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Performance and Quality of Muskmelon (*Cucumis melo* L.) as Influenced by Crop Spacing and Rates of Swine Manure Application

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Abstract

Field and laboratory studies were conducted to determine the effect of plant spacing and rate of swine manure application on the growth, yield, nutrient concentration, uptake and proximate composition of muskmelon (*Cucumis melo*). The experiments were laid out as a 3×4 factorial fitted in a randomized complete block design (RCBD) with 3 replications. The treatments consisted of four rates of swine manure (0 t ha^{-1}, 5 t ha^{-1}, 10 t ha^{-1} and 15 t ha^{-1}) and three crop spacing (50 × 50 cm, 75 × 75 cm, 100 × 100 cm). The results showed that spacing had no significant effect on the number of leaves, leaf area, stem diameter and number of branches, but substantially increased the vine length at 100 × 100 cm. Number of flowers and fruit weight per plant increased with raw spacing, while the number of fruits per plot and fruit yield (t ha^{-1}) increased with a decrease in plant spacing, whereas the narrowest spacing of 50 × 50 cm produced the significantly highest fruit yield (25.47 t ha^{-1}). The concentrations of P, Ca, Mg and Fe (4.28, 6.81, 4.55 and 0.80 mg kg^{-1}) were the highest at 100 × 100 cm spacing compared to other treatments. However, N concentration (1.18) and uptake of N, P, Ca, Mg, Fe and Na was highest at spacing of 75 × 75 cm and at 10 t ha^{-1} swine manure rate. The effect of spacing on proximate composition of muskmelon did not follow a particular pattern; however, wider spacing of 75 × 75 cm and 100 × 100 cm at 10 t ha^{-1} favoured most of the proximate composition compared to the narrowest spacing of 50 × 50 cm and other manure rates. Although there was no significant difference in fruit yields of 10 and 15 t ha^{-1}, application of 15 t ha^{-1}, swine manure out-yielded 10 t ha^{-1}, by 8.55%.

Keywords: flowers; fruit; muskemelon; nutrients; vine length

Introduction

Muskmelon (*Cucumis melo*) belongs to the family Curcurbitaceae. It is an annual plant with a trailing vine growth. The fruits are an extremely healthful food choice (Hodges and Lester, 2006). They could serve protective roles in reducing chronic diseases such as cancer and cardiovascular disease. Muskmelon is rich in bioactive compounds such as phenolics, flavonoids and vitamins, as well as carbohydrates and minerals (especially potassium). In addition, it is low in fat and calories (about 17 kcal/100 g) and contains a large amount of dietary fibre, 90% water and 9% carbohydrates, with less than 1% of protein and fat respectively (USDA, 2014).

Inspite of the usefulness of this crop, the yield is still low due to under cultivation at a large scale and also poor agronomic practices which include incorrect spacing, pest and disease infestation, infertile soil, over reliance on inorganic fertilizer, amongst others.

Excessive reliance on mineral fertilizers has been associated with environmental and economic problems during the past decades (Cakmak, 2002). Thus organic farming has emerged as a sustainable agricultural approach that includes economic, environmental, and social measures (Pacini *et al.,* 2003). Recent studies showed that the yield of organically grown melon crops can be similar or higher than that of conventionally grown melons (Bullock *et al.*, 2002; Fernandes *et al.*, 2003; Morra *et al.*, 2003; Curuk *et al.*, 2004; Melero *et al.*, 2006). The application of organic matter can affect plant growth by providing the soil with various forms of nitrogen (N), as well as hormone-like compounds (Picolo *et al.*, 1992). El-Desuki *et al.* (2000) reported that organic manure addition at higher level (20 m^3/fed.) improved plant growth, NPK content, total yield and fruit quality. Numerous researchers have reported yield increase due to reduction in both plant and row spacing of muskmelon (Davis and Manert, 1965; Knavel, 1991; Maynard and Scott, 1998).

In light of the above, the objective of the present study was to determine the effect of crop spacing and swine manure application on the growth, yield, nutrient concentration, uptake and proximate composition of muskmelon.

