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PRE-HARVEST BEHAVIOR OFPAPAYA GENOTYPES DURING THE SPRING IN THE CENTER OF VERACRUZ

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Abstract: Veracruz is the main supplier of papaya fruits, highly desired by Mexicans, it is grown in the center of the state. In Mexico, Creole and introduced papayas have been cultivated, however, most of them presented phytosanitary problems that restrict their production such as: virosis, anthracnose, mites, phytoplasmas, and high temperatures that cause damage to production; Due to the above, genetic strategies that consider wild accessions have been suggested. To address this problem, the objective of this work was to evaluate the behavior during preharvest of papaya genotypes grown in the center of Veracruz in relation to each other and to adverse environmental factors such as temperature. The research was carried out in the spring in commercial orchards located in the municipality of Cotaxtla, Ver. Four treatments were considered: T1= MSXJ Hybrid, T2= Maribel Variety, T3= Intenzza Hybrid, T4=H. Strength + Padded. The study variables were: plant height, number of leaves, height of the first floral bud, number of flowers, number of fruits, number of aborted flowers, number of aborted fruits, and number of fruits with carpeloidia. 24 plants per treatment were evaluated, the experimental unit was one plant. The data was taken from February to June, during the pre-harvest stage, to appreciate the effect of temperature on the genotypes. It was analyzed with a randomized block design and Tukey's mean test was performed. The months with the warmest temperatures, with their maximums above 33.0° C were: May and June. The damage of the temperatures during these months appeared in the flower abortion, fruit abortion and carpeloid damage, which affected the number of fruits of each genotype. In May, the greatest amount of carpeloidia and abortion in flowers occurred, in June the abortion in fruits.

Due to their response to temperature, it is considered that the preharvest behavior of treatments 1 and 2 are equally competitive genotypes in papaya production in central Veracruz. Treatment 1 presented reduced effect due to temperatures.

Keywords: flower abortion, MSXJ, carpeloidia

INTRODUCTION

Papaya as a fruit is integrated into the daily diet of Mexicans. In Mexico, 19,312 ha are planted. Veracruz, with 3,525 ha planted, is the main producer and supplier of papaya fruit in Mexico, followed by Colima, Michoacán, Oaxaca and Chiapas; while in Oaxaca and Chiapas the yields are 61 and 42 tons ha-1, in Veracruz they are 32 tons ha-1, in the municipalities where papaya is grown the most are Cotaxtla, Tierra Blanca and Tlalixcoyan, located in the center of Veracruz (SIAP, 2019).

The family Caricaceae with its 35 species is divided into six genera: Carica papaya (one species), Cylicomorpha spp. (two), Horovitzia cnidoscoloides (one), Jarilla spp. (three), Jacaratia spp. (eight), Vasconcellea spp. (20), C. papaya, cultivated for its fruits, separated from its sister clades 25 million years ago, Mesoamerica is considered one of the centers of plant domestication in the lowlands of southwestern Mexico, before the Olmecs and Mayans, from 5000-4000 years BC (Antunes and Renner, 2012). In Mexico, native papayas such as Cera, Cocos and Mamey have been cultivated, as well as introduced as the Hawaiian Solo type: Kapoho, Rainbow, Sunup, Sunrise and Sunset, others such as Tainung, Red Lady, Intenzza, Sensation, Maradol (Santamaria, 2012), Passion Red, Lenia, Mulata and Maribel. Intenzza and Maribel papaya crops have increased in large areas in central Veracruz.

The main phytosanitary problems that affect papaya in Mexico reduce the production and income of producers and have a cost of $24,579.00 per hectare, which represents 17% of the cost of the technological package. These problems are the virus (De los Santos et al., 2000; Noa, 2003; Rodríguez, 1994), anthracnose (Rodríguez et al., 2018a; Rodríguez et al., 2018b) and in the last ten years mites stand out. (Abato, 2011; Reyes-Pérez et al., 2013; Rodríguez-Escobar and Salas-Reyes, 2016), phytoplasma (Lebsky et al., 2010; Rojas-Martínez et al., 2011) and high temperatures (De los Santos et al., 2000; Jeyakumar et al., 2007; Vázquez et al, 2010).

