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Effect of Paclobutrazol on botanical characters of flowers and fruits in the emergence of parthenocarpic mango cultivar Ataulfo

Efecto del Paclobutrazol sobre caracteres botánicos de flores y frutos en la aparición de mango partenocárpicos cultivar Ataúlfo

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Abstract
The presence of parthenocarpic mangoes in the Ataulfo cultivar in Ecuador has caused a decrease in the production. This has led to an annual decrease in the productive area of this cultivar. The objective of the research was to evaluate botanical characters of flowers and fruits in the appearance of parthenocarpic mango in Ataulfo cultivar, this was carried out in two mango-producing areas in Palenque-Los Ríos and Cerecita-Guayas, 50 plants were randomly taken for each treatment with paclobutrazol (PBZ) and without (PBZ) in the two zones simultaneously in 2019 and 2020. The variables evaluated were: weekly flowering behavior, percentage of hermaphrodite and staminate flowers, number of leaves in the last foliar growth before flowering, number of panicles per tree, percentage of mangoes with seeds and parthenocarpics. Descriptive statistics were obtained for each variable, including the mean, median, mode, standard deviation, and variability coefficients. The t-test method was used between the samples from the two populations. Flowering with PBZ began in week 22 in Cerecita and in week 27 in Palenque. All the evaluated variables that had PBZ had statistical significance except for the number of parthenocarpic mangoes with and without PBZ in Palenque. In the areas where PBZ was applied, it was possible to advances plant flowering by two weeks in the two study areas and with an increase in the percentage of female flowers vs. staminate by panicles.
Keywords: Anthesis, Mango Ataúlfo, Paclobutrazol, Parthenocarpy

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Resumen

La presencia de mangos partenocárpicos(mango niño) en la variedad ataúlfo en Ecuador ha hecho que disminuya la producción de este cultivo. Ello ha incidido en una disminución anual del área productiva de esta variedad. El objetivo de la investigación fue evaluar caracteres botánicos de flores y frutos en la aparición de mango partenocárpicos en variedad Ataúlfo, esta se realizó en dos zonas productoras de mangos en Palenque-Los Ríos y Cerecita-Guayas, se tomaron al azar 50 plantas para cada tratamiento con paclobutrazol (PBZ) y sin PBZ en las dos zonas de manera simultánea en los años 2019 y 2020. Las variables evaluadas fueron. Comportamiento semanal de floración, porcentaje de flores hermafroditas y estaminadas, número de hojas en el último crecimiento foliar antes de floración, número de panículas por árbol, porcentaje de mangos con semillas y partenocárpicos. Se obtuvo los estadígrafos descriptivos a cada variable entre los que se encuentran la media, la mediana, la moda, la desviación estándar y los coeficientes de variabilidad. Se utilizó el método de la prueba de U de Mann-Whitney. La floración con PBZ inicia en la semana 22 en Cerecita y en la semana 27 en Palenque. Todas las variables evaluadas que tenían PBZ tuvieron significancia estadística a excepción del número de mangos niños con y sin PBZ en Palenque. Las áreas que tenían PBZ, logró adelantar dos semanas la floración en las dos zonas de estudio y con un aumento en el porcentaje de flores femeninas vs estaminadas por panículas.
Palabras claves: Antesis, Mango Ataúlfo, Paclobutrazol, Partenocarpia

Introduction

The Ataúlfo mango is a cultivar of Mexican origin with more acceptance in international markets. Although its genealogy is uncertain, since its progenitors are unknown, it has been mentioned that it possibly comes from a mutation or is the product of natural hybridization (Infante *et al*., 2011, p. 32).

Currently, the use of growth regulators is essential for the success of mango growers in Brazil, playing an important role in flower induction, allowing staggering production throughout the year and obtaining good quality fruit Oliveira (2020). In our country the use of growth regulators has been normalized, almost all mango export plantations use them in their crop management programs, to advance flowering and be the first to start harvesting to gain better prices in the international market and in local sales.

