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Posibles factores que producen la caída de fruto de *Myrciaria dubia* (HBK) Mc Vaugh, "camu camu" durante la fenología reproductiva de la colección "cinco cuencas" en el centro experimental San Miguel - IIAP, Loreto, Perú

Possible factors which produce fruit drop of *Myrciaria dubia* (HBK) Mc Vaugh, "camu camu" during the reproductive phenology in the collection "cinco cuencas" from the San Miguel experimental center-IIAP, Loreto, Peru

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Resumen

Se evaluaron plantas de "camu camu" en cinco cuencas de Loreto (Perú), según el porcentaje de frutos con síntomas de infestación por plagas, la retención de flores y frutos en cada una de las cuencas y diámetros de ramas, y la influencia de la precipitación y temperatura en el proceso de caída de frutos según el estado fenológico. En el factor genético, la cuenca del río Putumayo destacó por presentar mayor retención de frutos, mayor rendimiento y peso promedio de frutos, así como menor ataque por plagas. Durante el proceso fenológico que duró 12 semanas, la etapa crítica de caída de flores y frutos ocurrió durante las primeras 7, siendo la retención de flores del 5.12%. Las plagas observadas son causantes del 9.27% de la caída, siendo el 9.15% causada por *Edessa* sp., y 0.12% por *Conotrachellus dubiae*. El otro 90.73% fue originado por otros factores no determinados tales como fisiológicos, nutritivos, competencia, vientos, lluvia. Los factores ambientales de temperatura y precipitación, ejercen una influencia directa e inversamente proporcional a la caída de frutos, respectivamente.

Palabras clave: Fruticultura, camu camu, *Myrciaria dubia*, mejoramiento genético, caída de fruta, fisiología.

Abstract

"Camu camu" plants were evaluated in five basins in Loreto (Peru), according to the percentage of fruits with symptoms of pest infestation, retention of flowers and fruits in each basin, diameters of branches, and the influence of precipitation and temperature in the process of falling fruit as the phenological stage. In the genetic factor, the Putumayo river basin highlighted by a longer retention of fruit, higher yield and average fruit weight and less attack by pests. During the phenological process that lasted 12 weeks, the critical stage of flower and fruit drop occurred during the first seven, with the retention of flowers of 5.12%. The pests are causing the observed fall 9.27%, 9.15% being caused by *Edessa* sp., And 0.12% for *Conotrachellus dubiae*. The other 90.73% was caused by other undetermined factors such as physiological, nutritional, competition, wind, rain. Environmental factors of temperature and precipitation have a direct influence and inversely proportional to the fall of fruits, respectively.

Keywords: Fruit growing, camu camu, *Myrciaria dubia*, genetic improvement, fruit drop, physiology.

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1. Introduction

Camu camu (*Myrciaria dubia* Mc. Vaugh H.B.K) is a fruit that has reported the highest content of vitamin C, between 877 and 6112 mg Ascorbic Acid per 100 g of pulp (Pinedo *et al.*, 2001 and Yuyama *et al.*, 2002).

In Peru, the natural populations of "camu camu" are in the lowland forests of Loreto particularly in the Ucayali river basins (Sahua Supay lake), Napo (Nuñez lake), Amazonas (Charo and Yarapa) and Nanay (Flores, 1997). The camu camu's pulp export has shown an increasing tendency from 1995-2000, as a result of his introduction to the Japanese market. This acceptance is attributable to its exceptional vitamin C content and the nutritional and metabolic functions (Pinedo, 2002).

Yields of "camu camu" under natural conditions ranged from 7 to 18 t/ha, with an estimated plantation "camu camu" from a selection of the best adult plants, under natural conditions and without fertilization produce between 25 and 30 kg of fruit, each of them can produce 20 to 25 t/ha with a planting density of 833 plants/ha. These results are achievable with the use of appropriate technology (Villachica, 1996). The Ibero - American States organization estimates that just Japan requires approximately 230 thousand tons of "camu camu" annually, a level that far exceeds national supply (INRENA, 2000).

It has been estimated that 46% of *Myrciaria dubia* flowers are pollinated and that 15% of the immature fruit aborted before maturity (Peters and Vasquez, 1986). Being 27% the effective fertility of flowers that are succeeds in produce mature fruits (Inga *et al.*, 2001). Because of the importance of this native fruit "camu camu" to Loreto region and that there was little information about the causes that produce the fruit fall in this crop, the objectives of this study were to investigate the main reasons that originate fruit drop during the reproductive phenology in this crop and determine the influence of different factors in this process.

