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EVALUATION OF WATERMELON RESPONSE TO POPULATION DENSITIES AND COW DUNG MANURE IN AN ULTISOLS

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ABSTRACT

Field experiments were conducted in 2016 to evaluate the effects of different population densities and cow dung manure application rates on growth, yield and nutritional quality of watermelon in an Ultisol, Nigeria. The plant population densities were 15,625, 12,346, 10,000 and 8,264 plants ha^{-1} while the cow dung rates comprised 10, 7.5, 5 and 2.5 t ha^{-1}. The treatments were arranged in a randomized complete block design. Results show that vine length, number of leaves on main stem, number of lateral branches and main vine diameter were significantly ($P<0.05$) affected by the different plant population densities and were higher in plots with lower population densities compare to plots with higher population densities. Numbers of primary lateral branches were higher in plots with higher population densities than plots with lower population densities. Vine length increase with increase rate of cow dung manure and plots with highest rate of cow dung manure recorded the highest vine length in both locations. Carbohydrate and dietary fiber increased with increased rate of cow dung manure up to when cow dung rate was 7.5t ha^{-1}. Number of fruits per plant and average fruit weight decreases with increase in plant population densities. Number of fruits per plot, and weight of fruit per plot were significantly affected by cow dung rate. There were no significant differences in number of fruits per plot, average weight of fruits and weight of fruit per plot when cow dung was applied at 5.0, 7.5 and 10t ha^{-1}. Cow dung application rate of 5 t ha^{-1} and a plant population of 10,000 plants ha^{-1} is therefore recommended for watermelon growers in an ultisol.

Keywords: Cow dung manure; growth and yield; nutritional quality; population density; watermelon

INTRODUCTION

Watermelon belongs to the family Cucurbitaceae (Schippers, 2000). Its centre of origin has been traced to both the Kalahari and Sahara deserts in Africa (Jarret *et al*., 1996) and these areas have been regarded as point of diversification to other parts of the world (Schippers, 2000). In Nigeria, the crop has a wide distribution as a garden crop, while as a commercial vegetable production; its cultivation is confined to the drier savanna region of Nigeria (Anon, 2006). Watermelon is a heavy feeder of nutrient especially nitrogen (Rice *et al*., 1986; Schippers, 2000). Extensive use of inorganic fertilizer causes reduction in number of fruits, delays and reduces fruit setting, which subsequently delay ripening and leads to heavy vegetative growth (Aliyu *et al*., 1992; John *et al*., 2004).

Higher yield per area in watermelon is related to dense in-row plant spacings (Huitron-Ramirez *et al*., 2009). High plant density is recommended for watermelon seed production because more fruit per unit area is achieved at a denser spacing (Edelstein and Nerson, 2002). When the number of plants per unit area is increased, the fruit number per area is enhanced (Motsenbocker and Arancibia, 2002). Thus, the relatively high yield at denser in-row spacings is due to a high number of fruits per unit area (Duthie *et al*., 1999). However, the fruit weight could be negatively impacted by high plant densities (Motsenbocker and Arancibia, 2002; Goreta *et al*., 2005). Researches on diverse vegetable crops have shown that yield increases linearly when the in-row plant spacing is reduced (Knavel, 1988; Ban *et al*., 2006).

Cultivation of watermelon was mainly carried out in arid and semi arid zones of Nigeria. However, watermelon consumption is on the increase in the southern guinea savannah, which led to increase cultivation of watermelon in the area. There is need to carry out research on the appropriate population density and cow dung application rate that will give the optimum yield of watermelon in the area. Hence, this study was conducted to evaluate the effect of different population densities and cow dung manure application rates on nutritional quality, growth and yield of watermelon in an Ultisols, Kogi State, Nigeria.

MATERIALS AND METHODS

Study Area

Field experiments were conducted at the experimental field plot of Kabba College of Agriculture, and at the research site of the Lower Niger River Basin Development Authority, Ejiba in 2016. Kabba and Ejiba are both located in the Southern Guinea Savanna Ecological Zone of Nigeria on latitude 07° 53' N and longitude 6° 8' E and Latitude 8˚18'N and Longitude 5˚39'E, respectively. The sites are 453 and 246 m above sea level. The major soil order within the experimental sites is Ultisols (Babalola, 2010 and Ajiboye and Ogunwale, 2010).

