

BLOOMING PATTERN OF PASSION FRUIT FLOWER (*PASSIFLORA EDULIS* SIMS.) UNDER DIVERSIFIED FLASHES

¹Das, M.R., ²T. Hossain, ²M.A. Baset Mia,
²J.U. Ahmed, ³A.J.M. Sirajul Karim and ⁴M.M. Hossain

¹Department of Agricultural Extension, Agriculture Training Institute, Gazipur, Bangladesh

²Department of Crop Botany,

³Department of Soil Science,

⁴Department of Horticulture,

Faculty of Agriculture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh

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ABSTRACT

Passion fruit has great potential to attract for its lucrative flavor, taste and deliciousness to grown up the economic condition of the farmer in the developing country. Study of flower blooming can play vital role in developing high yielding varieties of this fruit. Field and laboratory experiments were conducted at the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh to determine the flowering behavior of yellow passion fruits (*Passiflora edulis* Sims.) at five flashes. The results revealed that third flash showed the best performance in respect of all floral biological attribute namely floral primordia initiation, period of flower bud formation to blooming, flowering duration, number of floral bud, number of flower bloomed, percent flowers opened, flowering interval, bud size, initiation, completion and withering of floral parts. Thus, the results may be concluded that third flash would be the best for better fruit production.

Keywords: Passion Fruit, Flash, Flowering Behavior, Flowering Interval, Withering

1. INTRODUCTION

Passion fruit (*Passiflora edulis* Sims.) belongs to the family *Passifloraceae* with the basic number of chromosomes $n = 9$ ($2n = 18$). *Passiflora* genus contains more than 450 species but 12 species are being cultivated. Only single species *Passiflora edulis* Sims. is highly commercialized for its quality fruit production (Kole, 2011). Due to its rapid production rates in comparison with other fruits and its demand in the market, both for fresh consumption and industrial processing sour passion fruit (*Passiflora edulis* Sims) is of great interest to fruit producers (Madureira *et al.*, 2012). There are two recognized forms of edible passion fruit-purple and yellow. The yellow passion fruit (*Passiflora edulis* Sims) is widely cultivated in Brazil and its fruits are consumed fresh.

The passion flower is native to Brazil, widely cultivated in frost free area including India, Sri Lanka (Shivanna, 2012; Kishore *et al.*, 2010). It is largely distributed around the tropics and humid subtropics. The species of the *Passiflora* genus are widely distributed in tropical and subtropical regions (Silva *et al.*, 2009) where the solar radiation is high, humid and shaded environment are present. It is cultivated for its ornamental, medicinal and nutritive characteristics (Shivanna, 2012). The fruit is gaining prominence for its excellent taste and flavor for the diverse group of people in the world. It is an excellent fruit having high amount of beta carotene, potassium and dietary fiber (Gahakwa *et al.*, 2012). The flower of passion fruit has a mild sedative and can help to induce sleep. Passion flower has been used in the treatment of nervous and easily excited children bronchial asthma, insomnia,

Corresponding Author: Das, M.R., Department of Agricultural Extension, Agriculture Training Institute, Gazipur, Bangladesh

nervous gastrointestinal disorders and menopausal problems. Passion flower is sometimes used as a mild hallucinogen, reduction of asthma symptoms. Yellow passion fruit extracts can kill cancer cells. The phytochemicals responsible for these anti-cancer effects are carotenoids and polyphenols (Patel *et al.*, 2009). It is also known as parcha, granadilla, maracuyá, ceibey, lilikoi and linmangkon (Joy, 2010). In Bangladesh, passion flower is known as '*humkalota*' and considering taste, flavour and colour with tang-juice the passion fruit is also called a '*tangfal*' (Ullah *et al.*, 2009).

Passion fruit is a woody perennial vine crop (Banu *et al.*, 2009) is an allogamous plant mainly due to its floral morphology and self-incompatibility of sporophytic type (Souza *et al.*, 2010) being cultivated for its edible fruits.

