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STUDIES ON FLORAL BIOLOGY OF PASSION FRUIT (*PASSIFLORA* SPP.)

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Abstract

Floral biology of purple, yellow, giant and *Passiflora foetida* was studied at the ICAR Research Complex, Mizoram Centre, Kolasib, Mizoram, India during 2005-07. Purple, giant and *P. foetida* had major bloom during March-April, July-August and September-October. While major bloom in yellow was mainly during May-June and September-October. Purple, giant and *P. foetida* had the maximum duration of bloom of 42.4, 22.5 and 32.6 days, respectively during March-April with the maximum duration of effective bloom of 12.5 8.6 and 10.4 days in purple, giant and *P. foetida*, respectively. Yellow had the maximum duration of bloom for 28.4 days and effective bloom of 10.5 days during May-June. Most of the flowers of purple (54.5%) and giant (58.5%) opened between 6-7 hrs, while the maximum per cent of anthesis in yellow (70%) took place between 12-13 hrs. Pollen dehiscence and pollination in purple and giant mainly occurred between 7-8 hrs, while 13-14 hrs was the major period of pollen dehiscence and pollination in yellow. The earliest anthesis (5-6 hrs), anther dehiscence (6-7 hrs) and pollination (6-7 hrs) were recorded in *P. foetida*. The maximum stigma receptivity was recorded on the day of anthesis in all the passion fruits. Completely curved style was more common in all passion fruits that gave the maximum fruit set. The maximum number of bees observed between 7-8 hrs in purple and giant and between 13-14 hrs in yellow. The most common pollinating bee in purple, giant and yellow was *Apis mellifera*, while *A. cerena* was in *P. foetida*

Introduction

The genus *Passiflora* L., belongs to family Passifloraceae with its major centre of diversity in Brazil (Knight *et al*., 1962). There are two recognized forms of edible passion fruit; purple (*Passiflora.edulis* Sims) and yellow (*Passiflora* f. *flavicarpa* Deg.). The purple passion fruit is originally native of Tropical America, whereas yellow passion fruit is being considered as a mutation of the purple variety or as a natural hybrid between purple and another related species of passion fruit (Akamine & Girolami 1959). *Passiflora quadrangularis* L., the giant granadilla, is also cultivated to a limited extent for local consumption. It grows best in a hot, moist climate and produces a round or oblong, pale-yellow to yellowish-green fruit when ripe, which may reach up to 8 inches in size. *Passiflora foetida* L., a wild species, bears very small fruits and has unique characters of being highly precocious and very short fruit maturity period (Hutchinson, 1967). Purple and yellow are commonly cultivated in northeast region of India, while Kavery (hybrid between purple and yellow) is common in south India (Kishore *et al*., 2006).

Passion fruit has hermaphrodite, solitary flowers, located in the leaf axils. There are usually five stamens. The ovary is borne over the androgynophore. There are three styles united at their base, and at the top of style there are three bifurcated stigmas (Vanderplank, 1996). Passion fruits are protandrous as anther dehisces before stigma

becomes receptive and stigma remains receptive from the time of flower opening to closing (Cox, 1957). Purple, giant and *P. foetida* are self-fruitful, so they bear more fruits/vine. The flowers of the yellow are perfect but self-sterile and self-incompatible which lead to poor fruit set (Bruckner *et al*., 1995).

The style of passion flower shows rhythmic movement, at anthesis, its style is in upright position and it starts curving in due course of time. According to the style curvature, there are three kinds of flowers in passion fruit: a) completely curved (CC) style, where style is curved in such a way as to bring stigmas close to the anthers; b) partially curved (PC) style, where the style curves partially, but stigmas remain above the anthers, forming a 45˚ angle with them; and c) style without curvature (WC), where the style does not curve, and the stigmas for an angle of approximately 90˚ with the anthers. The three flower types can be found on a single plant; however, CC flower are the most common, and WC flowers are relatively less common (Knight & Sauls, 1994).

Flowers are large, attractive, colourful and fragrant and produce plentiful nectar and pollen that facilitates insects for cross-pollination. The principal insects visiting passion fruit include *Apis mallifera* (honey bee) and *Xylocopa vanpuncta* (carpenter bees). Carpenter bee is the most effective pollinator as it has large body and its body brushes along the anther and stigma while obtaining nectar. On the other hand honey bees are not effective pollinator because of their foraging habit (Hammer, 1987). He further observed that *Apis cerana* and *Apis dorsata* were detrimental to fruits by removing pollen before stigma becoming receptive.

