

Evaluation of papaya autogamy.

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EVALUATION OF PAPAYA AUTOGAMY.

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ABSTRACT - The level of autogamy and the pollination-fertilization sequence of papaya flowers were studied for cvs. Sunrise, Waimanalo, Kapoho, Higgins, and 298F5, in the Canary Islands ; as well as its parthenocarpic tendency of some cultivars. Clear differences were found between cultivars regarding percentage of fruit set, proportional to the percentage of germinated pollen grains found in the flower stigma prior to anthesis.

ESTIMATION DE L'AUTOGAMIE CHEZ LE PAPAYER.

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RESUME - Etude du niveau d'autogamie et de la séquence pollinisation-fécondation chez les fleurs de papayers Sunrise, Waimanalo, Kapoho, Higgins et 298F5 dans les conditions des Canaries, ainsi que de la tendance parthénocarpique de quelques cultivars. On observe de nettes différences entre ceux-ci en ce qui concerne la mise à fruit en relation directe avec les pourcentages de grains de pollen germés sur le stigmate de la fleur avant l'anthèse.

INTRODUCTION

European market prospects for papaya in the coming years are fairly promising, anticipating its rapid expansion up to at least 1995 (Anon., 1987 a, b). Current supplies are essentially hermaphrodite 'Solo'-group fruits from Ivory Coast, Hawaii and Brazil (Fajac, 1986).

As the papaya is quick to produce and yields are high, it is of obvious interest in the subtropics although low temperatures (< 20°C) may limit production due to diminished pollen viability among other causes. While production in cool, subtropical environments might be based on dioecious populations (Cohen *et al.*, 1988), in less extreme subtropical areas the use of hermaphrodite cultivars is an alternative that merits exploring.

In recent years, papaya growing in greenhouse - which raises daytime temperatures substantially above open-air

temperatures - has begun in the Canaries (Galán Saúco, 1990). The results to date are promising, and this may lead in the near future to greenhouse implementation in other subtropical areas as has already happened with banana greenhouse cultivation (Calabrese *et al.*, 1989).

Greenhouse cultivation brings about notable ecological changes which will doubtless affect pollination, be it done by wind action or by insect intervention - an issue still pending solution in the case of the papaya (Allan, 1963 b ; Free, 1975). Under this peculiar condition, the faculty of autogamy - already observed in some conditions for hermaphrodite flowers, particularly of the 'Solo' group (Mendes de Carvalho, 1966 ; Allan, 1963 a) - would be highly desirable as it increases production considerably.

The present work studies the time sequence from pollination to fertilization, evaluating both the autogamy level of hermaphrodite flowers and the tendency towards parthenocarpic production in female flowers of several cultivars of the 'Solo' group.

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MATERIALS AND METHODS

The cultivars used were 'Sunrise', 'Higgins', 'Waimanalo', 'Kapoho' and '298F5'. Trials were begun in summer (August) of 1985, using 13-month old seedlings.

To quantify the level of autogamy, 20 hermaphrodite flowers/cultivar near anthesis were bagged and the resulting percentage of fruit set was recorded. A further 10 flowers per cultivar also near anthesis were observed under a fluorescence microscope to establish presence of pollen grains in the stigma.

To determine the precise moment in which autogamy occurs, 5 hermaphrodite flowers of the cv. Sunrise were sampled, at 3, 4 and 5 cm. lengths. The flowers were fixed in acetyl:alcohol:formaldehyde (Johansen, 1940) and washed five times in water over a 2hr30 min period, then transferred to a 5% sodium sulphite solution and left overnight. After softening the pistils at 100°C during 5 minutes (Jefferies and Belcher, 1974), the ovaries were transversally cut at the tip, middle, and bottom, and each stigma was longitudinally sliced into 10 pieces. Both ovaries and stigma were squashed and stained with aniline blue at 0.1% in 0.1 N K₃PO₄ solution (Linskens and Esser, 1957). Pollen grain germination and pollen tube growth were checked under fluorescence microscope.

