

# Avocado

*Persea americana* Mill



# Origin and races

- Family: *Lauraceae*
- Genus: *Persea*
- Species: *americana*
- Latin name: *Persea americana* Mill.
- Origin: Central America – Mexico and Guatemala





## **Avocado = (Aztec ) Ahuacatl**

Another names: Palta (Inca) ,Custard apple (Africa),  
abogado (Spain), avocat (France)



## Origin: Mexico and Guatemala





## History of the crop

<http://www.avocado.org/about-california-avocados/>

Avocado has grown wild in Mexico for ca. 10,000 years, and cultivated for ca. 2,500 years 500 years ago, avocado began to be distributed to other countries.



# Origin and races

Seedling fruit of avocado  
from: San Jerónimo, Costa Rica, April 1997.



**Birnbaum et al., 2003**

# Origin and races

## Variation in seed size and fruit shape of some avocado seedling



**Fig. 3.1.** Variation in seed size and fruit shape within seedlings of the same progeny.

Whiley et al., 2002



# Origin and races

## Variation in colour and shape

Variation in West Indian race avocados obtained from a seedling grove in the Yucatan, Mexico.





**The avocado is divided into 3 types, called races. The 3 races differ in:**

- Thickness of the pericarp
- Time between flowering and fruit maturation
- The "anise" (licorice) smell of their leaves

Other differences include: sensitivity to frost, resistance to salinity, etc.

## Main characteristics of the 3 races

Race	Topography	Anise smell	Pericarp	Time from flowering to fruit maturation	Resistance to frost	Resistance to salinity
Mexican	High mountains	+	Thin	5-7	High	Low
Guatemalan	Mountains	-	Thick	9-12	Medium	Medium
West Indian	Tropical valleys	-	Medium	6-8	Low	High

# Origin and races

## Origin: Central America – Mexico and Guatemala



West  
Indian  
(plain)

Guatemalan  
(mountains)

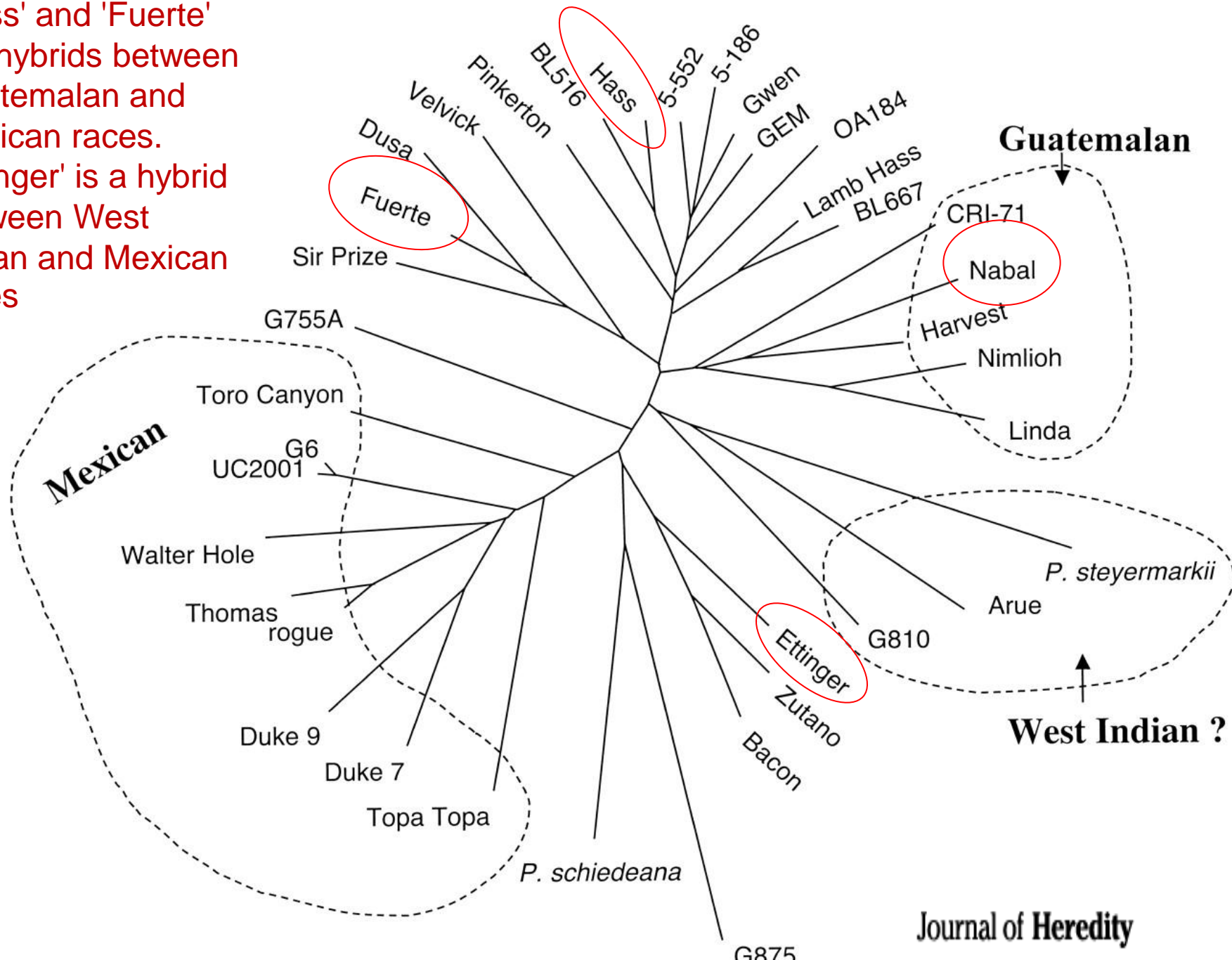
Mexican  
(high  
mountains)



# Origin and races

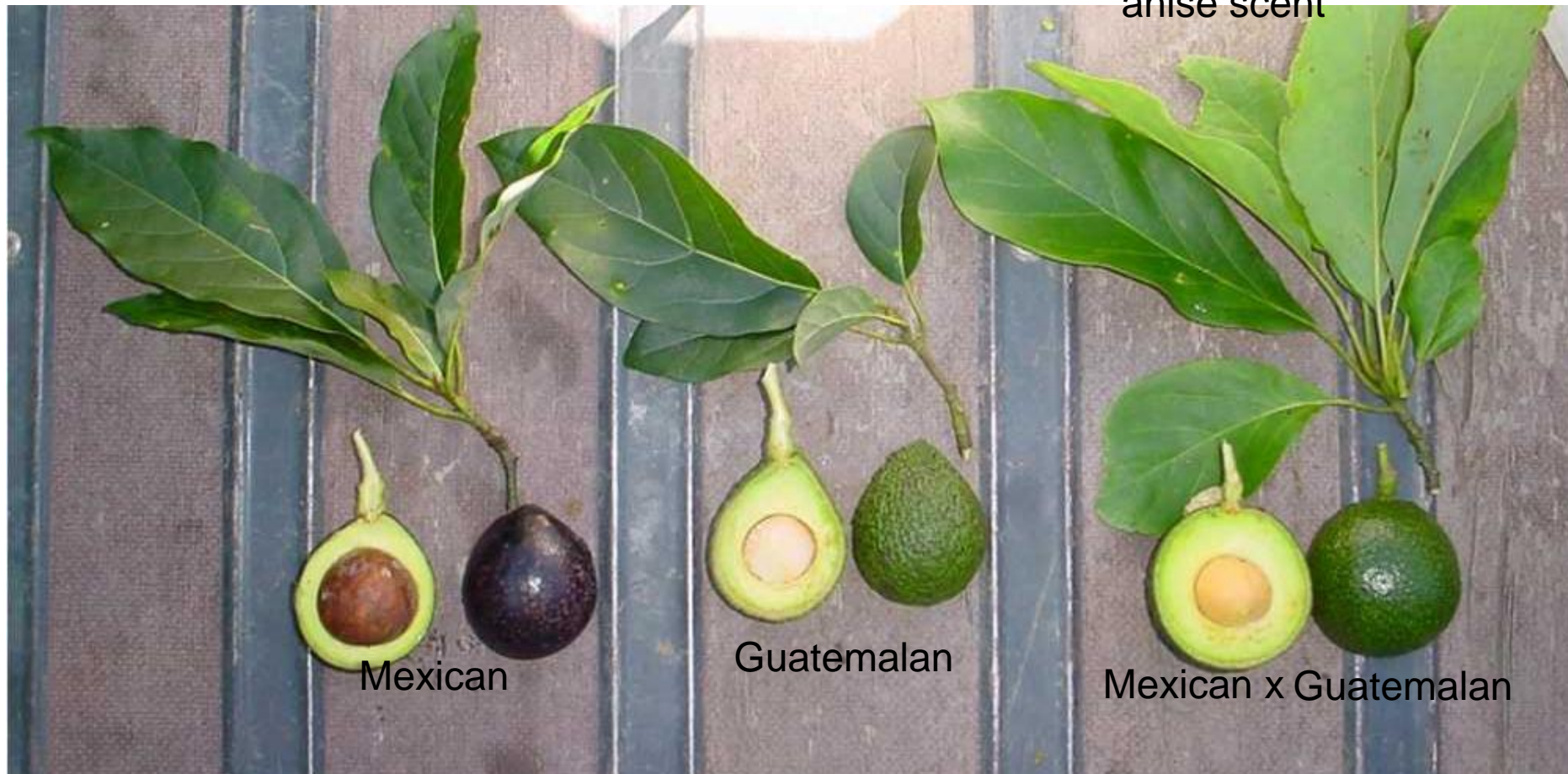
- There are many hybrids of these 3 races.
- Some hybrids are natural occurrences and others stem from artificial hybridization.
- 'Nabal' belongs to the Guatemalan race, but 'Hass', 'Fuerte' and 'Ettinger' are hybrids of 2 different races.

