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COFFEE (C*offea arabica*) POLLINATION WITH AFRICANIZED HONEYBEES IN VENEZUELA

Antonio José Manrique and Rafael Ernesto Thimann

SUMMARY

*In order to evaluate the pollination potential of Africanized honeybees, 10 hives were placed between rows of a coffee (*Coffea arabica *L.) plantation at "El Laurel" Experimental Station, of the Central University of Venezuela, Miranda State, Venezuela. Secondary branches were selected randomly from 60 adult plants. Yields from uncovered (T_1) and mesh covered (T_2) branches, as well as from uncovered branches located 1km away from the hives (T_3) were compared. Number of flowers blooming per branch, mature grains per branch and weight of the wet/dry grains harvested were recorded. The numbers of mature grains relative to flowers showed differences ($p<0.05$) with percentages of 91.6 (T_1), 82.6 (T_2) and 86.9 (T_3). Differences ($p<0.05$) were found in wet weight (g/grain) with values of 2.05 (T_1), 1.71 (T_2) and 1.83 (T_3). Highly significant differences ($p<0.01$) were found for dry weight (g/grain) with values of 0.45 (T_1), 0.37 (T_2) and 0.41 (T_3). The results suggest that the use of honeybees as coffee plant pollinators increases the percentage of mature grains/branches; thus increasing yields.*

RESUMEN

*Con la finalidad de estudiar el efecto de la abeja africanizada como agente polinizador en la producción de café, se realizó un ensayo en la Estación Experimental "El Laurel" de la Universidad Central de Venezuela, Estado Miranda, Venezuela, en un cafetal de 14 hectáreas de superficie, donde se seleccionaron 60 plantas adultas de café (*Coffea arabica *L.) al azar y de cada una se seleccionó una rama secundaria. En los callejones del plantío fueron colocadas 10 colmenas de abejas africanizadas, tres días antes de la floración. Se comparó el producto de ramas sin (T_1) y con (T_2) cobertura con una malla fina, así como de ramas sin cobertura en plantas ubicadas a más de 1km de distancia de las colmenas (T_3). Se determinó el número de botones florales por rama, número de granos maduros por rama, y peso húmedo y peso seco de los granos cosechados. Los tratamientos T_1, T_2 y T_3 arrojaron resultados estadísticamente diferentes ($p<0,05$) en peso húmedo (g/grano) con valores medios de 2,05, 1,71 e 1,83, respectivamente. En peso seco (g/grano) hubo diferencia altamente significativa ($p<0,01$) entre T_1, T_2 y T_3, con valores de 0,45, 0,37 y 0,41, respectivamente. El porcentaje de granos formados relativos a flores también mostró diferencias significativas (T_1= 91,6%, T_2= 82,6% y T_3= 86,9%). Los resultados obtenidos muestran que la polinización con abejas africanizadas promueve un incremento en el peso y la cantidad de grano formados, aumentando la productividad.*

Introduction

In Venezuela, coffee and cocoa have been the most important cash crops for trading and exports since the 18th century until oil was exploited, providing giving jobs for more than 60000 families in the highlands and their slopes, which constitute more than 35% of the land, where no other cash crop can be harvested without causing erosion. National coffee yields of 7.5 *quintals* (1q=100 pounds) per hectare are considered low (MAT, 2002) and for this reason research has been carried out to rationally and economically increase crop yields. This can be done by integrating the coffee crops with (e.g.) sheep to control weeds and supply organic matter to the soil, diverse fruit plant species (trees) for shade, small production of minor or secondary crops used for the everyday meals (cassava, squash, yams and others) and by the use of honey bees to increase entomophily pollination efficiency.

Coffee (*Coffea arabica*) is defined as an autogamous plant with some degree of cross-pollination with insect intervention. The great majority of coffee varieties have very aromatic flowers that produce abundant nectar and pollen that attracts insects (Henao, 1991). Non-attractive flowers and a short blooming period are cited as limiting factors in the use of honeybees for coffee crops (Couto, 1995). However, even though the blooming period is short, there are two sequences in it, one period of dense flower populations that bloom simultaneously followed by another short period of blooming where the honey bees can get nectar from the extra-floral nectaries located on the edge of the leaves (Sánchez, 1995). In spite of being considered by beekeepers in Venezuela as an excellent plant for honey production, preliminary work by Manrique (1996) has not led to this conclusion. While beekeepers agree on the use of honeybees to pollinate coffee crops, Badilla and Ramírez (1991) indicated that cross-pollination of coffee is still un-explained. On the other hand, Gómez (1986) pointed out that *C. arabica* species are self pollinated, but the use of honeybees would increase yields. An adult coffee

