Traits Association of Canary Melon (*Cucumis melo* L. var. *inodorous*) Grown in a Humid Tropical Environment

Ekemini Edet OBOK (✉)
Aniekeme Christopher UKPONG
Emmanuel MACHA

Summary

A two-year field study was conducted to investigate the growth and productivity of canary melon in a humid tropical rainforest environment in Nigeria. The study used the 'Juan' cultivar and evaluated twelve traits across four sowing periods. Results showed that total rainfall, sunshine duration and relative humidity remained similar across the two-year period, but significant differences in mean maximum and minimum temperatures were observed. The interaction of year and season significantly impacted plant characteristics, including seed germination, number of leaves per plant, vine thickness, vine length, leaf area, leaf area index, number of fruits per plant, fruit weight, fruit volume, rind thickness, total soluble solid contents and fruit yield. The study identified three clusters based on similarities and differences in canary melon traits, which could be useful for selecting traits to improve canary melon in humid tropical environments.

Key words

cluster analysis, cucurbits, fruit breeding, tropics

Crop Improvement Unit, Department of Crop Science, Faculty of Agriculture, University of Calabar, Calabar, Cross River State, Nigeria

✉ Corresponding author: e.e.obok@unical.edu.ng

Received: July 3, 2024 | Accepted: August 27, 2024 | Online first version published: December 27, 2024

Introduction

The *Cucurbitaceae* family, which includes, cucumbers, gourds, melons, pumpkins and squashes, includes hundreds of wild species and cultivated varieties (Jeffrey, 1990; Schaefer and Renner, 2010). These species are used (grown) for their fleshy, usually edible, pericarp. This edible pericarp can be sweet, as in muskmelons (cantaloupe), honeydew melons or watermelons, or starchy, as in gourds, pumpkins, and squashes (Gebhardt et al., 1982). While cucurbit fruits are not significant sources of calories or protein, they can be important sources of dietary fibre, minerals, pro-vitamin A (beta-carotene) and vitamin C (Gebhardt and Thomas, 2002; Falade et al., 2020; Obok et al., 2023). One of the species in the *Cucurbitaceae* family, canary melon (*Cucumis melo* L. var. *inodorus*), originated in Africa and Southwest Asia and over time has travelled from Africa to Asia to Europe and to North America (Sabo et al., 2013). Canary melon is also known as Golden Langkawi in Malaysia for its striking golden yellow colour and dense white flesh (Adeyeye et al., 2017). Canary melons are recorded as having arrived in Italy in the late 15th century (Sturtevant, 1919; Pitrat et al., 2000; Goldman, 2002; Pistrick, 2003). It is an important commercial crop in many countries and is mostly cultivated in the temperate regions of the world due to its good adaptation to temperate soil and climate (Villanueva et al., 2004; Zulkarami et al., 2010). The total yield of melon (including cantaloupes) in Africa in 2020 was 224.50 t ha^{-1} with the following five countries as top producers: Morocco (30.0 t ha^{-1}), Egypt (27.5 t ha^{-1}), Sudan (24.0 t ha^{-1}), South Sudan (22.6 t ha^{-1}) and Niger (22.4 t ha^{-1}) (FAOSTAT, 2022). In Nigeria, canary melon is mostly grown in the northern part of the country, particularly Gombe, Taraba and Bauchi, where it is popular because of its sweet pulp and pleasant aroma (Adeyeye et al., 2017). The fruit is high in dietary fibre, rich in bioactive compounds such as phenolic flavonoids and vitamins as well as carbohydrates and minerals especially potassium, but low in fat and calories (Schaffer et al., 1987; Schaffer et al., 2000; Villanueva et al., 2004). It is not cultivated and consumed in southern parts of Nigeria as is the case in the north. It is evident that canary melon is an import fruit vegetable in West Africa (Fajinmi et al., 2022), but there is no study that is currently exploring the improvement of its growth and yield traits in the humid tropical agroecology of Nigeria. Ayeni (2020) studied the effect of year and planting density on postharvest quality of canary melon and Akinyode et al. (2019) investigated the performance of canary melon in different soil types in southwestern Nigeria. Other studies on canary melon (off-field) in Nigeria researched the nutrient composition of canary melon seeds and their oil characteristics (Raji and Orelaja, 2014; Warra et al., 2015; Yangomodou et al., 2021). Studies have shown that the association of qualitative and quantitative traits of *Cucumis melo* are important for selection and improvement during growth, at harvest and post-harvest (Schaffer et al., 2000; Burger et al., 2006; Hatem et al., 2014; Khoshnam et al., 2015; Chikh-Rouhou et al., 2021). The aim of our study was to evaluate the performance of canary melon in Calabar over two years and then assess important growth and yield traits that could contribute to its improvement and subsequently other breeding purposes focusing on the humid tropical environment.