'Hass' and 'Fuerte'  
are hybrids between  
Guatemalan and  
Mexican races.  
'Ettinger' is a hybrid  
between West  
Indian and Mexican  
races



# Origin and races

## Natural hybrids





# The reproductive biology of the avocado

## Pollination



## To set fruit, the tree has to pass through 5 steps:

1. **Differentiation** to flowering (Nov-Dec)
2. **Normal flower development** – male and female (Jan-Mar)
3. **Pollination** – pollen movement between flowers
4. **Fertilization** – pollen (n) tube growth in the style until the male gamete conjugates with the female gamete – egg cell (n) to create the zygote (2n)
5. **Fruit development**

## Differentiation

- During the fall – 3 to 5 months before flowering (in deciduous plants – 9 months before bloom)
- In a heavy crop load ("On" year) → reduction of differentiation, especially in 'Hass'
- The main reasons:
  1. Lots of fruit → many seeds/tree → high synthesis of gibberellin → reduction of differentiation potential
  2. Competition between the fruits and buds for assimilates → less C to the buds → less differentiation



## **How can we reduce "alternate bearing"?**

1. Thin some of the fruit → reduction of competition
2. Inhibit the fall vegetative flush (which needs a lot of carbohydrates) using growth retardants ('Kultar', 'Magic')

## Flower development

- Usually, there are no problems with avocado flowers.
- A very cold winter ( $<0^{\circ}\text{C}$ ) or a very hot spring ( $>35^{\circ}\text{C}$ ) can harm the female and male flower organs.

# Pollination and fertilization

## Pollination and fertilization (spring)

Bloom → first step for obtaining fruit

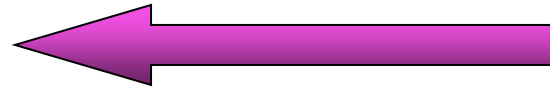


# Pollination and fertilization

Avocado fruit



Avocado flower



**Who is in charge of the transfer from flower to fruit?**

**Honeybee**



# Pollination and fertilization

The honeybee is responsible for the pollination process (transfer of pollen grains from one flower to another).

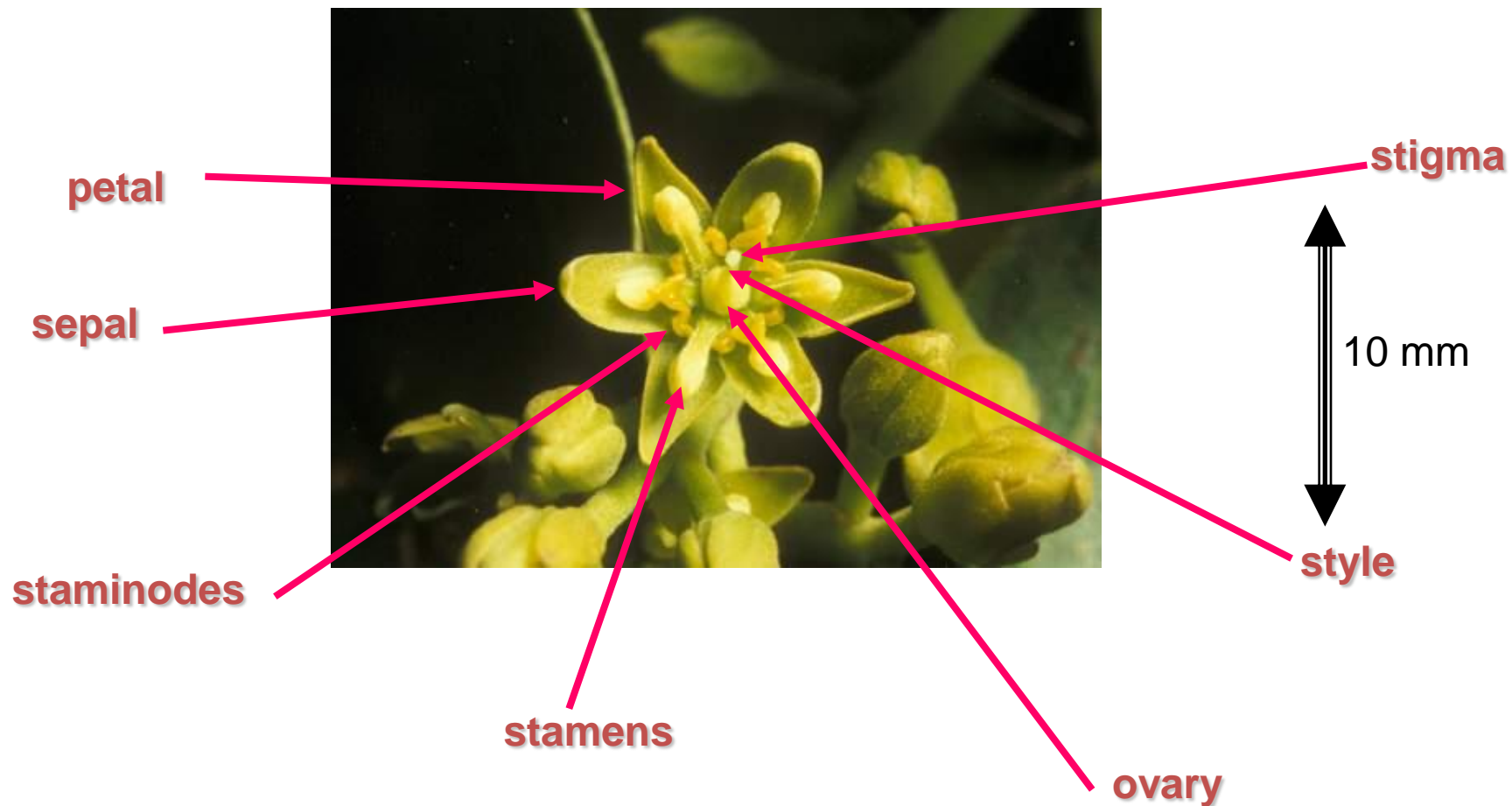


# Pollination and fertilization

- To understand the pollination of avocado flowers, we need to be familiar with the flower's structure and its suitability to honeybees.
- Avocado flowers are very small (5 mm diameter) and they are carried on big inflorescences with hundreds of flowers.
- Each mature tree contains ca. 1 million flowers.
- The single flower is bisexual – contains male and female organs in the same flower.

# Pollination and fertilization

## Avocado flower



# Pollination and fertilization

- To reduce the potential for self-pollination (encourage cross-pollination), a unique mechanism has developed in the avocado tree, termed "protogynous dicogamy".

Dicogamy – Male and female organs do not mature at the same time.