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Materials and Methods

Soil properties

The studies were carried out at the Experimental Farm and at the Central Laboratory, Faculty of Agriculture, University of Benin, Benin City, Nigeria. The location lies between latitude 6° 14' N and 7° 34' N and longitude 5° 40' E and 6° 43' E. The experimental field was manually cleared and debris worked into the soil. Prior to planting, composite soil samples were collected from a depth of 0 – 30 cm, using soil auger and swine manure were also collected. Samples were air-dried and packaged for routine soil physico-chemical analysis. Soil pH was determined using a pH meter. Organic carbon was determined by wet oxidation method (Walkley and Black, 1962) as modified by Jackson (1969). Total nitrogen was obtained by macro Kjeldahl method as modified by Jackson (1969). Available P was extracted by Bray I method (Bray and Kurtz, 1945) and P was estimated by the blue colour method of Murphy and Riley (1962). Exchangeable K and Na were determined using flame photometer, while Ca and Mg were determined using the Atomic Absorption Spectrophotometer. The results of the soil analysis and swine manure are presented in Table 1.

Experimental design

The experiment was laid out in a 3 × 4 factorial arrangement fitted into a randomized complete block design (RCBD) with 12 treatments replicated 3 times. The treatments were based on rates of organic manure application (0 t ha^{-1}, 5 t ha^{-1}, 10 t ha^{-1} and 15 t ha^{-1}) and different plant spacing (50 × 50 cm, 75 × 75 cm and 100 × 100 cm). The swine manure used for the experiment was incorporated into their respective plots, depending on the treatment, and left for two weeks before sowing; three seeds were sown per hole and latter thinned to one seedling per stand at a spacing of 50 × 50 cm, 75 × 75 cm and 100 × 100 cm, giving a plant population of 1,440,000; 266,429 and 90,000 plants/ha respectively. Plots were mulched with dry grasses to conserve moisture and weeding was carried out 2 and 6 weeks after planting (WAP).

Data collection

Four plants were randomly tagged per plot for data collection. Data were collected on vine length (cm), number of leaves, number of branches, leaf area (cm) and stem diameter (cm) at 4 WAP and commenced until 7 WAP, while data for the number of flowers, number of fruits, fruit fresh weight (g), fruit diameter (cm) and fruit yield (t ha^{-1}) were taken between 8 - 15 WAP.

Determination of nutrient concentration and uptake and proximate composition of muskmelon fruits

At harvest, fruits were collected from each of the plots, washed and chopped into small bits, labelled as samples and oven dried at a temperature of 70 °C for 48 hours. After, they were crushed in preparation for laboratory analysis.

Proximate analysis was carried out using the methods of AOAC (1990). The Crude Protein content was also determined using the micro-kjeldahl method as described by AOAC (1990). The mineral elements N, P, Ca, Mg, Fe, Na, were analysed using standard laboratory procedures The mineral uptake were the product of the oven dry weight of the tissues and the corresponding value of the nutrient in the tissues.

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA), using SAS (Statistical Analysis Software) and least significance difference (LSD) test at 5% level of probability was use to compare the significant treatment mean.

Table 1. Physical and chemical analysis of soil prior to planting and chemical properties of swine manures used

Parameters	Soil	Swine manure
pH	5.40	6.41
Total Nitrogen (g kg^{-1})	0.03	1.46
Available Phosphorus (mg kg^{-1})	11.52	8.34
Potassium (cmol kg^{-1})	0.32	0.65
Calcium (cmol kg^{-1})	0.88	0.83
Magnesium (cmol kg^{-1})	0.32	0.63
Sodium (cmol kg^{-1})	0.23	0.34
Hydrogen (cmol kg^{-1})	0.65	-
Aluminium (cmol kg^{-1})	0.06	-
Organic carbon (g kg^{-1})	20.37	-
Sulphur (mg kg^{-1})	8.44	-
Sand (%)	88.20	-
Silt (%)	4.62	-
Clay (%)	7.18	-
Organic matter (%)	20.37	32.62
ECEC	2.46	-
Textural class	Sandy loam	

