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Effect of Incomplete Pollination on the Physical Quality Attributes of Apple (*Malus* × *domestica* Borkh.) cv. Red Delicious

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Authors' contributions

This work was carried out in collaboration between all authors. Authors EAP and MUR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SSU and MTA managed the analyses of the study. Authors TAB, IR and GH managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

An investigation was carried out at Commercial orchard, Shalimar (Jammu & Kashmir) during 2016-17 to find out the effect of different stigma excision levels (incomplete pollination) on the physical characteristics of Apple fruit (*Malus* × *domestica* Borkh.) cv. Red Delicious. The six treatments were

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pinching off 0, 1, 2, 3, 4, or 5 styles below the stigma from each of forty flowers per side. The remaining stigmata were hand-pollinated on the second day following treatment. Flowers were pollinated with Golden Delicious pollens. Only flowers with five stigmata were used and each flower was considered an experimental unit. The results revealed that the maximum fruit length (7.09 cm), fruit diameter (7.34 cm), shape index (0.96), fruit weight (203.21g), fruit firmness (8.15 kg/cm^2), seed number (8.57), were recorded in fruits from flowers with no stigma pinched. Therefore, indicating that improved seed set (proper pollination) provides a relatively inexpensive and efficient practice to improve the physical quality attributes of apple fruit.

Keywords: Apple; stigma excision; physical characteristics; quality; improvement.

1. INTRODUCTION

Apple (*Malus × domestica* Borkh.) is the most popular and widely grown fruit crop throughout the world. India ranks 4th in apple production with the annual production of 24, 97,680 MT on an area of 313,040 ha [1]. Himachal Pradesh, Jammu and Kashmir and Uttarakhand are the main contributors of apple production in India, while as, Jammu and Kashmir dominates with a production of 19,66,417 MT over an area of 161,773 ha [2]. However, Apple productivity in the state is very low i.e. 12.16 MT/ha which is far below the level achieved by the horticulturally advanced countries like Chile (47.22 MT/ha), Netherland (44.94 MT/ha) and Belgium (46.22 MT/ha) and also the proportion of 'A' grade apple is low. There are various factors that determine whether high yields of good quality fruits are achieved in apple. These include quality of flowers, the efficacy of pollination, the severity of natural or induced abscission of fruitlets, and the persistence of fruit till harvest.

Consumers demand consistent and uniform fruit quality whereas apple fruit is prone to a range of quality defects induced during the growth period or after the harvest. These defects are of serious concern to the growers. Also, as market preferences can change quite quickly, apple grower must be able to respond. Because the international market is competitive this imposes considerable pressure to develop strategies that accommodate these changes without impacting profit. To develop the strategies required to efficiently manage the crop, it is necessary to elucidate the origins of the quality defects.

The factors associated with development of some quality attributes of fruits are either poorly understood or completely neglected. Management practices are often unable to remedy negative impacts or are applied in the final stages of fruit quality development with often small effects but at large expense. Differences in the levels of pollination among the five stigmas of apple flower can directly affect fruit quality and quantity, because of the resulting variable production and distribution of seeds [3, 4]. Hence, an understanding of the role of better pollination in the final quality attributes of an apple is essential for maintaining the status quo of apple as a profitable enterprise.

