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EFFECTS OF POPULATION DUE TO INTRA-ROW SPACING ON POSTHARVEST QUALITY OF GOLDEN MELON FRUITS

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Abstract

Golden melon (*Cucumis melo* L.) grown at different intra-row spacing contains different proximate compositions and are of disparate quality. A field experiment was conducted at the Federal University of Agriculture, Abeokuta, in the tropical rainforest/savannah transition zone of southwest Nigeria, to assess effects of population due to intra-row spacing on proximate composition and some fruit physical and biochemical qualities of golden melon. Treatments comprised of plant populations of 50,000, 25,000, 16,667, 12,500, and 10,000 plants/ha at 20, 40, 60, 80, or 100 cm intra-row with a constant inter-row spacing of 100 cm. Data were collected on proximate composition, carbohydrate, crude protein, ash, crude fiber, fat, dry matter and moisture content. Fruit length, fruit width, fruit firmness, titratable acids (TA), total soluble sugar (TSS) and vitamin C were determined. Results showed plant population due to intra-row spacing affected fruit proximate and quality traits. Population of 12,500 plants/ha from 80 cm intra-row spacing produced fruits with higher ash, fat, crude fibre and crude protein content; at 16,667 plants/ha (60 cm intra-row) produced fruits with higher carbohydrate content. Population of 12,500 plants/ha from 80 cm intra-row produced longer and wider fruits, with higher TSS and more vitamin C. Therefore, plant population from specific intra-row spacing could impact on the proximate composition and physico-chemical composition of golden melon.

Keywords: *Cucumis melo*, intra-row spacing, inter-row, proximate composition, fruit quality, and population

Introduction

Plant spacing, resulting in a specific population can cause increase or decrease in yield of melon (Jan *et al*., 2000; Oga and Umekwe, 2016); appropriate plant spacing is necessary for interception of sunlight which is necessary for optimum photosynthesis and efficiency of land use, light, water and nutrients (Aliyu *et al*., 2008). Increase in plant spacing, causing reduced population and nutrient area per plant leads to increase in morphological characters of cultivated crops (Baloch *et al*., 2001). Availability of total assimilates to fruits in melon is affected by plant density (Siva *et al*., 2017). Golden melon (*Cucumis melo* L.) is mostly cultivated in the temperate regions (Zulkarami *et al*., 2010). The quality of melon fruits involves attributes related to characteristics of pulp, such as firmness, soluble solids contents, subjective evaluation (regarding the external and internal appearance), reducing and total soluble sugars. More recently, the presence of health-promoting phytonutrients such as ascorbic acid, folic acid and beta-carotene, which is a precursor of vitamin A and is predominant in cultivars with salmon-colored pulp (Lester and Hodges, 2008). There is however, little information on the proximate composition and fruit quality of golden melon as influenced by population due to intra-row spacing. The objective therefore, was to assess effects of intra-row spacing on proximate composition and fruit quality of golden melon.

Materials and Methods

The experiment was conducted at the research farm of the Federal University of Agriculture Abeokuta, in the tropical rainforest/savannah transition zone of southwest Nigeria, latitude 7°15′N; longitude 3°25′E. The Oxic Paleudulf soil was mechanically ploughed and harrowed after another 2 weeks. Twenty raised beds, 3.0 × 3.2 m, with a 2 m border were constructed, using a hoe to raise the soil to a height of 25 cm. Treatments were arranged in a randomized complete block design. Ten kilogram seeds were treated with 10 g Dress Force®

