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LEAF BIOMETRICS AND CORRELATIONS WITH COMMERCIAL FRUIT YIELD OF PAPAYA CULTIVARS EVALUATED IN AMAZONAS

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Abstract: An experiment was carried out in the municipality of Iranduba/AM with the aim of measuring the characteristics of total number of leaves per plant (NTFP), average mature leaf length (CMFM), average mature leaf width (LMFM), petiole length (CP) and leaf area (AF) of papaya cultivars and evaluating their possible correlation with commercial fruit yield. The treatments consisted of fifteen papaya cultivars, spaced 3.5 m x 2.0 m apart. The experimental design was randomized blocks. The experimental unit consisted of 10 plants in a row, with a total experimental population of 600 plants, after sexing. The yield of commercial fruit (kg/ha) in January 2010 and in the quarter Jan-Feb-Mar/2010 (PFC), and the number of commercial fruit (nº fruit/ha) in January 2010 and in the quarter Jan-Feb-Mar/2010 (NFC), were obtained from weekly harvests of fruit at harvest point. The average data was submitted to analysis of variance using the software (Sisvar® software 5.6) (Ferreira, 2011), and the means of the characteristics were compared between the cultivars using the Scott-Knott test (1974). Leaf area was estimated using the mathematical model that relates it to the length of the central vein of mature leaves, according to Campostrini & Yamanishi (2001). The Caliman M5 cultivar had the highest NTFP and the highest CP, while the Sunrise Solo P.K. and Solo BS cultivars had the highest CMFM, the highest LMFM and the highest AF**.** The Caliman 01 cultivar stood out in terms of CP in the Jan-Feb-Mar/2010 quarter, and also in terms of NFC in the same period**.** The cultivar Brilhoso stood out in the month of January/2010, with the highest yield, both in terms of weight (PFC**)** and number (NFC**)** of commercial fruit. There was a significant positive correlation between the NFC measured in the Jan-Feb-Mar/2010 quarter and the NTFP measured in January 2010, as well as between the PFC in the Jan-Feb-Mar/2010 quarter and the AF, and between the NFC in the Jan-Feb-Mar/2010 quarter and the leaf area.

Keywords: *Carica papaya*; genetic variability; productivity; leaf area; crop management.

INTRODUCTION

In Amazonas, the low productivity of papaya plantations has generated a physical volume of fruit that is insufficient to meet local demand, which has put upward pressure on prices. Added to this problem is the low quality and lack of standard/uniformity of the fruit, the seasonality of supply, among other technical limitations that have been responsible for the shortage and lack of quality of the papaya sold on the Amazon market.

With the aim of contributing to alternatives, this work began with the general objective of introducing, evaluating and identifying cultivars adapted to the climate and soil conditions of the state of Amazonas, with high production potential and agronomic characteristics favorable to quality, for future recommendations to producers. At this stage, the specific objective was to evaluate the differential behavior of fifteen papaya cultivars in relation to the leaf structure of the plants, gauging the correlations between the characteristics, especially with the yield of commercial fruit.

MATERIAL AND METHODS

The experiment was conducted in the municipality of Iranduba/AM, on a sandy-clay yellow latosol. The altitude of the experimental area is 50 m; latitude 3º 15' S; longitude 60º 20' W. The climate, according to the Köppen classification, is tropical rainy type Afi (Antonio, 2005). The treatments consisted of fifteen papaya cultivars (Table 3), spaced 3.5m x 2.0m. The experimental design was randomized blocks. The experimental unit consisted of 10 plants in a row, with a

total experimental population of 600 plants, after sexing. Area preparation and cultivation followed the recommendations of Martins & Costa (2003), and planting took place on 29/04/2009. The drip irrigation system was installed on 25/07/2009.