Perez et al. (2011) in research conducted in Nayarit, Mexico, with the manila mango variety and paclobutrazol (PBZ), flowering was stimulated and harvest was advanced from 15 to 23 days. Moreira et al. (2018) in applications of PBZ on tommy atkins mango variety, advanced flowering by 30 days.

Leyva et al. (2016) in Mexico, deduced that, in areas producing this variety of mango with technological development of the crop, the presence of baby mango increases significantly compared to other plantations with less technical development. In research by Ramirez and Davenport, (2010, cited in Ferreira, 2020, p. 12), it is stated that "The use of PBZ in mango promotes the regulation of vegetative growth of plants, stimulating flowering and fruiting". Ferreira *et al*, (2020)

The Ataulfo mango variety is along with the varieties: Haden, Kent and Tommy Atkins one of the most cultivated Lucero, (2011). In recent years in Ecuador its productivity has fallen sharply because a large part of the fruit does not reach the commercial category as is the case of the so-called child mangoes and parthenocarpic mangoes, a phenomenon whose cause is supported by some not very clear hypotheses where they determine that extreme temperatures (≤15 and ≥35 °C) in flowering and fruit development are promoters of child mangoes. Perez et al (2019) where they establish that edaphic applications of boron of 50 and 100 gr. decreased the presence of seedless mangoes (p. 276).

Materials and methods

This research was carried out in two mango producing areas, in Cerecita parish, Guayaquil canton, and in Palenque canton, Los Ríos province. With the following geographical coordinates 583887, 9736736.98 and 17M 637149, 9839706.98 UTM projection, zone 17S, datum WGS84, Cerecita and Palenque respectively. The data obtained in this research correspond to the year 2019 and 2020.

Plants were used in full production of mango variety ataulfo, with a spacing of 7x7 in Palenque and 7x5 in Cerecita, 50 plants were taken at random for each treatment with paclobutrazol (PBZ) and without PBZ in the two areas simultaneously in 2019 and 2020. In Palenque there were marked differences in climate with rains in January, February, March, April and sporadic rains in May. In Cerecita, the rainy season begins in January, February, March and April with less incidence than in Palenque.

In the two mango producing zones, 100 mango trees were selected in areas with PBZ and without PBZ (50 trees per year and per area) to evaluate panicles, number of parthenocarpic mangoes and mangoes with seed or commercial mango per plant and number of leaves of the last growth. From this population, 50 mango panicles were randomly selected each year and the percentages of hermaphrodite and staminate anthesis were determined.

The data were organized and tabulated to obtain descriptive statistics for each variable, including the mean, median, mode, standard deviation and variability coefficients. The Mann-Whitney U test method was used.

Result

Flowering behavior at Cerecita

In the behavior of weekly flowering during 2020 (Figure 1), it is observed that in week 22 flowering began with 95% and in week 23 with 5%, however, the areas without PBZ had a delay of two weeks, initiating flowering in week 24 until week 26.

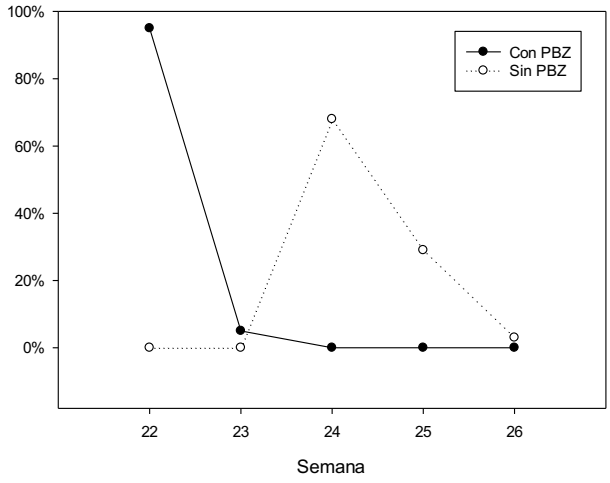

Figure 1. Flowering behavior in Cerecita (2020).