The floral biology of passion fruits has been studied in detail in other countries; very little work has been done in India. Since floral biology is the most important aspect for breeding work and for increasing fruit set, an experiment was laid out to study in detail the floral biology of passion fruit.

Materials and Methods

Studies were carried out during 2005-2007 on two -year-old vine of passion fruits growing at ICAR Research Complex Mizoram Centre, Kolasib, Mizoram, India. The mean temperature, relative humidity and annual rainfall were 28.5°C, 71.2 and 2650mm, respectively at the experimental site. Trials were laid out in randomized block design with four passion fruits viz., purple, yellow, giant and *P. foetida*. Four types of passion fruits were taken as four treatments, which were replicated twenty times.

The major bloom, minor bloom, duration of bloom and number of effective bloom were worked out on the basis of number of flower opened every day. In case of major bloom, five or more numbers of flowers per day was considered. While effective bloom was worked out by considering ten or more number of flowers per day. The time of anthesis, pollen dehiscence and pollination were recoded for a period of 15 days during each flush. For anthesis, three branches having uniform flower buds were tagged in two different directions of plant and data were recorded at an hourly intervals starting from 5 to 16 hours. Similarly the duration of bloom was recorded by tagging three branches having uniform flower buds and data were recoded at an hourly intervals starting from 5 to 18 hours. The number of dehisced anthers in each flower was recorded at an hourly interval in 20 flowers in east and west directions. In order to study the stigma receptivity, emasculated flowers were pollinated by hands one day before anthesis, on the day of anthesis and one day after anthesis and on the basis of fruit set stigma receptivity was worked out. Similarly, pollination was recorded at an hourly interval starting from anthesis by observing the transfer of pollens on stigma of more than 50% of flowers in each experimental vine. The pollinating agents were considered on the basis of their visits

on a flower within 15 minutes. To differentiate flowers on the basis of their style curvature; completely curved (CC) style, partially curved (PC) style and without curved style, twenty fully opened flowers in each experimental vine were randomly taken during bloom period and the percent was worked out. In order to work out the stigma receptivity under different style curvature, emasculated flowers were pollinated by hand on the day of anthesis and on the basis of fruit set, stigma receptivity was worked out.

The data recorded on various attributes during the studies were statistically analyzed following the method of Panse & Sukhatme (1985) to test the significance of treatments and to draw conclusions

Results and Discussion

The maximum duration of bloom and duration of effective bloom in purple, giant and *P. foetida* were recorded during March-April (Table 1). The duration of bloom in purple was approximately double than that of giant and about 30% more than that of *P. foetida*. Similarly, purple had about 50% and 20% more duration of effective bloom during March-April than that of giant and *P. foetida* respectively. The minimum bloom period and effective bloom period in purple, giant and *P. foetida* were observed during January-February.

A perusal of data presented in Table 1 revealed that in purple, giant and *P foetida* the major periods of bloom were March-April, July-August and September-October. The maximum duration of bloom of 42.4 days in purple, 22.5 days in giant and 32.6 days in *P. foetida* were recorded during March-April with the maximum days of effective bloom of 12.5 and 10.4 days in purple and *P. foetida* respectively. In yellow major blooms were occurred during May-June and September-October with the maximum bloom period and effective bloom period during May-June. Further yellow had no bloom during January to April.

A perusal of data presented in Table 2 revealed that, anthesis in purple and giant commenced from 5hrs and continued up to 10 hrs. The maximum anthesis in purple and giant was recorded between 6-7 hrs. In *P. foetida* anthesis started from 5 hrs and continued up to 9 hrs with the peak anthesis between 5-6 hrs. But anthesis in yellow started in afternoon 12-13 hrs and continued up to 16 hours. The maximum anthesis in yellow was recorded between 12-13 hrs. Nishida (1963) reported the similar pattern of anthesis in Hawaii but different bloom period in purple and yellow passion fruit. The duration of bloom, pollen dehiscence and pollination were also studied (Table 2) and it was observed that dehiscence started from 6hrs and continued up to 10 hrs in purple and giant with the peak dehiscence of 73.5% and 73.9% in purple and giant respectively between 7-8 hrs. While in *P. foetida* the maximum pollen dehiscence (74.9%) occurred between 6-7 hrs. The maximum pollination percentage was also observed between 7-8 hrs in purple (71.4%) and giant (65.8%). The pollen dehiscence in yellow was started from 11 hrs and continued up to 15 hrs. The maximum pollen dehiscence of 63.5% and pollination of 54.5% were recorded in yellow between 13-14hrs and 14-15 hrs respectively. A similar type of findings was reported by Cobert & Willmer (1980) who observed pollen dehiscence and pollination in yellow in afternoon. Passion flowers undergo rhythmic styler movement after anthesis and styles attain the completely curved position from erect position after pollen dehiscence. The peak pollination was recorded after anther dehiscence and the findings complied with the report of Cox (1957). He observed that the most effective time for pollination is after style has recurved as at this stage, the stigma is in the position where it is most likely to be brushed by pollinating insects and the stigmatic fluid is present to ensure adhesion by the pollen grains so the pollen tube growth can start.

