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Studies on the Floral Behavior of Dragon Fruit (*Hylocereus costaricensis*) and their Qualitative Characters

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ABSTRACT

Dragon fruit is a recently introduced and one of the high value premium fruit crops in India and it is gaining popularity with each passing day. The present study was conducted and various aspects of floral behavior including number of flushes per year, days interval between two flushes, frequency of bud emergence and flowering cycles were observed minutely. Total number of buds per pillar, per cent buds flowered and aborted per pillar, number of days required for full development of floral bud in different flowering seasons, period of anthesis and time of closing of flower in different flushes were noted. The qualitative aspects of the flower behavior such as flower bud shape, shape of apex, color of flower bud, length of pericarpel and perianth, shape of bracts, intensity of red color of bract, petal color, sepal pattern, primary and secondary color of sepal, color of sigma lobe, position of anthers in relation to stigma were recorded.

Keywords Dragon fruit, Floral biology, Flowers, Pitaya, Reproductive.

INTRODUCTION

Dragon fruit (*Hylocereus costaricensis* [F.A.C. Weber] Britton and Rose) is a fruit bearing vine member of the cactus family and one of the most beautiful and nutritious fruit crops in the world. It is originated in tropical and sub-tropical forest regions of Mexico and Central and South America and mainly cultivated in Thailand, China, Mexico, Australia, Cambodia, Guatemala, Malaysia, Sri Lanka, Taiwan, Japan and other countries (Britton and Rose 1963, Morton 1987, and Mizrahi *et al.* 1997). Dragon fruit was introduced in India (mostly in Kerala, Karnataka, Tamil Nadu, Maharashtra, Gujarat, Orissa, West Bengal, Andhra Pradesh and Andaman and Nicobar Islands.

MATERIALS AND METHODS

The experimental field was situated at 23.5^0 N latitude and 89^0 E longitude with elevation of 9.75 m above mean sea level (MSL). The soil texture of the

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Table 1. Number of flushes/ year, frequency of bud emergence and flowering cycles per pillar of dragon fruit (*Hylocereus costaricensis*).

Main season	Frequency of bud emergence		Flowering/cycles	
Number of flushes/ year	Date	Month	Date	Month
First flush	12th-14th	May	26th-28th	May
Second flush	6th-8th	June	21st-23rd	June
Third flush	29th-30th	June	14th- 15th	July
Fourth flush	23th-24th	July	8th- 10th	August
Fifth flush	17th-19th	August	29th-30th	August
Sixth flush	9th-11th	September	24th-25th	September
Seventh flush	5th-6th	October	20th-21th	October
Eighth flush	27th- 28th	October	14th-15th	November

Table 2. Days interval between two flushes in dragon fruit.

Number of flushes	Range	Mean ± SD	Average (days)
First - Second flush	20 - 26	23.0 ± 2.45	
Second - Third flush	21 - 25	23.6 ± 1.67	
Third – Fourth flush	21 - 27	24.6 ± 2.30	
Fourth - Fifth flush	23 - 28	24.8 ± 1.92	24.33
Fifth –Sixth flush	23 - 27	25.6 ± 1.67	
Sixth –Seventh flush	26 - 27	24.4 ± 1.67	
Seventh – Eighth flush	23 - 26	24.4 ± 1.34	

experimental field was sandy loam. The present experiment was conducted on 5 (five) years' old dragon fruit plants with the species *Hylocereus costaricensis* cv Royal Moroccan Red. Uniform cultural management was provided for all the plants/ pillars along with nutrients, plant protection measures and other parameters. NPK fertilizer doses (450: 350: 300 g/ plant) were applied in four split doses @10, 10 and 30% of total before flowering, 20,40 and 25% at fruit set, 30, 20 and 30% at harvest and finally 40,30 and15% of total NPK after two months of harvest. In this experiment 10 Nos. of pillar for each species were randomly selected spreading over entire period of flowering started from first flush to the eight flush in the field itself.

The observations on floral behavior were recorded with proper methods and instruments. Number of flushes per year, days interval between two flushes, frequency of bud emergence and flowering cycles were studied thoroughly and noted. Total number of buds per pillar, per cent buds flowered and aborted per pillar was recorded. The number of days required for full development of floral bud in different flowering seasons were recorded by tagging and monitoring the growth of the buds till full bloom stage. The period of anthesis and time of closing of flower in different flushes were recorded.

