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Impact of pollination schedules on the fruit characteristics of kiwifruit

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ABSTRACT

Timings of pollination are crucial for adequate fruit set, development, quality and yield of kiwifruit. A study was undertaken for three years (2020-22) to find out the effective pollination period (EPP) of commercial kiwifruit cultivars in Sikkim conditions. Ten-year-old vines of the female cultivar Monty and the male cultivar Allison were taken for the study. It was found that 8 am is the most important time to perform pollination for obtaining bigger-sized fruits. Fruit set was found to be 100% when pollination was performed at 9 am, 10 am and 3 pm. The yield was found to be the highest at 9 am (35.20 kg/plant) pollination time; TSS recorded 1.38-fold variations with the maximum at 8 am (19.1°B). Total acidity was recorded as the minimum at 9 am (0.64%) pollination. Further, ascorbic acid was recorded at to be the maximum at 9 am (118.9 mg/100g) pollination. Primary and secondary nutrients were also found to be higher in pollinated flowers from 8.00 am to 12.00 pm. Thus, efforts for producing good quality and marketable size fruits in kiwifruit the vines should the flowers should be within the 8.00 am to 12.00 pm pollination timings.

Key words: *Actinidia* spp., Pollination, Sikkim, Monty, Allison.

INTRODUCTION

Kiwifruit (*Actinidia* spp.), belonging to the family Actinidiaceae, is a dioecious crop, meaning that the male and female flowers develop on separate vines and are pollinated mainly by insects and, to a lesser extent, by wind. An essential component of kiwifruit cultivation is pollination. The process of transferring pollen from the anthers, transporting it, and depositing it on a flower that is ready to receive it is known as pollination. Either biotic or abiotic vectors can carry it out. The quantity and quality of pollen grains that reach the stigmas in kiwifruit determine how many seeds are formed, and this quantity and quality relationship is reflected in the fruit size. Ineffective pollination in kiwifruit produces uneven, oversized, and unmarketable fruit, which raises the proportion of unsellable fruit and lowers its market value (Castro *et al*., 1).

Due to its late spring bloom, it faces fierce competition from other plants that are also in blossom for insect visitation. Long, rainy seasons with intense rainfall combined with recurrent hailstorms that fall during the peak flowering season of kiwis in the Northeastern Hill Regions leads to a number of biotic and abiotic stresses when grown in open fields, which significantly lowers kiwifruit yield and fruit-set percentage. Understanding the ideal timing for pollination is crucial to obtaining the highest quality and productivity of fruits in general and kiwifruit in particular (Sanzol, 7). Generally, kiwifruit is pollinated during morning hours, but it can be pollinated in the afternoon also. More information needs to be available regarding the best timings for pollination, which will result in a superior quantity and quality of kiwifruit. Therefore, this study has been undertaken on hand pollination timings and their effect on the per cent fruit set, fruit growth, fruit yield and fruit quality under partial protection for successful organic kiwifruit production in Sikkim.

MATERIALS AND METHODS

Ten-year-old vines of the female plant, Monty, and the male plant, Allison, were used in this experiment. The kiwifruit vines were cultivated in an orchard situated in the ICAR RC NEH Region, Sikkim Centre, Gangtok, Sikkim (27 19 11.339 N, 88 36 9.793 E and 1348 m AMSL) and trained on T bar system, with plants spaced at 4 m × 6 m.

For three years (2020-22), the effective pollination period (EPP) was investigated. Wax paper bags were used for covering flower buds, measuring 10.0 × 25.0 cm. One day prior to anthesis, flower buds were bagged; they were still fully closed but had some white showing from the unfolding of the petals. The day the flower petals opened was considered as anthesis. Table 1 displays a comprehensive description of the environmental conditions that prevailed during the trial period.

Every year, a day prior to anthesis, pollen was harvested from staminate vines (Allison) and allowed to dry on paper at room temperature. After that, the pollen was sieved through a fine mesh (0.26 mm)

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Table 1. Weather parameters during three months 2020-22.

