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Agronomic Performance of Eight Sweet Melon Cultivars in Three Ecological Zones of Ghana

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Abstract: In this study, Sweet melons were evaluated in different ecological zones to select those best suited for exporters and other stakeholders in the horticultural industry. The aim of this study was to investigate the performance of eight Sweet melon cultivars (Alpes, Amaral, Kousto, Mirella, Makenna, Anish, Raneen and Alameda) for their growth, yield and fruit quality characters in three different ecological zones (Forest, Coastal and Guinea savanna zones) of Ghana in two seasons (2008 and 2009). The design of the field experiments was Randomized Complete Block Design with factorial combination of eight cultivars and two locations replicated three times. However, in order to obtain information on the effects of season, the results in both seasons were analyzed as a split-split-plot design with season as the main block, location as sub-plot and cultivar as sub-sub plot. Results indicated significant differences in agronomic performance among the varieties in the different ecological zones as well as significant cultivar×location interaction. Yield was higher at Binduri (Guinea savanna zone) and Kade (Forest zone) than at Sogakope (Coastal savanna zone). Cultivars Alameda and Ranneen recorded the highest fruit weight while Alpes had the lowest. Sugar content was lowest at Kade (Forest zone) and highest at Sogakope (Coastal savanna zone). Alpes, Anish, Mirella and Makeenna were found to be early maturing and can be recommended for export due to their earliness. From the studies all the varieties except Makeenna at Kade performed well in all the three agro-ecological zones and thus are suitable for cultivation.

Key words: Yield, varieties, evaluation, sugar content, forest zone, guinea and coastal savanna, Ghana

INTRODUCTION

Melon (*Cucumis melo*) originates from the Middle East to the Mediterranean and belongs to the family Cucurbitaceae (Maynard *et al*., 2001). There is remarkable diversity of melons in the *Cucumis melo* species, each having unique flavors, texture and appearance. These include Cantaloupe, Persian, Honeydew, Casaba, Galia, Crenshaw, Charentais, Winter Melon, Spanish/Canary and Japanese melons (Norman, 1992).

Melon production worldwide in 2009 was 31,053,716 tonnes, 0.33% more than the 30,953,684 tonnes produced in 2008. Overall production increased 42% since 2001. According to FAOSTAT (2009), melon production in the world was realized in 1.3 million ha area. In the same year, the melon production in the world was 26.7 million tones. China is the leading country in production of melon (51%) followed by Turkey (6%), United States and Spain (4%).

Melons are consumed as deserts, fresh-cut fruits and as juice (Saftner and Lester, 2009). The refreshing pulp, high nutritional, sweet pleasant aroma, bright color, firm flesh texture, high sugar content above 10% and proper fruit shape are important traits which make melons unique and a relish for for the imperial family in Japan (Gusmimi and Whener, 2005; De Melo *et al*., 2000; Long, 2005; Seko, 2004) and have high net potential profits (Best, 2001). The optimum temperature for melon production is 34°C and permissible range is from 10°C to 45°C (Baker and Reddy, 2001).

Sweet melons are generally of export significance in sub-Saharan Africa. Over the past years, there has been an increase in the export trend of horticultural exports (GEPC, 2010). As a result of the boost in the horticultural export earnings, the Government of Ghana through the Agricultural Services Sub-sector Investment Programme (AgSSIP) of the Ministry of Food and Agriculture (MOFA) implemented the Export Marketing and Quality

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Awareness Programme (EMQAP) programme to support the growth and development of Ghana's Horticulture Export Industry. Under the crop diversification option of the EMQAP, growers and exporters thought it worthy to diversify produce to the European markets. One of the crops selected for promotion and diversification for the export trade is Sweet melons. In view of the above, some melon varieties were imported by EMQAP, MOFA and evaluated at different ecological zones of the country to determine their growth performance, yield and fruit qualities attributes as well as recommend cultivars suitable for farmers and for export. The objective of this study was to evaluate the growth, yield and fruit quality characteristics of eight sweet melon cultivars in different ecological zones in Ghana.

MATERIALS AND METHODS

Experimental sites: Field experiments were conducted at three locations in 2008 and 2009. The locations were the University of Ghana Forest and Horticultural Crops Research Centre (FOHCREC) Farms, Kade, Eastern Region, Savannah Agricultural Research Institute (SARI) Farms, Binduri Bawku, Upper East Region and ATC Farms, Sogakope, Volta Region.