To time the pollination-fertilization sequence, 15 female cv. Sunrise flowers approaching anthesis were hand-pollinated and another batch of 15 flowers were left unpollinated. Both sets were bagged to avoid outside pollination. On days 1, 3 and 10, five flowers from each batch were fixed as described above to measure pollen tube growth under fluorescence microscope. At the same time, the stigmas were stained with 0.01% auramine in 0.05 M phosphate buffer in order to locate cutin (Heslop-Harrison, 1977).

RESULTS AND DISCUSSION

The stigma is papillate (Slide 1) and coated with a layer of cutin (Slide 2). Twenty-four hours after pollination, the pollen grains had germinated on the stigmatic surface (Slide 3) and begun to penetrate the transmitting tissue (Slide 4), reaching the tip of the ovary 48 hours later. The first fertilized ovules appeared some 10 days later (Slide 5). These observations coincide with those presented by Foster (1943), while Cohen *et al.*, (op. cit.) report a lapse of only 25 hours between pollination and fertilization. These differences could be explained in terms of the effect of temperature on pollen tube growth (Williams, 1970). However it should be noted that while the pollen tubes do reach the tip of the ovary 48 hours after pollination, they do not penetrate into the ovule until some 8 days later; a similar delay is found in peach (*Prunus persica*) where it has been interpreted as the time needed for the pistil to attain a specific developmental stage before fertilization can take place (Herrero and Arbeloa, 1989).

Both pollinated and unpollinated flowers will continue to grow throughout the flower lifespan. From an initial size of 2.5 cm at anthesis, flowers attain 3.56 cm 10 days later, while unpollinated flowers reached 3.34 cm in the same time.

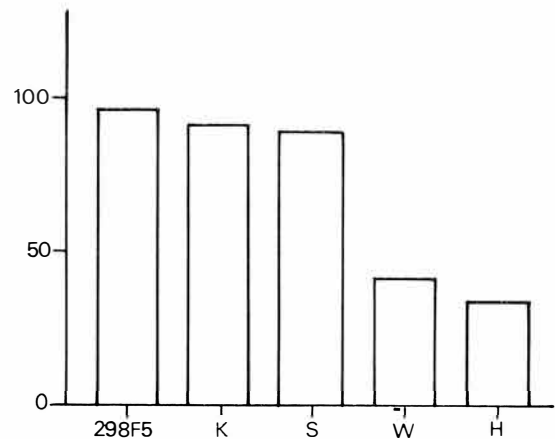


Fig. 1 - Percentage of autogamic fruit set of bagged flowers of cvs. Sunrise (S), Kapoho (K), 298 F5, Waimanalo (W) and Higgins (H.).

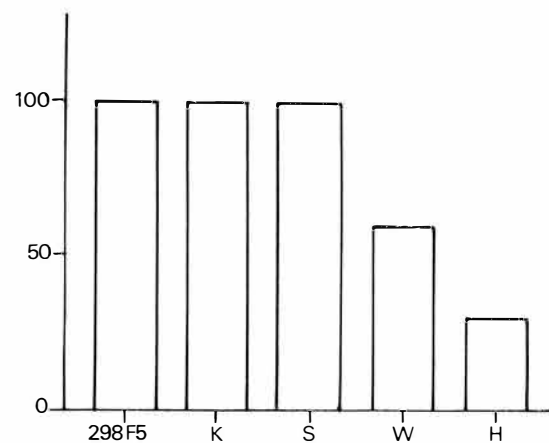
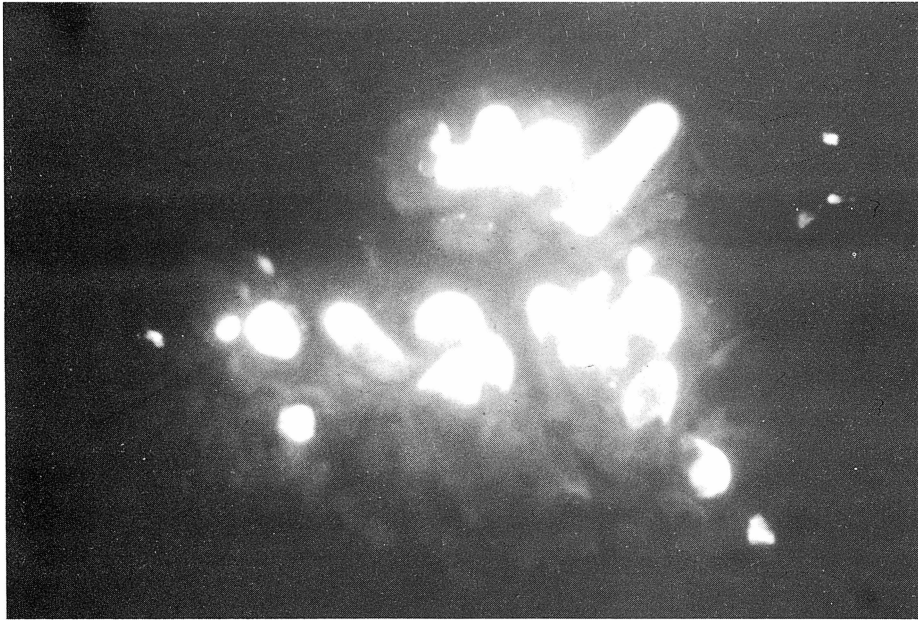


