

Effect of pollination levels and repeated pollination on the fruit set and size of kiwifruit, *Actinidia deliciosa* Chev

INDIRA DEVI, BS THAKUR and SOURABH GARG*

Department of Fruit Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan 173230 Himachal Pradesh, India

*Rajasthan Agricultural Research Institute, Durgapura
Jaipur 302018 Rajasthan, India

Email for correspondence: indiramehta90@gmail.com

ABSTRACT

Effect of pollination levels and repeated pollination on fruit set and size of kiwifruit was evaluated during 2012-2013 at the orchard of Department of Fruit Science, Dr YS Parmar University of Horticulture and Forestry Nauni, Solan. In different pollination levels flowers were hand pollinated by manipulating the number of styles and retaining 1, 2, 4, 6, 8, 10, 14, 16, 20, 24 and all styles. Data on fruit set was recorded 25 days after pollination. Results obtained showed that there was a high fruit set irrespective of the number of styles pollinated but when flowers with more than 10 styles were pollinated fruit set recorded was 100 per cent. Fruit growth was measured at 15 days interval and initially there was a rapid increase in fruit growth for 40 days and thereafter it slowed down till harvest. A single sigmoid growth curve was recorded. Maximum fruit size and number of seeds were obtained when all styles were pollinated. Fruit size was proportionate to the number of seeds; fruits with maximum number of seeds were largest in size. Repeated pollination showed adverse effect on the size of kiwifruit. Fruits of small size and with minimum number of seeds were recorded when flowers were repeatedly hand pollinated at 8 hours interval.

Keywords: Kiwifruit; fruit set; growth pattern; repeated pollination

INTRODUCTION

The chinese gooseberry popularly known as kiwifruit is a native of southwest China and is grown commercially in New Zealand, China, Australia, France, Spain, Italy and many other countries. The leading countries of kiwifruit production are New Zealand, Chile, France, Greece, Japan and USA (www.faostat.org). It belongs to the

genus *Actinidia* and family Actinidiaceae. The genus contains more than 50 species distributed in the temperate and subtropical regions of the Asian continent (Ferguson 1984). In India its cultivation is expanding rapidly under mid-hill conditions of Himachal Pradesh, parts of Uttarakhand and northeastern states especially Arunachal Pradesh. There has been a great demand for this fruit due to its medicinal value being

a rich source of vitamin C and potassium. Besides it is also rich in vitamin A, vitamin E and beta carotene and traces of omega-3 fatty acids present in the seeds. As the area under kiwifruit is increasing the demand is mainly for a large sized fruits. In fact fruit size is the limiting factor in its production. 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. Fruit size is greatly influenced by pollination. Inadequate pollination in kiwifruit gives rise to small undersized fruits with varying shapes rendering them unfit for marketing (Palmer Jones and Clinch 1974, Davison 1977). To obtain fruits of good size and quality pollinizer should be planted uniformly in the orchard for assured pollination and subsequent fruit-set that is a prime factor in kiwifruit production. All members of the genus *Actinidia* are functionally dioecious with pistillate and staminate flowers occurring on the separate plants (Ferguson 1990). Unlike many other fruit crops kiwifruit does not have perfect flower. In the male plant the anthers are functional but they lack functional ovary. The opposite is true for the female plants. Therefore the flowers must be pollinated by the external means. Thus pollination is a prerequisite in kiwifruit production.

Kiwifruit is mainly pollinated by insects (entomophilous) and therefore requires large amount of pollen to produce high quality fruits (Holcroft and Allan 1994).

However unfavourable environmental conditions at blossom and inadequacy of pollinating insects result in pollination deficits that leads to low productivity and reduced quality of fruits. Under these situations hand pollination is employed for commercial kiwifruit production. Every flower on vine is capable of setting and developing into a fruit. The morphological structure of kiwifruit flower is suited for the deposition of maximum pollen grains on the stigmatic surface of the styles that vary in number from 26-38 depending on the variety. The styles should be properly pollinated otherwise uneven pollination gives rise to small undersized fruits with varying shapes. The ultimate size of the fruit seems to be determined by the number of styles pollinated or the number of pollen grains deposited on the stigmatic surface.

MATERIAL and METHODS

Field trials were conducted on 28 year old kiwi vines maintained at the orchard of the Department of Fruit Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP during 2012-2013. The vines of male Allison were uniformly distributed in the orchard in the ratio of 1:9 with the female vines of the variety. The study was conducted on one pistillate cultivar Allison with a pollinizer variety Allison male.

