

IMPACT OF HONEYBEE POLLINATION ON QUANTITATIVE AND QUALITATIVE PARAMETERS OF APPLE (VAR., RED DELICIOUS) IN RELATION TO POLLINIZER PROPORTION

TAHMINA MUSHTAQ* AND SHEIKH BILAL

Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar - 191 121, Jammu and Kashmir, INDIA
e-mail: tttahmina2@gmail.com

KEYWORDS

Apple (*Malus domestica* Borkh)
Honeybees
Pollinizer ratio
Quantitative parameters
Qualitative parameters

Received on :
01.01.2016

Accepted on :
22.02.2016

*Corresponding
author

ABSTRACT

Research was carried out for two consecutive years to find out the effect of pollinators vis-a-vis., pollinizer ratio on qualitative and quantitative parameters of apple in Kashmir. Three colonies of *Apis mellifera* L. were kept in two different orchards with pollinizer ratio of 5% and 10%. Data yielded revealed that controlled release of three hive units in orchard with 10 per cent pollinizer ratio showed significantly better results both quantitatively; fruit set (70.07%), (fruit drop (10.49 %), seed number (9.373 ± 0.084), fruit yield (303.7 kg/tree) and qualitatively; fruit size (78.733 ± 0.255 mm), fruit diameter (77.732 ± 0.687 mm), fruit weight (237.285 ± 5.702 g), fruit volume (250.476 ± 3.904 ml) and fruit colour (98.95%) as compared to naturally pollinated orchards with 10% pollinizer proportion. Similarly, controlled release with three hives in orchard with 5 % pollinizer proportion also gives a standard quality fruit (size; 72.744 ± 0.792 mm and diameter; 72.595 ± 0.184 mm) with a good commercially profitable yield (256 kg/tree) over naturally pollinated orchard (5% pollinizer proportion). The studies revealed that in conventional orchards with inadequate pollinizer ratio, growers can get good benefits from controlled release of three hives, which can significantly boost their production and improve the quality of fruit as well.

INTRODUCTION

Pollination is an essential process for the propagation of sexually reproducing plants, hence needs external agents to get task of pollination accomplished. More than 75% of major world crops depend on animal pollination, nearly 15% of animal pollination is carried out by bees (Vimla and Khan, 2014). Apple has a gametophytically self incompatible (SI) system, which prevents inbreeding and promotes out crossing (Stern *et al.*, 2001). Pollination in apple is very important and inseparable component in respect of regular and consistent fruit production however, inadequate pollination adversely effects fruit production (Sharma *et al.*, 2006). G.Meerabai, 2012 reported that due to low pollinizer ratio pollination was poor which resulted in poor fruit set. Orchards having low proportion of pollinizers suffer a setback in pollination and result in low yields (Sharma *et al.*, 2004). Presence of honey bees as pollinators in apple orchards enhances the usefulness of the pollinizers by distributing pollen to varied distances (Dulta and Verma, 1987). Cross pollination is brought by insect pollinators that visit flowers for the nectar and/or pollen collection. There is a possibility that the deficiency in proportion of pollinizers may be offset to a great extent, by provision of more number of bee colonies (Rana *et al.*, 1998). Thus the honey bees are the most important pollinating insects (Sharma *et al.*, 2012). This means that apple trees require a pollinator and a pollinizer for good fruit-set (Somerville and White, 2005). Honeybees are the most

efficient pollinators among insects because they can be managed in sufficient number and show flower constancy (Mishra *et al.*, 1976).

In Kashmir valley, apple is the main commercial fruit fetching higher income to the state. However, from the last few years, a major setback in its production has been reported due to lack of efficient pollinators and sufficient pollinizers. This paper aimed to analyze the impact of controlled release pollinators viz-a-vis., pollinizer ratio (5 and 10%) on qualitative and quantitative parameters of apple.

MATERIALS AND METHODS

The study was carried out for two consecutive years in kashmir during 2011-12, four orchards were selected, two orchards (T_1 & T_3) with controlled release of three hives (*Apis mellifera*) having 5 and 10 percent pollinizer ratio and another two orchards (T_2 & T_4) of each category were kept as control (natural pollination). The bee colonies with 9-10 frame strength were evenly spaced in the orchards two days before the initial bloom (10%).

