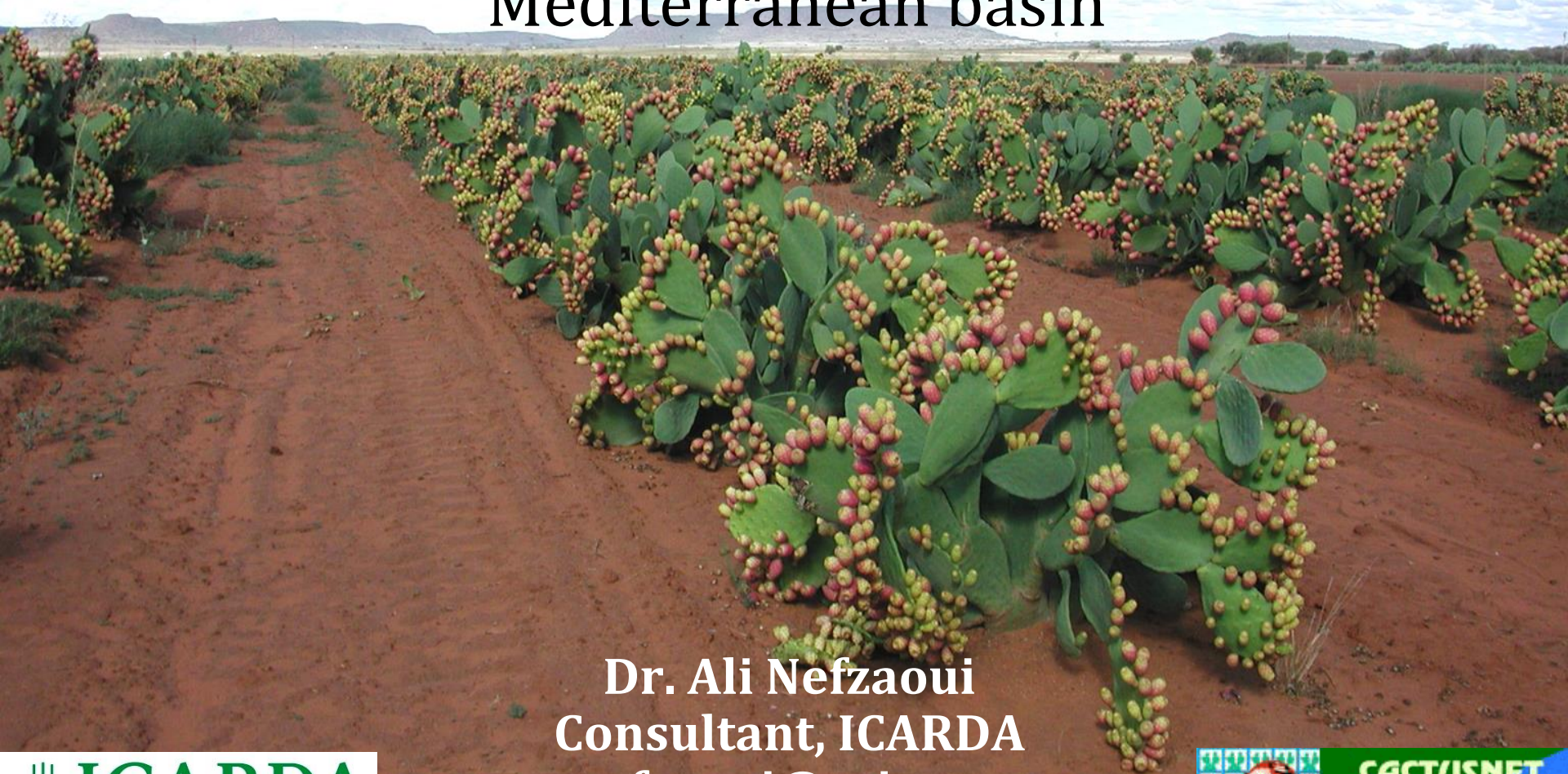


Multiple Uses of cactus Pear (*Opuntia ficus-indica*) and threat of recent cochineal (*Dactylopius opuntiae*) outbreaks in the Mediterranean basin

