

# Nutrient Status and Ameliorating Effects of *MORINGA* Leaves or Poultry Droppings on Soil Ph and Garden Egg Yield

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## Abstract

Sustainable production of crops on tropical soils requires soil amendment to remediate soil acidity status and raise fertility level. Industrial lime and inorganic fertilizers are either not available or too expensive to buy. This study was carried out with the objective of investigating the effects of two organic manures, *Moringa* (*Moringa oleifera* Lam.) leaves and poultry droppings, on soil acidity amelioration and increased fertility for sustained production of garden egg (*Solanum aethiopicum* L.). The field trials were conducted at the Teaching and Research Farms of the University of Agriculture, Makurdi, and the Faculty of Agriculture, Cross River University of Technology, Obubra in 2009 and 2010. Two varieties of African garden egg (Gilo and Kumba) and two organic manure sources (*Moringa* leaves litter or poultry droppings) were factorially combined. The experiment was laid out in a Randomized Complete Block Design with three replications. Treatments were applied at the rates of 0, 5, 10 and 20 t ha<sup>-1</sup> *Moringa* leaves and 5, 10 and 15 t ha<sup>-1</sup> poultry droppings. The results obtained showed that all rates of the manure reduced the soil pH within 30 days after incorporation in both years and locations. At 60 days after application, and up to 140 days after incorporation, all manure rates increased the soil pH in both locations and years. The highest increase occurred with 15 t ha<sup>-1</sup> poultry droppings at 140 days after incorporation. With no manure application, there was a steady decrease in pH up to the harvest time. All manure rates significantly ( $P < 0.05$ ) increased the yield of the garden egg varieties over when no manure was used. Poultry droppings at 15 t ha<sup>-1</sup> produced the highest fruit yield in both years and locations. The crop yields were significantly ( $t < 0.05$ ) higher in Makurdi than Obubra in both years. Yield for 2010 was significantly higher than 2009 in both locations. *Moringa* leaves at 20 t ha<sup>-1</sup> or poultry dropping at the rate of 15 t ha<sup>-1</sup> may be used to remediate soil pH and improve fertility for sustainable production of garden egg in the Guinea savanna or the Rainforest agro-ecologies.

**Keywords;** Garden egg, *Moringa*, poultry droppings, soil acidity remediation

## 1. Introduction

Declining soil fertility has been identified as the fundamental cause of declining crop yields in many parts of Africa (Sanchez *et al.*, 1997). Soil acidity is a major constraint in soil fertility maintenance particularly in the humid tropics. As the soil pH declines, the supply of most plant nutrients decreases while aluminum and a few micronutrients become more soluble and toxic to plants. These problems, according to Harter (2007), are particularly acute in humid tropical regions that have been highly weathered. Sanchez and Logan (1992) had earlier observed that one-third of the tropics or 1.7 billion hectares of tropical land is acidic enough for soluble aluminum to be too toxic for most crop plants.

One of the problems of soil acidity includes the fixation of phosphorus by the oxides of Al and Fe to form complexes that are insoluble in water, making it unavailable to the plants. Aluminum, hydrogen and manganese cause root injuries, which affect the uptake of some important mineral nutrients from the soil and this consequently affect crop growth and yield (Lee *et al.*, 2007). Onyekwere *et al.* (2004) also reported that soil acidity has negative effects on bacteria population and activities, which could lead to reduced nitrogen transformation in the soil.

Liming materials and fertilizers are either not available or too expensive for subsistence farmers in the tropics. The use of liming materials from agricultural and domestic wastes has been found to improve the availability of nutrients in the soil, increase crop yields and activities of soil micro organisms due to amelioration of soil pH (Ojeniyi *et al.*, 1999; Ano and Agwu, 2005; Kekong *et al.*, 2010). Similarly, materials from agricultural and domestic wastes have been investigated for soil fertility improvement (Booth and Wickens, 1998). *Moringa* has been reported to possess wide adaptations and high nutrients composition in its biomass (Bosch, 2004) and, unlike poultry droppings, is renewable and more environmental friendly. Our objective was to evaluate the efficacy of *Moringa* leaves or poultry droppings for soil pH regulation, soil fertility maintenance and garden egg yield.