Passion fruit has hermaphrodite, solitary flowers, located in the leaf axils having five stamens and the ovary is borne over the androgynophore. There are three styles united at base and at the top of style there are three bifurcated stigmas (Matthews and Endress, 2008). It is protandrous as anther dehiscence before stigma becomes receptive which persists from time of flower blooming to withering. The style of passion flowers shows rhythmic movement which is in upright position and it starts curving in course of time resulting expression of self-incompatibility. The self-incompatibility is an important factor for fruit production (Souza *et al.*, 2010).

In some areas, passion fruit plants produce flower and fruit twice a year, plants usually begin blooming and fruiting in the second year. It grows well in hot and moist climatic conditions. It is a special type of flower and blooming pattern is rather different from other alien fruit crop of Bangladesh. Banu *et al.* (2009) reported flowering of passion fruit from April to September in hilly regions of Bangladesh. They also reported variation in time for two accessions of passion fruit. Kishore *et al.* (2010) recorded the maximum duration of bloom and duration of effective bloom of *P. foetida* during March-April at Mizoram of India when mean temperature, relative humidity and annual rainfall were 28.5°C, 71.2% and 2650 mm, respectively. It is a long day plant and day length require more than 10.5 h (Ullah *et al.*, 2009). Flower blooming of passion flowers were reported variable by Kishore *et al.* (2010) *Passiflora* species have flowering behavior varying among the year and consequently with variation in fruit production and harvesting time (Ataide *et al.*, 2012). Detailed information regarding the flowering behavior of passion fruit is not available which is important for breeding aspect for increasing fruit set. With this view in mind an experiment was conducted to study the flowering pattern of passion fruit throughout the year under varied flashes.

2. MATERIALS AND METHODS

The experiment was conducted at the experimental farm of the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh where the climate is characterized by heavy rainfall. The soil of the experimental field was clay loam in texture and acidic in nature having pH 5.8. The experimental plot was well-drained high land where vine cuttings were transplanted in pits (50×50×50 cm³).

The yellow passion fruit (*Passiflora edulis* Sims.) was used as test material for the experiment and vine cuttings were transplanted in the pits where the pit to pit distances were 2.5 m. Trellises required for the production of passion fruit for the life of the vine and a single row trellises system was used. The spacing of the passion fruit directly related to the spacing of the poles of the trellis and vines were pruned in late winter, irrigation and management practices were done as and when necessary. Yellow passion fruit vines begin flowering in the April-May, usually peaking in mid-August and continuing until October or November. Data on flower bud initiation, duration of flower bud initiation, days required from bud initiation to flower blooming were recorded. Other flowering attributes namely, duration at different flashes, flower buds per plant, percent of flowers bloomed, bud size, flowering initiation and completion, withering of floral parts were recorded. These parameters were computed from mean of two consecutive years (2008 and 2009) of 30 flowers. The collected data were analyzed statistically using MSTAT-C computer package (Michigan State University, East Lansing, MI, USA) following the methods of Gomez and Gomez (1984) and Kishore *et al.* (2010). The Analysis of Variance procedure (ANOVA), differences among treatment means were determined using the Least Significant Difference (LSD) at 5% level of significance.

3. RESULTS

3.1. Floral Primordial Initiation

Passion fruit produces solitary flower bud at the axils of leaf. Flower bud is a reproductive organ of passion fruit from which flower is developed. Floral primordia initiation started in April (**Table 1**). It showed first bud flash in April 10, second in May 09, third in June 15, fourth in July 02 and finally fifth in August 03. It is assumed that flowering period and numbers of flashes are affected by climatic condition as well as geographic position of cultivation. Weather data has been shown in **Fig. 1-4**.