Experimental Design and Field Trial

The plant population densities were 15,625 (0.8 x 0.8 m), 12,346 (0.9 x 0.9 m), 10,000 (1 x 1 m) and 8,264 plants·ha^{-1} (1.1 x 1.1 m) while the cow dung rates comprised 10, 7.5, 5 and 2.5 t ha^{-1}. The net plot size measured 8.0 × 4.0 m. Seed bed was constructed by ploughing and harrowing in each season. Cow dung manure was incorporated into the plots based on treatments two weeks before sowing. Watermelon seeds of Sugar Baby variety was used in a 4 x 4 factorial arrangement fitted into a randomized complete block design in factorial fashion with three replications.

Weeds were controlled through manual hoeing and subsequently by hand pulling as the watermelon vines spread and covered the plots to thus suppress weed growth. Labdacyalothrin (Karate 2.5 EC) was applied four times at the rate of 1.5 L ha^{-1} beginning from fifteen days after sowing (DAS) to control pest infestation during the growing period of the crop. Routine maintenance of the experimental plot was carried out such as weeds and pest control.

Data Collection and Analysis

Data on growth and yield variables were collected. Vine length was measured with a tape rule, number of leaves were counted, number of branches and number of fruits were also counted and total yield were measured using measuring scale.

Data regarding vine length, number of leaves and branches, % carbohydrate, protein total fat and dietary fibre, fruit number and total yield were subjected to analysis of variance (ANOVA). Treatment means were separated using least significant difference (LSD) at 5% significant level.

RESULTS

The results of the soil physical and chemical properties prior to cropping are presented in Table 1. The cow dung chemical analysis results were 40.4%, 2.14%, 1.10%, 0.72%, 1.62% and 0.28% for organic carbon, total N, phosphorus, potassium, calcium and magnesium respectively. The C/N ratio was 18.9 (Table 2).

Table 1: Properties of the soils at the sites of the experiment

Parameters	Kabba	Ejiba
Particle size (g kg^{-1})		
Sand	607	672
Clay	216	156
Silt	177	172
oil texture	Sand clay loam	Sand clay loam
Soil pH1:2.5 soil: water	6.2	6.7
Bulk density (g/cm^3)	1.36	1.51
Total porosity (%)	38.4	40.6
Organic matter (%)	1.58	1.96
T0tal N (%)	0.18	0.21
Available P($mgkg^{-1}$)	2.01	2.56
Exchangeable cation ($cmolkg^{-1}$)		
K	0.28	0.48
Ca	2.54	1.78
Mg	2.93	1.43
Na	1.66	1.87

Table 2: Chemical composition of cow dung (%) used

Composition	Values
Organic carbon (%)	40.41
Total N (%)	2.14
Available P (%)	1.10
Potassium (%)	0.72
Calcium (%)	1.62
Magnesium (%)	0.28
C: N	18.88

Effect of different population densities and cow dung manure on growth characteristics of watermelon are presented in Table 3. Vine length, number of leaves on main stem and main vine diameter were higher in plots with lower population densities (10,000 and 8,264 plants ha^{-1}) compared to plots with higher population densities (15,625 plants ha^{-1}). Numbers of primary lateral branches were higher in plots with higher population densities (15,625 and 12,346 plants ha^{-1}) than plots with lower population densities (10,000 and 8,264 plants ha^{-1}). Vine length increase with increase rate of cow dung manure. Plots with highest rate of cow dung manure recorded the highest vine length in both locations which was statistically similar with 5 and 7.5 t ha^{-1}.

Table 3: Effects of different population densities and cow dung manure rates on growth of water melon

Treatment	Vine length (cm)		Number of leaves on main stem		Number of lateral branches		Main vine diameter (cm)	
	Ejiba	Kabba	Ejiba	Kabba	Ejiba	Kabba	Ejiba	Kabba
PPD (Plants ha^{-1})								
15,625	106.4	127.8	12.6	12.9	4.29	4.46	3.2	3.34
12,346	117.4	138.3	12.8	13.1	4.63	4.28	3.9	3.96
10,000	127.6	187.6	14.4	16.3	3.31	4.05	4.6	4.99
8,264	170.4	174.3	15.6	16.6	3.36	3.16	4.9	4.36
$LSD_{(0.05)}$	27.14	32.95	0.94	0.77	0.440	0.370	0.81	0.890
Cowdung rate (t ha^{-1})								
10	132.8	187.5	15.3	16.8	4.41	4.53	4.3	4.6
7.5	135.6	191.1	13.9	15.6	4.50	4.61	4.0	4.6
5.0	134.6	189.9	14.0	15.4	4.44	4.38	3.8	4.3
2.5	113.1	131.8	12.6	14.9	4.63	4.93	2.6	3.9
$LSD_{(0.05)}$	11.60	27.60	1.34	0.90	Ns	0.110	1.00	0.09
Interaction								
AXB	ns	ns	Ns	ns	Ns	ns	ns	ns

