Cu (mg/100g)	Fe (mg/100g)	% K	P (mg/100g)
Dry	1.850	4.248	10.56	0.967	0.248	0.1661	0.5123
Fresh	3.50	2.950	6.34	0. 628	0.1493	0.0962	0.4450

Table 2: Chemical properties of the dry and fresh Moringa leaves

2.3. Screen-house Experiment

After six weeks of incubation, the potted soil samples were used to grow maize to monitor the effects of the different rates of moringa leaf incorporation on growth of the plant. The experiment was laid out in the screen-house in a completely randomized design (CRD) with three replications. The thirty soil media used in the incubation experiment were used to grow the maize in the screen-house for twenty-eight days. Stem height and leaf area were used to express the morphological growth of the plant. The plant height was measured from the base (root-shoot junction) to the tip of the plant using a meter pole while the leaf area was measured using Mongelard's formula (1968) modified by Obi and Imonide (1991). The formula is as stated below:

Area (A) of a leaf = ¾ Length (L) X Breath (B) of a leaf

A = 3/4LB

Total Leaf Area (TLA)/Plant = Sum of ¾ Length X Breath of the leaves/Plant

TLA = $(3/4LB)_1 + (3/4LB)_2 + (3/4LB)_3 + \ldots\ldots\ldots\ldots (3/4LB)_n$

Where $_{1, 2, 3}$.....and $_n$ were the different leaves on the plant

3. Results and Discussion

3.1. Incubation Experiment

Table 3 shows the result of the physical properties of the incubated soil after six weeks of the incorporation of the dry and fresh moringa leaves. There were no significant differences ($p > 0.05$) in the percentage clay and sand contents of the soil except percentage silt. However, the texture of the soil remained sandy-loam. Table 4 shows the chemical properties of the soil/moringa mixtures six weeks after incubation. There were significant increases ($p < 0.05$) in the soil pH, organic matter content, total N, cation exchange capacity (CEC) and available P. The soil media treated with dry moringa leaves experienced higher increases of the above properties than those treated with fresh moringa leaves. The increments were as follows: for pH (from 7.2 to 8.5for dry leaves and 6.8 to 6.9 for fresh leaves), % organic matter (from 2.42% to 3.74% for dry leaves and 1.29% to 1.69% for fresh leaves), total nitrogen (from 0.135% to 0.201% for dry leaves and 0.084% to 0.1125% for fresh leaves), CEC (from 8.33 to 11.67 for dry leaves and 6.00 to 8.33 for fresh leaves) and available P (from 30.78 ppm to 45.70 ppm for dry leaves and 23. 01 ppm to 29.23 ppm for fresh leaves). There were no significant differences ($p > 0.05$) in the exchangeable bases (K, Ca, Mg and Na) and base saturation. There were no traces of aluminium in the media.

Treatment Factor	Treatment Rates	Textural Class	% Clay	% Silt	% Fine Sand	%Coarse Sand
Dry	0	SL	0.7	9.7	21.7	58.0
Dry	50	LS	8.7	11	27.3	53.0
Dry	100	SL	12.0	1.7	22.0	54.3
Dry	150	SL	11.3	12.3	20.3	56.0
Fresh	0	SL	10.7	9.7	21.7	58.0
Fresh	50	LS	8.0	9.7	23.7	58.7
Fresh	100	LS	9.3	8.3	25.3	56.3
Fresh	150	LS	6.0	9.7	26.0	58.3
	Moringa		2.827	0.935	4.147	1.629
	Rate		3.997	1.322	5.864	2.303
$LSD_{0.05}$	Moringa x Rate		5.653	1.870	8.294	3.257

Table 3: Soil particle size distribution after six weeks of incubation
LS = Loamy sand, SL = Sandy loam

Trmt factor	Rates	pH H_2O	pH KCl	% C	%OM	% N	Ca meq/ 100g	Mg meq/ 100g	K meq/ 100g	Na meq/ 100g	CEC meq/ 100g	% B.sat	Al meq/ 100g	H meq/ 100g	Avail P (ppm)
Dry	0	6.3	5.2	0.89	1.54	0.076	2.9	1.5	0.409	0.204	6.07	81.09	0.00	3.1	21.76
Dry	50	7.2	6.7	1.41	2.42	0.135	5.5	1.6	0.697	0.214	8.33	95.88	0.00	0.8	30.78
Dry	100	8.5	7.8	1.84	3.17	0.145	6.8	2.2	1.048	0.220	11.67	88.02	0.00	0.7	39.48
Dry	150	8.4	8.0	2.17	3.74	0.201	5.0	2.7	1.347	0.230	10.60	86.71	0.00	0.9	45.70
Fresh	0	6.3	5.2	0.89	1.54	0.076	2.9	1.5	0.409	0.204	6.07	81.09	0.00	3.1	21.76
Fresh	50	6.9	6.1	0.86	1.48	0.084	3.1	1.3	0.267	0.204	6.00	79.91	0.00	0.9	23.01
Fresh	100	6.8	6.3	0.75	1.29	0.103	3.9	1.3	0.595	0.214	6.47	89.27	0.00	0.9	27.36
Fresh	150	6.8	6.4	0.94	1.62	0.112	3.6	2.3	0.522	0.220	8.33	80.00	0.00	0.8	29.23
	Moringa	0.12	0.243	0.084	0.146	0.137	0.88	0.61	0.134	0.014	0.908	8.81	0.00	0.82	3.39
	Rate	0.17	0.344	0.119	0.207	0.193	1.25	0.87	0.189	0.020	1.284	12.45	0.00	1.16	4.79
$LSD_{0.05}$	Moringa x Rate	0.25	0.486	0.168	0.292	0.273	1.77	1.22	0.267	0.029	1.815	17.61	0.00	1.64	6.78

Table 4: Chemical properties of the soil after six weeks of incubation
Trmt = Treatment, OM = Organic matter, B.sat = Base saturation, Avail = Available

3.2. Screen-House Experiment

Figures 1 and 2 show the effects of incubated soils, treated with fresh and dry moringa leaves, on stem height and leaf area of maize. Incorporation of fresh moringa leaves at 100 g gave the tallest plants and leaf area.