For assessing the cumulative impact of pollinators and pollinizer ratio on quality and production of apple fruit, Ten (10) apple trees of Red Delicious variety of uniform size, age and vigor were taken up to serve as replications. The data regarding assessed parameters were studied as per methodology ascribed by Dulta 1986 and using "Apple Descriptor" (UPOV) by International Union for The Protection

of New Varieties of Plants, Geneva, 2005

Quantitative parameters

At blooming period four branches with at least 50 flowers / branch were selected from the four equidistant quadrants of the tree and tagged to study the following parameters

Flower intensity was determined as per apple descriptor (UPOV) taking 3 as light, 5 as moderate and 7 as heavy. Fruit-set (spur basis) was recorded 10 days after petal fall and percentage was measured as follows:

$$\text{Percent Fruit set per 50 flowers} = \frac{\text{No. of fruits obtained}}{\text{No. of flowers observed}} \times 100$$

Fruit drop was determined based on initial fruit-set as the number of fruits dropped.

Fruit-retention was recorded one week before harvesting of fruit as fruits retained finally at maturity.

Fruit yield was calculated as the number of fruits (Kg/tree) harvested from each tree.

Qualitative parameters

The improvement in the quality of fruit was assessed on a sample of 20 apples taken from each replicate tree from each orchard after harvesting in terms of weight, size, diameter, shape, colour, volume and number of seeds per fruit. Fruit size (mm) and Diameter (mm) was determined with the help of Vernier caliper taking < 65mm as small, 65-70mm as medium and > 70mm as large. Fruit shape was observed as per apple descriptor (UPOV) taking 3 as conical, 5 as round and 7 as oval. Fruit colour was depicted as per apple descriptor (UPOV) depicting 2 as orange, 4 as red, 6 as purple and 8 as brown. Fruit weight was measured by top pan analytical balance. Fruit volume (ml) was determined by Water displacement method on the line of the principle that the volume of an object is equal to the amount of water displaced by it. Number of seeds/fruit was counted by longitudinally cutting the fruit into two equal halves.

Data were analyzed statistically.

Ø Analysis of variance technique (ANOVA)

Ø Summary statistics with confidence interval 95 per cent.

RESULTS

Data on quantitative and qualitative parameters of apple is summarized as below:

Impact on quantitative parameters

Perusal of the data documented in Table 1 revealed that all the four different treatments viz., controlled release of 3 hives in orchard with 5% pollinizer ration (T_1), natural pollinated orchards with 5% pollinizer ratio (T_2), controlled release pollination of 3 hives in orchard with 10% pollinizer ratio (T_3), and natural pollinated orchards with 10% pollinizer ratio (T_4) differ significantly with respect to different quantitative characteristics observed. Average flower intensity does not reveal any significant difference, while rest of the parameters differed significantly. Controlled release pollination of 3 hives in orchard with 10% pollinizer ratio (T_3), being superior with high initial fruit set/50 flowers (42.288 ± 0.902), per cent fruit

set (70.07%), fruit retention at maturity (35.188 ± 0.515) and yield (303.70kg/tree) but with minimum drop (10.49%) compared to natural pollinated orchards with 10% pollinizer ratio (T_4) in which case the initial fruit set/50 flowers (20.925 ± 0.497), per cent fruit set (21.69%), fruit retention (10.950 ± 0.574) and yield (128.90kg/tree) with maximum fruit drop (44.44%) was observed. Similarly, treatment T_1 having better initial fruit set/50 flowers (35.350 ± 0.740), percent fruit set (61.925%), fruit retention (31.075 ± 0.483), yield (256.55kg/tree) and fruit drop (12.87%), in comparison to treatment (T_2) in which case initial fruit set/50 flowers, percent fruit set, fruit drop, fruit retention and yield of 19.1 ± 0.531 , 19.200 per cent, 47.99 per cent, 9.475 ± 0.538 and 113.05 kg/tree respectively, was observed.