FOHCREC-Kade is in the forest zone and is 114 m above sea level on latitude 6°.0854'N and longitude 0°.5400'W. The dominant soil is Haplic Acrisol (FAO/UNESCO, 1990). The annual rainfall amount ranges between 1200-1300 mm and the distribution is bi-modal with two peaks around June-July and September-October. Temperature ranges between 25-38°C (Ofosu-Budu, 2003).

Binduri in the Bawku district is about 213 m above sea level on latitude 10.57976'N and longitude 0018719'W. It is typically a Guinea savannah Belt and the dominant soil is Haplic Lixisol (FAO/UNESCO, 1990). The annual rainfall amount is 950 mm and the distribution is uni-modal with the peak around September-October. Temperature ranges between 26.9-40.8°C.

Sogakope which is in the Coastal Savannah belt is on latitude 6.1824605'N and longitude 0.1062630'E and its soil type is Ferric Luvisol (FAO/UNESCO, 1990). The annual rainfall amount recorded is about 800.1 mm.

Experimental procedure and treatment: The design of the field experiments was Randomized Complete Block Design with factorial combination of eight cultivars and two locations replicated three times. However, in order to obtain information on the effects of season, the results in both seasons were analyzed as a split-split plot design with season as the main block, location as sub-plot and cultivar as sub-sub plot. Eight cultivated Sweet melons, i.e., Alpes, Amaral, Kousto, Mirella', Makenna, Anish, Raneen and Alameda were used. 'With the exception of Anish and Raneen which were obtained from ENZA ZADEN Seed Company, Netherlands, all the melon cultivars were purchased from RIJK ZWAAN Seed Company, Netherlands. The plots measured 16×20 m with a distance of 2.5 m between plots.

Seeds of melon cultivars were nursed in 66-celled seed trays. Land preparation included ploughing and harrowing. Before harrowing compound fertilizer 15-15-15 NPK was broadcasted by hand at the rate of 250 kg ha^{-1}. Seedlings were transplanted 4 weeks after sowing onto mulched plots spaced at 1.5×40 cm. Potassium nitrate at the rate of 80 kg ha^{-1} was applied on a split application at 21 and 50 days after transplanting. Other agronomic practices including irrigation, weeding and top dressing were conducted uniformly as required in all plots. The experiments were conducted between September and December in both years, 2008 and 2009.

Parameters measured: The following parameters were taken; days to emergence, days to opening of first male and female flowers, days to fruit maturity, fruit diameter and length, earliness of fruit bearing, fruit shape, fruit weight, fruit skin colour, flesh colour, percent sugar content (Brix), days to maturity and pH of fruits. The diameter of the fruits was measured with a caliper after cutting them diametrically. In the laboratory the sugar content (Brix) was determined with a digital pocket refractometer (ATAGO POCKET PAL-1) and pH determined with a digital pH meter (ATAGO DPH-1). Sugar content in the fruits was evaluated using 5 individual melons per cultivar. The 5 readings were averaged to calculate average percent sugar (Brix %). Rind color, flesh color evaluations were based on the same 5 melons used for Brix.

Data analysis: Data collected were analyzed using analysis of variance (ANOVA), GenStat version 11 and means separated using the Least Significant Differences (LSD) at $p = 0.05$. Correlation analysis for the parameters taken was also established using Spearman's rank correlation coefficient at $p = 0.05$.

RESULTS

The general findings of this study on the growth, yield and fruit quality performance of eight sweet melon cultivars evaluated in three different ecological zones

Table 1: Rainfall data in ecological zones during the experimental period of study

	Forest zone (Kade)		Guinea Savanna zone (Binduri-Bawku)		Coastal Savanna zone (Sogakope)	
Month	2008	2009	2008	2009	2008	2009
Rainfall (mm)						
September	46.8	39.4	106.0	297.8	98.7	12.1
October	197.4	162.6	62.5	141.5	118.6	4.2
November	160.0	145.0	0.0	0.0	85.8	0.0
December	118.6	88.4	0.0	0.0	18.3	0.0
Total	522.8	435.4	168.5	439.3	321.4	16.3

Meteorological Services Agency, Mempeasem, Accra

Table 2: Main effects of Season, location and Cultivar on agronomic and yield characters of melons

