



# Tropical and Subtropical Fruits

Department of Horticulture  
College of Agriculture  
Isfahan University of Technology

# Bananas and Plantains

Latitude: 30° N and S



# Bananas and Plantains

Family: Musaceae

Genus: *Musa*

---

Species:

*M. acuminata*

*M. balbisiana*

## Systematic Description

- Family: Musaceae
- Genus: *Musa*
- *Ensete* (*E. ventricosa*)
  
- *Musa*
  - Eumusa* (*M. acuminata*, *M. balbisiana*)
  - Rhodochlamys*
  - Callimusa*
  - Australiamusa* (*Fe'i*)
  - Incertae sedis*

# Genus Musa

## Section Eumusa

- Major species of economic importance
  - *Musa acuminata* (A genome)
  - *Musa balbisiana* (B genome)
- Ploidy levels of commercial bananas
  - Diploid, AA and BB
  - Triploid, AAA, AAB, ABB
  - Tetraploid, AAAA, AABB, ABBB
- Major evolutionary events
  - Probably millennia ago



- **Form of consumption:** dessert, cooking and beer types
- **Genomic composition:**
  - AAA dessert, highland beer and cooking bananas
  - AAB plantains and desert bananas
  - ABB cooking bananas
  - AA wild and edible types
  - BB wild types



# Types of Bananas

- Banana
  - Desert banana, fresh consumption
  - AAA
- Plantain
  - Cooking, Meal, Vegetable banana
  - Plátano, banano macho
  - AAB or ABB









*baked plantain*



# Eumusa

22, 33, 44

*M. acuminata*, *M. balbisiana*



J. Van den Bergh, Bioversity

## Genus *Musa* Section Eumusa

### Major species

- *Musa acuminata* (A genome)
- *Musa balbisiana* (B genome)

### Ploidy levels of bananas and plantains

- Diploid, AA and BB
- Triploid, AAA (Banana), AAB (Plantain), ABB (Plantain)
- Tetraploid, AAAA, AABB, ABBB

# *Rhodochlamys*

$2n=22$

*M. velutina*



# *Callimusa*

$2n=20$

*M. coccinea*



## *Australiamusa*

$2n=20$

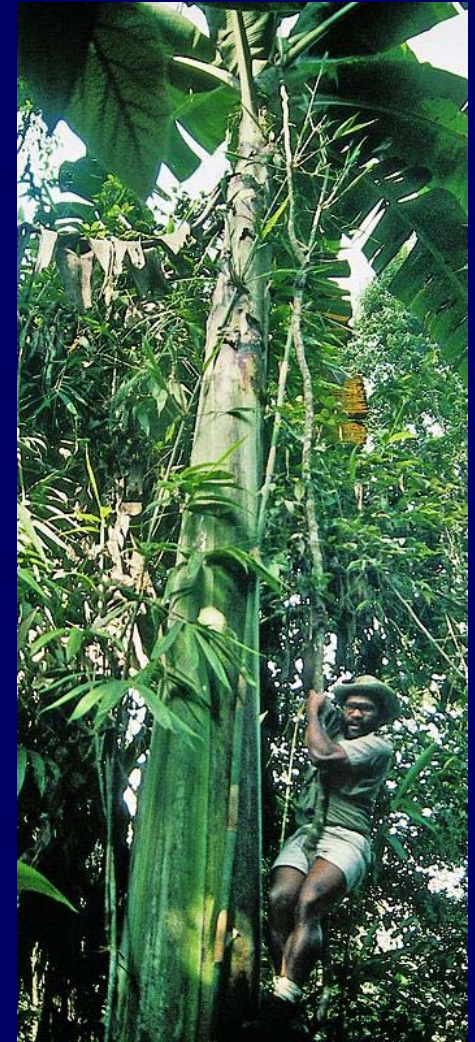
Fe'i Banana (*M. fehi*)



*Incertae sedis*

$2n=14$

*M. ingens*

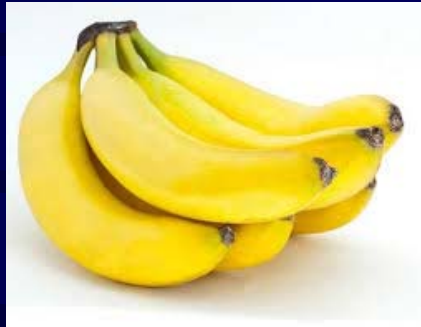


## Scientific Name

*Musa sapientum* (Banana)

*M. paradisiaca* (Plantain)

*Musa* (AAA) 'Gros Michel'



*Musa* (AAA) 'Dwarf Cavendish'

*Musa* (AAA) 'Robusta'

*Musa* (AAB) 'Poovan'



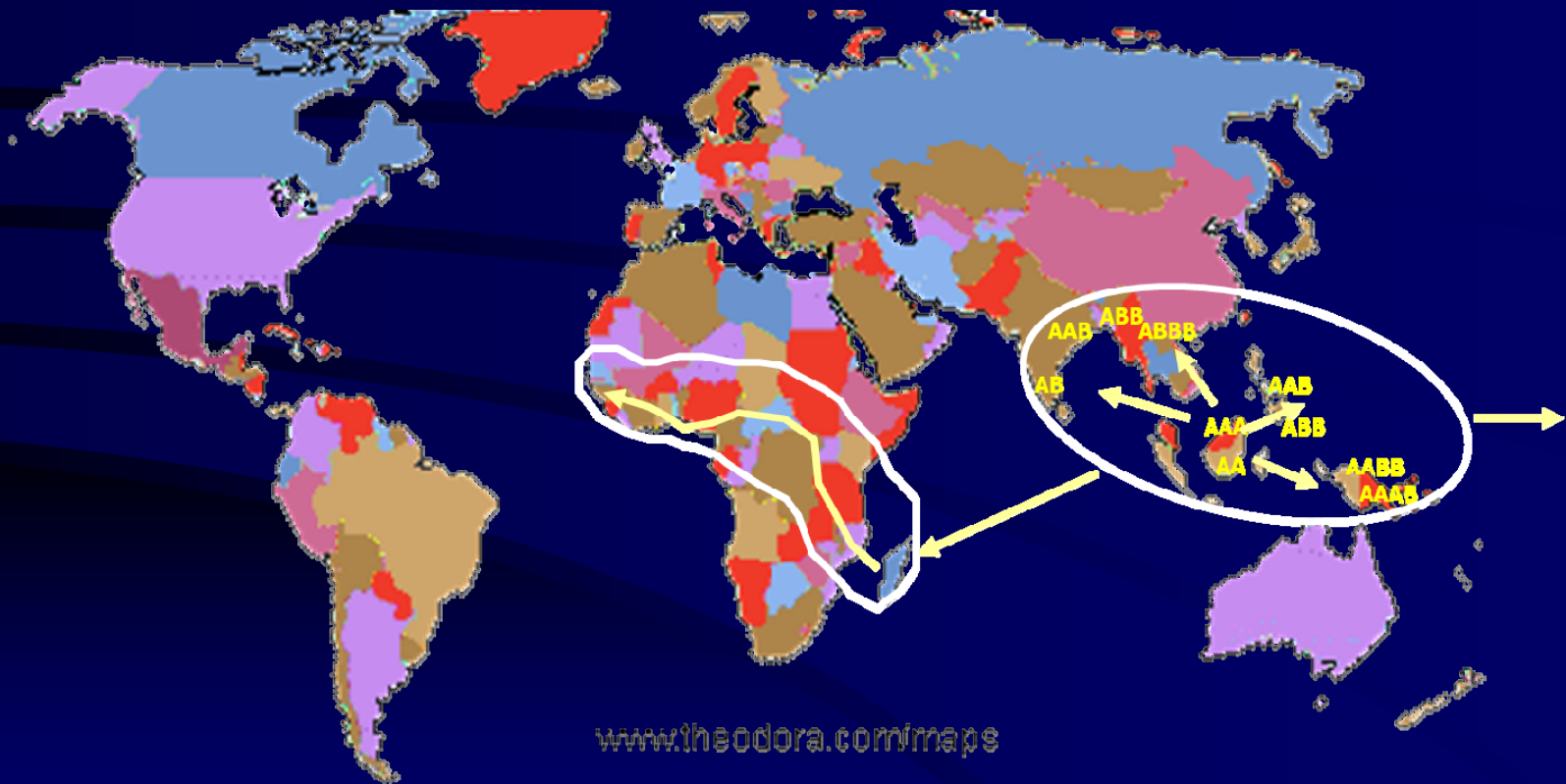


# Adaptation: Hot Humid Tropics

- Temperature
  - Frost free
  - Mean temperature of 27 C (80 F)
  - Minimum winter temp of 15.5 C (60 F)
- Moisture
  - Rain, 100 mm (4.0") per month
- Soil
  - Good drainage is needed
  - Slightly acid, pH 5.5 to 6.5