(containing Imidacloprid 20% +Metalaxyl-M 20% + Tebuconazole 22% WS) and sown on beds with a drill at specified intra-row spacing on 4th August 2018 and repeated on another plot of land close by on 3rd August 2019. A basal application of 250 kg/ha of pre-compounded N15-P15-K15 fertilizer was applied at 3 weeks after planting (WAP). The fertilizers were drilled into furrows 15 cm from plants. Weeds were controlled manually at two weeks interval. Plants were established at densities of 50,000, 25,000, 16,667, 12,500 or 10,000 plants/ha with a constant inter-row distance of 100 cm and intra-row spacing of 20, 40, 60, 80 and 100 cm, respectively, and replicated 4 times. The experiment was rain-fed and there was no need for pest control. Healthy, mature fruits were harvested, beginning at 10 weeks after planting (WAP) in 2018 and 11 WAP in 2019. Number of fruits per plant, average fruit weight, and fruit yield were estimated. After harvest, fruit samples were analyzed for moisture content, ash, fat, crude fiber, crude protein, carbohydrate, using established methods (AOAC, 2005). Fruit length and fruit width were measured using a Vernier caliper; fruit firmness was measured using a hand- held penetrometer and total soluble solids measured using a hand-held Brix refractometer (model Atago 1140, Japan). Total titratable acid was estimated by titrating 10 mls of freshly-prepared undiluted golden melon juice with 0.1N sodium hydroxide in a beaker, using 2-3 drops of phenolphthalein as indicator to a pink colour end point. Vitamin C was estimated using titration method with the indicator dye 2, 6-dichloroindophenol to a faint pink end point. Data were subjected to analysis of variance using GENSTAT discovery (12th ed., VSN International, Hemel Hempstead, UK), Spacing and year of cultivation as factors. If interactions were significant, they were used to explain results. If Interactions were not significant, means were separated using least significant difference at $P \leq 0.05$.

Results and Discussion

Environmental conditions varied. Total rainfall of 1403.6 mm in 2018 was lower than1413.2 mm in 2019. During the experimental period, total rainfall of 605.2 mm in 2018 was higher than 472.1 mm in 2019. During the reproductive phase, rainfall was lower in 2018 (173.4 mm) than in 2019 (310 mm). Mean temperature of 79.6ºC was lower during the experimental period in 2018 relative to 87.03ºC in 2019. Relative humidity was lower in 2018 (225.3%) compared to 2019 (256.1%).The year of cultivation did not affect the moisture content and dry matter content but affected the ash, fat, crude fibre, crude protein and carbohydrate contents. Plant density and the interaction affected all the fruit proximate composition (Table 1).

Table 1: Analysis of variance (mean square) on the proximate composition of golden melon

Source	Df	Moisture content	Dry matter content	Ash content	Fat content	Crude fiber	Crude protein	Carbohydrate
Year (Y)	1	0.271	0.284	0.252*	4.179**	0.145*	0.977**	5.918**
Plant density (P)	4	0.782**	0.785**	0.187**	0.257**	0.269**	0.108*	2.522**
Y × S	4	1.112**	1.099**	0.094*	0.145**	0.075*	0.027*	1.103**

Fruits harvested in 2019 had more moisture content, while those planted at 10,000 plants/ha had more moisture content. More moisture was observed in fruits planted at 16,667 plants/ha in 2018 when compared to planting at 50,000, 25,000, 12,500 plants/ha in 2018 and 25,000, 16,667 plants/hain 2019, but similar to planting at 10,000 plants/ha in 2018 and 50,000, 12,500 and 10,000 plants/hain 2019 (Figure 1a). Fruits with higher dry matter content were produced in 2018, while planting at 25,000 plants/haproduced fruits with higher dry matter content (Figure 1b). Fruits with higher ash content were produced in 2018 at 12,500 plants/ha, significantly different from planting at 50,000, 25,000, 16,667 and 10,000 plants/ha in 2018 and 2019, but similar when compared to planting at 12,500 plants/ha in 2019 (Figure 1c). Fruits with higher fat content were produced in 2019 at 25,000 plants/ha, significantly higher than planting at 50,000, 25,000, 12,500 and 10,000 plants/ha in 2018 and 12,500 plants/ha in 2019, but similar when compared to planting at 16,667 plants/ha in 2018 and 50,000, 16,667 and 10,000 plants/ha in 2019 (Figure 1d). Fruits with higher crude fibre content were produced in 2018 at 12,500 plants/ha; they were significantly higher than planting at 16,667 plants/ha and 10,000 plants/ha in 2018 and 50,000 plants/ha, 25,000 and 16,667 plants/ha in 2019, but similar when compared to planting at 50,000 and 25,000 plants/ha in 2018 and 12,500 and 10,000 plants/ha in 2019 (Figure 1e).