Cerecite, flowering behavior by week year 2019.

Figure 2 shows that flowering began at 95% in week 22 and at 5% in week 23; however, the areas without PBZ were delayed by two weeks, beginning flowering in week 24, with irregular behavior, ending flowering in week 35.

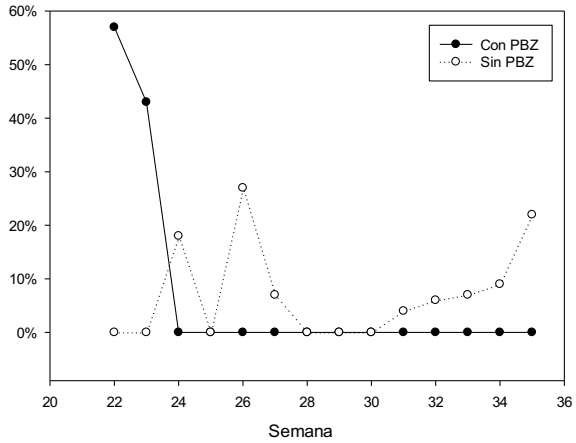

Figure 2. Weekly flowering behavior in Cerecita (2019).

Palenque, flowering behavior per week year 2020

Figure 3 shows that flowering began in week 27 with 95% and in week 28 with 5%; however, the areas without PBZ had a delay of five weeks, with flowering beginning in week 33 and ending in week 38.

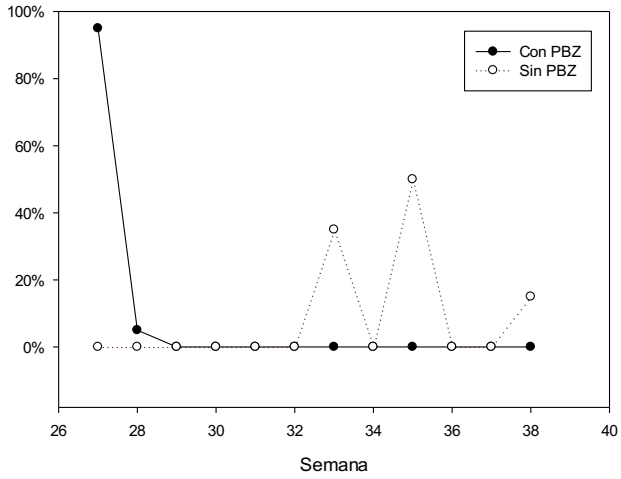

Figure 3. Flowering behavior by week year 2020

Palenque, flowering behavior per week year 2019

Figure 4 shows that flowering began at 90% in week 29 and at 10% in week 30; however, in the areas without PBZ, the onset of anthesis began at the same time as PBZ, possibly due to the management of the plantation, which was extended until week 33.

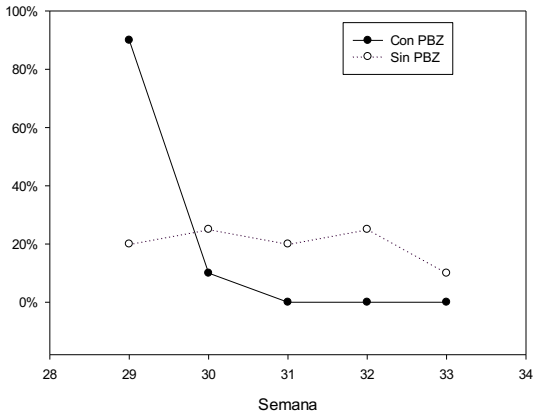

Figure 4. Flowering behavior by week in 2019.

Percentage of hermaphrodite and staminate flowers in two mango producing locations year 2020.

