

EFFECT OF DIFFERENT MODES OF POLLINATION ON FRUIT SET, FRUIT WEIGHT AND SEED NUMBER IN KIWIFRUIT [*Actinidia deliciosa* (A. Chev.) C. F. LIANG AND A. R. FERGUSON]

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ABSTRACT

The present investigation was carried out to study the effect of different modes of pollination on fruit set; fruit weight and seed number in kiwifruit during 2015-16. Four pistillate cultivars viz. Hayward, Bruno, Monty and Allison and two staminate cultivars viz. Allison and Tomuri of kiwifruit were selected for the study. A high (95.55-100 %) percent fruit set was observed under hand pollination in comparison with (83.28-93.99 %) open pollination in the various cultivars. The fruit retention percentage under hand pollination was higher (82.45-100 %) than (77.41-90.32 %) that of open pollination across all the cultivars. Fruit size was proportionate to the number of seeds; fruits with maximum numbers of seeds were largest in size. Maximum fruit weight (98.50 %) and number of seeds (1060.33) was observed with hand pollination compared to open pollination. Under different modes of pollination hand pollination was found beneficial in improving the fruit quality of kiwifruit over open pollination. Therefore hand pollination is recommended in kiwifruit to get quality production.

INTRODUCTION

Kiwifruit [*Actinidia deliciosa* (A. Chev.) C. F. Liang and A. R. Ferguson] is a functionally dioecious fruit species native to China and grown in many parts of the world for its edible fruit. It belongs to the genus *Actinidia* and family Actinidiaceae. The genus contains more than 50 species distributed in the temperate and sub-tropical regions (Ferguson, 1984). Out of these, *Actinidia deliciosa* var. *deliciosa* and *A. chinensis* are the only two species bearing edible fruits. This fruit has gained enormous popularity in the past four decades in many countries of the world. It is also known as 'China's miracle fruit' and 'Horticultural wonder of New Zealand'.

Kiwifruit is functionally dioecious, i.e. pistillate and staminate flowers occur on separate plants. Flowers of pistillate vines appear perfect, but their stamens produce non viable pollen and have functional ovary. Staminate vines produce male flowers that contain viable pollen, but they have no functional ovaries (Ferguson, 1990).

Pollination is the most important factor to ascertain the crop and morphological structure of the flower make it suitable for insect pollination. More than 75 per cent of major world crops depend on animal pollination, nearly 15% of animal pollination is carried out by bees (Vimla and Khan, 2014). Fruit size is greatly influenced by pollination (Mizugami *et al.*, 2007). Fruits less than 50 g are considered to be inferior as they do not fetch good price. On the other hand, fruits above 100 g are considered desirable from commercial point of view.

Inadequate pollination leads to small unmarketable fruits with few seeds (Palmer and Clinch, 1974; Davison, 1977) because there is a close correlation between fruit size and seed number (Pyke and Alspach, 1986). Successful pollination and fruit set depends upon receptivity of flowers during the few days following anthesis, so it is crucial to identify the main factor limiting the effective pollination period (Gonzalez and Coque, 1995). Fruit shape and quality was enhanced when pollen distribution was performed correctly and on proper time (Demaria *et al.*, 2009). So, the present studies were conducted in order to ascertain most efficient mode of pollination resulting in higher fruit set, fruit retention and other fruit characters like fruit weight.

MATERIALS AND METHODS

The present investigation was conducted at the Kiwi Block of Department of Fruit Science, Dr Y S Parmar University of Horticulture and Forestry, Nauni, District Solan (Himachal Pradesh) during the year 2015-16 at an elevation of 1275 m above mean sea level. The climate of the area is mild-temperate.

