



Research Article

STUDIES ON FLORAL BIOLOGY IN STRAWBERRY (*Fragaria x Ananassa*) UNDER HILLY CONDITIONS OF UTTARAKHAND (BEARING HABIT, TIME AND DURATION OF FLOWERING, BUD DEVELOPMENT, FLOWER CHARACTERS, ANTHESIS AND DEHISCENCE)

KANDWAL MADHURI¹, MANJU^{2*} AND THAKU NIDHIKA³

Department of Fruit Science, College of Horticulture, VCSG, Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal, Uttarakhand.

*Corresponding Author: Email-ansh.hort@gmail.com

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Abstract- To know the floral biology of strawberry, a field experiment conducted at the experimental farm of VCSG, COH, Bharsar during 2015 – 2016. The vegetative growth started mainly during December to February under hilly conditions of Bharsar. The time of flowering and its duration was recorded between February to June. As monthly observation the flowering under Bharsar conditions commenced from last week of February to second week of June with the peak period 20 to 26 days after opening of first flower. The flowers were hermaphrodite with male and female reproductive organ present in same flower. The maximum rate of anthesis and dehiscence in strawberry plants was found between 10 am to 12 noon. Rise in temperature and fall in humidity were found to hasten anthesis as well as dehiscence

Keywords- Strawberry, Anthesis, Dehiscence, Flowering, Pollination.

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Introduction

Strawberry (*Fragaria x ananassa*) is a soft fruit crop which belongs to the family Rosaceae and genus *Fragaria*. The fleshy fruit of strawberry is classified as an aggregate fruit [1] one of the youngest domesticated plant. Inflorescence develops terminally and the branch structure shows great variability [2]. The number of inflorescence per plant depends on cultivar, size of plant, growth [3] and climatic condition. The climatic condition is especially important during flower initiation and differentiation [4]. Each inflorescence normally contains primary, secondary, tertiary and quaternary flowers, but the number of flowers per inflorescence varies with cultivar and growing conditions [5]. Proper knowledge about flowering and bearing habit of strawberry will contribute in its cultivation efforts. There is little literature about its flowering and fruit set in India, Therefore, to enlighten this part of the strawberry cultivation present study is conducted. The aim of the present study was to investigate the floral and reproductive biology of *Fragaria x ananassa* examining the implications of floral biology and breeding systems on its life cycle. Alternatively, it expected to give information, which would be useful in management strategies for protecting its endangered populations.

Material and Methods

A field experiment was carried out during 2015 -16 at VCSG College of Horticulture, Bharsar, Pauri Garhwal, U.K. The climate of Bharsar is mild summer, higher precipitation and colder or severe cold prolonged winter. The South-east monsoon commences towards the end of June while the North-east monsoon causes occasional winter showers during November-February. The twenty five experimental plants were selected from the particular location of Bharsar Campus.

Result and Discussion

Bearing habit

In strawberry, the flowers were mainly borne on current shoots. The inflorescence was compound cymose. Flowers were hermaphrodites, which were borne mainly on primary branch. It produces 2-3 inflorescences per plant with 10–25 flowers per plant. The flowering percentage was observed to be about 96% in all the plants. In the Royal Sovereign the number of inflorescences varied between 2 to 3 percent crown [6]. He further pointed out that the number of inflorescence initiated each year by each plant might be expected to depend upon the duration of the active growth period.

Time and duration of flowering

The flowering of strawberry plants started from last week of February up to second week of June and total period was recorded to be about 90 to 95 days. As per the observation, the flowering in strawberry under hilly conditions of Bharsar commences between the last weeks of February to second week of June with peak period 20-36 days after opening of first flower [Table-1]. The first flower of strawberry has been reported to appear in January [7] and the fruit matured in about three weeks. Ali and Chauhan [8, 9] have reported that flowering season varies not only from place to place but also from year to year. This difference can be attributed to weather conditions, time of planting and cultural practices.

Flower bud development

The whole period of flower bud development in the plants under study, from its first appearance to the full bloom stage was divided into VIII stages. The morphological changes of buds in different stages of development are discussed below.

Stage I: Flower buds at this stage were just visible to the naked eye, when minutely observed. They were delicate, greenish, roughly conical and highly

pubescent. The average size (length and width) of buds was recorded as 0.30×0.20 cm.

