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Effects of rates and frequency of application of organic manure on growth, yield and biochemical composition of *Solanum melongena* L. (cv. 'Ngwa local') fruits

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1 SUMMARY

Objective: *Solanum melongena* is a biennial plant. The growth and yield of the crop is in most cases hampered by inadequate and untimely supply of nutrients to replenish the lost ones due to continuous picking of fruits. Hence, studies were carried out to ascertain the optimal rate of organic manure and the frequency of its application on the growth, yield, and some vitamins and mineral composition of the fruits of *S. melongena* L.

Methodology and results: Four rates of organic manure (0, 10, 20, and 30 t ha^{-1}) were applied at three varying frequencies namely: single, split, and split-split. The study was a 3 X 4 factorial laid out in a randomized complete block design (RCBD) with three replications. Data were collected on the growth, yield, some vitamins and minerals attributes of the crop. Days to flowering, plant height, number of trusses per plant, and number of leaves per plant increased with increase in rate of organic manure. At maturity, 30 t ha^{-1} of organic manure gave the highest mean value on number of leaves per plant, and plant height which was statistically similar to the values obtained in plants that received 20 t ha^{-1}. Increase in rates of organic manure increased the individual fruit weight of the harvested fruits, which declined as the harvest progressed. Split-split method of organic manure application increased the individual fruit weight over the split, and single dose applications, respectively. The application of 30 t ha^{-1} of organic manure gave a significantly higher number and weight of fruits from the second month of harvest (July) to the last month (October). Single and split-split application of organic manure gave a significantly higher number and weight of fruits in the months of June, July and September, October, respectively. The application of 30 t ha^{-1} as single dose and split doses gave a significantly (p=0.05) higher levels of vitamins B_1 (6.57mg) and B_2 (7.89mg), respectively, than other rates.

Conclusion and application of finding: Split-split application of 20 t ha^{-1} of organic manure is recommended to reduce cost of production since there was no significant (p=0.05) difference between the rate and frequency from higher rate of 30 t ha^{-1} at all the frequencies.

2 INTRODUCTION

Solanum melongena L. also known as Eggplant, Garden egg, Brinjal, and 'Anara' belongs to the family of Solanaceae, and genus Solanum. The plant is a short-lived biennial herb branching in habit with a height of 0.5 to 1.5m. *Ngwa local* (an Eggplant) is a fruit vegetable because the leaves are not consumed. The green fruits are consumed fresh and served to visitors as cola in 'homes' and the red fully matured fruits are used to make stews (Agbo and Nwosu, 2009). Eggplant supplements starchy foods in addition to being good source of protein, minerals and

vitamins (Lombin *et al.*, 1988; Zenia *et al.*, 2008). *S. melongena* fruit aids in lowering blood cholesterol levels, and in regulating high blood pressure (Chevallier, 1996). As a biennial crop, Eggplant will require high quantity of nutrients to sustain its growth. These nutrients can easily be made available through the use of inorganic fertilizers but there are problems associated with its use which include: leaching, soil degradation, underground water pollution, fast release of nutrients. Organic manure application is known to supply plant nutrients and improve the soil structure. It has been reported that application of organic manure showed a significant (p=0.05) increase in yield than inorganic manure in eggplant production (Ullah *et al.,* 2008; Anoop and Chauban, 2009). The use of organic manure as fertilizer is essential in improving soil productivity and crop production (Dikinya and Mufwanzala, 2010). The rate of organic manure application has been shown to influence growth and yield of plants (Offiong *et al.*, 2010). Application of organic manure beyond the critical threshold of the soil on the other hand, may cause potential damage to the crop in form of reduced fruit yield due to higher vegetative growth (Dikinya and Mufwanzala, 2010). Nutrient requirement of crops differ, therefore, research towards identification of the preferred nutrient requirements of each crop is vital. *S. melongena* L. cv. 'Ngwa local' fruit is increasing in demand as an important vegetable crop in Nigeria and limited information is available on its manure requirements for optimal nutrient uptake, fruit quality and crop yield. Fruit yield is significantly lowered after six weeks of first harvest. The reduction in yield of *S. melongena* is mainly attributed to inadequate and untimely supply of nutrients to replenish the lost ones due to continuous picking of fruits. Hence, the objectives of this study were to determine the optimal rate of organic manure and the frequency of its application on the growth, yield and some vitamins and mineral composition of the fruit of *Solanum melongena* L. cv. 'Ngwa local'.