Qualitative parameters

The data recorded on various qualitative characteristics enumerated in Table 2 revealed that all the four different treatments viz., controlled release of 3 hives in orchard with 5% pollinizer ration (T_1), natural Pollinated orchards with 5% pollinizer ratio (T_2), controlled release pollination of 3 hives in orchard with 10% pollinizer ratio (T_3), and natural pollinated orchards with 10% pollinizer ratio (T_4) differ significantly. Results obtained indicated that the improvement in fruit quality with respect to fruit diameter (78.733 ± 0.255 mm), fruit size ($72.595 \pm 0.184\text{mm}$), fruit weight ($237.285 \pm 5.702\text{g}$), fruit volume (250.476 ± 3.904 ml), fruit colour (98.95%), fruit shape (conical) and seed number ($9.373/\text{fruit}$) was pronounced more in treatment T_3 followed by treatment T_1 in which the fruit diameter ($72.744 \pm 0.782\text{mm}$), fruit size ($72.595 \pm 0.184\text{mm}$), fruit weight ($172.555 \pm 1.879\text{g}$), fruit volume ($188.128 \pm 0.748\text{ml}$), fruit colour (94.65%), fruit shape (conical) and seed number ($8.173/\text{fruit}$) was observed compared to T_4 with fruit diameter ($66.614 \pm 0.477\text{mm}$), fruit size ($60.203 \pm 0.256\text{mm}$), fruit weight ($124.940 \pm 3.198\text{g}$), fruit volume (114.748 ± 0.498 ml), fruit colour (67.45%), fruit shape (round with conical base) and seed number (4.063) and treatment T_2 with fruit diameter ($61.957 \pm 0.207\text{mm}$), fruit size ($53.366 \pm 0.399\text{mm}$), fruit weight ($113.863 \pm 1.208\text{g}$), fruit volume ($131.602 \pm 1.883\text{ml}$), fruit colour (54.75%), fruit shape (conical) and seed number ($3.648/\text{fruit}$).

DISCUSSION

The present studies revealed that quantitative and qualitative parameters were found to be influenced significantly because of interaction between the pollinator population present and the pollinizer proportion in the orchard. However, pollination efficiency in terms of enhancement of fruit set, fruit retention, yield and reduction in fruit drop increased by placing three *Apis mellifera* L. colonies in orchards with 10% pollinizer ratio. Significantly superior results in terms of quality were obtained in orchards where honey bees were introduced over control, this may be due to adequate pollinizer ratio accompanied by increased pollination (Mattu and Hem raj, 2013). The results are in conformity with the findings of Sharma et al., (2004), who reported that increase in fruit set (37.75%) and fruit yield (38.39 tonnes/ha) with placement of three colonies was significantly higher in the orchards with sufficient pollinizers ($> 10\%$) as compared to the pollinizer deficient orchards ($< 10\%$) having fruit-set and fruit yield of 21.75 per

Table 1: Average effect of insect pollinators vis-à-vis pollinizer ratio on the quantitative parameters of apple during 2011 – 12

Treatments	Flower intensity (UPOVNo)	Initial fruit set	Fruit drop	Per cent fruit set after June drop	Fruit retention at maturity	Fruit yield (kg/tree)
T1	7(32.58 ± 1.06)	35.350 ± 0.740	4.550 ± 0.296 (12.87%)	61.925 ± 1.057	31.075 ± 0.483	256.55 ± 0.497
T2	7(31.5 ± 3.17)	19.100 ± 0.531	9.175 ± 0.503 (47.99%)	19.200 ± 1.076	9.475 ± 0.538	113.05 ± 0.975
T3	7(34.05 ± 2.71)	42.288 ± 0.902	4.438 ± 0.236 (10.49%)	70.075 ± 0.939	35.188 ± 0.515	303.70 ± 2.525
T4	7(32.65 ± 3.17)	20.925 ± 0.497	9.300 ± 0.497 (44.44%)	21.690 ± 2.001	10.950 ± 0.574	128.950 ± 1.465
Mean	7(32.69)	29.42	6.87	43.22	21.67	210.56
C.D (pd ^{0.05})	NS	0.90	0.4	1.62	0.620	1.833