Results

The soil had a sand content of 88.22%, 4.62% silt and 7.18% clay. Organic matter was low (3.5%), while the pH was slightly acidic (5.4), with a total nitrogen content of 0.03 g/kg. The results of the swine manure showed that it is a rich source of primary plant nutrients adequate for crop production (Table 1). The effect of spacing on vine length was significant. The widest spacing of 100 × 100 cm produced the longest vine length (46.82 cm), followed by 50 × 50 cm spacing (40.32 cm), while 75 × 75 cm spacing (32.53 cm) had the shortest vine length (Table 2). Application of 10 t/ha and 15 t/ha swine manure significantly increased vine length (30.91 cm and 33.91 cm) respectively above the control (17.02 cm). Number of leaves and branches were not significantly influenced by spacing. Number of leaves and branches increased with increase in swine manure application from 0 t ha^{-1} to 15 t ha^{-1}. The effect of spacing and swine manure application were not significant for leaf area and stem diameter. Plant spacing and swine manure significantly influenced yield and yield components except spacing on number of fruit/plant and fruit diameter (Table 3). The narrowed spacing had significantly higher fruits/plot and fruit yield per ha, while yield and yield components increased with higher swine manure applied. Swine manure application rate had no effect on the number of flowers of muskmelon. Swine manure increased the number of fruits from 0 t ha^{-1} up to 10 t ha^{-1}, while a further increase in manure rate did not result in a significant increase in number of fruits per plant. Number of fruits per plot decreased with increasing raw spacing and increased with increasing manure application rate. Fruit weight per plant did not follow a particular pattern; however, 75 × 75 cm produced significantly highest fruit weight (429.08 g) per plant, above 100 × 100 cm (350.13 g) and 50 × 50 cm (318.16 g) which were statistically similar. Application of 10 t ha^{-1} and 15 t ha^{-1} significantly produced the highest fruit weight per plant, above 0 t ha^{-1} and 5 t ha^{-1}. The fruit yield (t ha^{-1}) decreased with an increase in spacing, whereas significantly the highest fruit yield (25.47 t ha^{-1}) was obtained at the narrowest spacing of 50 × 50 cm, followed by 14.34 t ha^{-1} at 75 × 75 cm and the lowest fruit yield (7.01 t ha^{-1}) was obtained at the widest spacing of 100 × 100 cm.

Although, the effect of spacing on proximate composition of muskmelon did not follow a particular pattern; the wider spacing of 75 × 75 cm and 100 × 100 cm significantly improve the quality of muskmelon, more than 50 × 50 cm spacing. The effect of spacing on moisture content and crude protein content of muskemelon was not discernible; however, the application of manure increased their contents from 0-10 t ha^{-1}. The significantly ($P < 0.01$) high moisture content of muskemelon fruits in this experiment shows that muskemelon have a high moisture content (%), which ranged between 92.79-99.06%. The ash content, ether extract and crude fibre contents increased with increase in spacing and with increase in manure application up to 10 t ha^{-1}, but decreased at 15 t ha^{-1} manure rate applications. There was no discernible pattern observed for nitrogen extract content with plant spacing and manure application; wider spacing of 100 × 100 cm tends to favour most of the proximate parameters measured except percentage of nitrogen free extract (Table 4). Similarly, the wider spacing of 100 × 100 cm increased the concentration of most nutrients in muskemelon compared to the narrower spacing, except for nitrogen and sodium. Similarly, the nutrient concentration increased with increase in manure application up to 10 t ha^{-1} except for sodium. The highest uptake of most nutrient elements studied was obtained at 75 × 75 cm spacing, except for sodium and decreased at 100 × 100 cm spacing, except for iron, which was the highest at 75 × 75 cm. In all the nutrients studied, the application of 10 t ha^{-1} recorded the highest nutrient uptake which decreased with a further increase in manure rate to 15 t ha^{-1}.

Table 2. Effect of spacing and swine manure on some vegetative parameters of muskmelon (*Cucumis melo* L.)