Table 3. Stigma receptivity in terms of fruit set in passion fruit.

Passion fruit	% fruit set one day before anthesis	% fruit set on day of anthesis	% fruit set one day after anthesis
Purple	2.2	65.8	3.2
Yellow	1.6	42.5	1.9
Giant	2.1	48.5	3.1
P. foetida	2.3	82.5	2.9
CD (0.05)	0.06	0.91	0.1

Stigma receptivity in passion fruit was studied and it is apparent from data that the maximum receptivity of stigma was on the day of anthesis (Table 3). The maximum fruit set was recorded when flowers were pollinated on the day of anthesis. The fruit set was significantly minimal when flowers were pollinated one day before and after pollination. The findings comply with the report of Duarte & Sierra (1997), who reported that the stigma of yellow passion fruit was receptive on the day of anthesis. Ciampolini *et al*., (1981) reported that stigma secretes exudates on its surface which provide suitable medium for pollen germination, so the exudates might have secreted on the day of anthesis which made stigma receptive and led substantially higher fruit set.

The type of style with respect to their curvature is presented pictorially (Fig. 1&2) and graphically (Fig. 3). In all the passion fruits the % of flowers with CC stigma was about 80%. The maximum number of WC flower was found in purple followed by *P. foetida*, while yellow had minimum % of WC. Similarly the maximum percent of PC style was recorded in giant followed by yellow. The per cent fruit set under different types of styles (Fig. 4) was also studied and it was observed that no fruit set was recorded in case of WC flower, while the maximum per cent of fruit set was recorded under CC styles. The fruit set in partially curved style was about 1/3rd of completely curved style. The absence of fruit set in WC flowers may be due to an abnormality in the female gametophyte (Ruggiero *et al*., 1976).

Pollination of passion fruit was studied with respect to number of bees visited on a flower and number of flowers pollinated in an hour. The activities of bees were observed from 5 am but the maximum number of bees and number of pollinated flowers was observed between 6-7 hrs in *P. foetida* (Fig. 7) and between 7-8 hrs in purple (Fig. 5) and giant (Fig. 6). A sudden decrease in the bees number was recorded after 6-7 hrs in *P. foetida* and and 7-8 hrs purple and giant, respectively. In yellow the maximum bees number was recorded between 13-14 hrs and during this period the number of pollinated flowers was also the maximum (Fig. 8). A sharp decrease in bees' number was observed afterwards. The increase in number of bees after one hour of anthesis may be due to the secretion of nectar from the base of androgynophore.

The type of bees visiting passion flowers during peak pollination period was also studied (Fig. 9) and it was observed that in purple, *Apis cerena* and *A. mellifera* were major pollinating agent, while in giant *A. mellifera* was the most common bee. In *P. foetida* the activities of *A. cerena* was more than *A. mellifera*. In purple and *P. foetida* no *Xylocopa* spp., Bee was observed during peak pollination period. In yellow *A. mellifera* (Fig. 11) was the most common bee visitors followed by *A. cerena* (Fig. 10) and *Xylocopa* spp.

Fig. 1. Completely curved (CC) style of purple passion fruit.

Fig. 2. Partially curved (CC) style of purple passion fruit.

Fig. 3. *A. cerena* pollinating flower of yellow passion fruit.

Fig. 4. *A. mellifera* pollinating flower of yellow passion fruit.

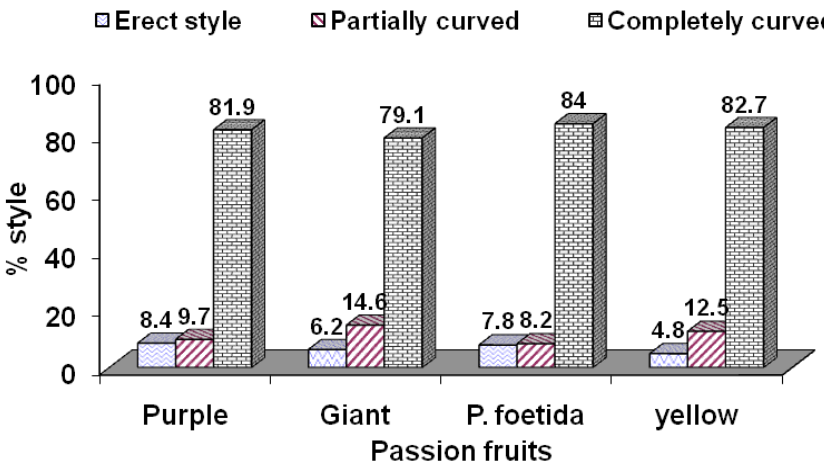

Fig. 5. Percent of different types of styles in passion fruits.

