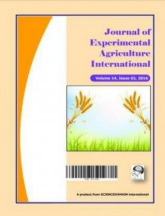

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Performance of Melon from *Momordica* Group as Affected by Pruning Techniques in Different Regions of Brazil

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Authors' contributions

This work was carried out in collaboration between all authors. Authors RNV and DM planned and conducted the study, performed the statistical analysis and wrote the first draft of the manuscript. Authors RNV, DAN, JASS, AQM, FSS, FATR, MCCLM and DM analyzed and interpreted results. All authors read and approved the final manuscript with the suggestions of the editors.

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ABSTRACT

This work aimed to evaluate the influence of two types of pruning techniques on agronomic traits of melon genotypes conducted under open greenhouse conditions equipped with a hydroponic system. The experimental design used was a split-plot with 2 pruning techniques x 19 genotypes in 4 replications. The study showed no significant difference within genotypes due to pruning technique (except for the number of days for maturity) and the pruning x genotype interaction. Therefore, the melon could be cultivated no matter the pruning technique used. Nevertheless, pruning based on

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two secondary branches seemed to be more suitable by preventing them from breaking, compared to that based on main branches. Melon genotype G-10 was found as a good compromise in terms of flowering precocity, fruit yield and quality.

Keywords: Vegetable crop; hydroponic cultivation; agronomic trait; genetic variability; fruit yield; pulp quality; plant staking.

1. INTRODUCTION

The melon (*Cucumis melo* L.) is a vegetable fruit belonging to the family of Cucurbitaceae, genus *Cucumis.* The species is classified intraspecifically in six botanical groups, based on the characteristics and uses of fruits: *cantalupensis, inodorus, conomon, dudaim, flexuosus* and *Momordica* [1]. Among these, two groups are of economic importance, *inodorus* and *cantalupensis*, which present a great variation in fruit morphology that allows them to be grouped into specific types of market, such as galia and charentais (*cantalupensis*) and varietal types yellow, piel de sapo and honey dew (*inodorus*) [2].

The other botanical groups are not cultivated on a large scale in Brazil, but they are important in specific regions, where they are known by several common names, such as snow melons in Rio Grande do Sul and Paraná, papoco melon in Maranhão, melon vitamin and melon caxi in Pernambuco, among other names that can be found depending on the location. Its fruits are commonly grown at small farms and sold in open markets and even in supermarkets in these regions [3,4].

The melons of *Momordica* group found in Brazil present a whitish, slightly yellowish pulp, naturally tasteless flavor with a soluble solids content close to 4%, which can be consumed "in natura" with sugar, honey or other sweeteners. They are also used in the preparation of soft drinks, salads and pickles when ripe or cooked when immature. When ripe fruits may cracked while their skin is usually a striped whitish yellow or green in color, separating it from the pulp, similar to a peeling, exposing the pulp and causing loss of fruit quality [3,4,5].

Therefore, to increase the productivity, precocity and quality of fruit, it is necessary to adopt conditions of cultivation in protected environment, use of vertical staking, adequate pruning, and protection of fruits among other cultural practices. Pruning aims to promote the source: drainage balance, through distribution of assimilates between vegetative and reproductive organs [6].

In cucurbitaceae the source: drainage ratio can be altered by pruning of stems or thinning of fruits, varying, respectively, number of leaves per plant, and consequently, leaf area (source) and demand for photoassimilates (drainage) [7], in this sense it is possible to obtain the increase in the yields, as well as fruits of better quality for commercial purpose.

In view of that, the objective of this work was to evaluate the agronomic performance for commercial characters of 19 genotypes of *C. melo* L. (*Momordica* group) conducted in two different types of pruning in the hydroponic system under protected environment.

2. MATERIALS AND METHODS

The experiment was conducted in a greenhouse, located in the Department of Agronomy, Phytotechnology area of the Universidade Federal Rural de Pernambuco, Campus of Dois Irmãos, Recife, PE, from April to July 2013. The data of temperature and humidity of the air were obtained by a Hobo mini data logger, whose results showed the temperature varying in the range of 21 to 46°C and the relative air humidity between 30 and 57%.

The seedlings were obtained from early planting in trays of expanded polystyrene with 128 cells filled with agricultural substrate for vegetables based on pinus bark and kept in a greenhouse with micro-sprinklers irrigation until reaching the ideal point for transplanting. With the appearance of the first definitive leaf, the seedlings were transplanted to pots with 5.0 L capacity, containing as inert substrate the coconut powder, with only one plant per pot, at a spacing of 0.60 x 1.75 m.

