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Some factors affecting pollination and yield of Hass avocados

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INTRODUCTION

Fuerte is the most popular avocado cultivar in South Africa according to tree numbers, closely followed by Hass. With the latter cultivar however, growers experience small fruit problems. Three organizations, namely Merensky Technological Services, Duivelskloof, the Department of Plant Production of the University of Pretoria, and the Plant Protection Research Institute of the ARC, Pretoria, undertook a collaborative 3-year study to determine the influence of Ettinger pollen on fruit set, yield and fruit size of Hass. Botanical, horticultural and apicultural aspects were addressed.

In this paper we report on the final test with caged trees, and on pollen trapping. Materials and Methods are not detailed, and apply to all three seasons in general. We then summarize the main results of the three years' investigations. The practical implications of these results for the avocado grower are briefly discussed. Finally, references of the published results of the collaborators in the SAAGA Yearbooks are listed. These papers contain other literature references, as well as brief literature reviews.

MATERIALS AND METHODS

The trials were carried out in two commercial avocado orchards during three seasons when the trees were 4-6 years old. The orchards at "Goedgelegen", Mooketsi, and "Silverfontein", Politsi, consisted of 1 ha blocks of Hass bordered on two sides by Ettinger trees. The Mooketsi orchard is situated in a dry bushveld area with an average annual rainfall of 550 mm. The Politsi orchard is situated in a high rainfall, escarpment area with eucalypt plantations, subtropical fruit orchards, and patches of indigenous forest. Here the average annual rainfall is 1300 mm.

Pollen

Female phase Hass flowers were either naturally bee-pollinated or artificially pollinated with pollen of different ages and of different cultivars. The flowers were stuck into agar in petri dishes, fixed, cleared, and stained. Pollen germination and tube growth were determined by fluorescence microscopy.

Pollination and Yield

Hass and Hass or Hass and Ettinger trees were caged in 40% shadecloth tents, with and without bees (Table 1). Fruit set and yield was determined for the caged trees, as well as for open pollinated Hass at different distances from Ettinger pollen donor.

Honeybees

Bees were counted on flowering avocado trees at different distances from apiaries and in different directions. Outgoing forager bees were also marked with fluorescent powder, and inflorescences were subsequently UV-scanned at different distances from hives and in different directions. Honeybee colony development was assessed during the avocado flowering periods. Pollen traps were installed on beehives during one flowering period only, and pollen pellets were identified and counted.

RESULTS AND DISCUSSION

The following results refer to the 1997/1998 season only.

Pollination and Yield

At Mooketsi, yields in two Hass orchard blocks with open pollination did not differ with regard to increasing distance from Ettinger pollen donors in 1998 (Figures 1 and 2), except for block number 1 in 1997, where the yield was significantly higher closer to the pollen donor. At Politsi also, no Hass yield differences were found (Figure 3).

Table 1. Caging treatments applied to avocados

Cultivar	Pollinator	Abbreviation	No. of cages
Ettinger x Hass	with bees	E x H + b	3
Hass x Hass	with bees	H x H + b	3
Ettinger x Hass	no bees	E x H - b	1
Hass x Hass	no bees	H x H - b	1

(Caging treatments from Politsi only)

The results of the controlled pollination treatments compared to open pollination are depicted in Figure 4. (For treatments and abbreviations, see Table 1). Yields of caged Hass trees without bees were extremely low. No yield differences were observed in Hass trees caged with either Ettinger or Hass in the absence of bees, neither when bees were present, except that the yield with bees was increased significantly, from 1 kg to 60 kg per tree. The yield of open-pollinated Haas trees was twice that of caged trees with bees. This may be explained by the fact that at this location, the large trees had to be pruned to fit the cages.

The results from both the Mooketsi and the Politsi orchards demonstrate that, under Mooketsi and Politsi conditions, honey bees play a more important role in Haas avocado production than does the pollen donor Ettinger.

Table 2. Pollen pellets collected by honeybees in a flowering avocado orchard at Politsi.