Materials and Methods

The experiment was conducted in 2021 and 2022 at the Department of Crop Science Teaching and Research Farm, the University of Calabar, Calabar, Cross River State. In each of the years, planting was done twice, in March and September, which coincided with the early and late planting seasons in the humid tropical rain forest of Nigeria, respectively. Canary melon fruits, *Cucumis melo* L. var. *inodorous*, was sourced and identified using descriptors for melon (*Cucumis melo* L.) according to the International Plant Genetic Resources Institute (IPGRI, 2003). Freshly harvested mature canary melon fruits were sourced from fruit vegetable farmers from Abuja, the Federal Capital Territory. Selected fruits were cleaned by washing in water then cut into two halves. Seeds were extracted by hand, then washed inside a sieve under running tap water to completely remove fruit pulp. The seeds were placed on paper towel and air-dried indoors for 72 hours. The pH of the experimental site has been previously reported by Obok et al. (2022) and is 4.13. Melons generally require a soil pH range of 5.5 to 6.5 (Obok et al., 2023). Agricultural lime ($CaCO_3$), was purchased from the Cross River State Agricultural Development Programme Office, Calabar, Cross River State. The field experiment was laid out in a randomized complete block design (RCBD) with three replications (blocks). Raised beds were made (4.0 m (length) × 2.5 m (breadth) × 0.3 m (height)). Agricultural lime ($CaCO_3$) was uniformly broadcast on the beds at the rate of 2 t ha^{-1} according to Obok et al. (2022) then worked into the soil by minimal tillage at a depth of 20 cm. A period of 7 days was allowed between lime application and sowing. No lime was applied in subsequent seasons. Seeds were sown at a depth of 2 – 3 cm using a spacing of 50 cm intra-row and 100 cm inter-row. Three seeds were planted per hole and were thinned to one plant per stand 14 days after sowing. Each bed (20 plants per 10 m^2) had 20 stands of fully established canary melon plants (20,000 plants per hectare). Manual weeding was done two and six weeks after planting (WAP). The experiment was entirely under rainfed conditions. Inorganic fertilizer, NPK 20:10:10 was uniformly applied at the rate of 80 kg N ha^{-1} (400 g NPK 20:10:10 per 10 m^2 plot) at 2 WAP which coincided with the first weeding. Insect pest attack was prevented using a systematic insecticide (marketed as Fighter® 35 EC) with the following active ingredients – lambda-cyhalothrin 15 g L^{-1} + acetamiprid 20 g L^{-1}. This was applied at the rate of 430 mL ha^{-1} for cucurbits (22 mL per 15 L knapsack sprayer, i.e., 0.45 ml in 306.8 mL of water to cover 10 m^2 (20 plants). Each plant received 15.36 mL of the mixture as foliar sprays at 2WAP and 4WAP. The net plot for each treatment plot in the bed was 1 m × 1 m, which accommodated six tagged plants for data collection. The following growth and yield data were obtained as described by IPGRI (2003):

1) Seedling emergence (%) – In each treatment plot (i.e., each bed), the total number of seeds that germinated and successfully emerged from the soil at 7 DAP were counted and expressed as a percentage of the total number of seeds planted per plot.
2) Number of leaves per seedling – The average number of fully opened leaves per seedling was counted in each plot.
3) Number of leaves per plant at maturity – The number of leaves per sampled plant was obtained by counting all leaves per plant in each plot.

4) Vine length (cm) – The length of each primary vine was measured using a rigid graduated metal tape positioned at the base of the vine at ground level to newly fully opened terminal leaves.
5) Vine thickness (mm) – At the mid-point of each vine length (i.e., at 50% of the entire vine length), vine thickness was measured using an electronic vernier calliper.
6) Leaf breadth (cm) – The horizontal dimension of the widest point on the leaf lamina was measured and leaf length was subsequently taken.
7) Leaf length (cm) – The vertical dimensions of fully mature and completely opened healthy and photosynthetically active leaves were taken at the mid-rib of the leaf – i.e., from the apex of the leaf to the point where the petiole terminates on the leaf lamina.
8) Leaf area (cm^2) – The leaf area was obtained as a product of the leaf length, leaf breadth and a constant (0.67) (Wu et al., 2010), adopted for a morphologically related *Cucumis melo* L.), muskmelon, with heart-shaped leaf lamina similar to canary melon.
9) Leaf area index – The leaf area index was calculated from the leaf area. It was expressed as leaf area multiplied by the number of leaves per plant then divided by plant spacing.
10) Number of fruits per plant – The number of mature and ripe fruits were counted per stand.
11) Fruit weight (g) – The weight of freshly harvested individual fruit at harvest was determined using a weighing balance.
12) Fruit volume (ml) – The fruit volume immediately after harvest was obtained using the water displacement method (Archimedes' principle of flotation). The volume of water displaced was equal to the volume of the fruit measured.
13) Rind thickness (mm) – The rind thickness was obtained by cutting the fruit horizontally, into two halves using a knife, then measuring the peel width using a hand-held electronic vernier calliper.
14) Total soluble solids (°Brix) – The sweetness of the fruits was assessed by extracting juice from the pulp of fully grown fruits that had been sliced in half after being collected. The proportion of total soluble solids was determined by measuring a homogenised sample of the fruit flesh and recording the percentage of solids directly from a Brix Scale placed over the refractive index scale. The Brix percentage was measured using a small handheld °Brix refractometer (RZ Brix RHB-32ATC model, YHEQUIPMENT CO., China).
15) Fruit yield ($t\ ha^{-1}$) – This was estimated as the total weight of fresh fruit obtained per plot (bed) (4 m × 2.5 m) then expressed on a per hectare (10,000 m^2) basis.