Table 1. Flower primordia initiation and days required for flower bud initiation at different flashes (2008 and 2009)

Flashes	Date of floral primordia initiation	Duration of flower bud initiation (days)	Days required from bud initiation to flower blooming
First	April 10	11±0.48	15±0.55
Second	May 09	14±0.41	13±0.24
Third	June 05	15±0.44	10±0.45
Fourth	July 02	13±0.23	12±0.24
Fifth	August 03	10±0.33	14±0.20

*Values are mean of two consecutive years (2008 and 2009) of 30 flowers

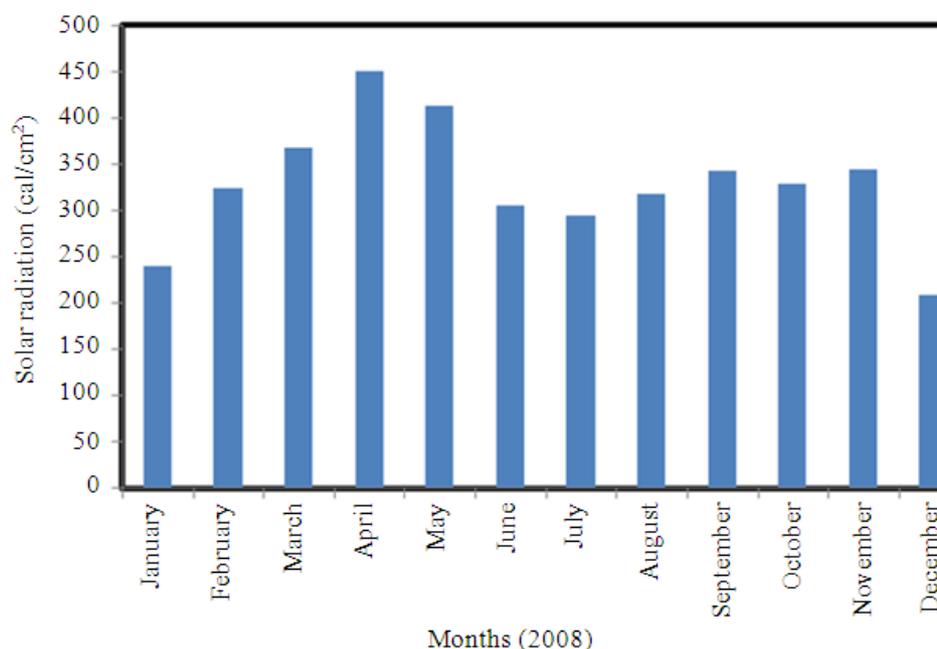


Fig. 1. Solar radiation during the experimental period (2008)



Fig. 2. Solar radiation during the experimental period (2009)

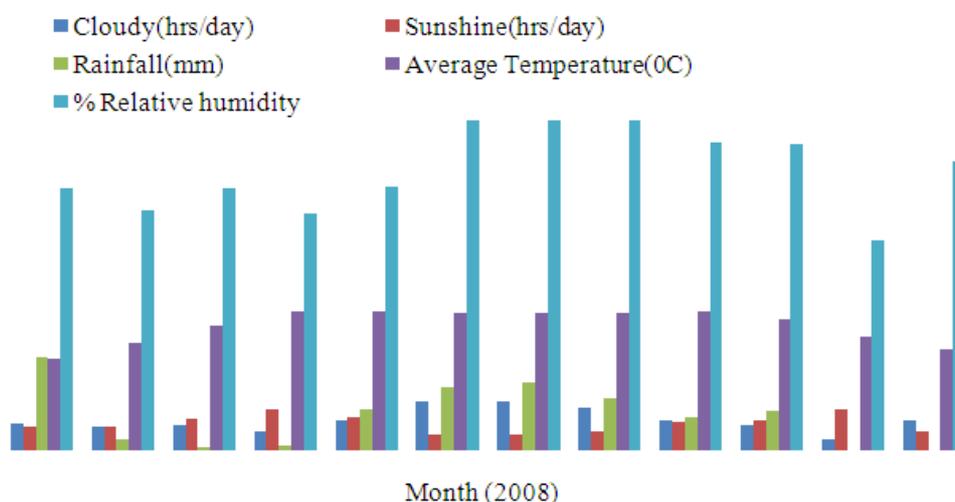


Fig. 3. Meteorological parameters of the experimental period (2008)