2. MATERIALS AND METHODS

The present investigation on "Effect of pollination and spatial pattern of flowers on retention of Apple fruit (*Malus × domestica* Borkh.) cv. Red Delicious." was carried out at Commercial orchard, Shalimar (Jammu & Kashmir) during 2016-17. Full bloom of Red Delicious occurred on 7-10th April. Clusters containing five flowers were selected and petals were removed from unopened ("popcorn" stage) flowers, which were tagged to receive one of six treatments in a completely Randomized Block Design replicated four times. Only flowers with five stigmata were used and each flower was considered an experimental unit. The six treatments were pinching off 0, 1, 2, 3, 4, or 5 styles below the stigma from each of 40 flowers/side. The remaining stigmata were hand-pollinated on the second day following treatment. Flowers were pollinated with Golden Delicious pollens. The number of seeds/fruit was counted by cutting the fruit equatorially and then removing the seeds from core. Chaffy and shrivelled seeds were discarded. The length of retained fruits from each treatment in each replication was measured with the help of a digital vernier calliper, averaged and expressed in centimetre (cm). The diameter of retained fruits from each treatment in each replication was measured at cheek position with the help of a digital vernier calliper, averaged and expressed in centimeter (cm). L/D ratio was calculated by dividing the length of fruit with the diameter of corresponding fruit. Retained fruits from each treatment in each replication were weighed individually on a sensitive monopan balance and average weight was recorded in grams. Fruit firmness was measured with the help of Effegi penetrometer model, Ft-3-27 having 7/16 diameter of the head with a penetration of 5/6. In each treatment, fruits were punched at three different places on its surface after removing about one square inch of peel and firmness was recorded as kg/ cm^2. Fruit growth rate (diameter based) at different stages of growth was obtained at 15 days interval from day 5^{th} of petal fall to 4^{th} June by measuring diameter of tagged fruits with the help of a vernier calliper as they grew.

3. RESULTS AND DISCUSSION

3.1 Seed Number

Present studies revealed that with increase in number of stigmata excised there was corresponding decrease in the average seed number (Table 1). Maximum seed number (8.57) was obtained in T_0 (no stigma excised). These results are in conformity with Ward et al*.* [5] who reported that stigma excision induced seed variability in apple. Similar findings were reported by Sheffield et al*.* [4] in Summerland McIntosh. The decrease in seed number with stigma excision could be explained by the fact that the female organ of the apple flower, the gynoecium, comprises five carpels; each has a stigma, a style and an ovary that normally contain two ovules. Therefore a single stigma excised leads to decrease in seed complement (10 seeds) by 2 seeds.

3.2 Fruit Size (Length and Diameter)

Present studies revealed that with the increase in stigmata excised there was a corresponding decrease in fruit size (Table-2). This is because of the fact that seeds contain hormones (Auxins, Gibberellins and cytokinins) necessary for fruit growth and development and enhance mineral elements [6]. Similar results were confirmed by Tomala and Dilley [7], Miller and Kaiser [8], Volz et al*.* [9], Keulemans et al*.* [10], Uemura *et al.* [11] who found that seed count affects fruit size. A high number of seeds may well stimulate better growth, through a greater attraction of nutrients coming from other parts of the tree. Fruit size is determined by cell number, cell size and intercellular space [12]. However, cell number, which is determined early in apple development, accounts for most of the variation in fruit size [13] and it is mainly influenced by seed number [6].

3.3 L/D Ratio

Studies revealed that the L/D ratio decreased with an increase in the number of stigma excised (Table 2). Maximum L/D ratio (0.96) was recorded in fruits from flowers with 0 stigma excised while minimum L/D ratio (0.93) was recorded in fruits from flowers with 4 stigmata pinched. The suppressive effect of stigma excision on L/D ratio is probably due to the decreased cell division and cell elongation. These results are in agreement with the findings of Luckwill et al*.* [6] who reported that seeds contain hormones (Auxins, Gibberellins and cytokinins) necessary for fruit growth and development and enhance mineral elements. The ratio of fruit length to diameter increases with increasing seed number in both apple and pear [14].

3.4 Fruit Weight

There was a negative correlation between the number of stigmata excised and fruit weight (Table 3). Maximum weight (203.21 g) was recorded in fruits from flowers with 0 stigma pinched. Significantly minimum weight (147.44 g) was recorded in fruits from flowers with 4 stigmata excised. As stigma excision reduces seed number, therefore lower the seed count, the lower the sink strength in the fruit, which is reflected by a decrease in fruit weight due to the lower metabolic activity. These findings are in agreement with Ward et al*.* [5] and Keulemans et al*.* [15] who reported that higher seed number facilitates fruit growth and fruit weight. Reducing the seed content of fruit by excising stigmata may have caused those fruit to be weaker sinks for photosynthate through much of the early growing season, thereby limiting their size potential and weight.

