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Agronomic Evaluation of Four Exotic Tropical Varieties of Watermelon (*Citrullus lanatus* L.) in Two Agro-environments in Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

The research was conducted to evaluate the agronomic performance of five tropical varieties of watermelon (*Citrullus lanatus* L.) in two agro-environments (Agbani and Iwollo) during the 2013 and 2014 planting season in Enugu State, Southeastern Nigeria. The experiment comprises of five varieties of watermelon namely; *New Dragon*, *Empire, Dark Belle*, *Koloss* and *Kaolack* (control) which was laid out in a randomized complete block design with four replications Results from the study showed that there was no significant ($p > 0.05$) differences in leaf area index at Agbani site for the two seasons at 30 and 60 days after planting. *Dark Belle* had the highest fruit weight at harvest in Agbani site with 13.04 t ha^{-1} and 8.08 t ha^{-1} in 2013 and 2014 planting seasons, respectively, while Iwollo site produced a fruit yield of 1.75 t ha^{-1} (2013) and 0.81 t ha^{-1} (2014). *Dark Belle*, *Koloss* and *Kaolack* are recommended for Agbani soils and soils under similar conditions and location. *Dark Belle* is identified as the best adapted variety of watermelon for Agbani and Iwollo soils and locations of Enugu State. However, Iwollo soils and soils under similar conditions and location may not be good for commercial watermelon production during the rainy seasons.

Keywords: Agro-environment; exotic tropical watermelon; growth; yield; degraded ultisol.

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1. INTRODUCTION

Watermelon (*Citrullus lanatus*) belongs to the family *Cucurbitaceae* and in the same family with cucumber and pumpkin. It is a tender, warm season vegetable crop which can be grown in all parts of Nigeria. Watermelon is a vine-like (trailer) flowering plant and one of the most common type of melon. Its fruit which is also called watermelon is a special kind referred to by botanists as "PEPO", a berry which has a thick rind (Exocarp) and fleshy center (Mesocarp and Endocarp) [1,2].

There are more than 100 varieties of watermelon ranging in weight from less than 1.4 kg to more than 32 kg and may be round or oblong in shape. It has a smooth skin and may vary in color from light green to dark green. Some varieties have stripes. The flesh may be red, orange, yellow or white. The flesh is juicy and crunchy. The seeds are usually black and embedded in the fruit. Its cultivation is confined to the drier savanna region of Nigeria [1,2,3]. It is a traditional food plant in Africa with potential to improve nutrition, boost food security, foster rural development and support sustainable land use [4,5,6,7].

Watermelon is mainly produced in the Northern part of Nigeria and is consumed a lot in the southeastern Nigeria. Hybrid watermelons are taking over fields everywhere because farmers are in search of crops with better qualities. Due to extensive research all over the world for hybrid seeds in recent years, the watermelon growers and consumers now have choice of several improved qualities such as high yield, disease resistant and early maturity.

Despite the numerous economic benefits of the crop, yield across Nigeria is still low [8]. Introduction and selection of exotic tropical varieties with wide adaptability over diverse environment is important.

There is paucity of literature on the growth and yield performances of different exotic tropical watermelon in Agbani and Iwollo agro-ecology of Enugu state, south eastern Nigeria. The objectives of this study were:

1) To test, identify and select the watermelon genotype(s) with the highest adaptability across two agro-environments in a tropical ultisol in Nigeria.
2) To relate the yield parameters of five watermelon varieties to soil properties for determination of their effects on yield variations across two agro-environments.

2. MATERIALS AND METHODS

2.1 Description of the Experimental Sites

This experiment was carried out for 2 consecutive planting seasons (2013 and 2014) at two locations in southeastern Nigeria. The first site was at the Teaching and Research Farm of Faculty of Agriculture and Natural Resources Management, Enugu State University of Science and Technology, Nigeria (06°52'N, 07°15'E; mean elevation 450 m above sea level). The area has an annual rainfall of 1700 – 2010 mm. The rainfall pattern is bimodal and is between April and October, and the dry season is between November and March. The soil's textural class is loam with an isohyperthermic soil temperature regime [9] and is classified as Typic Paleustult [10].

The second site was at the experimental farm of Enugu State College of Agriculture and Agro-entrepreneurship, Iwollo Nigeria (06°26'N; 07°16'E). It has an annual rainfall of about 1800 - 2000 mm which spread between April and November. The textural class is silt-loam [11].