2. Materials and methods

This research was performed on the Experimental Center "San Miguel" from the Peruvian Amazon Research Institute (Belen district), located in the left margin of the Amazon River upstream from the mouth of Itaya river (between 3° 40´ and 3° 45´ S; 73° 10´ and 73°11´ W) (Figure 1).

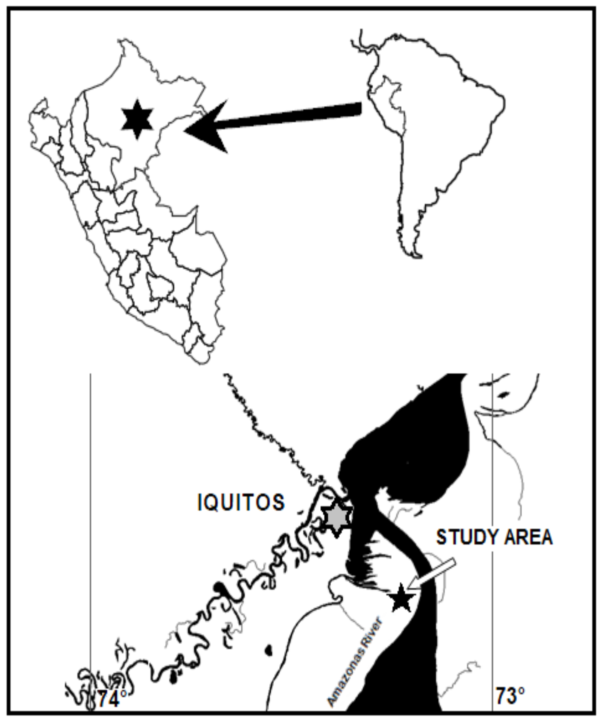

Figure 1. Study area location.

The camu camu's Germplasm Bank is settled down in final field is composed by 1200 shrubs originating in five Amazon basins (Itaya, Tigre, Napo, Curaray and Putumayo).

In the collection "Cinco Cuencas", fruit drop was evaluated in a total of 25 plants from the basins: Putumayo, Napo, Curaray, Tigre and Itaya (five from each basin), in order to this, we performed an inventory of reproductive phenological stage of the 1200 plants of the study area, from which, were randomly selected 5 plants in each basin among plants with at least 80% of tertiary branches with flower buds. The percentage of fertilization and abortion rate of fruits, were estimated periodically, using a subsample of marked branches. We measured the diameter of each tertiary branch and are listed from 1 to 5, belonging to the number one (1), who has the greatest diameter, thus continuing to number five (5), who has the smaller diameter. We count all flower buds and flowers in each branch. Throughout the reproductive period of the shrubs, fruit numbers were recorded weekly until harvest, in the same way the fallen fruits were counted and we identify the symptoms of pests that these could present using the identification key of camu camu's damages caused by pests according to Delgado and Couturier (2004).

According to the fruits found during each phase of the reproductive phenology of this crop, we calculated the total production of flowers, immature and mature fruits of each branch, and total fruit drop by plant, which would be used to measure the performance according to the source of each plant.

The average temperature recorded during the study period was 27.48 °C. Rainfall varied throughout the evaluation period between 0.3 mm and 196.6 mm (estimation per weeks). We used the split-plot experimental design with five treatments (Basin), five replications (plants) and five subreplications (branches). Descriptive statistical calculations, analysis of variance and correlations were made by the SPSS and INFO-GEN softwares.

3. Results and discussion

The counts of flowers / fruits were done weekly for 12 weeks that in average reproductive phenology takes place.

The research determined that in terms of genetic factor (origin), the Putumayo River Basin highlighted by presenting greater retention (29.86%), meaning that 100 fruit set only 29 reach maturity or harvest plants, contrary to Curaray River, which showed reduced ability to retain the fruit (22.09%) (Figure 2). Additional to this, the branches with more dimension of diameter (R1), showed the highest fruit retention (31.12%) with 0.04 of significant difference between branches 1 and branches 5, according to Tukey test (Figure 3).

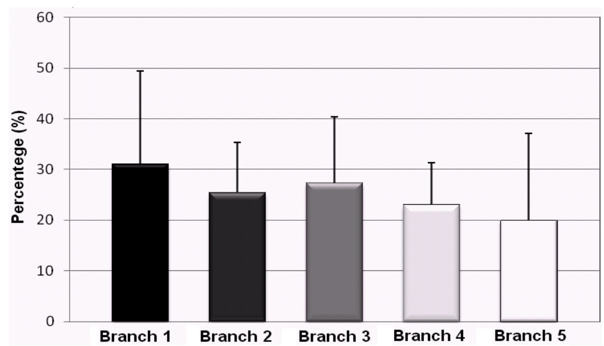

Figure 2. Retention from unripe to ripe fruit by basin.