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RESUMO

*Com a finalidade de estudar o efeito da abelha africanizada como agente polinizador do café (*Coffea arabica *L.), foi desenvolvido um experimento na Estação Experimental "El Laurel" da Universidade Central da Venezuela, no Estado Miranda, Venezuela. Em um cafezal foram escolhidos 60 pés de café ao acaso e selecionado um ramo secundário de cada pé. Foram utilizadas 10 colônias de abelhas africanizadas, espalhadas no cafezal três dias antes da floração. Foram determinados os productos de ramos sem cobertura (T_1), ramos cobertos com uma malha fina (T_2) e ramos sem cobertura em pés situados a mais de 1km de distância das colônias (T_3). Foram realizadas as seguintes medições: números de botões florais por ramo, número de grãos maduros por ramo e pesos (úmido e seco) dos grãos coletados. Os tratamentos T_1, T_2 e T_3 foram estatisticamente diferentes em pesos úmido (gramas/grão) com valores médios de 2,05, 1,71 e 1,83, cada. Também houve diferenças estatísticas (P<0,01) em peso seco (gramas/grão) entre T_1, T_2 e T_3 com valores médios de 0,45, 0,37 e 0,41, respectivamente. A percentagem de grãos formados mostrou diferenças estatísticas (T_1=91,6%, T_2=82,6% e T_3=86,9%). Os resultados obtidos mostram que a polinização com abelhas africanizadas promove um aumento no peso e na qualidade dos grãos formados, melhorando a produtividade.*

plant has from 10000 to 50000 flowers, but almost 90% of them fall due to pollen incompatibility, defects of the embryonal sac or no pollination at all. Amaral (1972) suggested that a coffee plant can have different types of flowers in the same blooming period, and Badilla and Ramírez (1991) add that the loss of unmatured grains can be caused by a hormonal stimuli produced by cross-pollination with other plants of the same species that promotes the phenomenon.

Malerbo (1996) used chemical attractants in a coffee crop that bloomed simultaneous to an orange plantation and observed that the honeybees preferred foraging for pollen when few flowers were opened and foraging for nectar when a great number of flowers were open.

Amaral (1972) selected a patch of coffee plants where half of the plants were covered with mesh and the other half were uncovered and found a 13.6% increment of mature grains in uncovered plants, noting the benefit of entomophily pollination. Furthermore, the same author found that the closer the hives were to the coffee crop, the higher the number of honey bees that visited them, suggesting distances of 25m rather than 50 to 100m. Raw and Free (1977) obtained increases of 59% in the *Caturra* coffee production due to honey bee pollination. For this reason, Free (1993) suggested that the coffee growers should place hives among crops during the blooming periods, as a means to achieve higher yields.

The purpose of the present work was to evaluate the pollination effect of Africanized honeybees in coffee (*Coffea arabica* L.) production at an experimental station.

Materials and Methods

Facilities

Research was carried out at the "El Laurel" Experimental Station, Central University of Venezuela, Miranda State, which is located in a premountain forest considered by FONAIAP (1988) to have the best coffee production climatic conditions, such as 80% relative humidity, 1400mm annual rainfall, 17°C average temperature and 1400m altitude.

Biological material

The experimental area was a 14ha coffee (*Coffea arabica* L var. Catimor) crop, with seven year plants and a density of 2m between rows and 1m within plants. Shade was provided with adult *Inga* spp. trees. Sixty adult plants were selected randomly and from each one a secondary branch was marked with a white plastic ring. Three days before the flowers bloomed, 10 hives with strong Africanized honeybee colonies were placed between rows in a 7ha plot, each hive separated by 30m, so as to saturate the surroundings with honeybees. The other 7ha plot, with the same agro-ecological conditions, was located 1km from the first plot. Three different treatment groups were considered: 20 uncovered branches (T_1) and 20 branches covered with a fine mesh (T_2), both in the hive-containing plot, and 20 uncovered branches from the plot located 1km away from the hives (T_3). The bee colonies were fed with sugar syrup (1:1) one month prior to flower blooming.

Measurements

Secondary branches were selected two days before placing the hives in the experimental area, and floral sprouts counted. Following the sixth day of blooming, the covering mesh and the beehives were retired. Three months later, grains formed were counted so as to compare their numbers with the matured grains harvested later by hand. The mature harvested grains were counted, placed in paper bags to determine wet weight, and then de-pulped and dried for three days at 38°C to determine dry weight. For statistical analysis, the multiple comparison Tukey test was applied to the recorded data.

Results and Discussion

Foraging behavior of honeybees

Coffee flowers standard blooming behavior was closely related to the beginning of the rainy season in the region, where rainfall above 10mm was followed by a reduction of the hydric balance, as mentioned by Benezra (1987). Early in the morning coffee flowers began opening, until the afternoon. The highest numbers of pollinating agents foraged mostly between 7 and 10am and from 4 to 5pm (Figure 1). These specific hours of forage might be related to the moderate solar radiation on the crop, which promotes a rise in temperature and humidity that

