

ROLE OF HONEY BEES (*APIS MELLIFERA* L.) FORAGING ACTIVITIES IN INCREASED FRUIT SETTING AND PRODUCTION OF APPLES (*MALUS DOMESTICA*)

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ABSTRACT:- The study was executed at Murree Hills, Pakistan to evaluate the effect of honey bee (*Apis mellifera*) foraging activities on number of apple fruits per panicle and enhancement of apple weight. Apple Ameri trees were applied with natural pollination (T_1), pollination by honey bees only (T_2), natural pollination augmented with honey bees (T_3) and no pollination (T_4 , control). There was a significant increase in the apple fruit setting and weight gain in pollinated plants compared to non-pollinated plants. Maximum number of fruits per panicle were 5.33 ± 0.51 (Mean \pm SE) whereas the highest fruit weight 170 ± 2.65 g (Mean \pm SE) was recorded in plants provided with augmentation of honey bees along with natural pollination. The lowest fruit weight of 80 ± 3.05 g (Mean \pm SE) and the minimum 0.33 ± 0.19 (Mean \pm SE) fruits per panicle were observed in the plants with no pollination. There was 1515%, 406% and 909% percent increase in number of fruits per panicle in trees provided with different types of pollination viz., natural pollination plus honey bees augmentation (T_3), plants pollinated with honey bees only (T_2) and natural pollination treated plants (T_1), respectively over the trees with no pollination. Similarly, the percent increase in apple weight gain over the control was recorded as 31%, 113% and 56% in trees provided with *A. mellifera* pollinated plants only (T_2), plants naturally pollinated + augmentation of *A. mellifera* (T_3) and plants having natural pollination (T_1), respectively.

Key Words: Apis Mellifera, Malus Domestica, Pollination, Murree Hills, Fruits Per panicle and Fruit Weight.

INTRODUCTION

Apple (*Malus domestica* Borkh) had origin in the temperate countries of the Western Asia, between Black Sea and Caspian Sea. Now, it is widely cultivated throughout the world. In Pakistan, different apple varieties having variation in colour, size, shape and taste are cultivated in areas of

1300 meter altitude, which are bordering China, Afghanistan and Iran. In 1998-99, area under apple cultivation in Pakistan was 45.875 thousand hectares with 589.281 thousand tonnes production. Apple is delicious and nutritious with vitamin C, B and A besides essential minerals and 11% sugar and pectin is manufactured from its peel. (Anonymous, 2001).

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One of the most important and primary requirement in production and setting of fruits is the pollination, particularly for 90% of the angiosperms (Ollerton et al. 2011). Insects mainly bees facilitate this essential ecological service (Michener 2007). Poor pollination efficiency of bees due to their less number leads to low yield and poor fruit quality (Garratt et al. 2014).

Apis mellifera contributes significantly in enhancement of yield and quality of insect pollinated crops that are cultivated commercially and also in supporting self pollinated crops throughout the world (Hoehn et al., 2008). Pollination by honey bees has turned out to be the basic input for guaranteed pollination and contributing in higher yield and high fruit quality. This can only be accomplished by managing optimal number of pollinators (Kumar and Kumar, 2014).

Khan and Khan (2004) observed honey bees foraging in five apple cultivars at their blooming phase. The superior fruit quality (seeds number and fruit size) in these varieties were obtained when pollinizers benefitted. In un-caged Starkrimson and Kala Kulloo, the yield was 140-170 Kg contrary to 35-42 Kg in caged trees. The foraging bumble bees and honey bees visited umbels preferably that have open male flowers in abundance, however, honey bees only were the best pollinators for almost all apple cultivars.

Munawar et al. (2009) carried out studies with hypothesis that pollination due to *A. mellifera* in black seed *Nigella sativa* had enhanced yield and seed number. They concluded that honey bees visits in black seed enhanced number of seeds set

and the yield. Promoting pollination by honey bees would enhance seed yield in black seed and also other plants.