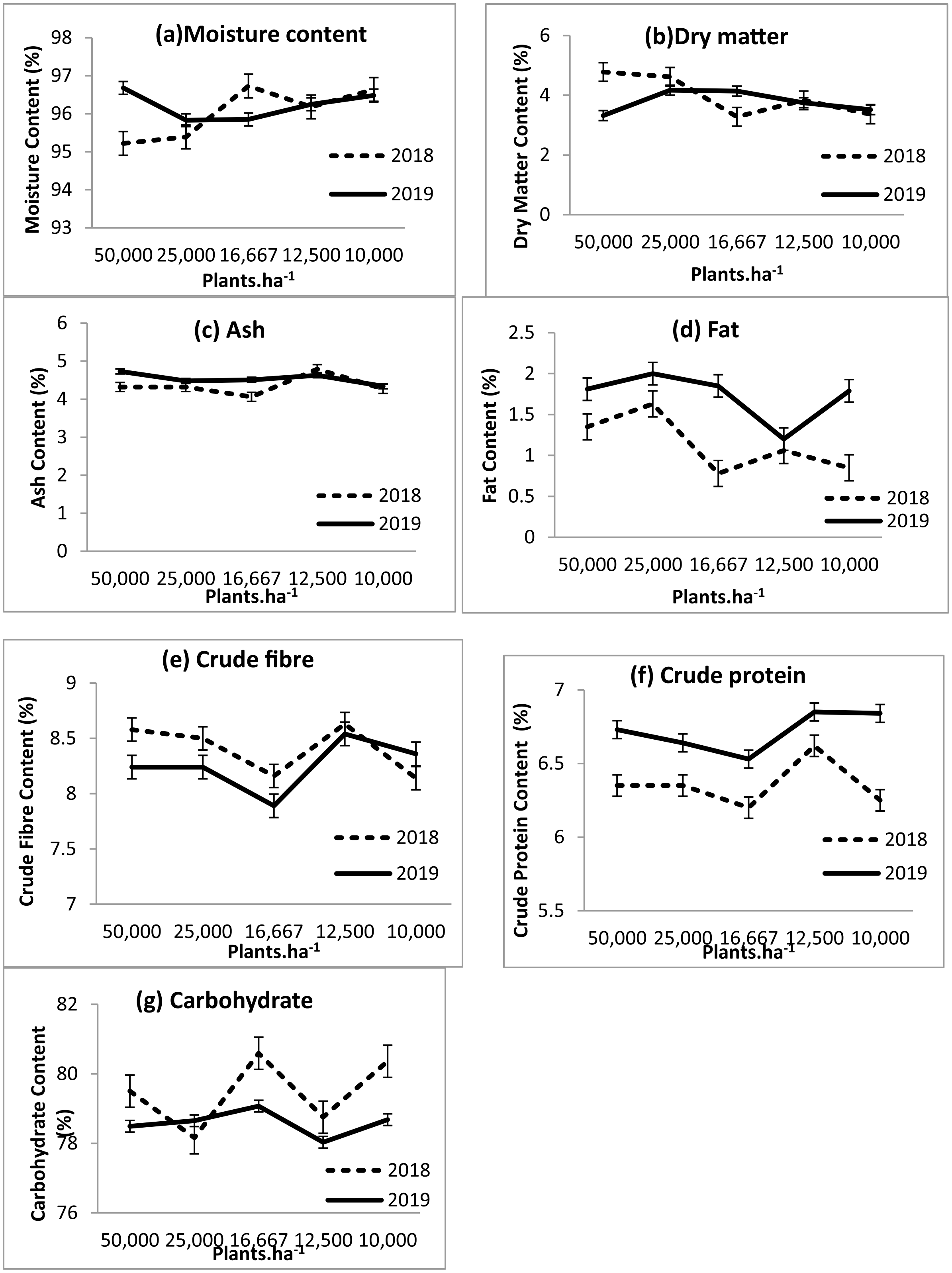


Figure 1: Contents of: moisture (a), dry matter (b), ash (c), fat (d) crude fiber (e), crude protein (f), and carbohydrates (g) in golden melon as influenced by year ×plant density interaction. Data in the interaction analyzed with Least Squares Means and means separated with Least Significant Differences, p≤0.05.

