



Research Article

STUDIES ON BEARING BEHAVIOUR, ANTHESIS AND ANTHOR DEHISCENCE IN KIWIFRUIT UNDER HIGH HILL CONDITIONS OF UTTARAKHAND

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Abstract- The present investigations entitled "Studies on Floral biology, Pollination and Fruit set in Kiwi fruit [*Actinidia deliciosa* (A. Chev.)] under hilly conditions of Uttarakhand" was carried out at the near the P.G. Girls hostel at College of Horticulture, Uttarakhand University of Horticulture and Forestry, Bharsar, from March to May 2016. The different parameters for floral biology, pollination and fruit set were recorded on the basis of time period. The results showed that kiwi plant shows simple dichasium type of bearing habit. Flowering period starts from first week of second week of April to first week of May with total duration of flowering of 32 days to complete 8 stages of floral bud development. Maximum anthesis of flower occurs between 6am-8am in male flowers and 8am-10am in hermaphrodite flowers. Maximum anther dehiscence takes place 15 minutes after the anthesis. From the above findings, it is concluded that for crop improvement and other programmes April third week to May first week is preferred under hilly conditions of Uttarakhand.

Keywords- Anthesis, Dehiscence, Kiwi, Stigma, Hermaphrodite, Anther.

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Introduction

Kiwifruit (*Actinidia deliciosa*) belongs to the family actinidiaceae. It is also known as Chinese gooseberry and national fruit of New Zealand. The plant is highly androdioecious in nature in which both male and hermaphrodite flowers were born on different plants. Kiwi plants are highly woody perennial vines, which are known as liana. The plants have alternate phyllotaxy with compound leaves. The plants are highly deciduous in nature which means they usually shed their leaves during the winter season. The kiwi plants requires minimum of 700 - 800 hours of chilling requirement in which the plants faces a temperature of below 7° C. Both female and hermaphrodite flower required same type of conditions for the flowering.

Fresh Kiwi fruit have high nutritional value (per 100 g) i.e., Energy 255 kJ (61 kcal), Carbohydrates 14.66 g, Sugars 8.99 g, Dietary fiber 3.0 g, Fat 0.52 g, Protein 1.14 g, lutein and zeaxanthin 122 µg, Thiamine (Vitamin B1) 0.027 mg, Riboflavin (Vitamin B2) 0.025 mg, Niacin (Vitamin B3) 0.341 mg, Vitamin B6 0.63 mg, Folate (Vitamin B9) 25 µg, Vitamin C 92.7 mg, Vitamin E 1.5 mg, Vitamin K 40.3 µg, Calcium 34 mg, Iron 0.31 mg, Magnesium 17 mg, Phosphorus 34 mg, Potassium 312 mg, Sodium 3mg, Zinc 0.14 mg, Manganese 0.098 mg [1]. Flowers of kiwifruit are scented, particularly staminate flowers, but produce no nectar [2]. Bharsar is located at mid hill condition of Uttarakhand. With an altitude of 1900 m. Average rainfall of Uttarakhand is 540 - 630 mm. This place faces a severe winter in spring season with heavy snowfall. In winter (November -February) temperature falls upto -4°C. Snowfall continues for 1-2 month period. This situation is highly suitable for Kiwifruit cultivation but the lack of knowledge about kiwi fruits and its cultivar, the production is still not achieved a commercial export rate at this region. To make the kiwifruit successful in this region evolution of new varieties is very important. But the problem with breeding programme is the lack of knowledge

about flower bearing habit, pollination time and time of fruit set in this region and the regions having similar climatic conditions.

Material and Method

The different parameters like bearing habit, flower bud development, time and duration of flowering, floral morphology, anthesis, anther dehiscence, stigma receptivity, mode of pollination and fruit set is recorded over complete flowering period to study the flowering habit. Studies are conducted in both male and perfect flowers separately.

To study the bearing habit, increase in the length and diameter of the shoot, number of leaves and their emerging pattern on the shoots and emerging pattern of inflorescence is recorded at two days interval from the day of dormancy breaking to opening of last flower.

To study the flower bud growth and development, increase in the length and diameter of the bud and length of the pedicel was recorded at an interval of two days from the appearance of bud to its opening.