Table-1 Time and duration of flowering

Beginning of flowering	Peak period of flowering	End of flowering	Duration of full blooming (days)	Duration of flowering period (days)
05/03/2015	14/03/2015 to 19/04/2015	07/06/2015	36	94
05/03/2015	29/03/2015 to 01/05/2015	11/06/2015	33	89
09/03/2015	25/03/2015 to 20/05/2015	10/06/2015	26	94
09/03/2015	31/03/2015 to 03/05/2015	09/06/2015	34	94
11/03/2015	23/03/2015 to 12/04/2015	08/06/2015	20	90

Stage II: The next stage i.e. stage II was observed with conical to oval in shape and slightly pubescent. The buds were slightly bigger than those in stage one. The size of the buds increased slowly and was recorded as 0.50×0.30 cm.

Stage III: During stage III the buds were plump and pubescent. This stage was distinguished by the appearance of purplish tinge. The size of buds was 0.90×0.50 cm.

Stage IV: This stage was distinguished by the lobes of the epicalyx, which start separating out and sepals were visible at the top of the bud. Margin of the epicalyx have a purplish tinge. The buds measured about 1.10×0.50 cm. In the stage V the buds acquire a more roundish and full shaped. In this stage the lobes of the epicalyx separate out and were erect. The size of bud was measured to be 1.50×0.70 cm.

Stage VI: The next stage was distinguished by the disappearance of purple

coloration and the distinction of the sepals which give room to the producing corolla. The size of bud was measured to be 1.60×0.70 cm.

Stage VII: In next stage the corolla had started opening. The pistils and stamens were also visible from the top of the bud. The lobes of the calyx and epicalyx have parted. Movements of honey bees around the buds become more frequent and noticeable. The size of bud was measured to be 1.60×0.70 cm.

Stage VIII: To reach the last stage the flower buds take only two to two and half hour from preceding one. This is the full bloom stage depicting an anthesis flower exposing the various whorls and reproductive parts. The buds size was measured to be 1.90×0.70 cm.

The total time required for flower bud to reach the anthesis was recorded 16 to 18 days in strawberry plants [Table-2] and [plate-1]. It has been reported in apple that the flower bud development period as determined on the basis of length/diameter ratio appeared to be a good indicator for observing flower bud development. There were seven bud development stages in apple [10].

Table-2 Chronology of bud development stages from its emergence to full bloom

S. No.	Days required for passing one stage to next							Total days required
	I-II	II-III	III-IV	IV-V	V-VI	VI-VII	VII-VIII	
1	3	2	3	4	4	1	2 hours	17
2	4	2	2	4	4	2	2 hours	18
3	3	3	3	3	4	2	2 $\frac{1}{2}$ hours	18
4	3	3	2	4	3	1	2 $\frac{1}{2}$ hours	16
5	4	2	3	3	2	2	2 $\frac{1}{2}$ hours	16
Average	3.4	2.4	2.6	3.6	3.4	1.6	2 hours 3 minutes	17