During 2015, in an investigation that was transplanted in May, from August 19, including September and October, temperatures increased above 35°C, reaching a maximum of 44°C on October 2, when the plants they began to present fruits larger than 5 cm, we recorded the mortality of 4 to 6 aborted/fallen flowers, in the five genotypes: which was recorded simultaneously in the producers' plot; an exercise was carried out with the producers and the four to six lost flowers caused damage of 8 kg per fruit plant, this implied 16 tons ha-1 equal to losses for the value of $64,000.00, similar information was provided by several researchers, who mention that temperatures from March to May above 35° C decreased the net assimilation of CO2 and stomatal conductance, and also caused female sterility, due to ovary atrophy, the fruit does not develop and there is even deformation of the fruits (carpeloidia) (Chávez et al., 2017; De los Santos et al., 2000; Hueso et al., 2015; Jeyakumat et al., 2007 and Vázquez et al., 2010). Heat stress causes irreversible damage to plant metabolism and development. In papaya clones subjected for 18 months to temperatures of 28-36°C, growth acceleration was produced, with tall but weak plants, with small fruits and early maturity; it affects sporogenesis with yield damage, it also causes poor pollen viability, in addition these researchers suggest that temperature will influence the expression of sex in papaya and that the flowers do not produce fruits (Chávez et al., 2017).

Due to the lack of national papaya seed, the introduced varieties and hybrids were used, however, these have shown susceptibility to pests and diseases, in addition to the above, it has been suggested that genetic strategies be used to face the problem of thermal stress through wild accessions or related species (Wahid et al., 2007), for this reason some materials have been produced in which Creole genotypes are used as parents with tolerance to various problems that occurred in the introduced ones, thus the Azteca hybrids were developed and MSXJ; The MSXJ hybrid was developed in Tabasco, from a parent Maradol father (MST) and as mother the Creole line "J", from the first it inherited height to the first fruit, color and consistency of the fruit and from the Creole line tolerance to diseases, mites and carpeloidia (Mirafuentes et al., 2013), and the BS and BS2 varieties that, although they have registered tolerance to high temperatures, their loss of firmness restricts them from the export market (Santamaría et al., 2015).

To know the behavior of the papaya genotypes, growth variables have been studied such as: plant height, height to the first fruit, number of flowers, type of fruits; and yield variables: number of aborted flowers, number of fruits, number of aborted and deformed fruits or with carpeloidia (Mirafuentes et al., 2008; 2013a, b; Vargas et al., 2004). Based on the aforementioned, the objective of this work was to evaluate the behavior during preharvest of papaya genotypes grown in the center of Veracruz in relation to each other and to adverse environmental factors such as temperature.

MATERIALS AND METHODS

The investigation was established in the plantations of two producers, located in the municipality of Cotaxtla, close to the Federal highway. The concentration and analysis of data was carried out at the facilities of the Cotaxtla Experimental Field.

The plants were produced in germinating trays, in a greenhouse, they were transplanted in the second half of January, on loam soils.

They were sown in a row, at distances between rows of 3 m and between plants 1.5 m, two irrigation straps were placed on them. The plants received the management of the technical producer, such as nutrition, irrigation, pest control, diseases, weeds. Thus, the treatments were T1= MSXJ Hybrid, T2= Maribel Variety, T3= Intenzza Hybrid, T4=H. Strength + Padded.