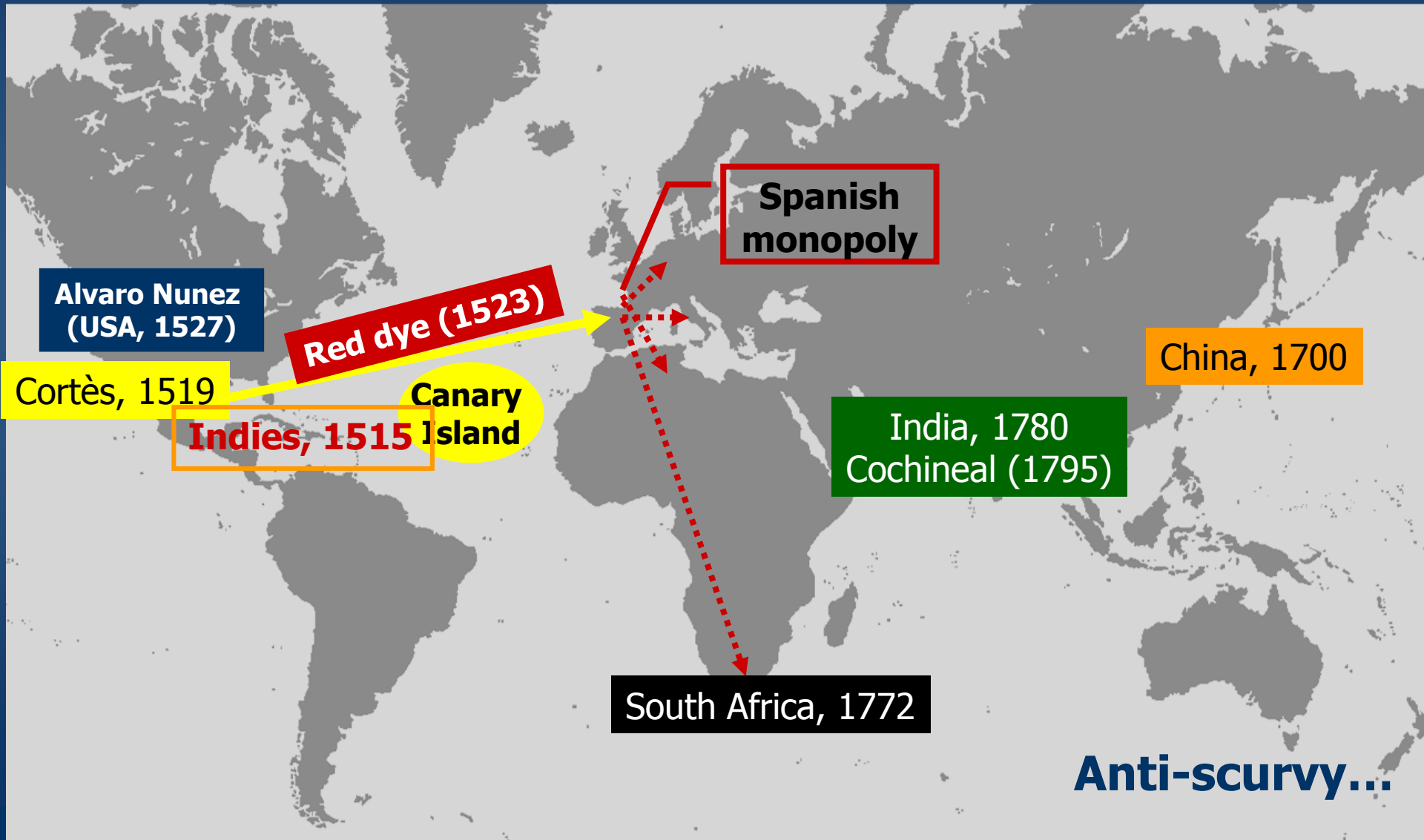


Dr. Ali Nefzaoui
Consultant, ICARDA
a.nefzaoui@cgiar.org

Outline

1. Introduction: History, Astonishing plants...
2. How cacti can help developing marginal dry areas and combating desertification?
3. Cactus: Multipurpose spp.
 - a. Fruit
 - b. Agri-food and nopalitos
 - c. Forage
 - d. Cosmetic and medicinal uses
4. Cochineal and Red Dye
5. The FAO-ICARDA International Technical Cooperation Network on Cactus (FAO-ICARDA Cactusnet)