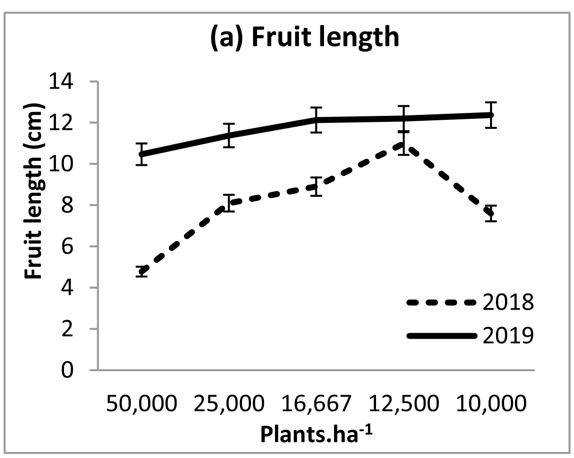
Fruits with higher crude protein content were produced in 2019 at 12,500 plants/ha, significantly higher than planting at 50,000, 25,000 and 10,000 plants/ha in 2018 and 16,667 plants/ha in 2019, but similar relative to planting at 16,667 plants/ha in 2018 and 50,000, 25,000 and 10,000 plants/ha in 2019 (Figure 1f). Fruits with higher carbohydrate content were produced in 2018 at 16,667 plants/ha, significantly higher than planting at 50,000, 25,000 and 12,500 plants/ha in 2018 and 50,000, 25,000, 16,667, 12,500 and 10,000 plants/ha in 2019, but similar when compared to planting at 10,000 plants/ha in 2018 (Figure 1g).

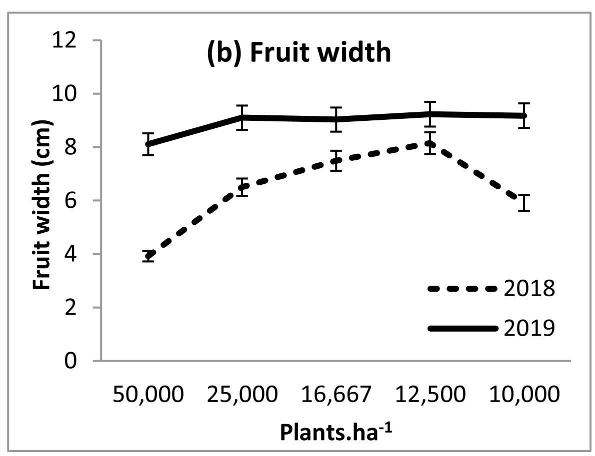
The year of cultivation affected the fruit length, fruit breadth, firmness, total titratable acids and the vitamin C content but did not affect the total soluble solid content. Plant density affected the fruit length, fruit breadth, total soluble solid, total titratable acids and the vitamin C content but did not affect the fruit firmness. The interaction affected all the fruit quality parameters studied (Table 2).

Table 2: Analysis of variance (mean square) on some fruit quality parameters of golden melon

Source	df	Fruit length	Fruit width	Fruit firmness	Total soluble solids	Total titratable acids	Vitamin C
Year (Y)	1	99.190*	48.285*	0.14*	0.363	0.0002*	11.396**
Plant density (P)	4	12.702*	6.247*	0.059	3.047*	0.0006*	2.749**
Y × P	4	4.374*	2.389*	0.07*	3.857*	0.0005*	3.371**

Bigger fruits were produced in 2019 compared to 2018. Fruits planted at 10,000 plants/ha in 2019 were significantly bigger in comparison to fruits planted at 50,000, 25,000 and 16,667 plants/ha in 2018 but similar when compared to 12,500 plants/ha and 10,000 plants/ha in 2018 and 50,000, 25,000, 16,667 and 12,500 plants/ha in 2019. (Figures 2a and 2b). Fruits harvested in 2019 were more firm relative to those planted in 2018. Fruits planted at 25,000 plants/ha in 2018 were significantly more firm when compared to those planted at 16,667, 12,500 and 10,000 plants/ha in 2018 and 50,000 plants/ha in 2019, but similar when compared to those planted at 50,000 plants/ha in 2018 and 25,000, 16,667, 12,500 and 10,000 plants/ha in 2019 (Figure 2c). Fruits harvested in 2019 had more soluble solids when compared to those harvested in 2018. Fruits planted at 25,000 and 12,500 plants/ha in 2019 had significantly more soluble solids relative to those planted at 16,667 in 2018 and 50,000 and 16,667 plants/ha in 2019, but similar when compared to those planted at 50,000, 25,000, 16,667 and 10,000 plants/ha in 2018 and 16,667 plants/ha in 2019 (Figure 2d). Fruits planted at 12,500 plants/ha in 2018 had significantly more titratable acids when compared to those planted at 25,000, 16,667 and 10,000 plants/ha in 2018 and 50,000 plants/ha in 2019, but similar when compared to those planted at 50,000 plants/ha in 2018 and 25,000, 16,667, 12,500 and 10,000 plants/ha in 2019 (Figure 2e). Fruits harvested in 2019 had more vitamin C content relative to 2018. Fruits planted at 10,000 plants/ha in 2019 had significantly more vitamin C content, compared to those planted at 50,000, 25,000, 16,667, 12,500 and 10,000 plants/ha in 2018 and 50,000, 25,000, 16,667 and 12,500 plants/ha in 2019 (Figure 2f).