2.2 Field Preparation, Maintenance and Varieties Used

The sites were slashed and cleared of grasses. At each site, a total land area of 15 m x 17 m (255 m^2) was mapped out for the experiment. The experiment was carried out on the same plots in the 2013 and 2014 planting seasons. The field was divided into 4 blocks with each block having 5 experimental units giving a total of 20 plots.

The experimental units were demarcated by 1 m alley and each experimental unit (bed) measured 3 m × 3 m (9 m^2). The experimental beds were prepared manually with traditional hoe. The experimental treatments were five different watermelon varieties which includes four exotic (*New Dragon, Empire, Dark Belle, Koloss*) and a local variety *Kaolack*, which is an open pollinated variety. The treatments were laid out in a randomized complete block design with four replications.

New Dragon has fruit that is oblong shaped, quite uniform and about 5 - 6 kg in weight. It is medium green with dark green stripes. The flesh

is red, finely textured and very sweet. It is a hybrid and matures approximately in 80 days. *Empire* has oval-shape fruit that is long, with narrow dark stripes on light green. It has a beautiful appearance. The fruit is about 6 kg with durable rind. Relative period of maturity is 80 days after planting (DAP). The flesh is bright red and juicy. It is a hybrid. *Dark Belle* is uniquely football sized (small) and oval shaped. It has medium dark green color with darker (instincts) green stripes. It has a thin but tough rind that should ship well. The fruit weighs between 2.5 kg and 4 kg and matures in about 69 days after planting. The dark red flesh is sweet and juicy with fruit flavor that receives numerous positive comments from lovers of watermelon (consumers). It has very high fruit setting and yield. This variety performs even better in hot and dry seasons and adaptable to all types of soil. It is a hybrid. *Koloss* has fruit that is light green with dark green stripes. It is round in shape and weighs about 5 kg to 10 kg. The fruit is sharp red. It has a thick rind that preserves its taste for a long time after harvest. It is a hybrid. *Kaolack* is a very popular variety in Africa. Its fruit weighs about 4 kg to 8 kg. It is round in shape, light green in colour with medium green stripes. The variety has a good post-harvest shelf conservation capacity and long distance transport potentials. *Kaolack* is appreciated by the consumers for its medium red, crispy and sweet flesh.

In this study, *Kaolack* was used as the control due to its popularity in both Northern and Southern Nigeria [12].

The four varieties of exotic tropical water melon seeds were imported from China and were obtained from the Enugu State Ministry of Agriculture and Natural Resources whereas *Kaolack* which was used as the control was purchased from "Technisem Seed Company", the leading vegetable seed distribution company in Nigeria.

The seeds were planted at two per hole at 2 cm depth using a spacing of 1 m x 1 m. A total of 6 plants were planted in each plot making a plant population of 120. Lost stands were replaced. Weeding was also carried out during the period of the experiment usually with the aid of hand hoe at three weeks intervals for three times. Poultry manure was applied at planting of the watermelon seeds. The insecticide used was *Lambda* Cypermethrin which was sprayed at an interval of 10 days and was diluted in 1 ml to 1 liter as recommended by [13]. NPK fertilizer 15-15-15 was applied in bands, 21 days after planting in order to boost the fertility of the soil.

2.3 Data Collection

Data were collected from four plants at the two central rows in each plot. Percent emergence was determined at 10 days after planting. Vine length was determined by measuring the length of the plant from the soil level to the tip of the topmost leaf using a measuring tape at 30 and 60 days after planting. Leaf area index was computed at 30 and 60 days after planting by the equation stated below:

$$\text{Leaf area index} \frac{\text{number of leaves per plant} \times \text{area of leaf per plant}}{\text{Area of land covered by plant}}$$

Yield data were collected at harvest (full maturity). Each plant was harvested separately. Number of fruits per plant was obtained by visual counting of fruits per plant. Fruit weight per hectare was recorded at harvest using electronic weighing balance. Days to 50% flowering was calculated by counting the number of days starting from the day of planting to 50% anthesis.