In Cerecita, the number of hermaphrodite flowers in the area where PBZ was used represented 33% and staminate anthesis 67%, in contrast to the areas without PBZ where the percentage of hermaphrodite flowers was 23% per panicle and staminate flowers 77%, which represents the trend per panicle in terms of hermaphrodite and staminate flowers. In Palenque the amount of hermaphrodite flowers in the area where PBZ was used represented 30% and staminate anthesis 70%, in contrast to the areas without PBZ where the percentage of hermaphrodite flowers was 24% per panicle and that of staminate flowers 76 %, which represents the trend by panicle in terms of hermaphrodite and staminate flowers. Figure 5

Percentage of hermaphrodite and staminate flowers in two mango producing locations year 2019.

In Cerecita, the number of hermaphrodite flowers in the area where PBZ was used represented 33% and staminate anthesis 67%, in contrast to the areas without PBZ where the percentage of hermaphrodite flowers was 23% per panicle and staminate flowers 77%, which represents the trend per panicle in terms of hermaphrodite and staminate flowers. In Palenque, the number of hermaphrodite flowers in the area where PBZ was used represented 30% and staminate anthesis 70%, in contrast to the areas without PBZ where the percentage of hermaphrodite flowers was 24% per panicle and that of staminate flowers 76%, which represents the trend per panicle in terms of hermaphrodite and staminate flowers.

Table 1. Percentage of hermaphrodite and staminate flowers in two mango-producing localities.

Location	% hermaphrodite flowers year 2019	% of flowers in the year 2019	% hermaphrodite flowers year 2020	% staminate flowers year 2020
Cerecite with (PBZ)	32	68	33	67
Cerecite without (PBZ)	23	77	22	78
Palenque with (PBZ)	30	70	30	70
Palenque without (PBZ)	24	76	24	76

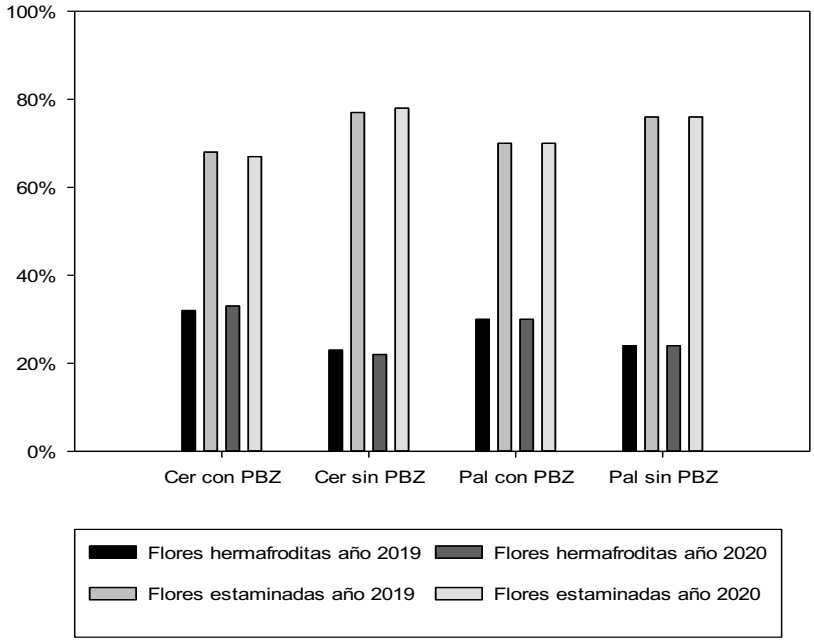

Figure 5. Percentage of staminate vs. hermaphrodite flowers in two mango producing areas with PBZ and without PBZ year 2019-2020.

Beginning of flowering in two 2019-2020 production zones.