Two pollination methods namely open pollination and artificial hand

pollination were studied. In open pollination or control the flowering shoots were tagged and left open for fruit set to occur under natural conditions. Under artificial hand pollination the flowering buds of selected vines were bagged before opening. After opening the styles of the pistillate flowers (which numbered from 24 to 40) were manipulated by retaining only specific number of styles (1, 2, 4, 6, 8, 10, 14, 16, 20, 24 and all styles) per flower and discarding the remaining styles by clipping with scissors. The retained styles were hand pollinated with the freshly dehiscent pollen of male Allison which were collected before anthesis early in the morning and were used for pollinating female flowers of cultivar Allison with the help of camel brush. After cross pollination the flowers were rebagged and labelled. The per cent fruit set was recorded 25 days after pollination using the following formula:

$$\text{Fruit set (\%)} = \frac{\text{\# fruit set}}{\text{\# flowers pollinated}} \times 100$$

The same flower was repeatedly hand pollinated at 8 hours interval for two days and the effect on fruit size was recorded. In each replication 5–20 flowers were used. In order to study the growth pattern fruit size was measured at 15 days interval starting from 25 days after pollination until harvest. The experiment was laid out in a randomized block design (RBD) with 13 treatments each replicated thrice.

Observations on fruit size, weight, volume and number of seeds were recorded after harvesting of the fruits. The size of the fruit was expressed in terms of length and diameter. The length and diameter of the fruits were measured with the help of digital Vernier calliper. The length of the fruit was determined by measuring the length between the calyx and style end of the fruits. The diameter was measured in two perpendicular directions in the centre of the fruit. All fruits harvested in each treatment and replication were weighed on electronic top pan balance. Volume of fruit was measured by water displacement method. Number of seeds per fruit was counted by macerating whole 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.

RESULTS and DISCUSSION

Data on fruit set was recorded 25 days after pollination. From the perusal of data it is evident that there was a high fruit set irrespective of the number of styles pollinated. The fruit set ranged from 93 to 100 per cent in different treatments (Table 1). The flowers with one style recorded as high as 93 per cent and under control recorded a low of 86 per cent. There was

100 per cent fruit set when flowers with more than 10 styles were pollinated.

The results of present study are in line with the observations of Gonzalez et al (1998) who studied the effect of different pollination systems on fruit set and showed that higher fruit set (97%) was obtained in hand pollination as compared to 87 per cent in control. They advocated that hand pollination significantly increased fruit weight and produced higher percentage of marketable fruits compared to open pollination. In another study Costa et al (1993) recorded a fruit set of 97–100 per cent in hand pollination. Palmer Jones and Clinch (1974) reported that every flower on pistillate vine is capable of setting and developing into a fruit.

In order to ascertain whether there was any effect of different pollination levels of pollination on the growth pattern fruit size (L x B) was recorded at 15 days interval commencing from 25 days after pollination till the fruits were harvested and the data are presented in Table 2 (Fig 1). Initially there was a rapid increase in fruit size for the first 40 days after pollination and thereafter a slow and constant increase in growth was recorded till the fruits reached maturity by the end of October or 180 days after pollination. No increase in growth was observed after end of October. A similar growth pattern was observed in fruits obtained from different levels of pollination. A similar trend of fruit growth was observed

by Hall et al (2002). They reported that the growth curve of kiwifruit usually has two phases the first one of rapid growth and the second one of slower growth. Davison (1983) also observed a simple growth curve for Hayward cultivar.

In contrast to the above reports Pratt and Reid (1974) observed a triple sigmoid growth curve in the cultivars Hayward, Abbott and Bruno. On the other hand Buwalda and Smith (1990) reported that the growth of kiwifruit follows a double sigmoid curve.

Plate 1 shows the style manipulation in kiwifruit flowers.

Data pertaining to the effect of different pollination levels on the fruit size, weight, volume and number of seeds are presented in Table 3. The results of the present study revealed that when a flower with single style was pollinated the resultant fruit weighed 40.81 g at harvest and the seed number was 422. There was a proportionate increase in fruit weight and seed number with the increasing style number. Maximum fruit weight (65.38 g) and seed number (603) was recorded when all the styles of the flower were pollinated. These results are in accordance with the finding of Vaissiere et al (1991) who reported that fruits from bagged flowers were smaller and contained fewer seeds than those from open pollinated flowers. Results of the hand pollination experiments

Pollination levels, repeated pollination effect on kiwifruit

Table 1. Effect of different pollination levels on fruit set of kiwifruit

# styles	# flowers pollinated	Fruit set (%)
1	45	93.00 (9.69)*
2	45	95.40 (9.81)
4	45	95.50 (9.82)
6	60	96.60 (9.87)
8	60	95.00 (9.95)
10	45	100.00 (10.00)
14	45	100.00 (10.00)
16	45	100.00 (10.00)
20	45	100.00 (10.00)
24	45	100.00 (10.00)
All	45	100.00 (10.00)
Control	60	86.60 (9.35)
Repeated	45	100.00 (10.00)
CD _{0.05}		0.09