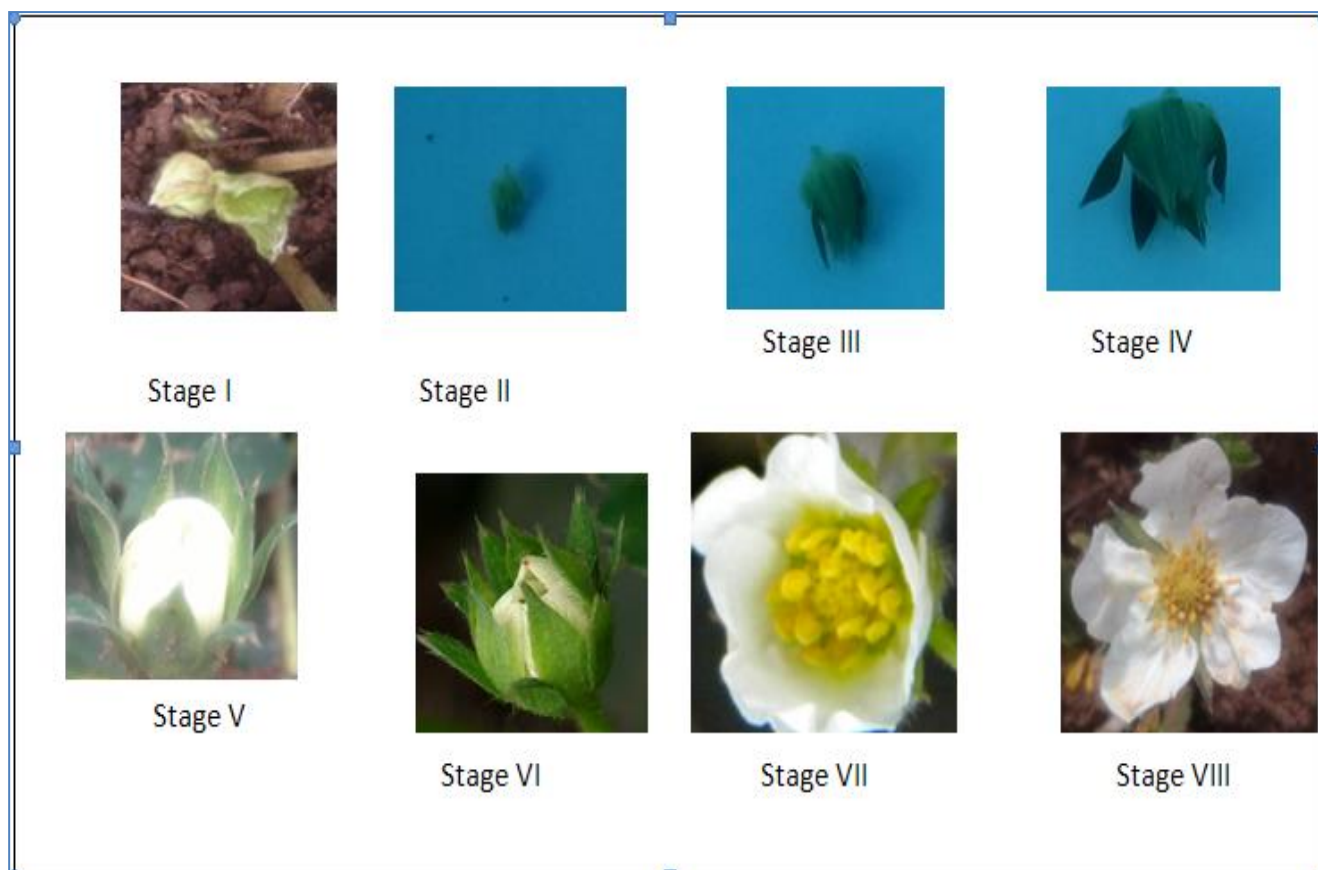


Plate-1 Stages of bud development

Bud growth behavior

It is evident from [Fig-1] that in the initial stages, there was a slow growth of buds in all the aspects, viz., size and shape but after 10 days, there was recorded a fast growth. However, during the later period of bud development i.e. fewer days prior to the anthesis, the bud growth in length was little faster than radial growth. It took 16-20 days for reached from initial stage to anthesis.

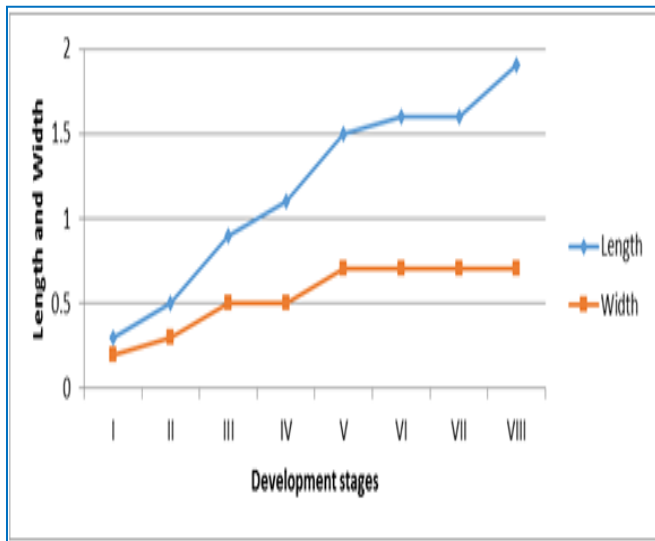


Fig-1 Bud growth behavior of strawberry

Floral morphology

The flowers are hermaphrodite, actinomorphic, complete, perfect, and hypogynous. The colors of flowers was white with an average size (height × diameter) 1.2 × 0.9 cm and consisted of following four whorls: Calyx- Sepals five, gamasepalous and united at the base; Corolla- five, polypetalous; Androecium-perigynous, indefinite (20 to 22), stamens are arranged in three whorls in cyclic

