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# PERFORMANCE OF GENERATIONS OF UENF/CALIMAN 01 PAPAYA AND CORRELATIONS BETWEEN GERMINATION, VEGETATIVE AND REPRODUCTIVE DEVELOPMENT[1]

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**ABSTRACT –** The aim of this study was to characterize the seeds quality and the plant development of F1 and F2 generations of hybrid UENF/Caliman 01 papaya, and the relations between the physic-chemical and physiological quality of seeds, vegetative and reproductive development of plants in the field for 360 days, and fruit quality. The relative contribution (Cr %) to the genetic divergence for each characteristic was estimated. For those with higher importance for each group (Cr ≥ 25%), the Pearson correlation and the canonical correlation analysis were applied. The F1 seeds showed higher physic-chemical and physiological quality, with greater length (0.55 cm), sugar and lipid levels (5.13 and 11.58 mg $g^{-1}$, respectively), germination and normal seedlings percentages (94 and 98.31%, respectively). The F2 plants showed higher stem diameter (81.08 mm), fruits insertion height (184.8 cm) and fruits number (11.73). It was observed that higher levels of lipid in the seeds were associated with lower fruits number. Lower levels of sugar and lipid of the seeds and lower speed germination index were associated with lower survival. Thus, seed quality is associated with survival of hybrid UENF/Caliman 01 papaya plants in the field, but it does not have relation with the vegetative and reproductive development of plants.
**Index terms**: biometrics, *Carica papaya*, plant breeding, seed physiological quality.

## DESEMPENHO DE GERAÇÕES DO MAMOEIRO UENF/CALIMAN 01 E CORRELAÇÕES ENTRE GERMINAÇÃO, DESENVOLVIMENTO VEGETATIVO E REPRODUTIVO

RESUMO - Objetivou-se caracterizar a qualidade de sementes e o desenvolvimento das plantas das gerações F1 e F2 do mamoeiro híbrido UENF/Caliman 01, e as relações entre a qualidade físico-química e fisiológica de sementes, o desenvolvimento vegetativo e reprodutivo das plantas em campo por 360 dias, e a qualidade dos frutos. Foi estimada a contribuição relativa (Cr%) de cada característica para a divergência genética. Com aquelas de maior importância para cada grupo (Cr ≥ 25%), foram aplicadas as análises de correlação de Pearson e de correlações canônicas. As sementes F1 apresentaram maior qualidade físico-química e fisiológica, com maiores comprimento (0,55 cm), teores de açúcares e de lipídeos (5,13 e 11,58 mg g-1, respectivamente), porcentagens de germinação e de plântulas normais (94 e 98,31%, respectivamente). As plantas F2 apresentaram maiores diâmetro do caule (81,08 mm), altura do painel (184,8 cm) e número de frutos (11,73). Observou-se que maior teor de lipídeos nas sementes apresentou associação com menor número de frutos. Ainda, menores teores de açúcares e de lipídeos das sementes e menor velocidade de germinação apresentaram associação com menor sobrevivência. Assim, a qualidade das sementes está associada à sobrevivência das plantas do mamoeiro híbrido UENF/Caliman 01 em campo, mas não apresenta relação positiva com o desenvolvimento vegetativo e reprodutivo das plantas.
**Termos para indexação**: biometria, *Carica papaya*, melhoramento de plantas, qualidade fisiológica de sementes.

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## INTRODUCTION

The papaya improvement research has been aimed to the development of national hybrids, appearing a demand for these genotypes evaluation for their agronomic potential. (MARIN et al., 2006 a, b; DIAS et al., 2011; DANTAS et al., 2015; LUZ et al., 2015).

The papaya hybrids are obtained by the crossing between progenitors with different genetic pools, resulting in high hybrid vigor materials (MACEDO et al., 2013). In general, papaya hybrids have higher yields than the cultivars (LUZ et al. 2015). A crossing between a Solo group originator (Sunrise Solo) and a Formosa group originator (JS12) generated the hybrid UENF/Caliman 01 and it shows superior morpho-agronomic characteristics.

Plants generated from the planting of hybrids F1 seeds (at maximum heterosis) show ideal morpho-physiological characteristics while the planting of F2 seeds can generate plants that show segregation and heterogeneity in the orchard, which compromises the quality of crops (ANDRADE; PEREIRA, 2005; MARIN et al., 2006 a, b). Therefore, the evaluation of hybrid genotypes at maximum heterosis and their segregating generations become important.