3 MATERIALS AND METHODS

The field experiment was conducted at the Research Farm of the Department of Crop Science, University of Nigeria, Nsukka during the 2009 growing season. Nsukka is in the derived Savanna Agro-ecology (06^0 52' N, 07^0 24' E and 447 m altitude). Rainfall is bimodal with an annual total of about 1500 mm.

3.1 Medium preparation and transplanting: The soil used to grow the crop was collected from a four years old fallowed land in the Department of Crop Science research farm within the top 15 cm depth. The soil was used to fill black polyethylene bags measuring 12 cm X 24 cm X 15 cm with perforations at the base to three quarter full and spaced at 80 cm X 60 cm and arranged in a completely randomized design with three replications. Six weeks old seedlings of 'Ngwa local' were transplanted into the prepared soil in each polyethylene bag. All the agronomic practices required for *Solanum melongena* production were ensured except for manure rate and the frequency of its application.

3.2 Treatments: Four rates of organic manure (0, 10, 20, and 30 t ha^{-1}) were applied at three varying frequencies namely: single; split, and split-split. The source of the organic manure was well decomposed Pig dung applied at two monthly intervals (April, June, and August) after transplanting for the varying frequencies of applications.

3.3 Measurements: Data were collected on nine plants per replication to determine days to flowering, plant height, plant girth, number of leaves per plant, branches per plant, trusses per plant, flowers per truss, fruits per truss, fruits per plant, and fruit yield at vegetative, flowering, and reproductive stages. Plant height was measured with a calibrated rule from the base to the apex. Plant girth was determined using venier calipers at 5cm above the soil surface. Fruit yield was determined by recording the number and weight of harvested fruits in each of the nine sampling plants using sensitive weighing balance. Picking of fruits started on 1st June, 2009 and ended on 30th October, of the same year.

3.4 Vitamins and minerals: Determination of Vitamin A was according to Jakutowicz *et al.* (1977) procedure. Two grams of the sample was weighed into a 100 ml beaker, 6 ml of absolute ethanol was added to precipitate the vitamins, and then 10 ml of heptane was added to extract the carotenes and was shake vigorously for 5 minutes and allowed to settle for 30 minutes. Furthermore, 3 ml of the heptane layer was transferred into a spectrophotometric cuvette. The standard curve and the blank were prepared. The absorbance was read at 450 nm. The concentration of vitamin A was calculated using the formula:

$$Concentration\ of\ Vitamin\ A = \frac{Abs\ of\ test\ sample}{Abs\ of\ Std} X \frac{concentration}{wt\ used}$$

Where Abs = Absorbance
Std = Standard
Wt = Weight of sample used.

Determination of Vitamin E was according to Jakutowicz *et al.* (1977) procedure. Two grams of the sample was weighed into a 100 ml beaker, 6 ml of absolute ethanol was added to precipitate the vitamins, and then 10 ml of heptane was added to extract the carotenes and was shake vigorously for 5 minutes and allowed to settle for at least 30 minutes. Also, 5 ml of the heptane layer was transferred into a test tube and 5 ml of 5 % 4,7-diphenyl, 10-phenal thralin was added and allowed to stand for 10 minutes for colour development and the absorbance taken at 534 nm. The standard curve and the blank were prepared and the concentration of vitamin E was calculated using the formula:

$$Concentration\ of\ Vitamin\ E = \frac{concentration\ of\ test\ sample}{Abs\ of\ Std} X \frac{concentration}{wt\ of\ sample}$$

One gram of the sample was weighed into 100 ml beaker to determine the Vitamin B_2, (Onwuka 2005) and 50 ml of 0.2 HCL was added and boiled for 60 minutes, cooled and adjusted to 6.0 pH using sodium hydroxide (NaOH). The pH was lowered to 4.5 with a one normal hydrochloric acid (1 NHCL) before filtering into 100 ml flask for mark up. 10 ml of filtrate was added into two tubes with 1ml of acetic acid; 0.5 ml of 3 % Potassium tetraoxomanganate VII ($KMnO_4$) solution was added and allowed to stay for 2 minutes before adding 0.5 ml of 3 % hydrogen peroxide (H_2O_2), and mixing. The absorbance was read at 470 nm wavelength. The standard curve and the blank were prepared and the concentration of vitamin B_2 was calculated using the formula:

$$Riboflavin\ mg/g = \frac{x}{y} X \frac{1}{w}$$

where: W = weight of sample used
X = reading of sample – reading of blank
Y = reading of standard – reading of blank.

