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Research Article

The Role of Bee Pollinators in Improving Berry Weight and Coffee Cup Quality

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Abstract: The study was conducted at Kiambu County in Kenya. The aim of this study was to investigate whether pollination improves the coffee yield and quality of processed coffee in terms of taste and aroma. Among the parameters evaluated when grading coffee for sale in world market are berry weight and cup quality. No previous work in Kenya describes the role of bee pollinators in enhancement of coffee yields and quality. Data on berry weights and the resulting processed coffee quality from different pollination levels in organically grown coffee were analyzed. Results from this study indicate that coffee benefits immensely from pollinators. The highest berry weight and coffee cup quality were recorded in open pollinated and cross pollinated coffee. There were significant differences in weight and cup quality ($p<0.001$) between open pollinated coffee and wind pollination, self pollination and autogamy. The study concludes that pollination not only improves the coffee yields but also enhance the coffee cup taste and aroma. High quality coffee fetches higher prices in the world coffee market.

Keywords: Berry weights, *Coffee arabica*, cup quality, pollination

INTRODUCTION

In agriculture, pollination is an important input in crop production comparable to any other input of crop production such as fertilizer, labor or pesticides (Kasina, 2007). Most crops produce optimally in presence of pollinators (Ricketts, 2004). Studies have documented that 87 of the 124 most commonly cultivated crops are animal pollinated (Black *et al*., 2007). Biotic pollinators with a special emphasis on bees augment coffee yields boosting the economic returns from coffee (Kitti, 2006).

Coffee is among the world's most popular beverage and the quality of coffee determines its marketability. Marketability of coffee in international trade depends on coffee quality which is dependent on bean size, bean weight or density, bean shape and color, processing of the coffee and coffee cup quality (taste, flavor and cleanliness of the coffee). The top Kenyan grades regularly achieve prices more than double that achieved by other grades. During grading, the bigger the bean size the higher the quality. Coffee beans weight or density is also important for its quality. Light beans over-roast during normal roasting and reduce the flavor, acidity and often introduce a flattish, common or ordinary taste that can turn a potentially fine cup of coffee into a mediocre one (ITC, 2002).

C. arabica is the coffee species that is more commonly grown in Kenya and it is rated worldwide among the best in quality and it is used to blend coffee from other parts of the world (Karanja, 1997; Kinuthia *et al*., 2005). No previous studies in Kenya have investigated whether different pollination levels have an impact on coffee quality and productivity. Other inputs of crop production have been given priority in policy formulation masking the importance of pollination in crop productivity (Kasina, 2007). The rationale of this study was to investigate whether various pollination levels are important or how they impact on the yield and cup quality of processed coffee.

MATERIALS AND METHODS

Pollination treatments: An area of 100 m by 100 m with 5 year old coffee plants of SL 28 variety was selected and divided into four plots and from each plot 5 healthy plants were selected. Guard rows were left around the farm. Pollinator exclusion bags of two size categories (course mesh of 1 mm whole size and fine nylon mesh of 10 μm hole) were fixed on selected coffee branches when flowers were at bud stage. To exclude crawling insects especially ants, sticky glue was applied at the base of the selected plant and on the branch slightly beneath the bagged flowers (Roubik,

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2002a; Klein *et al*., 2003b, c). The plants were subjected to 6 treatments per plant namely:

- **Autogamy (control):** Flowers were covered with pollinator exclusion bags of fine nylon mesh gauze (10 μm) to exclude pollinators and wind.
- **Open pollination:** This treatment combined autogamy, wind and pollinators. Flowers were marked but left uncovered to allow wind and pollinators to have access to flowers.
- **Wind pollination:** This treatment combined wind pollination and autogamy. Flowers were covered with pollinator exclusion bags with 1 mm openings to allow wind access but no pollinators.
- **Manual pollination with pollen from the same flower:** This treatment combined autogamy and manual pollination with self pollen. Flowers were covered with pollinator exclusion bags of fine mesh (10 μm) to exclude wind and pollinators. Pollen grains from the anther of the selected flower were rubbed onto the stigma of the same flower using a small paint brush with fine bristles. The paint brush was cleaned thoroughly before using it on a different plant by immersing it in alcohol (Newton, 2005).
- **Manual pollination with pollen from different flowers from the same plant:** This combines autogamy and manual pollination with self pollen.
- **Cross pollination:** Combined autogamy with manual pollination with pollen from neighboring plants. Flowers were covered with pollinator exclusion bags of fine mesh to exclude wind and pollinators. Pollen grains from a flower from a neighboring plant were gently rubbed onto the stigma of the selected flowers by use of a small paint brush (Klein *et al*., 2002; Manrique and Thiemann, 2002; Roubik, 2002a; Ricketts *et al*., 2004; Philpott *et al*., 2006; Vergara and Badano, 2008).

RESULTS

Berry weights: Berry weights were used as an indication of coffee yield since the heavier the berry, the higher the yield (Manrique and Thiemann, 2002). Coffee berries started ripening 8 months from the time of pollination and berry picking commenced when more than 50% of berries in a plant were ripe. Several random sub-samples of 10 berries were picked per treatment and their wet weight recorded using a Pesola balance in the field (Roubik, 2002b). The average weight of berries per treatment was calculated and then subjected to ANOVA and Dunnetts T3 test used for multiple comparisons.