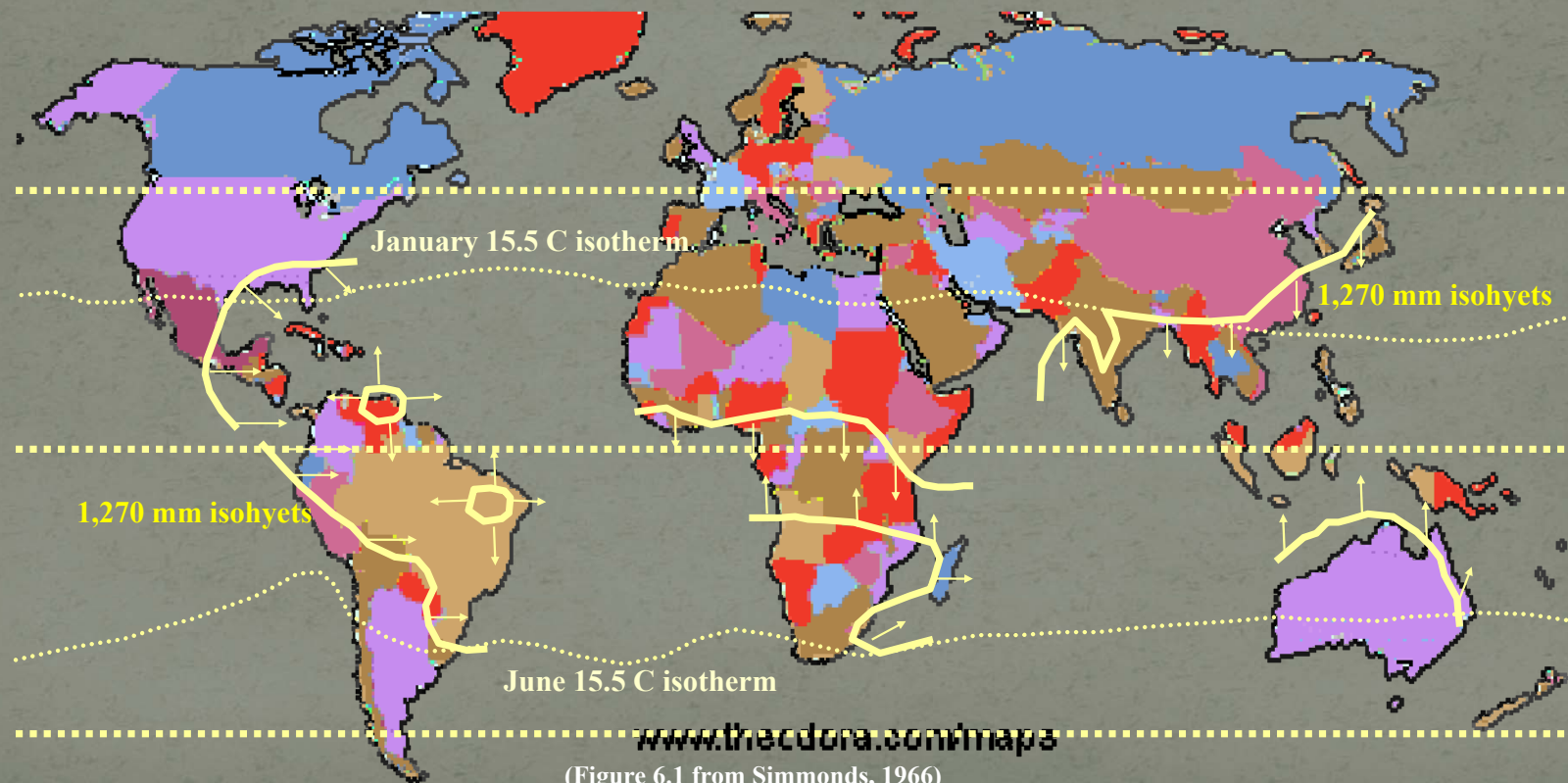
## Origin:

**Banana** plants are native to tropical regions of Southeast Asia (Malaysia, Philippine, Indonesia, India)



# Banana Cultivation and Climate

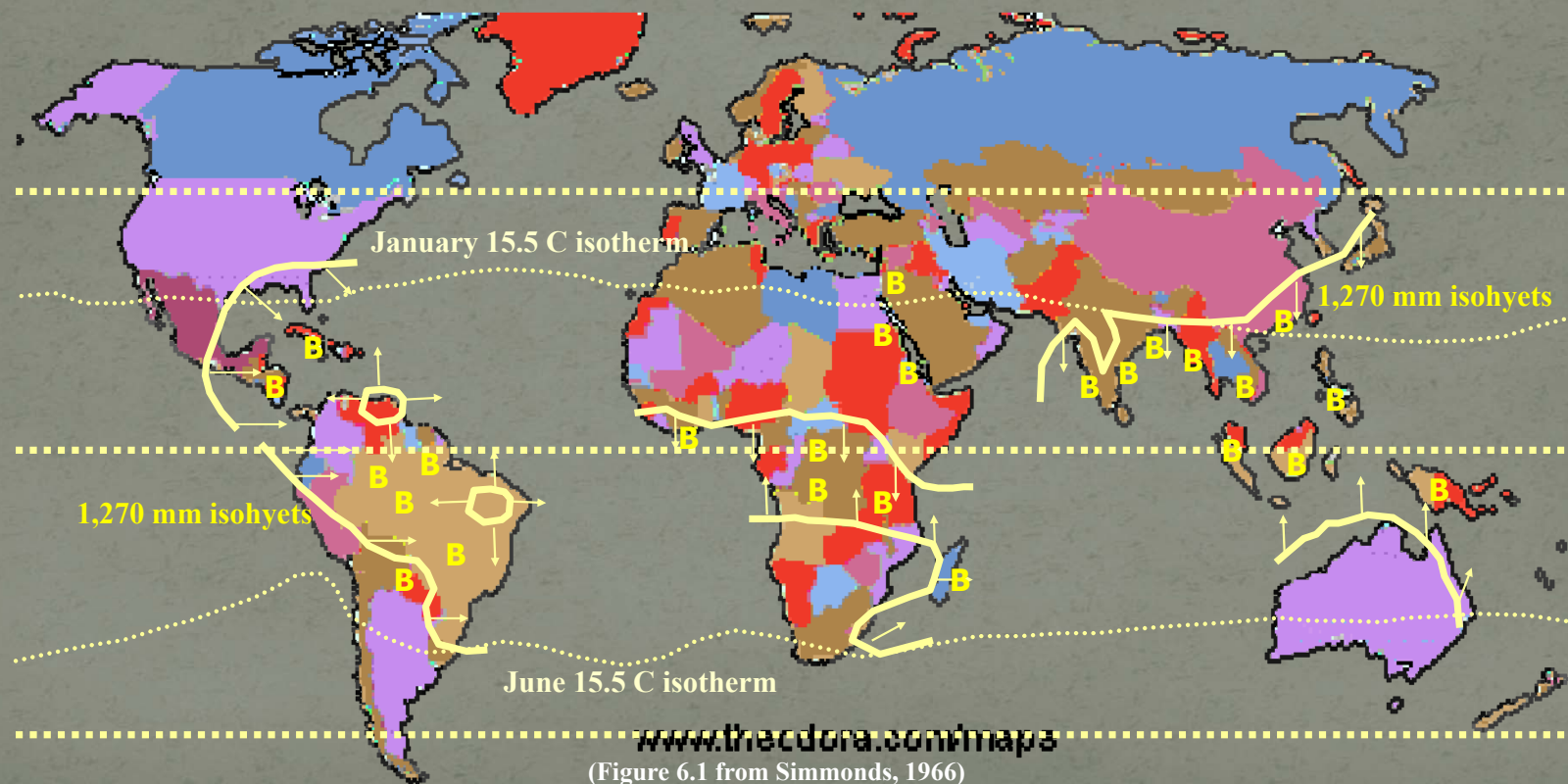
Most Banana/Plantain Production within Region with Winter Temperate Greater than 15.5 C (60 F) and Rainfall greater than 1,270 mm (50")



(Figure 6.1 from Simmonds, 1966)  
Tropical Horticulture - Texas A&M University

# Banana Cultivation and Climate

## Bananas Grown for Local Consumption

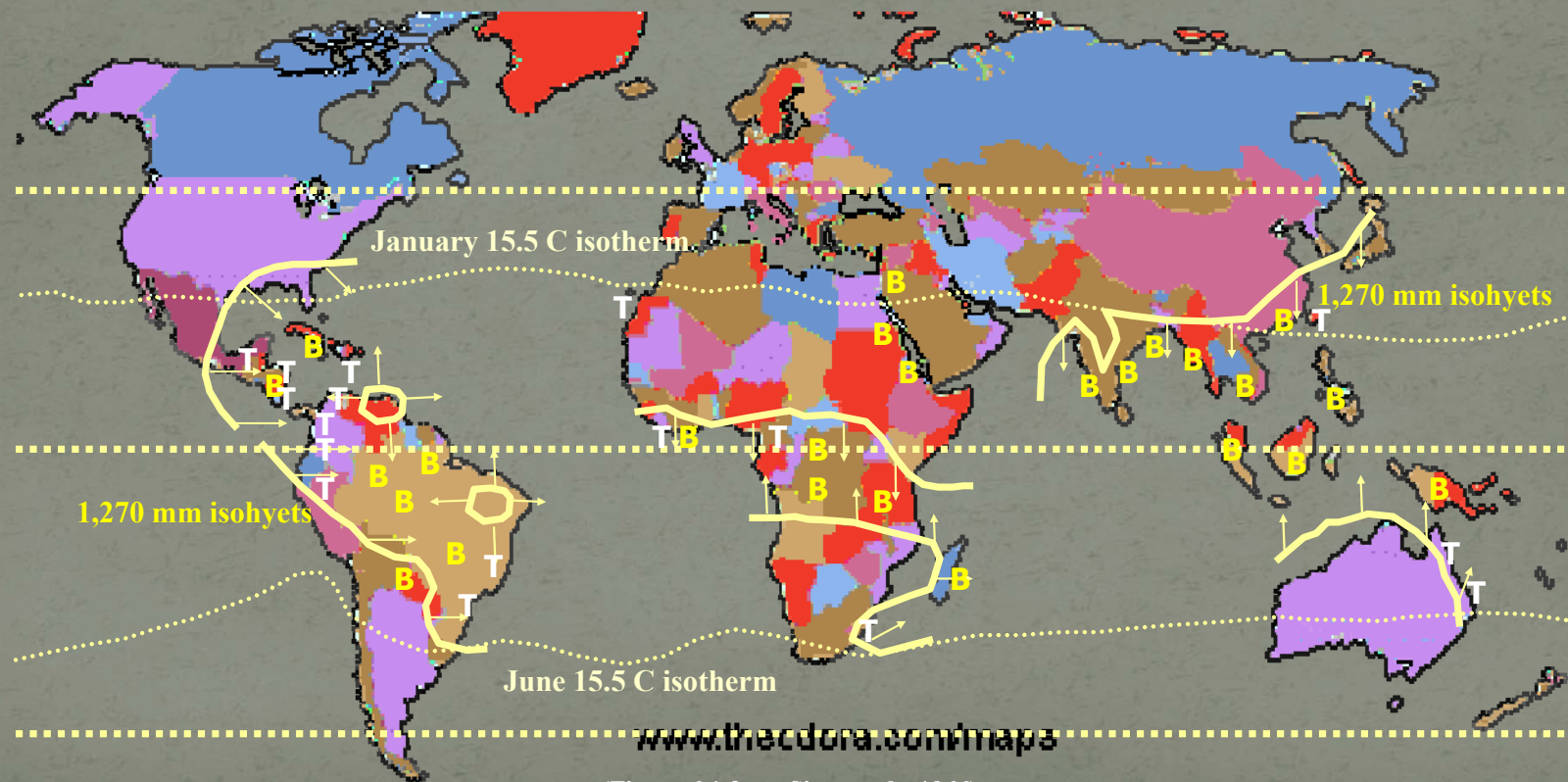


(Figure 6.1 from Simmonds, 1966)