Determination of vitamin $B_1$was according to Pearson (1976), 70 mls of 0.1 m HCl was added to one gram of the sample and boiled for 30 minutes in a boiling bath with frequent mixing. The extract was cooled to below 50^0 C and the pH adjusted between 4 and 4.5 by addition of 2.5 m of sodium acetate solution using bromocresol green as external indicator. 5 mls of freshly prepared phosphatase mix was added and incubated at 45-50^0 C for 3 hours, then cooled to room temperature. The mixture was centrifuged to obtain clear supernatant liquid and quantitatively transferred to 100 ml volumetric flask, then diluted to 100 ml with water. 5 ml of 3 % acetic acid was added before transferring 25 ml of the extract into a flask where 10 ml of almost boiling KCl solution, 5 ml of alkaline potassium ferric amid solution, 25 ml of water saturated isobutyl alcohol and 5 ml of 15 % NaOH were added. The standard was prepared and the absorbance taken at 245 nm.

$$Thamine\ mg/g = \frac{x}{y} X \frac{1}{w}$$

where: W = weight of sample used
X = reading of sample – reading of blank
Y = reading of standard – reading of blank.

Sodium and potassium was determined using flame photometer. The standard curve and the blank were prepare and the absorbance taken at 589 nm and 767 nm for sodium and potassium, respectively.

$$\% = \frac{PPM\ x\ 100\ x\ DF}{1\ million}$$

3.5 Experimental design and statistical analysis: The experiment was factorial in randomized complete block design (RCBD) with three replications. The two factors were: frequency of organic manure application (3 levels), and rates of organic manure (4 levels). A total of twelve (12) treatment combinations were obtained. Fruit samples for laboratory analysis were taken as they were laid out in the field into the laboratory and

analyzed as such. Data collected on growth parameters, yield and some vitamins and minerals were subjected to analysis of variance following factorial in RCBD format using GenStat discovery edition 3. Fisher's least significant difference (F-LSD) was used for mean comparisons among frequency of application and rates of organic manure when the F-test for the effects was significant (P=0.05).

RESULTS

The chemical composition of the organic manure (Table 1) showed that it contained organic matter, nitrogen, potassium, phosphorus among other elements at high levels.

Table 1: Chemical Composition of the Pig Manure

Chemicals	Composition (%)
Carbon	12.47
Organic matter	21.5
Nitrogen	0.981
Potassium	0.72
Phosphorus (ppm)	86.61
Calcium	12.8
Magnesium	12.8
Sodium	0.29

At flowering stage, days to 50 % flowering, plant height, number of trusses per plant, and number of leaves increased with increase in rate of organic manure (Table 2). There was an increase in days to 50 % flowering and decline in plant height with increase in rate and frequency of application. Single dose application, gave a significantly (p=0.05) higher number of leaves, and plant girth than other doses at the flowering stage.

Table 2: Main Effects of Rate and Frequency of Manure Application on Growth Parameters of *Solanum melongena* at flowering stage.

