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Original Research

Varietal and Spatiotemporal Bearings on Watermelon (*Citrullus lanatus* (Thunb.) Mansf.) Production in Calabar, Nigeria

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ABSTRACT

Purpose: *An empirical study was conducted in Calabar, Nigeria, from August to November 2019 to determine how planting dates and varieties affected rainfed watermelon (Citrullus lanatus ((Thunb.) Mansf.)) growth and yield. Calabar holds the potential to support watermelon cultivation, but detailed information on its agronomic requirements is lacking in this area.*

Research Method: *The experimental conditions included three planting dates (7 August, 27 August, and 16 September 2019) and four watermelon varieties (Koloss, Sugar Baby, Kaolack, and Heracles). The treatment combinations were organized in split-plots and placed into a randomized complete block design, with three replications.*

Findings and Values: *All the watermelons planted on August 27 performed better than those planted on August 7 and September 16. The main vine length, number of leaves, number of branches, leaf area index, relative growth rate, and net assimilation rate showed that watermelon planted on August 27 performed best. A significant increase (P < 0.05) in fruit yield, weight, girth, length, sugar content, and number of fruits was observed on the 27 August planting date compared to August 7 and 16 September planting dates. The August 27 planting date yielded 77.29 and 129.39 more fruit than August 7 and September 16, respectively. Heracles and Koloss yielded more fruit per hectare than the others. Fruit yield was ranked as follows: Heracles > Koloss > Kaolack > Sugar Baby. Heracles and the planting date of August 27 had a significant effect on fruit production. The production cost 3 and economic returns analysis showed that August 27 was the best time to plant Heracles watermelon in Calabar.*

Keywords: *Economic returns, Fruit growth, Planting date, Rainforest, Watermelon.*

INTRODUCTION

In accordance with Chomicki *et al.* (2020), watermelon, scientifically known as *Citrullus lanatus* ((Thunb.) Mansf.), is a member of the Cucurbitaceae family and is indigenous to tropical and subtropical regions of Africa (Chomicki & Renner 2015). In the 1850s, David Livingstone discovered watermelon growing wild in the Kalahari Desert in Botswana (Wehner 2008). Due to its delicious water and pulp, people around the world widely grow the crop (Dupriez & de Leener 1989). The crop originated in Africa and has since spread to other regions of the world, including Asia, Europe, North America, and other regions (Chomicki & Renner 2015).

Based on the data provided by FAO (2025), China (mainland) (1.488million ha), India (126,000 ha), the Russian Federation (97,334 ha)

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, Senegal (90,938 ha), and Brazil (80,833 ha) are the top fivecountries in terms of area harvested. In terms of production, China (63.8 million tonnes), India (3.63 million tonnes), Türkiye (3.15 million tonnes), Algeria (2.51 million tonnes), and Brazil (1.78 million tonnes) are the top five countries, whereas the Dominican Republic (337,743 kg/ha), Botswana (122,725 kg/ha), Guyana (115,128 kg/ha), Tunisia (103,966 kg/ha), and Greece (61,657 kg/ha) are areas with the highest yields (FAO 2024, 2025).

Even though most of the watermelon production in Nigeria takes place in the northern regions of the country, there does not appear to be any official watermelon production figure available for Nigeria. There have been indications that watermelon and some specialty fruit crops production can be expanded to southern parts of Nigeria (Obok *et al.* 2022, Obok *et al.* 2023, Obok *et al.* 2024). The ability of mature watermelon fruits to serve as a substitute for water is one of the many advantageous characteristics of the crop, in addition to the high nutritive value that they possess (Nadeem *et al.* 2022). The fruits contain a higher concentration of glucose, fructose, amino acids, malic acid, carotene, and fat (Meghwar *et al.* 2024, Nissar *et al.* 2025).

Choosing the right time to plant watermelon gives it the opportunity to fully express its genetic potential and adapt to its environment (Mousa 2017, Dube *et al.* 2021). Several studies have demonstrated that the timing of planting crops influences their overall performance (Rameeh 2012, Qiang *et al.* 2024a, Qiang *et al.* 2024b). It is possible for crops to be subjected to water and heat stresses if the planting dates are not chosen correctly (Passioura 2006).