Time and duration of flowering is studied by recording the observation over number of flowers open per day per branch from the day of first opening of flower to the last opening of flower. The peak flowering period is predicted by the estimating the average 75% opening of flowers in the flowering period.

Floral morphology is studied by observing the data's on different parameters of the flower with respect to flower size, colour, number of sepals, number of petals, number of anthers, number of styles, their size and stamens length.

With the view to record the time of anthesis in kiwi fruit under investigation, the flower buds (at balloon stage) likely to open on the next day were tagged which is present on all the four side of the plant. Next morning, the number of flowers

opened were recorded at two hours interval starting from 6 am to 6 pm.

The observations for the mode of dehiscence under present study were recorded by picking the stamens from freshly opened flowers (both male and hermaphrodite) and examining them under hand lense. Five flowers located on different parts of each the experimental plants were tagged. On each day, after anthesis, the number of anthers dehisced were recorded at every two hours interval with the help of hand lens, between 6am to 6pm. If anther dehiscence time is too short, then the time interval for the recording of observation was reduced as par the requirement. The dehisced anthers were removed from the flowers to avoid recounting.

Result and Discussion

Bearing behaviour

Under present investigation, vegetative growth mainly emerged during March and April, which is immediately after winter under hilly conditions of Bharsar. The kiwifruit cultivar produces flowers mainly during April to May on current season growth. Which was different form the findings of Snelgar *et al.* (2007) in which kiwifruit vines reached 50% bud break on 13 September. This changes may be due to presence of climatic variation [3].

The flowers are produced on lateral shoots of current season growth. The inflorescence was compound simple dichasium or cymule type, which is two to three flowered cyme, having a single terminal flower and one or two, opposite lateral flowers. Flowers were both male and hermaphrodite, which are borne on different plants. Kiwifruit plants were generally a perennial hardy woody vein, which is known as liana. Stems were stout purplish brown, young canes ascending with alternate type of phyllotaxy. Leaves are compound in nature. In male plants, the flower buds appear on every alternate leaf base [Table-1]. Flower buds are begins to appear after opening of three four leaves. In hermaphrodite plants, each flower bud appear on every leaf base. Similarly Brundel (1975) also studied that flower buds are begins to appear simultaneously with the appearance of leaf bud [4].

Table-1 Bearing behaviour in both male and hermaphrodite plants.

Sex forms	Male flowers	Hermaphrodite flowers
Inflorescence		
Average number of inflorescence per individual bearing shoot	4	6
Number of individual flower per inflorescence	12	18
Total number of new shoots per primary branch	28	30
Total number of inflorescence bearing shoots per branch	15	16

Flower bud development

Eight stages of flower bud development were observed in both male and hermaphrodite cultivars under study. The total time required for flower bud to reach the anthesis was 32 [Table-2] days in kiwifruit plant. The growth of flower buds in both male and hermaphrodite cultivars under present investigation showed slow growth for initial days. The differences in flower bud development period may be due to the genetic makeup of the individuals, which appears to be a principle factors like in controlling flower bud development. Similar results were obtained by Brundell (1975) in his findings [4].

Stages of the male flower bud development

In male plants the initiation of the flower bud takes with the initiation of vegetative shoots. The flower bud will appear at every leaf base and shows following stages of development [Fig-2]:

Stage I: The first stage of development flower bud acquires 4 days to complete. The flower buds were roundish in shape with pointed tip and completely covered with hairy mass. Buds were completely pink in colour. The sepal edges were completely covered with light whitish hairs. In this stage, the pedicel was not prominent and bracts were not clear.

Stage II: In the second stage of development flower, it takes 4 days to complete with the final average diameter, length and pedicel length of the bud was 0.48 cm, 0.23 cm and 0.18 cm respectively. The flower bud is roundish in shape with the flat tip. The hairy mass was still covering the flower bud. The buds were pinkish in colour with greenish sepal end which had whitish hairs. There was a appearance of new lateral buds on pedicel of the old bud. In this stage pedicel was prominent and distinguishable.

Stage III: The third stage of development flower bud takes 4 days to complete. In this stage pedicel is prominent, the flower bud is roundish in shape with the flat tip. The hairs were barely covered the flower bud and start to turn from pink to greenish colour with the end which had whitish hairs.