Protogynous – The stigma (female organ) is receptive before the anthers release their pollen (the gynoecium = female part is the first to open)

- Avocado flowers open twice:
  1. Female opening on day 1
  2. Male opening on day 2



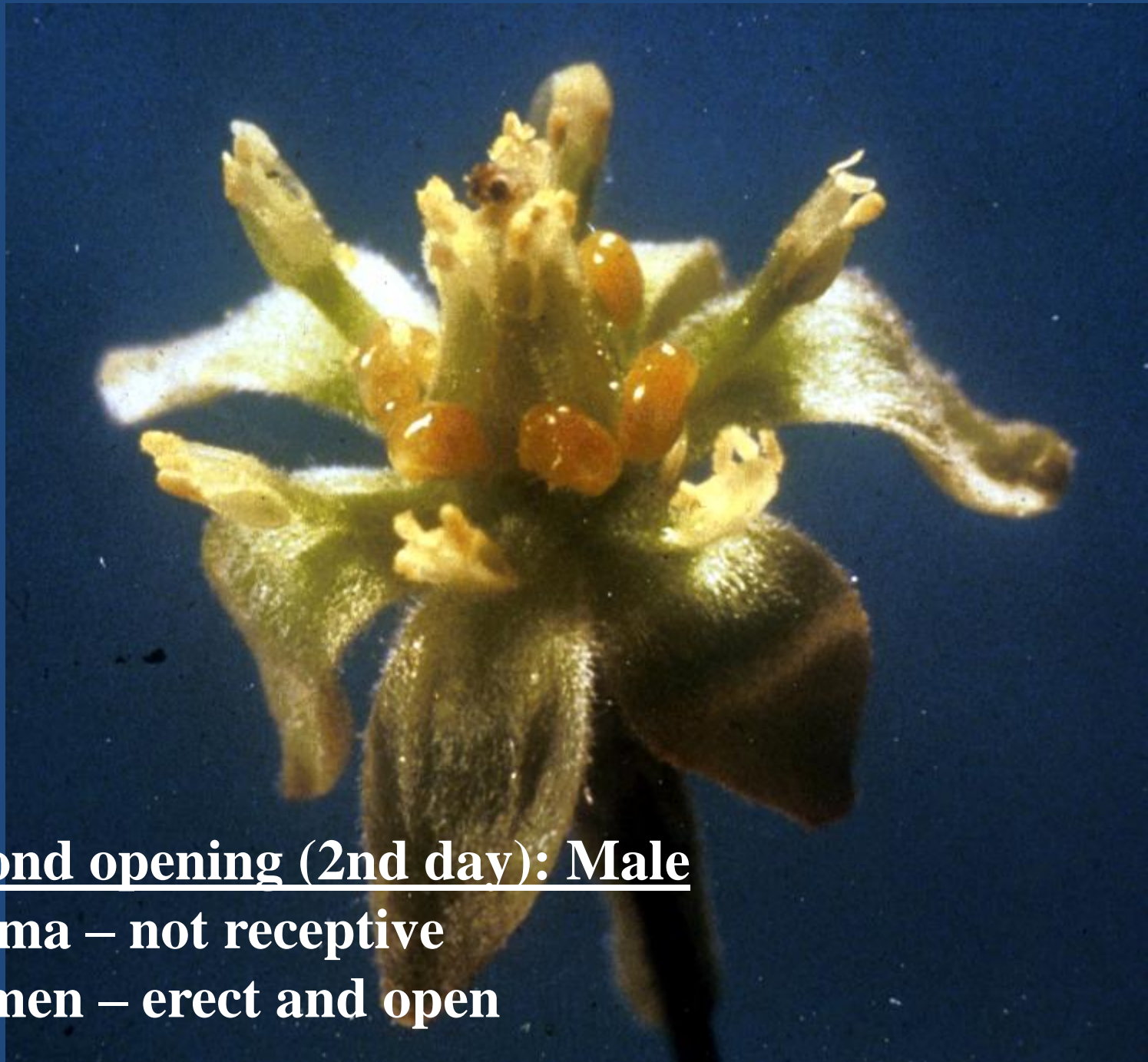
**First opening (1st day): Female**

**Stigma – receptive**

**Stamen – closed and "tightened down"**



**At night the flower is closed**



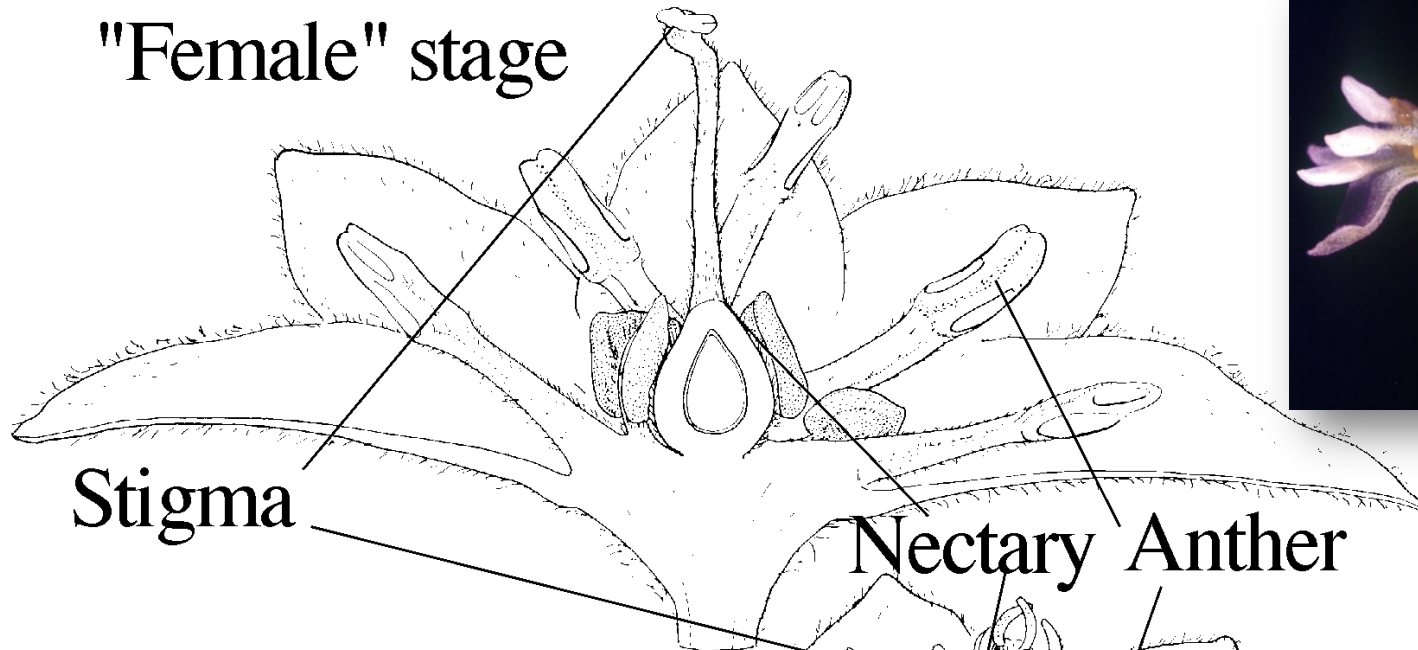
**Second opening (2nd day): Male**

**Stigma – not receptive**

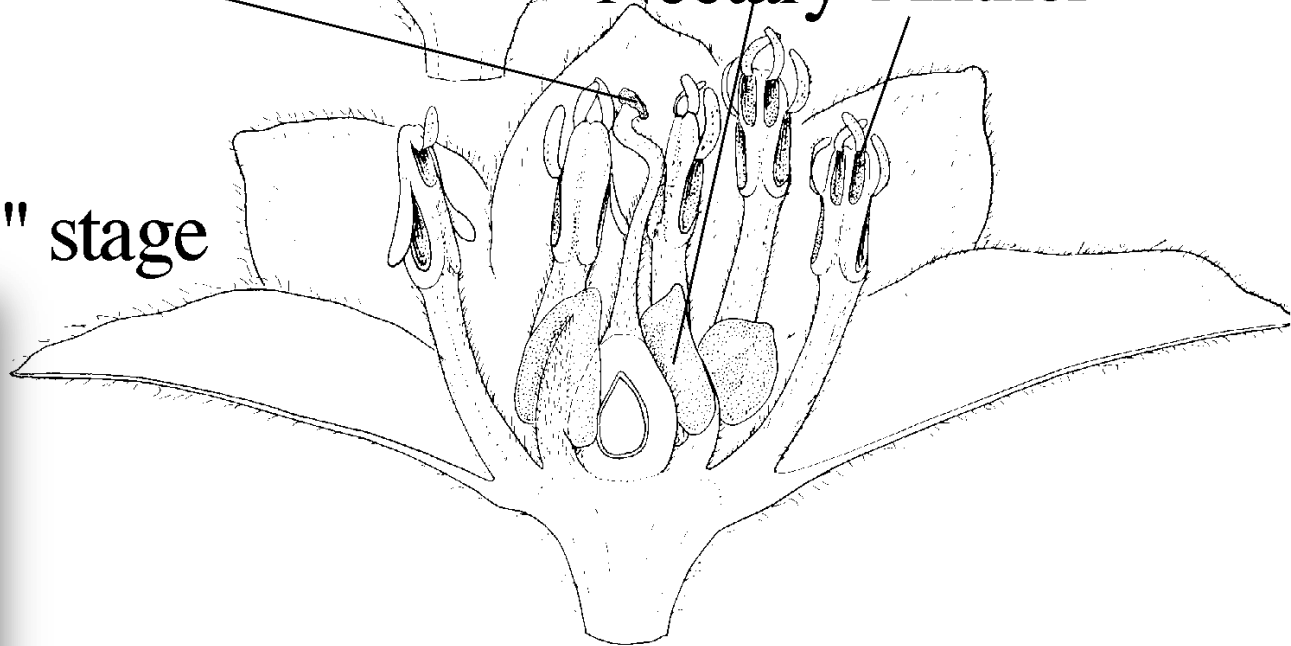
**Stamen – erect and open**

# Pollination and fertilization

"Female" stage



"Male" stage







## Flowering groups/types

- All avocado cultivars belong to one of two flowering types – A or B.
- 50% of cultivars belong to A and 50% to B.



