

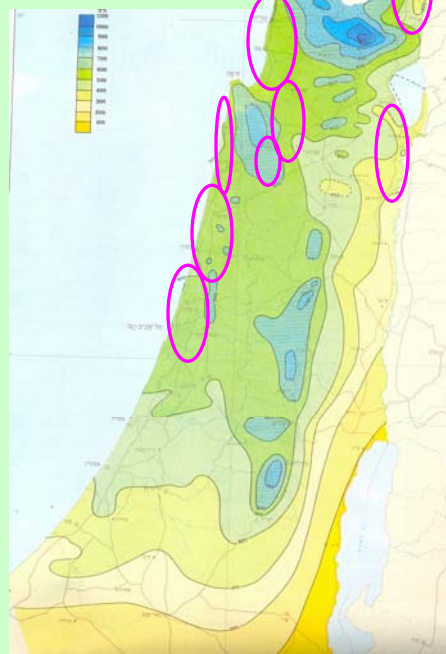
Regions of Avocado growing in Israel

Altitude: mostly in the coastal plain and in the internal valleys. Sometimes on hills, up to 300 m. above sea level.

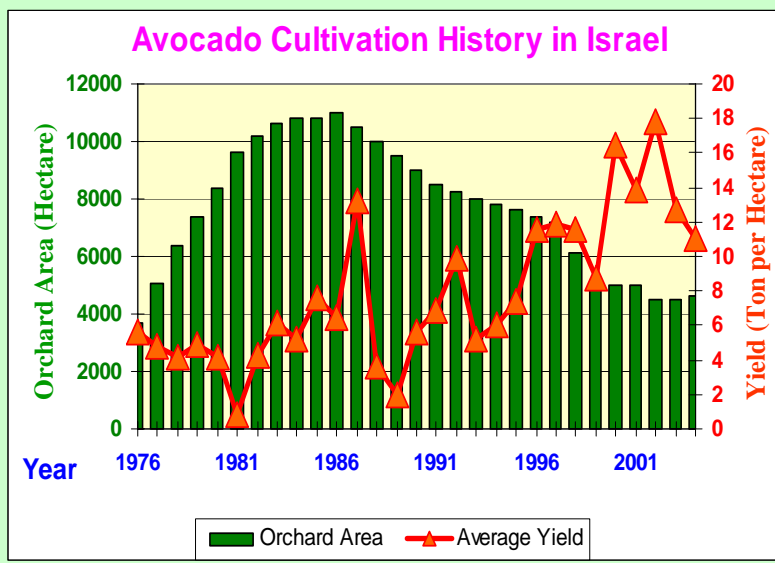
Precipitation: mostly in the rainy regions. Not in the desert area.

Temperatures: within the mild and the hot regions only.

Annual precipitation



Last 28 years of avocado cultivation in Israel: orchard area and average yield

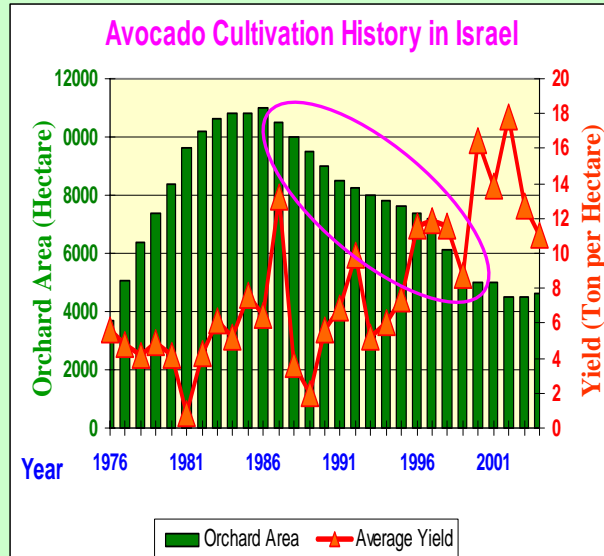


Reasons for avocado orchard area decrease (from the mid 80's):

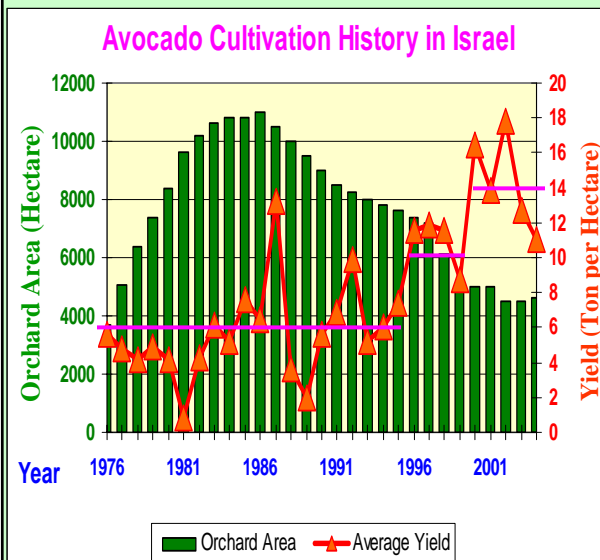
Shortage of fresh water: Due to successive dry years.