## 2. Materials and Methods

The study was carried out at the Teaching and Research Farms of the University of Agriculture, Makurdi (7° 45'

N, 8° 35' E) and Faculty of Agriculture, Cross River University of Technology, Obubra (6° 06' N, 8° 18' E). Makurdi is located within the sub humid Guinea Savanna agro ecology of Nigeria while Obubra is in the Rainforest zone. Makurdi has an annual rainfall of 1000 mm – 1250 mm while its mean annual temperature is 25.4°C. Obubra is characterized by a mean annual rainfall of 2250 mm – 2500 mm, with an annual temperature range between 25°C and 27°C.

The design of the experiment was a factorial combination of organic manure sources: *Moringa* leaves (M) or poultry droppings (P), with two varieties of garden egg: Gilo (V<sub>1</sub>) and Kumba (V<sub>2</sub>). Treatments consisted of 0, 5, 10 and 20 t ha<sup>-1</sup> M; and 5, 10 and 15 t ha<sup>-1</sup> P. Each of these was factorially combined with the two varieties of garden egg to give M<sub>0</sub>V<sub>1</sub>, M<sub>0</sub>V<sub>2</sub>, M<sub>5</sub>V<sub>1</sub>, M<sub>5</sub>V<sub>2</sub>, M<sub>10</sub>V<sub>1</sub>, M<sub>10</sub>V<sub>2</sub>, M<sub>20</sub>V<sub>1</sub>, M<sub>20</sub>V<sub>2</sub>, P<sub>5</sub>V<sub>1</sub>, P<sub>5</sub>V<sub>2</sub>, P<sub>10</sub>V<sub>1</sub>, P<sub>10</sub>V<sub>2</sub>, P<sub>15</sub>V<sub>1</sub>, and P<sub>15</sub>V<sub>2</sub>. The experiment was laid out in a Randomized Complete Block Design and replicated three times.

At the commencement of the experiment, a composite sample from ten random points was collected using a soil Auger at the 0-20cm depth for both years and locations.

Post manuring and planting soil samples were collected for each treatment and replication. Samples for each treatment were bulked for the three replications at 30, 60, 90 days after application (DAP) and at harvest (140 DAP). These samples were air-dried, sieved through a 2 mm mesh and packed in paper bags for laboratory analysis.

A net plot of inner ridges in each plot (treatment) was used with four tagged plants for fruit count per plant per harvest and fruit weight. The mean cumulative number of fruits per plant for the number of harvests was taken. The cumulative yield per net plot from first harvest to the last harvest for each plot was calculated as yield in tonnes per hectare.

The soil samples collected were subjected to routine analyses at the Soil Science Laboratory of the Federal University of Technology, Minna, Nigeria, and the Federal University of Agriculture, Makurdi, Nigeria.

Particle size distribution (PSD) was determined by the Bouyoucos (Hydrometer) method as described by Udo *et al.* (2009). Soil pH was determined in both water and KCl in a ratio of 1:1 soil: water and 1:2.5 soil: KCl (Udo *et al.*, 2009).

The Walkley – Black wet method as outlined by Page *et al.* (1982) was used to determine organic matter. Total Nitrogen was determined by the Macro Kjeldahl method as described by Udo *et al.* (2009), while available phosphorus was determined by Bray-I method as outlined by Page *et al.* (1982). Exchangeable cations were determined by the ammonium acetate extraction method as described by Udo *et al.* (2009).

Analysis of variance (ANOVA) for RCBD was performed on the garden egg yield and yield components using the computer software Genstat, (Genstat, 2005). F-LSD was calculated at the probability levels of P < 0.05 and P < 0.01 to separate the means. T-test was used to determine the location and year effect on crop yield (Gomez and Gomez, 1984).