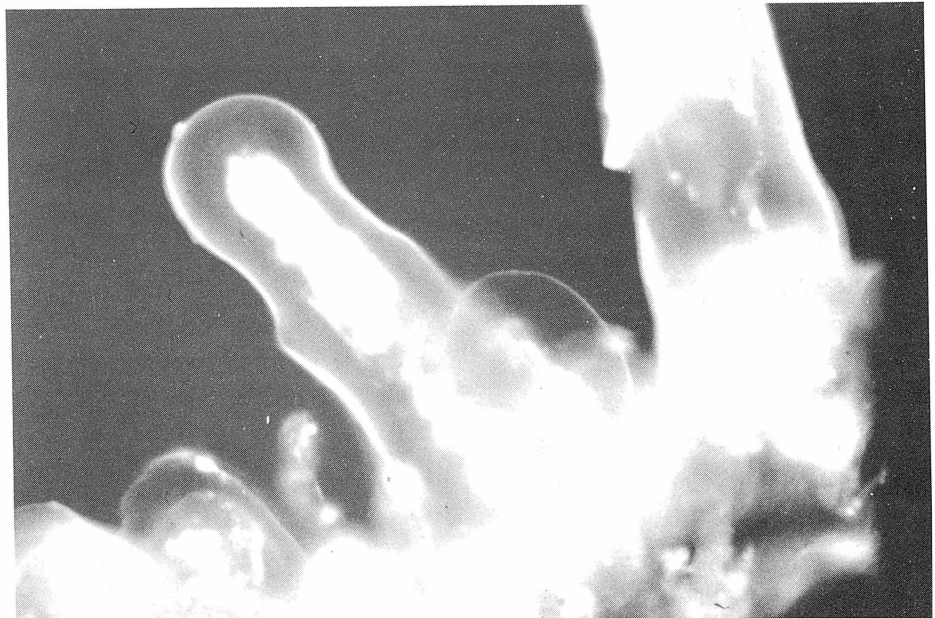
Fig. 2 - Percentage of flowers with pollen grains in the stigma of floral buds before anthesis, of cvs. Sunrise (S), Kapoho (K), 298 F5, Waimanalo (W) and Higgins (H).

The evaluation of natural parthenocarpy occurring in bagged female flowers showed that only cvs. Sunrise and 298F5 had a tendency towards partial parthenocarpy producing respectively, 35% and 5% of parthenocarpic fruits although all of these were of adequate commercial size and quality. Contrarily, 'Higgins', 'Waimanabo' and 'Kapoho' did not produce any parthenocarpic fruit under trial conditions.