The experimental design used was a split-plot with 2 pruning techniques x 19 genotypes in 4 replications. In one case, the plants were conducted with main stems with the elimination of secondary buds until eighth leaves. In the

Table 1. Melon genotypes collected from different regions of Brazil

Genotypes	Place of collection of genotypes	
G-01	São José do Egito-PE	
G-02	Granito – PE	
G-03	Triunfo – PE	
G-04	Petrolina - PE	
G-05	São Lourenço da Mata - PE	
G-06	Ibimirim - PE	
G-07	Lagoa de Itaenga - PE	
G-08	Serra Talhada - PE	Açude Cachoeira
G-09	Serra Talhada - PE	Fazenda Saco/IPA
G-10	Floresta – PE	Curralinho
G-11	Floresta – PE	Riacho do Navio
G-12	Arcoverde - PE	
G-13	Buíque – PE	
G-14	Belo Jardim - PE	
G-15	Mocambinho - MG	
G-16	Juazeiro - BA	
G-17	Jeremoabo - BA	
G-18	Santa Tereza do Oeste - PR	
G-19	Nova Petrópolis - RS	

other case, plants were conducted with two secondary stems where after the appearance of the fifth leaf, pruning was performed on the third leaf with the removal of tertiary buds until the eighth leaf. The tertiary and secondary branches that appeared after the eighth leaf, were pruned after the second leaf. Subplots were composed of 19 genotypes of melon collected from different regions of Brazil (Table 1).

Required nutrients and water were supplied to plants through a solution containing initially 2250 g of calcium nitrate, 1350 g of potassium nitrate, 600 g of monoammonium phosphate (MAP), 1200 g of magnesium sulfate, 75 g of iron chelate (EDDHA-Fe) and 75 g of solid micronutrient mixtures chelated by EDTA. Additional solution supplied at fruiting included 225ml of boric acid solution (pre-prepared with the dilution of 25g of the solid substance in 1L of water) and 450g of monopotassium phosphate (MKP).

Macro and micronutrients were diluted in 3000 liters of water and distributed through a drip irrigation system equipped with 2L h-1 emitters, automatically controlled by a digital timer and the amount of irrigations and time of each adjusted according to conditions.

Fruit thinning resulted in only two fruits per plant which were protected by a mesh bag for better yield and quality at harvest. Agro-morphological traits investigated were the following: fruit length (FL), fruit width (FW), fruit length/width ratio (L/W), pulp thickness (PT), soluble solids content (SSC), fruit weight (FWe), number of days for male flowering (NDMF), number of days for female flowering (NDFF), number of days for maturation (NDM), expression of sex (ES) and presence or absence of fruit rupture (FR).

Data collected were subjected to the analysis of variance and the means were compared by the Scott-Knot test at 5% probability using the Genes Stat software vs 2017.3.1 [8].

3. RESULTS AND DISCUSSION

There was no significant difference within genotypes due to pruning (except for NDM) and pruning x genotype interaction. This indicates that no melon genotype behaved differently from one pruning technique to the otter. Therefore, the melon could be cultivated no matter the pruning technique used. Nevertheless, pruning based on maintaining two secondary branches seemed to be more suitable by preventing the breaking of branches in connection with their less thickness, compared to that based on main branches (Table 2).

Concerning the flowering-related traits, it was observed a monoic sexual expression in all genotypes which was reported by different authors [5,9,10]. This characteristic favours pruning of main and/or secondary branches and conduction only with secondary and/or tertiary branches which are concerned by female flowering and therefore fruit production.

In relation to the number of days for male, female and fruit ripening, which are fundamental from the agronomic point of view since they are linked to precocity (Table 3), it was observed on

Table 2. Mean values of agronomic traits of melon genotypes resulted from the analysis of variance

Sources of variation	DF	FL (cm)	FW (cm)	L/W	PT (cm)	SSC (%)	Fwe (kg)	NDMF	NDFF	NDM
Blocks	3	-	-	-	-	-	-	-	-	-
Prunning	1	1,19^{ns}	0,05^{ns}	0,04^{ns}	0,11^{ns}	0,01^{ns}	36843,13^{ns}	7,60 ^{ns}	0,16^{ns}	65,65*
Error a	3	13,5^{ns}	2,84^{ns}	0,05^{ns}	0,10^{ns}	0,18^{ns}	263764,5^{ns}	8,35^{ns}	12,09^{ns}	4,17^{ns}
Genotypes	18	66,4*	7,26*	0,72*	0,82*	3,19*	520969,23*	16,86*	62,57*	34,28*
Prunning x Genotype	18	9,76^{ns}	0,99^{ns}	0,17^{ns}	0,23^{ns}	0,18^{ns}	75111,03^{ns}	3,81^{ns}	12,41^{ns}	8,36^{ns}
Error b	108	10,37	1,18	0,14	0,23	0,22	129776,58	2,90	7,53	8,22
CV 1 (%)	-	11,04	15,82	7,54	12,31	15,22	33,24	8,27	7,89	2,96
CV 2 (%)	-	9,68	10,24	11,81	18,76	16,59	23,32	4,88	6,23	4,15
General Average	-	33,28	10,65	3,18	2,59	2,82	1545,07	34,96	44,07	69,13