### 3. Results

Results of initial soil properties before application of treatments in the two locations and manure analyses are presented in Tables 1 and 2. The soils at both locations were sandy-loam, low in organic matter (OM), N, P, exchangeable cation and CEC. The CEC and OM were, however, relatively higher in Makurdi than Obubra. The soils were slightly acidic in Makurdi and moderately acidic in Obubra with a higher exchangeable acidity in Obubra than Makurdi. The *Moringa* leaves showed higher concentration of N, K, Ca and organic carbon than poultry manure in both locations and a higher concentration of P and M in poultry droppings than *Moringa* leaves.

Changes in soil pH presented in Tables 3 and 4 showed that application of *Moringa* leaves and poultry droppings increased the pH of the soils at all the manure rates especially at the higher rates from 60 days after incorporation. At 30 days after application, there was a slight decrease in the soil pH in all treatments, including the control. The control showed a steady decline in soil pH from 30 days and up to 140 days after incorporation of the manures in the two locations and in the two years. From 60 days after incorporation of the *Moringa* leaves and poultry droppings, there was an increase in the soil pH up to 90 days. There was no further increase beyond 90 days after the manures application. The highest increase in soil pH was observed in poultry droppings at 15 t ha<sup>-1</sup>. Soils that received 20 t ha<sup>-1</sup> *Moringa* leaves followed this increase in soil pH after poultry droppings at 15 t ha<sup>-1</sup>. The least increase was observed in the manure rates of 5 t ha<sup>-1</sup>, either in *Moringa* leaves or poultry droppings, in both locations and in both years.

Results showing plant dry matter and number of fruits per plant as affected by the different manure sources are presented in Tables 5. In both the years, application of poultry dropping at 15 t ha<sup>-1</sup> or *Moringa* leaves at 20 t ha<sup>-1</sup> produced the highest amount of plant dry matter in each location. The lowest yields were obtained when no manures were used. There was no significant difference in dry matter yield between Gilo and Kumba varieties of the crop in Makurdi or in Obubra within each year. The number of fruits per plant followed the same trend as that of plant dry matter in both the years and locations. Across nutrient sources, Gilo variety of

garden egg significantly produced higher number of fruits per plant than Kumba in both the years.

At each treatment level, there was no significant difference in fruit yield between the two varieties of garden egg in 2009 or 2010 (Table 6). Across varieties, the highest amount of fruit yield was obtained at the highest amount of *Moringa* leaves used in each of the years. However, the highest amount of fruit with poultry dropping was obtained at 10 t ha<sup>-1</sup>, both in 2009 and 2010. All the yield differences were significant. The lowest yield in each variety was obtained when no manures were used. Across nutrient sources, Gilo variety of garden egg produced higher fruit yield than Kumba in both years and locations.. However, fruit yield difference between the two varieties in 2010 was not significant in Makurdi.

Results of year and location effects of *Moringa* leaves biomass and poultry droppings on the yield of garden egg are presented in Tables 7. Application of *Moringa* leaves or poultry droppings produced fruit yields that were significantly higher ( $t < 0.05$ ) in 2010 than in 2009 at all treatment levels and locations. Within the same year, fruit yields were significantly higher in Makurdi than Obubra at all the treatment levels.

#### 4. Discussion

The consistent increases in soil pH with increasing rates of poultry droppings as observed in this study agreed with the earlier findings by Ojeniyi *et al.* (1999), Ano and Agwu (2005) and Kekong *et al.* (2010). Akanbi and Ojeniyi (2007), with Chromolaena leaves and Ogeh (2010) with almond leaves residue, reported similar results on the increase in soil pH due to incorporation of a plant source of manure, as observed with *Moringa* leaves in this study.

The mechanism responsible for this increase in soil pH was probably due to ion exchange reactions which occur when terminal OH<sup>-</sup> of Al<sup>3+</sup> and Fe<sup>2+</sup> hydroxyl oxides are replaced by organic anions which are products of decomposition of organic manures as suggested by Bell and Besho (1993). The ability of organic manure to increase soil pH can be attributed to the enrichment of the soil through mineralization of cations particularly Ca. Natschner and Schwartzman (1991) reported that such basic cations are released upon microbial decarboxylation. Narambuye and Haynes (2006) reported that the short-term effects of manure in reducing potentially toxic Al<sup>3+</sup> solution are attributed to both increase in pH and a complexing effects by soluble organic matter. The decrease in soil pH within the first 30 days was similar to the observations of Haynes and Mokolobate (2001). They opined that this initial decrease in soil pH with organic manure application was due to the buffering reserves of acidity in soils and nitrification of accumulated N. Similarly, Narambuye and Haynes (2006) noted that in the early stages of degradation, microbial processes of decarboxylation of organic acid anions during manure decomposition are unlikely to contribute to elevated pH.