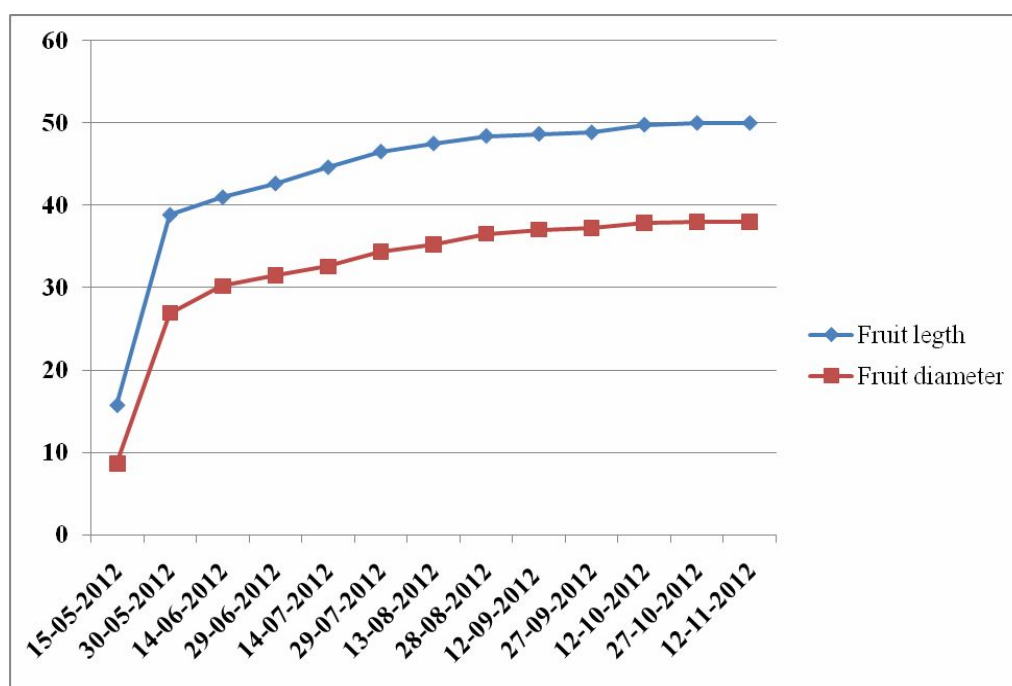


Fig 1. Growth pattern of kiwifruit at 15 days interval

Table 2. Growth pattern of kiwifruit at 15 days interval

Date	Fruit length (mm)	Fruit diameter (mm)
15-05-2012	15.79	8.69
30-05-2012	38.83	26.93
14-06-2012	40.97	30.20
29-06-2012	42.62	31.45
14-07-2012	44.59	32.56
29-07-2012	46.49	34.34
13-08-2012	47.46	35.19
28-08-2012	48.38	36.52
12-09-2012	48.63	37.01
27-09-2012	48.82	37.24
12-10-2012	49.74	37.84
27-10-2012	49.95	37.98
12-11-2012	49.95	37.98

Table 3. Effect of different pollination levels on fruit size, weight, volume and number of seeds

# styles pollinated	Fruit size (mm)		Fruit weight (g)	Fruit volume (ml)	# seeds
	Length	Width			
1	49.88	32.89	40.81	38.25	422
2	50.02	35.91	42.26	40.32	424
4	53.33	35.57	45.31	43.14	437
6	55.50	36.91	50.07	47.42	478
8	54.87	38.33	53.95	51.12	512
10	55.05	37.43	55.31	54.13	515
14	55.76	40.19	59.44	56.31	547
16	56.51	42.35	60.34	58.16	559
20	58.06	40.34	60.82	58.80	567
24	65.72	45.10	61.36	58.93	584
All	66.44	47.51	65.38	63.31	603
Control	49.01	36.88	42.41	40.14	449
Repeated	46.71	32.39	32.37	30.12	415
CD _{0.05}	0.12	0.91	0.02	0.07	26.7