This study was undertaken to comprehend effect of foraging activities of *A. mellifera* on apple trees for increase in apple weight and apple fruits panicle.

MATERIALS AND METHOD

The studies were carried out in apple orchards of Aliot and Osia areas of Murree Hills, Pakistan. This type of area has cold, snowy winters, relatively cool summer. Precipitation is received year round with two maximum, first one during winter and second one at summer, July–August. Total mean precipitation annually is 1,789 mm (70.4 inch) and located at 33.83°N 73.35°E. For the aptness of honey bees foraging activities, apple tree were treated with natural pollination (T_1), pollination by honey bees only (T_2), doing natural pollination with augmentation of honey bees (T_3) and no pollination (T_4 , control) in plants.

For each treatment, three full-grown apple plants with similar canopy were randomly selected. The plants pollinated only by *A. mellifera* (T_2) were restricted with 2mm nylon mesh of size 4m×4m×4m (due to this size of mesh no other pollinator enter). In each cage, three-framed nucleus hive having *A. mellifera* was placed. It was ensured that no other insect could enter in these cages.

For treatment 'natural pollination with augmentation of *A. mellifera* (T_3) all other pollinators were also allowed free visits to the randomly selected

plants. The eight-framed *A. mellifera* colony was used for augmentation. Following the general recommendation for pollination purpose (Abrol, 2009), one bee colony was placed in one acre.

For 'Control (T₁)' treatment, three apple trees were randomly selected and on each tree three randomly selected panicles were bagged in 2mm nylon mesh to disallow entry of pollinators (Cayuela et al. 2011).

For natural pollination treatment, were tagged ten kilometers to avoid the approach of *A. mellifera* bees apple plants. Three panicles were randomly tagged in each treatment. The mean fruit weight in grams was worked out dividing total weight of fruits by total fruits number. Per panicle mean number of fruits were calculated when total fruits number was divided by 3. Statistical analysis of the data was done using SPSS 21.0 for Windows. DMRT test was also applied to the mean values.

RESULTS AND DISCUSSION

The maximum mean number of fruits per panicle (5.33 ± 0.51) were recorded on apple trees provided with natural pollination with augmentation of honey bees, which is significantly higher as compared to all other treatments. (Figure 1) showed the aptness of foraging activities of *A. mellifera* on fruit setting of apples at Murree Hills.

The minimum of 0.33 ± 0.19 fruits per panicle were observed in the control treatment. The descending order of mean number of fruits panicle⁻¹ was 5.33 ± 0.51 , 3.33 ± 0.33 , 1.67 ± 0.19 and 0.33 ± 0.19 (Mean \pm SE) in apple plants given natural pollination combined with pollination by *A. mellifera*, trees

with natural pollination, apple plants pollinated by *A. mellifera* only and control plants, respectively. All the treatments were significantly different from each other. As per the percent increase of 406%, 1515% and 909% in number of fruits per panicle was recorded in apple trees which had pollination done only by honey bees, plants provided with natural pollination additionally augmentation of *A. mellifera* and trees with natural pollination only, respectively over the plants without pollination (Table 1). In addition, the percent increase due to *A. mellifera* pollination plus natural pollination and pollination occurring naturally over the pollination done by only *A. mellifera* was 219% and 100%, respectively. Percent increase in number of fruits per panicle of plants treated with pollination naturally occurring and also by honey bees was 60% over the apple trees only naturally pollinated.

The ascending order of mean fruit weight in grams was 80 ± 3.05 g, 105 ± 3.60 g, 125 ± 4.50 g and 170 ± 2.65 g (Mean \pm SE) in non-pollinated plants, apples with pollination of *A. mellifera*,