Origin of cacti... dissemination



Desert Wisdom

- Agaves and cacti with their substantial biomass productivities and their high WUE should be considered for the terrestrial sequestration of atmospheric CO₂ in underexploited arid and semi-arid regions. Such regions are poorly suited to C3 and C4 crops without irrigation.
- ... *Opuntia ficus indica* can generate a carbon sequestration of 20 T DM (equivalent to 30 T CO₂/ha/year) under sub-optimal growing conditions...

DESERT WISDOM
AGAVES and CACTI
CO₂, Water, Climate Change



PARK S. NOBEL

Few statistics

Regions/countries	Area cultivated, (x 1000 ha)
Brazil	600
Other South American Countries	75
Mexico	230 + 3 M
Other North American countries	16
Tunisia	600
Algeria	150
Morocco	150
Italy	70
Total	1891 + ~ 3 M

The *Cactaceae* family

- About **1600 species**, origin: native in America, but worldwide dissemination
- The most known is *Opuntia* genera; *Opuntia ficus indica* is cultivated in more than 20 countries
- It has been consumed by humans for more than **9000 years**
- From 1998 to 2000: more than **600 researchers published over 1100 articles** on Cacti

Registered commercial cultivars (50; 2007 Mexico)



REYNA
Opuntia albicarpa



BURRÓN
Opuntia albicarpa



MILPA ALTA
Opuntia ficus-indica



CRISTALINA
Opuntia albicarpa



ROJO PELÓN
Opuntia ficus-indica



R. SAN MARTÍN
Opuntia megacantha



VILLANUEVA
O. albicarpa



MONTESA
O. megacantha



PICO CHULO
O. megacantha



GAVIA
Opuntia albicarpa



TORREAJA
Opuntia megacantha



AMARILLA PLÁTANO
Opuntia megacantha



ROJO VIGOR
Opuntia ficus-indica



ROJO LIRIO
Opuntia megacantha



NARANJÓN LEGÍTIMO
Opuntia albicarpa

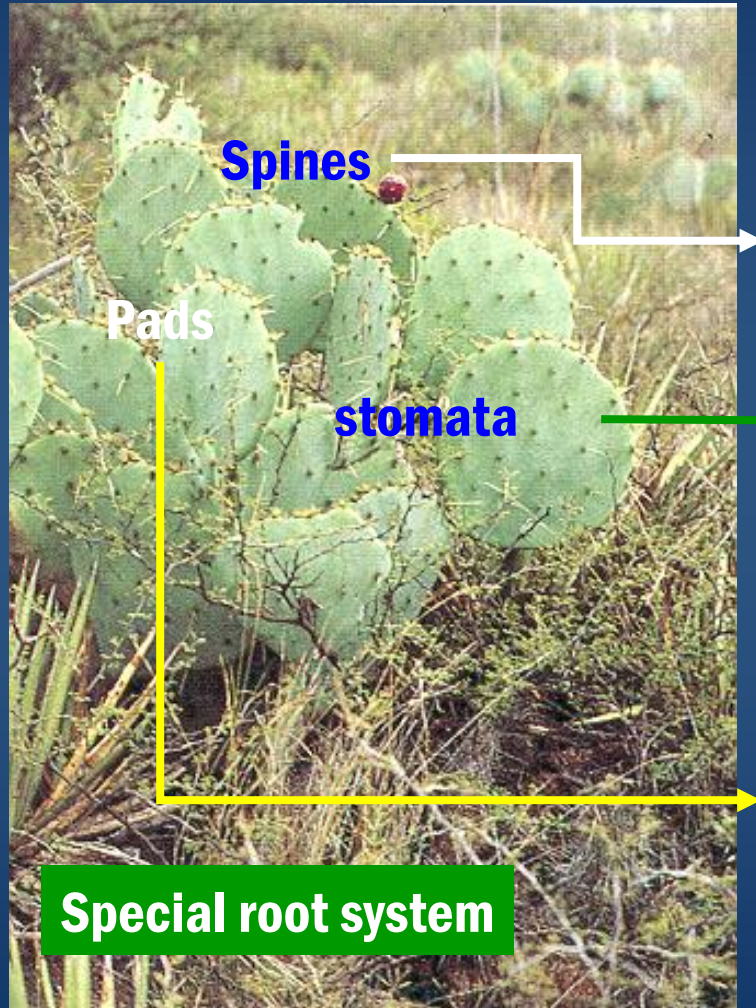
Astonishing plants !