In order to increase the papaya agribusiness competitiveness and the sustainability, researches on improvement propose methodologies to the early selection of superior genotypes, which depend on the evaluation of characters that are easy to measure, if they manifest before the production and they are correlated with characteristic of interest such as the production and fruit quality (SILVA et al., 2007, 2008; OLIVEIRA et al., 2010, 2012; FERREIRA et al., 2012; REIS et al., 2015; SARAN et al., 2015). Characters that show great genetic variability can be used in the selection processes of progenitors and hybrids for the use *per se* or in crosses for the synthesis of improved hybrids (DANTAS et al., 2015).

Researches suggest that the early selection of hermaphrodite and more productive papaya plants can be carried out by the evaluation of stem and canopy diameters, plants height, leaves width and flowering characteristics (SILVA et al., 2007; OLIVEIRA et al., 2010; 2012; FERREIRA et al., 2012). It is known that the seeds vigor mainly performs in the early stages of development, being directly linked to the percentage and speed of seedlings emergence and higher survival (MARCOS FILHO, 2005; CARDOSO et al., 2009; MACEDO, 2013). However, there are no studies about the association between the germination characteristics and the vegetative and/or reproductive development of papaya.

The evaluation of a genotype should be based on a simultaneous selection of a number of important characteristics for the culture, beyond the investigation of the relations between these characteristics (CRUZ et al., 2011). Thus, in order to promote progress in researches in the propagation area and improvements of the papaya, we aimed to study the characteristics related to seed quality, vegetative and plants reproductive development, characterizing the performance of F1 and F2 generations hybrid UENF/Caliman 01 papaya and relations between the evaluated characteristics.

## MATERIAL AND METHODS

The study was carried out at the Seed Analysis Laboratory of Agricultural Sciences Center of the Federal University of Espírito Santo and in a rural property in the municipality of Alegre, Espírito Santo, Brazil (20º 45'S and 41º 29'W and altitude of 138 m), between the months of July 2012 and October 2013. F1 and F2 seeds and hybrid UENF/Caliman 01 papaya seedlings were used. The University of Northern Fluminense Darcy Ribeiro (UENF) developed this hybrid in partnership with Caliman Agrícola S/A company, which has as progenitors cvs. Sunrise Solo (Solo group) and JS12 (Formosa group). The Caliman Agrícola S/A company provided the F1 seed and the F2 seeds were obtained from the fruits produced by the company.

**Physic-chemical quality of the seeds:** for the physical characterization, we evaluated initial moisture (M): determined by the oven method at 105 ± 3 ºC, at 24h, using subsamples of 0.18 g, expressed in percentage (moisture base); length (L): characterized as the distance between the base and the apex, and the diameter (D): measure from the middle portion of the seeds (mm). The weight of thousand seeds (WTS) (BRAZIL, 2009). For the biochemical characterization, seeds samples with approximately 0.1 g dry weight were macerated by the methanol, chloroform and water method (MCW, 1:1:1) and centrifuged. The higher liquid phase from the extraction (methanol + water) was used to quantify the soluble sugars; the lower one (chloroform) was used to quantify the lipids; the solid phase (pellet) was used to quantify the starch. Lipids quantification (L) – The solution of the lower phase was placed in Eppendorf tubes of 2 mL identified and weighted with a precision scale of 0.0001 g. Then, they were placed in the oven to dry at 60 ºC and weighted again (BLIGH; DYER, 1959, modified). Soluble sugars quantification (S) – The carbohydrates in the superior portion solution were hydrolyzed and dehydrate using concentrated

sulphuric acid, modifying the dehydrated simple sugars for furfural (YEMN; WILLIS, 1954). The products of this reaction condense with the anthrone, forming a colored teal substance that is used for the reading of soluble sugars made in spectrophotometer (FEMTO, Cirrus 80ST), at 620 nm. Starch quantification (St) – the solid phase (pellet) suffered digestion in HCl 3% in water bath (95-100 ºC) for 3 hours, centrifuged (4000 rpm for 5 min.) and collected the supernatant, with which proceeded the anthrone method, as described above. Total proteins quantification (P) – was carried out by inference on the nitrogen content (GALVANI; GAERTNER, 2006). Samples of seeds of 0.1 g of dry mass were crushed and suffered digestion block digester until the color changes to green, and then distillation and titration. The $NH_4^+$ produced in the digestion in sulphuric acid is distilled in a strongly alkaline medium. The nitrate is condensed in boric acid solution and titrated with HCl solution. The crude protein (CP) is expressed by the factor 6.25, considering that most of the proteins has in their molecules approximately 16% of nitrogen. The results of lipids, soluble sugars, starch and proteins quantifications were expressed in percentage (% m/m) of the seeds dry mass.

