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Aspects of floral biology in papaya (*Carica papaya* L.) cv. «Cartagena roja» in Lara state, Venezuela

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Abstract

In order to contribute the knowledge about floral biology of papaya, anthesis, dehiscence of anthers, quantity, and viability of pollen grain on different flowers and fruit set moment were studied. Anthesis, dehiscence of anthers and fruit set were evaluated by observations in field, selected each of floral types at random. Quantity and viability were determined by hematocytometer methodological, using aniline blue in lactofenol at 1%. The results indicated differences between floral types. As anthesis as fruit set begin slower in a type I flower. Dehiscence of anthers occurred before anthesis. The floral IV+ the biggest quantity of pollen grain, compared with the types IV and V. Viability percentages were 86,2; 86,7 and 82,7% for IV, IV+ and V floral types, respectively.

Key words: *Carica papaya,* anthesis, dehiscence of anthers, fruit set, pollen, viability.

Introduction

The papaya (*Carica papaya* L.), is a perennial original specie of Tropical America and pertaining to the *Caricaceae* family (2). Although its exact origin has been very discussed due to the great dissemination by the man (9).

In this specie 6 types differentiated from flowers are recognized: one feminine one, three hermaphrodites and two masculine, designated commonly like types I, II, III, IV, IV+ and V, respectively (10).

The hermaphrodites flowers distinguish by the number and distribution of stamens, form of ovary and characteristics of the corolla; these flowers also denominate «pentandria» (type II), «irregular» (type III) and «elongate» (type IV); the flowers of type III and in smaller degree of type II present stamens carpeloidy. The masculine flowers can be «functional masculine» (type IV+) and «masculine typical» (type V); these flowers do not develop fruits (10,

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20). According to the presence of these floral types the papaya plants can group in diverse sexual forms or genomes: androic form, which presents masculine flowers mainly (type V), ginoic form, with solely feminine flowers (type I) and the andromonoic sexual form, with hermaphrodites flowers of types II, III and IV, in addition to masculine flowers (IV+) (10). Researchers have demonstrated that the sex of the papaya is governed genetically but in spite of it has been reported that the floral development is under modifications by environmental factors, being the temperature, the light and the humidity, most influential. (12). The studies on the reproductive Biology of the papaya are fewer (17) and are located in Hawaii, India and South Africa. Parés (13) evaluating the reproductive behavior of the papaya Cartagena Amarilla cultivar in Venezuela, respectively found that the androic sexual form was precocious in initiating the flowering, taking 54 days after seedtime in field, whereas the sexual forms andromonoic and ginoic initiated their flowering to 59 and 61 days.

Mekako and Nakasones (11) indicated that the time from the emergency of the floral button to the anthesis of the flower, under the conditions in Hawaii, was of approximately 45 days in masculine flowers and 47 days in the feminine, whereas the hermaphrodites floral types delayed 49 days. On the other hand, Sippel *et al* (19) indicated a period of 10 weeks from the emergency of the floral button to the anthesis in cultivating «Sunrise Solo» under the conditions of South Africa. Possibly these differences also must be due to the climatic conditions, as indicate the authors previously mentioned. Parés (13) reported that the floral types produced by the andromonoic sexual form (II, III, IV and IV+) presented similar performance as far as the number of days passed from the emergency of the floral button to the anthesis, taking 33 days in average, whereas the floral type I produced by the ginoic sexual form took 35 days and the floral type V produced by the androic plants, delayed 30 days. Sippel *et al* (19) mentioned that under conditions of South Africa, all the floral types show a tip of anthesis at the end of the afternoon or at the beginning at night, being for the staminate and pistil flowers between 6 and 8 p.m., and for the hermaphrodites between 8 and 10 p.m.. These results are similar to the reported ones in India by Parés in Venezuela (13). According to Rodriguez *et al* (16), the dehiscence of anthers takes place before it happens the anthesis; mentioning Parés *et al* (14) that the liberation of pollen grains happens two days before the opening of the floral button for the case of types IV+ and V, whereas for the floral types IV, III and II the day of the anthesis follows one another, previous to this one. Parés *et al* (15) mention that the greater amount of pollen grains by flower produce the floral types IV, IV+ and V, being the amount of pollen grains produced by flower of 107,200, 106,776, 238,680,