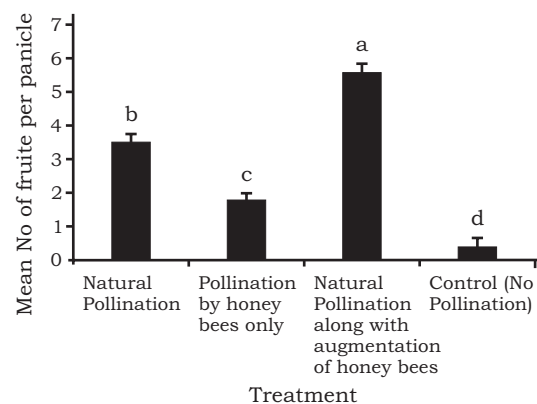


Figure 1. Effect of *Apis mellifera* L. foraging activities on fruit setting of apples

Table 1. Percent increase in number of apple fruits panicle-1 using different treatments of pollination by *Apis mellifera*

S.No	Pollination treatments	Mean No. of apples per panicle \pm SE	Percent increase over control	Percent increase over pollination by honey bees only	Percent increase over natural pollination
1	Pollination (natural)	3.33 \pm 0.33b	909%	100%	
2	Pollination by <i>A. mellifera</i>	1.67 \pm 0.19c	406%		
3	Pollination (natural) + augmentation of <i>A. mellifera</i>	5.33 \pm 0.51a	1515%	219%	60%
4	Plants without pollination (control)	0.33 \pm 0.19d			

naturally occurring pollination and *A. mellifera* accompanied with natural one, respectively (Figure 2). The highest mean apple weight 170 \pm 2.65g (Mean \pm SE) was obtained from trees supported with natural pollination with augmentation of honey bees, which was significantly higher as compared to all other ways of pollination and the control. Naturally pollinated trees showed 125 \pm 4.50 g (Mean \pm SE) apple weight that was significantly different from trees pollinated by honey bees only that

had apple weight of 105 \pm 3.60g (Mean \pm SE). The minimum apple weight 80 \pm 3.05g (Mean \pm SE) was recorded on trees without pollination

The percent increase in apple weight gain over the control was recorded as 31%, 113% and 56% in plants that had pollination due to *A. mellifera*, pollination (natural+ *A. mellifera*), and pollination (natural), respectively. Similarly, 62% and 19% enhancement in apple weight of trees given natural pollination with addition of augmentation of *A. mellifera* and pollination (natural), respectively was worked out when compared with apple weight of trees pollinated by honey bees only. When the percent increase in apple weight of trees having pollination (natural) with augmentation of honey bees was compared with those having natural pollination, 36% increase was found in former case.

In a study by Sujitratanunth (1992), fruit percentage of *Citrus maxima* was 66.9 % that was 274.5 % enhance of number of fruits over the cage without bees. In a study executed by Chaudhry (2008), the maximum

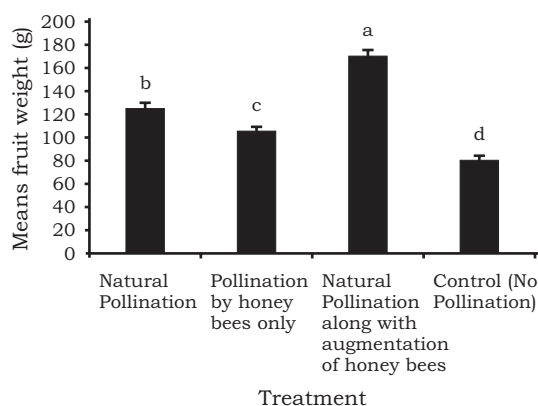
**Figure 2. Effect of *Apis mellifera* L. foraging activities on production of apples**

Table 2. Percent increase in mean apple fruit weight (g) using different treatments of pollination by *Apis mellifera*

S.No	Pollination treatments	Mean apple fruit weight (g) \pm SE	Percent increase over control	Percent increase over pollination by honey bees only	Percent increase over natural pollination
1	Pollination (natural)	125 \pm 4.50 ^b	56%	19%	
2	Pollination by <i>A. mellifera</i>	105 \pm 3.60 ^c	31%		
3	Pollination (natural) + augmentation of <i>A. mellifera</i>	170 \pm 2.65 ^a	113%	62%	36%
4	Plants without pollination (control)	80 \pm 3.05 ^d			

fruit set of 6.5 fruits per branch were recorded in those peach plants which were provided with colonies of honey bees at distance of less than 20 meter. In another research carried out by Cayuela et al. (2011), plants without pollination by honey bees (control) showed significantly less number of fruits per panicle in different plant species contrary to those which were pollinated by honey bees. According to Volz et al. (1996), the maximum apple weight of variety 'Braeburn' was 170g and those trees had treatment of pollination.