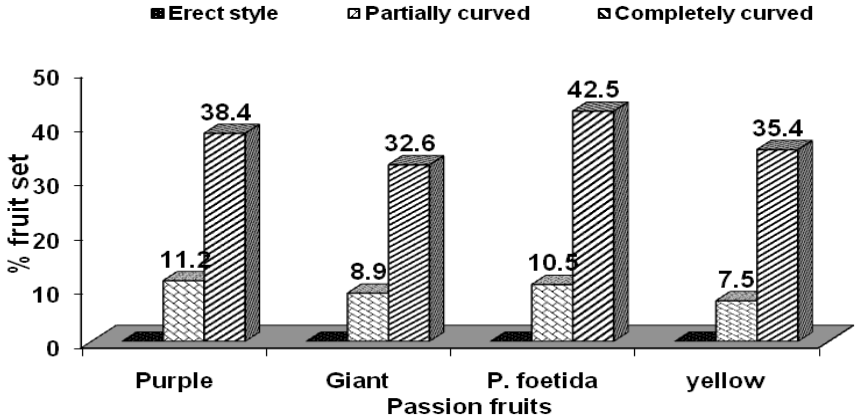

Fig. 6. Percent of different types of styles in passion fruits.

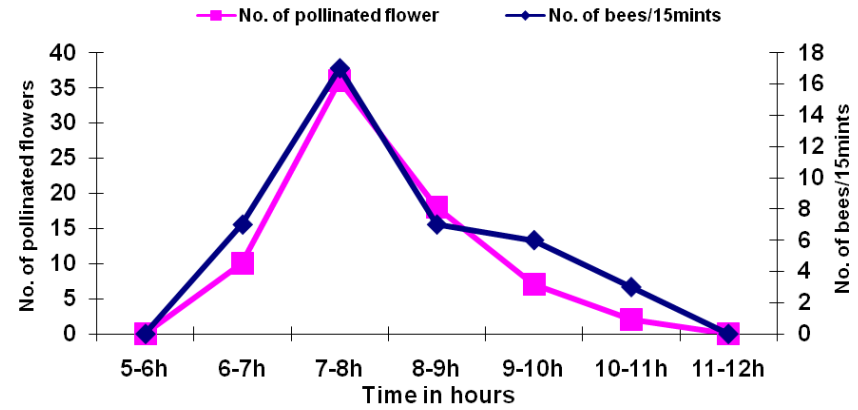

Fig. 7. Number of pollinated flowers and no. of bees visited in 15 minutes in purple passion fruit.

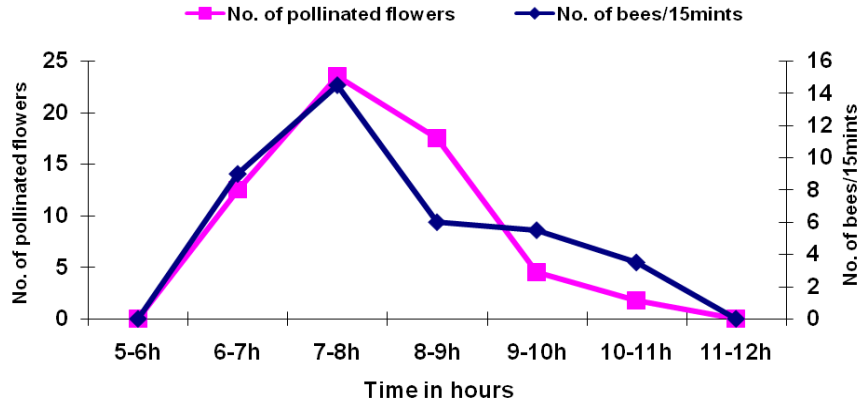

Fig. 8. Number of pollinated flowers and no. of bees visited in 15 minutes in giant passion fruit.