The following characteristics were assessed: total number of leaves per plant (NTFP), average mature leaf length (CMFM), average mature leaf width (LMFM), petiole length (CP), leaf area (AF). One leaf per plant was collected from the ten plants in each plot for each of the characteristics assessed, except for NTFP, where leaves from four plants/plot were counted. For CMFM, the longest length from the base of the central vein, from the median lobe to the tip, of leaves located in the lower part of the plant was measured. For LMFM, the same length leaves were used, taking into account the greatest width. The yield of commercial fruit (kg/ha) in January 2010 and in the Jan-Feb-Mar/2010 quarter (PFC), and the number of commercial fruit (nº fruit/ha) in January 2010 and in the Jan-Feb-Mar/2010 quarter (NFC), were obtained from weekly harvests of fruit at the point of harvest, which are those that have striations or bands on their skin with around 50% yellow coloring. Fruits weighing less than 350 grams, deformed, wrinkled and blemished peels, mechanically damaged and with a color different from the variety were considered non-commercial and eliminated from the evaluations. Correlations between the variables were established a posteriori. The average data was submitted to analysis of variance using the software (Sisvar® software 5.6) (Ferreira, 2011), and the means of the characteristics were compared between the cultivars using the Scott-Knott test (1974). Leaf area was estimated using the mathematical model that relates it to the length of the central vein of mature leaves, according to Campostrini & Yamanishi (2001).

RESULTS AND DISCUSSION

There was a highly significant effect of "cultivar" for all the characteristics studied (p < 0.01).

Table 3 shows that the Caliman M5 cultivar had the highest total number of leaves per plant (NTFP) and the longest petiole. The Sunrise Solo P.K. and Solo BS cultivars had the greatest average mature leaf length (MLCL), average mature leaf width (MLCW) and leaf area (LA), although Isla, Gran Golden and Brilhoso did not differ significantly from these two cultivars in terms of average mature leaf width (MLCW).

There was a highly significant "cultivar" effect for the commercial fruit yield (CFP) and commercial fruit number (CFN) characteristics in the two harvest periods evaluated (p < 0.01) (Table 4).

Table 5 shows that the Caliman 01 cultivar stood out in terms of commercial fruit yield (CFP) in the Jan-Feb-Mar/2010 period, and also in terms of the number of commercial fruits (CFN) in the same period, while the Caliman M5 cultivar did not differ significantly in terms of CFN.

When the date evaluated was January 2010, the cultivar Brilhoso stood out, showing the highest yield, both in terms of weight and number of commercial fruits (Table 5).

Table 6 shows a significant positive correlation between the number of commercial fruits per hectare measured in the Jan-Feb-Mar/2010 quarter and the total number of leaves per plant (NTFP) measured in January 2010. This table also shows significant positive correlations between commercial fruit yield (CFP) in the Jan-Feb-Mar/2010 period and leaf area, and between the number of commercial fruits (CFN) in the Jan-Feb-Mar/2010 period and leaf area.

Depth (cm)	pH 1/	MO /2	P 3/	K 3/	Ca2+ 4/	Mg2+ 4/	Al3+	H+Al 5/	SB 6/	t 7/	T 8/	V 9/	m 10/	Fe 3/	Zn 3/	Mn 3/	Cu 3/
	H O₂	g/kg	mg/dm³		cmol /dm³꜀							%		mg/dm³			
0-20	4,91	12,75	40	19	0,76	0,16	0,88	5,66	0,98	1,86	6,64	14,73	47,38	166	0,92	2,27	1,07
20-40	4,61	2,21	12	8	0,35	0,07	1,0	4,39	0,45	1,45	4,84	9,37	68,8	240	0,47	1,69	0,61

Table 1. Average observed data (1 composite sample/layer, each sample originated from 10 sub-samples/ sampled points) of the chemical characteristics of the soil collected before the experiment was set up, on December 4, 2008. Analysis according to Teixeira et al. (2017)

[1/] H₂ O 1:2.5;[2/] Organic matter = C (organic carbon) x 1.724 - Walkley-Black ;[3/] Mehlich 1 extractor;[4/] KCl extractor 1 mol L ;[-15/] Calcium acetate extractor 0.5 mol/L - pH 7.0; [6/] Sum of exchangeable bases;[7/] Effective cation exchange capacity;[8/] Cation exchange capacity at pH 7.0;[9/] Base saturation index;[10/] Aluminum saturation index.