2.4 Soil Sample Collection and Analysis

Three representative soil samples were randomly collected from each plot and bulked together to form a composite sample. A total of 20 composite soil samples were collected. Soil samples were collected from the top soil at a depth of 0 - 30 cm before planting in both locations. Samples were air dried, ground and passed through a sieve of 2 mm standard mesh size. The soil pH was determined with a pH meter using 1:2.5 soil to water ratio and 1: 2.5 soil to 0.1 N KCl (potassium chloride) suspension according to [14]. Organic carbon was determined using the Walkley and Black wet digestion method [15]. Total nitrogen was determined by micro-kjeldahl procedure [14]. Available phosphorus was extracted with Bray II extractant as described by [16] and determined colorimeterically using ascorbic acid method [17]. Exchangeable potassium was extracted using 1 N ammonium acetate (NH_4OAC) solution and determined by the flame emission spectroscopy as outlined by [18]. Aluminum and Hydrogen content (exchangeable acidity) were determined by titrimetric method after extraction with 1.0 N KCl [19]. The cation exchange capacity was determined by NH_4OAC displacement

method [20]. Calcium and magnesium were determined by the complexiometeric titration method as described by [21]. Particle size distribution analysis was done by the hydrometer method [22].

2.5 Data Analysis

Data collected were subjected to Analysis of Variance (ANOVA) as outlined by [23]. Means were separated using Fishers least significant difference (F-LSD) at 5% probability level. Pearson correlation was done to determine the association between the initial soil properties and the fruit weight at harvest. Statistical analysis was executed using GENSTAT Release 7.2 DE Discovery Edition 3 (2007) [24].

3. RESULTS AND DISCUSSION

3.1 Initial Soil Properties of the Study Sites

Table 1 shows the results of the initial soil properties of the two study sites (Agbani and Iwollo). It indicated that Agbani site had higher percentage of silt (9%) with sandy textural class whereas Iwollo had higher percentage of sand (90%) with sandy textural class.

The soil pH in H_20 for Iwollo was 4.9 and that in potassium chloride was 5.1, which showed acidity and also indicated the presence of strong mineral acids such as Aluminum (0.20 c mol kg^{-1}) and hydrogen (1.40 c mol kg^{-1}). This is evidenced by the presence of low exchangeable cations [Ca^{2+} (3.00 c mol kg^{-1}), Mg^{2+} (1.80 c mol kg^{-1}), K^{+} (0.06 c mol kg^{-1}) and Na^{2+} (0.12 c mol kg^{-1})] with corresponding increase in total nitrogen (0.126%), organic carbon (1.85%) and cation exchange capacity (20.80 c mol kg^{-1}), respectively. Iwollo also had available phosphorus of 7.46 c mol $kg^{-1.}$

At Agbani site, soil pH in water was 6.3 and in potassium chloride it was 5.5 with no aluminum. This indicates that Agbani site is good for watermelon production in terms of pH value. The organic carbon, and total nitrogen contents were found to be 0.49%, and 0.056%, respectively. The exchangeable bases [sodium (Na), potassium (K), calcium (Ca), and magnesium (Mg)] were 0.15 c mol kg^{-1}, 0.10c mol kg^{-1}, 4.40 c mol kg^{-1} and 2.60 c mol kg^{-1}, respectively. The hydrogen content was found to be 1.20 c mol kg^{-1} and available phosphorus (Bray 11) was found to be 15.64 mg kg^{-1} (Table 1). [25] soils at different sites always differ in properties, fertility, texture and structure but even if they are the same, certain factors such as continuous cultivation, climate, soil amendments and other farming activities and management could make them differ in texture and structure which in turn will affect the growth characteristics and yield indices of crops, fertility or nutrient status of the soil.

Table 1. Initial soil properties of the study sites (0 - 30 cm depth)

Parameter	Iwollo	Agbani
Particle size distribution (%)		
Fine sand	90 (2.11)	86 (0.19)
Clay	5 (0.33)	5 (0.47)
Silt	5 (0.13)	9 (0.17)
Soil pH (water)	4.9 (0.82)	6.3 (0.53)
Soil pH (KCl)	5.1 (0.21)	5.5 (0.74)
Organic carbon (%)	1.85 (0.64)	0.49 (0.60)
Total nitrogen (%)	0.126 (0.42)	0.056 (0.65)
Available phosphorus (c mol kg^{-1})	7.46 (0.91)	15.64 (0.18)
Exchangeable bases (c mol kg^{-1})		
Calcium	3.00 (0.54)	4.4 (0.53)
Magnesium	1.80 (0.28)	2.6 (0.61)
Potassium	0.06 (0.34)	0.10 (0.44)
Sodium	0.12 (0.48)	0.15 (0.80)
Exchangeable acidity (c mol kg^{-1})		
Hydrogen	1.40 (1.33)	1.20 (1.11)
Aluminum	0.20 (0.66)	-
Cation exchangeable capacity (c mol kg^{-1})	20.80 (0.55)	11.2 (0.25)