Main effect	DTMF	DTFF	Days to maturity	Fruit weight (g/fruit)	Yield (t ha^{-1})
Season (S)					
2008	36.4	46.4	61.4	1138.2	15.2
2009	36.4	46.7	61.6	1138.2	15.1
Sig.	ns	ns	ns	ns	ns
Location (L)					
Coastal Savanna Zone	37.2	47.0	60.2	1124.6	14.7
Forest Zone	39.0	48.9	63.3	1145.1	15.3
Guinea Savanna Zone	33.1	43.8	61.1	1144.8	15.4
Sig.	*	*	ns	*	*
Cultivar (C)					
Alameda	39.3	49.1	71.1	1783.2	23.1
Alpes	31.4	41.9	52.8	693.5	9.20
Amaral	38.9	49.4	68.1	1211.1	16.2
Anish	33.3	44.8	57.8	1061.8	14.2
Kousto	38.4	48.2	62.8	855.8	11.6
Makenna	36.1	45.5	57.2	902.2	12.1
Mirella	34.7	44.1	52.9	811.3	10.9
Ranneen	39.0	49.23	69.4	1786.7	23.9
Sig.	*	*	*	*	*
Interactions					
S×L	*	*	*	*	*
S×C	*	*	*	*	*
L×C	**	**	**	**	**
S×L×C	ns	ns	ns	ns	ns

DTMF: Days to opening of first male flower, DTFF: Days to opening of first female flower, ***Significant at p = 0.05 and p = 0.01, respectively, ns: Non-significant

studied showed that the melons adapted very well and can be cultivated especially in the two savanna zones to increase export volumes and income hence boost the horticulture export industry.

Main effects of season, location and cultivar on agronomic and yield characters of melons: The results of agronomic and yield characters are presented in Table 2. There were no significant differences in the characters studied in the two seasons or years (2008 and 2009). However, significant differences were observed for the locations and cultivars. Days to opening of the first male (DTMF) and First Female Flowers (DTFF) were significantly shorter at Binduri (Guinea savanna zone) and longest at Kade (Forest zone).

DTMF also showed significant differences among the cultivars. Alpes significantly took the shortest time (31.4 days) to flower followed by Anish (33.3) while 'Alameda' and 'Ranneen' took the longest time (39.0-39.3) (Table 2).

Days to First Female Flower opening (DTFF) also followed a similar pattern to DTMF. The female flower of Alpes significantly ($p<0.05$) had the shortest number of days to flower (41.9 days) while Alameda and Ranneen recorded the longest number of days to flower (49.1 and 49.2 days) (Table 2).

Results in Table 2 again show that days to maturity differed significantly ($p = 0.05$) among the locations and cultivars. Fruits at Sogakope significantly matured earlier (60.2 days) than the other locations. Cultivar differences were also observed. Alpes and Mirella recorded the shortest number of days (52.8 days) to fruit maturity while Alameda recorded the longest number of days (71.1 days).

Fruit yield (t ha^{-1}) significantly ($p = 0.05$) differed among the locations and cultivars (Table 3). Binduri and Kade had the highest fruit yield and Sogakope the least. In terms of cultivars, Ranneen and Alameda significantly recorded the highest yield (23.1-23.9 t ha^{-1}) while Alpes had the lowest (9.20 t ha^{-1}). Fruit weight among the cultivars ranged from 855.8-1786.7 g (Table 2).

Main effects of season, location and cultivar on fruit quality characteristics: The results of fruit quality characters are presented in Table 3. There were no significant differences between the two seasons or years in terms of fruit length, diameter and shape as well as the sugar content (Brix%). However, significant differences were seen in the locations and the cultivars studied (Table 3).

Fruit length and fruit shape in the locations was higher at Kade compared to the other locations. Fruit shape as measured by fruit length/fruit diameter showed that Anish, Alpes, Mirella, Makenna and Kousto had ratios of between 1.0 -1.1. This means that such fruits are round in shape. Ratios above 1.1 indicate fruits with oval to oblong shapes. Amaral, Alameda and Ranneen had ratios above 1.1 (Table 3).

Sugar content (Brix %) differed significantly in the locations and among the cultivars (Table 3). Sugar content at Sogakope (Coastal Savanna zone) was significantly the highest (13.1%) while Kade (Forest zone) recorded the lowest of 8.5%.

Fruit sugar content (Brix %) differed significantly (p = 0.05) among the cultivars (Table 3). 'Kousto' significantly had the highest sugar content (13.1%) and Anish the lowest (9.7%).

Interactions and correlations of agronomic and fruit quality characters: Results in Table 4 show analysis of variance for the mean squares of all the agronomic and fruit quality characters studied. The data indicates significant location (ecological zone) and cultivar (genetic) differences. The location and cultivar interaction (L×C) which was highly significant with the exception of fruit shape indicates that cultivars performed differently when grown at different ecological zones. Various interactions (L×Z×C) of the three factors did not have any significant effect on the agronomic and fruit quality characters studied (Table 4).