The study was conducted on three vines of each cultivar of 30 years old kiwifruit vines and experimental material comprises of four pistillate cultivars viz. Hayward, Bruno, Monty and Allison and two staminate cultivars viz. Allison and Tomuri. The vines were spaced at 4m × 6m and trained on standard T- bar trellis system. Male vines were uniformly distributed in the orchard in the ratio of 1:9 with the female

vines. The male vines from the same orchard were used for collecting pollen. Three vines of each of the kiwifruit varieties were selected for carrying out the pollination studies. The four healthy branches in opposite directions were selected and tagged for the pollination work in the varieties under the study. The three different methods of pollination viz. open pollination, hand pollination and bagging were adopted for the same.

In order to ascertain the fruit set under natural conditions (including wind and insect pollination), branches in all the four directions of the vine were selected for open pollination. The damaged or diseased flowers were removed. The selected flowers were allowed to open pollinate. The data was recorded after three weeks after full bloom. For hand pollination, healthy flower buds which were about to open (pop-corn stage) were selected for emasculation. The remaining opened and immature flower buds were removed from the branch. The emasculated flowers were covered with muslin cloth (insect-proof) bags. The stigmas having shiny appearance and showing signs of wetness/exudation of watery fluid were considered as receptive. Pollen grains of the selected male parent were applied to stigmatic surface of emasculated flowers with the help of camel's hair brush. The pollination bags were removed after the fruit set or petal fall. Bagging of staminate and pistillate flower buds was done with muslin cloth bags before anthesis to check the extent and success of self fruitfulness in them. The pollination bags were removed after the fruit set or petal fall.

After three weeks of petal fall, fruit set in each mode of pollination was recorded. The Fruit set and fruit retention percentage was worked out as per the method given by Westwood (1993) using the formula:

$$\text{Fruit set(\%)} = \frac{\text{No. of fruit developed}}{\text{Total no of flower}} \times 100$$

$$\text{Fruit retention(\%)} = \frac{\text{Total no.of fruits retained}}{\text{Total no.of fruits developed}} \times 100$$

To study the fruit characters fifteen representative fruit samples (five in each replication) were taken at an optimum maturity. All three given parameters were recorded from the same fruit samples. The length and diameter of fruits were measured with the help of Digital Vernier Calliper (Model No. CD - 6" CS) and expressed in millimetre. The length of fruit was determined by measuring the length between the calyx and styler end of the fruits. The diameter was measured in two perpendicular directions at the centre of the fruit. The weight of the fruits developed after each mode of pollination was taken by electronic top pan balance and average fruit weight was expressed as gram/fruit. Number of seeds per fruit was counted by macerating whole ripened fruit with water. After maceration, few drops of sulphuric acid were added to homogenize pulp and occasionally stirred for 10 minutes. The treated pulp was washed with water to remove mucilage from the seeds. The seeds were collected and dried on filter paper. Seed number was counted manually and expressed as number of seeds per fruit.

RESULTS AND DISCUSSION

Under open pollination maximum fruit set of 93.99 per cent was obtained in Monty which was closely followed by Bruno (91.11 %) and the lowest fruit set (83.28 %) was recorded in Hayward. Allison (Female) had 88.96 per cent fruit set (Table 1 & Plate 1). There was no fruit set observed under open pollination in both (Allison and Tomuri) staminate cultivars. No fruit set was obtained in the two staminate cultivars viz. Allison and Tomuri as well as in any of the pistillate cultivars under bagging (Plate 2). The fruit set ranging from 95.55 per cent (Hayward × Allison) to 100 per cent (Hayward × Tomuri,

Table 1. Effect of open pollination on fruit set and fruit characters in different kiwifruit cultivars

Serial No.	Cultivars	Fruit set (%)	Fruit retention (%)	Fruit length (mm)	Fruit breadth (mm)	Fruit weight (g)	Seed number
1	Bruno	91.11 (9.55)	89.87 (9.48)	63.13	36.49	42.83	358
2	Hayward	83.28 (9.13)	77.41 (8.80)	48.62	46.83	56.5	468.67
3	Monty	93.99 (9.69)	85.35 (9.24)	62.29	44.12	69.17	424
4	Allison (female)	88.96 (9.43)	90.32 (9.50)	53.62	39.97	46.5	534
C. D. at 5%		0.19	0.18	5.23	2.57	2.98	81.67