229,920 and 223,680 for the floral types II, III, IV, IV+ and V, respectively. The germination of pollen grains in papaya is presented in increasing form in the measurement in which the floral types approach the masculinity, presenting the viability *in vitro* of pollen grains the same isendency that the germination, which demonstrated by the high degree of existing correlation between the 2 variables, with $r^2 = 0,9956$ (15). Results allow to corroborate that the germination of pollen grains of papaya *in vitro* can be considered like a reliable test to determine their viability as indicates Cohen *et al* (3). The fixation of fruits varies between different the floral type floral from papaya; the floral type I produced by the ginoic plants is most delayed in fixing its fruits to comparison to the floral types produced by the andromonoic plants, delaying 10 days. From the floral types produced by the andromonoic plants, the II and III present a similar performance, taking 7 days in fixing their fruits, unlike flower IV which it turns out to be precocious, delaying 6 days from the floral opening (12). Possibly, this characteristic of the floral type it must to its unisexual constitution where the crossed pollination is obligatory, unlike the floral types produced by the andromonoic individuals, which release pollen before the floral opening (13). By previously exposed, and given the importance that has the study of reproductive Biology on the level of production and the handling of the plantations, it is considered to evaluate some aspects of the floral Biology of the papaya cv. Cartagena roja. For which the following objectives were formulated:

Determine the duration of the period from emergency of the floral button to the anthesis, for the floral types I, IV, IV+ and V.

Determine the moment of the dehiscence of anthers in the floral types IV, IV+ and V.

Consider the total amount and viability of pollen grains of the masculine flowers and hermaphrodite elongated.

Determine the time of fixation of the fruit for the floral types I and IV.

Materials and methods

The experiment was carried out in a block of 450 m^2, in the farm «La Esperanza», located in Bobare, Iribarren County of Lara state; the zone belongs to the thorny mount with precipitation annual average of 390 mm^3; potential evapotranspiration of 250 mm^3 monthly and temperature monthly average of 28ºC.

Material vegetable flowers of cv. Cartagena roja were used, this variety is characterized by being of high bearing, green stems and petioles of flowering to 4 months after the transplant and to present fruits of sure yellow crust reddish pulp and sweet flavor, when mature (4). Seedtime was made in polyethylene bags, the soil became disinfected previously with hot water. Plants was

protected initially of the sun placing them under shade, and 10 days before the transplant to field were put under total solar exhibition. The control of weeds during the phase of breeding soil was made manually. The subject population to study was conformed, once made to thinned, by 214 plants. At the three months of age the plants were taken to field where all the respective agronomical workings were made. The time average passed from the emergency of the floral button to the anthesis was determined marking visible a floral button, (4 mm approximately). 30 flowers of types I, IV IV+ and V were evaluated altogether. A flower by plant was evaluated selected at random with the exception of the androic sexual form of which evaluated three flowers by given plant its low proportion in the studied population (13). For the determination of the dehiscence of anthers 30 androic flowers (V and IV+) and 30 flowers of type IV were evaluated, selecting a flower by plant in the case of the flowers IV+ and IV and three of type V. The flowers were marked and it was open each one carefully; with the help of a magnifying glass, it was observed the moment at which it happened the dehiscence of anthers, and the number of days passed from the dehiscence of anthers was registered to the floral opening. (14). The amount and viability of pollen grains was determined at random selecting 5 flowers of types IV and IV+ and equal amount of flowers of same type V. The same had their mature anthers, nondehiscent, and were put to the laboratory in paper bags. The estimation of the total amount of pollen grains (viable and nonviable) by flower was made under the microscope stereoscopic and with the help of two needles of dissection an anther was opened, of each verticil, by flower on a 0.1 touchstone and then 0,1 milliliter of blue aniline in lactofenol to 1% was added, considered like volume of dilution, which colored the viable pollen grains; it was verified that all the pollen grains were free of anthers and these were retired of the liquid. The mixture was shaken well with a needle and a drop of this one was transferred using a pipette Pasteur to each one of the cameras of hematocytometer repeating the procedure until obtaining a total of four measurements by each dilution. In each measurement the grains were counted of pollen viable and nonviable (not colored and deformed) (7).