Tropical Horticulture - Texas A&M University

# Banana Cultivation and Climate

Bananas Grown for Export = T



(Figure 6.1 from Simmonds, 1966)  
Tropical Horticulture - Texas A&M University

## World Production (1,000s mt)

Region	Bananas	Plantains
Africa	7,051	22,478
Asia	40,738	996
Americas	24,378	1,835
Total	72,167	25,309

## World Production (%)

<b>Region</b>	<b>Bananas</b>	<b>Plantains</b>
<b>Africa</b>	<b>10%</b>	<b>89%</b>
<b>Asia</b>	<b>56%</b>	<b>4%</b>
<b>Americas</b>	<b>34%</b>	<b>7%</b>
<b>Total (1,000s mt)</b>	<b>72,167</b>	<b>25,309</b>

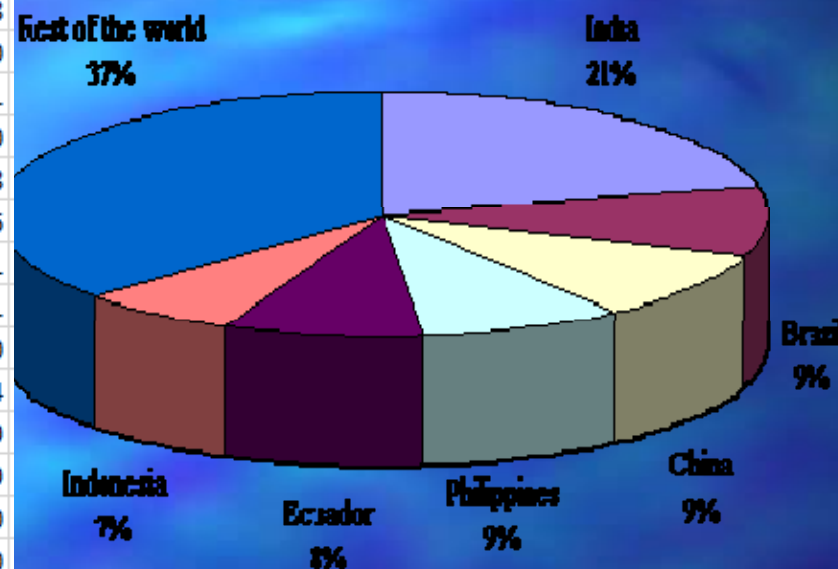
## World Production Leading Producing Countries

<b>Region</b>	<b>Bananas</b>	<b>Plantains</b>
<b>Africa</b>	<b>Burundi, Uganda, Egypt, Cameroon, Congo</b>	<b>Uganda, Rwanda, Ghana, Nigeria, Ivory Coast</b>
<b>Asia</b>	<b>India, Philippines, China, Indonesia, Thailand</b>	<b>Myanmar, Sri Lanka</b>
<b>Americas</b>	<b>Ecuador, Brazil, Costa Rica, Colombia, Guatemala</b>	<b>Colombia, Peru, Venezuela, Ecuador, Cuba</b>



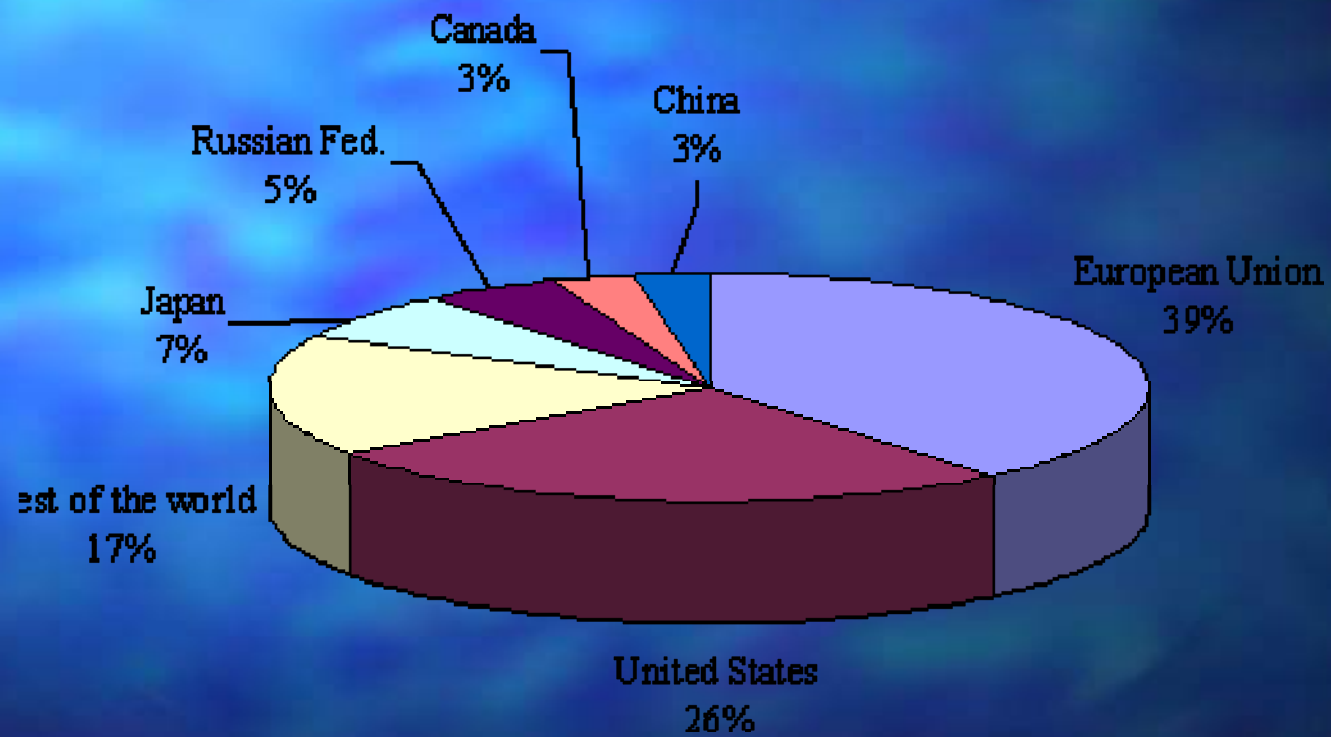
India	Bananas	2020	tonnes	31504000
China, ma	Bananas	2020	tonnes	11513000
Indonesia	Bananas	2020	tonnes	8182756
Brazil	Bananas	2020	tonnes	6637308
Ecuador	Bananas	2020	tonnes	6023390
Philippine	Bananas	2020	tonnes	5955311
Guatemala	Bananas	2020	tonnes	4476680
Angola	Bananas	2020	tonnes	4115028
United Re	Bananas	2020	tonnes	3419436
Costa Rica	Bananas	2020	tonnes	2528721
Mexico	Bananas	2020	tonnes	2464171
Colombia	Bananas	2020	tonnes	2434900
Peru	Bananas	2020	tonnes	2314514
Viet Nam	Bananas	2020	tonnes	2191379
Kenya	Bananas	2020	tonnes	1856659
Egypt	Bananas	2020	tonnes	1382950
Thailand	Bananas	2020	tonnes	1360670
Burundi	Bananas	2020	tonnes	1280048
Papua Ne	Bananas	2020	tonnes	1261605
Dominica	Bananas	2020	tonnes	1232039
Cameroon	Bananas	2020	tonnes	1209750
Rwanda	Bananas	2020	tonnes	1118841
Sudan	Bananas	2020	tonnes	923938

## Production



Area	Item	Value
Uganda	Plantains and cooking banana	7401579
Democratic Republic of Congo	Plantains and cooking banana	4891990
Ghana	Plantains and cooking banana	4667999
Cameroon	Plantains and cooking banana	4526069
Philippines	Plantains and cooking banana	3100839
Nigeria	Plantains and cooking banana	3077159
Colombia	Plantains and cooking banana	2475611
Côte d'Ivoire	Plantains and cooking banana	1882779
Myanmar	Plantains and cooking banana	1361419
Dominican Republic	Plantains and cooking banana	1053143
Sri Lanka	Plantains and cooking banana	975450
Rwanda	Plantains and cooking banana	913231
Ecuador	Plantains and cooking banana	722298
Venezuela (Bolivia除外)	Plantains and cooking banana	720998
Cuba	Plantains and cooking banana	594374
United Republic of Tanzania	Plantains and cooking banana	579589
Guinea	Plantains and cooking banana	486594
Bolivia (Plurinational State of)	Plantains and cooking banana	481093
Malawi	Plantains and cooking banana	385146
Gabon	Plantains and cooking banana	345890
Guatemala	Plantains and cooking banana	336447
Burundi	Plantains and cooking banana	314897

# Import



# Weather Problems

## ■ Wind

- 15-20 mph - leaf damage, twisting, breakage
- 40 mph - considerable damage
- 60 mph - complete destruction

## ■ Why

- Pseudostem not as strong as woody stem
- Large leaves that catch wind
- Shallow root system