Treatment and replicate mean of all growth and yield data were subjected to a two-way analysis of variance (ANOVA) and Pearson's bivariate correlation analysis using GenStat 16th Edition (Snell and Simpson, 2021). Duncan's New Multiple Range (DNMRT) used for the post-hoc test was performed at the $P \leq 0.05$ significance level. Hierarchical cluster analysis and Ward's method as the distance of similarity were conducted using PAST software version 4.10 (Hammer and Harper, 2001).

Results

Meteorological Conditions during Research (2021 and 2022)

A t-test was used to compare the mean monthly rainfall, total rain days, minimum and maximum temperature, sunshine duration and relative humidity across the two-year period of the study (Table 1). The mean differences between the total rainfall, total rain days, sunshine length and relative humidity in 2021 and 2022 were not statistically significant ($P > 0.05$). The difference in mean minimum temperature and mean maximum temperature between 2021 and 2022 was shown to be statistically significant ($P \leq 0.01$). In 2022, there was a drop in the overall amount of rainfall, the average highest temperature, the duration of sunshine and the relative humidity. In contrast, in 2021, there was a decrease in the number of days with rainfall and the average lowest temperature.

Year, Planting Season and Year × Planting Season Effects on Canary Melon Cultivation

From Table 2, the analysis of variance (ANOVA) in terms of the main effects, the year only had significant effect on the number of leaves per plant, vine thickness, vine length and total soluble solids of the canary melon grown in Calabar in 2021 and 2022. The field growth and establishment of canary melon is shown in Fig. 1. However, the latter year values were higher than the former year. The seasonal effect was significantly observed for seed germination, leaf area (LA), leaf area index, number of fruits per plant, fruit weight, fruit volume, rind thickness, total soluble solids and fruit yield of the canary melon. When interactions effects were considered from ANOVA of the proportion of canary melon seeds that germinated at 7 days after sowing, year × planting season had highly significant effect on this growth attribute. ANOVA for growth and yield data obtained at maturity (harvest) showed that year × planting season had significant effect on the mean number of leaves per canary melon plant, thickness of canary melon vines and total soluble solids of mature canary melon fruits. However, year × planting season had no significant effect on the length of canary melon vines, leaf area and leaf area index of mature canary melon leaves, the number of mature fruits obtained per plant, weight and volume of harvested mature fruits, thickness of the mature fruit rind and final fruit yield. The highest proportion of canary melon seeds that germinated was obtained in the late planting season (September) of 2021 (93.73%) and 2022 (96.56%). The lowest seed germination value (64.27%) was obtained in the early planting season (March) of 2021. However, seed germination in the late planting season of 2021 was statistically similar to values obtained in the early plating season of 2022 (88.56%). The average number of leaves per plant ranged from 26.53 (early planting season, 2021) to 72.35 (late planting season, 2022). Number of leaves per plant in the early (26.53) and late (33.93) planting seasons of 2021 were statistically similar. The range of vine thickness values were the lowest in early planting seasons (3.81 – 5.69 mm) and the highest in the late planting seasons (4.32 – 6.77 mm). The highest vine thickness value (6.77 mm) obtained in late planting season of 2022 was significantly different from all other values. The shortest vines were obtained in the early planting season of 2021 whereas the longest vines were obtained in the late planting season of 2022; these were statistically different.

Table 1. Meteorological conditions in Calabar obtained from mean monthly values of years 2021 and 2022

Weather data	2021	2022	|Mean Difference|	T-test$_{0.05\ (df = 11)}$
Total rainfall (mm)	246.31	195.87	50.44	ns
Total rain days	14.75	15.17	0.42	ns
Mean maximum temperature (°C)	32.09	31.27	0.82	*
Mean minimum temperature (°C)	23.30	23.71	0.41	**
Sunshine duration (h)	4.56	4.24	0.32	ns
Relative humidity (%)	81.25	80.75	0.50	ns

Note: |*, ** -Mean difference| is significant at the $P < 0.05$ and 0.01 levels, respectively (2-tailed). ^{ns} = not significant at $P < 0.05$.