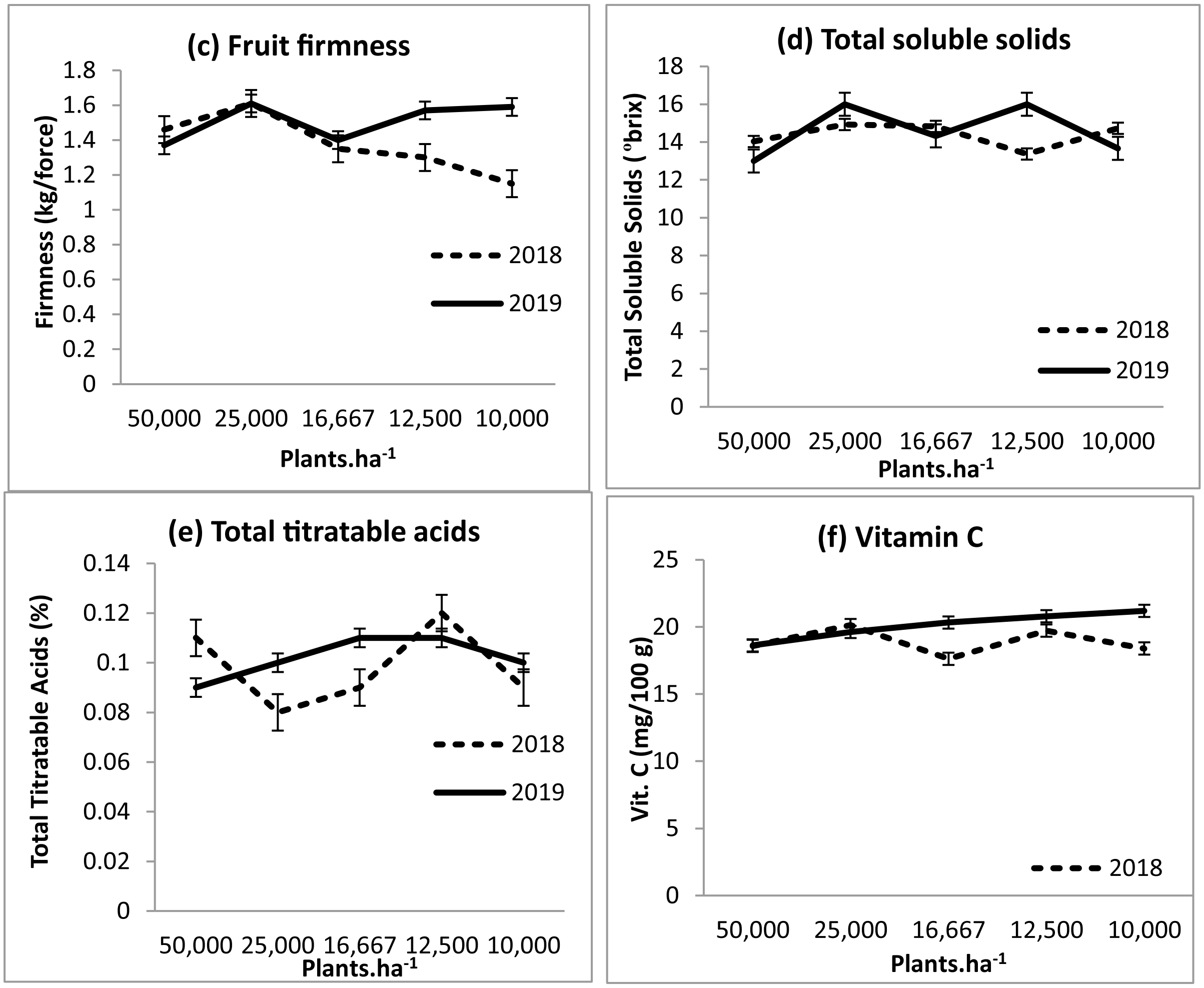


Figure 2: Fruit length (a), fruit width (b), fruit firmness (c), and contents of: total soluble solids (d) total titratable acids (e), and vitamin C (f) in golden melon as influenced by year × Plant density interaction. Data in the interaction analyzed with Least Squares Means and means separated with Least Significant Differences, p≤0.05.

Generally, rainfall has been the major supply of soil moisture in rain-fed cropping systems. Plants extract water from the soil and any change in the quantity of rainfall affects the supply of soil moisture, thereby impacting final crop yield. With insufficient soil moisture to meet the evaporative demand imposed by the atmosphere, plant leaves lose turgor pressure and stomata close. Entry of CO_2 into the stomata is therefore inhibited and photosynthesis is reduced, impacting biomass production, crop growth, partitioning, final yield and post-harvest qualities. Proximate composition of harvested fruits was observed to be greatly influenced by the weather condition, especially rainfall. More rainfall in 2018 supported production of more dry matter, fibre and carbohydrate, while more moisture, ash, fat and protein was produced in 2019 which was characterized by low rainfall. As moisture content increased, dry matter content reduced. Lower population, with wider intra-row spacing produced fruits with higher moisture content and reduced dry matter content, while higher population, with closer intra-row spacing produced fruits with higher dry matter content with reduced moisture content. This may be due to wider space available for plant growth which aided in the production of more assimilates. The ash, fibre, protein and carbohydrate contents of harvested fruits as influenced by intra-row spacing was inconsistent, as intra-row spacing of 80 cm (12,500 plants/ha) produced fruits with more ash, fibre and protein contents, while planting at 12,500 plants/ha (60 cm intra-row) produced fruits with higher carbohydrate content. Average temperature and temperature range during the growth period may negatively influence the chemical composition (Weston and Barth, 1997).