Stage IV: The fourth stage of the flower development was completed 4 days after the commencement, Pedicel was prominent attached to the base of the leaf. The bract is started to wither. The lateral buds are half of the size of the auxiliary bud. The hairy mass was completely disappeared from the flower bud. The buds were turned to the brownish colour and there is a completely disappearance of the pink colour. The flower buds are globular in shape.

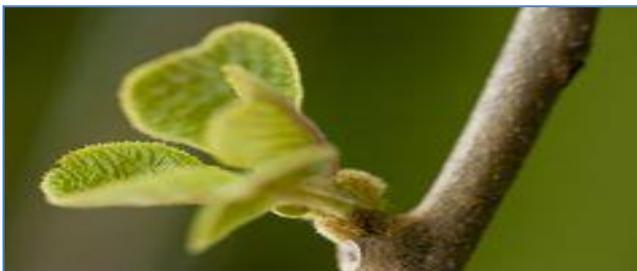
Stage V: In the fifth stage of development flower bud which takes 4 days to the flower bud is globular in shape. Pedicel is longer and attached to the base of the leaf. The bract is completely withered. The buds start to turn from greenish colour to brownish colour.

Stage VI: To complete the sixth stage of development flower bud takes 4 days. In this stage pedicel is longer than fifth stage. The flower bud was globular in shape. The buds were completely brownish in colour. The sepals were started to open slightly at the top of the flower bud and still tightly attached to the petals. There was a slight appearance of the petal at the top of flower bud.

Stage VII: The seventh stage of development flower bud completes 4 days after stage commencement. The buds were completely brownish in colour. The flower



IST Stage



IIND Stage



IIIRD Stage

Fig-1 Vegetative growth and bearing behaviour of kiwiplants

bud is globular in shape. The sepals were open at the top of the flower bud and still tightly attached to the petals. There was a prominent appearance of the petal at the top of flower bud. The flower buds were ready to enter the balloon burst stage.

Stage VIII: In the eighth stage of development, flower buds were completely brownish in colour. The flower bud was globular in shape. The sepals were open at the top of the flower bud and still tightly attached to the petals. There was a opening of petal at the top of flower bud have appeared. The flower buds were at the balloon stage.

Stages of the hermaphrodite flower bud development

The flower bud will appear every second alternative leaf base.

Stage I: The first stage of development flower bud acquire 4 days to complete The flower buds were roundish in shape with pointed tip and completely covered with the hairy mass. The flower buds were greenish in colour with pinkish sepal edges which contain light whitish hairs. The flower buds were completely covered with pink tinges over its surface. In this stage the pedicel is not prominent. Bracts are not clear.

Stage II: In the second stage of development flower, it takes 4 days to complete the roundish flower bud with flat tip and still covered the hairy mass. The buds were greenish in colour with pinkish sepal end which had whitish hairs. In this stage pedicel is prominent and distinguishable.

Stage III: The third stage of development flower bud takes 4 days to complete. The flower bud is roundish in shape with the flat tip and was still covered the hairy mass. The buds were greenish in colour with pinkish sepal end, which had whitish hairs. In this stage pedicel is prominent, distinguishable and dark pinkish with smooth hair like structure.

Stage IV: The fourth stage of flower development was completed 4 days after the commencement. Pedicel of the flower bud was prominent attached to the base of the leaf which was little dark pinkish in colour with smooth hair like structure. The bract was started to wither. The flower bud was globular in shape and the hairy mass was barely covers the flower bud. The buds were starts to turn the brownish colour and complete disappearance of the pink streak.

Stage V: In the fifth stage of development flower bud which takes 4 days to complete was globular in shape. The buds were completely brownish in colour. The hairy mass was completely disappeared from the flower bud. The sepals were starts to open at the top of the flower bud. There was a slight appearance white petals.

Stage VI: In the sixth stage of development, flower bud which takes 4 was globular in shape. The buds were completely brownish in colour. The sepals were starts to open at the top of the flower bud. The sepals were still tightly attached to the petals. There was a prominent appearance of the petal at the top of the flower bud.

Stage VII: The seventh stage of development flower bud completes 4 days after stage commencement. The buds were completely brownish in colour. The flower bud was globular in shape. The sepals were open from the top of the flower bud and still tightly attached to the petals. There is a prominent appearance of the petal at the top of flower bud. The flower buds were ready to enter the balloon stage.