Table 2. Year, planting season, year × planting season effects on growth and yield traits of canary melon in Calabar

Trait	Year (Y)		T-test$_{0.05\ (df = 10)}$	Season (S)		T-test$_{0.05\ (df = 10)}$	2021		2022		LSD$_{0.05}$
	2021	2022		2021	2022		Early	Late	Early	Late	Y × S
Growth											
Seed germination (%)	79.00	92.56	*ns*	76.41	95.15	*	64.27	93.73	88.56	96.56	6.286
Number of leaves per plant	30.23	57.94	**	35.04	53.14	*ns*	26.53	33.93	43.54	72.35	8.361
Vine thickness (mm)	4.06	6.23	***	4.75	5.54	*ns*	3.81	4.32	5.69	6.77	0.398
Vine length (m)	1.63	2.83	**	1.94	2.53	*ns*	1.32	1.94	2.55	3.11	0.279
Leaf area (cm^2)	69.87	73.44	*ns*	58.94	84.37	***	57.60	82.10	60.20	86.60	9.041
Leaf area index	0.01	0.01	*ns*	0.01	0.02	***	0.011	0.016	0.012	0.017	0.002
Yield											
Number of fruits per plant	2.75	3.33	*ns*	2.50	3.58	*	2.00	3.50	3.00	3.67	1.119
Fruit weight (g)	229.76	272.04	*ns*	203.91	297.89	**	199.80	259.70	208.00	336.10	65.058
Fruit volume (mL)	297.96	315.40	*ns*	227.32	386.04	***	216.40	379.50	238.20	392.60	56.525
Rind thickness (mm)	16.86	18.94	*ns*	14.59	21.21	**	14.41	19.31	14.76	23.12	4.290
Total soluble solids (°Brix)	15.85	17.68	*	15.97	17.56	*	14.70	17.00	17.24	18.12	0.454
Fruit yield (t ha^{-1})	15.76	16.92	*ns*	8.41	24.26	**	8.20	23.30	8.60	25.20	9.074

Note: |*, **, *** -T-tests for Year and Planting Season effects are significant at $P < 0.05$, 0.01 and 0.001 levels, respectively (2-tailed). LSD$_{0.05}$ = least significant difference at 95% confidence level for Y × S interactions effect; *ns* = not significant at $P < 0.05$.

Leaves with the largest surface areas (82 – 86 cm^2) were obtained from late planting seasons in both years. While the values of the leaf area of canary melon were lower (57 – 60 cm^2) in the first planting season of each year, these were not significantly different. The leaf area index followed the same pattern observed for leaf area. The value of the average number of fruits per plant was higher in the second planting season of 2022 (3.67) and lower in the early planting season of 2021 (two fruits per plant). However, the number of fruits in the early planting of 2022 (three fruits per plant) was statistically similar to all other seasons across the years. The heaviest fruits were obtained when canary melon was sown in the late planting season of 2022 (336.10 g) and this weight was significantly different from all other harvests. No statistically significant differences were obtained in the weight of mature individual fruits harvested from late (259.68 g) and early (199.83 g) plantings of 2021 as well as early planting of 2022 (207.98 g).

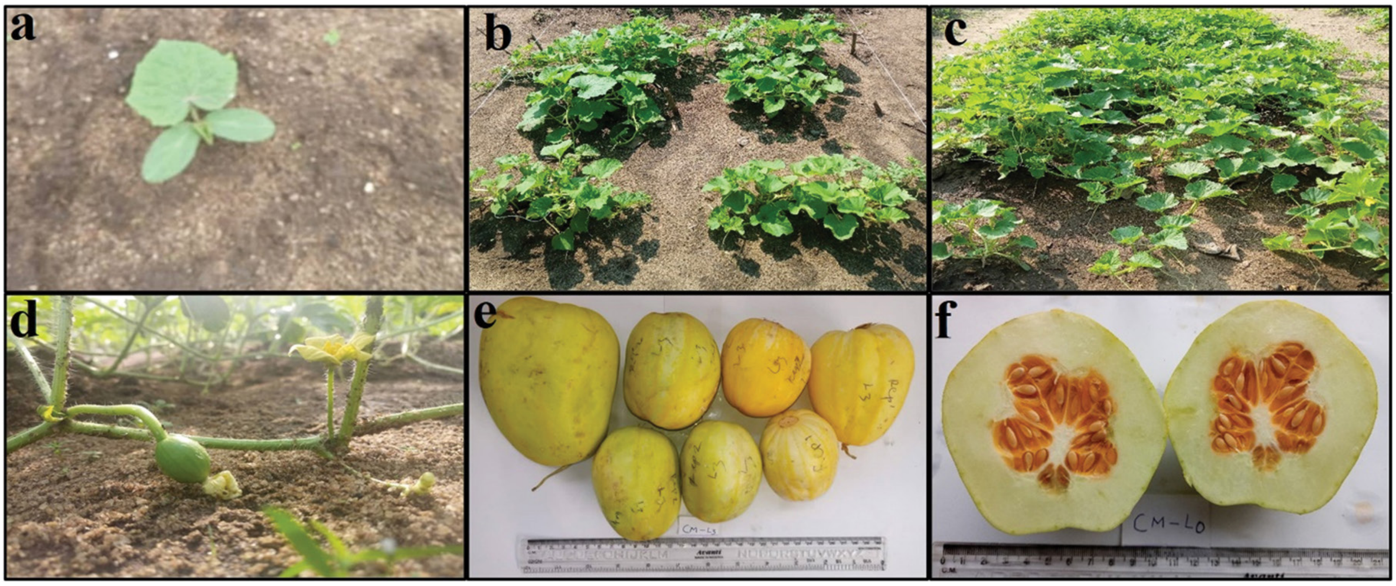

Figure 1. Canary melon plant at different growth stages (a – d) and at harvest (e – f). (a – seedling at 10 days after planting (DAP), b – established plants at 30 DAP, c – established plants at flowering, d – fruits formation stage, e – harvested mature fruits and f – transverse section of mature fruit).