Year	Month	Temperature (ºC)		Relative Humidity (%)		Rainfall (mm)	Evaporation (mm)	Duration of sunshine (in hrs)
		Max.	Min.	Max	Min			
2020	April	25.3	13.5	89.6	44.4	29.8	1.22	2.68
	May	26.3	15.3	92.6	46.0	35.9	1.22	2.37
2021	April	28.2	13.1	83.9	35.6	160.3	10.0	4.2
	May	26.7	15.5	91.4	58.9	423.0	6.7	2.06
2022	April	27.8	15.2	93	52	360.2	9.57	3.53
	May	27.2	15.9	94	50	384.5	10.3	2.87

screen to get rid of additional contaminants and dehisced anthers. Before being rebagged, the bag-isolated pistillate flowers were manually pollinated using the dried pollen. Thirty flowers were manually pollinated every day at 8, 9, 10, 11, 12 am and 1, 2, 3 and 4 pm using dried pollen. One treatment was used as a control where pollination was performed during a window of 10 am to 12 noon. Uniform and single flower inflorescences were pollinated by hand during the study. Immediately after hand pollination, flowers were rebagged using freshly labelled bags to avoid open pollination later on.

The flower parameters of kiwifruit were counted manually and measured using a scale. Fruit measurements were taken within three days of harvesting. Kiwifruit length and breadth were measured using a digital callipers (SDN20, BAKER®) and expressed in millimeters. Each day after pollination, the bags were removed to assess the fruit set of each EPP treatment. Fruit set (%) was counted manually. Fruit maturity (days) was counted as and when the range of titratable acid content: 2.1 ± 0.04% and pH: 3.38 ± 0.03 were met (Goldberg and Ben-Arie, 3). Average fruit weight (g) and yield (kg/plant) were measured with an electronic balance (Aczel®). Total soluble solids (TSS) were measured using a handheld refractometer (ERMA INC.). Total acidity was measured by the titrimetric method. Fruit juices' ascorbic acid content was calculated using the volumetric technique (Thimmaiah, 8). ICP-MS (Inductively Coupled Plasma Mass Spectrophotometer) Parkin Elmer Nex ION 300X was used for mineral estimation (Olesik, 6). Digested samples were analyzed for the ionic constitution using multi-element standards solutions and expressed in mg per 100 g of fresh weight. A completely randomized design was used for the pooled data of three years. All significant means were separated using LSD (P≤ 0.05) values. Data were analyzed using SPSS-17 software.

RESULTS AND DISCUSSION

The effect of hand pollination timings on kiwifruit appearance is presented in Fig. 1. Flower characteristics of kiwifruit cultivars Allison (Male) and Monty (Female) are presented in Table 2. Flower diameter (mm) was 1.55 times higher in Monty (Female) than in Allison (Male). The number of sepals was higher in Allison (male) than in Monty (female). Sepal length was 1.30 times higher in Monty (Female) than in Allison (Male). Sepal width was 1.15 times higher in Monty (Female) than in Allison (Male). Both Allison (Male) and Monty (Female) recorded the same number of petals (5-6). Petal length was found to be 1.26 times higher in Monty (Female) than in Allison (Male). Similarly, petal width was found to be 1.14 times higher in Monty (Female) than in Allison (Male). Number of stamens/anthers was 1.21 times higher in Monty (Female) than Allison (Male). Filament length was recorded as 1.88 times higher in Allison (Male) than in Monty (Female). Ovary diameter and stigma-style length were found to be 7.34 and 9.33, respectively. Number of stigma-style was 32.33. Fresh anther weight per flower was recorded to be

Table 2. Flower characteristics of kiwifruit cultivars Allison (Male) and Monty (Female).

Parameter	Allison (male)	Monty (female)
Flower diameter (mm)	33.79	52.40
No. of sepals	4-5	3-5
Sepal length (mm)	7.82	10.21
Sepal width (mm)	6.37	7.35
No. of petals	5-6	5-6
Petal length (mm)	18.94	24.02
Petal width (mm)	15.90	18.22
No. of stamens/anthers	108.33	131.33
Filament length (mm)	11.13	5.99
Ovary diameter (mm)	---	7.34
Stigma-style length (mm)	---	9.33
No. of stigma-style	---	32.33
Fresh anther weight per flower	98.47 mg	---

Fig. 1. Effect of hand-pollination timings on kiwifruit growth and appearance.

98.47 mg. McNeilage (5) has studied gender variation in kiwifruit in 1991.

Table 3 shows the effect of hand pollination timings on kiwifruit fruit length (mm). The fruit length was found to be the highest during 8 am pollination in all the periods of days after flowering. Similarly, the highest fruit width was recorded during 8 am pollination in all the periods of days after flowering (Table 4). Therefore, 8 am is the most critical time to perform pollination for obtaining big size fruits. Our results of the effect of effective pollination time on fruit dimensions have been in congruence with the previous studies (Gheshlaghi, 2).

The effect of hand pollination timings on the physical and biochemical parameters of kiwifruit is presented in Table 5. A significant impact of hand pollination timings on kiwifruit physical and

Table 3. Effect of hand-pollination timings on kiwifruit fruit length (mm). The data in the table represent the mean of three years' pooled data (2020-22).