Several factors have been identified as having an impact on watermelon production; these include biotic and abiotic challenges (Uwah *et al.* 2010, Sarria 2015, Malueva & Bocherova 2020, Bello *et al.* 2021, Yankova & Boteva 2022). These factors include the incorrect selection of planting dates and the utilization of varieties that produce low yields (Mrema & Maerere 2018, Dube *et al.* 2021). The timing of watermelon planting is an important factor in guaranteeing the highest possible yield, and seasonal differences in fruit numbers have also been reported (Gichimu *et al.* 2010). Some researchers found that the growth and yield attributes of different watermelon varieties were affected by genetic differences (Tindall 1986, Anburani *et al.* 2019, Abd Rabou & El-Sayd 2021, Naroui Rad *et al.* 2025).

There is a significant relationship between environmental and agronomic factors and the growth and yield of diverse crop species in Nigeria (Aladele *et al.* 2025). According to the findings of Uwah *et al.* (2010) and Obok *et al.* (2023), environmental factors have the potential to significantly impact the yield performance of watermelon varieties in terms of the number of fruits produced, the weight of the fruits, and the amount of sugar that is contained in the fruits. To satisfy the growing demand for fruit vegetables in Nigeria and to complement the production of significant fruit vegetables like watermelon, it is necessary to introduce and increase production in non-traditional agroecological areas that can support watermelon cultivation.

The first step is to determine the optimal time to sow the crop in these regions. This is an essential step, given that environmental changes occasioned by climate change could impact the optimum planting date of crops (Ritchie, 2024). For example, this procedure has been reported for watermelon (Paroon *et al.* 2019, Melo *et al.* 2020), other cucurbits (Helaly 2023, Olarewaju *et al.* 2023), maize (Baum *et al.* 2020, Cui & Xie 2022), rice (An 2020, Zhang *et al.* 2023), wheat (Nouri *et al.* 2017), and sorghum (Getachew *et al.* 2021). The primary purpose of our research was to ascertain the cultivation dates and watermelon types that are most ideal for maximizing watermelon output in Calabar, a non-traditional watermelon-growing area that is in the southeastern humid tropical agroecological zone of Nigeria.

MATERIALS AND METHODS

A field experiment was carried out at Calabar, Nigeria, from August to November 2019.

Calabar is located at longitude 8°20’E, latitude 4°58’N, about 39 m above sea level. Based on a data analysis between 1992 and 2021, Calabar has an annual rainfall range of 2282.8 to 7094.3 mm, an evaporation range of 2.3 to 2.9 mm, wind speed ranges from 3 to 5 knots, solar radiation ranges from 15.9 to 19.8 $MJ/m^2/year$, sunshine ranges from 2.6 to 4.4 hours, a maximum temperature range of 30.2 to 31.7°C, a soil temperature range of 26.1 to 28.9°C, and a relative humidity of 83 to 91 percent (Agbiji *et al.* 2024).

Our study investigated the influence of planting dates and varieties on the performance of watermelon in Calabar. Four varieties of watermelon (*Heracles, Koloss, Kaolack, and Sugarbaby*) were tested under three planting dates (August 7, August 27, and September 16). The treatment combinations were laid out in a split-plot arrangement fitted into a randomized complete block design (RCBD) with three replicates. Plot size was 5.4 m × 4.2 m (22.68 m^2), while the net plot size was 2.4 × 1.2 m (2.88 m^2), respectively. The replicates were separated by a 1.5 m path, while the plots were 1 m apart.

Four tagged plants in the net plot area provided the estimated growth and yield attributes. Soil samples were collected for routine physicochemical soil property analysis, according to Brady & Weil (2008). Watermelon seeds were sown at a depth of 2 to 5 cm using a 1.2 × 1.2 m planting distance.

Two seeds were sown per hole, and the seedlings were later thinned to one per stand at 2 weeks after planting (WAP). Weeding was done manually with a hand hoe at 3, 6, and 9 weeks after sowing. The response of plants to treatments was evaluated from data collected from the net plot area, which was first at 3 WAP and subsequently at every 2-week interval.