In Cerecita, flowering begins in week 22 in the areas that have PBZ. One of the *reasons for the* earlier flowering than the PBZ application period is the presence of rainfall, which generally lasts until the month of April. The areas that are not treated with PBZ, flowering begins from week 24 onwards, this depends a lot on the conditions in which the trees are (last vegetative growth, mature trees older than 2 months of age, pruning season and beginning of inductions).

In the Palenque locality, flowering begins in week 27 in the areas that have PBZ, one of the reasons for the delay in flowering, compared to the cerecita locality, is the presence of rain, where it generally rains until May. The areas that are not treated with PBZ, flowering begins from week 24 onwards, this depends a lot on the conditions in which the trees are (last vegetative growth, mature trees older than 2 months of age, pruning season and beginning of inductions). Unlike the Cerecita zone, the application season for PBZ is not the most optimal due to the presence of continuous rainfall in February and March.

Number of sheets 2019-2020

In Figure 6, it can be *observed* that in Cerecita the number of leaves had a mean of 8.21 leaves in the last leaf growth before panicle in the area with PBZ, in the area without PBZ they had a mean of 6.44 leaves in the last leaf growth before panicle. In Palenque the number of leaves had a mean of 7.04 leaves in the last leaf growth before panicle in the area with PBZ, in the area without PBZ they had a mean of 6.29 leaves in the last leaf growth before panicle.

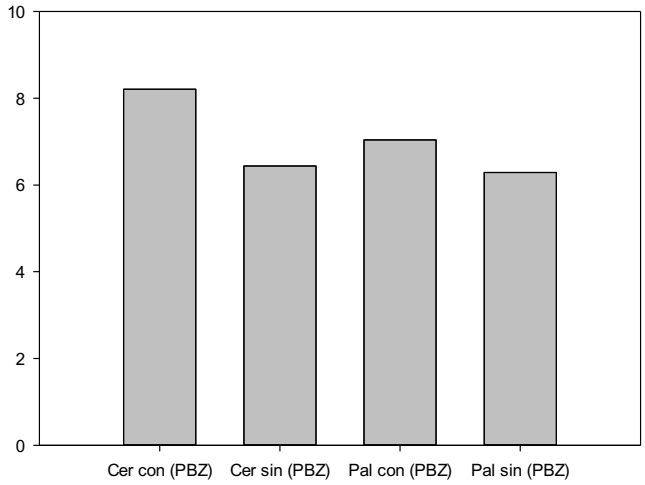

Figure 5. Number of leaves in the last flow before panicle 2019-2020

Number of panicles (average) year 2019-2020

Figure 7 shows that in Cerecita, the area with PBZ had an average of 302 panicles, the trees had an average height of 3.50 meters, while in the area without PBZ, the trees had an average of 321 panicles and an average height of 4 meters. In Palenque, as for the differences in panicles per plant, in the area with PBZ they had an average of 220 panicles with an average height of 3 meters, while in the area with PBZ they had an average of 205 panicles and the trees had an average height of 3 meters.

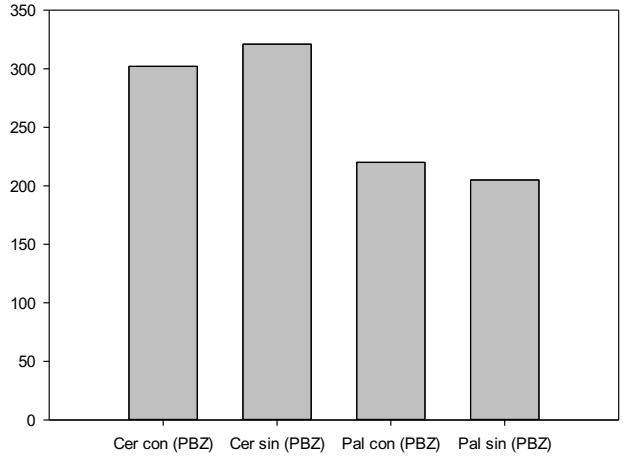

Figure 6. Number of panicles per plant

Percentage of mangoes with seed and parthenocarpic in two zones year 2019-2020.

