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Cactus pear fruit production: from plant biology to orchard management

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Worldwide land area 100,000 ha specialized plantations

Sicily production

CULTIVARS → Rossa, Gialla, Bianca

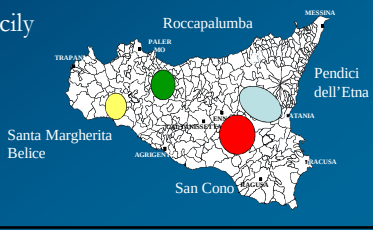
Summer Fruits ---------- 10%

Winter Fruits ---------- 90%

production period (October)

Italy

- Surface:
  - Ha 3500 Specialized plantation
  - Ha 15000 overall
- Production: 70000 tons
- Region : Sicily



Orchard Planting

- Soon after rains and with increasing temperatures
- Age of cladodes: 2-3 years
- The rows should be oriented north-south to maximize PAR (Photosynthetically Active Radiation) interception and cladodes faces perpendicular to the rows.
- Depth of the hole in the row: 50 cm; eventually the hole should be filled with cow manure or hand fresh soil with 30 g of N.
- Cladodes should be planted upright with the cut end on the ground, is recommended to place underground half of the planting cladode.
- Cladodes should be irrigated soon after planting.

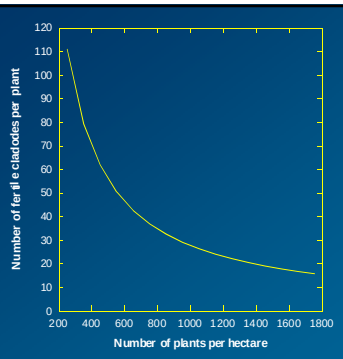
1, 2, or 3 cladodes in a hole

Planting Density

Sicily:
4 m in the row and 6 m between the rows
416 plants ha^{-1} (24 ton/ha)

Mexico:
2 m in the row and 4 m between the rows
1250 plants ha^{-1} (20 ton/ha)

Israel: 1.5 m in the row and 4 m between the rows
1600 plants ha^{-1} (18 ton/ha)



Number of fertile cladodes needed to get a crop yield of 20 t ha^{-1}, given 6 fruits (120 g) per cladode, in relation to orchard density.

Vegetative and reproductive behaviour of cactus pear trees.

Parameters	One year old cladodes				Two years old cladodes			
	1992	1993	1994	1995	1992	1993	1994	1995
Fertile cladodes (n)	53±9	47±10	75±8	65±10	19±5	18±6	14±3	14±2
Vegetative cladodes (n)	3±1	4±1	5±1	3±0.5	18+3	22±3	28±5	26±5
Fertile and vegetative cladodes (n^2)	4±0.5	6±0.5	4±1	4±1	17+3	16±2	12±5	11±7
Fruit (n)	236±44	308±84	462±92	324±78	60±18	57±11	52±12	28±6
New cladodes (n)	14±3	17±2	18±3	14±2	53±7	54±6	60±8	63±7
Fruit x cladode (n)	4.1	5.8	5.8	4.7	1.7	1.7	2.0	1.2

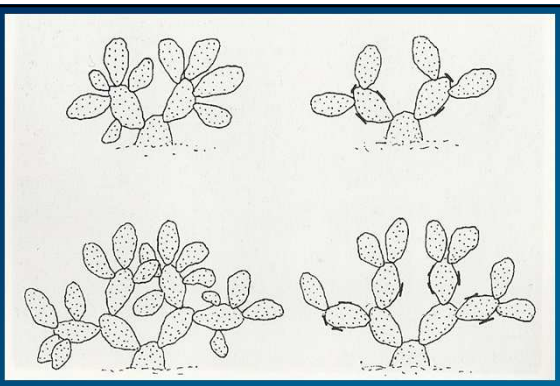
Orchard management

- pruning
- thinning
- irrigation
- fertilization

Pruning

In the first two year remove inner cladodes and those oriented downwards, horizontally or close to the ground; is recommended to clean the pruning tools with Bordeaux paste after use.

- Leave no more than 2 daughters cladodes on a parent cladode;
- remove developing cladodes from fertile parent cladodes;
- avoid pruning during rainy or cold periods;
- avoid summer pruning, unless for summer growth;
- control plant height at 2-2.5 m.