The following growth and yield attributes were measured as described by Obok *et al.* (2022), Obok *et al.* (2023), Obok *et al.* (2024), following the International Plant Genetic Resources (IPGRI) and guidelines for melons (IPGRI 2003), United States Department of Agriculture (USDA)/ Agricultural Research Service (ARS)/ Germplasm Resources Information Network (GRIN) descriptors for watermelon and the Union for the Protection of New Varieties of Plants (UPOV) descriptors (European Cooperative Programme for Plant Genetic Resources 2008): number of days to 50%, length of main vine, number of leaves per plant, number of branches per plant, leaf area index, crop growth rate, relative growth rate, net assimilation rate, number of days to first harvest, number of fruits, weight of fruits, fruit girth, fruit length, fruit total sugar content, and total fruit yield. We subjected the generated data to an analysis of variance using the statistical software GenStat package (Version 8.1). Significant means were compared using Fisher’s Least Significant Difference (LSD) Test at a 95% confidence level. Production cost and economic return analysis was carried out to determine the profit or loss incurred in the production process as described by Itam *et al.* (2018).

RESULTS AND DISCUSSION

The soil used in the experiment was sandy loam, had a low pH of 4.7, was rich in available phosphorus at 18.90 mg/kg, and had a base saturation of 85.1% (Table 1).

Spatio-temporal influence on watermelon growth and yield performances

The effect of planting dates was significant on the length of the main vine, number of leaves, number of branches, leaf area index, relative growth rate, net assimilation rate, number of days to 50% flowering, number of days to first harvest, and total sugar content of fruits (Tables 2–6). The effect of planting dates was equally significant ($P < 0.05$) on the number of fruits per plant, the weight of fruit at harvest (kg), fruit girth (cm), and total fruit yield (t/ha) (Table 6).The August 27 planting date outperformed the August 7 and September 16 planting dates by 77.29% and 129.39%, respectively, in terms of the number of fruits produced per plant. Equally, the effect of planting dates on the weight of melon was significant ($P < 0.05$). The August 27 planting date outperformed the August 7 and September 16 planting dates by 15.50% and 47.5%, respectively, in terms of weight of fruits.

Table 1. Physico-chemical properties of experimental soil.

Property	Value
Sand (%)	86.6
Silt (%)	5.3
Clay (%)	8.1
Textural class	Sandy loam
Soil pH (H_2O)	4.7
Organic carbon (%)	0.7
Available P (mg/kg)	18.9
Total nitrogen (%)	0.09
Exchangeable Ca^+ (cmol/kg)	3.0
Exchangeable Mg (cmol/kg)	1.6
Exchangeable K (cmol/kg)	0.09
Exchangeable Na (cmol/kg)	0.13
Exchangeable Al^+ (cmol/kg)	0.19
Exchangeable H^+ (cmol/kg)	0.08
Effective Cation Exchange Capacity (cmol/kg)	5.66
Base Saturation (%)	85.1

The total fruit yield obtained from the August 27 planting date was equally higher than those of the August 7 and September 16 planting dates, by 14.84% and 46.16%, respectively (Table 6). The superior performance of the watermelon planted on August 27 over the other planting dates could be attributed to changes in agro-climatic conditions during the growth period, particularly the differences observed in rainfall, temperature, and sunshine hours (Table 9).The results agree with the findings of Passioura (2006), Akpan *et al.* (2016), and Čimo *et al.* (2022). The study's results indicate that growing watermelon during excessive rainfall leads to conditions that reduce sunlight (Table 9) and decrease yield. Ufoegbune *et al.* (2014) reported that growing watermelon during periods of erratic rainfall resulted in low yield; watermelon yield losses are highest during rainy and humid seasons, according to Pereira *et al.* (2017). We observed better watermelon performance during periods of both adequate and moderate rainfall, as indicated by the planting date of August 27 (Table 9). Our result agreed with Mrema & Maerere (2018) that favourable conditions of alternate cool and dry periods support watermelon growth and yield.