Treatments	Vine length (cm)	No. of leaves	Leaf area (cm^2)	Stem diameter (cm)	No. of branches
Plants spacing (cm)					
50×50	40.32^{ab}	35.60^{a}	84.25^{a}	0.29^{a}	2.40^{a}
75×75	32.53^{b}	34.56^{a}	90.92^{a}	0.35^{a}	2.11^{a}
100×100	46.82^{a}	24.49^{a}	78.48^{a}	0.25^{a}	1.89^{a}
Significance	*	NS	NS	NS	NS
LSD	14.22	13.74	32.03	0.11	0.89
Swine manure (t ha^{-1})					
0	17.02^{b}	21.82^{b}	68.01^{a}	0.30^{a}	1.49^{b}
5	24.79^{ab}	28.75^{ab}	74.26^{a}	0.25^{a}	2.29^{ab}
10	30.91^{a}	36.27^{ab}	93.71^{a}	0.30^{a}	2.19^{ab}
15	33.91^{a}	39.37^{a}	102.21^{a}	0.34^{a}	2.57^{a}
Significance	*	*	NS	NS	*
LSD	13.84	15.87	36.99	0.13	1.03

Table 3. Effect of spacing and swine manure on yield and yield components of muskmelon

Treatments	No. of flowers/ plant	No. of fruits/plant	No. of fruits/plot	Fruit weight/plant (g)	Fruit diameter (cm)	Fruit yield (t/ha)
Plants spacing (cm)						
50 × 50	3.42[b]	1.47[a]	71.83[a]	318.16[b]	14.20[a]	25.47[a]
75 × 75	7.45[a]	1.58[a]	31.25[b]	429.08[a]	14.57[a]	14.34[b]
100 × 100	1.67[b]	1.63[a]	19.50[b]	350.13[b]	17.66[a]	7.01[c]
Significance	*	NS	*	*	NS	*
LSD	3.95	0.32	12.96	78.73	9.22	5.52
Swine manure (t ha^{-1})						
0	2.42[a]	0.97[c]	27.78[b]	176.29[c]	6.66[c]	8.14[c]
5	2.40[a]	1.46[b]	39.17[ab]	352.68[b]	11.57[bc]	13.96[bc]
10	4.94[a]	1.79[ab]	44.83[a]	446.35[a]	24.37[a]	18.44[ab]
15	6.94[a]	1.99[a]	51.67[a]	487.84[a]	19.32[ab]	21.89[a]
Significance	NS	*	*	*	*	*
LSD	4.56	0.37	14.97	90.90	10.64	6.38

Means with the same letter are not significantly different; **highly significant at 5% level of probability.

Table 4. Effects of spacing and levels of swine manure application on proximate composition of muskmelon

Treatments	Moisture content (dry matter basis)	Ash content (%)	Ether extract (%)	Crude fibre (%)	Crude protein (%)	Nitrogen free extract (%)
Plants spacing (cm)						
50×50	93.32[c]	8.08[c]	6.80[b]	4.18[c]	6.36[c]	67.80[a]
75×75	92.79[a]	9.80[b]	6.61[c]	4.28[b]	7.32[a]	64.95[b]
100×100	92.99[b]	10.65[a]	7.55[a]	4.43[a]	6.85[b]	63.31[c]
LSD	0.01	0.08	0.08	0.08	0.01	0.01
Significance	**	**	**	**	**	**
Swine manure (t ha^{-1})						
0	93.60[d]	7.72[d]	6.92[c]	3.78[d]	5.77[d]	66.15[b]
5	98.87[b]	10.15[b]	7.35[b]	4.48[b]	7.01[b]	63.40[d]
10	98.86[a]	11.80[a]	7.45[a]	4.68[a]	8.76[a]	64.83[c]
15	99.06[c]	8.98[c]	6.23[d]	4.22[c]	5.84[c]	67.55[a]
LSD	0.01	0.09	0.09	0.09	0.01	0.01
Significance	**	**	**	**	**	**

Means with the same letter are not significantly different; **highly significant at 5% level of probability.

Table 5. Effects of spacing and levels of swine manure application on nutrient concentration of muskmelon