The study variables for both plantations were measured: 1. Plant height, measured from the neck of the plant or ground level to the apical part of the bud; 2. Number of leaves, the leaves formed and that had exposure to the sun per plant were counted; 3. Height of the first lowest floral bud or fruit, the height from the ground to the first floral bud, flower or fruit that was closest to the ground was measured; 4. Number of flowers, the number of flowers present on the plant was counted; 5. Number of fruits, the number of fruits present on the plant was counted, the aborted ones were discounted; 6. Number of aborted flowers, counted the number of flowers that were withered, a different brown color than normal, or dehydrated, still attached to the plant; 7. Number of aborted fruits was counted the number of fruits present that presented yellow color and lack of development and 8. Number of fruits with carpeloidia. Those that were deformed were counted. Two lines of plants were considered, in each one 12 plants were evaluated, the experimental unit was one plant. The data collection was carried out weekly from February to June, with the exception of the months of April and May, in which only two samples were taken. weeks. The data from the months of May and June 2019 allowed us to appreciate the effect of temperature stress on the papaya genotypes, for this reason they were processed through random block analysis and the Tukey means test ($p \leq 0.05$). For the data on flower abortion, fruit abortion and carpeloidia, data transformation was performed using ArcoSeno $\sqrt{y}$. The statistical package used was SAS 9.3.

RESULTS AND DISCUSSION

The Analysis of Variance, for data from the months of May and June, showed that there were highly significant differences between the treatments.

For plant height (Alt), treatments 1 and 2 (MSXJ and Maribel) presented lower height, that is, a short bearing (Table 1). For number of leaves, treatment 4 (Intenzza hybrid with mulch) registered the highest number of leaves. For the variable height to the first floral bud, treatments 1, 2 and 4 presented lower height to the first floral bud; Regarding the number of flowers, treatment 1 and 2 presented the largest number of flowers.

For these first four study variables, in relation to the behavior of the three papaya genotypes cultivated in the center of Veracruz, the MSXJ and Maribel genotypes presented a statistically similar behavior. Regarding height to the first floral shoot, MSXJ presented a behavior similar to that registered for Huimanguillo, Tabasco, where the plant reached 44 cm at the first fruit and in Veracruz it was 50 cm, while in Yucatán it was 70 cm (Mirafuentes et al. 2013a); this height was lower than that of BS, which in Tabasco and Yucatán presented 80 and 88 cm as height to the first fruit respectively; this variety is registered as tolerant to heat stress (Santamaría et al., 2015).

The variables in Table 2 show highly

Variables	alt		NH		APBF		NF	
T1. MSXJ Hybrid	106.17	c	22.76	b	0.50	b	41.18	a
T2. Maribel variety	100.47	c	22.08	b	0.49	b	39.02	ab
T3. Hybrid Intensity	124.50	b	22.78	b	1.08	a	35.23	b
T4. H. Intenzza + Padding	141.56	b	26.40	a	0.70	ab	25.87	c

Table 1. Comparison of means of the variables height of the plant, number of leaves, height at the first shoot and number of flowers of papaya (Carica papaya L.).

Height: plant height; NH: Number of leaves; APBF: Height at the first flower bud; NF: Number of flowers (Tukey, P≤ 0.05).

Variables	nfru		AF		afru		car	
T1. MSXJ Hybrid	11.33	a	0.58	b	0.08	b	0	b
T2. Maribel variety	7.35	b	2.10	a	0.38	b	0.20	a
T3. Hybrid Intenza	2.50	c	1.58	ab	1.68	a	0.13	ab
T4. H. Intenzza + Padding	5.41	b	2.62	a	1.98	a	0.11	ab

Table 2. Comparison of means allows distinguishing differences for the response variables of the three genotypes of papaya (Carica papaya L.). Cotaxtla Experimental Field, May and June 2019.

Nfru: Number of fruits; AF: flower abortion; Afru: abortion of fruits; Car: carpeloidia. (Tukey, P≤ 0.05)).

TEMPERATURE	MARCH	APRIL	MAY	JUNE	JULY
Half	24.1	25.9	27.3	26.8	26.1
maximum	31.0	32.9	34.3	33.2	32.1
minimum	17.2	18.9	20.4	20.3	20.1

Table 3. Average temperatures of the "El Copital" Station, Veracruz, from 1981 to 2010. CONAGUA, August 2019.