Rate of Manure (t ha^{-1})	Days to 50% flowering	Plant Height (cm)	No of Branches/ Plant	Plant Girth (mm)	No of trusses/ plant	No of Leaves/plant	No of Flowers /truss
0	34.89	54.80	4.92	8.91	9.50	26.40	2.29
10	35.22	60.60	4.98	9.19	13.59	33.20	2.29
20	35.67	65.40	6.92	9.70	17.78	37.60	2.51
30	37.22	67.80	5.89	9.67	18.62	42.90	2.60
LSD (P=.05)	n.s	9.41	1.36	n.s	5.57	9.78	n.s
Frequency							
Single	34.08	66.10	5.45	10.37	17.85	42.00	2.44
Split	36.42	61.80	5.17	8.87	15.06	29.90	2.33
Split-split	36.75	58.50	6.28	8.87	11.71	33.30	2.50
LSD (P=.05)	n.s	n.s	n.s	0.86	4.82	8.47	n.s

n.s= non-significant

Higher rate of manure (30 and 20 t ha^{-1}) and single and split applications gave a significantly ($p<0.05$) higher number of trusses/plant at flowering stage than other rates and split-split application. At the beginning of fruit harvest (maturity), higher manure rate of 30 t ha^{-1} gave a significantly ($p<0.05$) higher plant height, girth and number of leaves/plant than 0 and 10 t ha^{-1} rate (Table 3). Split-split application gave a significantly ($p<0.05$) higher number of leaves/plant.

Table 3: Main Effects of Rate and Frequency of Manure Application on Growth Parameters of *Solanum melongena* at Maturity Stage (Beginning of fruit Harvest)

Rates of Manure (t ha^{-1})	Plant Height (cm)	Number of Branches/plant	Plant Girth (mm)	Number of Leaves/plant
0	83.10	24.04	10.50	60.40
10	92.20	24.64	11.01	100.30
20	101.80	27.32	11.93	108.30
30	108.40	27.57	11.76	115.70
LSD(p=.05)	11.74	n.s	0.99	11.92
Frequency				
Single	94.90	21.13	10.09	86.50
Split	97.90	25.42	10.93	104.60
Split-split	101.60	28.13	11.08	187.90
LSD (P=.05)	n.s	n.s	n.s	21.60

n.s = non-significant

The application of 30 t ha^{-1} of organic manure gave a significantly ($p<0.05$) higher number and weight of fruits from the second month of harvest (July) to the last month (October) (Table 4). Single and split-split application of organic manure gave significantly higher number and weight of fruits in the months of June, July and September, October, respectively. The control (0 t ha-1) was significantly ($p<0.05$) lower within the months under comparison.

Table 4: Main Effects of Rate and Frequency of Manure Application on number and weight of fruits Harvested for Five months

Rates of Manure (t ha^{-1})	June		July		August		September		October	
	Fruit number ha^{-1}	Wt. of fruits(t ha^{-1})	Fruit number ha^{-1}	Wt. of fruits (t ha^{-1})	Fruit number ha^{-1}	Wt. of fruits (t ha^{-1})	Fruit number ha^{-1}	Wt. of fruits (t ha^{-1})	Fruit number ha^{-1}	Wt. of fruits (t ha^{-1})
0	120,417	5.21	192,667	6.25	416,667	2.71	770,833	16.86	756,250	11.46
10	250,000	10.00	400,000	12.00	608,333	20.00	1,204,166			20.21
20	256,875	10.21	411,000	12.25	841,667	26.46	1,254,166	35.42	1,166,666	25.63
30	252,292	9.79	416,281	12.50	962,500	27.92	1,639,583	42.92	1,816,666	54.17
LSD(p=.05)	188.3	0.6	208.3	0.6	188.3	0.7	288.3	2.4	298.4	2.6
Frequency										
Single	260,417	10.42	416,667	12.50	393,750	12.08	1,102,083	31.04	958,333	18.54
Split	239,583	9.58	383,333	11.50	827,083	24.37	1,433,333	40.42	1,262,500	27.08
split-split	161,667	6.46	258,667	7.75	756,250	25.83	1,677,083	61.04	1,791,666	52.92
LSD(p=.05)	199.8	5.2	309.8	9.5	279.8	8.6	289.8	0.6	299.4	6.0

Wt. = weight, t ha^{-1} = tons per hectare

At the onset of harvest (June), crops treated with 30 t ha^{-1} of organic manure had larger single fruits weighing 160 g while the crops without manure application weighed 40 (g) (Fig. 1). There was a progressive decline in the individual fruit weight of all the rates of manure over the months except in August, where there was a slight increase in 10, 20, and 30 t ha^{-1} of organic manure applied. Also, the individual fruit weight declined with reduction in the rates of organic manure applied. The three

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frequencies of manure application gave equal size of fruit weight (40 g) at the onset of harvest (Fig. 2).