## Flowering groups/types

Figure 4. Timing of avocado flowering for “A” and “B” flower types.

		<u>DAY 1</u>		<u>DAY 2</u>	
		MORNING	AFTERNOON	MORNING	AFTERNOON
Flower-type cultivar	“A”				
	“B”				

**Table 1. Avocado varieties and flowering types.**

"A" Varieties	"B" Varieties
Hass	Bacon
Gwen	Ettinger
Lamb Hass	Fuerte
Pinkerton	Sharwil
Reed	Sir Prize
<i>GEM</i>	Walter Hole
<i>Harvest</i>	Zutano
.	<i>Marvel</i>
.	<i>Nobel</i>

*Note: Varieties in italics are from the UC Breeding Program and are currently under evaluation.*

reently available "B" varieties are classed as

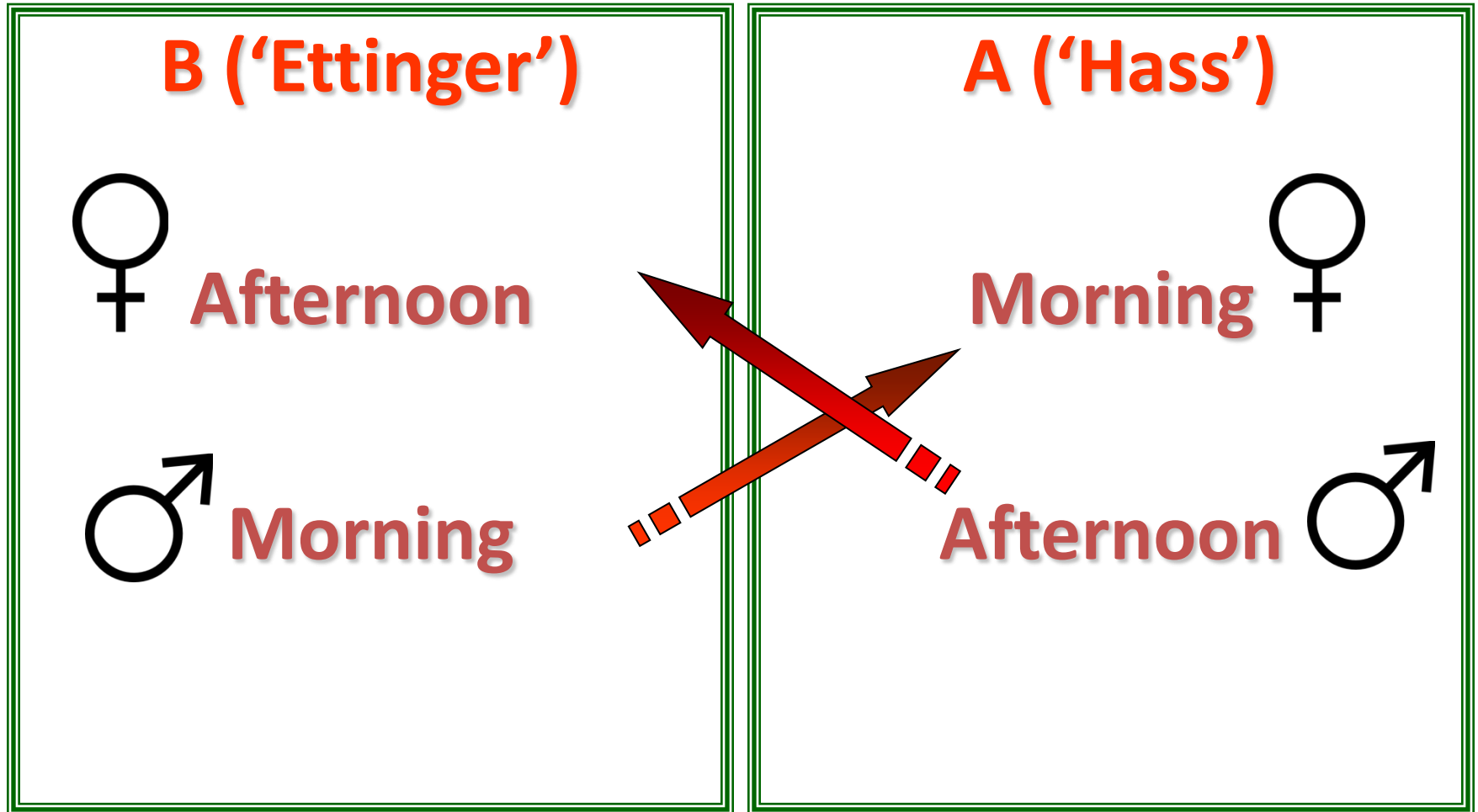
## Pollination

Pollination usually occurs between cultivars belonging to 2 different flowering types.

For example – cross-pollination of 'Hass' (A) by 'Ettinger' (B).

# Pollination and fertilization

## Pollination





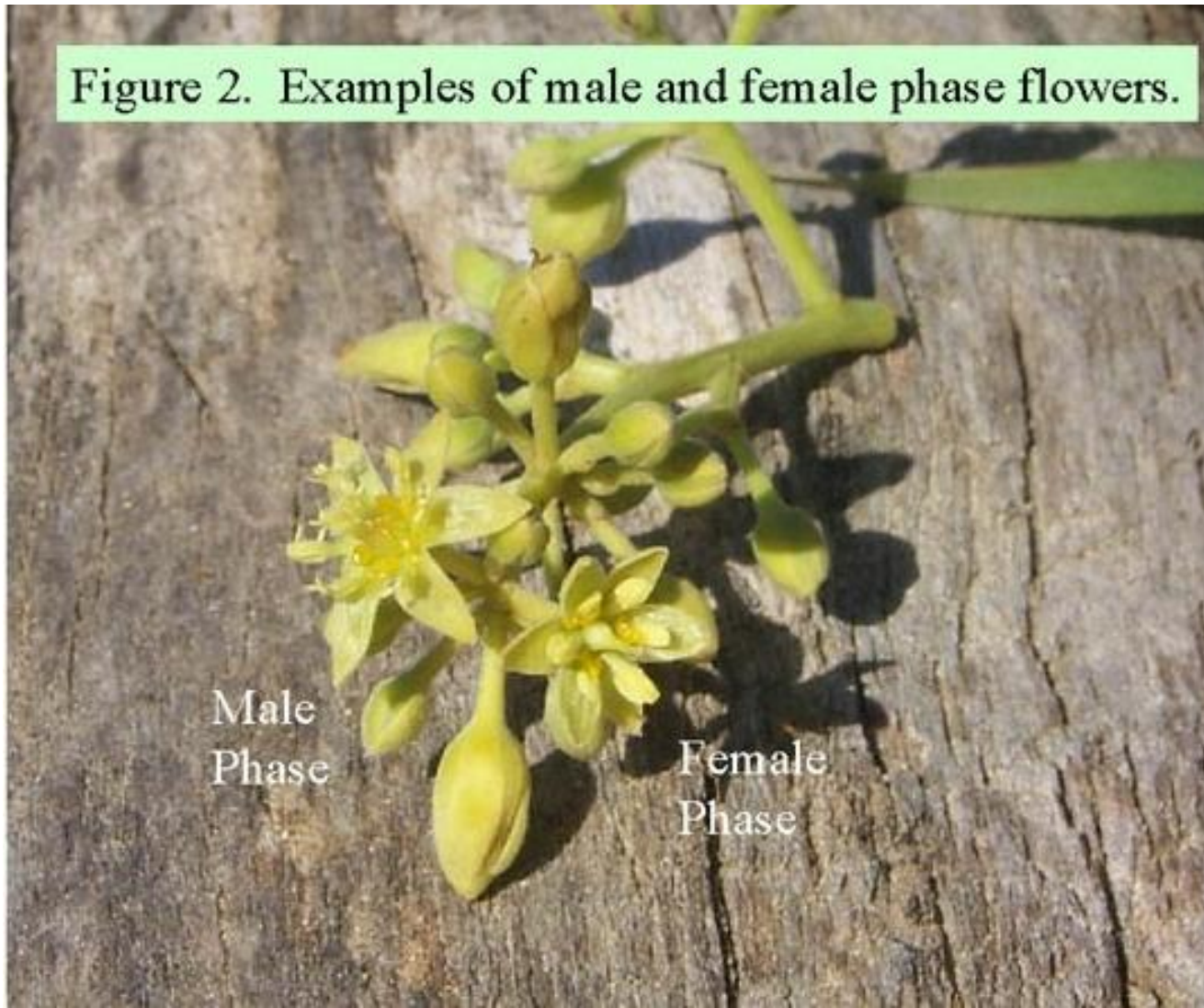
## Closed pollination

Sometimes there is overlap between male flowers and female flowers on the same tree, so they can fertilize each other (a type of "self-pollination" occurring within the same tree) but not with the same flower.