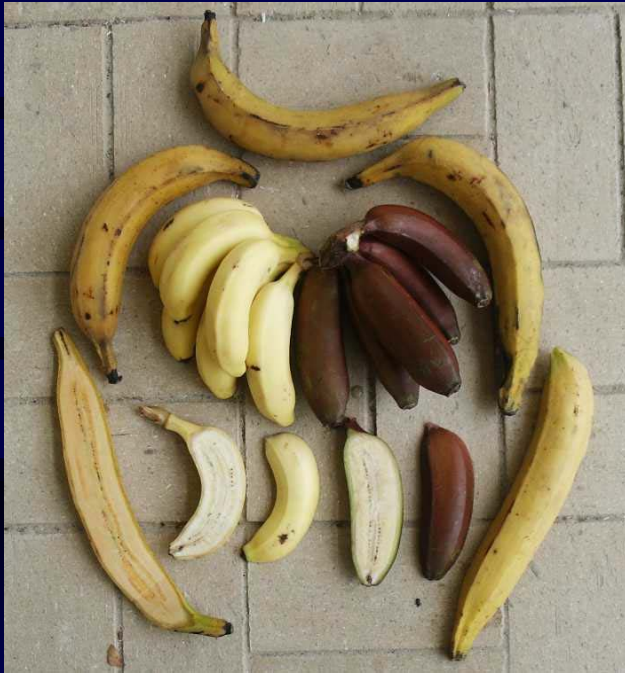
## Banana cultivars

### Cavendish

- Currently the leading cv for export
- Heavy production, cycle 11 months
- Smaller plant (2-3 m) - less wind damage
- Shipped packed in boxes

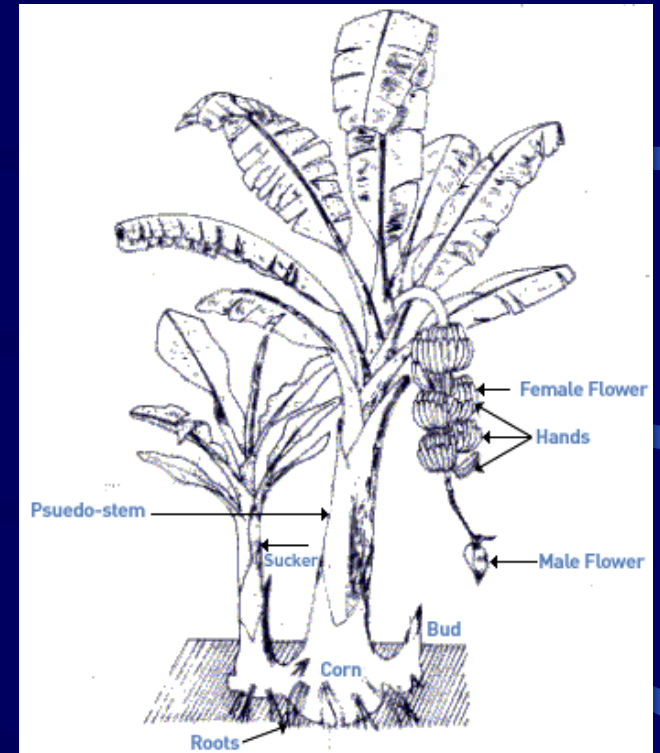


# Varieties



## Plant Structure

- Monocot
- Perennial herb (2-9 m)
- Monocarp
  - All leaves/inflorescence origin from under ground corm
  - Largest plant without woody trunk
  - Pseudostem, leaf bases



# Plant Structure

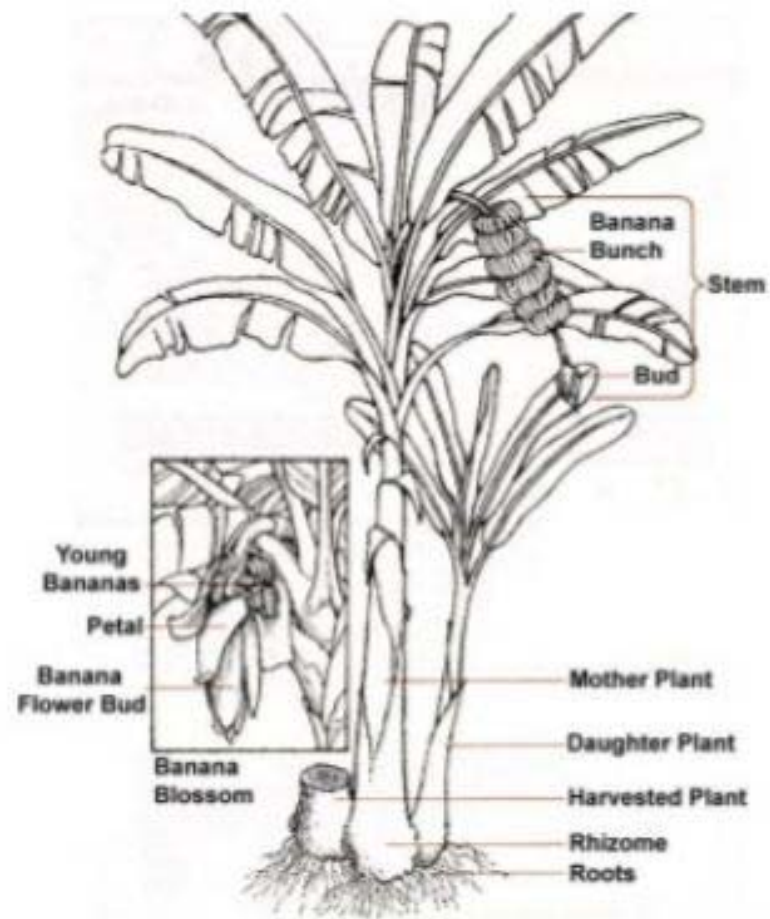
## Monocot

### ☒ Perennial herb

- All leaves/inflorescence origin from under ground corm
  - Spreads via rhizomes
  - Plants “walk”
- Largest plant without woody trunk
  - Pseudostem, leaf bases
- Fruits once