- Not determined in the soil, values in parentheses are standard deviations

3.2 Percentage Emergence of Five Tropical Varieties of Watermelon at 10 Days after Planting

There was no significant differences ($p > 0.05$) in percentage emergence among the water melon varieties observed at 10 days after planting (DAP) in both Agbani and Iwollo sites during 2013 and 2014 planting seasons (Table 2). The results indicated that neither the varietal differences of the treatments nor locational differences affected percentage emergence. [26] observed that seed germination and crop emergence are affected by soil water, soil temperature, soil air, mechanical impedance and some other edaphic factors.

3.3 Leaf Area Index of Five Tropical Varieties of Watermelon at 30 and 60 Days after Planting

There was a significant difference ($p < 0.05$) in the leaf area index at 30 DAP and 60 DAP in Iwollo site. At 30 DAP, *Koloss* had the highest Leaf Area Index (LAI) of 0.74 and 0.71 in 2013 and 2014 followed by *Dark Belle* with LAI of 0.57 and 0.47 and *Empire* 0.47 and 0.48 during the same planting seasons. *New Dragon* had the least LAI of 0.42 and 0.47 in 2013 and 2014 planting season, respectively. However, no significant differences ($p> 0.05$) were observed in the LAI among the varieties grown in Agbani at 30 DAP. In Agbani and Iwollo sites no significant difference ($p > 0.05$) in LAI was observed among the watermelon varieties at 60 DAP in 2013 and 2014 planting seasons. Leaf Area Index is an indicator of plant growth. Varietal differences influences the growth and yield of crops. [20] reported that differences in growth parameters of crops are normally determined by their genetic make-up.

3.4 Vine Length (cm) of Five Tropical Varieties of Watermelon at 30 and 60 Days after Planting

Significant differences ($p < 0.05$) were found between the varieties of watermelon grown in Iwollo and Agbani sites at 30 DAP in 2013 and 2014 planting season. *Koloss* had the longest vine at Agbani and Iwollo sites during the 2013 and 2014 planting seasons with vines measuring 185.5 cm (2013) and 161.3 cm (2014) at Agbani site. It was followed by *Empire* with vines measuring 145.3 cm (2013) and 147 cm (2014) long at the same site (Agbani). *Kaolack* (control) had the shortest vine length of 107.8 cm (2013) and 120.5 cm (2014) at Agbani site. The length of the vines at Iwollo site also followed the same trend in at 30 DAP with *Koloss* having the longest vines of 437 cm (2013) and 427 cm (2014) while *Kaolack* generally had, the shortest vine length of 301 cm (2013) and 255 cm (2014).

From the result obtained (Table 4), there was a significant difference ($p < 0.05$) in the length of the plants vines at 60 DAP in both sites. *Koloss* had the longest vine of 406 cm (2013) and 385 cm (2014) at Agbani site. This was followed by *Empire* which had a vine length of 365 cm (2013) and 375 cm (2014). *Kaolack* (control) gave the shortest length of vines 267 cm (2013) and 335 cm (2014) at Agbani site. Similar trend was observed in the length of vine at Iwollo site. The results indicated that *Koloss* and *Empire* had the highest vegetative growth among the watermelon varieties in both location.

3.5 Days to 50% Flowering of Five Tropical Varieties of Watermelon

The number of days to 50% flowering differed significantly ($p < 0.05$) among the varieties (Table 5) of water melon grown in Agbani and Iwollo site. *Dark Belle* was first to produce both male and female flowers and attained 50% flowering within 29 - 30days after plating at Agbani and Iwollo sites. This was followed by *Koloss* which produced 50 % of its flowers within 30 - 31 DAP, *New Dragon*, 31 - 32 DAP and *Empire* 32 - 34 DAP. The control *(Kaolack*) had 50% flowering within 34 - 37 DAP in 2013 and 2014 planting season in both locations.

Dark Belle, had early fruit setting implying early maturing qualities than the other varieties at Agbani and Iwollo sites. The observed variation in the number of days to 50% flowering agrees with the reports of [27,28,29,30] that hybrid crosses have higher yield potentials and quality.