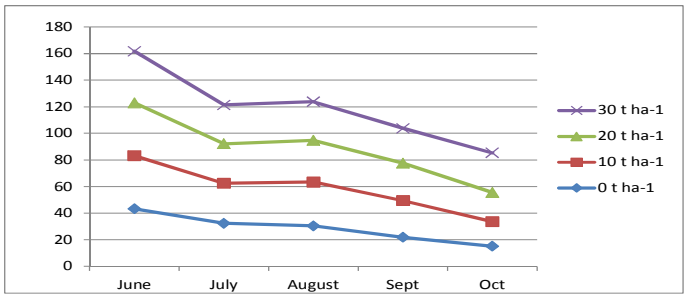

Figure 1: Influence of rates of manure on individual fruit weight (g) harvested over five months

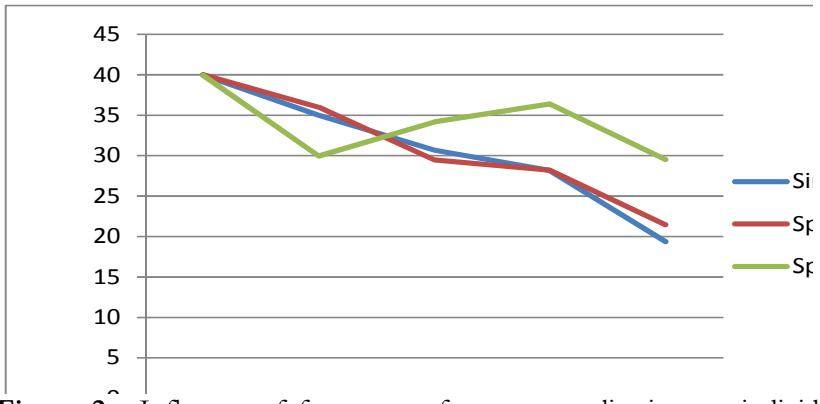

Figure 2: Influence of frequency of manure application on individual fruit weight harvested over five months.

However, towards the end of June and early part of the month of July, the sizes of fruits from split- split method reduced to 30 g while the other two were at 35 g. The effect of second application of manure in June on split-split plots resulted in increased fruit sizes from the end of July up to the month of September before there was a slow decline from 36 g to 29 g in October while the split and single dose plots stood at 22 g and 19 g, respectively. The interaction between manure rate and frequency of application indicated that application of 30 t $ha^{-1}$of organic manure by split-split and split methods, gave significantly($p<0.05$) higher level of potassium, sodium and vitamins B_1, B_2, respectively (Table 5). Application of 20 t ha^{-1} of organic manure by split-split method gave a significantly ($p<0.05$) higher level of Vitamin A while split application of 10 t ha^{-1} gave highly significant ($p<0.01$) level of Vitamin E (15 mg).

Table 5: Effects of Rates and Frequency of Manure Application on some Vitamins and Mineral of *Solanum melongena* L cv Ngwa local.

Manure Rate	Frequency of Application	Vit A	Vit B1	Vit B2	Vit E	K	Na
0	Single	3.29	3.00	3.60	5.00	190.0	8.0
0	Split	3.29	3.43	4.11	6.67	145.0	6.0
0	Split-split	2.00	6.43	7.71	7.34	175.0	10.0
10	Single	4.14	3.86	4.63	11.67	198.0	8.0
10	Split	4.14	4.43	5.31	15.00	195.0	8.0

10	Split-split	4.29	5.00	6.00	11.67	158.0	6.0
20	Single	3.43	4.86	5.83	11.67	207.0	4.0
20	Split	3.57	5.57	6.69	9.44	214.0	6.0
20	Split-split	6.00	5.14	6.17	6.67	185.0	8.0
30	Single	3.43	6.57	7.89	8.89	138.0	5.0
30	Split	4.43	6.63	7.71	8.89	158.0	7.0
30	Split-split	2.00	6.14	7.37	13.33	218.0	19.0
LSD(p=.05)		0.04	0.03	0.05	0.07	0.17	0.17