Decline of avocado fruit price: mainly in the European market.

Rising of orchard expenses: owing to the agriculture crisis in Israel.



Average yield increasing:



2000 and later: average yield has been stabilized around 14 ton/ha.

1995 - 1998: average yield of 10 ton/ha.

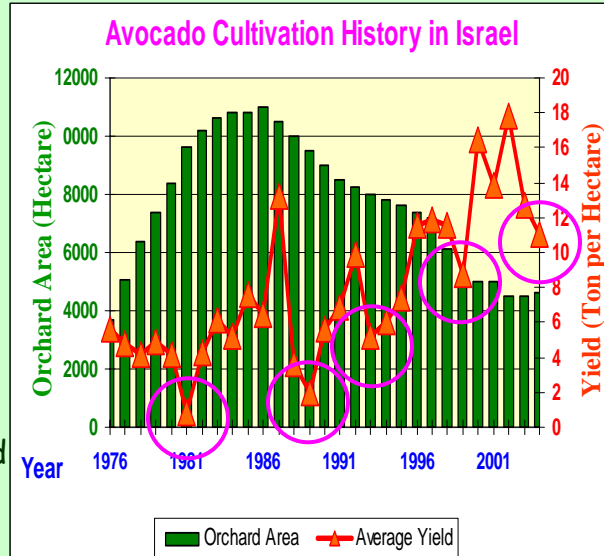
1970 - 1994: average yield of 6 ton/ha.

Reasons for the relative low-yield years (happens once in 5-10 years):

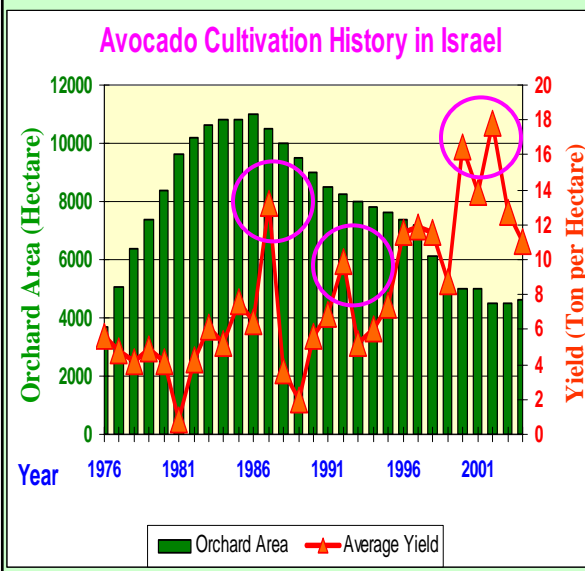
Climate disaster:
mainly a heavy
"Hamsin" during bloom
and fruit set.

Bad pollination
condition: due to
severe competition
for pollination.

"Off year": usually
after a very high-yield
year.



The relatively high-yield years are a product of an infrequent combination:



Good pollination
season: under
condition of very low
competition for
pollination.

Mild spring: with no
"Hamsin" spells.

This infrequent
combination may
appear when a hot and
dry winter is followed
by a cool spring.

Which factors produced the yield increase?

A. Adding pollinizer trees to solid-block orchards

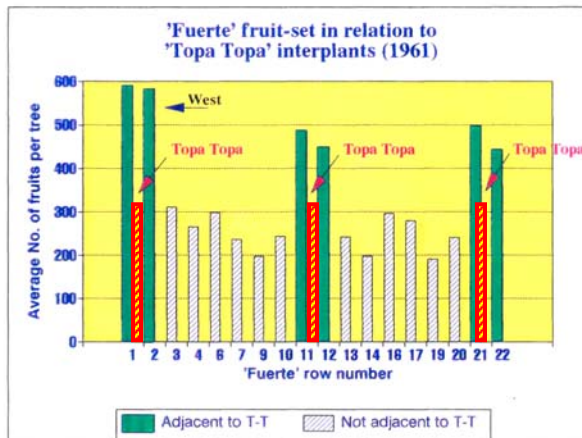
Bergh et al., 1966, California; Guil et al., 1986, Israel

Bergh et al., 1966:

'Topa-Topa' trees were inter-planted every 10th row in 'Fuerte' plot as wind breakers.