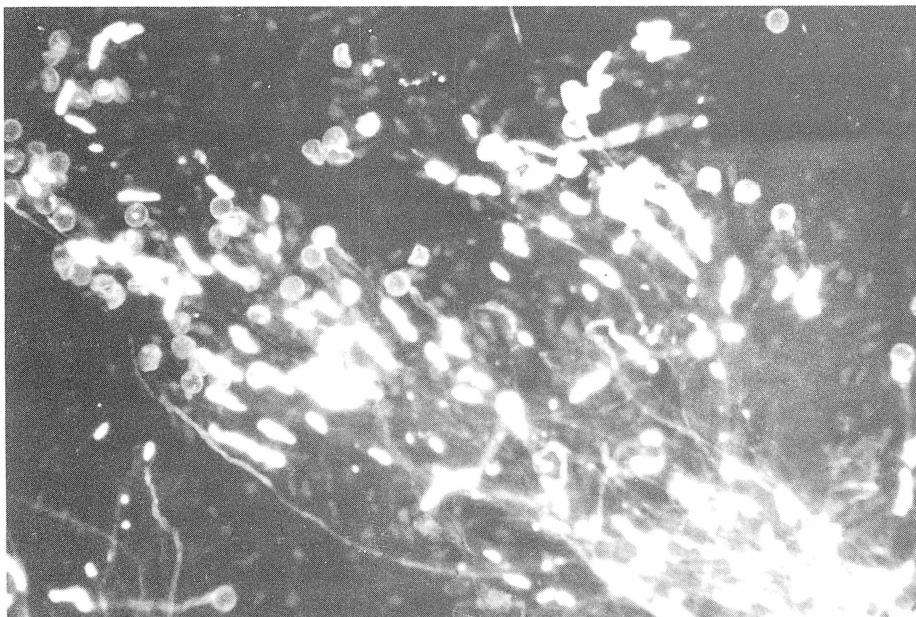
The level of autogamy reached (Fig. 1) indicates that although all the cultivars studied did show a certain degree of fruit set, clear differences were found between cultivars when dealing with bagged hermaphrodite flowers: '298F5', 'Kapoho' and 'Sunrise' had the highest level with respective fruit sets of 94.7%, 90% and 89.4%; 'Waimanalo' had 40% and 'Higgins' only 33%. These differences are in direct proportion to the flowers showing germinated pollen in their stigma before anthesis (Fig. 2): 100% for '298F5', 'Kapoho' and 'Sunrise', versus 60% for 'Waimanalo' and 30% for 'Higgins'.



Slide 1 - Papillate stigma of the papaya flower.