Fruit size in terms of fruit length and fruit breadth increase with reduced plant population was due to more space available to the plants as intra-row spacing increased, leading to reduced competition among plants, resulting in the buildup of photosynthase for the production of bigger fruits. Fruit texture was observed to increase as plant density reduced from 50,000 to 25,000 plants/ha after which a further reduction was observed as the plant population reduced to 10,000 plants/ha. This is as a result of proper partitioning of assimilates and fruit development leading to a well formed pericarp at reduced plant density. Hard pericarp at larger plant population and closer spacing may be attributed to the low moisture content observed at closer spacing, as the fruit moisture content increased, the pericarp becoming softer, leading to reduction in firmness. Total soluble solid increased as plant population decreased and intra-row spacing increased from 20 to 80 cm intra-row, while titratable acids were observed to reduce as TSS increased, although some acids may be translocated from the leaves and roots to the fruit (Bertin *et al*., 2000). Lower acidity may be a result of lower photosynthetic activity, resulting in lower carbohydrate accumulation in the fruits. Vitamin C content was observed to increase as plant density reduced and from 50,000 to 25,000 plants/ha and intra-row spacing increased from 20 to 40cm intra-row, while a decline was observed at 10,000 plants/ha. Kamol *et al*. (2014) reported that a reduction in vitamin C content upon ripening is associated with the oxidative destruction and ascorbic acid dehydrogenase activity.

Conclusion

Results show variation in the response of Golden melon in 2018 and 2019 implies that environmental factors such as rainfall, temperature and relative humidity impacted its proximate composition. Plant population density of 12,500 from intra-row spacing of 80 cm and inter-row spacing of 100 cm enhanced optimum proximate composition in terms of ash, fat, crude fibre and crude protein contents. Plant population density of 12,500 plants/ha from intra-row spacing of 80 cm and inter-row spacing of 100 cm enhanced optimum fruit quality of golden melon. Therefore, plant population density due to intra-row spacing of cultivating a crop can impact on the proximate composition and its physiochemical composition.

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