**Seeds physiologic quality:** the seeds were distributed in paper rolls, with three Germilab® sheets (*Germilab Ind. e Com. de Produtos para Laboratório Ltda*.), dampened with distilled water (2.5 times the mass of the dry paper), and maintained in germination camera at alternating temperature of 20-30 °C. The germination percentage (G) was evaluated, considering as germinated the seeds with primary root protrusion ≥ 0.2 cm, up to 28 days after the sowing; first and second germination count (FGC, SGC), carried out on 7, 14 and 21 days, respectively, considering the seedlings primary root protrusion, expressed in percentage; germination speed index (GSI), considering the seedlings with primary root protrusion, calculated according to equation proposed by Maguire (1962); percentage of normal seedlings (NS), considering the seedlings with all the structures formed (root, hypocotyl and cotyledons), calculated in relation to the germination percentage, 28 days after the sowing.

**Vegetative and reproductive development of the plants:** F1 and F2 seeds were sowed in plastic bags (10 x 15 cm) with HS Hortaliças® commercial substrate (Holambra substrates), kept in greenhouse shading. The seedlings were transplanted to the field 75 days after the sowing, with spacing of 1.5 x 2.0 m. Irrigations and fertilization were carried out according to the crops needs (PREZOTTI et al., 2007). We evaluated: plant height (PH) – it was evaluated from the soil to the canopy apex, and the result express in cm; stem diameter (SD) – it was evaluated in stem base close to the soil, and the result express in mm; leaves number (LN); survival percentage (SP); flowers number (FLN); hermaphrodite plants percentage (H); fruits number (FrN); panel height (PnH) – fruits insertion height express in cm.

**Fruits quality:** Fruits collected after 360 days were evaluated in relation to: length (FrL) and diameter (FrD) express in cm; fruits mass (FrM) and pulp mass (PM) in g; seeds per fruit number (SFrN); larger and smaller thickness of the pulp (LTFr and STFr) in mm, evaluated from the fruits collected after 360 days.

**Experimental design and statistical analysis:** regarding seeds quality, the experiment was carried out in a completely randomized design (CRD), with four repetitions of 25 seeds per genotype (F1 and F2 generations). The results obtained were analyzed using descriptive statistics (average and the standard error), and the average comparison by the Kruskal Wallis test (non-parametric).

Regarding the development of the plants, the experiment was carried out in randomized block design (RBD), with four blocks and five plants per plot, in an experimental area with 120 $m^2$. Evaluations were carried out every 60 days up to 180 days, and every 30 days up to 360 days. The results obtained were analyzed using descriptive statistics (average and the standard error), and the average comparison using the Kruskal Wallis test (non-parametric). For the plant development evaluation over time, the regression analysis was applied, and significant models were adopted ($p \leq 5\%$) and with the highest coefficient of determination (R2), using the R program (THE R FOUNDATION FOR STATISTICAL COMPUTING PLATAFORM, 2014)

The multivariate data analysis were proceeded and the following characteristics group were established: 1) Physic-chemical of seeds (M, L, D, S, St, L and P); 2) physiological of seeds (G, FGC, SGC, GSI, GMT, NS); 3) vegetative development of the plants (PH, SD, LN, SP); 4) reproductive development of the plants (FlN, H, FrN and PnH); 5) fruits quality (FrL, FrD, FrM, PM, SFrN, LTFr, STFr). For each group we evaluated the relative contribution of the characteristics for the genetic divergence between the generations by the Singh method. With the two most important characteristics for each group, we applied the Pearson correlation analysis and the canonical correlation between the groups of characteristics related to the seeds (1 and 2), named Group I *versus* Group II, which included the characteristics related to plant development and

fruits quality (4, 5 and 6). We used the Genes program (CRUZ, 2013).

