Viticulture in the Tropics and Subtropics

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Contents

Economic Aspects and Use of Grape

Grape: Economically, the most important fruit in the world.

Multipurpose Utilisation :

- Table grapes
- Wine, sparkling wine, dessert wine, brandy.
- Raisins
- Grape juice
- Jams and jellies
- "Pekmez"
- Grape seed oil
- Firewood

High ecovariance

High nutritional value

Climate

	Vegetation	Precipitation	Temperature
Inner Tropics	Evergreen rain forest	>1500 mm even spread	frost free, >25 ° C day - night difference 0-6 ° C
Outer Tropics	Savanna	<1500 mm dry season wet season	day-night difference increasing

Production in different zones

Zone	Sum of Temperatures > 10 ° C	Production						
I	< 1372	SW	WW	R	-	-	-	-
II	1372 - 1648	-	WW	R	B	-	-	-
III	1649 - 1926	-	WW	R	B	DW	(T)	-
IV	1927 - 2205	-	-	R	-	DW	T	-
V	> 2205	-	-	-	-	-	T	R
W Sparkling wine, B Brandy, T Table grapes, WW White wine, RW Red wine, DW Dessert wine, R Raisins								

Precipitation

determines:

- annual rhythm of growth and dormancy
- date of harvest

High Temperature

- Rapid growth and development
- First harvest, 18 months after planting (tropics)
- Accelerated berry development - must and wine quality.
- 2 - 3 harvests per year (tropics)
- High evapotranspiration : High water demand
- Lack of cool stimulus : Irregular bud break (figure)

Radiation

PAR (400 - 700 nm) upto 2000 - 2200 µmol quanta · m-2 · s-1

Day length

- Equator:12 h light / day
- Short day: 8 - 12 h light / day

Wind

Permanent winds, e.g. in coastal areas

- reduce growth
- lower yields

Annual Rhythm of Growth & Dormancy (figure)

Bud Dormancy and Bud Break				
	Correlative predormancy	Endogenous dormancy	Exogenous postdormancy	
Principle of dormancy	Apical dominance	Chemical inhibitors	Low temperature	
Induction of bud break	Decapitation, Topping	Cool stimulus, Cyanamide	Increasing temperature	

One harvest per year in the subtropics (figure)

Loss of external stimuli allow two (even three) harvests per year (figure)

Vegetative and Generative Devopment

Control of Bud Break

Cool stimulus

- Temperatures below 12 °C
- Tropics
  - Only in exceptional circumstances
  - Cold sea currents (Humbold current)
  - Irrigation, Monsoon: only small effects

Drought stimulus (Drought season)

Defoliation

- Alteration of the hormone metabolism (?)

Chemicals

- Cyanamide H_2CN_2, $CaCN_2$ ('Dormex', figure)
- Bordeaux mixture + Urea (`Black Bordeaux‘)

Irrigation

	Automatic control	Slope	Fertigation	Evaporation	Labour – L Capital – C
FurrowIrrigation	-	-	-	high*	L
Dripirrigation	+	+	+	low	C
Microjets	+	+	+	low	C
Overheadsprinklers	+	+	+	high	C
Flooding	-	-	-	high	L
Basins	-	+	-	low	L
Subsoilirrigation	+	+	+	low	C
* Lowering of evaporation by surge irrigation					

Irrigation: Examples

Type of Irrigation	Number of irrigations per year	Quantity of water per year	Water use efficiency %	Degree of salinity
Furrow	9	900	20 – 60	+
Overhead	8	600	60 – 80	++
Drip	53	400	90 – 95	±
from : Cole, 1979				

The effect of irrigation depends on the developmental stage of the grapevines

Time of irrigation and must quality

	Berry Stages	°Oechsle	Acidity ‰
Not irrigated	I-II-III	71	7.7
Irrigated	I-II-III	67	9.9
Irrigated	I-II	70	9.6
Irrigated	III	87	7.1
Date of Harvest : 5 October Variety : Müller-Thurgau			

Irrigation Scheduling

1. Plant Based Methods

- Water potential (Leaf, Shoot)
- Growth of shoots and tendrils
- Angle between leaf petiole and blade
- Trunk diameter
- Sap flow measurement (in trunk)
- Infrared photography (aerial photographs, canopy temperature)

2. Soil Based Methods

- Tensiometer
- Neutron scattering method
- Electronic sensors

3. Weather Based Modelling

- Evaporation : Class A - Pan

Water requirement (Litre / Grape): Epan x F x A

Epan = Evaporation of Class A - Pan

F = Crop Factor (Grape : 0.2 - 0.8)

A = Area (m^2) occupied by vine

Salinity in tropical and subtropical areas

1. Water and salt transport to the soil surface
2. Evaporation
3. Salt accumulation

Grape: Little tolerance to NaCl; Uptake and accumulation of Cl^-

Symptoms:

- Chlorosis and necrosis of the leaves (figure)
- Vessels remain green
- Yield reduction

Origin of Salinity

Natural Factors:

- High natural salt content in soil
- Low precipitation
- Insufficient drainage
- High water table
- Valley or basin