29.9.98	n=26	5.10.98	n=162
38.5% Unknown		48.8% Litchi	
34.9% *Persea*	Avocado	37.7% Trema	Pigeonwood
15.4% Bidens type	Blackjack type	10.5% Bidens type	Blackjack type
7.7% Proteaceae	Type unknown	1.8% Populus	Poplar
3.8% Unknown		0.6% *Melampsora* Fungal spores	
		0.6% Unknown	

(n = number of pollen pellets)

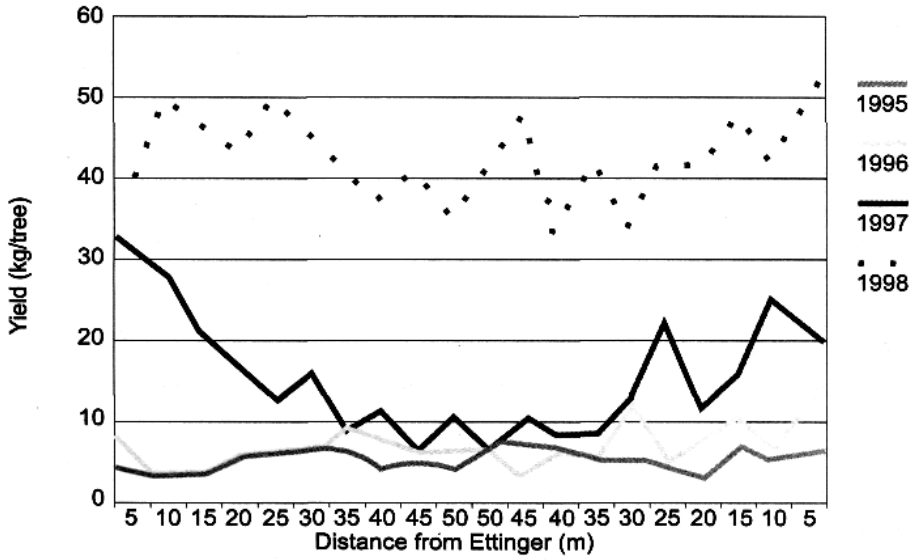

Figure 1. ***Hass yield as influenced by distance from Ettinger pollen donor over four consecutive years in orchard block 1 at Mooketsi (400 trees/ha)***

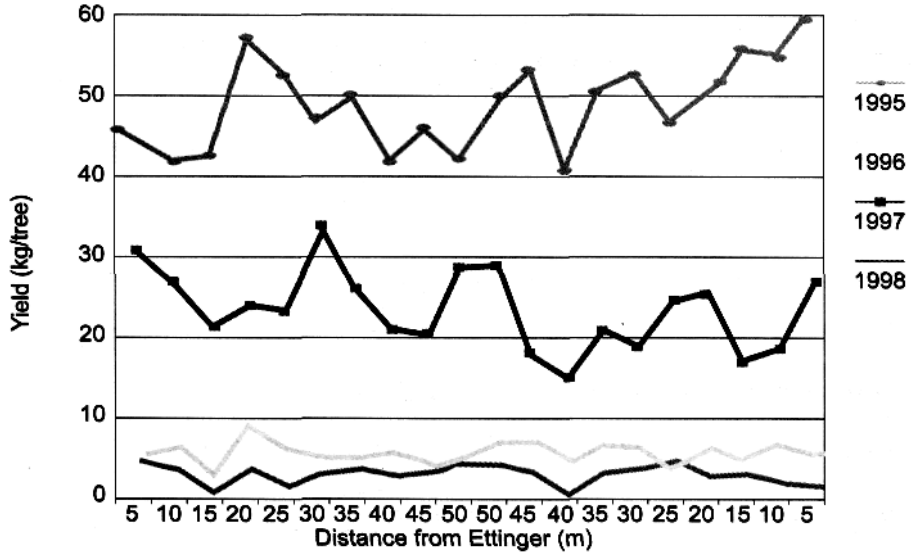

Figure 2. ***Hass yield as influenced by distance from Ettinger pollen donor over four consecutive years in orchard block 2 at Mooketsi (400 trees/ha)***