- **Ease of establishment** : ability to reproduce directly from pad to new plant. A low cost to establish and to maintain
- **Built in survival mechanism**. A drought tolerant and adaptable to a wide variety of soils and climates
- **A long live plant**, a producer of a **large biomass**, instant availability
- **An evergreen** : almost the only green plant in arid environment and prolonged drought
- **A multipurpose** plant

Astonishing plants/ Easy to establish



Astonishing plants/ Survival mechanisms



- modified leaves
- xerophytism,
- ability to condense water (air)

- Sunken
- Close when T° / Light intensity rises
- Closed for the largest portion of the day

Limited evaporation :

- Covered with a layer of wax (cutin)
- thick epidermis

Astonishing plants/ Survival mechanisms



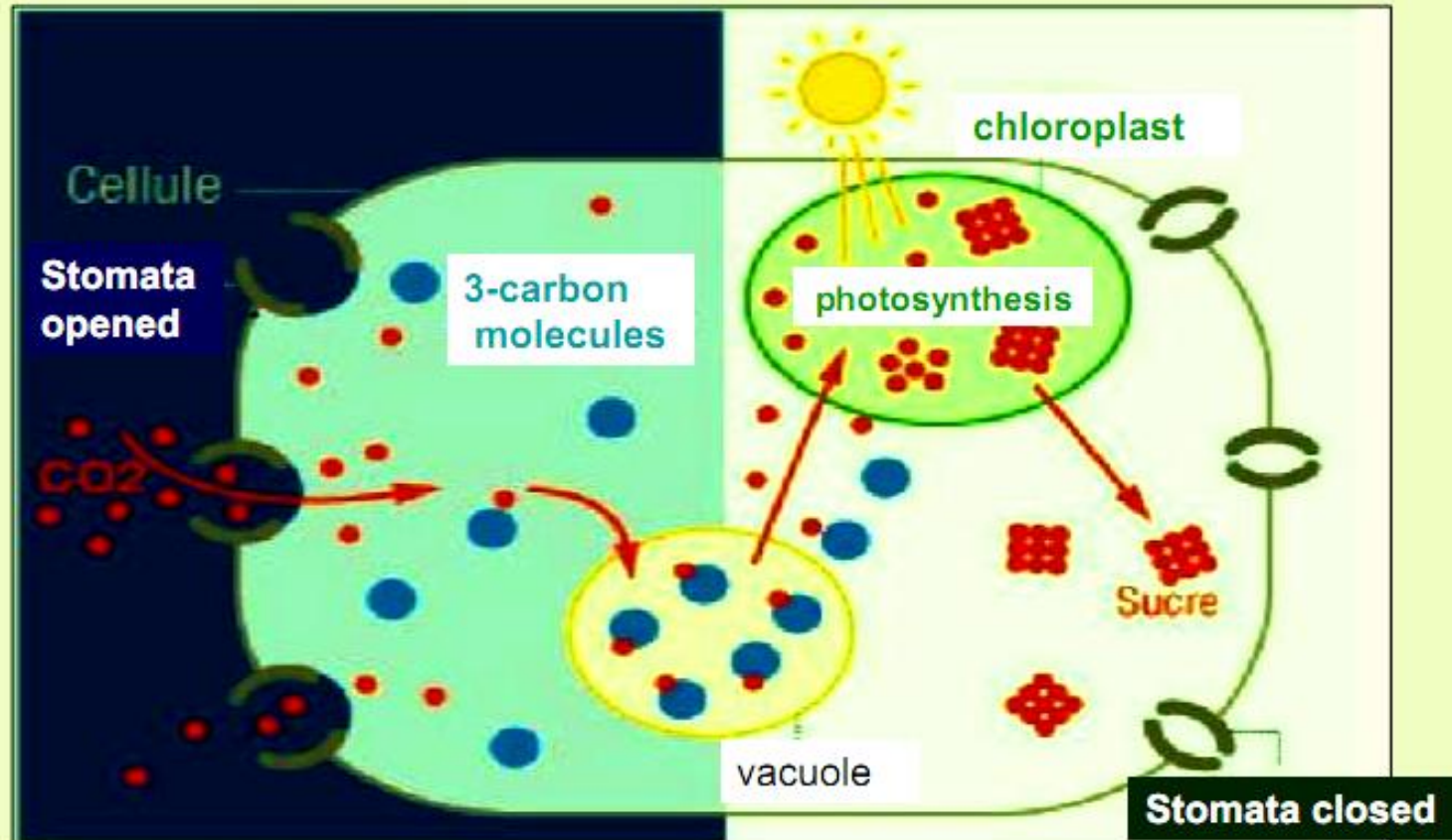
- ✓ **Adapted root system** : shallow, fleshy, with horizontal root spreading (maxim depth of 30 cm, spreading 4 to 8 m)
- ✓ **Xeromorphic** characteristics enabling the plants to survive prolonged periods of drought
- ✓ Water absorbed through the roots is combined immediately with hydrophilic mucus (**mucilage**) from which the water evaporates very slowly