Man-made Factors:

- High salt content of irrigation water
- Mineral fertilisation

Evapotranspiration (ET) in a Vinyard

ET (mm) = Transpiration of grape + Evaporation of soil

depends on

- Stage of development and age of grape
- Air humidity
- Available soil humidity (often limits yield and quality)
- Maximum water consumption of grape at fully developed canopy and low air humidity

is affected by viticultural management (figure)

- Canopy structure (open or closed canopy)
- Girdling,
- Frequency of irrigation
- Yield,
- Topping and defoliation

ET (Subtropics) : 650 - 800 mm / Vegetation period (ca. 10 mm / Day)
ET (Desert) : 1,110 mm / Vegetation period

Partial Rootzone Drying (PRD)

Method:

Only one side of the row is irrigated by drip while the other side remains dry. Swap sides every 14 days.

Physiology:

Roots function as sensors of soil humidity.

1. Increase of abscisic acid (ABA) in stressed roots
2. Transport of ABA in xylem
3. Stomatal conductance is reduced

Shoot and leaf growth is limited, leaf water status is not affected

Size of the root system is not reduced (different from standard drip irrigation)

Viticulture:

- Open canopy
- Higher degree of bunch exposure
- Alteration in berry anthocyans
- Increased water use efficiency

Yield and berry weight unaltered

from Stoll et al. 1998

Effects of Partial Rootzone Drying (PRD)

Variety		Control	PRD
Cabernet-Sauvignon	Yield, t / ha	15.2	15.4
	Amount of water, Ml / ha	1.4	0.7
	WUE, t / Ml	10.9	22.0
Riesling	Yield, t / ha	30.6	28.7
	Amount of water, Ml / ha	5.2	2.6
	WUE, t / Ml	5.9	10.9
From Dry et al. 2000		Ml = MegaLitre = 10^6 Litre	

Table Grape Production

Vitamin Content of Table Grapes

Vitamin		µg/100g
A	Thiamine	35 - 58
B1		37 - 130
B2	Riboflavin	20 - 25
B6	Pyridoxine	84 - 135
C	Ascorbic Acid	4.000 - 9.000
P	Rutin	+++
	Nicotinic Acid	170 - 330
	Pantothenic Acid	78
	Folic Acid	4 - 10
	Biotin	1.5

Quality of Table Grapes

1. Appearance

- Berry:
  - Size
  - Colour
  - Imperfections
- Cluster
  - Shape
  - Size
  - Compactness

2. Palatability

- Seed number
- Taste
- Physical attributes

3. Transport and storage tolerance

- Berry
  - Pressure resistant,
  - Firm
  - Elastic
- Rhachis:
  - Low water loss

4. Economic Production

- Constant yields
- Low waste
- Low production costs

Table Grape Varieties

Variety	Colour	Berry Weight g	Cluster Weight g	Taste	Storage & Transport Tolerance
Dattier de Beyrouth	green-white	> 7	250 - 450	aromatic	good
(Regina)		very large	large		
AlphonseLavallée	black-blue	5 – 7	450 - 700	neutral	good
		large	large	astringent	
ThompsonSeedless	green-gold	< 3	450 - 700	neutral sweet	sufficien
(Sultana)		small	large		
Emperor	red-blue-violet	5 - 7	>700	neutral	good
		large	very large		
Almeria	greenish-white	5 - 7	450 - 700	neutral	good
		large	very large		
Flame Tokay	light-red	5 - 7	450 - 700	neutral	good
		large	very large		

Muscat of Hamburg	darkblue-black	4 - 5	250 - 450	Muscat	
		large	large		
Perle of Csaba	gold-green	< 3	< 200	Muscat	
		small	small		
Muscat of Alexandria	green	4 - 5	250-450	Muscat	poor
		large	large		
Cardinal	red	> 7	450 -700	neutral	very good
		very large	large		
Perlette	green-white	5 – 7	450 - 700	aromatic	good
		large	large		
Italia	white	> 7	450 – 700	Muscat	sufficien
		very large	large		
Emerald Seedless	green	4 – 5	> 700	neutral	
		large	very large		
Queen of the Vineyards.	golden green	5 – 7	450 - 700	Muscat	good
		large	large		
RubySeedless	violet-blue	5 – 7	> 700	neutral	
		large	very large		

Figure: Time of Maturity

Breeding of new varieties for the tropics

Main Aims

- Fungus resistance
- Adaptation to climate
- Yield and quality

Genetics

Tropical *Vitis* species crossed with *Vitis vinifera*

1. *Vitis tiliaefolia = Vitis caribaea*
2. *Vitis shuttleworthii*
3. *Vitis gigas*
4. *Vitis rufotomentosa*
5. *Vitis smalliana = Vitis simpsonii*
6. *Vitis popenoei*
7. *Vitis munsoniana*

Improving Quality

Thinning:

- Removal of inflorescence
    - Improvement of fruit set
    - Increase of cluster weight

    - Recovery after high yield
- Removal of clusters
    - Yield control
- Removal of berries
    - Improvement of cluster shape (figure)
    - Loosening of compact clusters
    - Increase of berry size
        - Homogenisation of colour
        - Acceleration of ripening

Girdling:

- Phloem interruption (figure)
    - Increase of fruit set
    - Increase of berry size
    - Acceleration of ripening

Topping:

- Removal of apices
    - Increase of fruit set

Growth Regulators:

- Increase of fruit set
- Increase of berry size of seedless varieties (figure)
- Improvement of berry colour (figure)

Regulation of ripening

- Alteration of Microclimate by Irrigation (?)