## RESULTS AND DISCUSSION

The F1 seeds showed greater length (0.55 cm), greater sugar levels (5.13 mg $g^{-1}$) and lipids (11.58 mg $g^{-1}$) than the F2 seeds (0.42 cm, 2.93 mg $g^{-1}$ and 7.55 mg $g^{-1}$, respectively) (Figure 1A). The physiological characterization of the seeds highlighted that the F1 seeds showed greater vigor, with higher total germination percentages (F1 = 94% and F2 = 86%, of the counts performed at 7 (F1 = 6% and F2 = 0%) and at 14 days (F1 = 94% and F2 = 24%) and normal seedlings (F1 = 98.31% and F2 = 81.80%). The F1 seeds also showed faster germination (higher speed index, and lower average time of germination).

As the commercial propagation of papaya plant is carried out by seeds, the use of high quality seeds is essential for the establishment of vigorous and healthy seedlings. In general, physiological quality of the seeds is directly linked to the percentage and the emergence speed, which influence mainly in the early stages of seedlings development (MARCOS FILHO, 2005).

In general, comparing the F2 generation performance to F1 seeds, between the physic-chemical characteristics of the seeds, the F2 seeds showed lower performance for 62.5% of the characteristics (L, WTS, S, L and P). In relation to physiologic quality, the F2 performance was below 100% of the characteristics (G, FGC, SGC, GSI, AGT and NS).

The seeds of F1 generation hybrid, maximum heterosis, showed higher physic-chemical and physiological quality, corroborating with Macedo et al. (2013) results, which observed the heterosis effect in the physiological quality of papaya F1 seed, which showed high physiological quality. Thus, the plating of F1 seeds of hybrid UENF/Caliman 01 papaya is more suitable in order to obtain a homogeneous stand of the seedlings.

However, we found that the differences between the F1 and the F2 generations of the hybrid papaya became less evident after the transplanting of the seedling to the field (Figures 1B and 2), with synchrony in the vegetative and reproductive development between the generations.

For the plant height and stem diameter characteristics, we observed an adjusted response to the plateau model (Figure 2A and B). The F1 generation plants showed growth in height until 272 days, and F2 until 252 days, when there was a tendency to stabilize. For the stem diameter, the F1 and F2 generations plants showed stabilization after 244 and 263 days, respectively. 360 days after the transplanting, the F2 plants showed greater stem diameter (F1 = 69.90 mm and F2 = 81.08 mm) (Figure 1B).

For the leaves average number, the data were adjusted to the quadratic model, with maximum point estimated at 178 days for F1 generation plants and 214 days for the F2 (Figure 2C). The start of flowering was observed after 180 days and the fruit formation after 210 days (Figure 2D and E), and the F2 plants showed higher average number of fruits (F1 = 6.18 and F2 = 11.73) and higher panel height (F1 = 165.8 cm and F2 184.8 cm) (Figure 3), characteristics for which there was no adjustment to the regression models. However, despite of the higher average than F1, the F2 generation showed significant heterogeneity, especially in relation to the plants height, number and fruits format.

The F1 generation plants showed 100% of survival and the F2 showed only 75% of survival. Regarding the hermaphrodite plants percentage, the difference between the F1 and F2 generations was not observed (30 e 39.5%) (Figure 1B). The biometric characteristics of the fruits did not show difference between the F1 and F2 plants, except for the seeds per fruit number, which was higher for F1.

In general, the successive plantings with F2, F3 and F4 generations of hybrid papaya plants cause the loss of vigor, beyond the heterogeneity in relation to the characteristics of interest (ANDRADE; PEREIRA, 2005; MARIN et al., 2006 a, b). In this study, the vegetative and reproductive development of the F2 generation plants of hybrid papaya plants, as well as the fruit quality, do not suggest the reduction of hybrid vigor.

Although, segregating genotypes are not desired for the cultivation, in particular by the heterogeneity, the segregating generations may represent an important source of genetic diversity for the papaya improvement programs. Thus, the segregating generations study with the aim of select superior genotypes, in order to the *per se* use or as progenitors for the development of new cultivars become interesting (SILVA et al., 2007, 2008; DANTAS et al., 2015).