Varietal influence on watermelon growth and yield performances

The *Heracles* variety of watermelon showed much longer main vines, more leaves and branches per plant, a better leaf area index (LAI), faster growth rate, higher net assimilation rate, and more total sugar in the fruits compared to the other varieties. Furthermore, the *Heracles* variety displayed a significantly higher number of fruits per plant, heavier fruits, wider fruit girths, and a higher total fruit yield (t/ha), with the *Koloss* variety following closely behind (Tables 4–6). The *Heracles* variety out-yielded the *Koloss*, *Kaolack*, and *Sugarbaby* varieties by 2.02%, 6.82%, and 63.9%, respectively, in terms of the number of fruits per plant. Similarly, the *Heracles* variety out-yielded the *Koloss*, *Kaolack*, and *Sugarbaby* varieties by 3.92%, 40.70%, and 106.49%, respectively, in terms of the weight of fruits produced. In terms of total fruit yield per hectare, the *Heracles* variety outperformed *Koloss*, *Kaolack*, and *Sugarbaby* by 9.58%, 45.67%, and 114.34%, respectively.

Table 2. Length of main vine (cm) and number of leaves per plant as influenced by planting dates and varieties of watermelon in Calabar, Nigeria.

Treatment	Length of main vine (per plant) (cm)			Number of leaves (per plant)		
	5WAP	7WAP	9WAP	5WAP	7WAP	9WAP
Planting date (PD)						
August 7 (PD1)	95.54	198.60	275.1	25.5	79.40	109.53
August 27 (PD2)	107.29	332.37	336.29	31.29	125.99	128.99
September 16 (PD3)	87.98	169.74	266.96	23.37	51.56	64.66
±*SEM*	5.62	50.10	21.88	2.37	21.71	19.05
LSD (0.05)	10.25	18.08	30.07	3.51	11.91	9.52
Variety (V)						
Koloss (V1)	90.27	235.34	289.26	28.42	97.16	106.44
Sugarbaby (V2)	57.82	187.72	228.87	21.23	70.86	75.03
Kaolack (V3)	89.03	227.08	272.12	28.62	96.85	105.00
Heracles (V4)	106.63	263.11	320.97	39.96	111.68	115.39
±*SEM*	10.19	15.57	19.20	1.97	8.50	8.78
LSD (0.05)	14.14	20.87	34.72	1.05	15.75	10.99
PD × V interaction						
PD1 × V1	95.29	192.87	248.75	27.45	76.10	108.44
PD1 × V2	64.79	153.58	222.56	20.87	66.32	67.57
PD1 × V3	96.88	228.32	235.75	20.20	73.96	109.72
PD1 × V4	125.21	219.14	393.46	26.64	102.11	130.04
PD2 × V1	113.20	320.62	331.63	33.04	135.44	160.44
PD2 × V2	83.35	228.75	281.56	35.33	96.82	124.56
PD2 × V3	115.32	244.54	305.38	37.22	128.89	165.61
PD2 × V4	117.00	535.56	428.46	33.42	143.75	167.72
PD3 × V1	62.32	170.20	287.29	19.25	54.95	84.39
PD3 × V2	54.89	181.83	182.50	31.32	34.20	83.00
PD3 × V3	54.89	208.37	275.00	28.12	50.97	83.01
PD3 × V4	77.39	235.63	246.00	27.16	66.16	87.91
±*SEM*	7.43	18.41	13.33	1.74	10.25	10.10
LSD (0.05)	10.95	36.16	17.16	NS	NS	NS

WAP = Weeks After Planting; NS = not significantly different at 95% confidence level. LSD = least significant difference. SEM = standard error of mean values.

Table 3. Number of branches per plant and leaf area index as influenced by planting dates and varieties of watermelon in Calabar, Nigeria.