The fruit volume, rind thickness and yield followed a similar pattern of observations obtained from the individual fruit weights at harvest, but fruits harvested, fruit volume and rind thickness values obtained from canary melon cultivated during the late cropping season of 2021 were statistically similar ($P > 0.05$) to those obtained from crops planted in the late cropping season of 2022. On the average, total soluble solids of canary melon mature fruits expressed as total soluble solids in this study were found to be highest and lowest in fruits harvest from plants that were sown in the late and early planting season, respectively, in 2022 and 2021. The sweetest and highest fruit yield accompanied late planting of canary melon in Calabar over the two-year period.

Pearson's Bivariate Correlation and Cluster Analysis of Canary Melon Phenotypic Traits

The results from a pooled correlation analysis of combined growth and yield attributes data of canary melon grown in Calabar in the early and late planting seasons of 2021 and 2022 are presented in Table 3. These correlation results show that seed germination is positively associated with the number of leaves per plant, vine thickness, vine length, leaf area, leaf area index, the number of fruits per plant, fruit weight, fruit volume, rind thickness, total soluble solids and fruit yield. Also, leaf area, leaf area index and fruit volume have no significant association with vine thickness and vine length. The number of fruits per plant is strongly associated positively with all canary melon attributes measured in the study. The vine thickness and length have no association with the fruit volume, rather these two attributes positively influence fruit weight and number of fruits per plant. Leaf area and leaf area index are not associated with either vine length or vine thickness. Though it was observed that fruit yield had no significant association with the number of leaves per plant, vine thickness and vine length, fruit sweetness had positive association, ranging from 0.698 to 0.944, with the 10 growth and yield traits of canary melon considered in this study. Based on these, cluster analysis was conducted to further understand these associations. The results from the cluster analysis (Fig. 2) of all the phenotypic traits measured for canary melon in the study revealed that these traits were grouped into three clusters based on their similarity (dissimilarities) using Ward Linkage. Cluster 1 (blue) is composed of seed germination, total soluble solids and number of fruits per plant. Cluster 2 (red) contains number of leaves per plant, vine thickness and vine length. Cluster 3 (green) represents the largest cluster and consists of six phenotypic attributes of canary melon, namely leaf area, leaf area index, fruit volume, fruit yield, fruit weight and rind thickness.

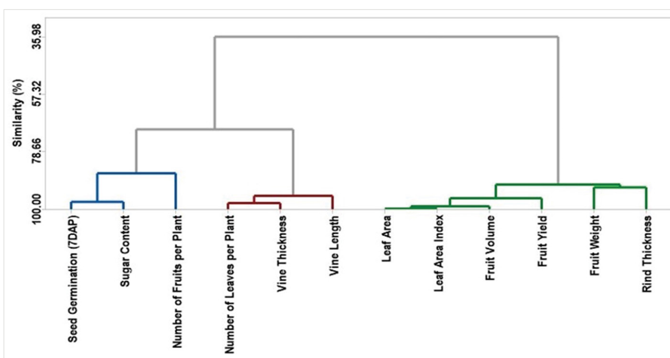

Figure 2. Dendrogram of cluster analysis of the growth and yield traits of canary melon using Ward linkage

Table 3. Pooled bivariate correlation analysis of growth and yield traits of canary melon in Calabar over two years (2021 and 2022)

	Seed germination (%)	Number of leaves per plant	Vine thickness (mm)	Vine length (m)	Leaf area (cm²)	Leaf area index	Number of fruits per plant	Fruit weight (g)	Fruit volume (ml)	Rind thickness (mm)	Total soluble solids (°Brix)
Number of leaves per plant	0.662*										
Vine thickness (mm)	0.679*	0.957**									
Vine length (m)	0.780**	0.900**	0.943**								
Leaf area (cm²)	0.765**	0.615*	0.497	0.563							
Leaf area index	0.742**	0.589*	0.468	0.528	0.997**						
Number of fruits per plant	0.777**	0.606*	0.596*	0.609*	0.814**	0.827**					
Fruit weight (g)	0.690*	0.740**	0.640*	0.666*	0.902**	0.890**	0.770**				
Fruit volume (ml)	0.747**	0.602*	0.483	0.541	0.981**	0.987**	0.847**	0.836**			
Rind thickness (mm)	0.640*	0.738**	0.585*	0.621*	0.857**	0.867**	0.764**	0.839**	0.884**		
Total soluble solids (°Brix)	0.944**	0.810**	0.841**	0.911**	0.719**	0.698*	0.795**	0.706*	0.719**	0.707*	
Fruit yield (t ha^{-1})	0.655*	0.561	0.432	0.509	0.934**	0.939**	0.806**	0.853**	0.944**	0.907**	0.650*

Note: |*, ** -Mean difference| is significant at the $P < 0.05$ and 0.01 levels, respectively (2-tailed). ^{ns} = not significant at $P < 0.05$.