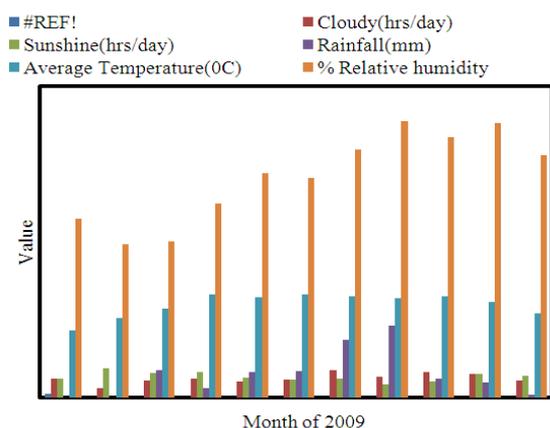


Fig. 4. Meteorological parameters of the experimental period (2009)

3.2. Duration of Flower Bud Initiation

Duration of bud formation at different flashes was noticed variable (Table 1). The duration of flower bud formation ranged from 10 to 15 days at different flashes. The third flash requires the longest duration of bud formation and fifth flash took the shortest. Passion fruit showed luxuriant growth from May to July (data not showed). Duration of flower bud formation is assumed to be associated with plant vigor and weather conditions.

3.3. Days Required from Bud Formation to Flower Blooming

Days required from bud initiation to flower blooming of passion fruit varied among the flashes

(Table 1). Days ranged from 10 to 15 at different flashes for flower blooming. At first flash, 15 days were required to open flower. The requirement of days from bud initiation to flower opening was recorded to be decreased with the advancement of plant age. At third flash only 10 days were required to open the flower after bud initiation. At fourth and fifth flashes it required 12 and 14 days, respectively from bud initiation.

3.4. Flowering Duration at Different Flashes

Flowering duration of passion fruit at different flashes was varied among the flashes (Fig. 5). The longest duration of flowering was recorded at third flash and the duration at other flashes was noticed to be declined.

3.5. Flower Buds per Plant

Number of flower buds per plant varied from first to fifth flash (Table 2). These numbers ranged from 85 to 232 at different flashes. Plant produced the lowest number of flower buds at fifth flash in a year. Buds per plant were recorded the highest at third flash. Time requirement was noticed very short from commencement of blooming to full bloom.

3.6. Number of Flowers Bloomed

Plant showed maximum blooming of flower at third flash during the month of June (Table 2). In fifth flash drastic reduction in number of flowers was observed in fifth flash in August.

Table 2. Production of flower buds and blooming of flowers at different flashes of passion fruit

Flashes	Flower buds per plant	Flowers opened from flower buds per plant	Percent of flowers open per plant
First	133±0.88	52±0.68	39.10±0.29
Second	219±0.86	125±0.71	57.08±0.29
Third	232±0.78	146±0.67	62.93±0.25
Fourth	200±0.99	105±0.65	52.25±0.29
Fifth	85±0.65	27±0.65	31.76±0.25
Mean	173.80	91.00	48.62