The yield of the adjacent 'Fuerte' rows was almost doubled.

The yield of the other rows was practically not influenced.

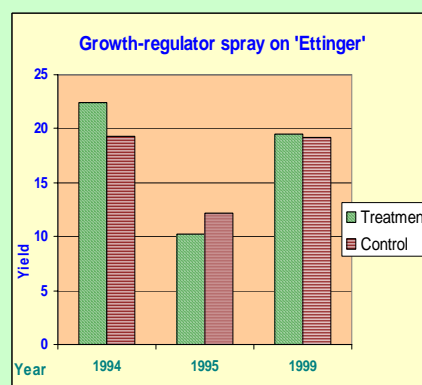
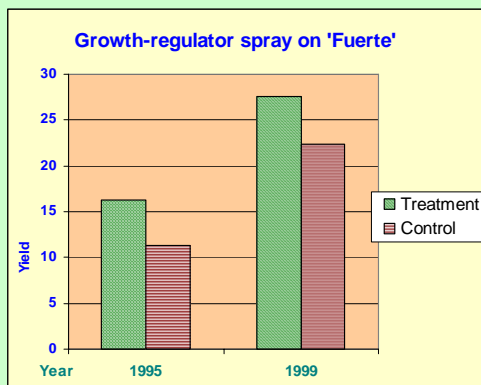


Source: Bergh et al., 1966, Proc. Amer. Soc. Hort. Sci. 89:167-174 (California)

Factors that produced the yield increase

B. Spraying with a growth regulator during bloom

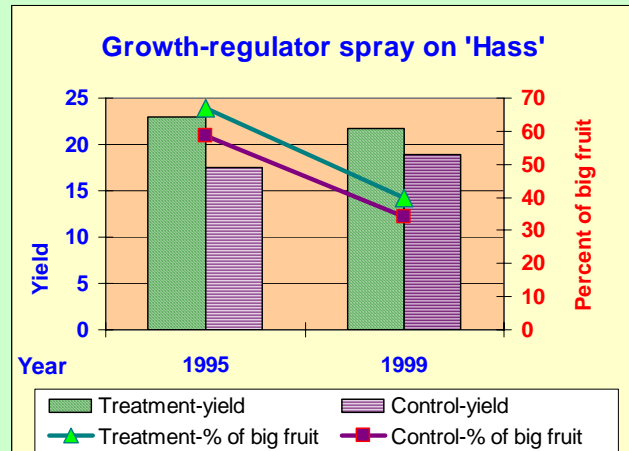
Adato, 1990; Peterman et al., 1999, Israel



Factors that produced the yield increase

B. Spraying with a growth regulator during bloom

Adato, 1990; Peterman et al., 1999, Israel



Factors that produced the yield increase

C. (Only) a small increase of honeybee-hive density in the orchards during bloom. Ish-Am, 1994. PhD Thesis

Hive density was raised from 0-2.5 hives/ha. To 3-4 hives/ha.

More attention has also been given to hive quality.



More factors that affected yield increase

D. Improving of irrigation, fertilization and pruning methods.

E. A selective elimination of low-yielding orchards.

What is the ultimate yield potential of the avocado in Israel?



Experiments in improving the honeybee efficiency as an avocado pollinator (1)

A. Kalman, 1976, Israel: Feeding the bees with sugar solution containing avocado flowers.

No positive results.

B. Melamud, 1981, Israel: Spraying the trees with attractive scent or with sugar solution.

No positive results.

C. Ish-Am, 1984, Israel: Distributing water basins throughout the orchard.

No positive results.



Experiments in improving the honeybee efficiency as an avocado pollinator (2)



D. Melamud & Eisikowitch, 1982, Israel: Starving the bees by attaching pollen- traps to the hive entrance.

No positive results.

E. Ish-Am, 1994, Israel: Starving the bees by blocking the hive entrance, to be open at the daily peak of the avocado bloom.

No positive results.

F. Melamud, 1983, Israel: Moving the hives within the orchard every few days.

No positive results.

Experiments in improving the honeybee efficiency as an avocado pollinator (3)

G. Melamud, 1983, Israel: Introducing young swarms to the blooming orchard.

Pollination improvement for a few days.

H. Ish-Am, 1998, Israel: Introducing the hives to the orchard in several waves, every few days.

Pollination improvement for a few days.

I. Vithanage, 1990, Australia; Ish-Am, 1994, Israel; Hofshi, 2000, CA: Increasing hive density up to 10 hives per hectare.