FV	GL	NTFP	CMFM	LMFM	CP	AF
Block	3	15,87	14,71**	0,63	1,96	786,59**
Cultivar	14	92,50**	11,03**	14,63**	30,59**	529,37**
Error	42	7,75	3,85	1,24	1,39	211,44
CV (%)		12,04	11,13	4,55	3,90	24,06
Average		23,12	17,62	24,44	30,21	60,43

Table 2. Mean squares of the variables total number of leaves per plant (**NTFP**), average mature leaf length (**CMFM**), average mature leaf width (**LMFM**), petiole length (**CP**) and leaf area (**AF**), referring to the evaluation carried out in **January 2010,** of fifteen papaya cultivars.

** Significant at 1% by F test.

Cultivars of papaya	NTFP (Nº leaf)	CMFM (cm)	LMFM (cm)	CP (cm)	AF (m² /ha)
Caliman 01	20,48 **C**	17,93 **B**	25,18 **B**	32,98 **B**	61,49 **B**
Caliman M5	34,10 **A**	18,55 **B**	24,81 **B**	35,49 **A**	66,52 **B**
Sunrise Solo P. K.	28,08 **B**	21,25 **A**	26,58 **A**	30,39 **C**	86,73 **A**
Soil BS	26,40 **B**	20,86 **A**	26,65 **A**	30,31 **C**	83,26 **A**
Taiwan	19,40 **C**	16,68 **B**	22,33 **C**	26,68 **D**	53,83 **B**
Isla	26,80 **B**	18,74 **B**	26,70 **A**	31,70 **C**	66,83 **B**
THBGG	20,48 **C**	16,43 **B**	22,45 **C**	24,50 E	52,34 **B**
Sunrise Solo	21,98 **C**	17,28 **B**	23,30 **C**	30,15 **C**	58,90 **B**
Regina	16,98 **C**	16,75 **B**	24,28 **C**	29,28 **D**	54,25 **B**
Gran Golden	27,78 **B**	18,08 **B**	27,50 **A**	29,65 **C**	62,67 **B**
Diva	25,98 **B**	16,49 **B**	23,06 **C**	31,86 **C**	52,68 **B**
Brilliant	18,08 **C**	17,24 **B**	26,29 **A**	33,29 **B**	57,22 **B**
Plus Seed	21,10 **C**	16,15 **B**	22,65 **C**	31,00 **C**	50,71 **B**
Golden	20,98 **C**	15,68 **B**	22,33 **C**	28,15 **D**	47,99 **B**
BSA	18,28 **C**	16,23 **B**	22,48 **C**	27,78 **D**	51,13 **B**

Table 3. Estimated average data for the characteristics total number of leaves per plant (**NTFP**), average mature leaf length (**CMFM**), average mature leaf width (**LMFM**), petiole length (**CP**) and leaf area (**AF**), measured in **January 2010,** of fifteen papaya cultivars.

Averages followed by the same capital letters in the column do not differ by the Scott & Knott test at 5%.

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FV	GL	PFC		NFC	
		Jan/2010	J/F/M/2010	Jan/2010	J/F/M/2010
Block	3	1,36	20,10	12,93	109,72
Cultivar	14	7,57**	68,03**	48,96**	351,60**
Error	42	0,98	6,78	10,49	36,78
CV (%)		73,36	47,18	63,12	32,47
Average		1,35	5,52	$5,13 \times 10^3$	$18,68 \times 10^3$

Table 4. Mean squares of the commercial fruit yield (**CFY**) and commercial fruit number (**CFN**) variables from harvests in **Jan/2010** and the **Jan/Feb/Mar/2010 quarter,** of fifteen papaya cultivars**.**