# Pollination and fertilization

## Closed pollination

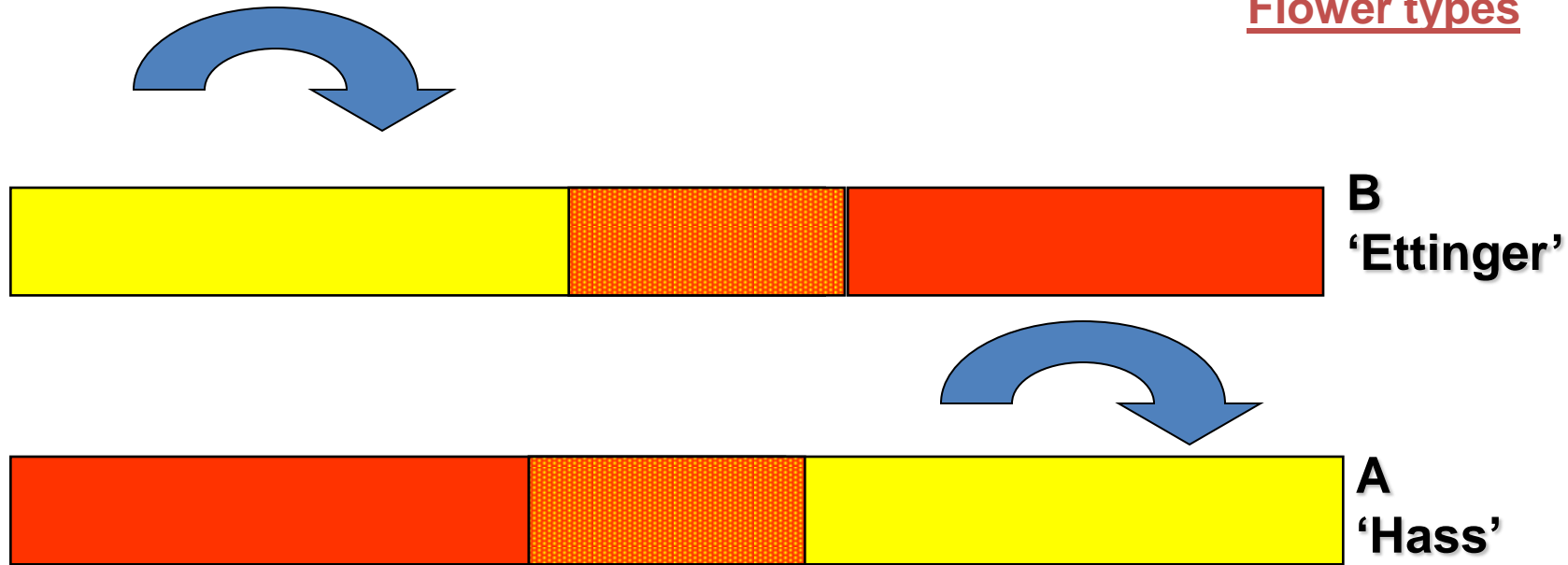
Figure 2. Examples of male and female phase flowers.



# Summary of pollination in avocado

## Self pollination

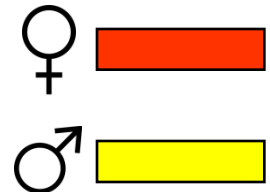
Flower types



6:00

12:00

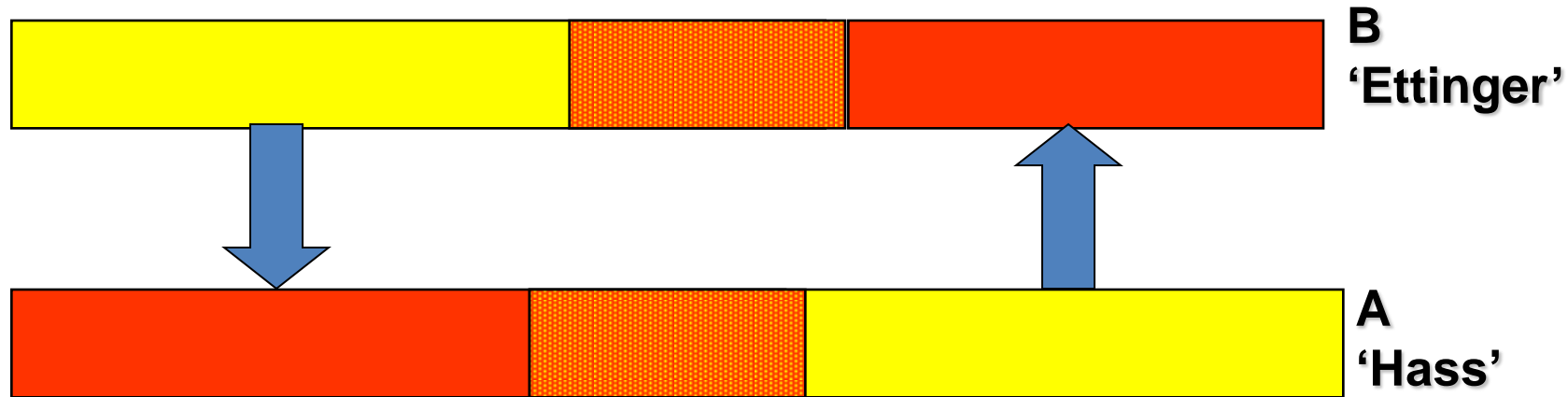
18:00



# Summary of pollination in avocado

## Cross pollination

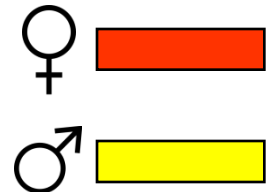
Flower types



6:00

12:00

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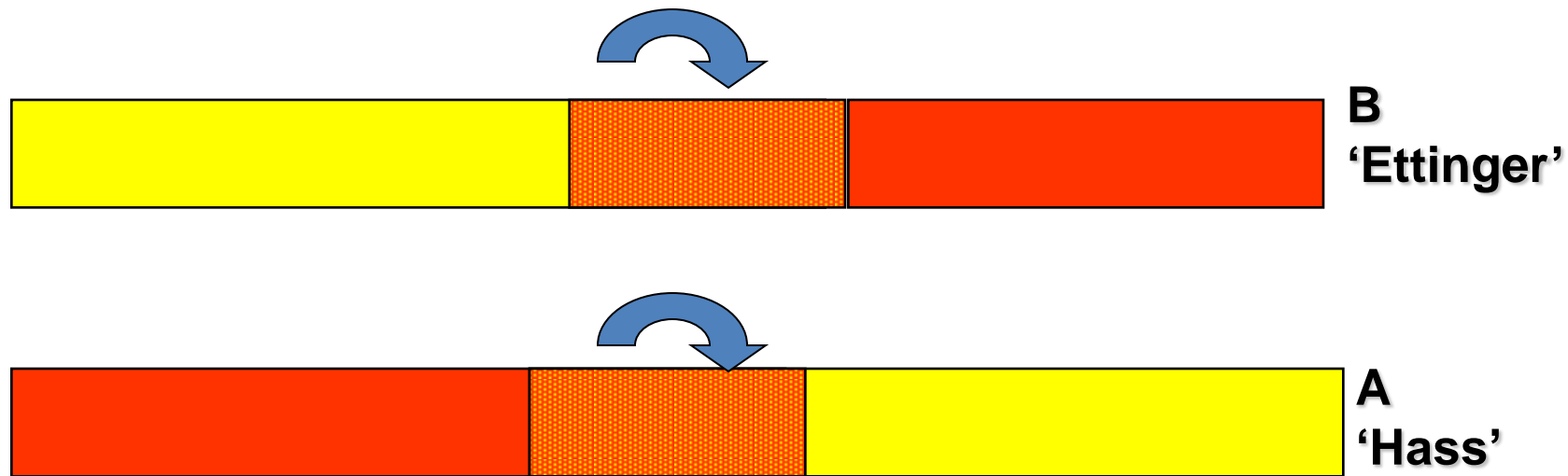