Figure 8 shows that in Cerecita the number of mangoes per tree varies, with an average of 32% of mangoes with seeds and 68% of parthenocarpic mangoes, while in the area without PBZ, there were fewer mangoes with seeds (28%) and 72% of parthenocarpic mangoes. In Palenque, the average number of mangoes per tree varied between 21% of mangoes with seeds and 79% of parthenocarpic mangoes, while in the area without PBZ, there was a lower number of mangoes, 16% of mangoes with seeds and 84% of parthenocarpic mangoes.

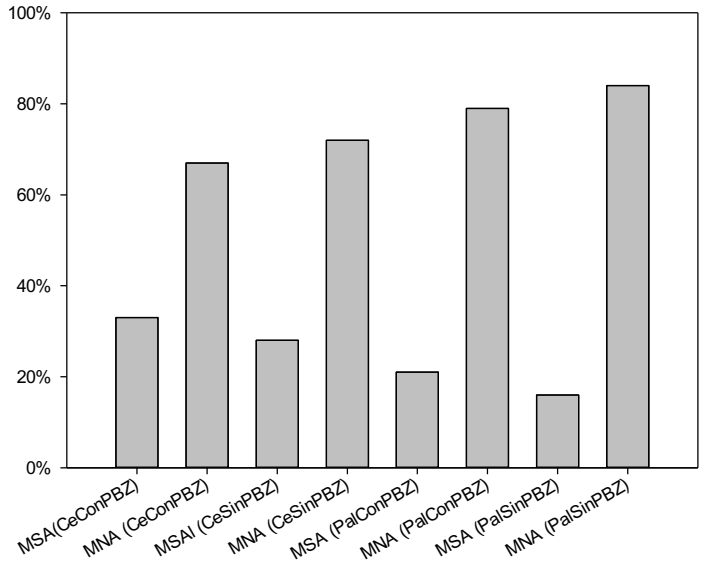

Figure 8. Percentage of mangoes with seeds and parthenocarpic in Cerecita and Palenque in 2019 and 2020.

The behavior of reproductive variables (Figure 9) shows that the use of PBZ did not make a difference with respect to panicles per plant, with mango and without mango. However, it did have an influence on the increase of hermaphrodite flowers, but not on staminate flowers. The mangoes per panicle were not affected by the use of this product, but the fruits per tree were, which had an increase of 33.67% with respect to the control. Another variable affected was the number of parthenocarpic mangoes, which increased by 11.03%.