Fruit length (FL), fruit length/width ratio (L/W), pulp thickness (PT), soluble solids content (SSC), fruit weight (FWe), number of days for male flowering (NDMF), number of days for female flowering (NDFF) and number of days for maturity (NDM).
^{ns} Not significant at 5% level of probability following F test.
` Significant at 5% level of probability following F test

Table 3. Mean values of agronomic traits of melon genotypes tested following two pruning techniques

Genotypes	FL $^{(1)}$ (cm)	FW $^{(1)}$ (cm)	L/W $^{(1)}$	PT $^{(1)}$ (cm)	SSC $^{(1)}$ (%)	FWe $^{(1)}$ (kg)	NDMF $^{(1)}$	NDFF $^{(1)}$	NDM $^{(2)}$	
									Prunning 1	Prunning 2
G-01	31.0 c	10.1 c	3.1 a	2.3 b	2.4 b	1.4 b	35 a	48 a	64 cA	67 aA
G-02	35.7 b	10.8 b	3.3 a	2.5 b	2.6 b	1.6 b	36 a	47 a	69 bA	70 aA
G-03	33.6 b	11.1 b	3.0 a	2.7 b	2.9 b	1.7 b	35 a	45 b	67 cB	72 aA
G-04	33.4 b	9.7 c	3.7 a	2.4 b	2.4 b	1.3 b	35 a	47 a	67 cA	71 aA
G-05	33.6 b	10.6 b	3.2 a	2.5 b	2.7 b	1.6 b	35 a	45 b	67 cA	69 aA
G-06	33.8 b	10.2 c	3.3 a	2.3 b	2.8 b	1.5 b	37 a	48 a	71 bA	71 aA
G-07	29.7 c	8.5 d	3.7 a	2.0 b	2.8 b	1.0 b	36 a	43 c	67 cA	67 aA
G-08	35.8 b	11.1 b	3.3 b	2.8 a	2.5 b	1.7 b	33 b	45 b	69 bA	70 aA
G-09	31.3 c	9.8 c	3.2 a	2.5 b	2.4 b	1.4 b	36 a	40 d	66 cA	67 aA
G-10	26.2 c	11.1 b	2.4 c	3.1 a	5.3 a	1.5 b	30 c	38 d	77 aA	73 aB
G-11	35.5 b	10.5 b	3.4 a	2.7 a	2.8 b	1.7 b	34 a	40 d	69 bA	71 aA
G-12	34.0 b	10.8 b	3.2 a	3.1 a	2.6 b	1.4 b	36 a	44 b	66 cA	69 aA
G-13	30.7 c	9.6 c	3.3 a	2.3 b	2.9 b	1.3 b	36 a	44 b	67 cA	69 aA
G-14	35.3 b	10.9 b	3.1 a	2.4 b	2.8 b	1.6 b	34 a	43 c	68 bA	71 aA
G-15	31.9 c	10.5 b	3.0 a	2.3 b	2.7 b	1.4 b	35 a	45 b	68 cA	70 aA
G-16	34.9 b	10.8 b	3.0 a	2.5 b	2.5 b	1.5 b	35 a	45 b	69 bA	70 aA
G-17	34.4 b	11.1 b	3.2 a	2.7 a	2.8 b	1.6 b	36 a	45 b	69 bA	70 aA
G-18	39.7 a	12.8 a	3.1 a	2.9 a	2.8 b	2.2 a	36 a	45 b	71 bA	72 aA
G-19	31.9 c	12.4 a	2.7 a	3.3 a	2.8 b	2.0 a	35 a	42 c	70 bA	73 aA

$^{(1)}$ Means followed by the same letter in the column do not differ by Scott Knott's test at 5% probability.
$^{(2)}$ Means followed by the same letter in column and row do not differ by Student t test at 5% probability.
Average for fruit length (FL), fruit width (FW), length/width ratio of fruit (L/W), pulp thickness (PT), soluble solids content (SSC), fruit weight (PWe), number of days for male flowering (NDMF), number of days for female flowering (NDFF) and number of days for maturation (NDM)

average that flowering begins at the day 35 for males and at day 44 for females. This means that female flowering occurred on average nine days after the onset of male flowering (Table 3).