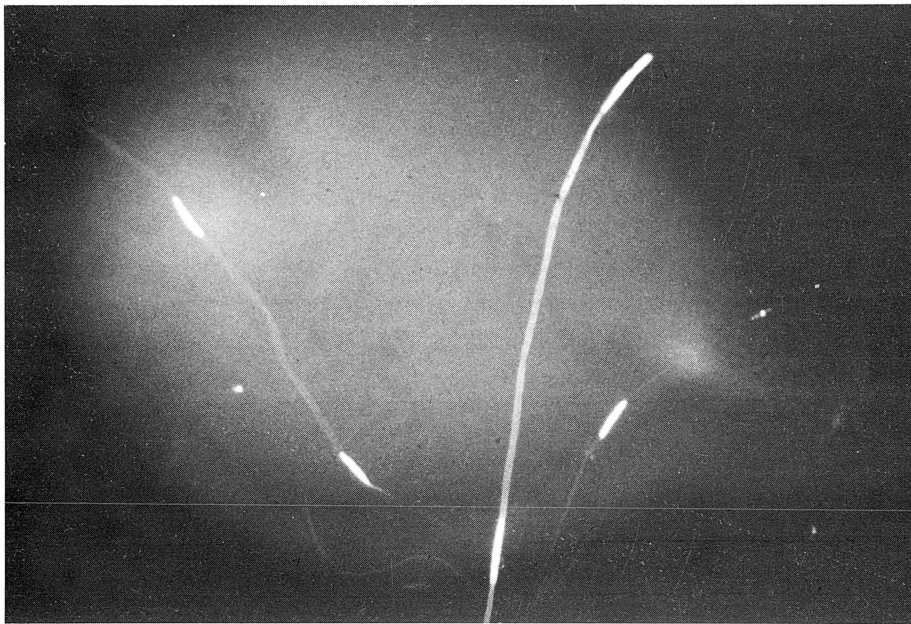
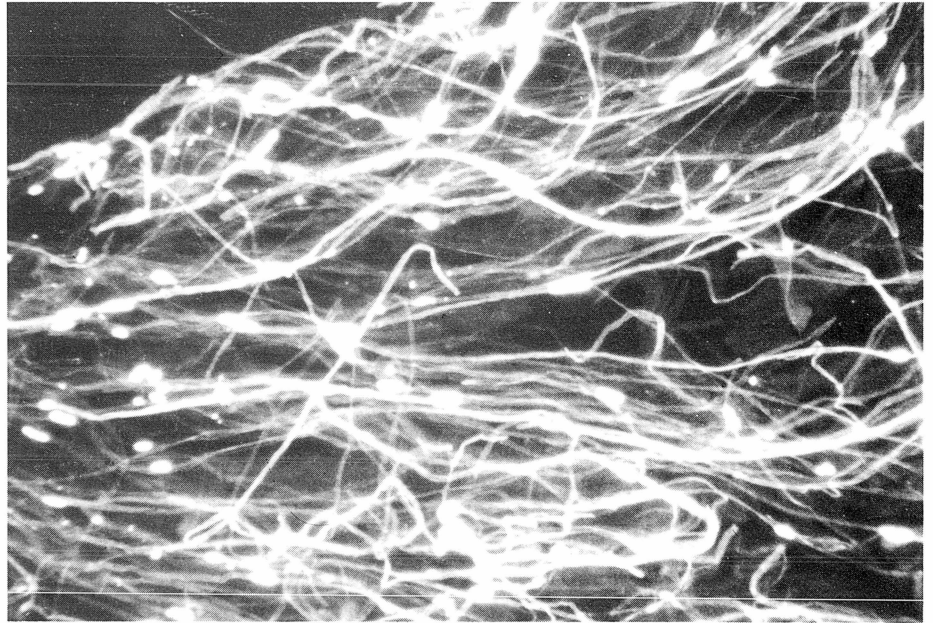


Slide 2 - Cutin-covered stigmatic papillas.



Slide 3 - Germinated pollen grains found on stigmatic surface 24-hours after pollination.

Slide 4 - Pollen tubes penetrating transmitting tissue.



Slide 5 - Reaching the ovary 10 days after pollination, pollen tubes surround the ovule and the first fertilized ovules appear.

The study to establish the moment at which pollination occurs in 'Sunrise' showed that while only a few pollen grains - some germinated and some not - could be found in the stigma of 3 cm buds, in buds measuring 4 cm the germinated pollen in the stigma had produced long tubes already penetrating the transmitting tissue. This indicates that anther dehiscence and stigmatic receptivity had already occurred. This is fully coincident with the 90% level of fruit set of seeded fruits, produced after bagging flowers of

this cultivar. Also, the fact that a clear correlation exists between fruit set and the pre-anthesis presence of germinated pollen makes it possible to use the latter as an indicator of the degree of autogamy expected from a given cultivar.

The results of the present work tend to confirm the presence of cleistogamy in papaya (Allan, 1963 a, b ; Popisil and Hrachova, 1984) and this character can be used not only in greenhouse plantations but in any area where pollination has previously proved difficult.

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EVALUACION DEL NIVEL DE AUTOGAMIA EN PAPAYA.

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RESUMEN - Se ha estudiado el nivel de autogamia y la secuencia polinización-fecundación en las flores de papaya de los cultivares Sunrise, Waimanalo, Kapoho y 298F5 en las condiciones canarias, así como la tendencia partenocárpica de algunos cultivares. Se observaron claras diferencias entre los cultivares en relación a los porcentajes de cuajado en proporción directa a los porcentajes de granos de polen germinados en el estigma de la flor antes de producirse la antesis.