Spearman's rank correlation was used to establish the relationship among the agronomic and fruit quality characters studied (Table 5). Days to maturity showed significant and positive correlation with DTFF (0.697)

Table 3: Main effects of Season, location and Cultivar on fruit and fruit and quality characters of melons

Main effect	Fruit length	Fruit diameter	Fruit shape	Brix (%)
Season (S)				
2008	15.6	12.8	1.2	11.2
2009	15.6	12.8	1.2	11.2
Sig.	ns	ns	ns	ns
Location (L)				
Sogakope	15.4	12.8	1.2	13.1
Kade	16.1	12.6	1.3	8.5
Binduri	15.4	12.9	1.2	11.8
Sig.	ns	ns	ns	*
Cultivar (C)				
Alameda	24.2	14.5	1.6	10.9
Alpes	12.1	12.0	1.0	11.1
Amaral	18.4	13.0	1.4	11.8
Anish	14.0	13.4	1.0	9.7
Kousto	12.8	12.0	1.1	13.1
Makenna	12.7	12.2	1.0	11.8
Mirella	12.4	12.2	1.0	9.8
Ranneen	18.6	12.9	1.5	11.2
Sig.	*	*	*	*
Interactions				
S×L	ns	ns	ns	ns
S×C	**	**	**	**
L×C	**	**	ns	**
S×L×C	ns	ns	ns	ns

DTMF: Days to opening of first male flower, DTFF: Days to opening of first female flower, *,**Significant at p = 0.05 and p = 0.01, respectively, ns: Non-significant

Table 4: Analysis of Variance showing Mean Squares of agronomic and fruit quality characters of melons

Source of variation	df	DTMF	DTFF	Days to maturity	Fruit weight (g)	Yield (t ha^{-1})	Fruit length (cm)	Fruit diameter (cm)	Fruit shape	Brix (%)
Season (S)	1	0.014	2.25*	1.563	0.001	0.220	0.006	0.028	0.003	0.006
Location (L)	2	434.64**	320.42**	127.01*	6638.5**	6.409*	8.723*	0.809*	0.087*	266.26**
S×L	2	1.797	1.688	2.271	204.8	0.139	0.331	0.016	0.003	0.059
Error a	8	7.990	13.42	12.28	1700.0	0.843	0.624	0.598	0.011	0.132
Cultivar (C)	7	161.26**	144.98**	982.24**	3311371.9**	555.42**	340.78**	14.07**	1.212**	21.61**
S×C	7	0.039	0.060	0.150	122.8	0.226	0.282	0.058	0.003	0.042
L×C	14	13.29**	6.46**	8.19**	418250.3**	74.61**	44.64**	5.901**	0.084	6.267**
S×L×C	14	0.032	0.092	0.072	92.5	0.275	0.267	0.082	0.003	0.014
Error c	84	0.568	0.657	0.438	456.0	0.416	0.384	0.255	0.018	0.123

DTMF: Days to opening of first male flower; DTFF: Days to opening of first female flower, *,**Significant at p = 0.05 and 0.01, respectively

Table 5: Correlation coefficient for agronomic and fruit quality characters of melons

	Brix (%)	Days to maturity	DTFF	DTMF	Fruit diameter (cm)	Fruit length (cm)	Fruit shape (LD)	Fruit weight (g)	Yield (t ha^{-1})
Brix (%)	*								
Days to maturity	-0.009	*							
DTFF	-0.108	0.697	*						
DTMF	-0.135	0.679	0.826	*					
Fruit diameter (cm)	-0.071	0.402	0.156	0.093	*				
Fruit length (cm)	0.026	0.787	0.528	0.411	0.628	*			
Fruit shape (LD)	0.045	0.805	0.573	0.529	0.356	0.795	*		
Fruit weight (g)	0.036	0.739	0.411	0.328	0.540	0.804	0.725	*	
Yield (t ha^{-1})	0.048	0.717	0.397	0.301	0.526	0.802	0.711	0.984	*

DTMF: Days to opening of first male flower; DTFF: Days to opening of first female flower, *Show the diagonal

and DTMF (0.679) as well as to fruit shape (0.808) and yield (0.717). There was also strong correlation between DTFF and DTMF. Fruit length correlated positively with fruit shape and yield. Fruit weight and total yield had significant and positive correlation. However, sugar content correlated significantly but negatively with days to maturity, DTFF, DTMF and fruit diameter.