For 84.2% of genotypes, the beginning of male flowering occurred between 34 and 37 days after sowing while in the precocious genotypes G-10 and G-08, at 30 and 33 days respectively. That of female flowering occurred between 38 and 40 days in precocious genotypes (G-09, G-10 and G-11) and in late-season genotypes (G-01, G-02, G-04 and G-06) between 47 and 48 days. Mid-season genotypes were split into 15.7 and 47 % with flowering dates between 42-43 and 44-45 days, respectively (Table 3).

The average fruit maturation occurred 69 days after sowing and 25 days after the beginning of female flowering (Table 2). For this trait, only

genotypes G-03 and G-10 behaved differently from one pruning technique to the other (Table 3). Under two secondary stem pruning technique, there was no different behaviour among genotypes, whereas, under one main stem pruning technique, only 47.4% of genotypes were precocious, with an average maturation date starting between 64 and 68 days after sowing, while that of genotype G-10 starting 77 days after.

Fruit maturation of mid-season genotypes (47%) occurred between 69 and 71 days (Table 3). Late-season genotypes are least appreciated by growers due to fewer crop cycles obtainable per year and the delay of economic return [11]. Similar variations in flowering and maturation dates of the *Momordica* group melon were reported in the literature [12].

Fruit size (length and diameter) and quality (ripe, non-cracked), are important agronomic traits for marketable melons of *Momordica* group in Brazil. That is why they are most appreciated by consumers. In this regard, fruits of higher average length of 39.7 cm were obtained on genotype G-18, while 58% of genotypes gave fruits with an average fruit length ranging from 33.3 to 35.8 cm and 36% of genotypes with that trait varying from 26.2 to 31.8 cm (Table 3).

The highest average fruit diameter was obtained on genotypes G-18 and G-19, with 12.8 and 12.3 cm respectively. On the other hand, the lowest average fruit diameter (8.5 cm) was obtained on genotype G-07. Around 58 and 26 % of genotypes presented an average fruit diameter ranging from 10.5 to 11.1 cm and from 9.6 to 10.1 cm, respectively. These data show an important variation in fruit diameter of *Momordica* group melon as reported by other authors [5,13].

The fruit length/width ratio in melon is a classification attribute of fundamental importance. Fruits with ratio ≤ 1.0 are classified as spherical and those with ratio between 1.0 - 1.5 are rather oval shaped. Fruits with ratio > 1.5 are classified as long [14]. Following this classification, genotypes investigated presented long fruits with an average length/width ratio of 3.1 (Table 2).

Average fruit length/width ratio of 89% genotypes falls between 2.7 and 3.7, while that of genotypes G-10 and G-08 were the lowest and intermediate, respectively (Table 3).

The highest average pulp thickness was observed on genotypes G-08, G-10, G-11, G-11, G-12, G-17, G-18 and G-19, with values ranging from 2.7 and 3.3 cm. The lowest average pulp thickness was observed on about 63% genotypes, with values ranging from 2.0 to 2.6 cm (Table 3). As a raw material used in the preparation of juices, ice cream and even normal meals, the pulp thickness is expected be as large as possible, although at fruit maturation point the pulp texture becomes farinaceous, brittle and prone to melting with a lower content of soluble solids [3].

Fruit coverage with mesh bags improves pulp structure even in case of fruit cracking which is a characteristic trait of *Momordica* group melon as reported by several authors [3,10,15,11]. Fruit cracking is a highly undesirable trait which is harmful for post-harvest conservation, long distance transportation and quality of marketable fruits.

Around 95% of genotypes presented fruits of on average 2.4 to 2.9% of soluble solids, except for genotype G-10 with 5.3% (Table 3). This trait is traditionally used to define melon fruit quality as the main market criterion [16]. In *Momordica* group melon, these values seemed to be rather low as reported by different authors [5,9,10,11].

All genotypes produced an average fruit weight of 1.5 kg (Table 2), with 89.4% of genotypes presenting the lowest fruit weights ranging from 1.0 to 1.7 kg. Genotypes G-18 and G-19 presented the heaviest fruits, with average weights of 2.2 and 1.9 kg, respectively and better yields. Similar findings obtained under field conditions rather than under greenhouse were reported by different authors [5,10,13,17].

4. CONCLUSION

The study showed no significant difference within genotypes due to pruning technique (except for the number of days to fruit maturity) and the pruning x genotype interaction. This indicates that no melon genotype behaved differently from one pruning technique to the otter. Therefore, the melon could be cultivated no matter the pruning technique used. Nevertheless, pruning based on two secondary branches seemed to be more suitable by preventing them from breaking, compared to that based on main branches. Melon genotype G-10 was found as a good compromise in terms of flowering precocity, fruit yield and quality.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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