The significant increase in yield and yield components of garden egg varieties is a manifestation of the positive effect of organic manures on soil properties that transformed into soil fertility and a confirmation of the high mineralizable nutrient composition of *Moringa* and poultry manures. This high mineralizable composition of organic manures have earlier been reported by Warman (1986), Bahmann and James (1997) and Duncan (2005). The yield response of the crop varieties due to these organic manure sources agreed with the assertions by Isitekhale and Osemota (2010) that organic manures are important short-term suppliers of nutrients as well as for long-term maintenance of soil organic matter. This yield response showed that the higher the pH above 5 in the soil, the higher the yield of garden egg. Ojeniyi *et al.* (1999) have earlier identified soil pH as one of the most important indicators of soil fertility in the tropics. Sanchez and Logan (1992) who stated that the level of pH, especially in tropical soils, is an essential determinant of its fertility corroborated the yield response of garden egg to increased pH levels above 5 and up to 6.7. The yield increase of Gilo garden egg due to poultry dropping was also reported by Kekong *et al.* (2010). The yield increase of garden egg varieties due to *Moringa* leaves manure agrees with the findings of Booth and Wickens (1988) who noted that the high protein biomass of *Moringa oleifera* was suited for use as natural fertilizer. Davis (2000) reported that the use of *Moringa* as a green manure significantly improved soil fertility.

The higher yield of Gilo variety over Kumba may be attributed to the genotypic characteristics of the crop. Sanginga *et al.* (2000) have reported this yield differences among crop varieties. They observed that some crop genotypes tend to have greater need for nutrients and are often more responsive to nutrient input.

The higher yield of garden egg varieties in Makurdi (Southern Guinea Savanna) than Obubra (Rainforest) could be attributed to soil properties and climatic variations. Chude (1998) reported that Cross River State soils in the Rainforest zone have low P and exchangeable cations, which are higher in the Nigerian Savanna and this has been confirmed in our current studies.

#### 5. Conclusion

The manurial and organic matter enrichment potentials of *Moringa oleifera* and poultry droppings and their positive effects on soil pH investigated in this study were found to be efficient in increasing soil pH and maintaining soil fertility for sustainable garden egg production. Application of these manures especially, the higher rates increased soil pH level and significantly increased garden egg yield, over the control. Poultry

droppings ( $15 \text{ t ha}^{-1}$ ) or *Moringa* leaves ( $20 \text{ t ha}^{-1}$ ) as alternatives are good sources of soil organic matter and Ca. These have facilitating effects on soil pH and plant nutrients release for optimum production of garden egg in the Nigerian Guinea Savanna and Rainforest agro-ecological zones. Additionally, production of *Moringa* for green manure is more environmental friendly and, even in the hands of the illiterate peasant farmers, is not detrimental to the environment.

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Table 1: Pre-cropping soil physical and chemical properties at the experimental sites in 2009 and 2010.

Soil parameters	Makurdi		Obubra	
	2009	2010	2009	2010
Sand (g/kg)	874	888	853	839
Silt (g/kg)	84	79	79	72
Clay (g/kg)	42	43	68	89
Texture class	S/L	S/L	S/L	S/L
pH (water)	6.16	6.20	5.50	5.48
pH (KCL)	5.00	4.80	4.30	4.20
Organic matter (%)	2.80	2.76	1.82	1.94
Total nitrogen (g/kg)	1.0	0.9	0.8	0.8
Available P (M/kg)	5.5	4.6	3.6	3.4
Exch. Ca (cmol kg <sup>-1</sup> )	3.40	3.10	2.50	2.61
Exchange. M (cmol kg <sup>-1</sup> )	0.30	0.28	0.22	0.24
Exchange. M (cmol kg <sup>-1</sup> )	0.92	0.98	1.01	1.08
Exchange Na (cmol kg <sup>-1</sup> )	0.16	0.15	0.17	0.18
Exchange. Acidity	2.30	2.25	2.75	2.85
CEC (cmol kg <sup>-1</sup> )	2.3	2.2	1.7	1.8