DISCUSSION

The significant variation in flowering behaviour with respect to the number of days to both first male and female flower opening observed among the varieties may be attributed to their genetic make-up as reported by Gichimu *et al*. (2008). The observation that the first flower in all the cultivars was always a male which opened a few days earlier agrees with Wehner *et al*. (2001) and Gichimu *et al*. (2008) who reported that in cucurbits exhibit three different characteristics with regards to flowering. These are among others (1) male phase-first few nodes bear only the staminate flowers, (2) mixed phase; both pistillate and staminate flowers appear in few nodes in the main axis and secondary branches in cycles and (3) female phase; few nodes produce mostly pistillate flowers. The revelation in this study showing that the cultivars produced their first female flowers few days after producing the first male flower agrees also with Gichimu *et al*. (2008). Again differences in flowering of the cultivars is in line with findings by Hassan Wasiullah *et al*. (2003) who attributed the differences to genetic variability as the possible reasons. The differences in maturity periods in the different locations or ecological zones may be attributed to environmental effects. The observation that some cultivars were found to be early while others were observed to be intermediate or late may be due to genetic or varietal differences (Adelberg *et al*., 1997). Kabura *et al*. (2008) and Berchie *et al*. (2010) found that early bloomers may have desirable attributes to temperatures, drought and can be used for cultivation in areas with erratic rainfall as well be utilized as insect infestation escape crops. Practically, results from this study provide sweet melon growers with early maturing cultivars especially to meet short window periods in the export market. The earliness of some of the melons indicate that they belong to the Galia and it is known fact that this group of melons have been researched on continuously by breeders for earliness. The early, intermediate and late cultivars provide a wider adaptation to a range of environments which provides an advantage of extending the cultivation of the crop (Berchie *et al*., 2010). Alizadeh and Carapetian (2006) also indicated that early flowering is an lead and an escape mechanism in times of harsh environmental conditions especially at the reproductive stage and may impact positively on pricing (Demirsoy and Demirsoy, 2004).

The differences in fruit shape may be due to the genetic make-up of the cultivars and not by the environment. Cultivars such as Alpes, Anish, Mirella, Makenna and Kousto that had round fruits (fruit shape ratios were between 1.0-1.1) may be more appealing to consumers and the export market.

The significant differences in cultivar and location interaction on fruit yield indicate that cultivar and location (ecological zones) effect were not independent of each other. This implies that different environments have different influences on the yield performance of sweet melons. Thus sweet melons express their genetic attributes differently in different ecological zones. The above findings agree with the observations of other researchers (Izge *et al*., 2007; Hassan *et al*., 2001; Hassan Wasiullah *et al*., 2003; Sana *et al*., 2003; Khoshnazar *et al*., 2000; Tsegaye *et al*., 2007) who reported similar differences in other crops as a result of genetic and environmental factors. The yield differences may also be due to differences in rainfall amounts (Table 1) as was also reported by Cabello *et al*. (2009).

The significant differences in sugar content among the cultivars and the locations may be attributed to differences in rainfall amounts (Table 1). According to Hosoki *et al*. (1990), sugar content in melons can be categorized into three classes. Fruits with Brix below 10 can be classified as class 1; 10-12 (class 2) and above 12 (class 3). Fruits in the Guinea and Coastal Savanna zones were found to belong to classes 2 and 3 while fruits in the forest zone were found to be in all the categories. Class 1 fruits are less sweet than classes 2 and 3. Thus fruits in the savanna zones were sweeter than those in the forest zone.

In term of cultivars the following classes have been categorised; class 1 (Anish and Mirella); class 2 (Alpes, Makenna, Amaral, Ranneen and Alameda) and class 3 (Kousto).

The positive correlations between the opening of the first female flower to number of days to maturity agrees with results obtained by Gichimu *et al.* (2008).

CONCLUSIONS

The study is the first documented report evaluating several sweet melon cultivars of export importance in Ghana. We recommend, Alpes and Anish for growers who may want to export due to their earliness and take advantage of drought escape, insect infestation as well as meeting the short European window periods in the export market. The work also revealed that the late maturing types, 'Alameda' and 'Ranneen' had the highest fruit yields. Fruit sugar content was highest in Kousto and may be recommended for fresh cut and supplies to the local markets (supermarkets, hotels) due to its sweet taste. It is also recommended that sweet melons should be cultivated in the Coastal or Guinea savanna zones due to the high sugar content of fruits produced in these locations. In the forest zone, cultivation in greenhouses will be the best option.

All the varieties adapted to all geographic conditions in all the locations or different ecological zones. However, studies on their physiological characterization as well as pest and diseases are imperative for further breeding or crop improvement purposes.

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