(a) *Period of anthesis* : Flower anthesis was recorded by visual observations in the field as the time between openings with protruding of stigma from the flower and partially petals spread out. The flowers selected for study were labelled.

(b) *Time of closing of flower* : The time of closing of flowers was recorded by visual observation in day 2 (two) of pollination that had shown withered and drooped down flowers at the pillar.

To determine for all the flower morphological characters (qualitative) of dragon fruit International

Table 3. Total number of buds, per cent buds flowered and per cent buds aborted per pillar in each flush of dragon fruit (*Hylocereus costaricensis*).

Number of flushes	Total number of buds per pillar			Per cent buds flowered per pillar			Per cent buds aborted per pillar		
	Range	Mean±SD	Average	Range	Mean±SD	Average	Range	Mean±SD	Average
First flush	20 -31	25.8 ± 4.66		50.0- 70.96	61.91± 9.14		29.04 -50.00	38.09±9.15	
Second flush	17 - 34	26.4 ± 7.02		47.06 - 78.13	65.38 ±11.61		21.87-52.94	34.62±11.61	
Third flush	20 - 37	28 ± 6.44		62.50 -76.67	69.22 ±5.76		23.33 -37.50	30.78±5.76	
Fourth flush	23 - 40	31.2 ± 6.83	26.8	53.13 -80.0	67.2 ±12.03	66.25	20.00 - 46.87	32.8±12.03	33.81
Fifth flush	20 - 42	32.2 ± 9.60		66.65 -76.31	70.93 ±3.49		23.69 -33.35	29.07±3.49	
Sixth flush	19 - 36	28.6 ± 7.02		53.83 -72.22	66.17±7.17		27.78 -46.15	34.31±7.05	
Seventh flush	16 -34	27 ± 7.42		63.33 -75.00	67.64 ± 4.72		25.00 -36.67	32.36±4.72	
Eighth flush	10 -20	15.2 ± 3.83		58.82 – 60.00	61.57 ± 2.38		35.00 - 41.18	38.43 ± 2.38	

Table 4. Days required for full development of floral bud of dragon fruit in different flowering seasons (*Hylocereus costaricensis*).

Number of flush	Range	Mean±SD	Average (days)
First flush	12 - 14	13.2 ± 0.84	
Second flush	13 - 16	14.4 ± 1.14	
Third flush	12 - 16	14.2 ± 1.48	
Fourth flush	13 - 17	14.2 ± 1.79	14.97
Fifth flush	14 - 18	15.8 ± 1.64	
Sixth flush	14 - 18	16.2 ± 1.79	
Seventh flush	15 - 17	15.6 ± 0.89	
Eighth flush	16 -18	16.8 ± 0.84	

Union for the Protection of New Varieties of plants (UPOV) descriptor on dragon fruit were followed. Flower bud shape, shape of apex, color of flower bud, length of pericarpel and perianth, shape of bracts, intensity of red color of bract, petal color, sepal pattern, primary and secondary color of sepal, color of sigma lobe, position of anthers in relation to stigma were observed and recorded.

RESULTS AND DISCUSSION

Total eight number of flowering flushes (May to November) per pillar per year (Table 1) was observed and noticeably in August alone two flushes i.e. fourth and fifth flushes were detected. Seven to eight flowering flushes was observed in *Hylocereus costaricensis* which was similar with the present investigation (Le Bellec 2004). Under Sri Lankan condition four to six number of flushes were reported (Pushpakumara *et al.* 2005).

The bud emergence was observed on 12–14th May in the first flush (Table 1 and Flow chart 1). It was recorded that two times of bud emergence occurred in different dates (flushes) of the same month i.e. from 6–8th (second flush) to 29–30th (third flush) in month of June and also in the month of October 5 and 6th (seventh flush) and 27 and 28th (eighth flush) respectively (Table 1). Abirami *et al.* (2021) reported initiation of flower bud from March in *Hylocereus costaricensis* and in April for *Hylocereus undatus*. The contradiction with Abirami *et al.* (2021) in the present findings might be due to the difference in ecophysiography.