S/L = sandy loam

Table 2: Nutrient composition of Moringa leaves and poultry droppings at Makurdi and Obubra in 2009 and 2010

Manure source	N (%)	P (%)	K (%)	Ca (%)	M (%)	Na (%)	Org. C (%)	C:N
Makurdi								
Moringa leaves	4.10	1.21	1.71	13.6	0.12	2.19	10.8	2.6
Poultry manure	1.80	2.4	3.2	6.2	1.96	0.10	7.9	4.4
Obubra								
Moringa leaves	4.02	1.18	1.80	12.4	0.11	1.16	11.1	2.8
Poultry manure	1.72	2.2	2.55	7.0	1.13	0.11	8.2	4.8

Table 3: Effects of different organic manure source, variety and days after application on soil pH at Makurdi and Obubra in 2009

Treatment	Makurdi				Obubra			
	Days after application of manure							
	30	60	90	140	30	60	90	140
M <sub>0</sub> V <sub>1</sub>	5.95	5.90	6.01	6.00	5.41	5.42	5.31	5.31
M <sub>0</sub> V <sub>2</sub>	6.00	6.01	6.00	6.01	5.42	5.32	5.31	5.30
M <sub>5</sub> V <sub>1</sub>	6.05	6.21	6.20	6.20	5.40	5.95	5.98	5.99
M <sub>5</sub> V <sub>2</sub>	6.08	6.20	6.21	6.20	5.39	5.98	5.97	5.98
M <sub>10</sub> V <sub>1</sub>	6.00	6.20	6.21	6.21	5.38	5.98	6.03	6.03
M <sub>10</sub> V <sub>2</sub>	5.98	6.22	6.23	6.23	5.39	6.00	6.04	6.04
M <sub>20</sub> V <sub>1</sub>	5.90	6.23	6.24	6.24	5.18	6.10	6.12	6.12
M <sub>20</sub> V <sub>2</sub>	5.99	6.23	6.24	6.23	5.18	5.95	6.10	6.10
P <sub>5</sub> V <sub>1</sub>	6.0	6.22	6.21	6.22	5.25	6.00	6.00	6.01
P <sub>5</sub> V <sub>2</sub>	6.0	6.23	6.23	6.22	5.26	6.01	6.01	6.01
P <sub>10</sub> V <sub>1</sub>	6.0	6.30	6.30	6.32	5.15	6.00	6.09	6.09
P <sub>10</sub> V <sub>2</sub>	5.98	6.30	6.11	6.22	5.06	5.95	6.08	6.08
P <sub>15</sub> V <sub>1</sub>	5.97	6.24	6.25	6.35	5.04	6.06	6.17	6.17
P <sub>15</sub> V <sub>2</sub>	5.99	6.24	6.35	6.35	5.05	6.05	6.16	6.17

M<sub>0</sub> – M<sub>20</sub> = *Moringa* leaves rates at 0, 5, 10 and 20 t ha<sup>-1</sup>; P<sub>5</sub> – P<sub>15</sub> = Poultry droppings rates at 5, 10 and 15 t ha<sup>-1</sup>; V<sub>1</sub>=Gilo, V<sub>2</sub>=Kumba

Table 4: Effects of different organic manure source, variety and days after application on soil pH at Makurdi and Obubra in 2010