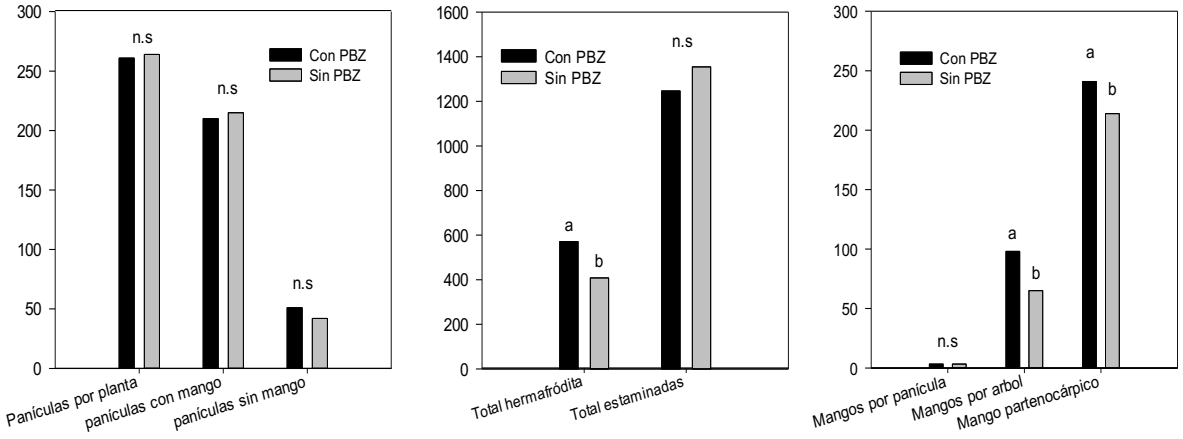

Figure 9. Behavior of reproductive variables

Regarding anthesis, hermaphrodite vs. staminate flowers with paclobutrazol (PBZ) and without PBZ, Oliveira et al. (2017) expressed that in research conducted in Brazil on mango cultivar "uba", noted that there was no increase in the proportion of staminate vs. hermaphrodite flowers, unlike this research that recorded the increase in the percentage of hermaphrodite flowers vs. staminate flowers in trees with Paclobutrazol (PBZ) in the two areas studied, hence the fact of having more hermaphrodite flowers within a panicle, the greater the probability of fertilization, Gehrke (2008) Gehrke states that the ratio of staminate flowers to perfect flowers influences fruit set and productivity.

The number of leaves in the last leaf growth before anthesis in the Cerecita and Palenque zones is higher in areas with PBZ, different to that investigated by Cardenas et al. (2003) where it was found that the use of paclobutrzol caused a restriction effect on vegetative sprouting. This could be due to the fact that in areas where paclobutrazol (PBZ) is applied, pruning and fertilization are usually done in December, so that where PBZ is not applied, pruning and fertilization are delayed, causing a limitation in leaf density in the vegetative flow.

The number of panicles per plant obtained high results with PBZ, as confirmed by Charnvichit et al,. (2008) (2008), PBZ applications inhibit the biosynthesis of gibberellins, for the development of shoot growth, by promoting shoot maturation and consequently favoring flowering.

In terms of the number of parthenocarpic or child mangoes per tree those with PBZ outnumbered trees without PBZ, Hernandez et al. says (2015) "Fruit stenospermocarpy is a rare phenomenon and is the result of partially formed seed fruits that are the result of embryo abortion after fertilization, which, on certain occasions, can also be the cause of the production of a seedless fruit." Likewise (Perez, 2019) "studied the behavior of pollen in hermaphrodite and male flowers. The results showed a similar number of pollen grains per anther and pollen,. viability and germination between the two forms of mango flower. Pollen germination was also

studied under different temperature conditions, and the results showed that the percentage of pollen germination improved throughout the flowering season with increasing temperatures. Pollen germination at controlled temperatures slowed down at low temperatures. Differences were found among genotypes in pollen behavior at different temperatures opening the possibility of selecting mango genotypes with pollen more adapted to low temperatures, especially for subtropical conditions. "p. 442

Parthenocarpic mangoes presented varied results with PBZ (Perez et al, 2007), coinciding with the results of this research where it was observed that there was a large number of parthenocarpic mangoes in trees where the hormone PBZ was applied, while those that were not applied with this growth inhibitor did not have a large presence of baby mangoes.

Conclusions

In Ecuador, flowering begins in week 22 of the year in the Cerecita area, Guayas, in the area with PBZ and in week 24 in the areas without PBZ. In the Palenque area, it begins in week 27 with PBZ and 29 in the area without PBZ. The proportion of hermaphrodite vs. staminate anthesis, although there are no statistical differences, it can be observed that the mean number of hermaphrodite flowers is higher than the staminate ones, therefore the probability of producing mango with seeds is high.

Harvesting begins in Cerecita 16 weeks after the panicles are 10 cm long, while in the Palenque area 14 weeks, when the panicle is 10 cm long. All the variables evaluated showed statistical differences between the areas treated with PBZ and without PBZ, however, in Palenque Mango niño with PBZ vs. without PBZ, did not show statistical differences, this could be due to the influence of (climate) at the time of anthesis and fertilization.

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