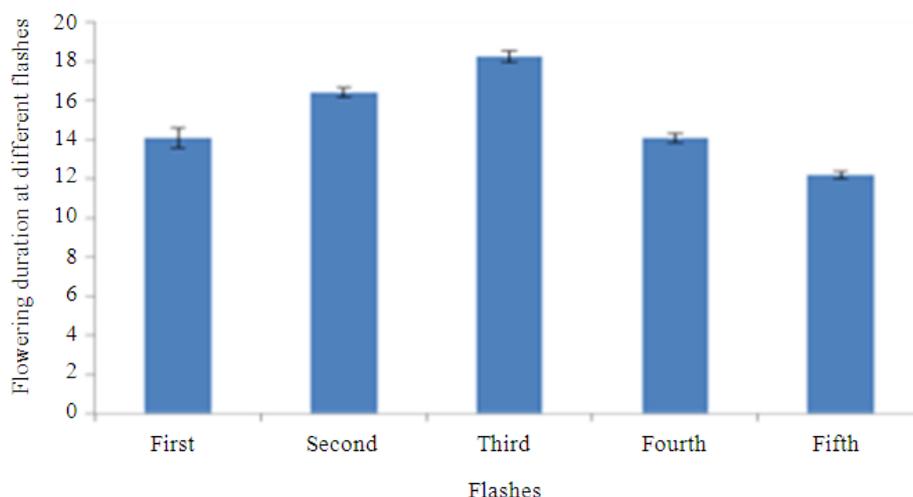


Fig. 5. Flowering duration of passion fruit under different flashes

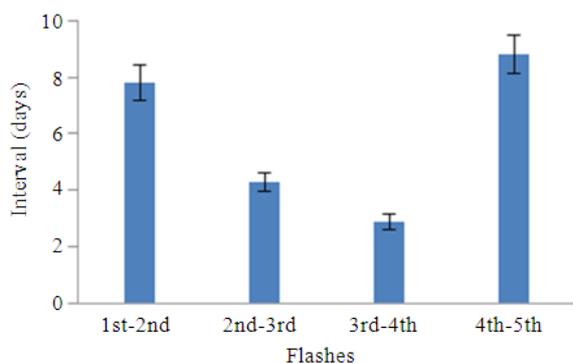


Fig. 6. Flowering intervals of different flashes of passion fruit

3.7. Percent of Flowers Opened

Flowering of a plant is associated with growth, development and prevailing environmental conditions (Table 2). At different flashes, percent of flowers per plant was recorded variable in number. Plant produced the highest percent of flowers at third flash in June. Flowering percent ranged from 31.76 to 62.93. The

flowering percent from first flash to third flash increased gradually with the advancement of plant age. On the other hand, with the further advancement of plant age a reverse trend was noticed.

3.8. Flowering Interval

Flowering intervals among different flashes ranged from 2.9 to 8.8 days (Fig. 6). This interval was recorded the longest (8.8 days) between fourth and fifth flashes followed by first and second, second and third and third and fourth flashes. The shortest interval (2.9 days) was noticed between third and fourth flashes. Passion fruit showed luxuriant growth in humid weather associated with high temperature (Fig. 3 and 4). Plants showed the shortest flowering interval during humid weather prevailing high temperature.

3.9. Bud Size

Bud size of passion fruit at different flashes ranged from 6.70 to 8.10 cm (Table 3). Bud size of passion fruit was recorded minimum at first flash. Compared with other flashes plant produced the largest buds (8.10

cm) and at third flash bud size was noted smaller. At third flash, passion fruit produced 12.19% larger bud compared with mean bud size. Similarly, fresh weight of each bud on previous day of flowering at different flashes varied. Fresh weight of bud was noted the largest at fourth flash. As other parameters plant produced the largest bud at third and fourth flashes.

3.10. Flower Initiation and Completion

Flowering initiation and completion of passion fruit at different flashes were presented in **Table 4**. At different flashes flowering initiation time ranged from 09:05 am to 11:10 am. Flowering initiation was recorded earlier at third flash. Before and after third flash flowering initiation was noticed to delay. At first flash flowering was recorded to delay. On the other hand, following completion ranged from 15:45 pm to 18:25 pm at different flashes. Among the five flashes flowering completion was noted earlier at third flash. Passion fruit requires high temperature and humidity for flowering which reviled during third flash in the present experiment. Temperature and humidity of experimental area has been shown **Fig. 3 and 4**. Total flowering time among different flashes ranged from 6 h 10 min to 7 h 15 min (**Table 4**).

Flowering pattern of passion fruit at different flashes was presented in **Fig. 7**. Flowering pattern of passion fruit at different flashes was observed variable. Flowering period at different flashes ranged from 09:00 am to 17:00 pm during crop year. At first flash flowering started at 11: 00 am and continued up to 16:00 pm. With the advancement of plant age flowering was noticed to start earlier up to third flash, but with the further advancement of plant age flowering was noticed to delay. Among the five flashes plant produced flower earliest (09:00 am) at first flash and completed flowering earliest (at 15:00 pm). At all flashes plants showed maximum blower between 12:00 and 13:00 pm. Plants produced the highest percent (35) of flowers at 12:00 noon at third flash. In the present experiment mid-day (12:00~13:00 hr) was noticed to be the best time for flowering of passion fruit. Plant produced 50~60% flowers at this period at 5 flashes.