Effects of reducing number of berries on berry weight (g)

Variety	Control	Immediately	7 - 10 days
		after fruit set	
Tokay	4.9	6.4	5.8
Malaga	3.8	6.0	4.6

Effects of girdling on berry weight

Variety : Thompson Seedless		
	Berry weight (g)	
Girdling at:	Control	Girdled
6 June (Stage I)	1.57	3.03
13 June		2.85
20 June		2.50
27 June		2.10

Application of Gibberellic Acid (GA) on Thompson Seedless

	10 ppm GA at bloom	*40 ppm GA at fruit set*
Number of berries	decreased	---
Berry size	increased	increased
Length of Pedicel	increased	---
Cluster	loose	compact
	GA at bloom and at fruit set	
Berry size	increased considerably	
Length of Pedicel	increased	
Cluster	loose	

Effects of gibberellic acid at the end of flowering

on berry weight and sugar concentration

Variety: Thompson Seedless		
GA Concentration	Berry Weight	Sugar Concentration
	(g)	(°Brix)
0 (Control)	2.69	19.8
5 ppm	3.10	20.7
10 ppm	3.47	21.1
20 ppm	3.49	21.3
40 ppm	3.60	19.2

Harvest, Packing and Storage

Coolstore: The storage ability of table grape varieties

Italia	1 - 2 months
Flame Tokay	
Thompson Seedless	
Red Malaga	2 - 3 months
Alphonse Lavallée	3 - 5 months
Almeria	
Emperor	
from Winkler et al. (1974)	

Optimal harvest time

indicated by

- the appearance of the grapes
- the sugar - acid relationship
- the storage and transport strategy
- the market price

Packing

- between the rows
- on accessways near vinyard
- in the packing house

Raisin Production

Vitamins in Raisins (Thompson Seedless)

Vitamins	µg/100g
Vitamin A	-
Vitamin B1	100 - 120
Vitamin B2	25 - 30
Vitamin B6	230 - 240
Vitamin C	-
Nicotinic acid	620
Pantothenic acid	55 - 60
Biotin	4.5
Folic acid	10

The Most Important Raisin Varieties

Varieties	Synonym	Dried Product
Thompson Seedless	Sultana	Sultanas
(white)	Oval Kishmish	Sultanine
Black Corinth	Zante Currant	Currants
(black)		
Muscat of Alexandria	Muscat Gordo Blanco	Raisins
(white)	White Hanepoot	Lexias
	Zibibbo	Zibebes

Improvement of Fruit Set by Girdling at the Onset of Bloom

	Variety: Black Corinth			
	Yield / Vine	Berries / Cluster	Weight of 100 Berries	Degree of Maturity
	kg		g	° Brix
Control	3.2	266	17.0	26.3
Girdling	10.9	361	34.9	25.9
	+ 240 %	+ 36 %	+ 105 %	

From: Winkler et al. 1974

Combined Gibberellic Acid and CCC Application at Full Bloom

	Variety: Black Corinth						
	Fruit Set	Undeveloped Berries %	Split Berries %	Berry Weight g	Sugar Content °Brix	Cluster FW g	Cluster DW g
Control	43.6	14.8	8.8	0.20	25.4	28.5	9.3
GA + CCC	53.5	11.2	6.2	0.32	26.4	73.3	23.3
	+ 23 %	- 24 %	- 30 %	+ 60 %		+ 157 %	+ 151 %

Drying

Potassium Carbonate - Oil Emulsion, "cold spray"

- 2.5 % K_2CO_3 solution, pH 10 (Potash)
- + 2 % Dipping oil (Olive oil)

produces

1. Fatty acid ethyl esters (Fatty acid + ethanol)

- C16 Palmitic acid 1 - 2 %
- C18 Stearic acid 50 - 54 %

2. Free fatty acids

- Palmitic acid 1 - 2 %
- Stearic acid 8 - 12 %

which increase permeability of the wax structures

Drying Systems (figure)

Without chemical pre-treatment				
Harvest	Drying Duration	Energy Source	Product	Country
1. Hand/Machine	Soil between rows 4-5 weeks	Sun	Naturals	USA
2. Hand	Drying racks	Sun	Currants	Greece
3. Hand	Drying house	Cool air	Kishmish	Afghanistan Australia, China
With chemical pre-treatment				
Potassium carbonate - oil emulsion, "cold spray"				
4. Hand	Drying racks	Sun	Sultanas Sultanines	Australia

	1-2 weeks	Heater		Greece, Turkey
5. Machine	Canopy	Sun	Sultanas	Australia
NaOH: "hot dip":				
6. Hand	Drying rooms	Heater	Golden Bleached	USA