Table 2. Percentage emergence of five tropical varieties of watermelon (*Citrullus lanatus* L.) at 10 days after planting in Agbani and Iwollo site in 2013 and 2014 planting season

Variety	Agbani		Iwollo	
	2013	2014	2013	2014
New dragon (F_1)	87.50	83.35	87.40	87.48
Empire (F_1)	83.35	87.50	83.33	83.33
Dark belle	83.33	83.33	87.48	83.35
Koloss (F_1)	91.68	83.35	87.48	87.48
Kaolock	87.48	87.48	83.35	87.50
F-LSD $_{(0.05)}$	NS	NS	NS	NS

F-LSD $_{(0.05)}$ - Fishers least significant at 0.05 probability level,
NS – Non significant at 0.05 probability level

Table 3. Leaf area index of five tropical varieties of watermelon (*Citrullus lanatus* L.) at 30 and 60 days after planting in Agbani and Iwollo site in 2013 and 2014 planting season

Variety	Agbani				Iwollo			
	Days after planting							
	30		60		30		60	
	2013	2014	2013	2014	2013	2014	2013	2013
New dragon (F_1)	0.51	0.45	3.68	3.52	0.42	0.47	3.45	3.28
Empire (F_1)	0.59	0.58	3.21	3.25	0.47	0.48	3.78	3.13
Dark belle	0.53	0.49	4.29	4.18	0.57	0.47	3.62	3.46
Koloss (F_1)	0.56	0.61	3.78	3.91	0.74	0.71	4.32	4.36
Kaolock	0.52	0.56	3.08	3.07	0.43	0.47	3.27	3.54
F-LSD $_{(0.05)}$	NS	NS	NS	NS	NS	0.03	1.16	NS

$F\text{-}LSD_{(0.05)}$ - Fishers least significant at 0.05 probability level, NS – Non significant at 0.05 probability level

Table 4. Vine length (cm) of five tropical varieties of watermelon (*Citrullus lanatus* L.) at 30 and 60 days after planting in Agbani and Iwollo site in 2013 and 2014 planting season

Variety	Agbani				Iwollo			
	Days after planting							
	30		60		30		60	
	2013	2014	2013	2014	2013	2014	2013	2013
New dragon (F_1)	132.80	130.80	325.00	375.00	105.00	123.00	276.00	277.00
Empire (F_1)	145.30	147.00	365.00	364.00	143.00	143.00	276.00	276.00
Dark belle	143.80	143.80	365.00	375.00	124.00	129.00	267.00	267.00
Koloss (F_1)	185.50	161.30	406.00	385.00	155.00	164.00	437.00	427.00
Kaolock	107.80	120.50	267.00	365.00	102.00	121.00	301.00	255.00
F-LSD $_{(0.05)}$	1.70	2.20	2.04	NS	0.17	0.02	0.003	1.02

$F\text{-}LSD_{(0.05)}$ - Fishers least significant at 0.05 probability level, NS – Non significant at 0.05 probability level

Table 5. Days to 50% flowering of five tropical varieties of watermelon (*Citrullus lanatus* L.) in Agbani and Iwollo site in 2013 and 2014 planting season

Variety	Agbani		Iwollo	
	2013	2014	2013	2014
New dragon (F_1)	32.20	32.50	31.50	32.50
Empire (F_1)	32.00	33.50	34.00	34.00
Dark belle	30.00	30.00	29.70	30.00
Koloss (F_1)	30.50	30.70	31.00	31.50
Kaolock	36.20	35.70	34.20	37.00
F-LSD $_{(0.05)}$	5.90	4.30	3.40	0.03

$F\text{-}LSD_{(0.05)}$ - Fishers least significant at 0.05 probability level

3.6 Number of Fruits of Five Tropical Varieties of Watermelon at Harvest

The results in Table 6, showed a significant differences ($p < 0.05$) for the number of fruits of watermelon varieties grown in Agbani site during 2013 and 2014 planting seasons. *Dark Belle* had the highest number of fruits [8.5 (2013) and 5.25 (2014)] in Agbani site, followed by *Koloss* 5.0 (2013) and 3.75 (2014) and *Kaolack* (control) 5.0 (2013) and 3.5 (2014). However, fruit shedding was observed in all the varieties. Female flowers were heavily shed during early fruiting in both 2013 and 2014 planting season.