Discussion

The first report on the possibility of growing canary melon in the humid tropical rain forest of Nigeria was made in 2022 (Obok et al., 2022). The aim of the study was limited to the establishment of an appropriate lime amount that could support the growth of this crop in the acid soil conditions characteristic for the humid tropics. The focus of this present study was motivated by the need to find out the associations between the various growth and yield attributes of canary melon which could provide useful information about their performance and the possibility of its improvements to compete with other fruit vegetable crops like watermelon and cucumber which are gradually gaining acceptance in the southern part of the country – a non-traditional home for such crops. From this study it is established that with he recommended lime rate of 2 t ha^{-1} we were able to grow the canary melon for four cropping seasons within two years in the humid tropics on southern Nigeria. This revalidated the earlier report by Obok et al. (2022). Year and season and their interaction effects have been reported to significantly influence canary melon cultivation in Calabar under rainfed and subsistence level farming. This is in agreement with Burger et al. (2006) on the fact that the melon (*Cucumis melo* L.) has a high degree of variation, especially in its fruit characteristics, which offers numerous opportunities for enhancing its genetics through the processes of introgression and recombination. In addition, Silva et al. (2019) report that melon growing requires high production technology, modern irrigation and intense fertiliser and agricultural chemical application. Breeders want stable yields and new cultivars that adapt to different environments. Also, according to Silva et al. (2019), producers agree that melon need to produce at least equivalent of 25.0 t ha^{-1} to be profitable. The results from our study showed that this volume of yield was obtainable in Calabar when the crop was cultivated during the second cropping seasons (September) in both years. Melon with outstanding fruit quality has a premium value both for consumption and marketing. The primary determinant of fruit quality in *Cucumis melo* is flavour, with a big factor being the total soluble solids, specifically sucrose (Burger et al., 2006). Cheema et al. (2011) point out that water stress makes mature *Cucumis melon* sweeter; this is a common farming practice that farmers use. Although water stress was not intentionally induced in this study, our results clearly indicate that in canary melon fruits °Brix values were lower during the early planting season (March) compared to the late planting season (September). These seasons are typically associated with high and low amount of rainfall, respectively.

It is possible to choose better genotypes by using correlation analysis to show how traits in plants are related. In our study, we have found that there is a positive association between total soluble solids of the fruits and all growth and yield attributes of canary melon that were evaluated. According to a report by Whitaker and Davis (1962), there is a correlation between high fruit density and the thickness of fruit flesh. Consequently, fruits exhibiting a greater thickness of rind demonstrate a correspondingly higher density. This finding is consistent with the results obtained from our study, where fruit volume and fruit weight showed strong positive correlations with rind thickness. In this study we found that number of fruits per plant and total soluble solids were in the same cluster. This striking result was in complete agreement with (Tomar et al., 2008). They proposed that giving more importance to the number of fruits per plant and the total soluble solids would be beneficial for an efficient selection programme aimed at improving fruit yield in *Cucumis melo*. This recommendation was based on their discovery that both the number of fruits per plant and the total soluble solids had a positive and direct impact on fruit yield per plant. Cheema et al. (2011) also reported that there was a positive correlation between fruit yield and fruit weight, number of fruits per plant and number of leaves per plant. Once again, this aligns partially with our research results, as we observed significant positive correlations between fruit yield and fruit weight. Additionally, both variables were classified into the same group through cluster analysis.

Conclusion

The results of this research reveal that there are differences in the expression and association of growth and yield traits of canary melon as influenced by variations in year, planting season and year × planting season interactions effect. Late season planting of canary melon in the humid tropical rainforest is recommended especially where rainfed agriculture is practiced. The strong positive correlation between seedling germination and all other phenotypic traits measured in the study shows that optimum plant establishment at sowing plays an important role in determining superior qualitative and quantitative traits in canary melon production. Important phenotypic traits for consideration in the improvement of canary melon were grouped into three: floral attributes (vine length, vine thickness and number of leaves per plant), photosynthetic efficiencies and fruits attributes (leaf area, leaf area index, fruit volume, fruit weight, fruit rind thickness and final fruit yield) and optimum plant establishment and fruit quality attributes (seed germination, number of fruits per plant and fruit sweetness). Canary melon cultivation should not be limited to a specific area in the tropics, we should cultivate additional varieties of canary melon in newer areas to enhance our understanding of genetic diversity in fruit quality traits and their interrelationships. This knowledge will enable us to develop unique combinations of attractive fruit traits in different agroecological areas.