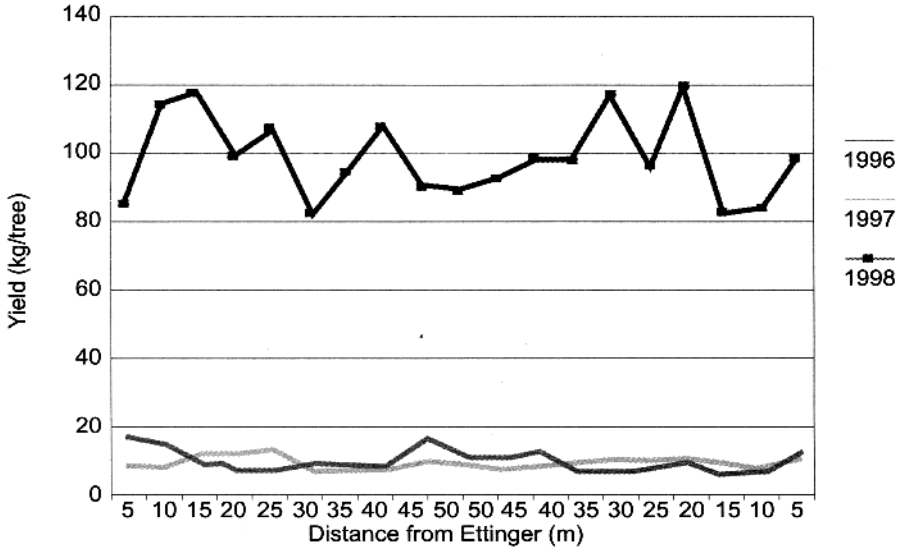

Figure 3. ***Hass yield as influenced by distance from Ettinger pollen donor over three consecutive years at Politsi (200 trees/ha)***

Honeybees

Colony development during flowering could not be followed through, because at Mooketsi the colonies were destroyed by honey badgers, a problem not encountered during the previous two seasons. At Politsi a number of hives were completely robbed out; in others the honey was stolen. One pollen trap was nevertheless maintained on a hive. The pollen pellet results of only two weekly samples are available (Table 2). The

other samples were lost in Pretoria when they were literally washed out in a severe storm during which the ceiling of the laboratory gave way under the rainwater.

In the previous year (Robbertse *et al.*, 1998) there was an almost total absence of bees on Haas trees in the Politsi orchard, except in very close proximity to the hives. This was ascribed to the greater attractiveness of Ettinger flowers, and/or the presence of competitive bee plants. Pollen traps were therefore installed the following season to establish the presence or not of other plants that are more attractive to bees.

Because of the pollen mishap mentioned above, the pellet sample sizes in Table 2 are small. They also represent only the latter part of the avocado flowering period. The results nevertheless demonstrate that Litchi, Trema and an unknown plant were strong contenders for honeybee visits. Honeybees' strong attraction to litchi flowers compared to avocado flowers has been observed by avocado farmers and beekeepers.