Treatment	10 DAF	30 DAF	60 DAF	90 DAF	120 DAF	150 DAF	At Harvest
8 am	10.9	37.0	67.9	72.6	73.1	78.1	79.5
9 am	10.6	34.9	55.8	69.4	72.2	77.2	78.5
10 am	10.8	31.8	59.1	68.5	74.3	76.7	77.3
11 am	10.6	35.3	63.1	67.9	70.9	73.2	74.3
12 am	9.4	29.0	59.9	65.4	68.0	66.4	70.6
1 pm	8.8	24.9	52.9	65.6	68.6	67.3	72.5
2 pm	8.3	23.6	53.2	63.2	65.0	68.8	69.5
3 pm	9.0	21.9	48.6	58.7	63.6	67.4	68.3
4 pm	10.4	33.6	61.7	69.4	70.0	75.1	76.0
Control	8.2	21.0	47.9	52.7	54.2	56.9	58.9
CD at 5%	0.61	3.44	6.88	4.09	3.67	4.85	4.04
CV %	3.79	7.03	7.23	3.75	3.23	4.07	3.33

Table 4. Effect of hand-pollination timings on kiwifruit fruit width (mm). The data in the table represent the mean of three years of pooled data (2020-22).

Treatment	10 DAF	30 DAF	60 DAF	90 DAF	120 DAF	150 DAF	At Harvest
8 am	8.0	17.7	36.8	40.4	41.7	46.5	47.4
9 am	7.7	17.8	35.8	40.1	42.2	45.2	46.2
10 am	7.7	14.7	36.5	37.3	42.3	45.0	45.5
11 am	7.4	16.1	36.6	39.0	41.3	44.5	45.0
12 am	6.4	15.8	34.7	36.6	39.3	41.4	42.9
1 pm	6.8	13.9	37.8	38.8	39.3	41.2	42.2
2 pm	6.4	14.8	35.9	37.5	40.8	41.5	42.1
3 pm	6.7	15.3	32.3	35.5	38.6	41.5	44.2
4 pm	7.8	17.8	35.2	38.7	42.0	43.3	46.8
Control	6.2	12.4	27.0	31.8	35.4	38.8	41.1
CD at 5%	0.92	3.63	4.94	2.21	7.96	2.12	4.24
CV %	7.77	13.92	8.50	3.52	11.86	2.97	5.72

Table 5. Effect of hand-pollination timings on kiwifruit physical and biochemical parameters. The data in the table represent the mean of three years' pooled data (2020-22).

Treatment	Fruit set (%)	Days taken to fruit set	Fruit maturity (days)	Av. fruit weight (g)	Yield (kg/plant)	TSS (%)	Total acidity (%)	Ascorbic acid (mg/100 g)
8 am	96.7	5.0	177.7	111.0	34.46	19.1	0.68	113.4
9 am	100.0	5.0	178.3	113.1	35.20	18.7	0.64	118.9
10 am	100.0	6.7	179.7	114.4	35.06	18.7	0.68	112.2
11 am	93.3	5.0	176.3	112.5	30.74	17.1	0.85	111.1
12 am	93.3	6.7	179.7	104.0	30.14	13.9	0.94	110.0
1 pm	90.0	6.0	181.7	79.8	27.04	14.6	0.98	108.9
2 pm	93.3	6.7	179.3	71.8	27.64	14.6	1.07	104.5
3 pm	100.0	8.0	178.7	71.0	26.66	13.8	0.94	103.4
4 pm	96.7	5.0	184.3	107.1	27.62	17.5	0.98	107.8
Control	73.3	8.0	184.7	68.4	18.38	14.4	1.37	97.8
CD at 5%	9.25	1.54	NS	5.8	2.4	1.2	0.15	7.7
CV %	5.92	14.92	3.11	3.7	6.5	4.4	9.88	4.2