Cactus fixes CO₂ as malic acid and releases O₂ during the night to prevent water losses through transpiration

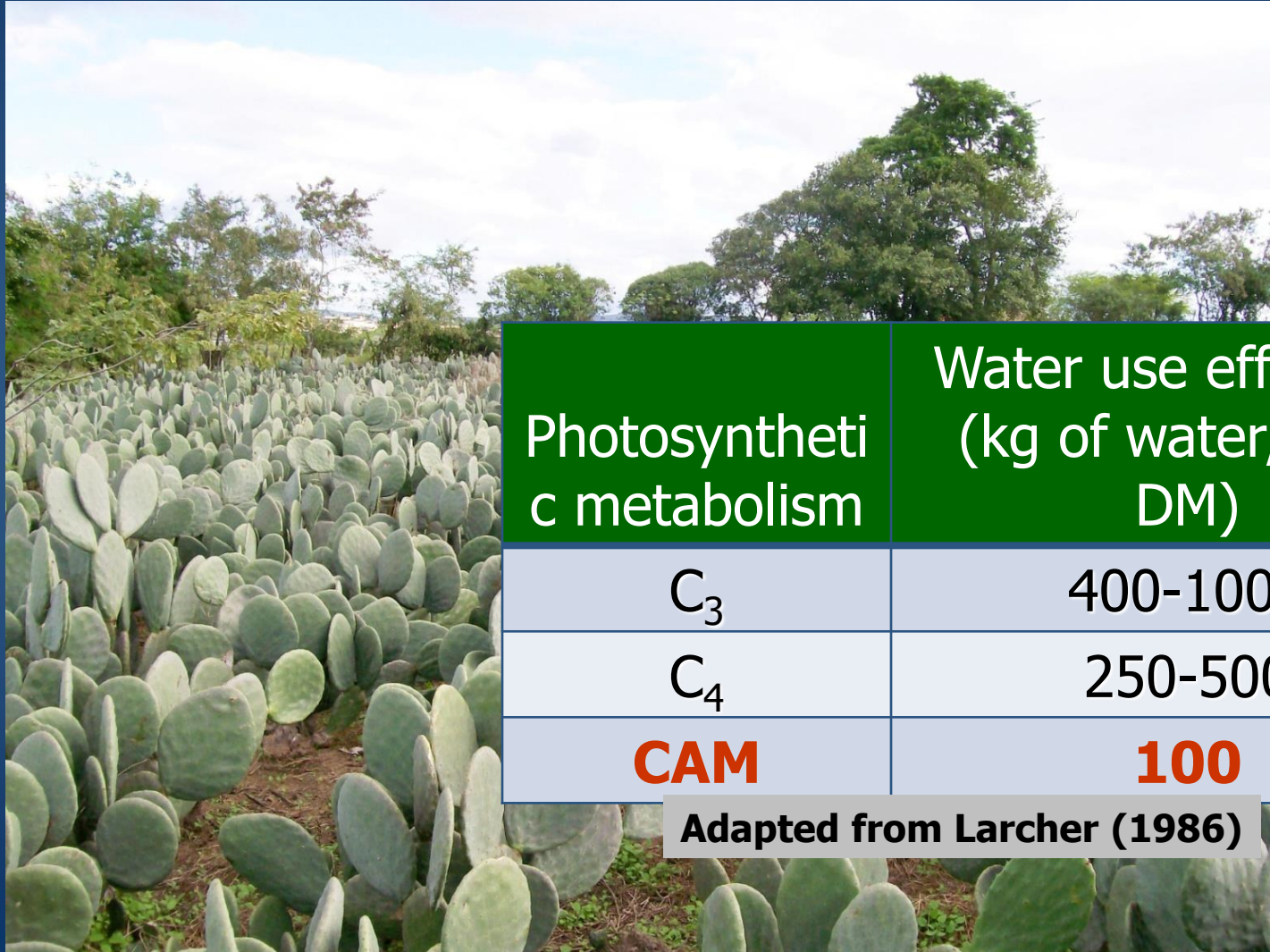
CAM: Crassulacean Acid Metabolism

night