Morphological markers, such as morphometry and coloration of fruits, may be used with success to determine the genetic relations in papaya genotypes (SARAN et al., 2015). However, from a set of characters, some are more representative in the diversity studies (CRUZ et al., 2011). In this study, within each group of characteristics, those who showed higher relative contribution (Cr $\geq$ 25%) for the diversity study between the F1 and F2 generations were: a) soluble sugars and lipids contents (Seeds

physical-chemical); b) speed index and average time of germination (physiological of the seeds); c) survival and stem diameter (vegetative), fruits number and panel height (reproductive); d) fruit and pulp mass (fruit quality) (Table 1).

There was a positive correlation between physic-chemical quality and physiological quality of the hybrid seeds: the sugar (S) and lipids (L) contents showed a positive correlation with the germination speed index (GSI), with values of 0.87** and 0.86**, respectively, and negative with average time of germination (ATG), with values of -0.90** and -0.79**, respectively (Table 2). The correlation between seeds quality characteristics was also observed with other species. In melon, the high correlation between the starch content and the average time of germination, which represented association with the highest seed vigor (WANG et al., 2011)? In *Brassica chinensis,* the correlation between the percentage and the germination time was observed (SANTANA; RANAL, 2006). In soybean, positive correlations between the lignin content and the percentage of normal seedlings were observed, which can provide greater storage potential and germination to the seeds (MENEZES et al., 2009).

The correlation analysis indicates that the seed quality has a positive influence on the survival of the plants in the field: we verified that the seed physic-chemical quality (higher S and L) showed direct relation to the physiological quality (higher GSI and lower ATG) which showed a positive correlation with seedlings survival (SV) after the transplanting (Table 2).

However, the seed quality has a negative influence on the plant growth, once we observed a negative correlation between the seed germination speed (higher GSI and lower ATG), stem diameter (SD) and fruits number (FrN) of the plants (Table 2). Thus, the characteristics that denote higher seed quality showed an inverse relation to the vegetative and reproductive development of the plants. This observation is explained because the seed vigor performs mainly in the early stages of seedlings development, being directly linked to the plant survival (MARCOS FILHO, 2005).

Investigating the relation between the characteristics groups, in other words, seed quality (Group I) *versus* plant development and fruit quality (Group II), we observed that the first three canonical correlations were significant (Table 3). This way, the groups were related in a dependent way and the first three canonical pairs should be considered (CRUZ et al., 2011).

The association between the groups was established mainly through the influence of the following canonical correlations: a) higher lipid content in the seeds (Group I) was decisive in the lower fruit number (Group II); and b) lower levels of sugars and lipids of the seeds, and lower germination speed (Group I), were decisive in the lower plant survival, and in the higher stem diameter and panel height (Group II) (Table 3).

Studies with papaya highlighted that the analysis of vegetative and juvenile characteristics can predict higher productivity and quality of the fruits. Plants with higher stem diameter can result in more productive plants (SILVA et al., 2007). The plant height, the number of flowers per stalk and the leaf width are related to the fruits number (OLIVEIRA et al., 2010). The highest number of fruits can be predicted by the higher canopy diameter and the decrease of plat height; greater fruit mass is related to higher stem diameter, panel size and fruit length (FERREIRA et al., 2012). Also associations between quality characteristics of papaya fruits: fruits with greater length, diameter and the diameter of the inner cavity tend to have a greater pulp weight and thickness (REIS et al., 2015).

Although the study of the relations between the characteristics groups show information of interest to the early selection, it is not always possible. In beans, the correlation between best size and higher productivity of grains was small and negative (SILVA et al., 2009). In this study, we investigated the correlation between germination and vegetative and reproductive development, do not being observed, however positive correlations that would allow an early selection.

**TABLE 1 –** Relative contribution (Cr%), in percentage, of F1 and F2 generation characteristics of hybrid papaya plant, by the method proposed by Singh (1981), based on $D^2$ of Mahalanobis.