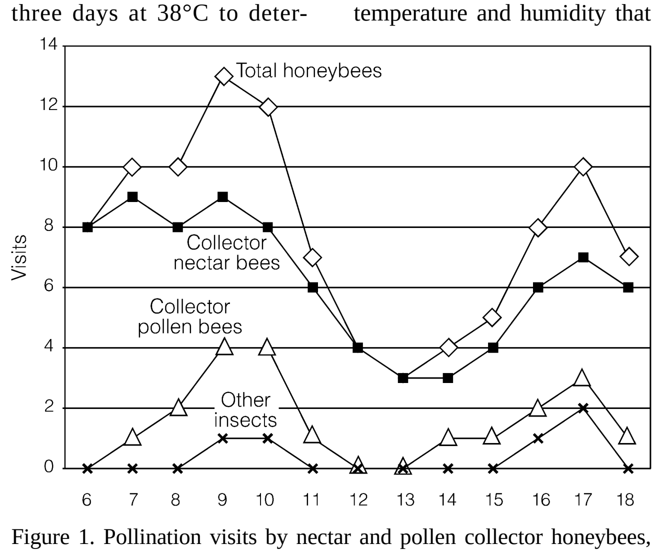

Figure 1. Pollination visits by nectar and pollen collector honeybees, and other insects, according to the hour.

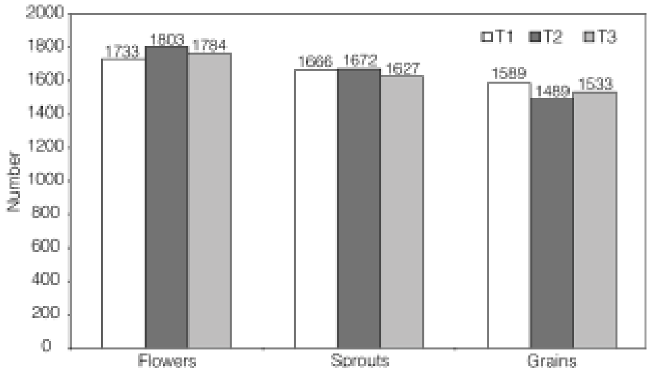

Figure 2. Flowers, sprouts and coffee grains obtained after honeybee and insect pollination for the three experimental groups.

TABLE I
WET AND DRY WEIGHT AND RIPE GRAINS PRODUCED

Experimental groups	TWW (g)	WW/GRAIN (g)	TDW (g)	DW/GRAIN (g)
T_1	3239.07 a	2.05 a	712.02 a	0.45 A
T_2	2546.21 c	1.71 b	551.88 c	0.37 C
T_3	2801.73 b	1.83 b	628.21 b	0.41 B

TWW= Total wet weight the grains, WW/GRAIN= Wet weight by formed grain, TDW= Total dry weight the grains, DW/GRAIN= Dry weight of grain formed.
Different letters indicate Significant differences are indicated by small letters (P< 0.05) and capital letters (P< 0.01).

stimulates nectar and aroma production. On the other side, honeybees were seen foraging mostly for nectar and less for pollen, in accordance with the observation of Badilla and Ramírez (1991). Carvalho and Krug (1950) observed that in days without sunlight the coffee flowers would not open and tend to self-pollinate.

Gómez (1986) pointed out that coffee crops were a good source of nectar for honey production, but in this work results showed low nectar (honey) yields, probably due to sunny days, continuous rain, low night temperatures and the short blooming period (5 days), affecting negatively the storage of nectar, in agreement with the results obtained by Manrique (1996).

Development and production of coffee grains

Figure 2 summarizes the average number of flower buds, mature flowers and ripe grains during the experimental period. Coffee grain counts were higher ($P<0.05$) in T_1 as compared to T_2 and T_3. The percentage of ripened grains, relative to flowers was also higher ($P<0.05$) in T_1 (91.6%) when compared to T_2 (82.6%) and T_3 (86.9%). These results differ somewhat from those of Amaral (1972) and Raw and Free (1977) who obtained increments in ripe grains of *Caturra* coffee of 13.6 and 59%, respectively, when honey bees were used to pollinate the crops.

The lower yields obtained in T_2 and T_3, could be due to a greater fall of non-mature grains or to the absence of fruit formation, which would indicate that a greater entomophily pollination is necessary in the formation of the grain, as suggested by Amaral (1972) who states that the smaller formation of coffee fruits in absence of insects indicates that a given plant has some flowers that require cross-pollination and others that are self-fertilized. On the other hand, Badilla and Ramírez (1991) indicate that the fall of non-mature fruits could be due to the fact that bees and other pollinators, when bringing pollen of other plants of the same species, produce a stimulus in the initial growth of the fruit, through a hormonal effect, that remains until the fruit achieves maturity.

Dry/wet weight of ripe grains

Table I shows the average weights for dry and wet ripe grains harvested. T_1 resulted in higher yields when comparing the total wet weight (TWW), with values of 27.2 and 15.6% above those from T_2 and T_3, respectively. When comparing the total dry weight per grain (DW/GRAIN) T_1 resulted in yields 21.6 and 9.75% higher than T_2 and T_3, respectively. Taking into account that T_3 did not have a control of natural/feral pollinating agents, the small (~10%) differences between T_1 and T_3 might give the impression that for higher yields of ripe coffee grains there is a need for honeybees to pollinate the crops.

Conclusion

The results suggest that the use of Africanized honeybees as pollinating agents for coffee crops might increase yields of ripe grains per plant.

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