*Figures in parentheses indicate the square root transformed values

Table 2. Effect of hand pollination on fruit set and fruit characters in different kiwifruit cultivars

Serial No.	Cross combinations	Fruit set (%)	Fruit retention (%)	Fruit length (mm)	Fruit breadth (mm)	Fruit weight (g)	Seed number
1	Bruno × Allison	98.41 (9.92)	95.65 (9.78)	74.94	37.34	57.5	620.33
2	Bruno × Tomuri	97.62 (9.88)	98.30 (9.91)	77.4	40.23	68	700.33
3	Hayward × Allison	95.55 (9.77)	88.29 (9.39)	68.42	55.44	98.5	1060.33
4	Hayward × Tomuri	100 (10.00)	82.45 (9.08)	64.99	53.95	91.5	908
5	Monty × Allison	100 (10.00)	94.89 (9.74)	73.15	47.2	90.33	655.67
6	Monty × Tomuri	95.76 (9.79)	87.63 (9.36)	73.1	46.8	91.83	755.67
7	Allison × Allison	98.33 (9.92)	100.00 (10.00)	72.11	43.11	74.33	752
8	Allison × Tomuri	97.78 (9.89)	100.00 (10.00)	71.26	43.91	76.17	784
C.D. at 5%		N/S	0.22	4.29	3.15	4.12	82.06

*Figures in parentheses indicate the square root transformed values.



a) Staminate cultivar



b) Pistillate cultivar

Plate 1: Fruit set in staminate and pistillate cultivar through open pollination

a) Staminate cultivar



b) Pistillate cultivar

Plate 2: Fruit set in staminate and pistillate cultivar through bagging

a) Tomuri



b) Allison

Plate 3: Fruit set with Tomuri and Allison as male parent in hand pollination

Monty × Allison) was observed under hand pollination (Table 2 & Plate 3). The combination Bruno × Allison recorded 98.41 per cent fruit set followed by Allison × Allison (98.33 %), Allison × Tomuri (97.78 %), Bruno × Tomuri (97.62 %) and Monty × Tomuri (95.76 %), respectively. However, statistically there was no difference in fruit set between various

cross combinations.

In the present study, the fruit set percentage under open pollination ranged between 83.28 per cent to 93.99 per cent which got increased under hand pollination ranging between 95.55 per cent to as high as 100 per cent. The hand pollination led to higher fruit set as compared to open pollination in