| Seed physic-chemical characteristics | Cr (%) |
|---|---|
| Moisture (M) | 06.02 |
| Length (L) | 16.42 |
| Diameter (D) | 05.82 |
| Thousands seeds weight (TSW) | 00.87 |
| Soluble Sugar (S) | 41.32 |
| Starch (St) | 02.48 |
| Lipids (L) | 25.81 |
| Total proteins (P) | 01.27 |
| Seed physiological characteristics | |
| Germination (G) | 07.25 |
| First count of germination (FCG) | 12.47 |
| Second count of germination (SCG) | 04.36 |
| Germination speed index (GSI) | 40.62 |
| Average time of germination (ATG) | 27.45 |
| Normal seedlings (NS) | 07.84 |
| Vegetative development | |
| Seedling height (SH) | 01.26 |
| Stem diameter (SD) | 38.14 |
| Leaves number (LN) | 04.46 |
| Survival (SP) | 56.14 |
| Reproductive development | |
| Flowers number (FlN) | 04.07 |
| Hermaphrodite plants (H) | 09.42 |
| Fruits number (FrN) | 60.34 |
| Panel height (PnH) | 26.17 |
| Fruits quality | |
| Length (FrL) | 00.04 |
| Diameter (FrD) | 00.96 |
| Fruit mass (FrM) | 38.37 |
| Pulp mass (PM) | 34.46 |
| Seeds number per fruit (SNFr) | 07.56 |
| Larger thickness of pulp (LTP) | 0.002 |
| Smaller thickness of pulp (STP) | 18.61 |

**TABLE 2 –** Pearson correlation between the characteristics of greater relative importance (Cr ≥ 25%): soluble sugar content (S), lipids content (L), germination speed index (GSI), average time of germination (ATG), survival percentage (SP), stem diameter (SD), fruits number (FrN), panel height (PnH), fruit mass (FrM) and pulp mass (PM), of seeds and F1 and F2 generations of hybrid papaya plants.

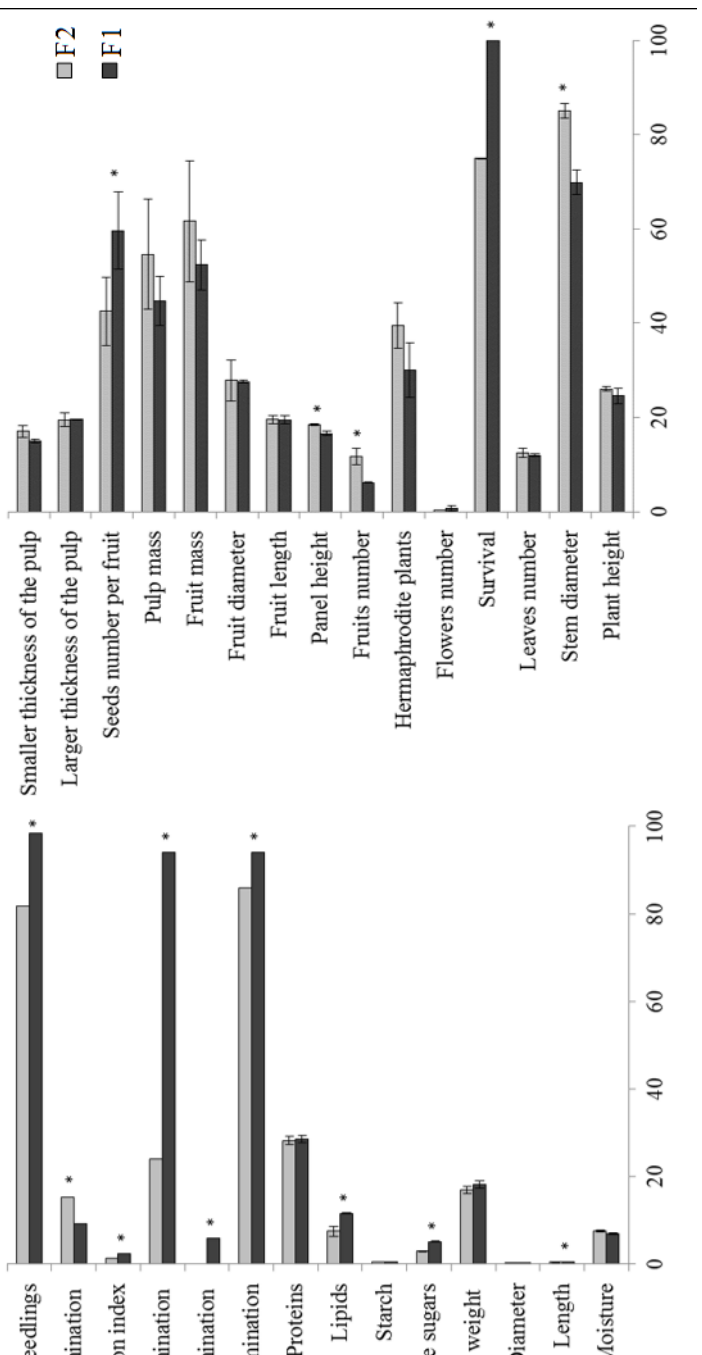
| Characteristics | S | L | GSI | ATG | SP | SD | FrN | PnH | FrM | PM |
|---|---|---|---|---|---|---|---|---|---|---|
| S | - | 0.62 | 0.87** | -0.90** | 0.82* | -0.97** | -0.62 | -0.89** | -0.25 | -0.29 |
| L | - | - | 0.86** | -0.79* | 0.63 | -0.56 | -0.92** | -0.36 | 0.03 | 0.00 |
| GSI | - | - | - | -0.98** | 0.82* | -0.82* | -0.81* | -0.60 | -0.22 | -0.27 |
| ATG | - | - | - | - | -0.86** | 0.82* | 0.76* | 0.67 | 0.25 | 0.31 |
| SP | - | - | - | - | - | -0.75* | -0.61 | -0.61 | -0.64 | -0.67 |
| SD | - | - | - | - | - | - | 0.55 | 0.89** | 0.24 | 0.27 |
| FrN | - | - | - | - | - | - | - | 0.41 | -0.02 | 0.03 |
| PnH | - | - | - | - | - | - | - | - | 0.09 | 0.13 |
| FrM | - | - | - | - | - | - | - | - | - | 0.99** |
| PM | - | - | - | - | - | - | - | - | - | - |