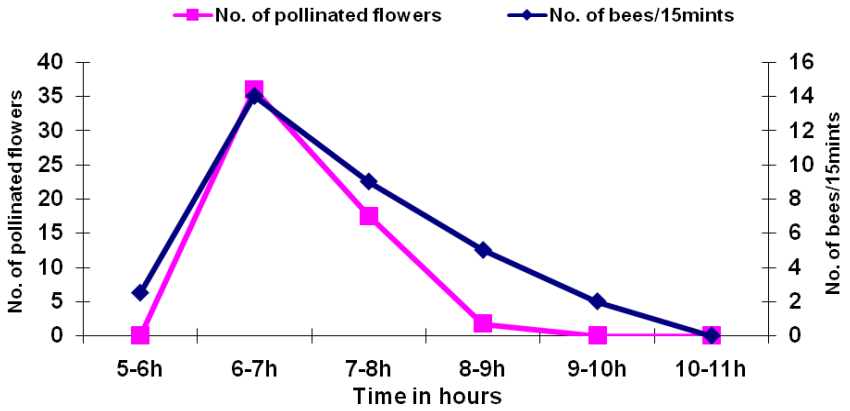

Fig. 9. Number of pollinated flowers and no. of bees visited in 15 minutes in *P. foetida*.

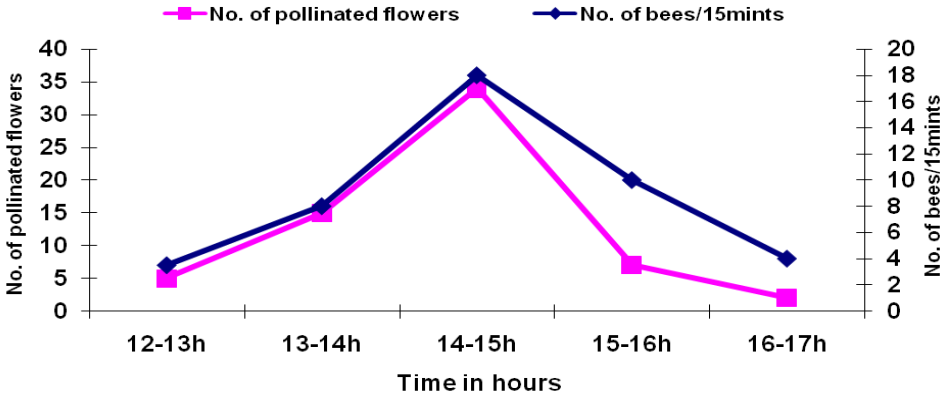

Fig. 10. Number of pollinated flowers and no. of bees visited in 15 minutes in yellow passion fruit.

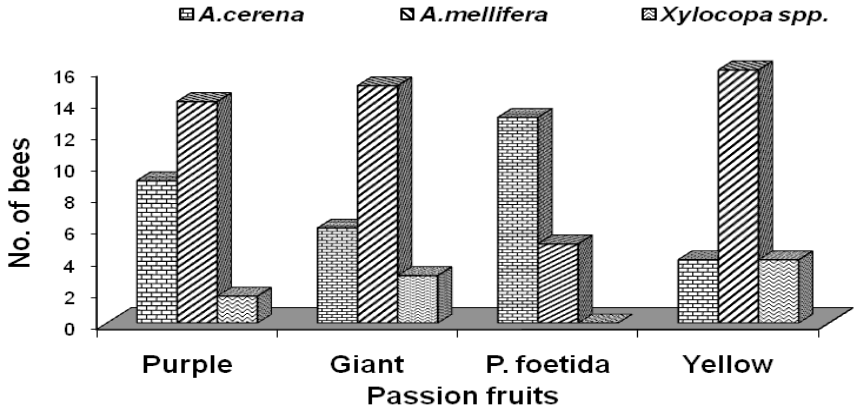

Fig. 11. Frequency of visiting pollinators in 15 minutes in passion fruits.

The absence of *Xylocopa* spp., during the pollination period of purple, giant and *P. foetida* may be due to its inactivation during morning hours. Hardin, (1987) reported that since the pollen grain of purple, giant and *P. foetida* were relatively smaller, lighter and less sticker than that of yellow, honey bees were the major pollinator and up to 25 per cent of open flowers produced fruits. On the other hand, Nishida (1968) reported that *Xylocopa* spp., were better pollinator for yellow passion fruit as it had relatively larger, heavier and stickier pollen grains which were better carried by big bees like *Xylocopa* spp. He further reported that the activity of *Xylocopa* spp., increased around midday due to the increase in temperature which coincided with the pollen dehiscence and nectar secretion in yellow passion fruit.

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