a) Open pollination

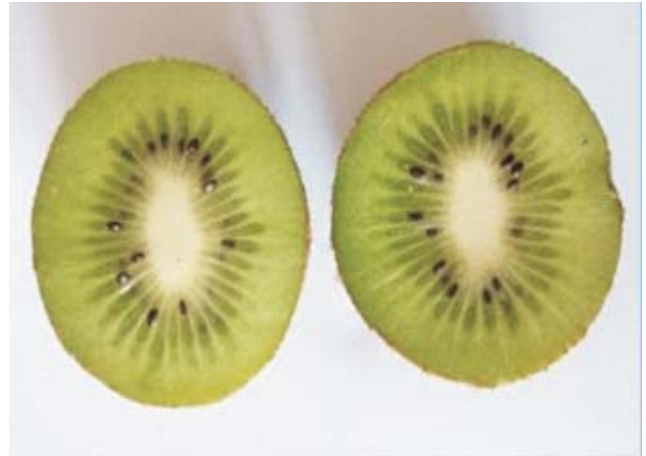


b. Hand pollination

Plate 4 (a,b) : Fruit size in different mode of pollination



Allison

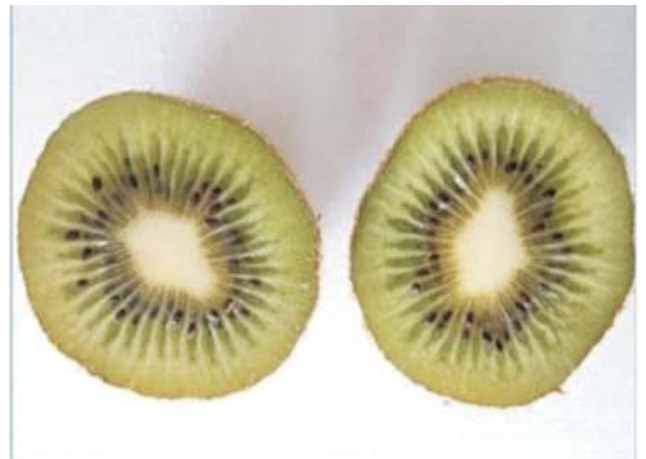


Hayward

a. Open pollination



Allison X Tomuri



Hayward X Allison

a. Hand pollination

Plate 5 (a,b): Number of seeds developed in different modes of pollination

kiwifruit. Such results of higher fruit set with hand pollination were also reported by various (Gonzalez *et al.*, 1994; Howpage, 1999; Razeto *et al.*, 2005; Kumatkar *et al.*, 2016) workers in the past. However, there is no significant effect of

pollen parent on the fruit set in various pistillate cultivars in the present studies and this finds support with the findings of Gonzalez *et al.* (1994). Under the bagging conditions the pistillate cultivars had no fruit set and this may be attributed to

the presence of non viable pollen in them. On the basis of present investigations, it can also be concluded that during any hybridization program the need for emasculation may be omitted as no fruit set could be recorded through bagging of pistillate flowers. Also, there was no fruit set found in bagging as well as open pollination in the staminate cultivars and this may be attributed to the absence of styles (Tomuri) and presence of rudimentary styles in Allison (male) flowers. Ferguson (1984) suggested that there can be pistil formation in male flowers but carpel locules with in the ovary remained compressed and neither placentae nor ovules were formed and the styles were short and vestigial without stigmatic papillae.

Under open pollination the minimum (77.41 %) fruit retention was recorded in Hayward and maximum (90.32 %) fruit retention was found in Allison which was at par with Bruno (89.87 %). The fruit retention in Monty was found to be 85.35 per cent. The highest (100 %) fruit retention was found in Allison \times Allison and Allison \times Tomuri which was at par with (98.30 %) Bruno \times Tomuri (Table 2). However, the lowest (82.45 %) fruit retention was recorded in Hayward \times Tomuri. The fruit retention in Bruno \times Allison was recorded as 95.65 per cent followed by Monty \times Allison (94.89 %), Hayward \times Allison (88.29 %) and Monty \times Tomuri (87.63 %), respectively. The present study indicates that the fruit retention under hand pollination is higher than that of open pollination across all the cultivars.

The fruit length under open pollination was found to be maximum (63.13 mm) in Bruno which was at par with (62.29 mm) Monty, followed by 53.62 mm in Allison (female) and minimum (48.62 mm) fruit length was recorded in Hayward. The fruit breadth under open pollination was found to be maximum (46.83 mm) in Hayward and minimum (36.49) in Bruno. The fruit breadth in Allison and Monty was 39.97 mm and 44.12 mm respectively (Table 1 & Plate 4a).

The data on fruit length under hand pollination reveals that the maximum (77.40 mm) fruit length was observed in Bruno \times Tomuri which was found to be statistically at par with (74.94 mm) Bruno \times Allison and (73.15 mm) Monty \times Allison. Whereas, the minimum (64.99 mm) fruit length was recorded in Hayward \times Tomuri (Table 2 & Plate 4b). The combination Monty \times Tomuri recorded 73.10 mm of fruit length which was followed by Allison \times Allison (72.11 mm), Allison \times Tomuri (71.26 mm), Hayward \times Allison (68.42 mm), respectively.