# Summary of pollination in avocado

## Closed pollination

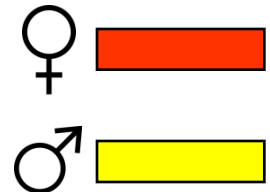
Flower types



6:00

12:00

18:00

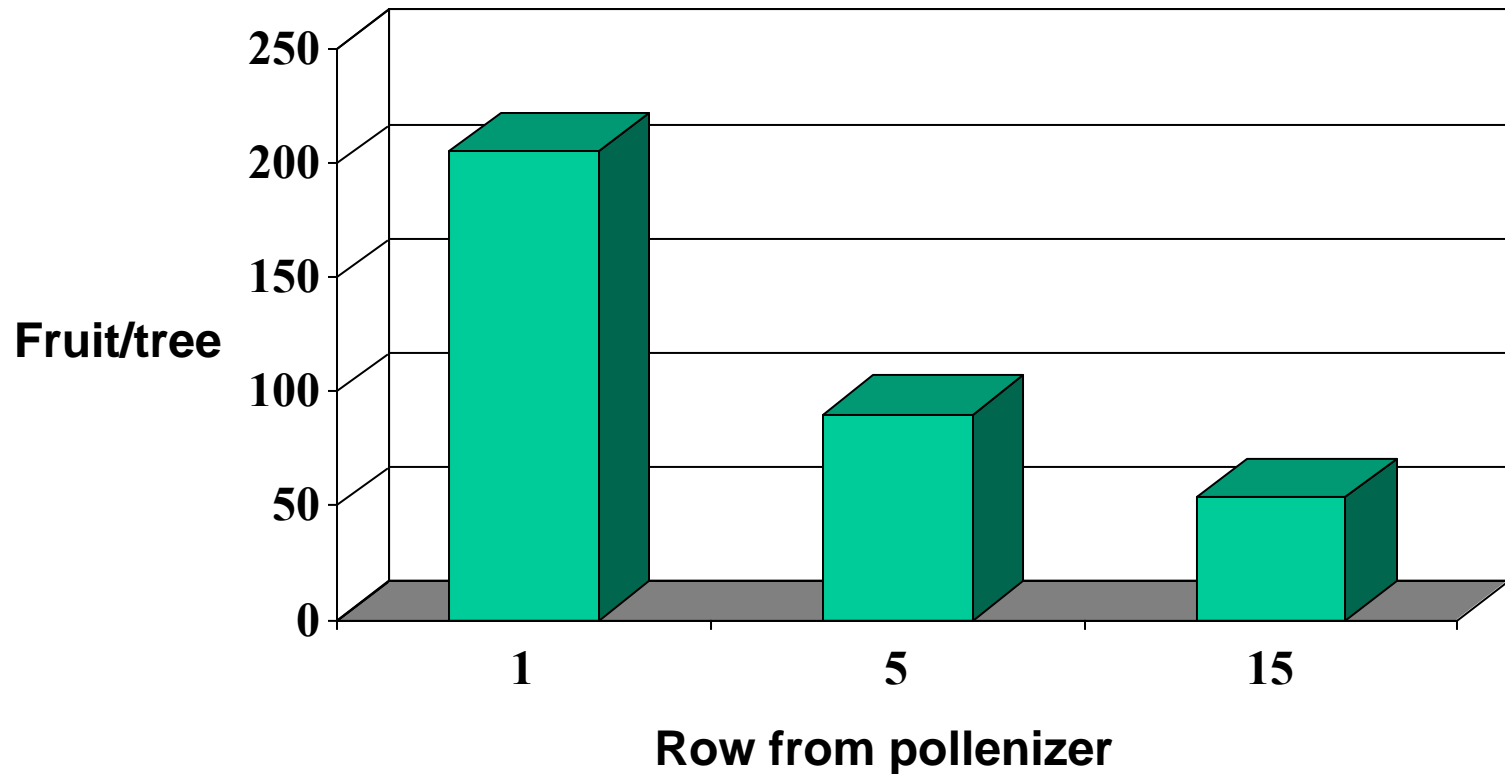


## Cross-pollination is preferred

1. Reduction in yield as the distance from the pollinizer increases.
2. Manual cross-pollination gives better fruit set and yield than self-pollination.

# Pollination and fertilization

## Influence of distance from pollenizer on yield of 'Hass' avocado



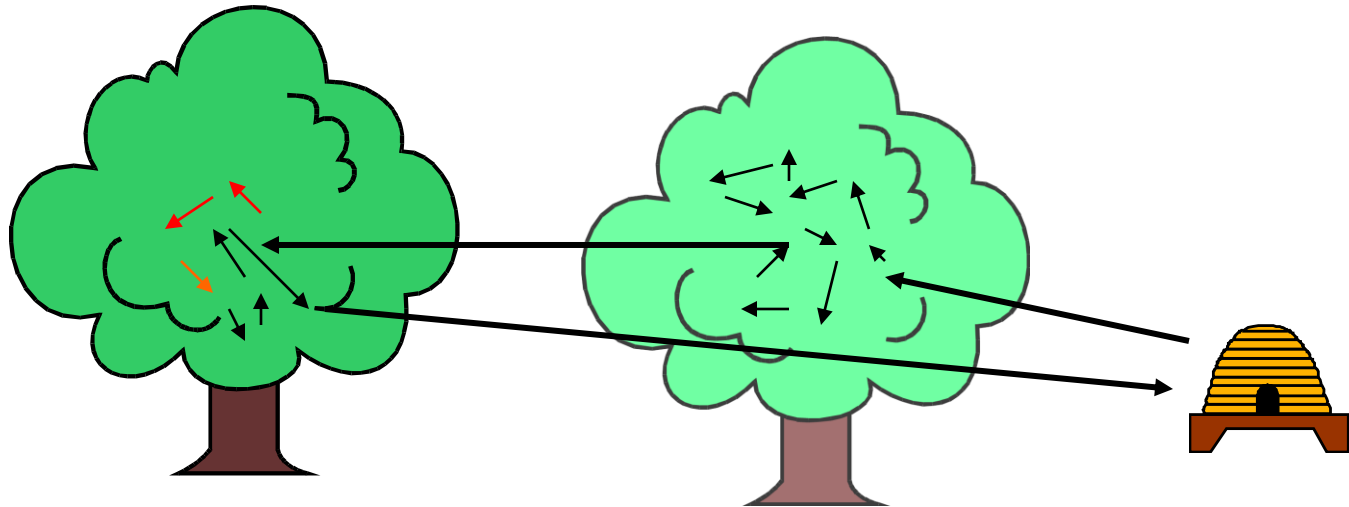
*Kobayashi et al., 2000. Scientia Hort. 86, 135-149*