The calculation of the total amount of pollen grains by anther, was made applying the following formula:

$$\text{Pollen Grains/anther} = \frac{\text{Nº/chamber} \times \text{Vol. of dilution} \times 10^{4}}{4}$$

The total number of pollen grains by flower was obtained multiplying the number of grains totals/anther by the total number of anthers of each flower. Whereas, the amount of pollen viable calculated applying the previous formula, using in the formula the number of viable pollen grains in place of the number of total grains. The complete procedure was repeated five times for

each type of flower.

In order to determine the moment of fixation of the fruits the number of days passed from the anthesis to the fall of the petals was registered; 30 flowers of the floral type IV of the andromonoic plants were marked and 30 feminine flowers (type I) of the ginoic plants, one by plant selected at random (14). These 2 floral types were evaluated by being those that produced commercial fruits. Once verified the assumptions that rule the variance analysis, the data of each evaluated variable were put under the variance analysis and a Duncan test of averages, both at a significance level of 5% of probability. The Statistic Analysis System was applied 6,12 (18), like statistical applicative.

Results and discussion

It was detected that the type of flower affects the duration of period from the emergency performance in relation to this variable (table 1).The types of flowers IV and V, presented a similar behavior in relation to this variable. Also the Duncan test allowed to classify other two groups of floral types, in function to the time from the emergency of the button floral until its opening, being constituted by types I and IV+, respectively, which take longer in initiating its anthesis, comparing to types IV and V.

Parés (13) working under the conditions in the basin of Valencia Lake and with Cartagena amarilla papaya, it obtained a similar tendency as far as the performance of the floral types in function to the anthesis. Although, the number of days passed for each case was higher, reporting 35 days for the feminine flower (type I), 33 days for all the floral types produced by the andromonoic plants and 30 days for the masculine flower (type V). On the other hand, Mekako and the Nakasones (11) found in the 26 line the group «Solo» a period of 45 days in masculine flowers and 47 days in feminine flowers, whereas the hermaphrodites delayed 49 days. Additionally, Arkle and Nakasone (1) and Sippel *et al* (19) reported a period of 9 to 10 weeks for the floral

Table 1. Days from button floral emergency of the (*Bfe)* to the anthesis.

Floral type	Sexual form	Days between *Bfe* and anthesis.
I	Ginoic	31.27 a
IV+	Andromonoic	30.42 a b
IV	Andromonoic	29.55 b
V	Androic	29.42 b

Averages with different letters represent significant differences according to the Duncan test with a 5% of probability

ontogeny. Some researchers have demonstrated that this period probably is affected nonsingle by characteristics genetics of the species but also by the climatic conditions prevailing in each region where the evaluations are made (1, 11, 19). In all the floral types evaluated the dehiscence of anthers it happened before the floral opening as indicated Rodriguez *et al* (16) and Parés *et al* (14). According to the made observations the dehiscence of anthers happened 2 days before opening the floral button for the case of types IV+ and V, whereas in floral type IV follow another a day before the anthesis (table 2). These results agree with the reported by Parés *et al* (14) who working with papaya Cartagena Amarilla indicate that the dehiscence of anthers of the floral types V and IV+ happen two days before the anthesis, whereas in types II, III and IV a day follows one another before the same. The total amount as the viability of pollen grains in the flowers of *Carica papaya* L. are affected by the floral type being type IV+ which produce the greater amount of pollen grains as well as presents greater percentage of viability (table 3). The results of this research agree with the report written by Lassoudiere (6) in the sense that mentions the amount of pollen produced by anther is among 10,000 to 14,000 grains. Nevertheless, Parés *et al* (15) mentioned that the amount of pollen grains produced by the floral types IV, IV+ and V are of 23,860, 22,992 and 22,368, respectively. Garret (5) indicated that the production of pollen of the papaya plants is influenced by environmental factors in addition to the cultivated genetic material, diminishing the amount significantly of pollen produced at the cold season of the year.