Stage VIII: In the eighth stage of development the flower buds were completely brownish in colour and globular in shape. There was a little opening of petal at the top of flower bud have appeared. The sepals were completely open but still tightly attached to the petals.

Table-2 Days taken to enter from one stage to another.

Stages of bud growth	Days taken to enter from one stage to another	
	Male flower	Hermaphrodite flower
Stage I	4	4
Stage II	4	4
Stage III	4	4
Stage VI	4	4
Stage V	4	4
Stage VI	4	4
Stage VII	4	4
Stage VIII	4	4
Total	32	32



Stage I



Stage II



Stage III



Stage IV



Stage V



Stage VI



Stage VII



Stage VIII

Fig-2 Developmental stage of male flower bud



Stage I



Stage II



Stage III



Stage IV



Stage V



Stage VI



Stage VII



Stage VIII

Fig-3 Developmental stage of hermaphrodite flower bud

Time and duration of flowering

In kiwifruit cultivar, the flowering started from last week of March up to second week of May and total period was recorded as 45 days [Fig-4]. As per the observation, the commencement of flowering in kiwifruit under hilly conditions of Uttarakhand takes place between the second weeks to third week of April (14 to 21 days after opening of first flower). Staminate flower was having early anthesis than pistillate flowers. This result were agreement with the findings of Hopping

(1990) and Kumar (1996) who stated that the kiwi plants have 45 - 50 days of reproductive cycle [5&6].

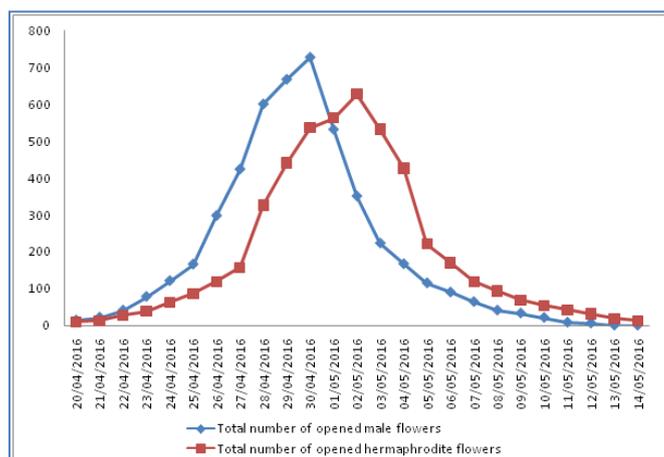


Fig-4 Time and duration of flowering in male and hermaphrodite plants

Flower morphology

The kiwifruit plant is basically having two type of sex form. They are male and hermaphrodite plants (gynodioecious). The male flower is fragrant, actinomorphic, bracteate, containing 5-6 calyx, 5-6 corolla, androecium part containing 210- 275 stamens, which are not fused. The hermaphrodite flowers are fragrant,

actinomorphic, bracteate, containing 5-6 calyx, 5-6 corolla, androecium part containing 140- 90 stamens, the gynoecium part contain 29 - 35 stigmas. Flower containing single ovary in which have 27-30 whorls of ovule sacs which is depends on species and cultivar. It was supported by the findings of Shastri *et al.* (2012) and Devi *et al.* (2015) who also recorded the same type of flower morphology in kiwi flowers [7&8].

Anthesis of flower bud

As per the observation recorded in the hilly conditions of Uttarakhand, the anthesis duration of male flowers shows gradually decreasing sequence from 6am to 2pm [Table-3]. The male flowers show maximum anthesis (65.46%) between 6am to 8am followed by 27.66% of flowering takes place between 8am to 10am and very little flowering takes place between 10am to 2pm. Whereas, the hermaphrodite plants show increasing rate of anthesis from 6am to 10am then decreasing rate of anthesis from 10am to 2pm. maximum anthesis (67.13%) takes place between 8am to 10am which occurs after the flowering of 26.13% between 6am to 8am and very little flowering takes place between 10am to 2pm. The male flower anthesis takes place earlier than hermaphrodite flowers due to synchronise the availability of pollen grains during the period of maximum receptivity of stigma, which was observed immediately after the anthesis. This finding is entirely different from the findings of Kumar *et al.* (1996); Sharma *et al.* (1970) who reported in their studies on flowering of apple and found Anthesis time of male and hermaphrodite plants in kiwifruit. that the percentage anthesis increased gradually from 8:00 am to 2:00 pm [6&9].