PPD = Plant population density

Table 4 presents the effect of different population densities and cow dung manure application rates on nutritional qualities of water melon. The results show that population density had no significant effect on any of the nutritional quality parameters. Carbohydrate and Dietary fiber were significantly affected and increased with increase rate of cow dung manure up to when cow dung rate was 7.5 t ha^{-1}. However, protein and total fat were not significantly ($P<0.05$) affected by both difference in population densities and cow dung application rates.

The number of fruits per plant and average fruit weight decreases with increase in plant population densities (Table 5). Plots with plant population densities of 10,000 and 8,264 plantsha^{-1} recorded the highest values of number of fruits per plant. Weight of fruit per plots was higher in plots with plant population densities of 10,000 plants per hectare at Ejiba (910.5 kg/plot) and Kabba (836.3kg/plot).

Table 5 shows that cow dung application rates of 5 – 10 t ha^{-1} had similar values for all the fruit components but significantly ($P<0.05$) higher than 2.5 t ha^{-1}.

Table 4: Effects of different population densities and cow dung manure rates on nutritional qualities of watermelon

Treatment	Carbohydrate		Protein		Total Fat		Dietary Fibre	
	Ejiba	Kabba	Ejiba	Kabba	Ejiba	Kabba	Ejiba	Kabba
PPD (plants ha^{-1})								
15,625	5.51	5.61	0.41	0.48	0.13	0.18	0.36	0.31
12,346	5.36	5.13	0.45	0.44	0.16	0.13	0.33	0.37
10,000	5.41	5.41	0.43	0.41	0.14	0.16	0.34	0.35
08,264	5.53	5.55	0.43	0.40	0.17	0.15	0.30	0.34
$LSD_{(0.05)}$	Ns	Ns	ns	Ns	Ns	ns	ns	ns
Cow dung rate (t ha^{-1})								
10	5.71	5.37	0.40	0.43	0.16	0.14	0.34	0.30
7.5	5.68	5.63	0.42	0.47	0.13	0.16	0.49	0.32
5.0	4.74	3.46	0.46	0.43	0.17	0.16	0.30	0.30
2.5	3.63	3.33	0.41	0.42	0.14	0.16	0.31	0.24
$LSD_{(0.05)}$	0.64	0.72	Ns	ns	ns	ns	0.07	0.04
Interaction								
AXB	Ns	Ns	Ns	ns	ns	ns	ns	ns

PPD = Plant population density

Table 5: Effects of different population densities and cow dung manure rates on yield of watermelon

Treatment	Number of fruits per plant		Number of fruits per plot		Ave. weight of fruits (Kg)		Weight of fruit per plot (kg)	
	Ejiba	Kabba	Ejiba	Kabba	Ejiba	Kabba	Ejiba	Kabba
PPD (plants ha^{-1})								
15,625	08.14	06.72	407	336	1.96	1.63	797.7	547.7
12,346	09.53	09.86	381	394	1.98	2.08	754.4	819.5
10,000	13.82	12.62	442	404	2.06	2.07	910.5	836.3
8,264	14.01	12.93	364	336	2.14	2.11	779.0	709.0
$LSD_{(0.05)}$	1.21	2.43	38.01	37.41	0.07	0.14	64.11	22.75
Cowdung rate (t ha^{-1})								
10	13.94	13.89	446	444	2.18	2.18	972.2	967.9
7.5	14.98	12.98	479	415	1.86	2.21	890.9	917.2
5.0	14.34	13.68	459	438	2.01	2.21	922.6	968.0
2.5	08.66	06.41	277	205	1.08	1.16	299.2	237.8
$LSD_{(0.05)}$	2.73	3.95	48.22	56.54	0.44	0.38	148.91	98.44
Interaction								
A*B	ns	Ns	Ns	Ns	ns	ns	ns	ns

PPD = Plant population density

DISCUSSION

Vine length, number of leaves on main stem and main vine diameter were higher in plots with lower population densities (8,264 plants per hectare) compared to plots with higher population densities (15,625 plants per hectare). These results are in agreement with the findings of Efediyi *et al.* (2009) who reported that the spacing has positive effect on plant height. These results also corroborated with the finding of Sabo *et al.* (2013) who reported an increase in watermelon vine length with an increase in spacing.