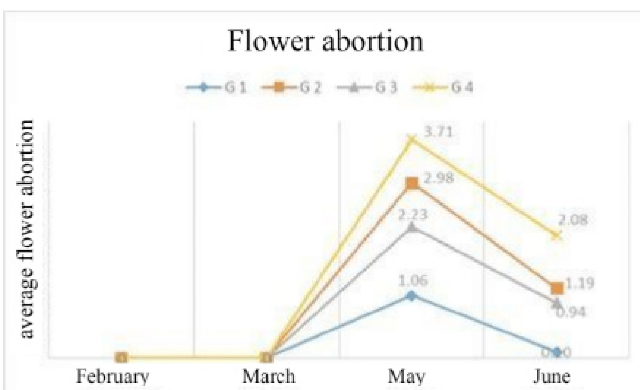

Figure 1. Flower abortion by month in genotypes. T1=MSXJ hybrid, T2= Maribel variety, T3= Intenzza hybrid, T4= Intenzza hybrid with mulch.

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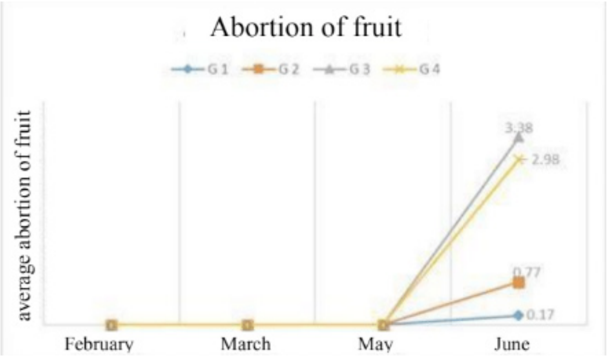

Figure 2. Fruit abortion per month in genotypes. T1=MSXJ hybrid, T2= Maribel variety, T3= Intenzza hybrid, T4= Intenzza hybrid with mulch.

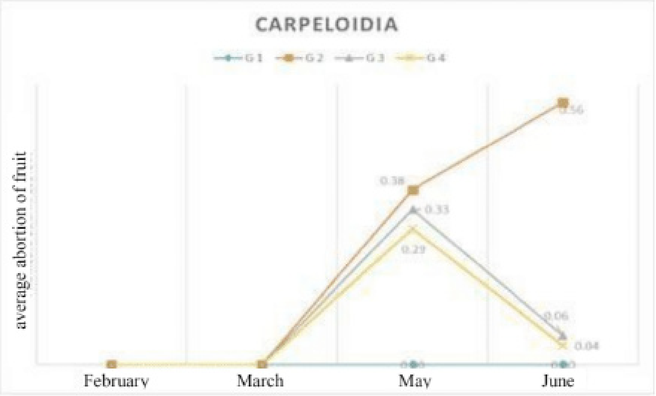

Figure 3. Carpeloidia or deformation of fruits by month.T1=MSXJ hybrid, T2= Maribel variety, T3= Intenzza hybrid, T4= Intenzza hybrid with mulch.

significant differences for the number of fruits in preharvest. The MSXJ hybrid presented an average of 11.33, higher than the other genotypes, similar results were recorded in other investigations Mirafuentes et al., (2013a). Regarding flower abortion (AF), the MSXJ and Intenzza genotypes had fewer aborted flowers. The abortion affected the Maribel and Intenzza genotypes with padding (T4). Here it must be noted that treatments 3 and 4 are from the same Intenzza hybrid. The difference is that the T4 has padding and this could have increased the temperature to the detriment of the flowers that aborted. Regarding fruit abortion (Afru), the MSXJ and Maribel genotypes presented the least amount of aborted fruits; the number of deformed fruits or with carpeloidia (Car), mainly affected the Maribel genotype.