Treatment	Number of branches per plant			Leaf area index		
	5WAP	7WAP	9WAP	5WAP	7WAP	9WAP
Planting date (PD)						
August 7 (PD1)	2.16	7.73	7.78	0.78	1.07	1.22
August 27 (PD2)	3.25	8.56	8.90	1.28	1.26	1.35
September 16 (PD3)	2.41	6.86	7.27	0.94	1.29	1.30
±*SEM*	0.33	1.39	1.59	0.15	0.22	0.09
LSD (0.05)	0.30	0.91	0.85	0.17	0.25	0.10
Variety (V)						
Koloss (V1)	3.05	8.21	9.00	1.40	1.71	1.81
Sugarbaby (V2)	2.46	6.29	6.40	0.80	1.03	1.09
Kaolack (V3)	3.02	8.36	9.62	1.50	1.70	1.82
Heracles (V4)	3.30	8.04	7.91	1.33	1.65	1.86
±*SEM*	0.18	0.85	0.92	0.17	0.16	0.13
LSD (0.05)	0.15	0.98	0.19	0.19	0.22	0.11
PD × V interaction						
PD1 × V1	2.88	7.39	8.95	0.97	1.09	1.44
PD1 × V2	1.60	6.08	6.70	0.60	0.73	0.84
PD1 × V3	2.73	6.13	7.33	0.66	0.83	1.36
PD1 × V4	2.41	7.32	8.13	0.89	1.63	1.27
PD2 × V1	3.31	8.82	9.13	1.31	1.69	1.95
PD2 × V2	2.71	7.08	7.33	0.87	1.43	1.20
PD2 × V3	3.55	8.55	12.95	1.52	1.70	1.79
PD2 × V4	3.43	9.78	6.20	1.45	1.21	1.45
PD3 × V1	2.97	8.43	8.92	1.92	2.36	2.03
PD3 × V2	3.07	5.71	5.17	0.93	0.93	1.23
PD3 × V3	2.77	10.39	8.60	1.31	1.56	2.31
PD3 × V4	3.65	6.03	7.26	1.10	1.37	1.71
±*SEM*	0.17	0.87	1.75	0.25	0.11	0.09
LSD (0.05)	NS	1.82	1.69	NS	NS	0.21

WAP = Weeks After Planting; NS = not significantly different at 95% confidence level. LSD = least significant difference. SEM = standard error of mean values.

Table 4. Relative growth rate (g/g/d) and Net assimilation rate (g/m^2/d) as influenced by planting dates and varieties of watermelon.

Treatment	Relative growth rate (g/g/d)			Net assimilation rate (g/m^2/d)		
	5WAP	7WAP	9WAP	5WAP	7WAP	9WAP
Planting date (PD)						
August 7 (PD1)	0.11	0.14	0.21	3.10	19.01	20.31
August 27 (PD2)	0.13	0.14	0.22	3.91	18.64	20.68
September 16 (PD3)	0.13	0.12	0.17	4.62	22.68	24.00
±*SEM*	0.01	0.04	0.06	1.31	2.91	8.05
LSD (0.05)	NS	NS	0.06	NS	NS	NS
Variety (V)						
Koloss (V1)	0.13	0.18	0.24	3.76	33.08	39.31
Sugarbaby (V2)	0.07	0.14	0.14	2.05	21.51	32.90
Kaolack (V3)	0.13	0.10	0.20	4.10	19.64	29.40
Heracles (V4)	0.13	0.14	0.21	5.65	28.08	28.68
±*SEM*	0.02	0.02	0.05	1.51	3.86	8.78
LSD (0.05)	NS	0.02	NS	NS	NS	16.10
PD × V interaction						
PD1 × V1	0.14	0.18	0.20	6.49	22.21	23.10
PD1 × V2	0.08	0.15	0.14	2.02	17.61	20.80
PD1 × V3	0.11	0.11	0.24	2.60	18.70	19.05
PD1 × V4	0.10	0.11	0.27	1.30	17.52	18.30
PD2 × V1	0.15	0.24	0.30	4.40	25.65	33.12
PD2 × V2	0.06	0.10	0.17	2.67	17.93	18.47
PD2 × V3	0.13	0.14	0.23	3.67	18.26	20.10
PD2 × V4	0.20	0.08	0.20	4.30	12.97	11.03
PD3 × V1	0.10	0.12	0.21	2.40	51.39	61.72
PD3 × V2	0.06	0.17	0.10	1.45	29.00	59.42
PD3 × V3	0.32	0.07	0.12	6.03	21.96	48.05
PD3 × V4	0.10	0.22	0.17	11.36	54.04	56.71
±*SEM*	0.02	0.02	0.07	1.65	6.84	8.78
LSD (0.05)	0.02	NS	NS	NS	NS	NS

WAP = Weeks After Planting; NS = not significantly different at 95% confidence level. LSD = least significant difference. SEM = standard error of mean values.