Withering is the terminal phase of developmental processes which includes flower wilting, shedding of flower parts and fading of blossoms. Withering of floral parts is a rapid process as compared to senescence of other plant parts.

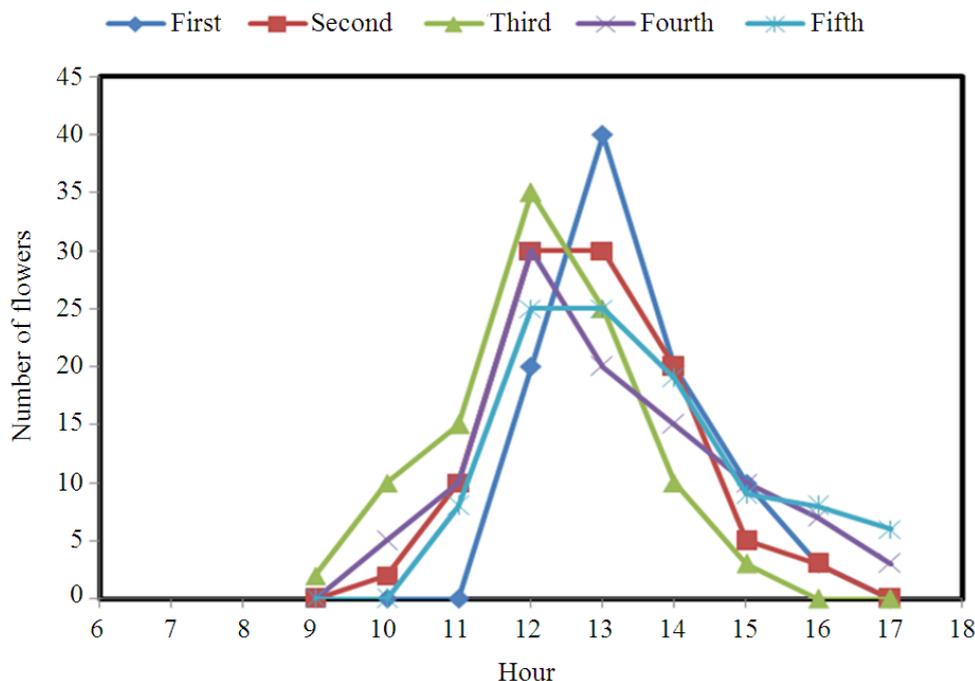


Fig. 7. Passion flowers bloomed at different flashes

Table 3. Bud size at different flashes of passion fruit on previous day before flowering

Flashes	Bud length (cm)	Change Over mean	Fresh weight (g)	Change Over mean
First	6.70	-7.22	2.84	-7.49
Second	6.80	-5.82	2.88	-6.19
Third	8.10	+12.19	3.26	+6.19
Fourth	7.40	+4.49	3.58	+16.61
Fifth	7.10	-1.66	2.79	-9.12
Mean	7.22	-	3.07	-

Table 4. Flowering time of passion fruit at different flashes (hours) in a day

Flashes	Flowering time (hours of a day)		
	Initiation	Completion	Total flowering time (hrs)
First	11:10	18.25	7 h 15 min
Second	10:25	16:35	6 h 10 min
Third	09:05	15:45	6 h 40 min
Fourth	09:50	16:05	6 h 15 min
Fifth	10:30	16:50	6 h 20 min

Table 5. Time of initiation of withering of floral parts of passion fruit after full bloom (in hours) at different flashes

Different Flashes	Different floral parts			
	Sepal	Petal	Stamen	Carpel
First	16.00	8.30	6.15	8.00
Second	17.00	8.00	6.25	9.00
Third	19.30	8.00	7.00	10.00
Fourth	18.25	8.00	6.30	8.25
Fifth	15.30	8.15	6.00	8.30

*Mean findings of 15 flowers

Withering of different floral parts at different flashes of passion flower initiated at different time after full bloom (Table 5). Among the floral parts, stamens started withering earliest. On the other hand among the flashes stamens of flowers of third flash were noticed to be withered with delay. Similar tendency of withering of carpels were noted, though the initiation of withering of carpel was recorded with some delay than stamen. Between the accessory organs of passion fruit flower, petal showed initiation of withering quite earlier than sepal. Among the flashes, sepal of flower of third flash was recorded to be delayed which may contribute for the growth of ovary into fruit as the ventral part of sepal is green in color.