3.5 Firmness

Studies revealed that the fruit firmness decreased with increase the number of stigma excised (Table 3, Fig. 1). Maximum fruit firmness (8.15 kg/cm^2) was recorded in treatment T_0 (no stigma pinched) while as minimum fruit firmness (7.04 kg/cm^2) was recorded in fruits from flowers with 4 stigmata excised. This could be explained by the fact that higher seed content is related with higher calcium concentration [10,16,17] and thus increased firmness. Enhancement in fruit firmness is attributed to the fact that calcium is an important constituent of the cell wall [18]. Calcium ions have been shown to bind pectin molecules and Knee and Bartley [19] suggested that these ions form bridges between pectin molecules in the middle lamella and are responsible for cell cohesion. Calcium affects physical properties of plant membranes by regulating their microviscosity or fluidity. Cellular senescence is accompanied by increase in microviscosity and the proportion of gel-phase lipid of membranes and calcium may diminish these trends [20].

3.6 Growth Rate (15 Days Interval)

The results indicated that fruit growth rate decreased with increase in the number of stigmata excised (Fig. 2). Maximum fruit diameter (8.12 mm) five days after petal was recorded in fruits from flowers with 0 stigma excised whereas minimum fruit diameter (5.82 mm) after same period was recorded in fruits from flowers with 4 stigma excised. This may be explained by the fact that fruits obtained from flowers with no stigma pinching contain more number of seeds. As seeds contain hormones (Auxins, Gibberellins and cytokinins) necessary for cell division, cell enlargement and act as strong sinks thereby attracting more photosynthates. These results are in agreement with the findings of Ward et al. [5], Tomala and Dilley [7], Miller and Kaiser [8], Volz et al. [9], Keulemans et al. [15], Uemura et al. [11].

Table 1. Effect of stigma excision on the seed number of apple cv. red delicious

Treatment		Seed number
T_0	(0 stigma pinching)	8.57
T_1	(1 stigma pinching)	7.50
T_2	(2 stigmata pinching)	5.75
T_3	(3 stigmata pinching)	3.55
T_4	(4 stigmata pinching)	1.50
T_5	(5 stigmata pinching)	-
	C.D($p \leq 0.05$)	0.20

Table 2. Effect of stigma excision on the length (cm), diameter (cm) and L/D ratio of apple cv. red delicious

Treatment		Length (cm)	Diameter (cm)	L/D ratio (shape index)
T_0	(0 stigma pinching)	7.09	7.34	0.96
T_1	(1 stigma pinching)	6.97	7.26	0.96
T_2	(2 stigmata pinching)	6.88	7.18	0.95
T_3	(3 stigmata pinching)	6.16	6.50	0.94
T_4	(4 stigmata pinching)	5.75	6.13	0.93
T_5	(5 stigmata pinching)	-	-	-
	C.D($p \leq 0.05$)	0.31	0.25	0.01