We may indicate that in this crop 25.35% of the unripe fruit reach harvest. It shows that, in this case, there is little difference between natural and established populations, because only 27% of fruit set to reach the stage of maturity in natural stands (Inga *et al.*, 2001).

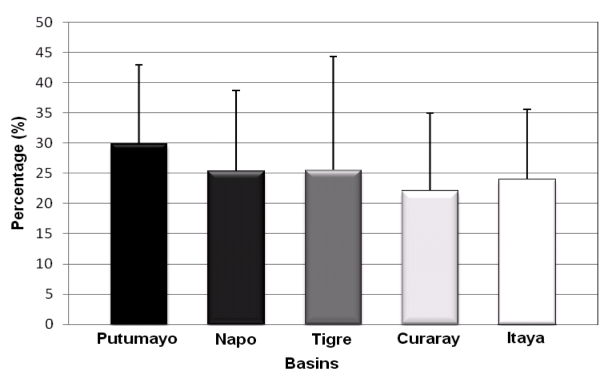

Figure 3. Retention from unripe to ripe fruit by branches.

The critical phase of flower and fruit drop during the reproductive phenology, occurred in the first 7 weeks of the process. In the first three weeks we have the greater level of fall flowers and the four subsequent drops occurs most fruit which belongs to the small unripe stage (Figure 4).

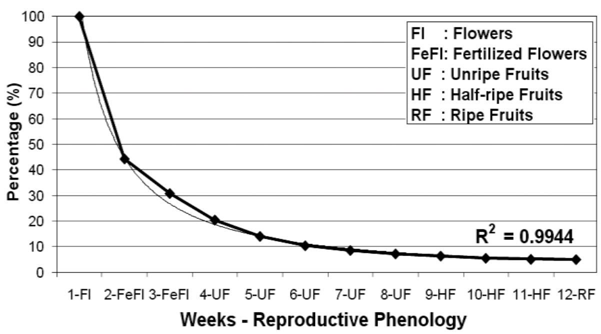

Figure 4. **"**Camu camu" retention since flowers to ripe fruits and critical phases (potential tendency).

The retention of "camu camu" from flowers to mature fruits is 5.1%, which is within the range of study by Iman (2000) says that in the same node we can found from 1 to 25 flower buds and in the best cases, three fruits reach maturation and harvest (4-12% from 25 flowers). The evaluation of flowering retention shows that 5.1% of flowers and 25% of unripe fruit reach harvest (Figure 4 and 5).

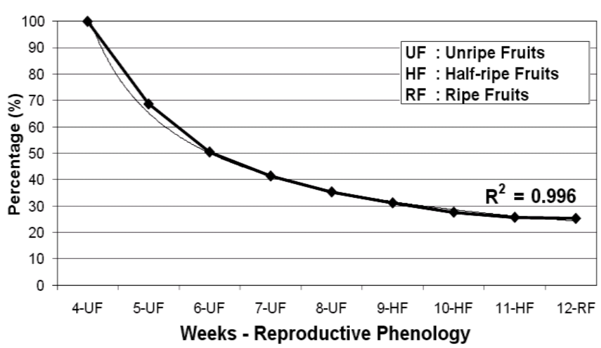

Figure 5. Camu camu's retention since unripe to ripe fruits (potential tendency).

Putumayo was the basin which had the highest yield and its average fruit weight, with 1614 g production by branch and 10.95 g. per fruit (Figure 6).

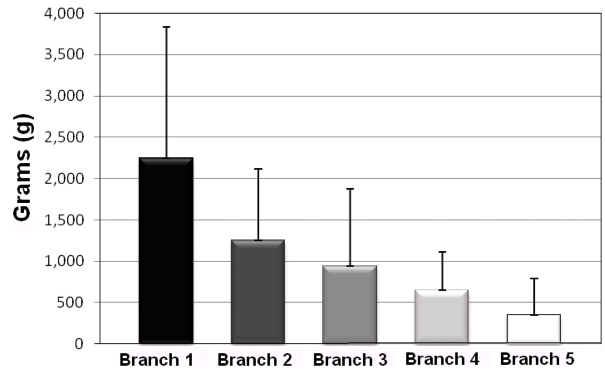

Figure 6. Camu camu's yield by branch and average fruit weight in each basin.