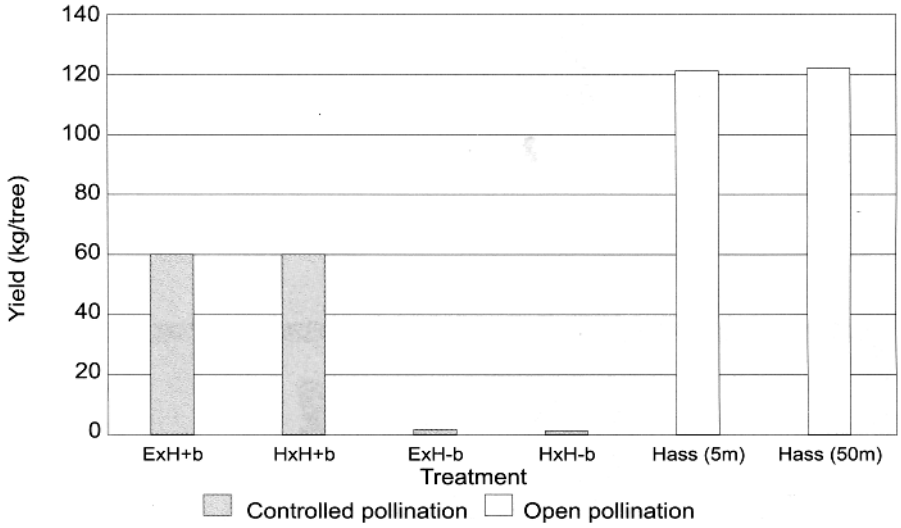

Figure 4. The influence on yield of Hass trees caged with Ettinger or Hass, with or without bees, and compared to open pollination at Politsi, 1998 (for abbreviation see table 1).

SUMMARY OF RESULTS, AND THEIR IMPLICATIONS FOR THE AVOCADO FARMER

- Low temperatures during avocado flowering change the female and male stages, reducing the chances for cross-pollination, and affecting pollen germination and pollen tube growth. (Flowers open at 20°C; optimum pollen tube growth at 25-28°C.
- Cold periods occur during avocado flowering, particularly if the flowering starts early, i.e. in July. Such cold snaps rarely affect bee activity, but pollen development is greatly curtailed. This results in strongly reduced fruit set during the cold period. There is little the avocado farmer can do about the weather, apart from keeping the cold factor in mind when choosing orchard sites.

- Ettinger and Fuerte pollen outperformed Haas pollen on Haas pistils, i.e. pollen tubes reaching the ovary (= effective pollination).
- In a Haas single cultivar orchard, a commercial avocado crop can nevertheless be obtained with sound horticultural practices and sufficient numbers of honeybees for pollination.
- Although Ettinger pollen remained viable for 3 days (could germinate), 24h old pollen could not effect fertilization.
- The transfer of fresh pollen by bees is thus necessary for pollination to result in fertilization and fruit set. Pollen carried on bees' bodies overnight in the hive is unlikely to result in effective pollination the next day.
- There is a tendency for a positive correlation between the number of pollen grains germinating on the stigma and the number of pollen tubes entering the ovule.
- The more pollen grains are deposited on the stigma by honey bees, the greater is the possibility for fertilization and resultant fruit set.
- Fruit drop (abscission) from 'Haas' trees crossed with Ettinger pollen was significantly less than fruit drop of Haas crossed with Haas.
- Although cross-cultivar pollination of Haas results in greater set in this cultivar, single cultivar orchards of Haas in South Africa can yield a commercial fruit crop with good orchard management and adequate numbers of bees during flowering.
- The difference in fruit set of caged trees (January counts) was highly significant with and without bees (Set was increased 2-5 times and yield 10 times).
- Sufficient numbers of wild and/or managed honey bees are essential for avocado production.
- There was no decline in Haas yield with increasing distance form Ettinger pollen donor, except for one orchard in one season.
- The strong dependency of Haas on close-by Ettinger pollen donor for a commercial yield, as is the case in Israel, was not demonstrated in local trials.
- The wild honey bee population can vary greatly from one flowering season to the next in the same orchard.
- Rather than relying on wild honey bees for pollination, avocado farmers should invest in hived honeybee colonies that are placed in the orchards.
- Hive placement: groups of 6-10 hives, not more than 400m apart. Recommended bee density: 5 bees/m^2 of flower canopy (or per 20 inflorescences).
- In many countries the recommended number of hives in flowering avocado orchards is 3/ha. This figure does not take into account the density of trees, tree size, and bee-attractive competitors like citrus and litchi.
- Honey bee colonies in flowering avocado orchards maintained colony size, but brood production declined. Little surplus honey was collected. (Avocado flowers are a medium source of nectar and a minor source of pollen for honey bees).

- At the recommended hive density for pollination, honey bee colonies store little or no surplus honey, and brood production declines. Beekeepers should be paid for avocado pollination.

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