CONCLUSION

In the present study, significant increase in mean number of fruits per panicle and apple weight was recorded on trees provided with natural pollination with augmentation of honey bee, *Apis mellifera* L. For higher apple yields, it is suggested that honey bee colonies may be placed in apple orchards during blossom period.

LITERATURE CITED

- Abrol, D. P. 2009. Bees and bee-keeping in India, 2nd edi. Kalyani Publishers, New Delhi. 501p.
- Anonymous, 2001. Available from URL: <http://www.pakissan.com>
- Cayuela, L., S. Arriaga and C. P. Ozers. 2011. Honeybees increase fruit set in native plant species important for wildlife conservation. Environ. Man. 48: 910-919.
- Chaudhry, O. P. 2008. Influence of Different colony placement distances on yield and quality parameters of peach (*Prunus persica* L.). Korean J. Apic. 23 (2): 89-95.
- Garratt M. P. D, T. D. Breese, N. Jenner, C. Polce, J. C. Biesmeijer and S.G. Potts. 2014. Avoiding a bad apple: insect pollination enhances fruit quality and economic value. Agric. Ecos. Environ. 184:34-40.
- Hoehn, P., T. Tschardtke, J. M. Tylianakis and I. Steffan-Dewenter, 2008. Functional group diversity of bee pollinators

- increases crop yield. Proc. Royal Soc. (B). 275: 2283–2291.
- Khan, M. R and M. R. Khan. 2004. The role of honey bees, *Apis mellifera* L. (Hymenoptera: Apidae) in pollination of apple. Pakistan. J. Biol. Sci. 7(3): 359-362.
- Kumar, R. and V. Kumar. 2014. Impact of pollination by European honey bee, *Apis mellifera* L on the yield and quality of litchi (*Litchi chinensis* Sonn.) fruits in India. Pest Manag. Hort. Ecos. 20(2): 127-132.
- Michener C. D. 2007. The Bees of the World. Second Edition. Johns Hopkins University Press, Baltimore, Maryland.
- Munawar, M. S., G. Sarwar, S. Raja, E. S Waghchoure, F. Iftikhar and R. Mahmood. 2009. Pollination by Honeybee (*Apis mellifera*) Increases Seed Setting and Yield in Black Seed (*Nigella sativa*). Int. J. Agri. Bio. 11(5): 611-615.
- Ollerton J., R. Winfree and S. Tarrant. 2011. How many flowering plants are pollinated by animals Oikos. 120:321-326.
- PARC. 2016. Pakistan Agriculture Research (<http://edu.par.com.pk/wiki/apple/>).
- Sujitratunanth, S. 1992. Pollinating management by honeybee, *Apis mellifera* L. on fruit production of pummelo, *Citrus maxima* (J. Burm.) Merr, cv. Tongdee. Ms. Thesis. Kastesart University, Bangkok. 72p.
- Volz, R.K., D. S. Tustin and I. B. Ferguson. 1996. Pollination effects on fruit mineral composition, seeds and cropping characteristics of 'Braeburn' apple trees. Scien. Hort. 66: 169-180.

AUTHORSHIP AND CONTRIBUTION DECLARATION

S.No	Author Name	Contribution to the paper
1.	Dr. Farid Asif Shaheen	Conceived and Conducted Research
2.	Dr. Khalid Ali Khan	Conducted Research
3.	Dr. Mureed Husain	Analyzed Data and Made Graph
4.	Dr. Rashid Mahmood	Wrote Manuscript and Proof Checking
5.	Mr. Muhammad Khalid Rafique	Conducted Research

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