In addition to this, the branches of larger diameter showed the highest average yield fruit (2249 g). This decreases as the branch's diameter decreases (Figure 7). Putumayo Basin presented an average fruit weight of 10.98 g being the largest among the five basins during the evaluation process, as indicated Guillen and Pinedo (2007), in the same collection, the largest average fruit weight had Putumayo Basin with 7.6 g. It is assumed that this ideal feature, present in the Putumayo Basin, could be used for genetic improvement of these plants since according to Bardales and Pinedo (2009), the average fruit weight could be transferred from mother plants, with 72% heritability.

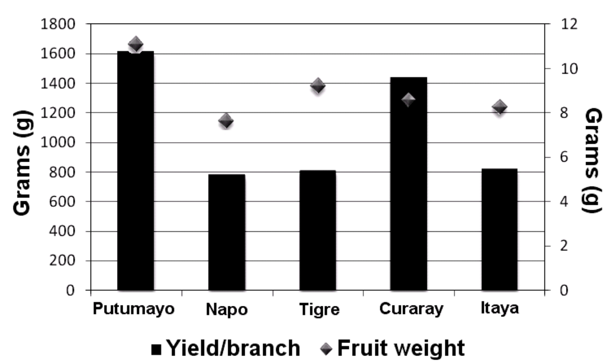

Figure 7. Camu camu's yield by branch´s diameter

The basins that showed the highest average yields were Putumayo and Curaray, with 1614 and 1435 g/branch, which are closely related to fruit number and average weight of these. But Guillen and Pinedo (2007) indicate that the same Germplasm bank, Curaray basin had the best average yield with 1 120 g/plant.

Regarding the causes of the fall fruit, Pests produced 9.27% of dropping; 9.15% by *Edessa* sp. and 0.12% by *Conotrachellus dubiae*. The 90.73% is due to other undetermined causes such as physiological, nutritional, wind, rain, among other things (Figure 8). Putumayo was the basin which had the lowest percentage of fruit drop with plagues symptoms of 5.51% in contrast to Curaray that had the highest percentage of 11.78%.

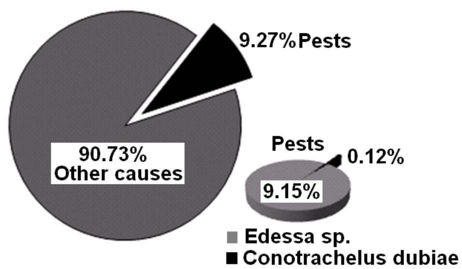

Figure 8. Drop causes of camu camu's flowers and fruits.

Drop fruit by environmental factors

Correspondingly, Putumayo Basin had the highest percentage drop by environmental factors either nutritional, physiological, and others, with a 94.47% drop by this factor. The total fall, between the five basins was 90.73%. Results that are very high, so it is assumed that there are environmental factors that are affecting productivity, which corroborate studies by Pinedo *et al.* (2001), Riva and Gonzales (1999) and Peters and Vasquez (1986), who determine that the highest productivity of *Myrciaria dubia* populations is likely due to the effect of the environment in which this specie grows. The influence of environmental factors on "camu camu" drop fruit, is displayed in the trend analysis and according to correlation analysis, which shows that in the case of temperature, it has an directly proportional influence because, as the temperature decreases, the fall fruit does likewise (Figure 9), unlike in the case of precipitation, this is inversely proportional to the drop, because at the time of less precipitation there is a greater drop, which decreases as precipitation increased (Figure 10).

The critical stage of flower and fruit drop that was recorded in the first seven weeks of evaluation, would be explained by Stoller (2009), who indicates that during the first weeks of cell division and cell differentiation within each strawberry, will determine whether this will be maintained in the tree or will be a flower aborted or will be aborted in post flower. This usually results in the formation or lack of seed's embryo formation.

Drop vs. temperature

There is a correlation of 70% between temperature and the percentage of flower and fruit drops during the corresponding reproductive phenological stages. This study indicates that the higher temperature (27.77°C) there is the greater proportion of drop flowers/fruit (58.59%) and when it decreases (27.32), the drop is also reduced (0.22%).