The date of first flowering observed from 26–28th in May as first flush and the last flowering started from 14-15 November (Table 1). In a study, it was found that the flowering time was affected by temperature (Mizrahi and Nerd 1999). In areas with highly moderate temperature, flowers appeared from May to November for *Hylocereus* species. In another study, the flowering and production season during summer, started from June to October (Zee *et al.* 2004). Tel-Zur *et al.* (2004) mentioned different clones showed wide variation in the date and length of flowering season. The day's interval between two flushes ranged from 20 days (first-second flush) to 28 days (fourth-fifth flush). The average days of interval in overall flushes was 24.33 days (Table 2).

The maximum number of flower buds (42 number) found in the fifth flush and minimum of flower buds (10 number) was recorded in the eighth flush followed by 16 flower buds in the seventh flush with an average of 26.8 buds per pillar (Table 3). Zee *et al.* (2004) found three to five spherical buttons emergence on the stem margins. As per Muniz *et al.* (2019) there was a great variation in the number of flower bud

Table 5. Period of anthesis and time of closing of flowers in different flushes of dragon fruit (*Hylocereus costaricensis*).

Number of flushes	Period of anthesis (pm)			Time of closing of flowers (am)		
	Range	Mean±SD	Average	Range	Mean±SD	Average
First flush	6.10 - 7.16	6.8 ± 0.49		7.07 - 8.11	7.5 ± 0.41	
Second flush	6.25 - 7.10	6.5 ± 0.34		7.15 - 7.46	7.3 ± 0.13	
Third flush	6.45 - 7.27	6.8 ± 0.37		7.18 - 7.48	7.3 ± 0.12	
Fourth flush	5.42 - 7.15	6.6 ± 0.73	6.52	7.08 - 8.20	7.7 ± 0.49	7.69
Fifth flush	5.44 -7.22	6.17 ± 0.72		7.53 - 8.45	8.1 ± 0.36	
Sixth flush	5.45 - 7.26	6.3 ± 0.66		7.42 - 8.38	7.8 ± 0.47	
Seventh flush	5.46 - 7.25	6.5 ± 0.71		7.56 - 8.46	8.0 ± 0.45	
Eighth flush	5.5 – 7.28	6.5 ± 0.73		6.55 - 8.35	7.7 ± 0.75	

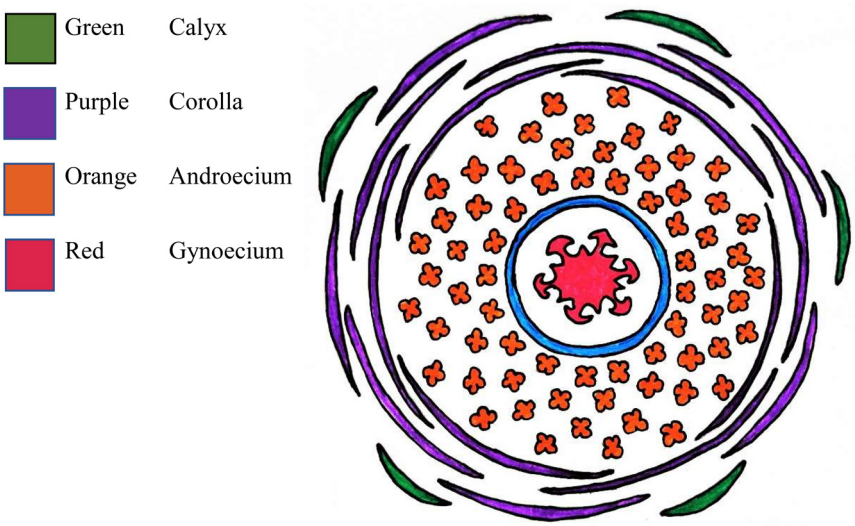


Plate 1. Floral diagram of dragon fruit flowers.