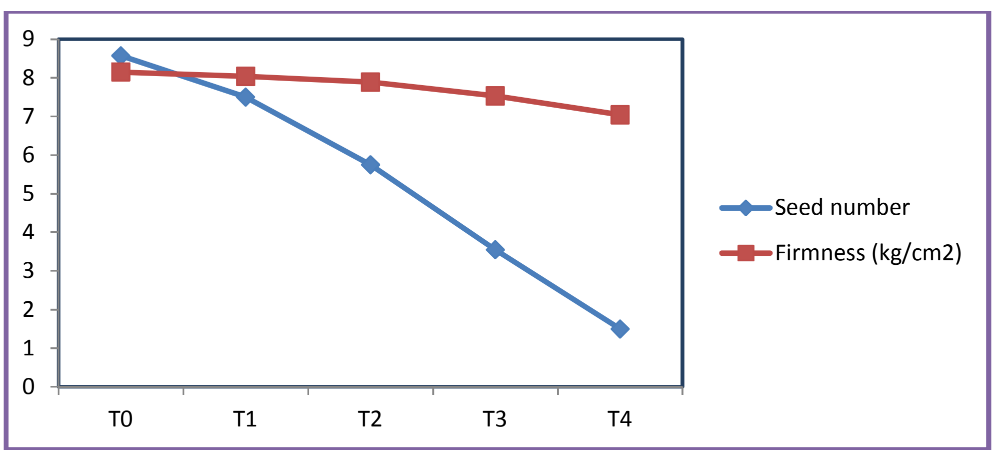

Fig. 1. Effect of stigma excision on the number of seeds and the firmness of apple fruit cv. Red Delicious

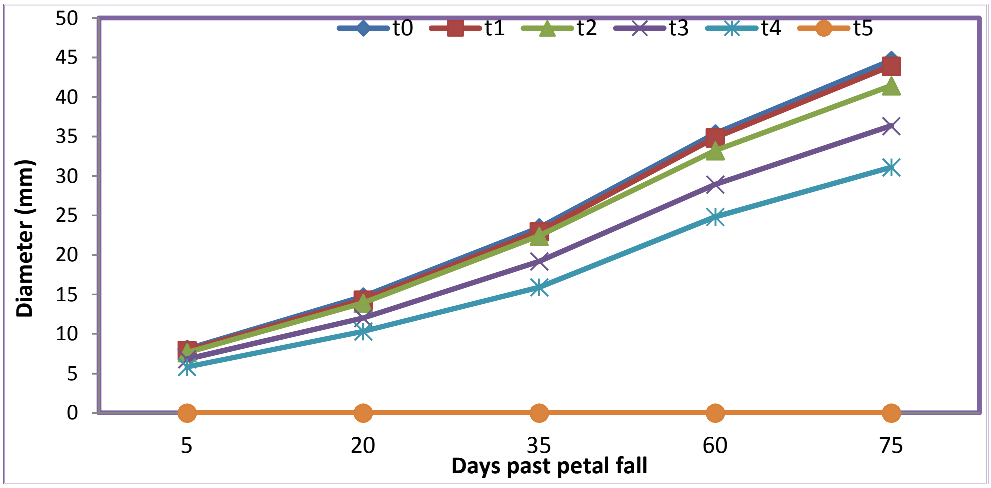

Fig. 2. Effect of stigma excision of apple cv. Red Delicious on fruit growth in terms of fruit diameter (mm)

Table 3. Effect of stigma excision on the weight (g), firmness (kg/cm^2) and seed number of apple cv. red delicious

Treatment		Weight (g)	Firmness (kg/cm^2)
T_0	(0 stigma pinching)	203.21	8.15
T_1	(1 stigma pinching)	199.25	8.04
T_2	(2 stigmata pinching)	188.44	7.89
T_3	(3 stigmata pinching)	165.72	7.53
T_4	(4 stigmata pinching)	147.44	7.04
T_5	(5 stigmata pinching)	-	-
	C.D($p \leq 0.05$)	2.35	0.11