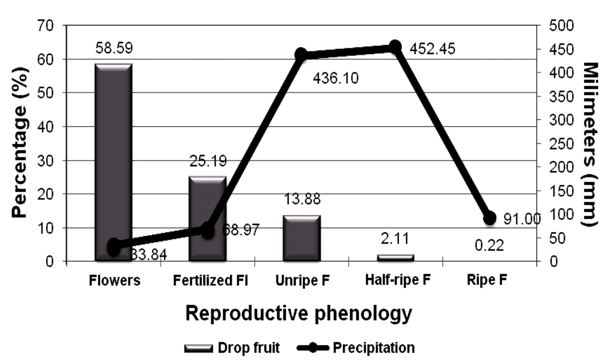

Figure 9. Drop fruits per phenology stage in relation with Temperature.

There are no previous studies that demonstrate this relationship. However, Pinedo *et al.* (1981) suggest that the influence of temperature on crop growth during flowering of Arazá is the same.

Drop vs. rain

Despite the absence of significance in the correlation between these variables, both follow an inverse trend. However, we attributed the low correlation of 30% between these variables, in the harvest the last week, rainfall decreases and despite this the percentage of fall leaves falling, it is noted that despite the decrease in precipitation is not reaches down as in the first weeks of evaluation, so anyway there is no high-grade dehydration of fruit and for this reason the fall does not increase. However, during this research, we have observed high levels of drop fruit in different phenology stages, caused by strong rains and intensive winds.

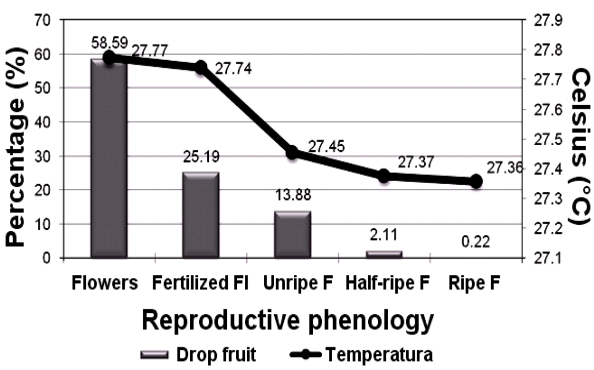

Figure 10. Drop fruits per phenology stage in relation with Precipitation.

According to Stoller (2009), during the summer or dry stage, many fruit trees experiment the drop experience, this happens in most fruit and fruit drop amount will depend on weather conditions as well as the variety of fruit being treated, but it will have the biggest drop in this period due to dehydration of fruits. Similarly Oliva *et al.* (2005), they observed that most plants yields have declined significantly in the years 1998, 1999 and 2000 and indicate that this occurred because of the precipitation effects. Because they get varying values of precipitation during the months of January, May, September and November with 363, 283, 188 and 161 mm / month in 1998, values are 31.2, 171, 195 and 159 mm/month. It is considered that these values have affected directly and significantly the reproductive phenology, resulting in poor performance.

Drop fruit with pest symptoms

Putumayo Basin was the basin which had the lowest percentage of fruit drop with pest symptoms with 5.51%, unlike Curaray basin that has the highest percentage of 11.78%. At this, Delgado and Couturier (2004), indicate that damage from insect pests cause huge losses in agriculture, which can be caused by the adult, larva, nymph or both of them. In this evaluation the pests found were *Edessa* sp. and *Conotrachelus dubiae*, which were infesting plants in adulthood in both cases and also by *Conotrachelus dubiae* in larval stage.

4. Conclusions

The bigger branches, besides that produce more fruits than thinner ones, are also more efficient to retain fruits. In the case of "camu camu", 25.35% from unripe fruit reach to harvest. However, the retention of flowers shows that only 5.1% of these reach the state of ripening fruit. About the genetic factor (origin), Putumayo River Basin stands out because it had the greater retention (29.86%). The critical drop phase (flowers and fruits) occurred in the first 7 weeks of the reproductive process.

Regarding the drop fruit causes, pests are causing the 9.27% of the drop, which the 9.15% is caused by the heteroptera *Edessa* sp. and 0.12% by the beetle *Conotrachellus dubiae*. The other 90.73% was caused by other undetermined factors such as physiological, nutritional, competition, wind, rain, among others. The temperature has a directly proportional influence to the flowers and fruits dropping; it means that as the temperature decreases, the fruit drop decreases as well. The precipitation has a inversely proportional influence to the dropping, because at the time of lower rainfall, there is greater drop, which decreases as precipitation increases.

There are ideal characteristics in Putumayo basin, like higher average fruit weight, more retention, more resistant to pests, which could be studied in a deeply way and in the case to be persistent, it would be used in improvement genetic plans in order to increase the fruit yields.

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