*,** significant in level of 5 and 1%, respectively, by t test.

**TABLE 3 -** Canonical correlations (r) and canonical pairs estimated between the seeds (Group I) and plants (Group II) characteristics of the F1 and F2 generations of hybrid papaya plants.

| Characteristics | Canonical pairs | | | |
|---|---|---|---|---|
| | 1º | 2º | 3º | 4º |
| | | | Group I | |
| Soluble Sugar (S) | 0.07 | -0.08 | -0.98 | 0.19 |
| Lipids (L) | 0.63(1) | 0.13 | -0.70 | -0.37 |
| Germination speed index (GSI) | 0.26 | -0.13 | -0.92 | -0.27 |
| Average time of germination (ATG) | -0.09 | 0.03 | 0.96 | 0.25 |
| | | | Group II | |
| Survival (SP) | 0.01 | 0.03 | -0.86 | -0.10 |
| Stem diameter (SD) | -0.16 | 0.23 | 0.90 | -0.32 |
| Fruits number (FrN) | -0.52 | -0.17 | 0.67 | 0.33 |
| Panel height (PnH) | 0.08 | -0.07 | 0.83 | -0.52 |
| Fruit mass (FrM) | 0.30 | 0.32 | 0.26 | 0.09 |
| Pulp mass (PM) | 0.33 | 0.33 | 0.31 | 0.12 |
| Canonical correlation (r) | 1.00* | 1.00* | 0.99* | 0.92ns |
| Degrees of freedom | 24 | 15 | 8 | 3 |

* ns = significant and no significant, respectively, at 5% level of probability, by the chi-square test. (1) Underlined values are the variables that




* ns = significant and no significant, respectively, at 5% level of probability, by the chi-square test. (1) Underlined values are the variables that predominated in the total variance explanation.

**FIGURE 1 –** Seeds (A) and plants (B) characteristics after 360 days F1 and F2 of hybrid papaya UENF/Caliman 01: moisture (%), length (cm), diameter (mm), thousands seeds weight (g), soluble sugar contents, starch, lipids and total proteins (%) (m/m), germination, first and second count of germination (%), speed germination index, average time of germination (days), and normal seedlings (%); plant height (cm.$10^{-1}$), stem diameter (mm), leaves number, survival (%), flowers number, hermaphrodite plants (%), fruits number, panel height (cm.$10^{-1}$), fruits length and diameter (cm), fruit and pulp mass (g.$10^{-1}$), seeds number per fruit ($10^{-1}$), larger and smaller thickness of the pulp (mm). * the averages are statistically different by the Friedman test ($p \leq 5\%$).