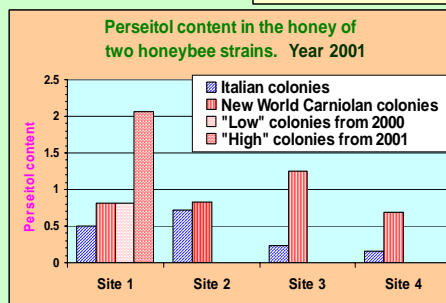
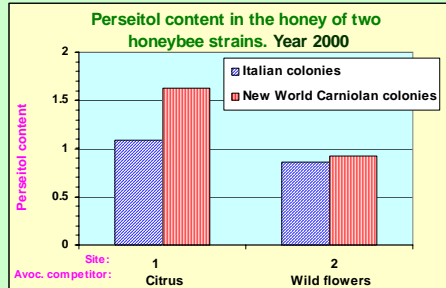
Significant improvement of pollination!



Experiments in improving the honeybee efficiency as an avocado pollinator (4)

J. Hofshi, 2000, CA;
Dag, 2003, Israel:
Looking for an
avocado preferring
honeybee race.

Results look quite promising!



Experiments with Bumblebees as avocado pollinators

Bombus terrestris is a native social bumblebee that lives in Northern Israel.

It was domesticated in Israel during the early 90's, mainly for tomato pollination.

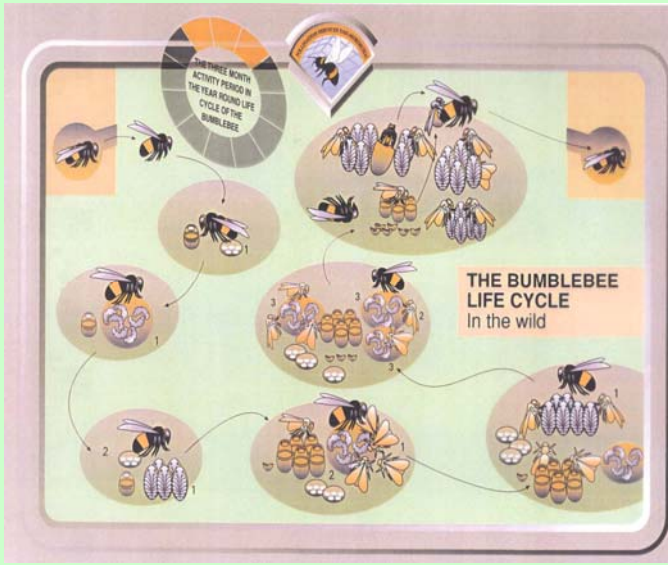
Experiments were conducted by Ish-Am et al., 1995-2000.



Life cycle of the Bumblebee

The bumble is a semi-social bee: the whole nest dies in the fall, and the queens only stay for the winter.

Active period of the nest lasts from early spring to late fall.



Advantages of the Bombus over the honeybee as a pollinator of the avocado

The Bombus:


Carries much more pollen on its bigger and more hairy body.

Works faster: visits 20 flowers/min., while the honeybee visits only 6-9 flowers/min.

More efficient as a cross-pollinator.

May less prefer other flowers to the avocado.





Experiment design



Treatments:

- Honeybee hives only, normal density (control).
- Honeybees and bumblebees, normal density each (HB+BB).
- Bumblebee hives only, normal density (BB).
- Honeybee hives in double density (HBx2).

Experiment were run for 6 years in 4 regions in Israel. BB treatment only for 2 years in one location.

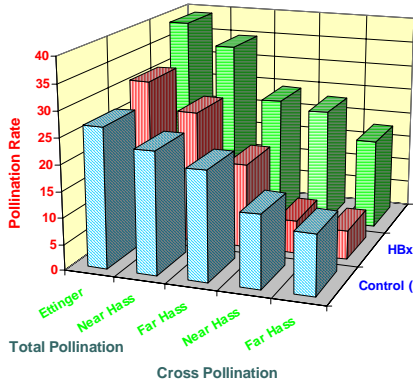
Experiment difficulties

1. Distance between treatments must be more than 2 km.
2. The BB treatment should placed where no HB hives exist, within radius of at least 2 km.
3. Towards the end of the season, hungry honeybees may aggressively enter BB hives and rob them.