Acknowledgements

We thank the Crop Improvement Unit of the Department of Crop Science, Faculty of Agriculture, University of Calabar for providing the enabling environment and logistics to carry out this study.

CRediT authorship contribution statement

Ekemini Edet OBOK: Conceived the project, supervised, revised and edited the draft and final mauscript. **Ekemini Edet OBOK, Aniekeme Christopher UKPONG**: Conceptualised, investigated, performed most of the experiments, analysed the data and drafted the manuscript. **Emmanuel Macha:** Performed some of the experiments and contributed to the editing of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Adeyeye A. S., Akanbi W. B., Olalekan K. K., Lamidi W. A., Othman H. J., Ishaku M. A. (2017). The Growth and Yield Performance of Sweet Melon as Affected by Planting Spacing in Northeast Nigeria. Int. J. Res. Agric. For. 4 (8): 17-21.

Akinyode E., Okafor B., Akinleye O. (2019). Investigations into the Performance of Canary Melon in Two Soil Types of Savannah Transition Ecology of Nigeria. In: Proceedings of 37th Annual Conference of the Horticultural Society of Nigeria Faculty of Agricultural Technology, Rufus Giwa Polytechnic, Owo, Ondo State, pp. 362 – 366.

Ayeni O. (2020). Effects of Population Due to Intra-Row Spacing on Postharvest Quality of Golden Melon Fruits. Nig Agric J 51 (3): 248-253.

Burger Y., Sa'ar U., Paris H. S., Lewinsohn E., Katzir N., Tadmor Y., Schaffer A. A. (2006). Genetic Variability for Valuable Fruit Quality Traits in *Cucumis melo*. Isr J Plant Sci 54 (3): 233-242. doi: 10.1560/IJPS_54_3_233

Cheema K. L., Iqbal M., Niaz S., Shafique M. (2011). Assessment of Variability of Muskmelon. Int J Veg Sci 17 (4): 322-332. doi: 10.1080/19315260.2011.554969

Chikh-Rouhou H., Tlili I., Ilahy R., R'him T., Sta-Baba R. (2021). Fruit Quality Assessment and Characterization of Melon Genotypes. Int J Veg Sci 27 (1): 3-19. doi:10.1080/19315260.2019.1692268

Fajinmi O. O., Olarewaju O. O., Arthur G. D., Naidoo K., Coopoosamy R. M. (2022). A Review of the Role of the *Cucurbitaceae* Family in Food Security in West Africa. J Med Plants Econ Dev 6 (1): a155. doi: 10.4102/jomped.v6i1.155

Falade O. S., Otemuyiwa I. O., Adekunle A. S., Adewusi S. A., Oluwasefunmi O. (2020). Nutrient Composition of Watermelon (*Citrullis lanatus* (Thunb.) Matsum. & Nakai) and Egusi Melon (*Citrullus colocynthis* (L.) Schrad.) seeds. Agric Conspec Sci 85 (1): 43-49.

Gebhardt S. E., Cutrufelli R., Matthews R. H. (1982). Composition of Foods. Fruits and Fruit Juices: Raw, Processed, Prepared. Agricultural Handbook No. 8-9, US Department of Agriculture, Human Nutrition Information Service, Washington, DC.

Gebhardt S. E., Thomas R. G. (2002). Nutritive Value of Foods, US Government Printing Office, Washington, DC.

Goldman A. (2002). Melons: for the Passionate Grower, Artisan Books. New York, NY., New York, NY.

Hammer Ø., Harper D. A. (2001). Past: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontol Electron 4 (1): 1-9.

Hatem M., Aly S. M., Khalil M. R. (2014). Types of Gene Action and Hybrid Vigour for Yield and Quality Traits of Melon (*Cucumis melo*, L.). J Plant Prod 5 (5): 801-820. doi: 10.21608/jpp.2014.55427

IPGRI (2003). Descriptors for Melon (*Cucumis melo* L.), International Plant Genetic Resources Institute, Rome, Italy.

Jeffrey C. (1990). An Outline Classification of the *Cucurbitaceae*. In: Biology and Utilization of the *Cucurbitaceae* (Bates D. M., Robinson R. W., Jeffrey C., eds), Cornell University Press. Ithaca, New York, Ithaca, New York,: 449-463. doi: 10.7591/9781501745447-039

Khoshnam F., Namjoo M., Golbakhshi H. (2015). Acoustic Testing for Melon Fruit Ripeness Evaluation during Different Stages of Ripening. Agric Conspec Sci 80 (4): 197-204.

Obok E., Macha E., Nwagwu F., Uwah D. (2022). Canary Melon (*Cucumis melo* L. var. *inodorus*) Response to Lime-Amended Acid Soil in the Humid Tropical Rainforest of Nigeria. Songklanakarin J Sci Technol.44 (4): 1145-1152.