Legend: Flower intensity	UPOV No.
Flowers/30cm branch	
Light (15-2)	3
Moderate (21-30)	5
Heavy (31-35)	7

Values are Mean ± CI (confidence interval) of N = 20; T1- 5% pollinizer ratio + 3 hives; T2-5% pollinizer ratio+ Natural pollination; T3 – 10% pollinizer ratio + 3 hives; T4 – 10% pollinizer ratio+ Natural pollination

Table 2: Average effect of insect pollinators vis-à-vis pollinizer ratio on the quality of apple during 2011 - 12

Treatments	Diameter (mm)	Size (mm)	Volume (ml)	Weight (g)	Seed (No.)	Fruit colour Overcolour Intensity	Fruit shape
T ₁	72.744 ± 0.782	72.595 ± 0.184	172.555 ± 1.879	188.128 ± 0.748	8.173 ± 0.130	4 (94.65%)	3.4 (3-5)
T ₂	61.957 ± 0.207	53.366 ± 0.399	113.863 ± 1.208	131.602 ± 1.883	3.648 ± 0.052	4 (54.75%)	5.5 (5-7)
T ₃	78.733 ± 0.255	77.732 ± 0.687	237.285 ± 5.702	250.476 ± 3.904	9.373 ± 0.084	4 (98.95%)	3.2(3-5)
T ₄	66.614 ± 0.477	60.203 ± 0.256	124.940 ± 3.198	114.748 ± 0.498	4.063 ± 0.134	4 (67.45%)	5.3(5-7)
Mean	70.012	65.974	162.161	171.239	6.314	Visualized as per Apple Descriptor	
C.D (pd ^{0.05})	0.642	0.605	3.560	2.750	0.132		

Legend:	Fruit Shape	UPOV No.	Fruit Colour	UPOV No.	Intensity Scale (over colour)
	Conical	3	Orange	2	1 (0-25%)
	Round	5	Red	4	2 (26-50%)
	Oval	7	Purple	6	3 (51-75%)
			Brown	8	4 (75-100%)

Values are Mean ± CI (confidence interval) of N=20; T₁ – 5% pollinizer ratio + 3 hives; T₂ – 5% pollinizer ratio+ Natural pollination; T₃ – 10% pollinizer ratio + 3 hives; T₄ – 10% pollinizer ratio+ Natural pollination

cent and 17.47 tonnes/ha, respectively. Similar findings were reported by Gautam *et al.*, (2004), who recorded a fruit-set of 78.80 per cent, when three honeybee colonies were placed in the orchards with 10% pollinizer proportion. Rana *et al.* (1998) determined a significant increase in per cent fruit set (32.48 to 53.55%), fruit retention (23.38-46.14) and reduction in fruit drop (29.23-12.13%) with increase in *Apis mellifera* colonies from 0-4 in apple orchards having adequate pollinizer proportion compared to orchards with low pollinizer proportion.

Besides, study also revealed that pollinators vis- a vis., pollinizer ratio can influence fruit quality by increasing the seed number which affect the sink strength of individual fruits, probably through hormones. The results are in line with the findings of Khan and Khan (2004) and Anand (2003) who demonstrated that the fruit quality (fruit size-10.5-13cm and seed number 10-15 per fruit) were higher when the main commercial cultivars were benefited with pollinizers (10%) and pollinators (2-3colonies/ha). Besides, there are evidences that levels of pollination affects quality of fruits (Volz *et al.*, 1996; Buccheri and Di Vaio, 2004; Matsumoto *et al.*, 2012). Similarly, Gautam *et al.* (2004) reported that sufficient pollinators (4-5 colonies/ha) together with suitable pollinizer proportion (10%) enhances

the cross pollination resulting in consistant quality fruit with sufficient number of seeds (9-10/fruit).