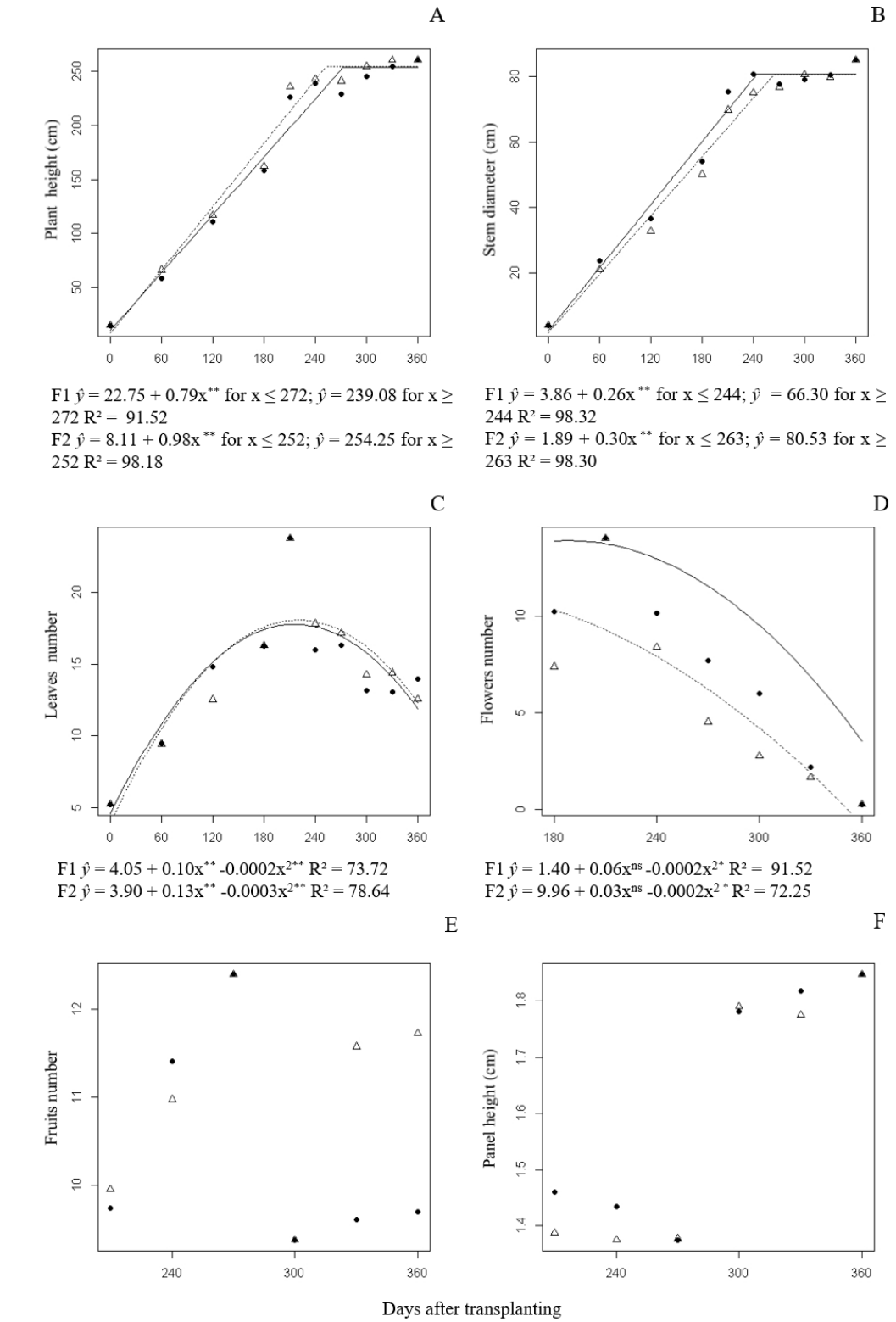



**FIGURE 2 –** Development of F1 and F2 generations of hybrid papaya plants during 360 days: A) plant height (cm); B) stem diameter (mm); C) leaves number; D) flowers number; E) fruits number; and F) panel height (cm). *,** and ns: significant in level of 5 and 1% probability, and no significant, respectively.

## CONCLUSIONS

The F1 seeds of UENF/Caliman 01 hybrid papaya showed superior quality and superior physiological quality and the planting of hybrid F1 seeds is more suitable in order to obtain a homogeneous stand of seedlings.

The F2 generation plants show superior performance in relation to the stem diameter, panel height and fruits number. However, they show higher mortality rates.

The highest physic-chemical and physiological quality of the seeds is associated to the highest plants survival in the field, but it did not show positive relation with the vegetative and reproductive development of the plants.

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