Treatment	Makurdi				Obubra			
	Days after application of manure							
	30	60	90	140	30	60	90	140
M <sub>0</sub> V <sub>1</sub>	6.01	5.95	5.94	5.95	5.11	5.10	5.10	5.09
M <sub>0</sub> V <sub>2</sub>	6.08	5.95	5.94	5.94	5.15	5.11	5.11	5.10
M <sub>1</sub> V <sub>1</sub>	6.01	6.25	6.50	6.51	5.14	5.60	5.61	5.61
M <sub>1</sub> V <sub>2</sub>	6.00	6.25	6.53	6.53	5.13	5.61	5.60	5.61
M <sub>2</sub> V <sub>1</sub>	6.01	6.22	6.60	6.61	5.11	5.64	5.95	5.64
M <sub>2</sub> V <sub>2</sub>	5.96	6.25	6.59	6.60	5.11	5.64	5.95	5.64
M <sub>3</sub> V <sub>1</sub>	5.91	6.23	6.64	6.65	5.11	5.9	6.00	6.01
M <sub>3</sub> V <sub>2</sub>	5.90	6.24	6.63	6.63	5.10	5.9	6.00	6.01
P <sub>1</sub> V <sub>1</sub>	5.91	6.30	6.58	6.50	5.29	5.61	5.60	5.61
P <sub>1</sub> V <sub>2</sub>	6.04	6.30	6.60	6.60	5.30	5.59	5.60	5.61
P <sub>2</sub> V <sub>1</sub>	6.01	6.41	6.58	6.58	5.25	5.90	6.00	6.00
P <sub>5</sub> V <sub>2</sub>	6.00	6.40	6.68	6.60	5.27	5.80	5.95	5.97
P <sub>3</sub> V <sub>1</sub>	5.98	6.31	6.70	6.71	5.25	6.60	6.10	6.10
P <sub>3</sub> V <sub>2</sub>	6.04	6.40	6.71	6.70	5.28	6.00	6.11	6.00

M<sub>0</sub> – M<sub>20</sub> = *Moringa* leaves rates at 0, 5, 10 and 20 t ha<sup>-1</sup>; P<sub>5</sub> – P<sub>15</sub> = Poultry droppings rates at 5, 10 and 15 t ha<sup>-1</sup>; V<sub>1</sub>=Gilo, V<sub>2</sub>=Kumba

Table 5: Plant dry matter and number of fruits per plant of two varieties of garden egg as affected by rates of application of *Moringa* leaves or poultry droppings at Makurdi and Obubra in 2009 and 2010

Treatment	Plant dry matter (kg/ha <sup>-1</sup> )				Number of fruits per plant			
	2009		2010		2009		2010	
	Makurdi	Obubra	Makurdi	Obubra	Makurdi	Obubra	Makurdi	Obubra
Control	58.5	58.3	58.0	55.5	11.2	8.50	26.5	25.0
M <sub>1</sub>	122.8	118.5	146.5	141.3	31.6	26.50	50.5	49.5
M <sub>2</sub>	190.0	183.8	208.7	203.0	37.3	30.17	70.2	59.5
M <sub>3</sub>	205.8	197.5	233.5	229.0	51.0	40.67	76.3	68.2
P <sub>1</sub>	126.5	134.7	142.0	131.3	41.33	37.17	49.5	44.83
P <sub>2</sub>	186.2	172.3	233.0	182.2	52.83	47.17	70.3	61.50
P <sub>3</sub>	200.3	199.8	257.0	246.8	64.50	57.67	84.8	73.33
LSD (P<0.05)	9.16	18.23	18.44	14.10	5.0	3.18	10.90	5.25
V <sub>1</sub>	148.9	145.5	175.5	162.1	52.4	44.67	81.8	74.3
V <sub>2</sub>	146.7	139.1	179.6	173.6	28.0	24.00	31.9	29.2
LSD(P<0.05)	NS	NS	NS	NS	2.26	1.42	4.88	2.35

NS = not significant; M<sub>0</sub> – M<sub>20</sub> = *Moringa* leaves rates at 0, 5, 10 and 20 t ha<sup>-1</sup>; P<sub>5</sub> – P<sub>15</sub> = poultry droppings rates at 5, 10 and 15 t ha<sup>-1</sup>; V<sub>1</sub>=Gilo, V<sub>2</sub>=Kumba