Numbers of primary lateral branches were higher in plots with higher population densities (12,346 and 15,625 plants per hectare) than plots with lower population densities (2,264 and 10,000 plants per hectare). The results showed that as spacing increased and watermelon number of lateral branches increased, this result could be due to low competition for water, nutrient and light between crops

Vine length increase with increase rate of cow dung manure up to 7.5 t ha^{-1} after which it drop with further increase rate of cow dung in both locations. These results are similar to other studies (Jama *et al*., 2000; ICRAF, 1997; Pholsen and Suksri, 2004, Gungula *et al*., 2005) on various crops. Indira (2005) attributed the increase in the number of leaves with increasing nutrient application to better root development and increased translocation of carbohydrates from source to growing points. It is also possible that increased number of leaves also had enhanced solar radiation interception.

Carbohydrate and Dietary fiber were significantly affected and increased with increase rate of cow dung manure up to when cow dung applied at 7.5 t ha^{-1}. Product quality in relation to application of organic manure has been widely reported (Togun *et al*., 2003). High fruit yield and nutrient contents of plants nourished with organic fertilizer could be due to the fact that the materials not only contained sufficient nutrients but the nutrients are slowly released to the plants. This prevents nutrient loss and leaching, as well as improving nutrient use efficiency (Ilupeju *et al*., 2015). Many research works have reported higher nutritional values of organically grown crops (Ilupeju *et al*., 2015). This could explain the better quality of watermelon fruit nourished with cow dung manure. Cow dung manure contained many active sites which improved soil cation exchange capacity (CEC) and fertility. This stimulates better nutrient uptake and utilization by the crop. These could be responsible for better carbohydrate and Dietary fiber content observed in this experiment.

Plots with lower plant population densities (10,000 and 8,264 plants ha^{-1}) recorded the highest values of number of fruits per plant and average weight of fruits. The few numbers of fruits per plant was observed in plot with the highest population density was probably due to less competition for nutrients, water and space enjoyed by watermelon with lower population densities (Ilupeju *et al*., 2011). The results suggest that decreased population density increased the average fruit weight of watermelon in this study. The findings are similar to those by Silvia *et al.* (2007).

Maximum yield of watermelon was achieved when the plant population was maintained at 12,346 and 10,000 plants ha^{-1} after which yield declined. In general, increase in plant population produces a greater biological yield per unit land area for most crops up to some upper limit or threshold density for species after which further increases in plant population density either maintain the yield or cause yield decline (Weiner, 1990). To achieve the highest yield per land area, crops should intercept solar radiation fully during the growth stage. Closer spacing as result of high population density may give crop competitive advantage over weeds (Auld *et al*., 1987; Weiner, 1990).

Fruits per plant decrease with increase in plant population density. When the number of plants per unit area is increased, the fruit number per area was enhanced, but the yield and fruit number per plant is reduced (Motsenbocker and Arancibia, 2002). Thus, the relatively high yield at denser in-row spacing is due to a high fruit numbers per unit area (Duthie *et al*., 1999).

Watermelon yield improved with application of cow dung manure and the highest yield was achieved at 5 t ha^{-1} in this experiment. The earlier reason adduced for the observation in the growth parameters may also have been responsible for that in the yield parameters. This is because the yield components followed a similar trend with the growth parameters. The fruit weight per hectare using cow dung manure resulted in greater yield than the control plots in both years. This could be attributed to its ability to maintain more favorable physical conditions of the soil and release of nutrients to plant in a balanced manner. Soil amendment using organic manure has been reported to improve soil conditions and enhance plant growth through replenishment of soil nutrients (Ehiokhilen *et al.*, 2017).

CONCLUSION

In conclusion, it can be inferred that cow dung manure application improve the growth and yield character of watermelon irrespective of the rate of application. There was no significant difference in number of fruits per plot, average weight of fruits and weight of fruit per plot when cow dung was applied at 5.0, 7.5 and 10t ha^{-1}. Among the different rates, 5 t ha^{-1} cow dung manure improves growth and yield of watermelon with minimum cost. Among the different population observed, plots planted at 1 by 1m (10,000 plants per hectare) gave the highest fruit yield of watermelon. Therefore, watermelon farmers should grow their crops at population density of 10,000 plants ha^{-1} and amend the soil using cow dung manure at the rate of 5t ha^{-1} for optimum yield of the crop.

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