Bombus experiment: Pollination rate and cross-pollination progenies

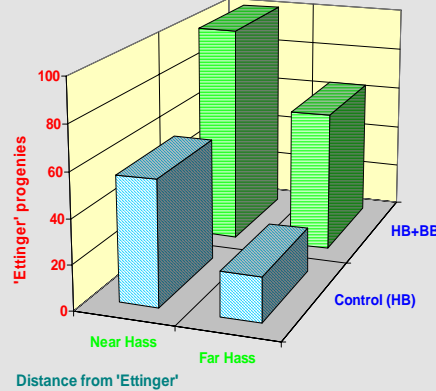
Bombus Experiment: Pollination Rate (%)
2 years, 10 measurements



Bombus improved mainly cross-Pollination.

Bombus significantly increased cross-Pollination progenies' percent.

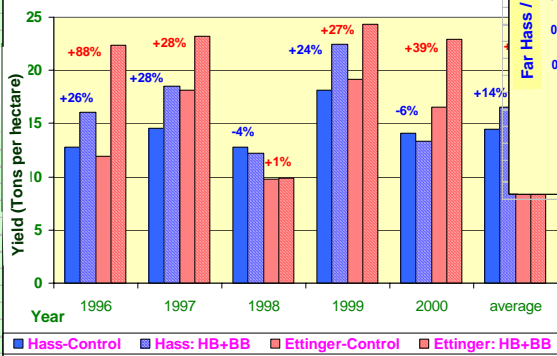
Bombus Experiment: Percent of 'Hass' fruits that are 'Ettinger' progenies



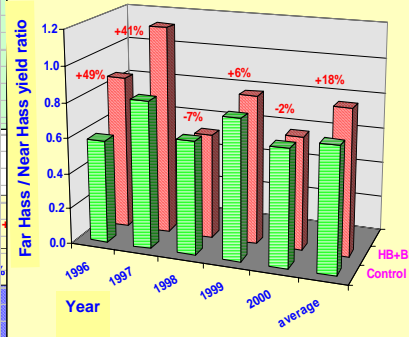
Bombus experiment: Yield, and yield-ratio of "far Hass" to "near Hass"

Bombus increased 'Ettinger' yield in 4 of 5 years (+36% on average), and 'Hass' yield in 3 of 5 years (+14% on average).

Bombus Experiment: Yield of Five Years



Far Hass to Near Hass Yield Ratio



Bombus increased 'Hass' yield ratio in 3 of 5 years (+18% on average).

Study of the original avocado pollinators in Central America (Ish-Am et al., 1999)

The avocado (Persea americana) is native to the Sub-Tropical region of Central America.

The avocado native pollinators should be much better adapted for its pollination than the European honeybee.

The study was carried out in Mexico and Guatemala, by Ish-Am et al., 1996-1999.



Geotrigona acapulconis, a stingless bee, one of the native avocado pollinators.

The original avocado pollinators in Central America

The native avocado pollinators are mainly social stingless-bee species.



Scaptotrigona mexicana, a stingless bee, native pollinator of avocado that was domesticated in Mexico.



Experimental import of *Scaptotrigona* hives from Mexico to Israel (Ish-Am et al., 2000-2003)

Thirteen modern *Scaptotrigona* hives were brought to Israel at the end of 2002, for experimental use as avocado pollinators.

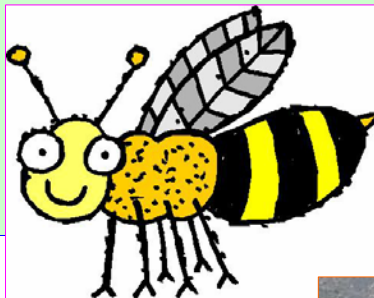
All the imported colonies died in April 2003, during a very heavy "Hamsin".

Modern hives of *Scaptotrigona mexicana*, as they are grown in Mexico.

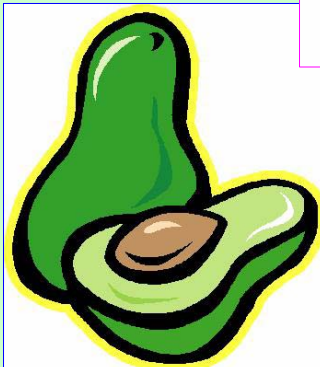


What should be done for the future?

For a heavy avocado crop one needs...

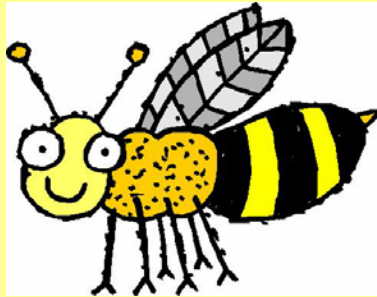


Enough honeybees in the orchard...



And adjacent pollinizer, of an adequate cultivar.





Thank you!!!