Floral formula = $\frac{\male\female\ Ca^{\infty}\ Co^{\infty}\ A^{\infty}}{G^{\infty}}$

The symbols expressed as :

$\male\female$ - Bisexual or hermaphrodite

Ca^{∞} - Calyx in many
Co^{∞} - Corolla in many
A^{∞} - Androecium in many
G^{∞} - Gynoecium (inferior) in many

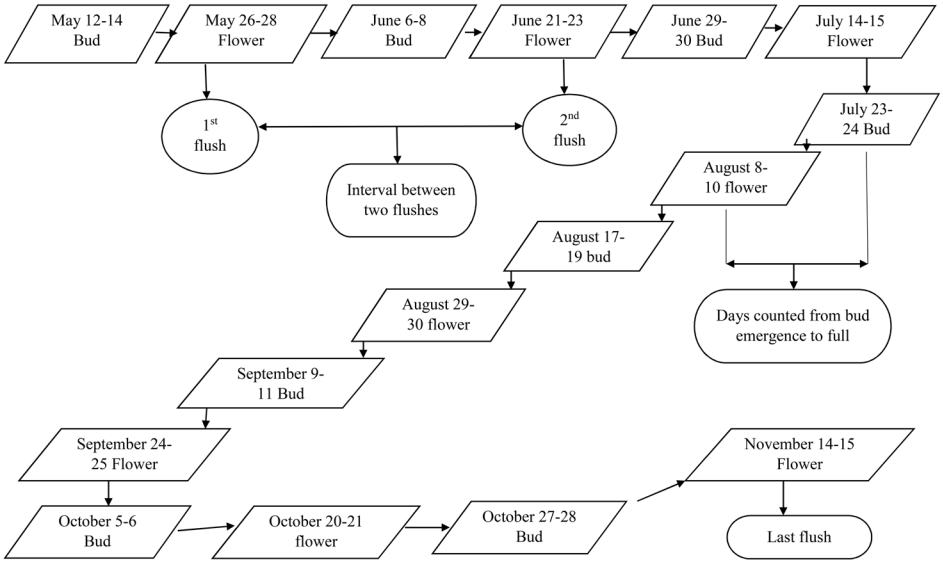
emergence per plant, with values ranging from 2 to 34, but with a similar mean number around 10 flower buds. The present findings were little bit different in the range of buds with above statements. It might be due to the difference in soil and climatic condition, vigour of plant with numerous buds/plants and may also due to the difference in cultural practices.

Table 6. Flower morphological characters (qualitative) of two different *Hylocereus* species of dragon fruit.

Descriptors of flowers	*Hylocereus costaricensis*
Flower bud shape	Ovate
Shape of apex	Acute
Color of flower bud	Yellowish red
Length of pericarpel	Narrow
Length of perianth	Short to medium
Shape of bracts	Ovate
Intensity of red color of bract	Green with dark red edge
Petal color	Milky white
Sepal pattern	Edged
Primary color of sepal	Light green
Secondary color of sepal	Edged
Color of stigma lobe	Cream
Position of anther in relation to stigma	Above

A minimum 47.06% to a maximum 80% of buds flowered successfully with an average of 66.25% whereas 33.81% average bud abortion was observed for all the flushes throughout the year (Table 3).

The period from emergence of floral bud to reach the stage of opening of flower varied from minimum 12 days (first and second flush) to a maximum 18 days for the development of flower buds (fifth, six and eight flush) with a mean of 14.97 days (Table 4). It was reported in a study that the period of floral buds and flowering varied between 15 to 20 days (Le Bellec 2004). The flower duration took 15 days in clone of VN White and 18 to 19 days in others (Tran *et al.* 2014). Patwary *et al.* (2013) observed the flower bud needed 28 days bloom form the emergence in HUP 001. The floral bud takes 14 to 18 days to obtain full blooming stage in pitayas (Tran *et al.* 2018). Similar



Flow chart 1. Pattern of bud emergence and flowering waves per pillar of dragon fruit.

observations were also made by Muniz *et al.* (2019).

The flowers started to open in the early evening and continued till night. In this period, when the flowers first started to open, the petals were invisible. The petals gradually extended and spread out. However, most of the flowers opened in between 5.42 to 7.28 pm and closed in between 6.55 to 8.45 am in the next day after the completion of pollination (Table 5). *Hylocereus* species flowers initiated anthesis at around 19.00 h and closing completely at 7.00 h of the next morning (Muniz *et al.* 2019).