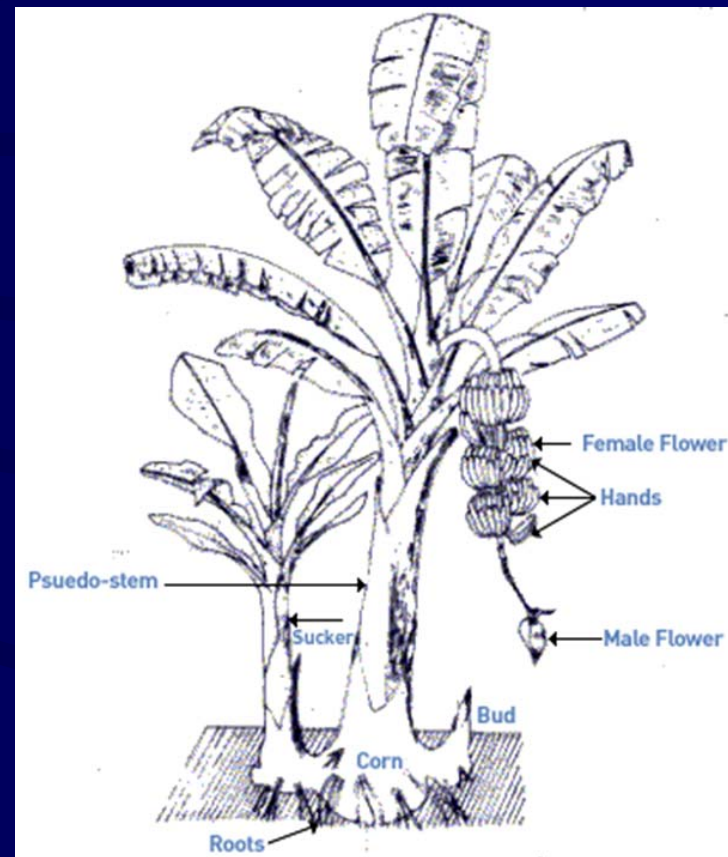
# Anatomy





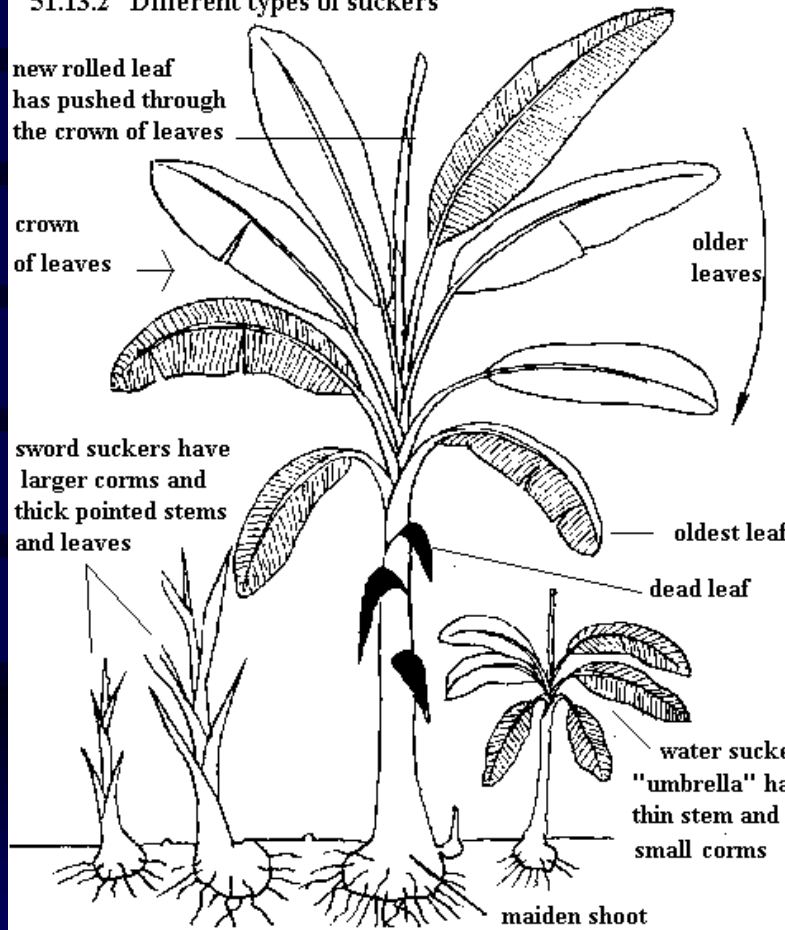
# Corm



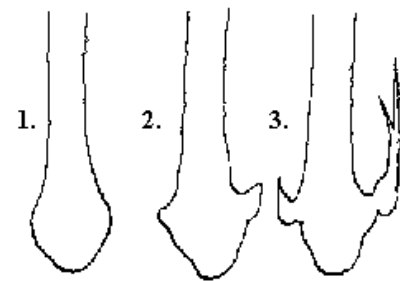




51.13.2 Different types of suckers



Suckers



Vertical section showing a sucker growing from a mother corm

Suckers

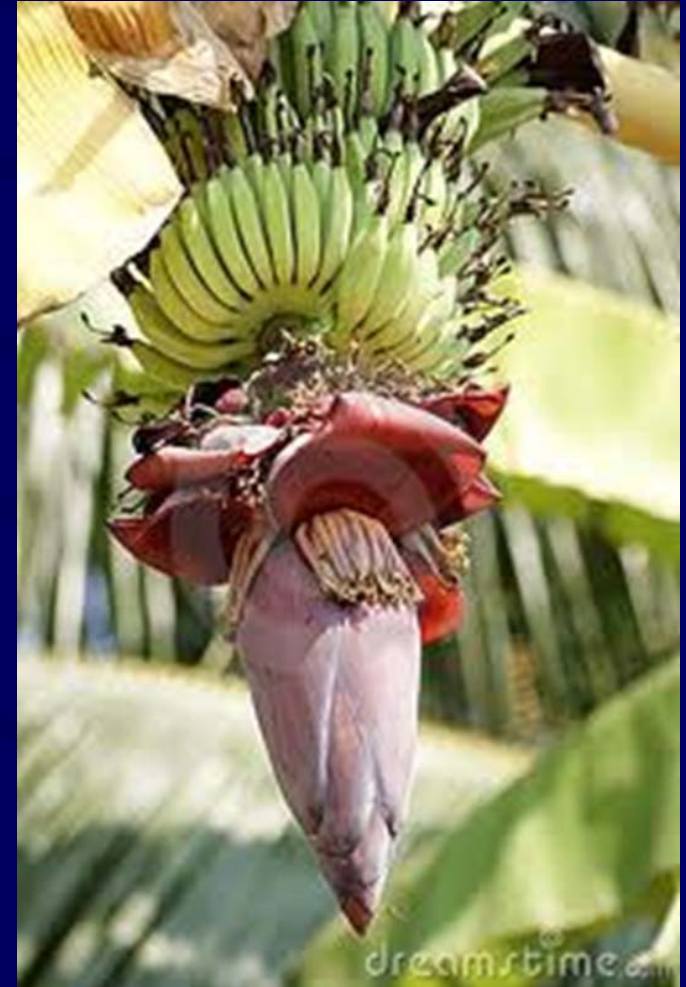


banana stool with many suckers growing from a mother corm

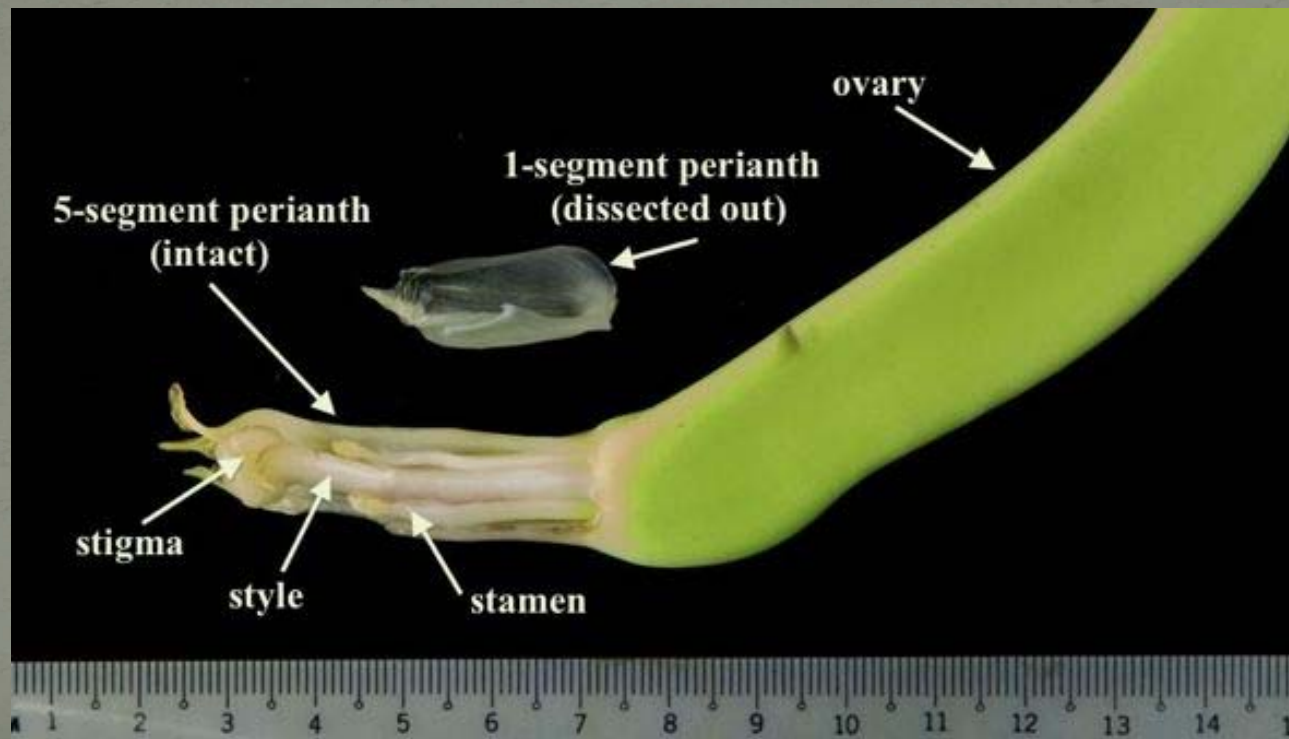
## Flower Structure

### Three types of flowers on inflorescence

- Female flowers - develop into fruit
- Neutral flower (Hermaphroditic flowers)
- Male flowers



# Female flower



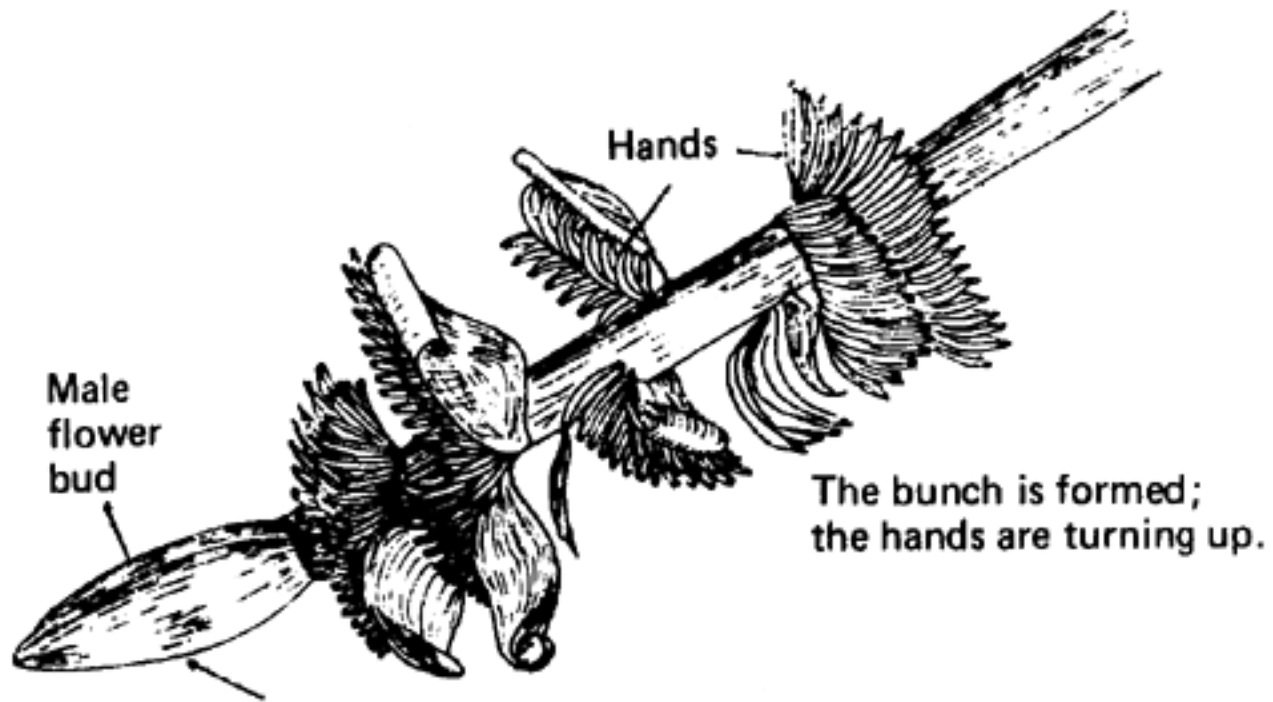
# Flower Structure

- Three types of flowers on inflorescence
  - Female flowers - develop into fruit
  - Hermaphroditic flowers
  - Male flowers
- Fruit is a berry



**Female flowers** have an inferior elongated trilobular ovary with 3 fused carpels bearing 6 petal (5 free and 1 fused) surrounding a thick style and non-functional staminodes. Ovaries of female flowers later become the fruit or finger.