Table 5. Number of days to 50% flowering, first fruiting, first harvest and total sugar content of fruits (%) as influenced by planting dates and varieties of watermelon.

Treatment	No of days to 50% flowering	No of days to first fruiting	No of days to first harvest	Total sugar content of fruits (%)
Planting date (PD)				
August 7 (PD1)	33.08	50.42	76.83	4.40
August 27 (PD2)	29.50	39.67	65.00	4.28
September 16 (PD3)	32.17	48.08	72.83	4.22
±*SEM*	1.07	3.26	3.47	0.05
LSD (0.05)	1.13	0.76	1.37	NS
Variety (V)				
Koloss (V1)	30.74	45.33	72.00	4.51
Sugarbaby (V2)	28.41	41.11	66.44	4.25
Kaolack (V3)	30.80	46.11	72.11	4.02
Heracles (V4)	30.94	45.67	75.67	4.60
±*SEM*	0.61	1.16	1.91	0.15
LSD (0.05)	1.31	0.88	1.58	0.04
PD × V interaction				
PD1 × V1	31.33	49.33	78.33	4.78
PD1 × V2	29.67	52.33	76.33	4.07
PD1 × V3	35.00	54.67	76.00	4.03
PD1 × V4	31.33	45.33	73.67	4.37
PD2 × V1	29.33	39.33	64.33	4.37
PD2 × V2	28.00	31.67	61.67	4.00
PD2 × V3	30.33	36.33	66.00	4.00
PD2 × V4	30.33	31.33	68.00	4.75
PD3 × V1	30.67	47.33	67.67	4.37
PD3 × V2	27.67	39.67	60.67	3.67
PD3 × V3	33.67	47.33	74.33	4.03
PD3 × V4	31.67	48.33	77.67	4.37
±*SEM*	0.60	2.00	1.86	0.08
LSD (0.05)	NS	1.52	2.74	NS

WAP = Weeks After Planting; NS = not significantly different at 95% confidence level. LSD = least significant difference. SEM = standard error of mean values.

Table 6. Number of fruits (per plant), weight of melon (kg), fruit girth (cm), fruit length (cm), and total fruit yield (t/ha) at harvest as influenced by planting dates and varieties of watermelon.

Treatment	Number of fruits per plant	Weight of melon (kg)	Fruit girth (cm)	Fruit length (cm)	Total fruit yield (t/ha)
Planting date (PD)					
August 7 (PD1)	3.39	2.58	48.12	38.60	17.92
August 27 (PD2)	4.60	2.98	50.92	39.20	20.58
September 16 (PD3)	2.62	2.02	39.72	36.50	14.08
±*SEM*	1.03	0.25	3.22	0.78	1.89
LSD (0.05)	0.51	0.25	4.01	NS	2.11
Variety (V)					
Koloss (V1)	4.65	3.06	52.67	39.90	20.87
Sugarbaby (V2)	2.77	1.54	34.35	31.60	10.67
Kaolack (V3)	4.25	2.26	40.68	36.18	15.77
Heracles (V4)	4.54	3.48	44.63	44.16	22.87
±*SEM*	0.57	0.16	3.18	1.57	1.19
LSD (0.05)	0.49	0.09	4.70	6.01	2.44
PD × V interaction					
PD1 × V1	3.78	3.35	55.85	43.11	20.26
PD1 × V2	2.55	2.29	39.12	32.10	11.96
PD1 × V3	3.55	3.01	46.23	33.09	16.00
PD1 × V4	3.65	2.68	49.85	45.12	22.21
PD2 × V1	6.06	3.46	52.67	39.30	24.70
PD2 × V2	2.77	1.86	37.30	31.40	11.68
PD2 × V3	6.06	2.50	41.25	36.43	16.48
PD2 × V4	3.62	3.51	49.00	43.16	29.47
PD3 × V1	4.12	2.36	50.50	36.40	17.64
PD3 × V2	1.84	0.47	26.32	31.41	8.37
PD3 × V3	2.97	1.28	34.57	36.30	14.47
PD3 × V4	2.79	3.09	39.64	43.80	17.03
±*SEM*	0.50	0.16	3.18	1.57	1.19
LSD (0.05)	0.84	NS	NS	NS	NS

WAP = Weeks After Planting; NS = not significantly different at 95% confidence level. LSD = least significant difference. SEM = standard error of mean values.