# Pollination and fertilization

## Cross-pollination

‘Hass’ ♀

‘Ettinger’ ♂

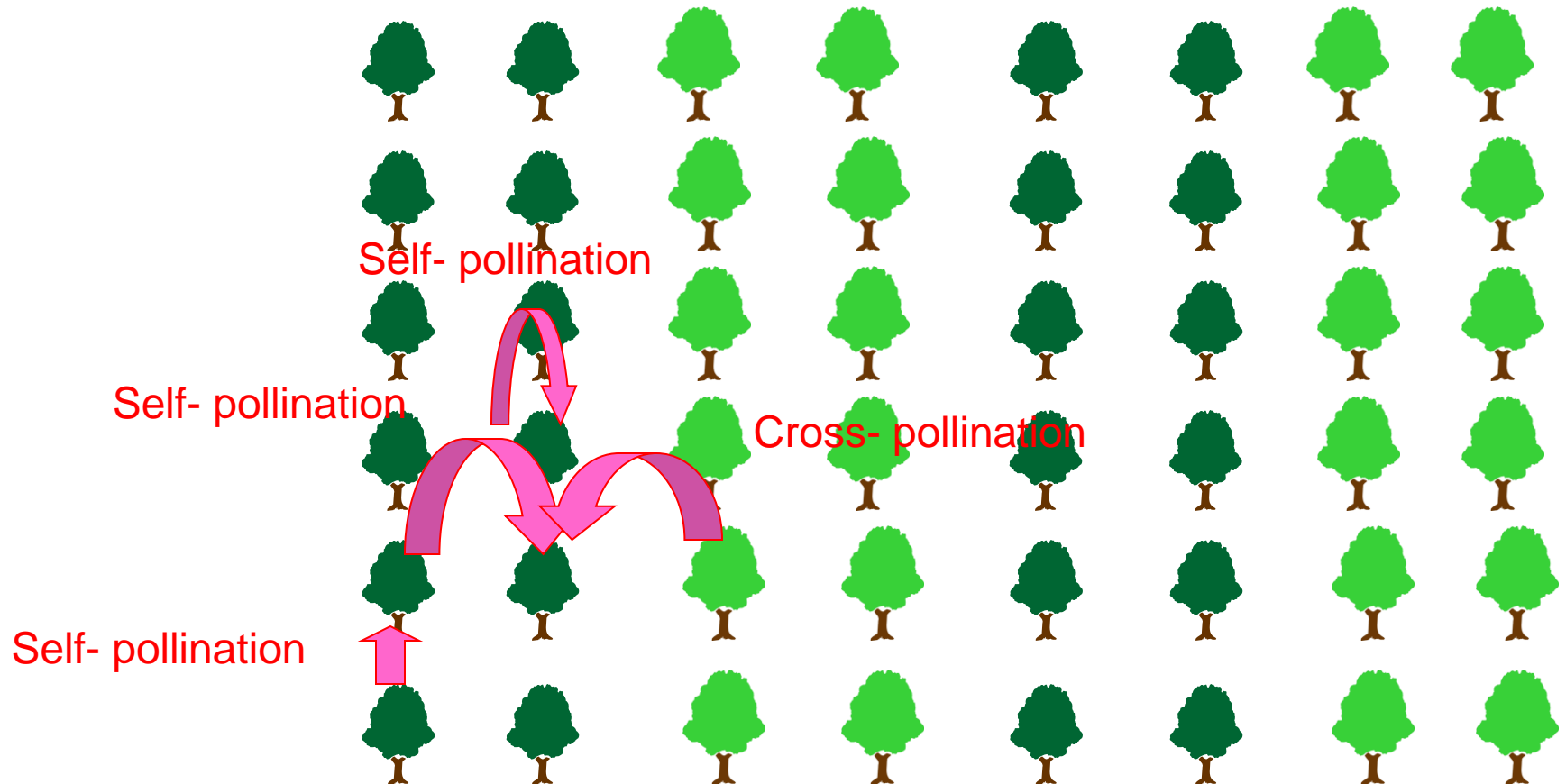




# Pollination and fertilization

## Cross-pollination

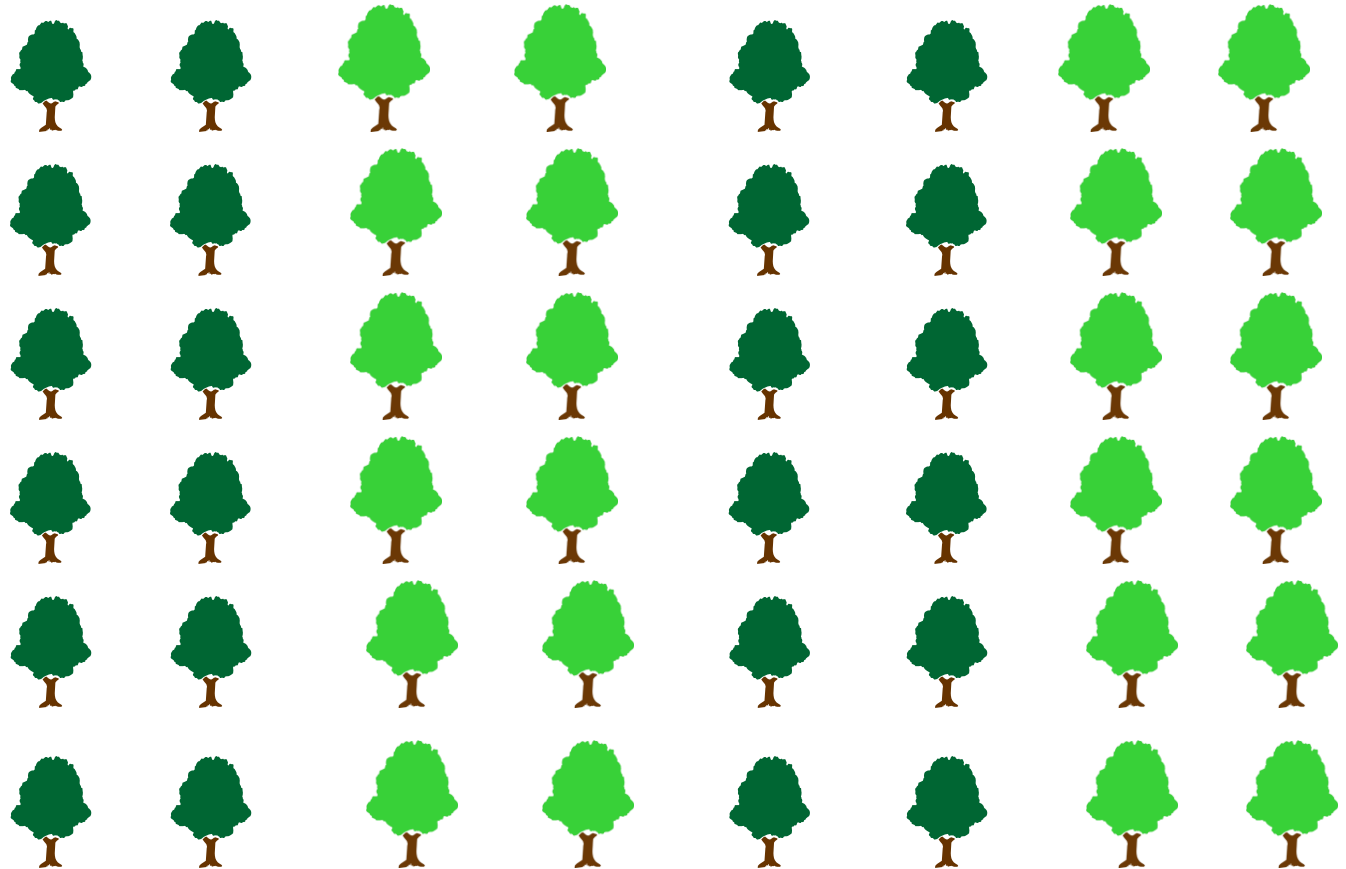
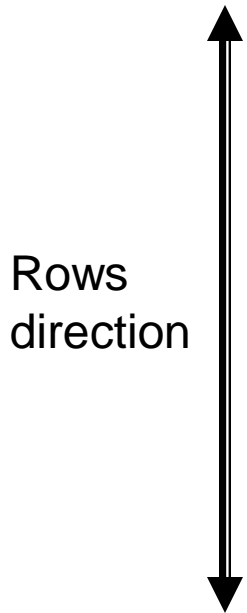
### Possible movement of honeybees in the orchard