Pollination levels, repeated pollination effect on kiwifruit

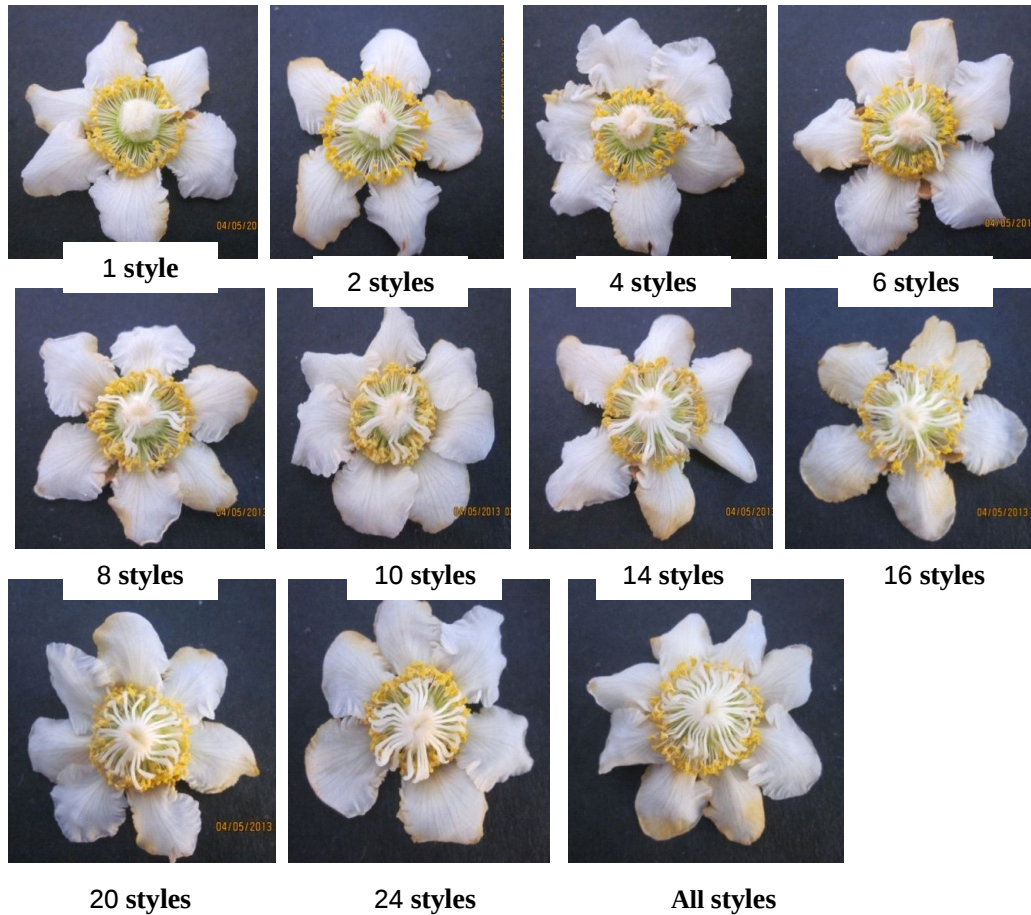


Plate 1. Kiwifruit flowers showing style manipulation

suggested that pollination intensity was the factor most affecting fruit size and shape.

Vasilakalis and Papadopoulos (1997) showed that there was a strong correlation between seed number and fruit size. In the present study although there was a proportionate increase in fruit weight but the ultimate fruit size was only 65.38 g and contained 603 seeds. The reason for small fruit size in the present study may be the

overloading of the vines with fruits and other cultural practices as has been reported by Vasilakalis and Papadopoulos (1997).

In the light of above results Clinch (1984) made an important observation and reported that the factors involved in attaining adequate fruit size in kiwifruit are poorly understood. Even with satisfactory bee visits to kiwifruit flowers and the subsequent formation of apparently adequate number

of seeds fruits may still not achieve its potential weight. Even in poor seasons some orchards achieve excellent results and in good season some orchards have very poor results suggesting that factors such as position of male vines relative to females, cultural methods and orchard microclimate may be important.

As far as repeated pollination is concerned there was a negative effect on the fruit size, weight and number of seeds per fruit. This suggests that repeated hand pollination of the same flower should not be advocated as is generally practised by some growers. Repeated pollination of the same flower over a period of two days resulted in small fruits weighing around 32 g. Hopping (1979) also reported that repeated hand pollination of the same flower over one or more days can result in fewer seeds per fruit than a single pollination. The reasons for this over pollination effect are not fully understood but limited evidence suggests that pollen tubes from successive pollinations compete with pollen tubes already in transit through the style and as a result the growth of some pollen tubes is arrested. Pollen tubes from successive pollination do not compensate for these arrested tubes and fewer seeds develop with small fruits at harvest.

CONCLUSION

The present study showed that a heavy fruit set occurs in kiwifruit

irrespective of the level of pollination. However manual pollination of different styles revealed that more the number of styles pollinated larger is the size of fruits. Artificial hand pollination resulted in better fruit set and fruit size compared to open pollination. Repeated hand pollination of the same flower was not effective in improving the fruit size rather it had an inhibitory effect. Repeated hand pollination should therefore be avoided in kiwifruit.

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Received: 10.3.2015

Accepted: 2.8.2015