The behavior of the three papaya genotypes cultivated in the center of Veracruz was mainly affected by the temperature (Table 3), in the areas where papaya is currently planted in the municipality of Cotaxtla. They stand out as the months with the warmest temperatures, with their maximums above 33.0° C in May and June. This research shows that for the center of Veracruz the temperature had an evident effect on the flowers in the Marible, Intenzza and Intezza genotypes with mulch, with flower abortion of 70, 50 and 87.5% while for MSXJ it was 25%. Regarding fruit abortion for Intenzza without and with mulch, 75 and 87.5% were registered, respectively, while for MSXJ and Maribel values of 2.5 and 17.5% of fruit loss were obtained, respectively. Regarding the problem of fruit deformation or carpeloidy, the total number of fruits of each one of the genotypes was taken to obtain the percentage of carpeloidy this way it is found that the Maribel and Intenzza genotypes presented a higher percentage of carpeloidy with 75 and 47.5 %, respectively, while intenzza with mulch was 55% with respect to the total number of fruits, on the contrary, MSXJ did not present fruits with this problem (Table 2). The above is related to what was expressed by several groups of researchers regarding the damage caused by temperatures above 33° C in papaya production (Chávez et al., 2017; De los Santos et al., 2000; Hueso et al, 2015; Jeyakumat et al., 2007; Vázquez et al., 2010).

Figure 1 shows the average flower abortion per month. It can be noted that in May the greatest number of aborted flowers was presented in all treatments, and coincides with the increase in average maximum temperature of 34.3 ° C (Table 3), affecting more in the Maribel and H. Intenzza treatments with Mulching, while the MSXJ and Intenzza treatments suffered less flower abortion, they were statistically different (Table 2). In June the average maximum temperature dropped and as a consequence less flower abortion was evaluated, and the damage on them was maintained

Intenzza treatments with Padding and Intenzza, it must be noted that treatment 4 and probably the heat of the plastic increased the temperature, which affected the flowers.

Figure 2 shows the average fruit abortion per month, it is observed that in June fruit abortion of all genotypes occurred, coinciding with the second highest average maximum temperature of 33.2 °C (Table 3), this it damages treatments 3 and 4 more, while treatments 1 and 2 suffered less fruit abortion and were statistically different (Table 2). Treatments 3 and 4 were affected during the warmer months by thermal stress, they lost the few flowers that they kept when they turned into fruits in June.

Figure 3 shows the average number of deformed fruits or carpeloidia per month, it is observed that in May the greatest amount of carpeloidia occurred in most treatments 2, 3 and 4, which coincides with the highest average maximum temperature of 34.3 °C

(Table 3), it damaged treatments 2 and 3 more, while treatment 4 presented less carpeloidia and treatment 1 did not. In June, treatment 2 was the only one that presented a strong carpeloid effect, a value that was significantly higher than in the other three treatments (Table 2). Treatments 3 and 4 already had almost no fruits, for this reason they did not present this fruit deformation and treatment 1 did not present this damage and therefore it was the one that presented the highest number of fruits and statistically different (Table 2). The effects of flower abortion,

Figure 4. Plant with "bench without fruits".

In this investigation, when taking into account the growth variables (Table 1), it is observed that treatments 1 and 2 (Maribel and MSXJ) are statistically similar, in addition to the fact that they present little fruit abortion, it can be considered that the preharvest behavior of both materials defines them as two equally competitive genotypes in papaya production in central Veracruz. MSXJ presented reduced damage due to temperatures above 33° C that occurred in the center of Veracruz, on yield variables such as flower abortion, fruit abortion and carpeloidia; this genotype is a combination of a commercial material and a wild accession (Mirafuentes et al., 2013), its tolerance is largely related to what was suggested by Wahid et al. (2007) to face the problem of thermal stress.

CONCLUSIONS

The MSXJ and Maribel genotypes presented an equally competitive preharvest performance in papaya production in central Veracruz.

The behavior of the MSXJ genotype presented a reduced effect due to temperatures above 33°C that occurred in the center of Veracruz.

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