Treatments	Nitrogen (%)	Phosphorus (mg/kg)	Calcium (mg/kg)	Magnesium (mg/kg)	Sodium (mg/kg)	Iron (mg/kg)
Plants spacing (cm)						
50×50	1.02[c]	3.45[c]	5.92[c]	4.08[c]	1.19[a]	0.64[c]
75×75	1.18[a]	3.96[b]	6.40[b]	4.37[b]	0.93[c]	0.67[b]
100×100	1.10[b]	4.28[a]	6.81[a]	4.55[a]	1.08[b]	0.80[a]
LSD	0.01	0.01	0.01	0.01	0.01	0.01
Significance	**	**	**	**	**	**
Swine manure (t ha^{-1})						
0	0.93[d]	3.38[d]	5.80[d]	4.05[d]	1.22[a]	0.62[d]
5	1.13[b]	4.07[b]	6.53[d]	4.44[b]	1.02[c]	0.77[b]
10	1.14[a]	4.55[a]	7.34[a]	4.78[a]	1.12[b]	0.79[a]
15	0.94[c]	3.71[c]	5.84[c]	4.07[c]	0.92[d]	0.65[c]
LSD	0.01	0.01	0.01	0.01	0.01	0.01
Significance	**	**	**	**	**	**

Means with same letter are not significantly different; **highly significant at 5% level of probability.

Table 6. Effects of spacing and levels of swine manure application on yield and nutrient uptake of muskmelon

Treatments	Nitrogen (%)	Phosphorus (mg/kg)	Calcium (mg/kg)	Magnesium (mg/kg)	Sodium (mg/kg)	Iron ((mg/kg))
Plant spacing (cm)						
50×50	13.55b	49.46b	81.22a	57.29b	16.23a	8.72c
75×75	17.86a	63.64a	100.48a	68.18a	14.55b	10.85a
100×100	13.17c	49.37c	79.29c	52.89c	12.46c	9.18b
LSD	0.01	0.01	0.01	0.01	0.01	0.01
Significance	**	**	**	**	**	**
Swine manure (t ha^{-1})						
0	14.28c	43.71c	75.39c	52.45c	15.54b	7.88d
5	15.54b	56.16b	87.58b	61.29b	13.80c	10.63b
10	18.28a	70.76a	112.98a	72.73a	16.57a	11.80a
15	11.34d	45.98d	72.05d	51.35d	11.74d	8.03c
LSD	0.01	0.01	0.01	0.01	0.01	0.01
Significance	**	**	**	**	**	**

Means with same letter are not significantly different; *significant at 5% level of probability; **highly significant at 5% level of probability.

Discussion

The physical and chemical properties of the soil used for the experiment gave the textural class of sandy loam. The potassium and total nitrogen were all below recommended critical levels of 0.15% N and 0.34 cmol kg^{-1} K, while the available phosphorus was a little above the critical concentration 10-16 mg/kg P for crop production (Adeoye and Akinola, 1985), hence the need for additional nutrient amendments to the soil. In addition, Ozores-Hampton (2012) revealed that organic manure amendments affect soil bulk density, water-holding capacity, soil structure, soil carbon content, macro and micronutrients, pH, soluble salts, cation exchange capacity (CEC) and biological properties (microbial biomass). The increase in vine length at wider spacing could probably be due to the fact that plants in the wider spacing had less competition for growth factors such as nutrients, moisture and sunlight and this is in agreement with the work of Elizabeth and Dennis (1994) who concluded that wider spacing gave the longest vine length and the closest spacing had the shortest vine length. Baloch *et al*. (2002) observed that reducing plant densities increased the nutrient area per plant and this led to an increase in morphological characters. Also, Morrison *et al.* (1990) explained further that well-spaced plants received more solar radiation and were therefore more photosynthetically efficient than closely spaced ones. The increase in the number of fruits per plot and subsequent the increase in yield per hectare as a result of decrease in spacing could be due to the fact that closer spacing had adequate ground cover and had higher plant biomass, which aid in the reduction of soil moisture and nutrient loss and this is in support of the work of Aniefiok *et al*. (2013), who observed from their study on the effects of plant spacing on growth of waterleaf that although wider spacing favoured individual's plant performance morphologically, densely populated plants produced greater mass per unit area compared with less dense plots. They also observed that widely spaced plants had higher moisture content than their closely spaced counterparts. Moniruzzaman *et al*. (2007) also reported higher seed yield of okra at the narrowest spacing and this also corroborates the findings of Falodun and Ogedegbe (2016) who recorded higher pod yield of okra at narrower spacing compared to wider spacing. The significant increase in some vegetative characters and yield with the 15 t/ha application of swine manure is similar to the work of Curuk *et al.* (2004) who reported increases in fruit yield after high manure input compared to customary inorganic fertilization and this further supports the work of Mohammed *et al*. (2013) who observed an increase in growth and yield of onion applied with moringa extract.