The maximum (55.44 mm) fruit breadth was observed in Hayward \times Allison which was at par with (53.95 mm) Hayward \times Tomuri and the minimum (37.34 mm) fruit breadth was recorded in Bruno \times Allison. The combination Monty \times Allison recorded 47.20 mm of fruit breadth followed by Monty \times Tomuri (46.80 mm), Allison \times Tomuri (43.91 mm), Allison \times Allison (43.11 mm) and Bruno \times Tomuri (40.23 mm), respectively.

In the present study, the fruit length under open pollination is highest (63.13 mm) in Bruno and lowest (48.62 mm) in Hayward. When hand pollinated the fruit length increased upto 77.40 mm in case of Bruno and 68.42 mm in Hayward. This increase in fruit length upon hand pollination as compared to open pollination was recorded in the other

cultivars also. As far as the fruit breadth is concerned, it also increased upon hand pollination in all the cultivars as compared to open pollination. The various (Paksasorn and Subhadrabandhu, 1990; Costa *et al.*, 1993; Razeto *et al.*, 2005) workers have also reported bigger fruits upon hand pollination. There was no significant difference found in fruit breadth under hand pollination with male parent.

Under open pollination maximum (69.17 g) fruit weight was observed in Monty and minimum (42.83 g) in Bruno (Table 1). The fruit weight in Allison and Hayward was recorded as 46.50 g and 56.50 g, respectively. Under hand pollination, the fruit weight varied from 57.50 g in Bruno \times Allison to 98.50 g in Hayward \times Allison. The fruit weight in Monty \times Tomuri was 91.83 g followed by Hayward \times Tomuri (91.50 g), Monty \times Allison (90.33 g), Allison \times Tomuri (76.17 g), Allison \times Allison (74.33 g) and Bruno \times Tomuri (68.00 g), respectively (Table 2).

The above work indicates that the fruit weight under open pollination was highest (69.17 g) in Monty and lowest (48.62 g) in Hayward. The fruit weight in Monty under hand pollination was upto 91.83 g and upto 98.50 g in Hayward. In other cultivars also, the fruit weight increased upon hand pollination. This finds support with the findings of Costa *et al.* (1993) and Pan *et al.* (1997). The fruit weight in Bruno was significantly higher (68 g) when hand pollinated using Tomuri as pollen source when compared with (57.50 g) Allison as pollen source. In Hayward, the fruit weight was significantly higher (98.50 g) when hand pollinated using Allison as male parent as compared with (91.50 g) Tomuri. However, in Monty and Allison (female) there was no significant difference in fruit weight with male parent under hand pollination.

The maximum of 534 seeds were observed in Allison which were found to be at par with (468.67) Hayward and minimum (358) was observed in Bruno under open pollination. The seed number in Monty was 424 (Table 1 & Plate 5a). The number of seeds under hand pollination ranged from 620.33 in Bruno \times Allison which was statistically at par with the seed number found in those of Monty \times Allison (655.67) and Bruno \times Tomuri (700.33) to 1060.33 in Hayward \times Allison. The combination Hayward \times Tomuri had 908.00 seeds followed by Allison \times Tomuri (784.00), Monty \times Tomuri (755.67) and Allison \times Allison (752.00), respectively (Table 2 & Plate 5b).

In the present study, the seed number under open pollination ranged between 358 (Bruno) to 534 (Allison) and a higher range of seed number ranging from 620.33 (Bruno \times Allison) to 1060.33 (Hayward \times Allison) was observed under hand pollination. The similar trend of increase in seed number was recorded in other cultivars also when hand pollinated. There was no significant difference in seed number in Bruno and Allison with male parent under hand pollination. Razeto *et al.* (2005) also reported the higher seed number with hand pollination. The seed number observed through hand pollination in Hayward is in agreement with the findings of Hopping and Hacking (1983); Zenginbal and Ozcan (2005). However, higher (1060.33) seed number was observed in Hayward when pollinated by Allison than (908.33) by Tomuri and there was higher (755.67) seed number in Monty when pollinated by Tomuri than (655.67) by Allison. This finds support with the findings of Gonzalez *et al.* (1994) who

reported that the seed number varied with some pollinizers.

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