Table 7. Production cost and economic returns for watermelon production at three planting dates (cost and revenue are expressed in Naira).

Item	Planting Date		
Materials and inputs (Cost)	August 7	August 27	September 16
Land acquisition	20,000	20,000	20,000
Seeds purchase	20,000	20,000	20,000
Fertilizer purchase	24,000	24,000	24,000
Tools and implements	10,000	10,000	10,000
Labour	25,000	25,000	25,000
Total Cost	99,000	99,000	99,000
Output (revenue)			
Number of fruits	242	374	230
Weight of fruits (kg)	2.5 – 3.0	2.8 – 3.2	2.0 – 2.5
Price of fruits	450 – 600	550 – 700	400 – 500
Total Revenue	108,900 – 145,200	205,700 – 261,800	92,000 – 115,000
Gross Revenue	127,050	233,750	103,500
Net Profit	28,050	134,750	4,500

Table 8. Production cost and economic returns analysis for four varieties of watermelon production (cost and revenue are expressed in Naira).

Item	Watermelon Variety			
Materials and inputs (Cost)	Koloss	Sugarbaby	Kaolack	Heracles
Land acquisition	10,000	10,000	10,000	10,000
Seeds purchase	10,000	3,000	6,000	11,000
Fertilizer purchase	8,000	8,000	8,000	8,000
Tools and implements	10,000	10,000	10,000	10,000
Labour	9,000	8,000	9,000	9,000
Total Cost	47,000	40,000	43,000	48,000
Output (revenue)				
Number of fruits	196	103	138	203
Weight of fruits (kg)	2.5 – 3.0	1.5 – 2.0	1.8 – 2.5	2.9 – 3.2
Price of fruits	450 – 600	250 – 400	300 – 450	500 – 700
Total Revenue	88,200 – 117,600	25,750 – 41,200	41,400 – 62,100	101,500 – 142,100
Gross Revenue	102,900	33,475	51,750	121,800
Net Profit	55,900	6,525	8,750	73,000

Table 9. Weather data (mean values) at the experimental location (Calabar) in 2019.

Month	Rainfall (mm)	Temperature (°C)	Sunshine (Hrs)	Relative Humidity (%)
January	25	24.5	11.9	79
February	55	28.5	12.0	83
March	187	29.6	12.1	82
April	149	28.8	12.2	81
May	273	27.6	12.4	83
June	555	25.9	12.4	85
July	753	25.1	12.4	91
August	310	24.4	12.3	88
September	233	25.6	12.1	88
October	286	26.1	12.0	81
November	156	24.6	11.9	80
December	93	23.2	11.8	80
Total	3075	313.9	145.5	1001
Mean	256	26.1	12.1	83
±SEM	60.78	0.58	0.06	1.10

Source: Department of Geography and Regional Planning, University of Calabar, Calabar. SEM = standard error of mean values.

The better performance of the *Heracles* variety compared to the other varieties can be attributed to differences in genetic makeup among the varieties studied. The superiority exhibited by the *Heracles* and *Koloss* varieties over the rest of the varieties could be attributed to the fact that both varieties were F1 hybrids, while *Kaolack* and *Sugarbaby* were native varieties. Improved varieties of crops are bred to make maximum use of available nutrients from the soil compared to the local varieties, which then resulted in higher fruit yields (Uwah & Solomon 1999).*Heracles* and *Koloss* had better growth characteristics and longer growth periods in the field than the other varieties (Tables 2–5). The higher fruit production of *Heracles* and *Koloss* varieties was likely due to a big increase in important features like the number of leaves and branches on each plant, which helped them capture more sunlight and move nutrients around better.Significant differences in certain growth and yield attributes observed among the varieties can be attributed to their genetic makeup. The higher number of leaves, number of branches, longer vines, higher number of fruits per plant, and superior yield attributes exhibited by *Heracles* and *Koloss* varieties were apparently due to genetic factors (Chadha 2001). Anburani *et al.* (2019) reported high heritability (broad sense) for 100-seed weight, number of seeds per fruit, single fruit weight, vine length, fruit diameter, fruit length, flesh thickness, number of male flowers, sex ratio, yield per plant, number of primary branches per plant, number of female flowers, and number of fruits per plant.