order, fine hairs at the base of the filament, anthers yellow, plump dehiscing by two longitudinal sutures; Gynoecium-carpels were 90 to 120, ovary superior. Ashman *et al.* [11] found that strawberry flowers were always actinomorphic, white, sometimes tinged with pink and usually 5 petalled. In some species, staminate and pistillate flowers were readily distinguished, but in others e.g. gynodioecious *Fragaria vesca* subsp. *bracteata* the pistillate flowers had anthers and were very similar to the bisexual ones. In raspberry flowers were white to pink in color, small about 0.5 to 1.5 cm and were initiated in the second year of planting [12]. The gynoecium consisted of 60 to 80 ovaries, each of which developed into a drupelet. There were 60 to 90 stamens. The flowers of *Rubus* were rather structurally similar to those of strawberries with five sepals, five petals, a very short hypanthium, many stamens and an apocarpous gynoecium of many carpels on a cone like receptacle.

Anthesis

The process of opening of flowers in strawberry took place rather quickly. The calyx segments were noted to separate out gradually due to the inner pressure of the protruding corolla. On the day of anthesis, the buds became balloon shaped and petals appeared slightly loose. First of all, a small split in the center of the upper portion of corolla was noticed. The splits slowly appeared as adjacent petals were pushed out and it divided the whole compact corolla into two clearly visible portions. After that all the petals continued to stretch out and large portion of stamens and fully expanded pistil became visible. The flowers finally opened exposing all the stamens and fully expanded pistil. The period of anthesis varied from 6 am to 6 pm with the peak period of anthesis (38%) having reached between 10 am to 12 noon [Table-3]. With the rise in temperature and decrease in relative humidity, the time and duration of anthesis were hastened. Kumar [13] reported that the percentage of anthesis increased gradually from 8:00 am to 2:00 pm., after which it decreased in all the cultivars. While Sharma [14] reported that the anthesis occurred between 6.00 am to 6.00 pm. with gradual increase up to 12.00 noon and then decreased slowly which ended by 6.00 pm. in apple cultivars.

Table-3 Time of anthesis

	Total no. of flowers observed	Percentage of flowers opened at different time interval							Temperature (°C)	Humidity (%)
		4-6 am	6-8 am	8-10 am	10-12 noon	12-2 pm	2-4 pm	4-6 pm		
27/04/2016	20	16	65	20	40	25	0	0	16	65
28/04/2016	20	16	65	15	45	15	5	0	16	65
02/05/2016	20	16	65	25	30	20	10	0	16	65
04/05/2016	20	17	60	20	40	10	10	0	17	60
09/05/2016	20	16	65	20	35	20	10	0	16	65
Average	20	16.2	64	20	38	18	7	0	16.2	64

Dehiscence

The rate of anther dehiscence was recorded to be higher between 10.00 am to 12.00 noon. Further dehiscence started after opening of flower in all the plants studied. The peak period of dehiscence was recorded between 10.00 am to 12.00 noon (44.54%), followed by (16.36%) between 12.00 noon to 2.00 pm. The anthers lobes started bursting marginally and all the anthers did not dehiscence synchronously, some of these started to dehiscence just after opening of flower. Sharma (1970) reported that the dehiscence in apple varieties began at 6.00 am with a progressive increase till 12.00 noon, ending by 6.00 pm. The dehiscence in general started almost at 8.00 am and ended around 4.00 pm.

Conclusion

Strawberry plants produce hermaphrodite or bisexual flowers during the period of February to June. Flowering continued for ninety to ninety five days and floral buds took 16 to 20 days for its development. Opening of the flowers started at 6 am in the morning and continue up to 4 pm with the peak period between 10 am to 12 noon. The anthers started to dehiscence just after opening of the flowers and complete within 8 to 9 hours. With these findings of the present study it has been suggested that the breeding operation in strawberry under study should be done

during spring season.

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Abbreviations: am- Ante meridiem, cm- centimeter, °C- Degree Celsius, etc- Etcetera, %- Per Cent, pm- Post meridiem, RH- Relative Humidity.

Conflict of Interest: None declared

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