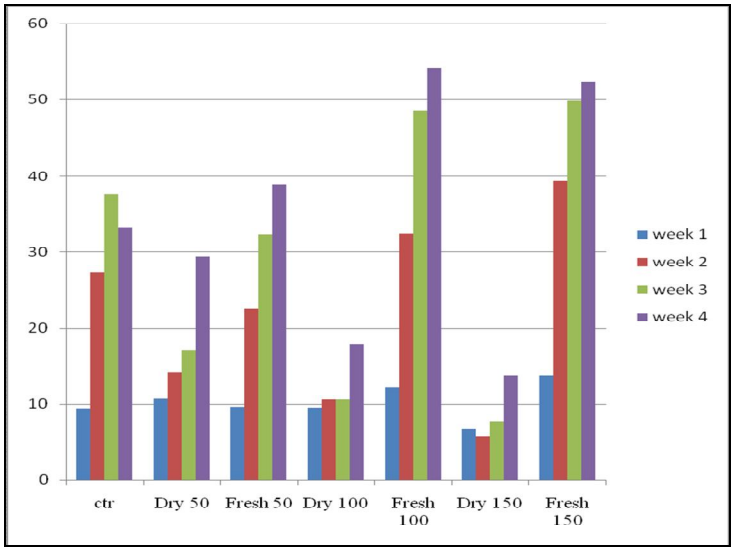

Figure 1: The effect of Moringa leaf treatments on plant height (cm) of maize (Zea mays L.) four weeks after planting.
**Ctr means Control*

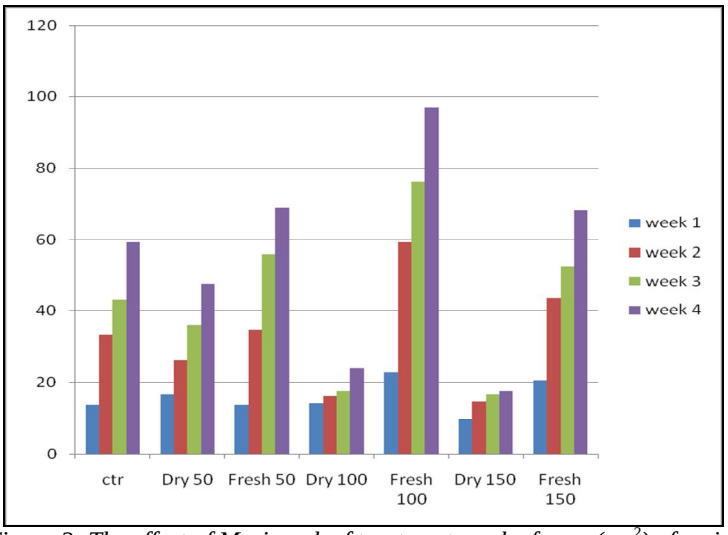

Figure 2: The effect of Moringa leaf treatments on leaf area (cm^2) of maize (Zea mays L.) four weeks after planting
**Ctr means Control*

Incorporation of moringa leaves into the soil as green manure has been found to enrich the soil and significantly increase crop growth (Fuglie, 2000 and 2005). Agboola (1985) considered organic matter to be the most active matter in the aggregation and stabilization of soil. Organic matter can hold water and thus help to prevent drying and shrinking of soil. Mbagwu (1985) reported decreased apparent density of structural aggregate from organic waste amended soil which had no significant effects on the intraporosity and particle size distribution of the aggregates. Incorporation of the municipal compost decreased the soil density. The decrease in density was attributed to the low density of the compost and the tendency to increase the pore size and volume at high dose. The study of Mbagwu (1985) showed that the decrease in bulk density obtained with rice shaving and poultry manure treated soils was directly related to organic matter content. This played a significant role in reducing the degree of compaction in the soil by forming bridges between soil particles which prevent them from packing too closely together as in a highly compacted soil.

Higher release of the nutrients in the soil media treated with dry moringa leaves could be as a result of the higher concentration of nutrients in the dry leaves per unit weight compared with the fresh leaves. The significant increase in the soil pH, organic matter, CEC, total N and available P were consistent with the previous work of Ndubuaku and Lucas (2000). Ndubuaku and Lucas (2000) also reported an increase in the rate of NO_3-N and slow release of K, Ca and Mg from cocoa and natural forest soils. Agboola (1985) noted the substantial contribution of soil organic matter to the nutrient contents of tropical soils. He obtained significant positive correlations between organic carbon and exchangeable Ca, Mg and base saturation. Most of the nutrients used by plants are held in organic matter until the soil organisms decompose the materials and release ammonium and other plant available nutrients.

The higher values of plant height and leaf area obtained with fresh leaf treatment could be as a result of adequate amount of nutrients released into the soil for optimum growth of the plant.

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