This was inconsistent with part of our results. The environment primarily controls these characters genetically, influencing them only to a limited extent. Our results on the outcome in the performance of watermelon due to varietal differences agree with the reports of Tindall (1986), Blomberg (2004), and Achigan-Dako (2008), which emphasized that there was a significant difference in the growth and yield performance of different varieties of watermelon. Sari & Solmaz (2023) further explained that watermelon has an extensive diversity, especially at the fruit and seed level, and different characters at the ploidy level; seedlings, leaves, flowers, fruits, and seeds in watermelons are used to characterize the species distinctions.

Spatio-temporal × Variety interactions influence watermelon growth and yield performance.

Interaction between the August 27 planting date and the *Heracles* variety revealed better performance in longer length of main vine, higher number of leaves per plant, higher number of branches per plant, larger leaf area index, higher relative growth rate, higher net assimilation rate, higher total sugar content of fruits, higher number and heavier weights of fruits, wider fruit girth, and higher total fruit yield (Tables 2–6).The significantly higher number of fruits per plant produced from the interaction of the August 27 planting date and the *Heracles* variety can be attributed to the superior attributes at the vegetative growth phase (Tables 2–5). The outcome of the interaction effect further indicated that the combined influence of environmental and genetic factors allows the watermelon plant to fully express its growth and yield potential. Akpan *et al.* (2016a), Dia *et al.* (2016b), Oraegbunam *et al.* (2016), and Malambane *et al.* (2021) reported that environmental and genetic differences can lead to varying performance in watermelon. Additionally, watermelon fruits exhibit significant diversity in terms of fruit size, shape, rind thickness, color, flesh texture, sugar content, carotenoids, flavonoids, and nutritional value (Choudhary *et al.* 2023), and part of these were in consonance with the results obtained from our study.

Production cost and economic returns are influenced by planting dates and varieties of watermelon.

The outcome of the economic returns for different planting dates indicated that producing watermelon on August 27 resulted in the highest quantity and weight of fruits, leading to the greatest revenue and maximized profit. Compared to the August 7 and September 16 planting dates, the August 27 planting date maximized profit at N134,750, which was followed by the August 7 planting date with a profit of N28,050, while the September 16 planting date had the least profit of N4,500 (Table 7). Furthermore, the economic returns for the *Heracles* variety showed the highest profit of N73,800 compared to the other varieties grown (Table 8). Economic return showed that the *Sugarbaby* variety suffered a loss of N6,525. The profit and loss incurred from the four varieties were in the following order: *Heracles* (N73,800) > *Koloss* (N55,900) > *Kaolack* (N8,750) > *Sugarbaby* (N6,525) (Table 8). Economic analysis has shown that the August 27 planting date for the *Heracles* variety yielded the highest profit, followed by those planted on August 7.

CONCLUSIONS

The findings of the study revealed that the August 27 planting date influenced the better performance of watermelon in Calabar. The *Heracles* variety had the best performance in growth and yield parameters when compared with other varieties used for the study. The *Heracles* variety responded better to the August 27 planting date because it exhibited superior performance relative to the other varieties in most of the measured parameters, as well as higher economic returns and profit. Therefore, the *Heracles* variety is recommended for cultivation in Calabar during late August to maximize yield as well as high economic returns and profits from the production. There is a need to include more watermelon varieties in subsequent studies, as this will enable wide choices for adaptation in areas outside Calabar and adoption by the farmers. Subsequent studies should also consider early planting seasons (March–April) in Calabar and its environs. Also, agricultural lime could be applied in areas with extremely low soil pH.

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