Obok E. E., Ekpiken F., Akpan J., Nwagwu F., Ittah M., Uwah D. (2023). Growth, Yield and Variance Components of Watermelon (*Citrullus lanatus*) Grown on Lime ($CaCO_3$)-Amended Acidic Soil of South-Eastern Nigeria. J Agric Sci (Belgrade) 68 (3): 283 – 300. doi: 10.2298/JAS2303283E

Pistrick K. (2003). Mansfeld's Encyclopedia of Agricultural and Horticultural Crops and the Mansfeld Phenomenon. Rudolf Mansfeld and Plant Genetic Resources Schriften zu Genetischen Ressourcen 22: 21-31.

Pitrat M., Hanelt P., Hammer K. (2000). Some Comments on Infraspecific Classification of Cultivars of Melon. In: Acta Hortic 510: 29-36. doi: 10.17660/ActaHortic.2000.510.4

Raji O. H., Orelaja O. T. (2014). Nutritional Composition and Oil Characteristics of Golden Melon (*Cucumis melo*) Seeds. Food Sci Qual Manag 27: 18-21.

Sabo M. U., Wailare M. A., Aliyu M., Jari S., Shuaibu Y. M. (2013). Effect of NPK Fertilizer and Spacing on Growth and Yield of Watermelon (*Citrullus lanatus* L.) in Kaltungo Local Government Area of Gombe State, Nigeria. Schol. J Agric Sci 3 (8): 325-330.

Schaefer H., Renner S. S. (2010). *Cucurbitaceae*. In: Flowering Plants Eudicots: Sapindales, Cucurbitales, Myrtaceae Berlin, Heidelberg: Springer Berlin Heidelberg.: 112-174. doi: 10.1007/978-3-642-14397-7_10

Schaffer A. A., Aloni B., Fogelman E. (1987). Sucrose Metabolism and Accumulation in Developing Fruit of *Cucumis*. Phytochemistry 26 (7): 1883-1887. doi: 10.1016/S0031-9422(00)81721-5

Schaffer A. A., Burger Y., Zhang G., Zhifang G., Granot D., Petreikov M., Yeselson L., Shen S. (2000). Biochemistry of Sugar Accumulation in Melons as Related to the Genetic Improvement of Fruit Quality. Acta Hortic 510: 449-454. doi: 10.17660/ActaHortic.2000.510.71

Silva E. M. d., Nunes E. W. L. P., Costa J. M. d., Ricarte A. d. O., Nunes G. H. d. S., Aragão F. A. S. d. (2019). Genotype and Environment Interaction, Adaptability and Stability of 'Piel de Sapo'Melon Hybrids through Mixed Models. Crop Breed Appl Biotechnol 19 (4): 402-411. doi: 10.1590/1984-70332019v19n4a57

Snell E. J., Simpson H. (2021). Applied Statistics: Handbook of GENSTAT Analysis, Chapman and Hall/CRC, New York: doi: 10.1201/9781003059844

Sturtevant E. L. (1919). Sturtevant's Notes on Edible Plants. Report of the New York Agricultural Experiment Station for the Year 1919 (II) (U. P. Hedrick, Ed). J. B. Lyon Company, State Printers, Albany, New York. doi: 10.5962/bhl.title.24577

Tomar R. S., Kulkarni G., Kakade D., Patel A., Acharya R. (2008). Genetic Variability, Correlation and Path Analysis in Muskmelon (*Cucumis melo* L.). Asian J Hort 3 (1): 158-161. doi: 10.24154/jhs.v3i2.569

Villanueva M. J., Tenorio M. D., Esteban M. A., Mendoza M. C. (2004). Compositional Changes during Ripening of Two Cultivars of Muskmelon Fruits. Food Chem 87 (2): 179-185. doi: 10.1016/j.foodchem.2003.11.009

Warra A., Sheshi F., Ayurbami H., Abubakar A. (2015). Physico-Chemical, GC-MS Analysis and Cold Saponification of Canary Melon (*Cucumis melo*) Seed Oil. Trends Ind Biotech Res 1 (1): 10-17.

Whitaker T., Davis G. N. (1962). Cucurbits. Interscience Publishers. Inc, New York.

Wu H.-C., Chan L.-F., Wei M.-L., Lu H.-Y. (2010). A Simple and Inexpensive Technique for Estimating Leaf Surface Area of Muskmelon (*Cucumis melo* L.). J Taiwan Agric Res 59 (2): 71-77.

Yangomodou O. D., Ferry N., Uthman-Akinhanmi Y. O., Solana O. I., Olugbemi M. T. (2021). Nutritional Composition, Antibacterial and Antifungal Activities of Canary Melon Seed (*Cucumis melo*) oil. FUW Trends Sci Tech J 6 (2): 391-396.

Zulkarami B., Ashrafuzzaman M., Razi I. M. (2010). Morpho-Physiological Growth, Yield and Fruit Quality of Rock Melon as Affected by Growing Media and Electrical Conductivity. J Food Agric Environ 8 (1): 249-252.

aCS89_34