# Pollination and fertilization

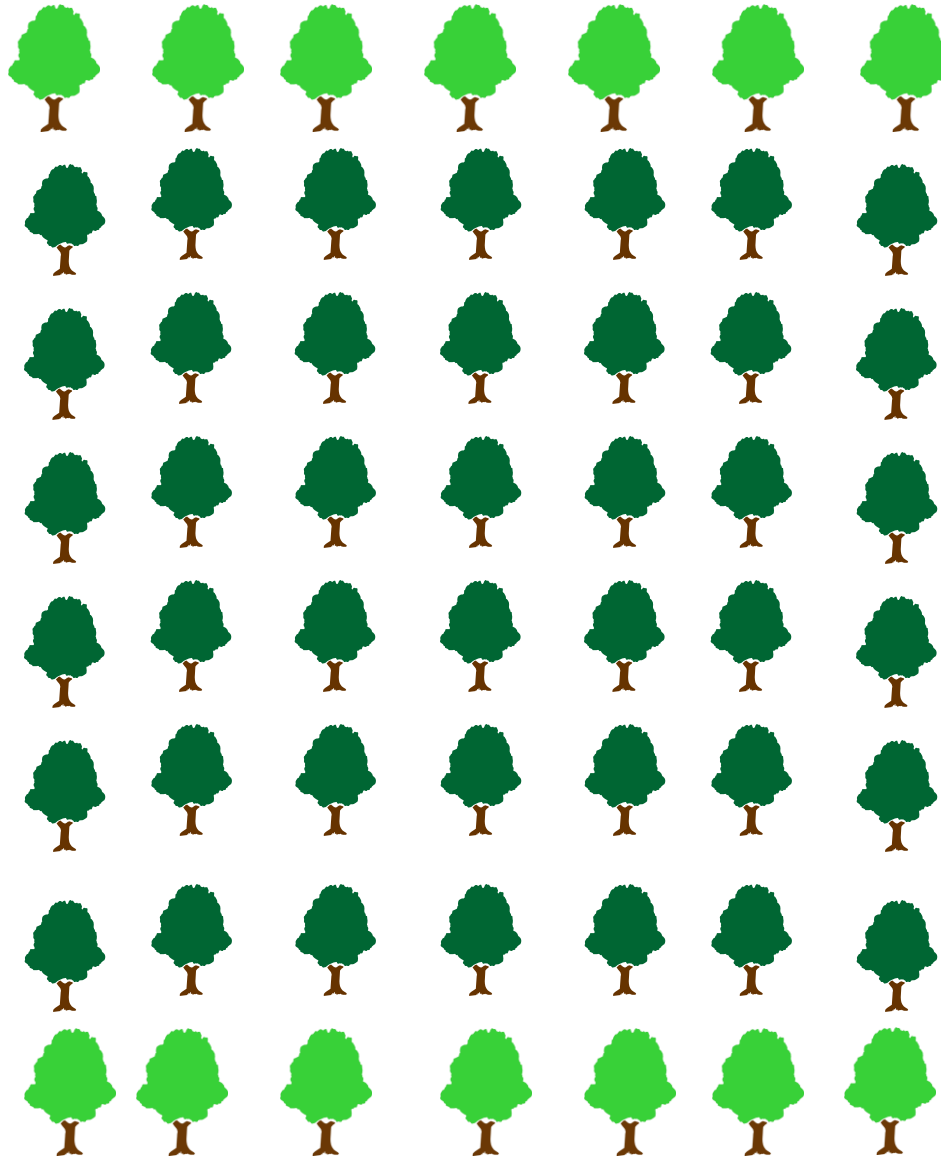
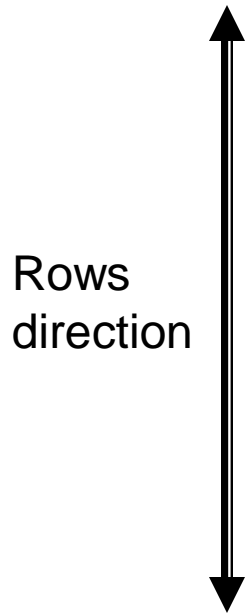
## Cross-pollination

**Couples of pollenizers**



# Pollination and fertilization

## Cross-pollination

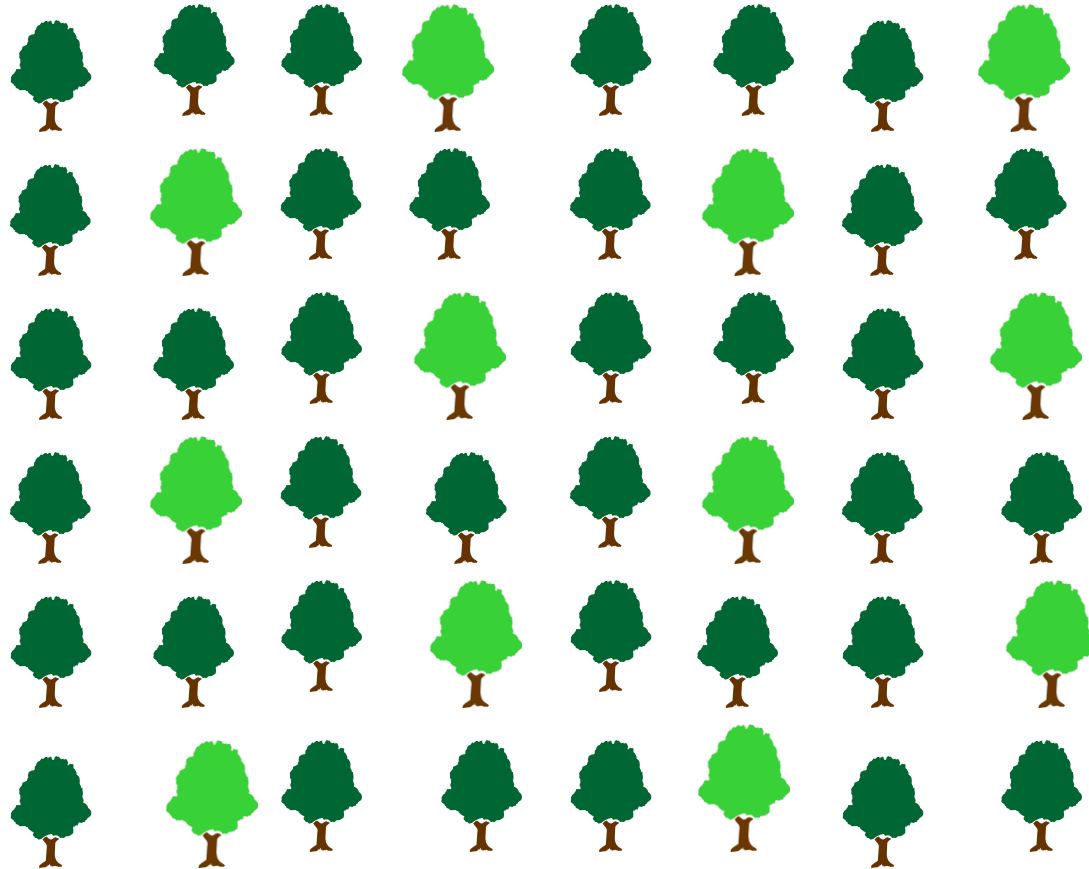
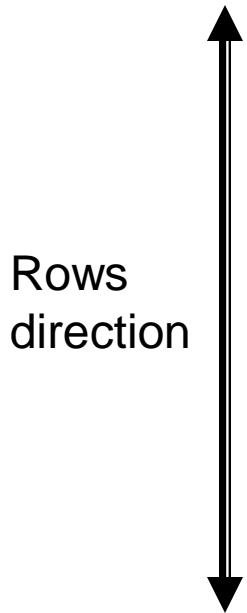


**Pollenizers  
at the end of  
the row**

# Pollination and fertilization

## Cross-pollination

Pollenizera at 1:9 ratio



## Summary of pollenizers in avocado

1. We need pollenizers in the orchard (a solid block of one cultivar is not desirable).
2. The distance between cultivars must be minimal.
3. The overlap between cultivars' flowering must be good.





## Is pollination a limiting factor for yield?

- Avocado tree has ca. 1 million flowers.
- Good yield = 500 fruit/tree (0.05%).
- Heavy yield = 1,000 fruit/tree (0.1%).
- Since many flowers are abnormal and there are many problems with fertilization, we need to pollinate many flowers (20-30 thousand) to obtain 500 fruits.
- To achieve this, we need a lot of pollination (10,000 flowers/tree per day) .

# Pollination and fertilization

## The importance of insects/bees to avocado pollination:

- In closed trees (net) – very low yield
- Wind pollination – almost no yield
- Conclusion – avocado needs insect pollination



# Pollination and fertilization

## How do the honeybees act as pollinators?

Honeybee is the ideal pollinator:

1. Needs nectar + pollen
2. Has a lot of hair on its body → collects and transfers the pollen grains

**Hair on the leg**



**HB with pollen pellets  
on its legs**



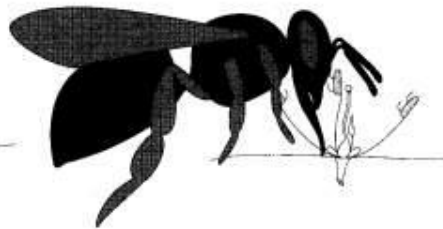
**HB on avocado flower**



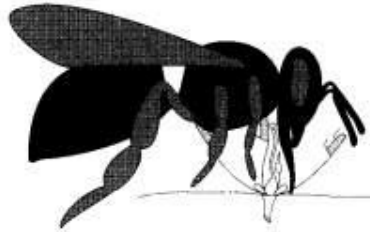
## Female stage

## Male stage

Side position  
on circular  
flower



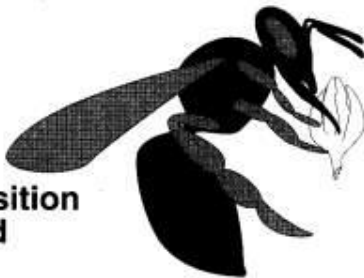
Top position  
on circular  
flower



Side position  
on cup and  
oval flower



Basal position  
on closed  
flower



HB collects nectar  
and touches  
stamens+ stigmas

## Competing flowers

- During March and April → many competing flowers outside the avocado orchard (citrus, mustard, etc.).
- Honeybees prefer the competing flowers, which are rich in nectar (citrus) or pollen (mustard).



## **Recommendations**

- 5-10 honeybees/tree per minute
- Introduction of hives at 10% bloom
- Density of 2.5-5 hives/ha
- Distance between hives – not more than 150 m