Empire and *New Dragon* gave the least number of fruits of 4.5 (2013) and 1.0 (2014), 3.0 (2013) and 1.75 (2014) respectively at Agbani site. The same trend was also observed in Iwollo site though no significant difference ($p > 0.05$) was found among the varieties. However, *Empire* and *New Dragon* yielded no fruit at Iwollo in 2013 and 2014 planting seasons. Pest and diseases also contributed to the decrease in fruit number at maturity in both Agbani and Iwollo sites.

Furthermore, from the comparison of the two study areas, it showed that all the watermelon varieties had a higher number of fruits at Agbani site than Iwollo site in 2013 and 2014. The actual number of fruit set will depend on variety, cultural practices, environmental/soil conditions, irrigation and number of pollinating insects. Moreover, *Dark Belle* produced the first fruit before other varieties did in both locations during the seasons. *Dark Belle* had the highest fruit number across

the sites in 2013 and 2014 and is hereby recommended for famers in Agbani and areas with similar soils and ecological conditions.

3.7 Fruit Weight (t ha^{-1}) of Five Tropical Varieties of Watermelon at Harvest

There was a significant differences ($p < 0.05$) in the weight of water melon fruits only at Agbani in 2013 and 2014 planting seasons. *Dark Belle* had the highest fruit weight of 13.04 t ha^{-1} and 8.08 t ha^{-1} in 2013 and 2014 cropping season, respectively at Agbani site, followed by *Koloss* with 9.96 t ha^{-1} and 6.61 t ha^{-1} at the same site. *Kaolack* (control) had 9.96 t ha^{-1} and 5.77 t ha^{-1}. *New Dragon* had 8.28 t ha^{-1} and 4.13 t ha^{-1} while Empire gave the least fruit weight of 7.98 t ha^{-1} and 2.83 t ha^{-1}at Agbani site in 2013 and 2014 planting seasons. At Iwollo site, *Dark Belle* gave a maximum yield of 1.75 t ha^{-1} and 0.81 t ha^{-1}. However, *New Dragon* and *Empire* had no fruit yield at Iwollo in 2013 and 2014 planting seasons.

Table 6. Number of fruits of five tropical varieties of watermelon (*Citrullus lanatus* L.) in Agbani and Iwollo site in 2013 and 2014 planting season

Variety	Agbani		Iwollo	
	2013	2014	2013	2014
New dragon (F_1)	3.00	1.70	0.00	0.00
Empire (F_1)	4.50	1.20	0.00	0.00
Dark belle	8.50	5.20	1.00	0.50
Koloss (F_1)	5.00	3.70	0.20	0.40
Kaolock	5.00	3.50	0.70	0.20
F-LSD $_{(0.05)}$	1.30	0.05	NS	NS

F-LSD$_{(0.05)}$- Fishers least significant at 0.05 probability level, NS – Non significant at 0.05 probability level

Table 7. Fruit weight (t ha^{-1}) of five tropical varieties of watermelon (*Citrullus lanatus* L.) in Agbani and Iwollo site in 2013 and 2014 planting season

Variety	Agbani		Iwollo	
	2013	2014	2013	2014
New dragon (F_1)	8.28	4.13	0.00	0.00
Empire (F_1)	7.98	2.83	0.00	0.00
Dark belle	13.04	8.08	1.75	0.81
Koloss (F_1)	9.96	6.61	0.53	0.42
Kaolock	9.96	5.77	1.36	0.42
F-LSD $_{(0.05)}$	2.08	3.10	NS	NS

F-LSD$_{(0.05)}$- Fishers least significant at 0.05 probability level, NS – Non significant at 0.05 probability level

Table 8. Relationship between fruit weight of watermelon (*Citrullus lanatus* L.) and soil initial properties in Agbani and Iwollo site in 2013 and 2014 planting season

Parameter	Agbani		Iwollo	
	2013	2014	2013	2014
Clay	0.852**	0.950***	0.613*	0.772**
Silt	0.382	0.521*	0.742**	0.711**
Sand	-0.513*	-0.679*	-0.514*	-0.579*
Soil pH (water)	0.714**	0.623*	0.841**	0.781**
Soil pH (KCl)	0.526*	0.701**	0.540*	0.710**
Organic carbon	0.959***	0.716**	0.848**	0.714**
Total nitrogen	0.711**	0.681**	0.574*	0.660*
Available phosphorus	0.551*	0.689*	0.642*	0.712**
Calcium	0.677*	0.812**	0.814**	0.722**
Magnesium	0.527*	0.837**	0.963***	0.794**
Potassium	0.645*	0.731**	0.976***	0.811**
Sodium	0.525*	0.772**	0.819**	0.925***
Hydrogen	-0.762**	-0.827**	-0.927***	-0.847**
Aluminum	∞	∞	-0.846**	-0.872**
Cation exchangeable capacity	0.753**	0.587*	0.885**	0.744**
Base saturation	0.411	0.526*	0.476	0.361