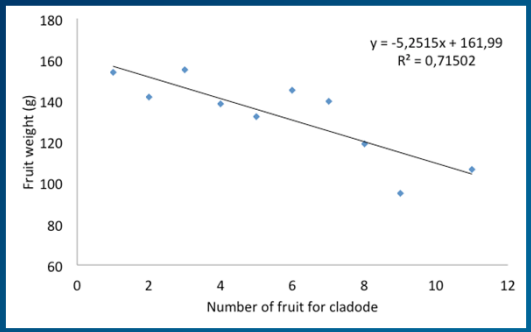


Pruning during second and third year from planting

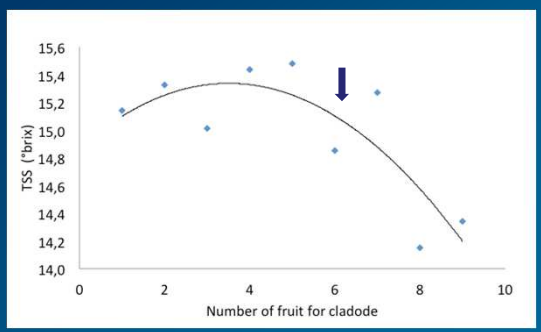
Fruit thinning

- Fruit growth rate and harvest size decrease with fruit number per cladode, when more than six fruits are left on a fruiting cladode
- Thinning times are from 2 weeks before bloom to 2 weeks after set, is recommended to maintain no more than 6 fruits for each cladode

Relationship between average fruit weight and number of fruits per cladode in five 8-years-old *Opuntia ficus-indica* trees, cultivar Gialla, grown in a commercial orchard, at Roccapalumba (Sicily - Italy).



Relationship between average TSS and number of fruits per cladode in 8-years-old *O. ficus-indica* trees, grown in a commercial orchard (Roccapalumba - Italy).



Fertilization

Pre-planting:

- 3 - 5 kg of ***cow manure*** tree^{-1}
- 300 - 400 kg ha^{-1} of P_2O_5
- 300 - 500 kg ha^{-1} of K_2O

In South Africa is considered as optimum in the soil the availability of 500-600 mg kg^{-1} of calcium, 150 di potassium, 80-100 di magnesium e 12-15 di phosphorus (Wessels, 1988)

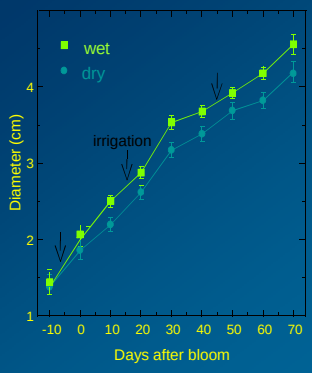
Fertilization

From November to January:

- phosphorus: 30 kg ha^{-1}
- potassium: 120 kg ha^{-1}
- nitrogen: 60 kg ha^{-1}

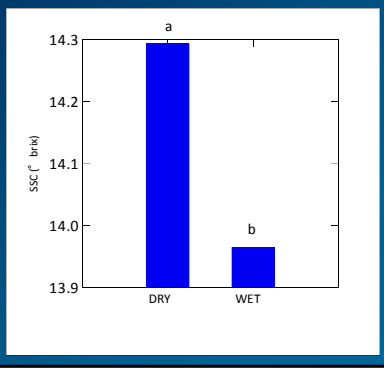
Irrigation

- Localized irrigation
- 3-5 times (relating to the soil and the environmental conditions)
- about 1.000 m^3/hectares



Seasonal fruit growth in cladodes bearing 6 fruits.