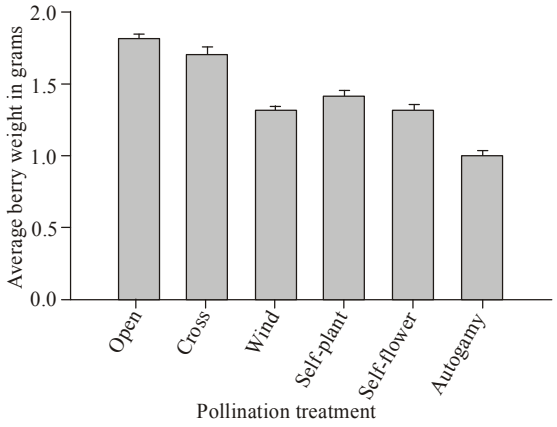

Fig. 1: Average berry weights in different pollination levels

Berry weights in different pollination levels: The highest berry weight was recorded in open pollinated plants (1.8 g), followed by cross pollinated plants (1.65 g) while the lowest berry weight (1.03 g) was from autogamy (Fig. 1). There were significant differences ($p<0.001$) between weight recorded in open pollination and the other pollination treatments namely; wind pollination, self pollination and the control. However, there were no significant differences ($p>0.001$) between open pollination and cross pollination. Open pollination and cross pollination had similar weights, autogamy and self pollination within flower were similar and wind pollination and self pollination within plant were in the same weight subset. However, there were no significant differences ($p>0.001$) between homogenous subsets in the six pollination levels.

Coffee cup quality analysis: Coffee berries were harvested upon ripening, processed, dried and ground. Coffee liquoring was done by three experts trained on coffee liquoring. Coffee was graded on basis of cup quality (taste and aroma) and export quality giving a percentage score per coffee sample. The average percentage quality from three analysts was subjected to ANOVA and Turkey HSD test for multiple comparisons.

Coffee quality analysis: The highest cup quality was from open pollinated coffee and its average rating was 75.5%. The lowest quality was from autogamy and its average rating was 34.7% (Fig. 2). Autogamy and pollination using self pollen were in the same subset and showed the lowest average quality, wind pollination was in its own category while open pollination and cross pollination were in the same category with the highest average value. There were no significant differences in coffee quality within the

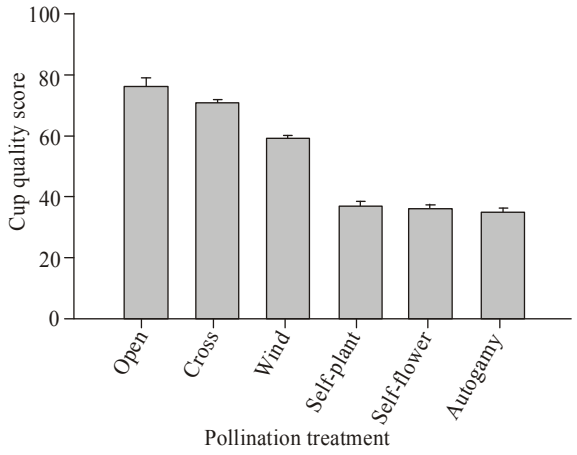

Fig. 2: Average quality of processed coffee in different pollination treatments

different homogenous sub-sets. There were no significant differences ($p>0.001$) between open and cross pollinated coffee in terms of quality. However, significant differences in average quality ($p<0.001$) occurred between open pollination and the other pollination treatments namely; wind pollination, self pollination and the control.

DISCUSSION

Calculations of pollination success by use of fruit set alone may either overestimate or underestimate pollination service value. An overestimation may result from the assumption that fruit set corresponds directly to the quantity of coffee beans harvested later (Olschewski *et al*., 2006). Berry weights give a better indication of pollination success. Various pollination levels resulted to different weights.

Results from this study indicated that various pollination levels significantly improve coffee berry weights. The results are similar to other studies on coffee that have shown that fruit weight is approximately 25% greater when pollinators have access to coffee flowers (Klein *et al*., 2008; Manrique and Thiemann, 2002). Other studies have also given an indication that pollination success translates to higher coffee yields though various percentages are given as indicators (Klein *et al*., 2003c; Klein *et al*., 2003b; Klein *et al*., 2003a).

Bee mediated pollination has been shown experimentally to increase coffee fruit weight and the give rise to improved fruit shape. It also leads to uniform ripening of coffee berries thus no field losses (Roubik, 2002a; Ricketts *et al*., 2004). Enhancement of number of fruits set and fruit quality would be ascribed to out crossing effects by pollinators depositing pollen grains from different coffee plants to coffee flowers and a higher efficiency of pollen deposition (Olschewski *et al*., 2006). Coffee berry size is enhanced by fruit set and the more successful fruit set is the larger the berry size and the higher the yields (Roubik, 2001).

This study has established that pollination enhances taste and aroma of processed coffee. Pollinator absence not only affects the total harvest but also quality of yield through misshapen fruits and unusually small fruits of inferior biological qualities associated with pollinator failure. Absence of pollination in coffee has been documented to lead to misshapen low quality fruits known as “pea berries” (Roubik, 2002a).

In a nutshell this study provided evidence that pollination services are important for enhancement of coffee yield and quality. Presence of pollinators during coffee flowering was found to lead to significantly heavier berries which translate to higher yielding coffee. Pollination also improves the quality of coffee cup through giving coffee a better taste and aroma and this is important when marketing coffee. Pollination is therefore an important ecosystem function for coffee productivity and conservation of wild bee species is important in coffee farms since in Kenya pollination is mainly feral.

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