REFERENCES

- Anand, R. 2003.** Pollination studies in apple (*Malus x domestica* Borkh. M.Sc. Thesis, Department of Fruit Breeding & Genetic Resources, University of Horticulture & Forestry, Nauni, Solan.
- Buccheri, M. and Di Vaio, C. 2004.** Relationship among seed number, quality and calcium content in apple fruits. *J. Plant Nutrition*. **27**: 1735-1746.
- Dulta, P. C. and Verma, L.R. 1987.** Role of insect pollinators on yield and quality of apple fruit. *Indian J. Horticulture*. **44**: 274-279.
- Dulta, P. C. 1986.** Comparative morphometric and biochemical studies on flight muscles of genus *Apis* and its role in apple pollination. *Ph.D. Thesis H.P. University Shimla-5*.
- Gautam, D. R., Jindal, K. K. and Sharma, G. 2004.** Fruit Setting Problems of Apples under Changing Climatic Scenario of North-Western Himalayas of India. Proc. VIII IS on TZFTS. *Acta Hort.* **662**: 435-441.
- G. Meerabai. 2012.** Visitation rate, effectiveness and efficiency of pollinators to *Cadaba fruiticosa* (Linn) druce. *The Bioscan*. 7(3): 483-485.
- Khan, M. R. and Khan, M. R. 2004.** The role of honey bees *Apis*

mellifera L. (Hymenoptera: Apidae) in pollination of apple. *Pakistan J. Biological Sciences*. **7(3)**: 359-362.

Matsumoto, S., Soejima, J. and Maejima, T. 2012. Influence of repeated pollination on seed number and fruit shape of 'Fuji' apples. *Scientia Horticulturae*. **137**: 131-137.

Mattu, V. K. and Raj, H. 2013. Quantitative and Qualitative effects of Honey bee pollination on Apple crop in Shimla Hills of Western Himalaya, India, *International J. Advanced Biological Research*. **3(3)**: 354-359.

Mishra, R. C., Dogra, G. S. and Gupta, P. R. 1976. Some observations on insect pollination of apple. *Indian Bee J.* **38**: 20-22.

Rana, B. S., Goutam, D. R., Goyal, N. P. and Sharma, H. K. 1998. Effect of honey bee pollination on yield parameters of apple in relation to pollinizer proportion. *Indian Bee. J.* **60(1)**: 9-11.

Sharma, G., Roshan, A. and Sharma, O. C. 2006. Floral biology and effect of pollination in apple (*Malus domestica*). *Indian J. Agricultural Sciences*. **75(10)**: 667-669.

Sharma, H. K., Thakur, J. R. and Gupta, J. K. 2004. Effect of bee pollination and polliniser proportion on apple productivity. *Acta-Horticulturae*. **662**: 451-454.

Sharma, H. K., Partap, U., Bisht, K., Tewari, P. and Phartiyai, P. 2012. Impact of pollination in enhancing the apple production in Nainital district of Uttarakhand. *Advances in Pollen Spore Research* **30**: 99-102.

Somerville, D. and White, B. 2005. Pollination of apple by honey bees. *Agnote DAL-132, NSW Department of Primary Industry*.

Stern, R. A., Eisikowitch, D. and Dag, A. 2001. Sequential introduction of honeybee colonies and doubling their density increases cross-pollination, fruit-set and yield in 'Red Delicious' apple. *J. Horticultural Science and Biotechnology*. **76(1)**: 17-23.

UPOV "Apple Descriptor". 2005. Guidelines for the conduct of tests for Distinctness, uniformity and Stability by International Union for The Protection of New Varieties of Plants, Geneva. p. 45.

Vimla Goswami and Khan, M. S. 2014. Impact of honey bee pollination on pod set of mustard (*BRASSICA JUNCEA* L.; CRUCIFERAE) at Pantnagar. *The Bioscan*. **9(1)**: 75-78.

Volz, R. K., Tustin, D. S. and Ferguson, I. B. 1996. Pollination effects on fruit mineral composition, seed and cropping characteristics of 'Braeburn' apple tree. *Scientia Horticulturae*. **66**: 169-180.