**Male flowers** have a smaller ovary, slender style, 5 stamens with long anthers that may or may not produce pollen.

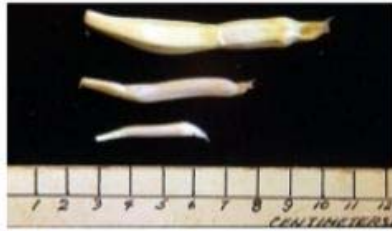






**Banana flowers**

**Banana flowers**



**Banana inflorescence**



# Banana flower



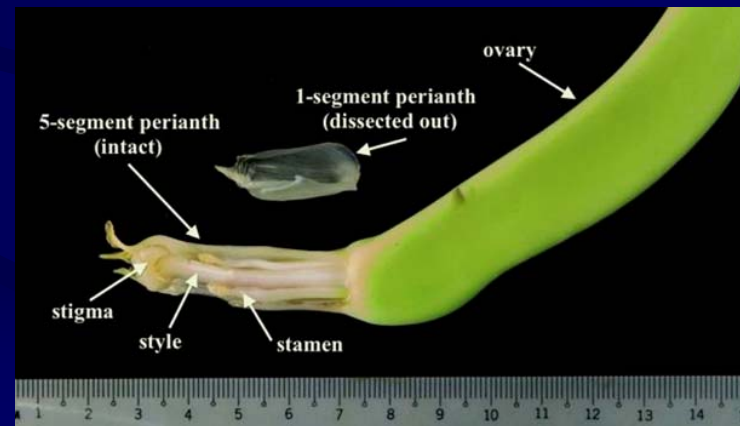
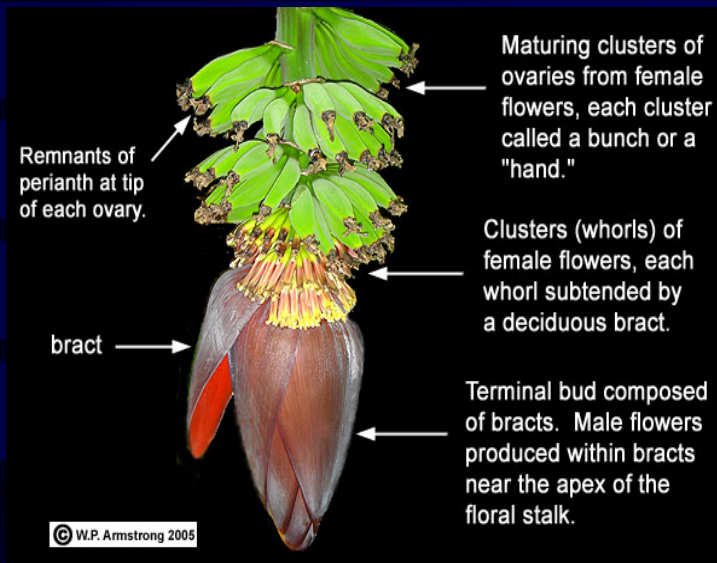
# Female flower







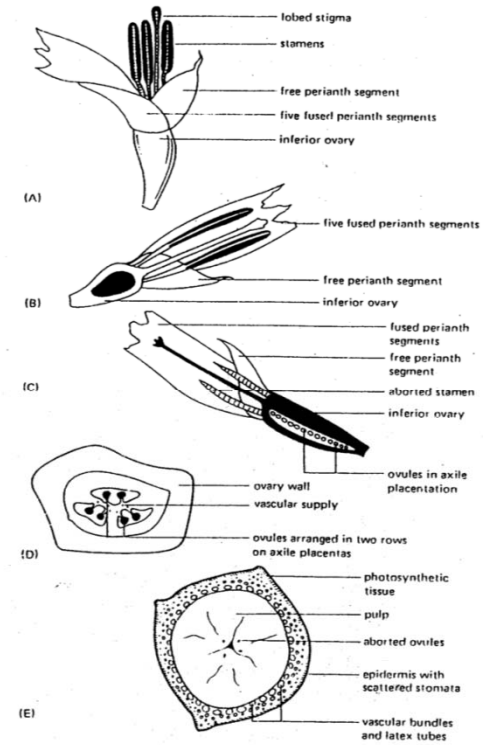
# Female flower







Male flower



شکل ۱-۶: (A) گل خنثی (x1). (B) برش طولی گل خنثی (x1). (C) برش طولی گل ماده (x1). (D) برش عرضی میوه جوان (x2). (E) برش عرضی میوه بالغ (x1).

# Banana flower

Three months from  
flowering to harvest



# Production

- Banana plants
  - Take 8-9 months to flower
    - 11-14 leaves
    - Six leaves needed for good production
  - Bunch take 3 months to develop
  - Fruiting cycle for Dwarf Cavendish is 11 months
- Banana plants “walk”

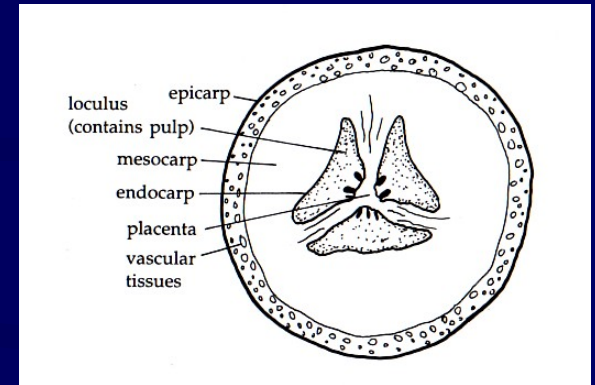
# Fruit

Fruit is a berry



alamy stock photo

FAPK3P  
www.alamy.com



# Botanically the Banana is a Berry

One pistil

One or many seed

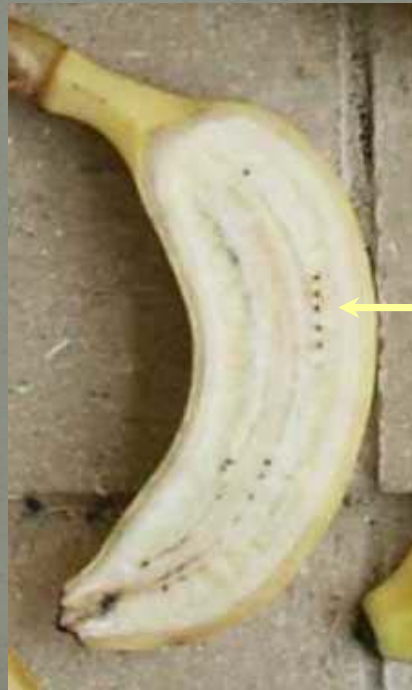
## Other Berries

Tomato

Kiwi

Grape

Persimmon



Seed Remnants

# Production Cycle

Propagation •

Vegetative •

Rhizomes that are 6-8" diameter •

Planted within hours of digging •

Special fields for production of rhizomes for new orchards •

Nematode problems •

Hot water treatment (65°C) •

Chemical dips •

**Seedy Bananas  
used for wind  
breaks**



## Soil

- Loamy soil, Deep, Well drained and aerated
- pH 5.8-6.5
- Salt sensitive



## Climate Requirement

- Tropical Plant (Wet tropical- Dry subtropical)
- Cardinal Temperature: minimum 18 °C, optimum 27 °C. maximum 38 °C
- Banana can tolerate temperature 15 °C for short time
- Temperatures below 12 °C (start chilling injury)
- Temperatures below 6 °C (severe injury and plant death)
  
- Wind: 25 -30 km/h, 65 km/h, 100 km/h

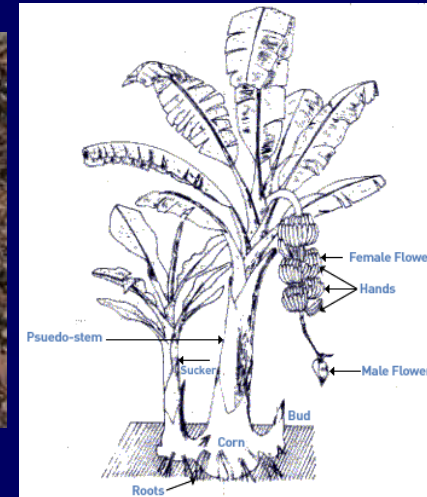


## Comparison between tropical and subtropical region (Cavendish cv.)

Traits	Wet Tropical	Subtropical
Mean of leaf number in month (warm season/cold season)	3.5/2.5	4/0.5
Total leaf number in year	40	25
Planting to harvesting (Month)	9-11	15-20
Flowering to harvesting (warm season/cold season, days)	98-117	110-204