According to Aisha *et al*. (2007), crops cultivated with organic manures are not only free from harmful chemicals; they are also safer, healthier and tastier. They are of high nutritional quality and are devoid of all forms of pollution that arise from agricultural techniques. Apart from supplying plant nutrients, Akinfasoye and Akanbi (2005) also justified that they improve soil physical and microbial properties and eliminate pollution of underground water.

Moisture content determination is an integral part of the proximate composition analysis of food. The high moisture content in muskemelon (92.79 - 99.06%) is in agreement with the finding of Adetuyi *et al*. (2011) in their study on okra. Also this is in accordance with the finding of Gopalan *et al*. (2007) (89%) and (Nwachukwu *et al*., 2014) (88.47%). Moisture content of any food is an index of its water activity and is used as a measure of stability and susceptibility to microbial contamination (Uyoh *et al*., 2013). The high moisture content in vegetables makes them vulnerable to microbial attack, hence spoilage (Nwofia *et al*., 2012). This high moisture content also implies that dehydration would increase the relative concentrations of other food nutrient and therefore improve the shelf-life and preservation of the fruits (Aruah *et al*., 2012).

The mean crude protein content in the present study (3.78-4.68%) was lower than that reported by Abolaji *et al.* (2017) (19.85%) for grain amaranth, but almost comparable with the findings of Nwachukwu *et al*. (2014)

(4.81 g/100 g). Muskemelon can be considered a high protein vegetable when compared with *Gnetum africanum* (1.5 g/100 g) and *Pterocarpus* (2.0 g/100 g) (Nzikou *et al.*, 2006) and this implies that muskemelon fruits can serve as a good source of protein.

Nwofia *et al.* (2012) reported that diet is nutritionally satisfactory, if it contains high caloric value and a sufficient amount of protein. The ash content is a measure of the nutritionally important mineral contents present in the food material. The level of ash content ranged from 7.72% to 11.80%; on dry weight basis, this result showed that the sample contained a considerable amount of ash, which indicates that that muskemelon would provide essential valuable minerals, needed for body development. The mean ash content obtained hereby was higher than that reported by Abolaji *et al.* (2017), 2.25% respectively.

Dietary fats function in the increase of palatability of food by absorbing and retaining flavors (Antia *et al.*, 2006). Excess consumption of fat has been implicated in certain cardiovascular disorders such as atherosclerosis, cancer and aging; in this regard, the consumption of muskemelon diet should be encouraged to reduce the risk of above diseases in human. The fibre content of muskemelon in the hereby study can be considered high when compared with *Amarantus hybridus* (1.6 g/100 g), which may suggest that consumption of muskemelon will improve digestibility and absorption processes in large intestine, helping to stimulate peristalsis, thereby preventing constipation.

The increase in the moisture content, crude fibre and crude protein as a result of increase in manure levels is an indication that manure improves the quality of crops. The highest nutrient concentration in the wider spacing of 100 × 100 cm and higher uptakes observed with 75 × 75 cm plant spacing of most nutrient elements could probably be indications that plants at these spacing distances might have experienced better soil conditions to enable them absorb these nutrients effectively. However, the highest yield per hectare obtained at the narrowest spacing of 50 × 50 cm earlier observed in this study could be due to the fact that closer spacing had adequate ground cover and higher plant biomass. The increase in nutrient concentration and uptake up to 10 t/ha suggests that the fertilizer application enhances the uptake of nutrients up to a certain optimum fertilizer levels. This corroborates the results of Falodun and Egharevba (2017). They attributed the better nutrient uptake at higher levels to the availability of adequate amount of nutrients in the soil at these levels and this improved the plant capacity to absorb the nutrients.

Conclusions

Application of swine manure at higher application rate improved muskmelon yield. Closest spacing tested of 50 × 50 cm produced the highest yield, but smaller fruits, probably because of higher number of plants per hectare. The spacing of 75 × 75 cm could also be adopted, as it produced higher fruit weight compared to the other treatments evaluated. Swine manure rate at 10 t/ha gave the highest yield and best qualities of muskmelon in the present study.

Conflict of Interest

The authors declare that there are no conflicts of interest related to this article.

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