The shape of the flower bud is ovate with acute apex and yellowish red in color (Table 6). The pericarpels are narrow with short to medium perianth and edged sepals. The pericarpels are green with dark red edge that intensifies the color of the bracts that are ovate in shape. Petals are milky white and sepals are light green with edged secondary color. The stigma lobe color is creamy white and the stigma is positioned above the anthers in the typical hermaphrodite flower of dragon fruit (Table 6).

Hylocereus costaricensis showed hermaphrodite (bisexual) flower, free calyx, free corolla, free stamens (androecium) were present in many, ovary inferior to insertion point of other floral whorls (Plate 1). The floral whorl are epigynous to the gynoecium. Similar to the cactus flower, *Hylocereus* spp. is also bisexual with an inferior ovary (Mandujano *et al.* 2010).

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REFERENCES

Abirami K, Swain S, Baskaran V, Venkatesan K, Sakthivel K, Boommayasamy N (2021) Distinguishing three dragon fruit (*Hylocereus* spp.) species grown in Andaman and Nicobar Islands of India using morphological, biochemical and molecular traits. *Sci Reports* 11 : 2894.

Britton NL, Rose JN (1963) The Cactaceae : Description and illustration of plants of the cactus family. Vol 1 and 2. Dover, Newver, New York.

Le Bellec F (2004) Pollinization et fecundation d' *Hylocereus undatus* et d' *H. costaricensis* a l'ile de la Reunion. *Fruits* 59 : 411—422.

Luders L (1999) The pitaya or dragon fruit. *Prim Ind Fish North Territ Aust*, pp 778.

Mandujano MC, Carrillo-Angeles IG, Martínez-Peralta C, Golubov J (2010) Capítulo 10. Reproductive biology of Cactaceae. In : Ramawat KG (ed). Desert plants-biol Biotech Springer. New York, USA, pp 197—230.

Mizrahi Y, Nerd A (1999) Climbing and columnar cacti : New arid land fruit crop. In : Perspective on New Crops and New Uses. Janick J (edn). ASHA Press, Alexandria VA, pp 358—366.

Mizrahi Y, Nerd A, Nobel PS (1997) Cacti as a crop. *Hortic Rev*- 18 : 291—320.

Morton JF (1987) Strawberry pear. In : Fruits of warm climates. Florida flair books, *Miami* pp 347—348.

Muniz JPO, Bomfim IGA, Correa MCM, Freitas BM (2019) Floral biology, pollination requirements and behavior of floral visitors in two species of pitaya. *Revista Ciencia Agronomica* 50 (4) : 640—649.

Patwary MA, Rahman MH, Barua H, Sarkar S, Alam MS (2013) Study on the growth and development of two dragon fruit (*Hylocereus undatus*) genotypes. *The Agricult* 11 (2) : 52—57.

Pushpakumara DKNG, Gunasena HPM, Kariayawasam M (2005) Flowering and fruiting phenology, pollination vectors and breeding system of dragon fruit (*Hylocereus* spp.). *Sri Lankan J Agric Sci* 42 : 81—91.

Tel-Zur N, Abbo S, Mizrahi Y (2005) Cytogenetics of semi-fertile triploid and aneuploidy intergeneric vine cacti hybrids. *J Heredity* 96 (2) : 124—131.

Tran DH, Yen CR (2014) Morphological characteristics and pollination requirements in red pitaya (*Hylocereus* spp.). *Int J Biol Biom Agric Fd Biotech Engg* 8 (3) : 202—206.

Tran DH, Oanh KLT, Yen CR (2018) Flowering phenology and mating system of a red skin pitaya (*Hylocereus* spp.) germplasm collection in Taiwan. *Asian J Adv Agric Res* 7 (3) : 1— 8.

Weiss J, Nerd A, Mizrahi Y (1994) Flowering behavior and pollination requirements in climbing cacti with fruit crop potential. *Hort Sci* 29 (12) : 1487—1492.

Zee F, Yen CR, Nishina M (2004) Pitaya (dragon fruit, strawberry pear). Cooperative extension service, college of tropical agriculture and human resources, University of Hawaii at Manoa, Honolulu, Hawai.