# Propagation

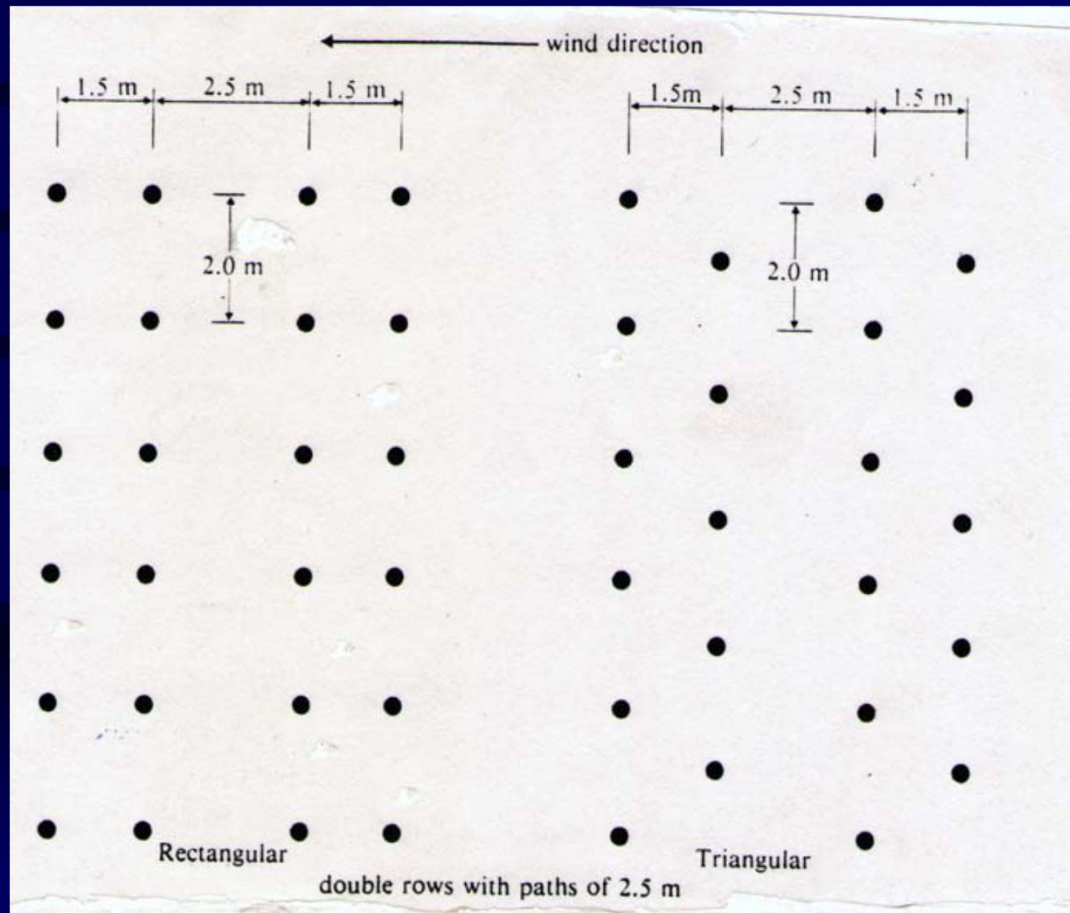
- Sward sucker
- Water sucker



- Corm



# Planting

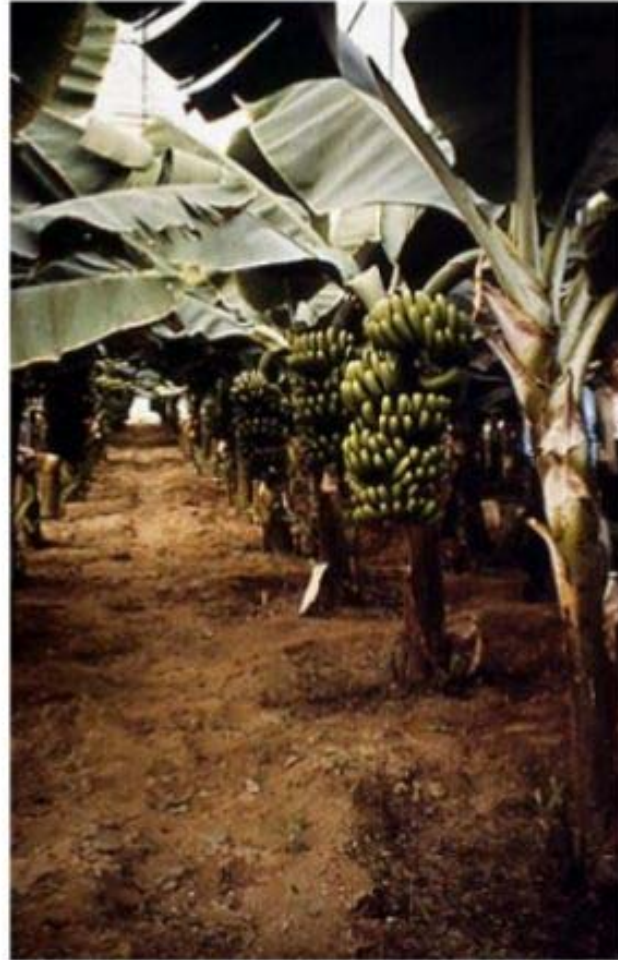






**Banana**

**Banana**



Tropical Horticulture - Texas A&M University

## Irrigation

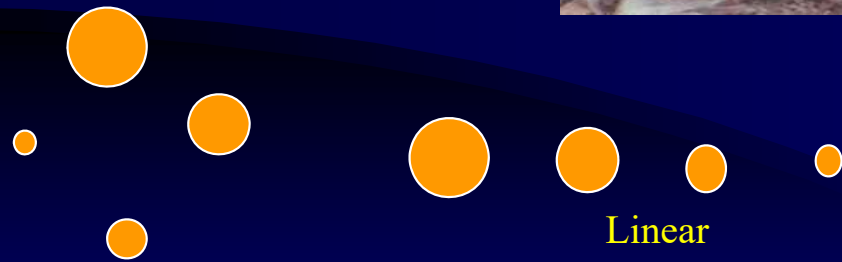
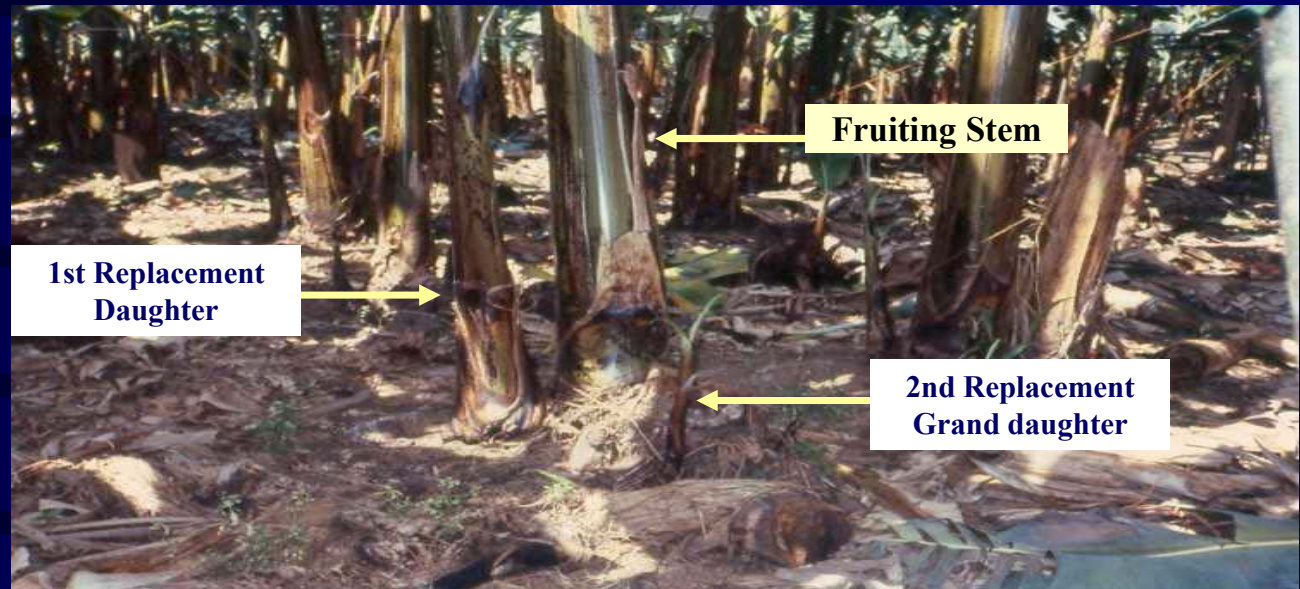
- Cultivar , Climatic condition and Soil
- Leaf surface
- Roots are distributed in upper (90% in the top 30 cm of soil)
- Low capability of roots to take up water
- Quick drought response



# Orchard Management

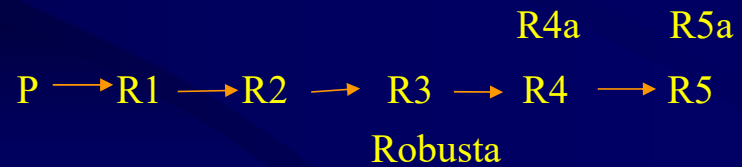
De-suckering:

Ratoon crop

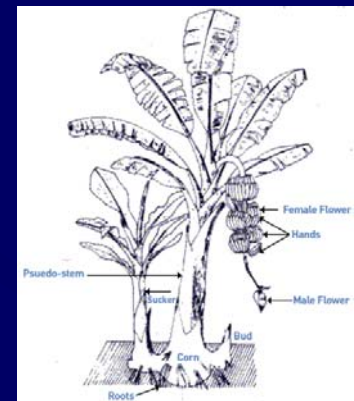


Rotating

Linear

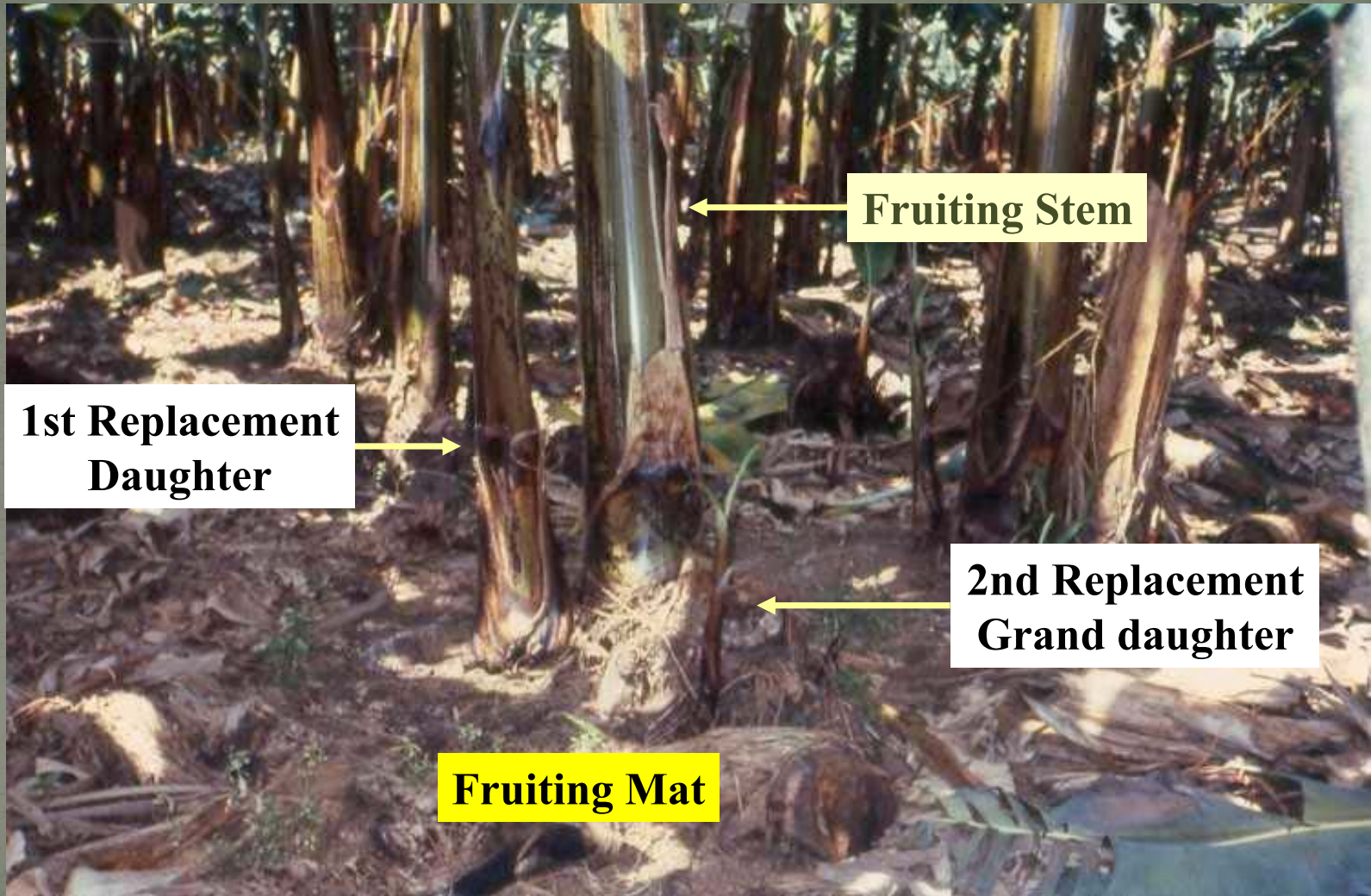


Robusta



# Training and Plant Selection

- Banana plants “walk”
  - Select and train sucker for next crop to not interfere with growing bunch
  - When harvest fruit the sucker should be 2 m (5-6’)
  - Eliminate suckers that are
    - Poorly positioned
    - Too small
    - Unhealthy

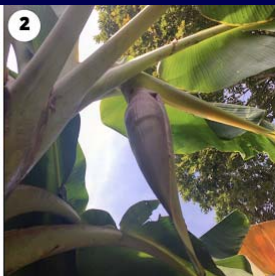




De-flowering

Male bud removal

Bunch covering

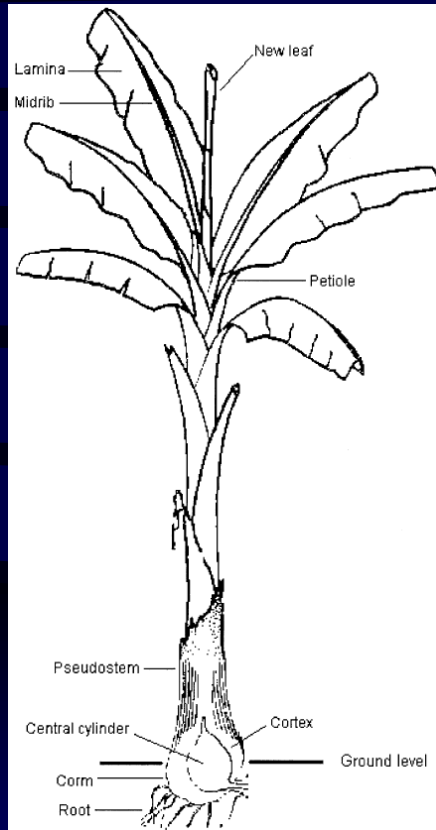


Leaf pruning

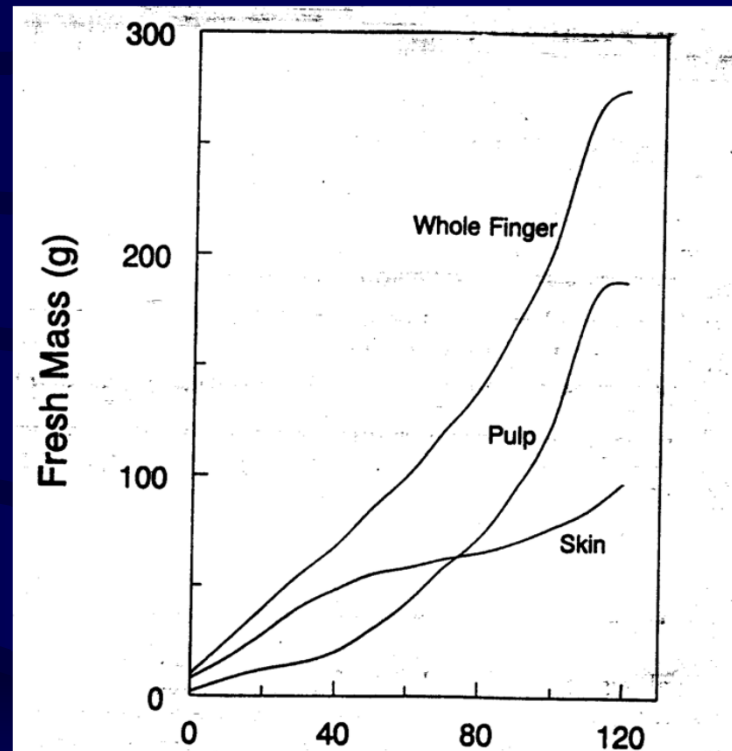
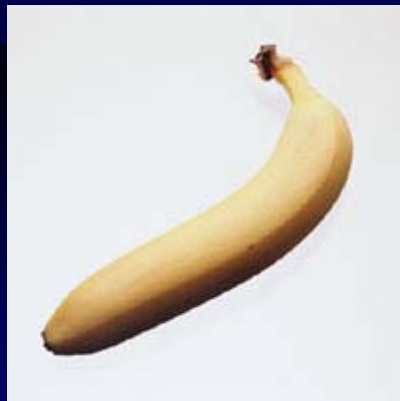


Bunch propping

# Flower Induction



# Fruit Growth and Development



# Bagging of the Fruit

- Weekly inspection
  - Last true hand is 4" long
  - Remove terminal end of bunch
  - Mark with ribbon - colors change with the week
  - Cover with perforated polyethylene bag
- Why
  - Protection
    - Pests
    - Damage from leaves
    - Dust and dirt
  - Advance ripening



Troj

# Fertility

- Forty tons of bananas per hectare
  - 80 kg N = 80 kg N
  - 20 kg  $P_2O_5$  = 9 kg P
  - 240 kg  $K_2O$  = 200 kg K



# Supporting the Crop

- 52% of plant weight is the raceme
  - Prop with poles
  - Guide lines to base of adjacent plant
  - Leaf pruning can reduce problems with wind damage



Tex

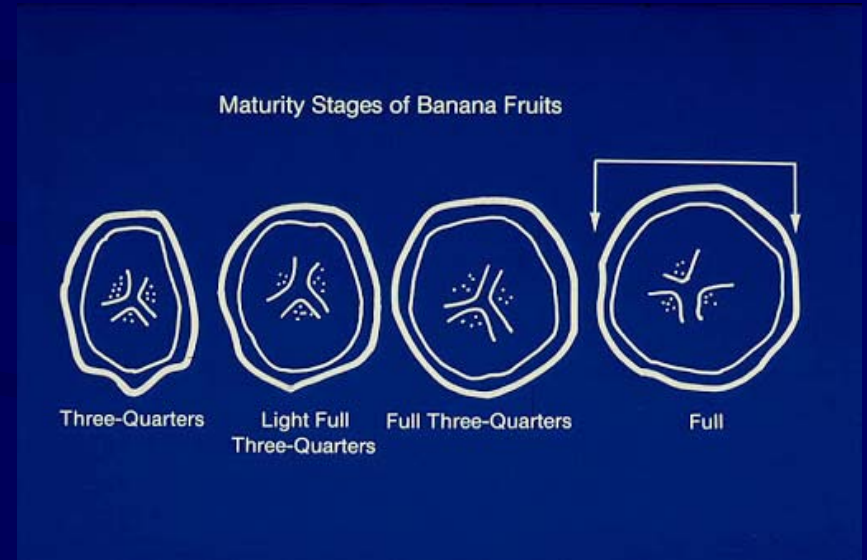
# Harvest

- Crew harvests at 3-4 day intervals
  - Look for colored ribbons which indicate age of bunch
- Minimum size
  - 5 hands
  - Pick green, with certain size
- Banana bunch weighs 90-110 lbs
  - Two man operation
  - Hung on hook on cable system

## Harvesting Time

### Climacteric

- Old of bunch
- Changes in cross section area
- Fruit diameter



## Harvesting Method

- Cable system runs from banana field to the packing house
- Separate into hands, Wash to prevent staining, Pack in boxes



## Removal Mother Plant



## Yield

Bunch

8 Hand (15 fingers)

Finger (150 200 g)

Bunch weight: Average 18- 24 kg

Gros Mitchel: 40 kg per bunch (Yield: 18 tone/hect.)



- Cable system runs from banana field to the packing house



# Fruit Packing and

Separate into hands  
Wash to prevent staining  
Pack in boxes





# Fruit Packing and Quality

- Pack in boxes
- Only pack unblemished fruit



# Post Harvest

- Storage temperature
  - 57 - 59 F
  - Below 56 F may cause chilling injury
- Bananas are ripened for marketing
  - 58-64 F
  - Ethylene treatment

# Nutritional Value

- 100 gm edible pulp
  - 85 calories, mostly carbohydrates
  - Vitamin, A, C, B<sub>1</sub>, B<sub>2</sub>, niacin
  - Minerals, very high in K
    - Reduce risk of high blood pressure and strokes