Irrigation influence on fruit sugar content



Fruit parameters in relation to thinning and irrigation

	Fruits (n)	Fresh weight (g)	Flesh (%)	Fruits> 100 g (%)
Wet	6	126	52	84
	15	95	50	29
	15□ 6	108	49	54
Dry	6	104	53	33
	15	89	46	10
	15□ 6	97	54	30

Orchard management for off-season crop

Italy

Scozzolatura (may-june)

Spring flush removal of flowers and new cladodes

Production (1:1) (October)

one prod./year

Barbera & Inglese 1993

Israel

N fertilization (80-120 kg ha^{-1})

&

Irrigation (after summer crop)

Production (20-30% s.c.) (few months after summer crop)

two prod./year

Nerd et al. 1993

Blooming date and fruit ripening of summer production and scozzolati

	Blooming time	Ripening time	Fruit growth time
Summer prod.	01/06-15/06	10/08 - 25/08	70 - 80
Scozzolati	07/07 - 20/07	01/10 – 30/10	90 - 105

Fruit quality parameters at harvest

	Weight (g)	Pulp (%)	TSS (° Brix)
Summer crop	120.5 ± 8.5	55.1 ± 3.0	12.15 ± 0.07
Scozzolati	163.19 ± 2.30	61.1 ± 0.85	13.26 ± 0.05

Orchard management

- fertigation
- Scozzolatura

Orchard management → Reflowering → *O. ficus-indica* late cropping

Late cropping (*double scozzolatura*)

The effect on flower bud production of the removal of the 1st (spring) and 2nd flush of flowers and cladodes was studied in a commercial plantation of cactus pear (*O. ficus-indica*) established in Sicily and covered, during winter, time with a polyethylene tunnel.

Orchard management

- Bloom (early june)
- I Scozzolatura (full bloom)
- I Reflowering (early july)
- II Scozzolatura (full bloom)
- Fertilization (250 g N/tree)
- Irrigation (250-300 l/tree)
- II Reflowering (end of august)
- Coverage (polyethylene tunnel)>November-December
- Harvest (January-February)

O. ficus-indica trees in plastic tunnel

Blooming date and fruit ripening of scozzolati and out of season

	Blooming time	Ripening time	Fruit growth time
			days
Scozzolati	02/07 - 12/07	15/10 - 1/11	102 - 120
Out of season	20/08 - 30/08	1/02 - 2/03	162 - 190

Average monthly temperatures in the field and under the tunnel during the fruit development period of fruits coming from the 3rd- flush of bloom

Month	Temperature ° C	
	Full field	Tunnel
October	19.0	-
November	14.5	17.5
December	11.5	14.5
January	11.0	13.5
February	10.5	16.0

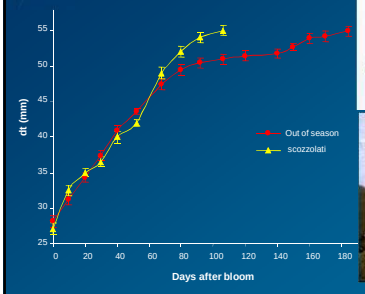
Min e Max monthly temperature (tunnel)

Month	Temperature ° C	
	Min	Max
October (full field)	15	23
November	12	23
December	8	17
January	6	16
February	10	22

Photosyntetic activity (malic acid cladode day/night accumulation) (full field and tunnel) (February)

	November		February	
	Tunnel	Full field	Tunnel	Full field
Malic Acid (mM/D.W.)	3.15	3.78	4.61	2.90
Light (µmol m^{-2} d^{-1})	8.9	11.7	9.7	14.5
T max / T min (° C / ° C)	27/12	21/12	22/9	15/8

Cumulative growth curve for fruits coming from the 2nd- and 3rd- flush of bloom



Fruit quality parameters at harvest

Fruits	Weight g	Pulp %	TSS ° Brix	pH	Malic Ac. %	Seed/pulp n° /g	Fertile seeds %
Scozzolati	163.19 ± 2.30	61.1 ± 0.85	13.26 ± 0.05	6.26 ± 0.03	0.3 ± 0.01	3.9 ± 0.2	55 ± 1.3
Out of season	170.4 ± 7.11	62.9 ± 0.92	12.1 ± 0.07	6.11 ± 0.01	0.2 ± 0.01	4.1 ± 0.1	50 ± 1.8

Out of season fruits of Cactus pear (February) cv. *Gialla* in Sicily

cactus pear fertile cladodes can still produce flower and vegetative buds even after a double removal of the spring flush and of the second induced one

O. ficus-indica trees in Tunnel

for late cropping is essential to have adequate environmental conditions during winter to get normal fruit ripening and marketable quality