*∞ - Not determined in the soil, * = Significant at 0.05 probability level (2 - tailed), ** = Significant at 0.01 probability level (2 - tailed), *** = Significant at 0.001 probability level (2 - tailed)*

Comparing the fruit weight of the varieties of watermelon in both locations, varieties grown in Agbani site gave higher fruit weight than Iwollo site in 2013 and 2014 planting season. Low yield of all the varieties at Iwollo site could be attributed to the high soil acidity level, presence of aluminum and high exchangeable cations observed in the soil. According to [31] soil acidity is a major cause of low crop yield throughout the humid tropics and this has been associated with aluminum and manganese toxicity and deficiencies caused by imbalances among the basic cations. The implication of these is that nutrient status of Iwollo site has been affected by erosion/leaching. [32,33] noted that the loss of soil productivity following erosion is manifested in unfavorable chemical change which impair the overall fertility status of agricultural land resulting in loss of essential elements through run–off and sediments. *Dark Belle* was found to perform better than other varieties in both locations with maximum fruit weight of 13.04 t ha^{-1} at Agbani site in 2013 planting season. Based on the results of this study, the high fruit yield of *Dark Belle* at Agbani site during the experimental period could be related to the ability of *Dark Belle* to effectively adapt to the environmental factors of Agbani location. *Dark Belle*, *Koloss* and *Kaolack* are recommended for Agbani soil and soils under similar conditions and location.

3.8 Relationship between Fruit Weight of Watermelon at Harvest and Initial Soil Properties at Iwollo and Agbani Agro-Environments of Enugu State, South-Eastern Nigeria

Fruit weight correlated positively with clay and silt at Agbani and Iwollo sites in 2013 and 2014 cropping season, whereas a negative association was observed between percent sand and the fruit weight in the same period. The correlation coefficient (r) between fruit weight and percent sand was -0.513 (2013) and -0.679 (2014) in Agbani site whereas it was- 0.514 (2013) and -0.579 (2014) in Iwollo site. This indicated that the percent sand at both sites had inverse relationship with fruit yield. Therefore, the percentage sand increased with decreasing effect on fruit weight of watermelon.

The results also revealed that fruit weight showed positive correlation 0.714 (2013) and 0.623 (2014) in Agbani site and 0.841 (2013) and 0.781 (2014) in Iwollo site with soil pH. Organic carbon and total nitrogen also had a positive correlation with fruit weight. Fruit weight at harvest increased as organic carbon and total nitrogen increased. Exchangeable cations correlated positively with the fruit weight at both locations. This indicates that calcium, magnesium, sodium and potassium resulted in increased fruit weight of watermelon at Agbani and Iwollo sites respectively. However, there is an inverse relationship between hydrogen content [-0.762 (2013) and -0.827 (2014)] in Agbani site and [-0.927 (2013) and 0.847 (2014)] in Iwollo site and fruit weight at harvest. In Iwollo site, a Negative correlation between aluminum [-0.872 (2013) and -0.846, (2014)] and fruit weight was observed. Whereas, in Agbani site aluminum was not observed in the soil. This means that increase in aluminum and hydrogen content resulted in decrease of watermelon fruit weight at harvest. According to [30], in the root of plants, aluminum has been shown to interfere with many physiological processes including the intake and transport of calcium and other essential nutrients, cell division, cell wall formation and enzyme activities and thus suppresses crop growth and yield.

4. CONCLUSIONS

The results presented in this study indicated that water melon varieties grown in Agbani site had higher fruit weight per hectare at harvest than Iwollo site. *Dark Belle* was found to perform best compared with the other varieties in terms of fruit weight at harvest in both locations with maximum yield of 13.04 t ha^{-1} at Agbani site in 2013 planting season.

Dark Belle, *Koloss* and *Kaolack* are recommended for Agbani soil and soils under similar conditions and location. *Dark Belle* is identified as the best adapted variety of watermelon for Agbani and Iwollo soils and locations of Enugu State. However, Iwollo soil and soils under similar conditions and location may not be good for commercial watermelon production during the rainy seasons.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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