4. DISCUSSION

Generally passion fruit showed flower blooming during April to August when the temperature and humidity are high. In the experimental location, during

April to August the weather parameters showed higher values than rest of the months. In Bangladesh passion fruit blooms flowering during this period. The findings of Kishore *et al.* (2010) are similar with the present study that maximum flower blooming occurred during March to June. Flowering behavior is an important criterion for plant breeder in variety development. Kishore *et al.* (2010) reported that purple, giant and *P. foetida* had major bloom during March-April, July-August and September-October at Mizoram, India during 2005-2007. They also reported the minimum bloom period and effective bloom period in purple, giant and *P. foetidaa* during January-February. It is assumed that flowering period and numbers of flashes are affected by climatic condition as well as geographic position of cultivation. In another study, Banu *et al.* (2009) mentioned that days from flower bud to full bloom in case of plants grown from cutting required 14 days, but in case of plants grown from seeds required 13 days. Time required from bud initiation to flower opening ranged from 10.00 to 15.00 days at different flashes in the present study which are supported by Banu *et al.* (2009). The highest frequency of flower blooming during 11 am to 1.00 pm might be due to higher solar radiation and temperature accompanied with high humidity (Fig. 1-4). Maximum photosynthesis and diurnal respiration accelerated the phenomena.

Kishore *et al.* (2010) reported that different species of cultivated *Passiflora* spp. respond differently to environmental factors. The radiation of the sun, which can be characterized by its quality, duration and intensity are a basic factor for plant development and

flower production (Santos *et al.*, 2012). The irradiance of the environment in which the plants grow is of fundamental importance, because the adaptation of the plants to this environment depends on the adjustment of their photosynthetic apparatus, so the light is used in a possibly more efficient way (Santos *et al.*, 2012). High irradiance may reduce the productivity of tropical plants (Santos *et al.*, 2012). The duration of flower bud formation in the present study was recorded the longest at third flash (June) which was associated with the vigor of plant and weather condition.

Joy (2010) observed that the influence of seasonality on the physical characteristics of the yellow passion fruit (*Passiflora edulis* f. *flavicarpa*) was significantly better in moderate temperature (October to December 1995) and rainfall.

Santos *et al.* (2012) reported that photoperiod, air temperature and soil moisture determines the yield of yellow passion fruit (*Passiflora edulis* f. *flavicarpa* Sims.). The flowering, the fructification and the yield were not significantly affected by the different times of lighting.

Similar findings regarding floral withering of parts were reported by Lambers *et al.* (2008) who explained that during withering, developmental and environmental stimuli enhance the upregulation of catabolic processes causing breakdown and mobilization of cellular components.

5. CONCLUSION

The results indicated that duration of bud formation at different flashes was noticed variable and the longest duration was required under third flashing condition. Similarly, days required from bud initiation to flower blooming varied from 10 to 15 at different flashes. At third flash only 10 days were required to open flower form bud initiation. Plants produced maximum number of flowers per plant during third flash in June from the total buds. Flowering interval among different flashes were recorded variable. The shorted interval (3 days) was noticed between third and fourth flashes. Passion fruit produced largest size of buds at third and fourth flashes. Flowering initiation (blooming) during third flash was recorded at 09:05 h which was earlier than other flashes. Flowering percent at 12:00 was observed the highest (35%) during third flash followed by second and fourth flashes. Withering of sepals was noted to be delayed during third flash which positively contributed to ovary development and fruit setting.

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