Table 6: Fruit yield of two varieties of garden egg as influenced by rates of application of *Moringa* leaves or poultry droppings at Makurdi and Obubra in 2009 and 2010

Treatment	Fruit yield (t ha <sup>-1</sup> )			
	2009		2010	
	Makurdi	Obubra	Makurdi	Obubra
Control	1.18	0.92	3.32	2.97
M <sub>5</sub>	2.42	2.78	7.88	6.73
M <sub>10</sub>	5.47	5.77	10.42	8.30
M <sub>20</sub>	7.22	6.68	10.37	9.17
P <sub>5</sub>	4.40	4.03	7.97	6.15
P <sub>10</sub>	9.18	8.65	11.87	10.13
P <sub>15</sub>	7.28	6.62	10.02	8.10
LSD (P<0.05)	0.47	0.67	1.31	0.77
V <sub>1</sub>	5.89	5.39	8.53	7.66
V <sub>2</sub>	4.67	4.65	8.30	6.79
LSD(P<0.05)	0.21	0.31	NS	0.34

NS = not significant; M<sub>0</sub> – M<sub>20</sub> = *Moringa* Leaves rates at 0, 5, 10 and 20 t ha<sup>-1</sup>; V<sub>1</sub>=Gilo, V<sub>2</sub>=Kumba

**Table 7: Location and year effects on fruit yield of two varieties of garden egg as affected by rates of application of *Moringa* leaves or poultry droppings at Makurdi and Obubra in 2009 and 2010**

Treatment	Fruit yield (t ha <sup>-1</sup> )							
	2009		2010		Makurdi		Obubra	
	Makurdi	Obubra	Makurdi	Obubra	2009	2010	2009	2010
M <sub>0</sub> V <sub>1</sub>	1.17	1.00	3.10	2.93	3.10	1.47	2.93	1.00
M <sub>0</sub> V <sub>2</sub>	0.90	0.03	3.53	3.00	3.53	0.90	3.00	0.83
M <sub>5</sub> V <sub>1</sub>	2.81	3.30	7.33	6.87	7.33	2.80	6.87	3.30
M <sub>5</sub> V <sub>2</sub>	2.03	2.27	8.43	6.89	8.43	2.03	6.60	2.27
M <sub>10</sub> V <sub>1</sub>	6.40	6.67	10.17	8.47	10.17	6.40	8.47	6.67
M <sub>10</sub> V <sub>2</sub>	4.53	4.87	10.67	8.13	10.67	4.53	8.13	4.87
M <sub>20</sub> V <sub>1</sub>	7.97	4.20	11.00	9.63	11.00	7.97	9.63	7.20
M <sub>20</sub> V <sub>2</sub>	6.47	6.17	9.73	8.70	9.73	6.47	8.70	6.17
P <sub>5</sub> V <sub>1</sub>	4.87	4.37	6.97	6.67	6.97	4.87	6.67	4.37
P <sub>5</sub> V <sub>2</sub>	3.93	3.70	8.97	5.63	8.97	3.93	5.67	4.37
P <sub>10</sub> V <sub>1</sub>	7.73	6.93	10.00	8.60	10.00	7.73	8.60	6.93
P <sub>10</sub> V <sub>2</sub>	6.83	6.30	10.03	7.60	10.03	6.83	7.60	6.30
P <sub>15</sub> V <sub>1</sub>	9.87	9.17	12.33	10.63	12.33	9.87	10.67	9.17
P <sub>15</sub> V <sub>2</sub>	8.50	8.13	11.40	9.60	11.40	8.50	9.60	8.13
$\bar{X}$	5.28	5.05	8.42	7.23	8.42	5.28	7.23	5.04
SE±	0.069		0.177		0.35		0.14	

M<sub>0</sub> – M<sub>20</sub> = *Moringa* leaves rates at 0, 5, 10 and 20 t ha<sup>-1</sup>; P<sub>5</sub> – P<sub>15</sub> = Poultry droppings rates at 5, 10 and 15 t ha<sup>-1</sup>; V<sub>1</sub>=Gilo, V<sub>2</sub>=Kumba



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