biochemical parameters was observed except for days to fruit maturity. The fruit set was found to be 100% during 9 am, 10 am and 3 pm, and the lowest fruit set was recorded during control timing. Pollination during 8 am, 9 am, 11 am and 4 pm took the least time for the fruit set (5 days), whereas pollination at 3 pm and control timings recorded the highest days for the fruit set (8 days). Fruit maturity duration showed a non-significant variation in pollination timings. Average fruit weight was recorded maximum for 10 am (114.4 g) pollination followed by 9 am (113.1 g) pollination, while minimum was recorded in 3 pm (71.0 g) pollination. Yield was found to be highest in 9 am (35.20 kg/plant) pollination and lowest in control (18.38 kg/plant) pollination (1.91-fold variation). TSS recorded 1.38-fold variations with the maximum at 8 am (19.1°B) pollination and minimum at 12.00 pm (13.9°B) pollination. Total acidity was recorded as highest in control (1.37%) pollination, and the minimum was recorded at 9 am (0.64%) pollination. Ascorbic acid was recorded maximum in 9 am (118.9 mg/100 g) pollination, and lowest was recorded in control (97.8 mg/100 g) pollination. Management factors like crop load, nutrients, irrigation, anthesis time, flower quality, pollination systems, beehive management, types of training systems, fruit placement on vines in a specific training system, and leaf-to-fruit ratio also have an impact on the final fruit quality (Gheshlaghi, 2). The findings on the influence of pollination systems on fruit set and fruit quality in kiwifruit by Gonzalez *et al.* (4) are similar to our findings.

The effect of hand pollination timings on kiwifruit primary nutrient concentrations is presented in Fig. 2. Nitrogen concentration was found to be highest at 11 am (184 mg/100 g fresh weight) pollination and lowest was recorded at 2 pm (132 mg/100 g fresh weight) pollination. Phosphorus concentration was recorded as highest during 9 am (32 mg/100 g fresh weight) pollination, while the lowest was recorded at 3 pm (22 mg/100 g fresh weight) pollination. Potassium concentration was recorded the highest during 4 pm (291 mg/100 g fresh weight) pollination, while the lowest was recorded in control (229 mg/100 g fresh weight) pollination.

The effect of hand pollination timings on kiwifruit secondary nutrient concentrations is presented in Fig. 3. Calcium concentration was found to be highest at 9 am (45 mg/100 g fresh weight) pollination and lowest was recorded at 1 pm and control (37 mg/100 g fresh weight) pollination. Magnesium concentration

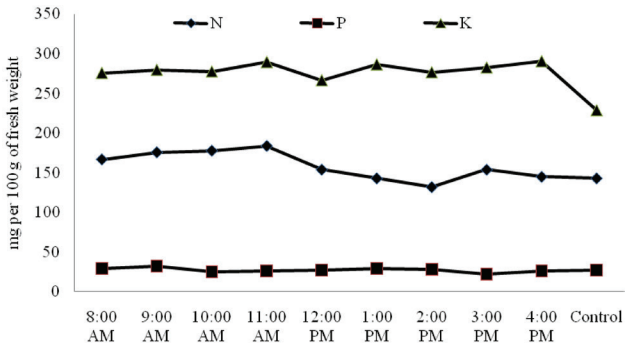

Fig. 2. Effect of hand-pollination timings on kiwifruit primary nutrient concentrations. The data in the figure represent the mean of three years' pooled data (2020-22).

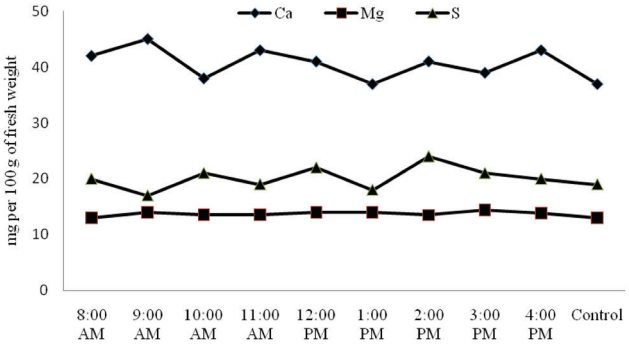

Fig. 3. Effect of hand pollination timings on kiwifruit secondary nutrient concentrations (pooled means for three years).

was recorded highest during 3 pm (14.4 mg/100 g fresh weight) pollination, while the lowest was recorded in 8 am and control (13 mg/100 g fresh weight) pollination. Sulphur concentration was recorded as highest during 2 pm (24 mg/100 g fresh weight) pollination, while the lowest was recorded at 9 am (17 mg/100 g fresh weight) pollination. For the first time, the differences in primary and secondary nutrient concentration in kiwifruit due to the different timings of pollination have been reported by our study. However, more detailed studies must be conducted on other cultivars to see the effect of pollination timings on fruit quantity and quality.

AUTHORS' CONTRIBUTION

Conceptualization (SKD, AY), Conducting experiments (SKD, AY), Writing manuscript (SKD, AY). Both authors have contributed equally to the work.

DECLARATION

The authors declare that they do not have any conflict of interest.

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