** Significant at 1% by F test.

Cultivars of papaya	PFC				NFC			
	Jan/2010		J/F/M/2010		Jan/2010		J/F/M/2010	
	(t/ha)	%	(t/ha)	%	(Nº Fruits X 10^3 /ha)	%	(Nº Fruits X 10^3 /ha)	%
Caliman 01	4,18 B	86	17,25 A	100	8,72 B	64	34,17 A	100
Caliman M5	1,34 B	27	9,00 B	52	6,50 B	48	33,71 A	99
Sunrise Solo P. K.	1,50 B	31	6,93 C	40	6,38 B	47	25,62 B	75
Soil BS	1,04 B	21	6,10 C	35	4,53 C	33	22,50 B	66
Taiwan	0,63 B	13	3,89 D	23	3,04 C	22	14,07 C	41
Isla	1,09 B	22	6,66 C	39	5,57 B	41	24,65 B	72
THBGG	1,46 B	30	5,00 C	29	7,80 B	57	22,96 B	67
Sunrise Solo	1,28 B	26	4,61 C	27	5,94 B	43	18,40 B	54
Regina	0,41 B	8	2,61 D	15	1,43 C	10	9,12 C	27
Gran Golden	0,61 B	13	3,10 D	18	3,38 C	25	14,06 C	41
Diva	0,96 B	20	3,90 D	23	6,07 B	44	18,98 B	56
Brilliant	4,88 A	100	9,29 B	54	13,68 A	100	23,41 B	69
Plus Seed	0,68 B	14	2,23 D	13	3,57 C	26	9,87 C	29
Golden	0,16 B	3	1,32 D	8	0,36 C	3	5,06 C	15
BSA	0,00 B	0	0,89 D	71	0,00 C	0	3,57 C	10

Table 5. Estimated average data, with respective percentages in relation to the highest, for the characteristics commercial fruit yield (**CFY**) and number of commercial fruits (**CFN**) from harvests carried out in **Jan/2010** and in the **Jan/Feb/Mar/2010** quarter, for fifteen papaya cultivars.

Averages followed by the same capital letters in the column do not differ by the Scott & Knott test at 5%.

Variables	PFC		NFC	
	Jan/2010	J/F/M/2010	Jan/2010	J/F/M/2010
	(t/ha)		(Nº Fruits x 10^3 /ha)	
NTFP (Nº leaf)	,13	0,18	0,10	0,52*
AF (m² ha)$^{-1}$	,14	0,37*	0,23	0,55*

Table 6. Simple linear correlation (r) between the variables commercial fruit yield (**CFR**) and number of commercial fruits (**NFC**) from the **Jan/2010** harvest and the **Jan/Feb/Mar/2010** quarter, with the variables total number of leaves per plant (**NTFP**) and leaf area (**AF**), measured in **January 2010,** of fifteen papaya cultivars.

* Significant at 5% by t-test.

CONCLUSIONS

The Caliman M5 cultivar had the highest **NTFP** and **CP**.

The Sunrise Solo P. K. and Solo BS cultivars had the highest **CMFM**, the highest **LMFM** and the highest **AF**, although Isla, Gran Golden and Brilhoso did not differ significantly from these two cultivars in terms of **LMFM**.

The Caliman 01 cultivar stood out in terms of **PFC** in the Jan-Feb-Mar/2010 quarter, and also in terms of **NFC** in the same period, while the Caliman M5 cultivar did not differ significantly in terms of **NFC**.

The cultivar Brilhoso stood out in **January/2010**, showing the highest yield, both in terms of weight (**PFC**) and number (**NFC)** of commercial fruit.

There was a significant positive correlation between the **NFC** measured in the **Jan-Feb-Mar/2010 quarter** and the **NTFP** measured in January 2010.

There were significant positive correlations between **CFP** in the **Jan-Feb-Mar/2010 quarter** and **PA**, and between **CFN** in the **Jan-Feb-Mar/2010 quarter** and leaf area.

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