On the base of statistical analyses to the viability tests, (Figure 3) the evaluated floral types can be classified in two groups; first constituted by the floral types IV+ IV with 86.65 and 86.21 % of viability, respectively and the second conformed by the floral type V to 82.71 % of viability. Nevertheless, Parés *et al* (14) mentioned that the percentage of viable pollen grains by flower was significantly greater in the floral type V, followed by the types IV+ and IV which statistically present a similar performance. These differences can have no only by characteristics genetics of the species but also by the climatic conditions prevailing in each region where the evaluations are made (5, 8). In the observations, the fixation of fruits or period passed from the floral opening to the senescence of the petals, is affected by the floral type (table 4). When comparing the averages was the floral type I, of the ginoic sexual form was the plus delayed in fixing its fruits, delaying 8 days in average, compared with the floral type IV, which took in average 6 days from the floral opening. The same tendency was obtained by Parés *et al* (14) who indicate that the floral type I produced by the ginoic plants is most delayed in fixing its fruits to comparison with the floral types produced by the andromonoic plants.

Table 2. Period from dehiscence of anthers (*Da)* until the anthesis.

Floral Type	Days between *Da* and anthesis
IV	1.0952 b
IV +	2.0000 a
V	2.2381 a

Averages with different letters represent significant differences according to Duncan test with 5% of probability

Table 3. Total amount and viability of pollen grains

Floral Type	Pollen grains/flower	Viability (%)
IV+	148.400+6482.7 a	86.65 + 3.75 a
IV	104.400+4960.3 b	86.21 + 5.50 a
V	107.600+4085.7 b	82.71 + 4.05 b

Averages with different letters represent significant differences according to Duncan test with 5% of probability

Table 4. Days between anthesis until the fixation of fruits (*Ff*)

Floral Type	Sexual Form	Days between anthesis and *Ff*
I	Ginoic	7.8 a
IV	Andromonoic	6.4 b

Averages with different letters represent significant differences according to Duncan test with a 5 % of probability.

They indicate that the feminine flower delay 9 days in fixing their fruits, flowers II and III showed a similar behavior taking in average 7 days unlike the elongate flower which delayed 6 days. Possibly these differences must to that the floral type I obligatorily needs the crossed pollination, due to their unisexual constitution, unlike the andromonoic individuals which give off its pollen before the floral opening (Parés, 13).

Conclusions

The type of flower affects the duration of the period from the emergency of the floral button to the anthesis, happening itself of more delayed way in the floral type I, which I take 31.27 days, whereas the floral types IV+, IV and V took 30,42; 29,55 and 29.42 days, respectively. The

dehiscence of anthers before appeared before the anthesis happening 2 days in the floral types IV+ and V, and a day before in type IV. The floral type IV+ produced the greater amount of pollen grains by flower in comparison to the floral types IV and V being produced amount 148,400, 104,440 and 107,600, respectively. The floral types IV+ and IV produced the greater percentage of grains of pollen viable by flower in comparison to the floral type V; being the percentage of viability 86,65; 86,21 and 82.71 %, respectively. The fixation of fruits happens 8 days in the feminine flower, whereas in the floral type IV pass 6 days from the floral opening to the fixation of the fruits.

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