K=Potassium, Na= Sodium

DISCUSSION

The delay on days to flowering in plants that received 30 t ha^{-1} of pig manure may be as a result of higher vegetative growth as reflected on the growth parameters (plant height, plant girth, number of trusses per plant, and leaves per plant) resulting from the increased nutrients supplied by the pig manure. These improvements in growth parameters with increase in rates of organic manure applied agrees with the findings of Fawuzi (1977); Uzo (1971) and Mohammad *et al.,*(2010)) where nutrient application was reported to delay anthesis in eggplant, and tomato. The decline in plant height, plant girth, and number of trusses per plant with increase in frequency of organic manure application at flowering stage indicates that higher nutrients supplied by the single dose were beneficial for the initial boost in the growth of the Solanum species. However, unsustained supply of these nutrients during the second flush at maturity stage retarded the growth of the plants that received single dose application of pig manure which underscores the importance of split application of organic manure in fruit vegetables. This is most probable because continuous fruit harvest is a means of nutrient removal from the soil which requires adequate replenishment to maintain a sustainable high harvest as indicated in the improvement in split-split application of organic manure over the single dose in growth parameters. The higher number and weight of fruits obtained from the application of higher rates of organic manure is in accordance with the studies of Asiegbu and Uzo, (1984); Devi *et al.,*(2002); Ogar and Asiegbu, (2005); Aujla *et al.,*(2007); and Mohammad *et al.,*(2010) where higher rates of nutrients increased the average fruit weight and volume.

The low performance of the (0 t ha^{-1}) control treatment was as a result of nutrient stress by the plants which agrees with Aujla *et al.,* (2007), and Akanbi *et al.* (2007) where similar reports were also obtained. The decline in the individual fruit weight over the months in all the rates is due to competition for the products of photosynthesis by the increased number of fruits. The highest individual fruit weight obtained from 30 t ha^{-1} was as a result of higher nutrient base supplied by the rate when compared with other rates where there was reduction in weight with decrease in rate of organic manure applied. The increase in the month of August can be attributed to fresh nutrient supplied by the organic manure. The decline in individual fruit weight of single and split methods of application can be attributed to continuous removal of nutrients from the soil by plants through fruit harvest and leaching without replenishment as evident in split-split method where there was increase after the August application both in weight and number of fruits. The steady increase in fresh weight of fruits with increase in rate of organic manure suggests that quantity of manure applied affects nutrients availability for uptake by plants for storage. This fact may highlight the possible soil physical characteristics improvement benefits derivable from the use of organic matter (Amon and Adetunji, 1967; Hafez, 1974; and Mbagwu and Ekwualor, 1990) in enhancing the overall crop growth and yield. The results of variations in fruit sizes as a function of quantity and frequency of manure application indicates that both factors influence the fruit size of 'Ngwa local' eggplant. Frequency of manure application seemed to be more critical as the split- split application of the different rates maintained high level of fruit size for the five months of harvest.

Higher concentration of chemical composition in the fruits was favoured with increased and

unconstrained nutrient supply to the plants. This is demonstrated in higher level of the vitamins and minerals in higher rates of nutrients at split and split-split frequencies in most cases. This suggested that the vitamins and minerals responded differentially to the nutrient levels and frequencies and could thus be a means of improving quality of fruits in the species. Our results are in agreement with the reports of Waring *et al.* (1985) on the stable growth and differential chemical properties of plants provided with balanced level of nutrients.

CONCLUSION

Application of 30 t ha^{-1} of pig manure resulted in a significantly (p=0.05) higher performance of growth parameters of 'Ngwa local' at flowering and maturity stages as well as in fruit vitamins and mineral composition in most cases when compared to 0 and 10 t ha^{-1}. Split-split application of the pig manure provided an unconstrained nutrient supply and resulted in the production of higher number of leaves at maturity stage which translated to good photosynthetic activity to have produced more fruits. Application of 30 t ha^{-1} and 20 t ha^{-1} of pig manure gave statistical (p=0.05) similar yield in number and weight of fruits, hence 20 t ha^{-1} applied as split-split is recommended to save cost in *Solanum melongena* L. cv. 'Ngwa local' production.

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