4. CONCLUSION

Stigmata excision as a model for incomplete pollination and fertilization is very effective and provides an easy system. It permitted us to establish a range of seed numbers in the treated flowers. Seeds play an important role in sink strength of growing fruit early in the season. Reducing the seed content of fruit by excising stigmata causes those fruits to be weaker sinks for photosynthesis through much of the early growing season, thereby limiting their size potential. Therefore, it may be concluded that improved seed set (proper pollination) provides a relatively inexpensive and efficient practice to improve the physical quality attributes of apple fruit in an organic way.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anonymous. All India area, production and productivity of apple. Indian Horticulture Database, National Horticulture Board, Ministry of Agriculture; 2015.
2. Anonymous. District wise area and production of major horticultural crops in Jammu and Kashmir state for the year 2015-16. Department of Horticulture, Jammu and Kashmir; 2016.
3. Carr SGM, Carr DJ. The functional significance of syncarpy. Phytomorpholy. 1961;11:249–256.
4. Sheffield CS, Smith RS, Kevan PG. Perfect Syncarpy in Apple (*Malus x domestica* 'Summerland McIntosh') and its Implications for Pollination, Seed Distribution and Fruit Production (Rosaceae: Maloideae). Annals of Botany. 2005;95:583-591.
5. Ward DL, Marin RP, Byers RE. Relationships among day of year of drop, seed number and weight of mature apple Fruit. Hort Science. 2001;36:45-48.
6. Luckwill LC, Weaver P, MacMillan J. Gibberellins and other growth hormones in

apple seeds. Journal of Horticultural Sciences. 1969;44:113-124.
7. Tomala K, Dilley DR. Calcium content of McIntosh and Spartan is influenced by the number of seed per fruit. Proceedings of the fifth international controlled atmosphere research conference Wenatchee, Washing, USA; 1989.
8. Miller DD, Kaiser K. Relationships among apple weight, seed number, seed weight, germination date and apple seedling vigor. Research circular, Ohio Agricultural Research and Development Center. 1994;298:56-62.
9. Volz, RV, Palmer JW, Gibbs HM. Within-tree variability in fruit quality and maturity for ‘Royal Gala’ apple. Acta Horticulture. 1995;379:67-79.
10. Luckwill LC. Studies of fruit development in relation to plant hormones. I. Hormone production by the developing apple seed in relation to fruit drop. Journal of Horticultural Science. 1953;28:14-24.
11. Uemura D, Morita I, Kaneduka A, Taguchi T, Kume Y, Tagichi S. Efficiency of artificial pollination to ´Fuji´ apple tree. Bulletin of the Akita Fruit Tree Experiment Station 2001;27:1-12.
12. Goffinet MC, Robinson TL, Lakso AN. A comparison of ‘Empire’ apple fruit size and anatomy in unthinned and hand-thinned trees. Journal of Horticultural Science. 1995;70:375-387.
13. Pearson JA, Robertson RN. The physiology of growth in apple fruits. IV. Seasonal variation in cell size, nitrogen metabolism and respiration in developing Granny Smith apple fruits. Australian Journal of Biological Sciences. 1953;6:1-20.
14. Denne MP. Fruit development and some tree factors affecting it. New Zealand Journal of Botany. 1963;1:265-294.
15. Keulemans J, Brusselle A, Eyssen R, Vercammen J, Van Daele G. Fruit weight in apple as influenced by seed number and pollenizer. Acta Horticulture. 1996; 423:201-210.
16. Bramlage WJ, Weis SA, Greene DW. Observations on the relationships among seed number, fruit calcium and senescent breakdown in apples. Hort Science. 1990;25:351-353.
17. Parray EA, Rehman MU, Ali MT, Dar MS Bhat IA, Rafiq et al. Effect of stigma excision on the bio-chemical characteristics of apple (Malus × domestica Borkh.) cv. Red Delicious. International Journal of Chemical Studies. 2017;5(5):1654-1656.
18. Rashid A, Kirmani NA, Bhat MI. Combined effect of soil and folair potassium application on quality of apple under temperate conditions. SKUAST Journal of Research. 2009;11:246-249.
19. Knee M, Bartley IM. Composition and metabolism of cell wall polysaccharides in ripening fruits. In: Recent Advances in the Biochemistry of Fruits and Vegetables (Eds. Friend J, Rhodes MJC) London: Acadamic Press. 1981;133-148.
20. Ferguson IB. Calcium in plant senescence and fruit ripening. Plant, Cell and Environment. 1984;7:477-489.

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