Table-3 Comparison between the time of anthesis in male and hermaphrodite flowers

Date	Number of buds tagged	Male plant flower						Temperature (°C)	Relative humidity (%)
		Percentage of anthesised buds							
		6 - 8am	8 - 10am	10am - 12pm	12 Noon - 2pm	2- 4pm	4 - 6pm		
25-04-2016	250	64.4	27.6	6.8	1.2	0	0	18.2	65
26-04-2016	250	67.2	26.8	5.2	0.8	0	0	19.3	72
27-04-2016	250	58	33.6	7.2	1.2	0	0	16.5	76
28-04-2016	250	64.4	28.4	6.8	0.4	0	0	20.1	69
29-04-2016	250	68.8	24.8	5.2	1.2	0	0	19.5	73
30-04-2016	250	70	24.8	4.4	0.8	0	0	19.7	75
Average	250	65.46	27.66	5.93	0.93	0	0	18.88	71.66
25-04-2016	250	32	60	6.8	1.2	0	0	18.2	65
26-04-2016	250	29.2	63.2	7.6	0	0	0	19.3	72
27-04-2016	250	20.8	74	4.4	0.8	0	0	16.5	76
28-04-2016	250	28.4	64.4	6.8	0.4	0	0	20.1	69
29-04-2016	250	24	70	5.2	0.8	0	0	19.5	73
30-04-2016	250	22.4	71.2	5.2	1.2	0	0	19.7	75
Average	250	26.13	67.13	6.00	0.73	0	0	18.88	71.66

Table-4 Comparison between the time of anther dehiscence in male and hermaphrodite Flower

Date	Male plant flower					Temperature (°C)	Relative humidity (%)
	Percentage of anthersdehised						
	15 min after anthesis	30 min after anthesis	45 min after anthesis	60 min after anthesis	75 min after anthesis		
25-04-2016	68.47	22.16	5.91	2.46	0.98	18.2	65
26-04-2016	60.22	23.29	10.22	3.97	1.70	19.3	72
27-04-2016	77.71	13.85	6.02	1.80	0.60	16.5	76
28-04-2016	72.39	17.79	6.13	2.45	1.22	20.1	69
29-04-2016	63.33	21.66	10.55	2.77	1.66	19.5	73
Average	68.42	19.75	7.77	2.69	1.23	18.72	71
Hermaphrodite plant flower							
25-04-2016	72.90	13.54	8.36	3.18	1.99	18.2	65
26-04-2016	74.39	14.63	6.91	2.84	1.21	19.3	72
27-04-2016	78.07	15.00	4.23	2.30	0.76	16.5	76
28-04-2016	76.95	15.62	3.51	1.95	1.56	20.1	69
29-04-2016	77.99	16.60	2.70	2.31	0.77	19.5	73
Average	76.06	15.08	5.14	2.52	1.26	18.72	71

Anther dehiscence

Both male and hermaphrodite flower shows anther dehiscence in a gradually decreasing order immediately after anthesis and continues up to 75 minutes after anthesis [Table-4]. The maximum anther dehiscence (68.42% and 76.06%

respectively) was observed within first 15 minutes after anthesis and terminates after the 75 minutes in both male and hermaphrodite flowers. In both male and hermaphrodite flowers anthers were dehised by splitting longitudinally from base

to the tip. In male flowers there is 75% of split had observed where as in hermaphrodite flowers only 15% split of anthers was observed during the anther dehiscence. In both type of flowers pollen grains were dry and powdery in nature. It was not possible to place an accurate time on the pistillat Anther dehiscence because the split occurred slowly and, unlike the staminate flowers, the only pollen available was that exposed by the split. This observation is similar with Goodwin (1986) which was supported by Craig *et al.* (1988) [10&11].

Conclusion

Under hilly conditions of Uttarakhand, kiwifruit show flowering during April - May with maximum receptivity of stigma on the day of anthesis, so it is recommended that pollination (cross pollination) in kiwi fruit should be practiced on the day of anthesis in the early morning and for better fruit set cross pollination should be facilitated.

Author Contributions: Research and supervision of research work.

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

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Conflict of Interest: None declared

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