day



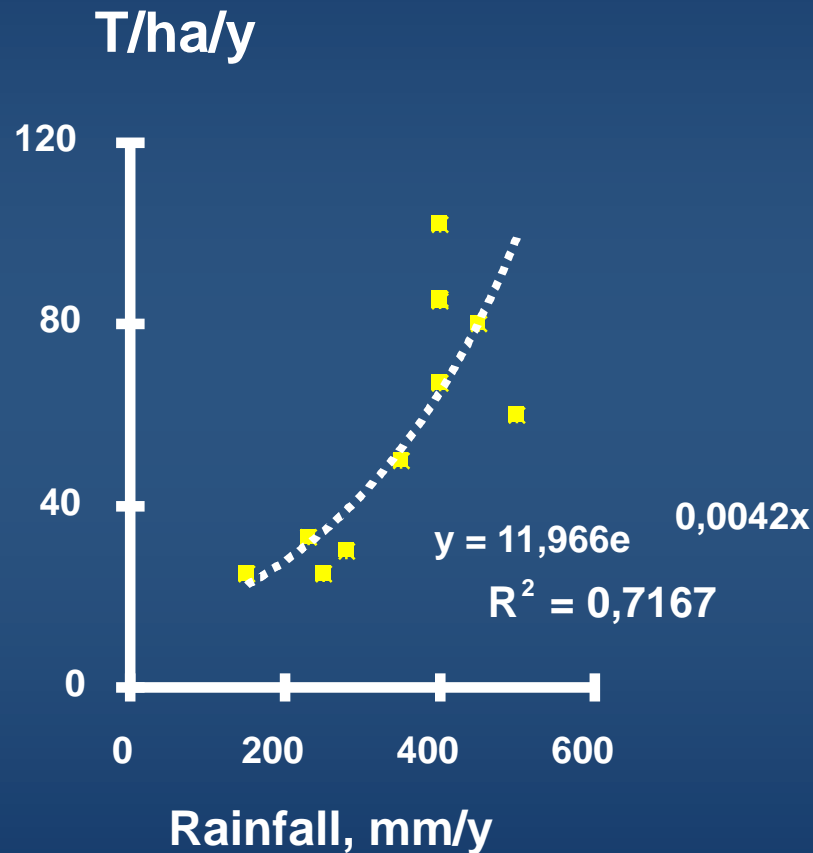
Astonishing plants/ CAM metabolism and WUE



Photosynthetic metabolism	Water use efficiency (kg of water/kg of DM)
C_3	400-1000
C_4	250-500
CAM	100

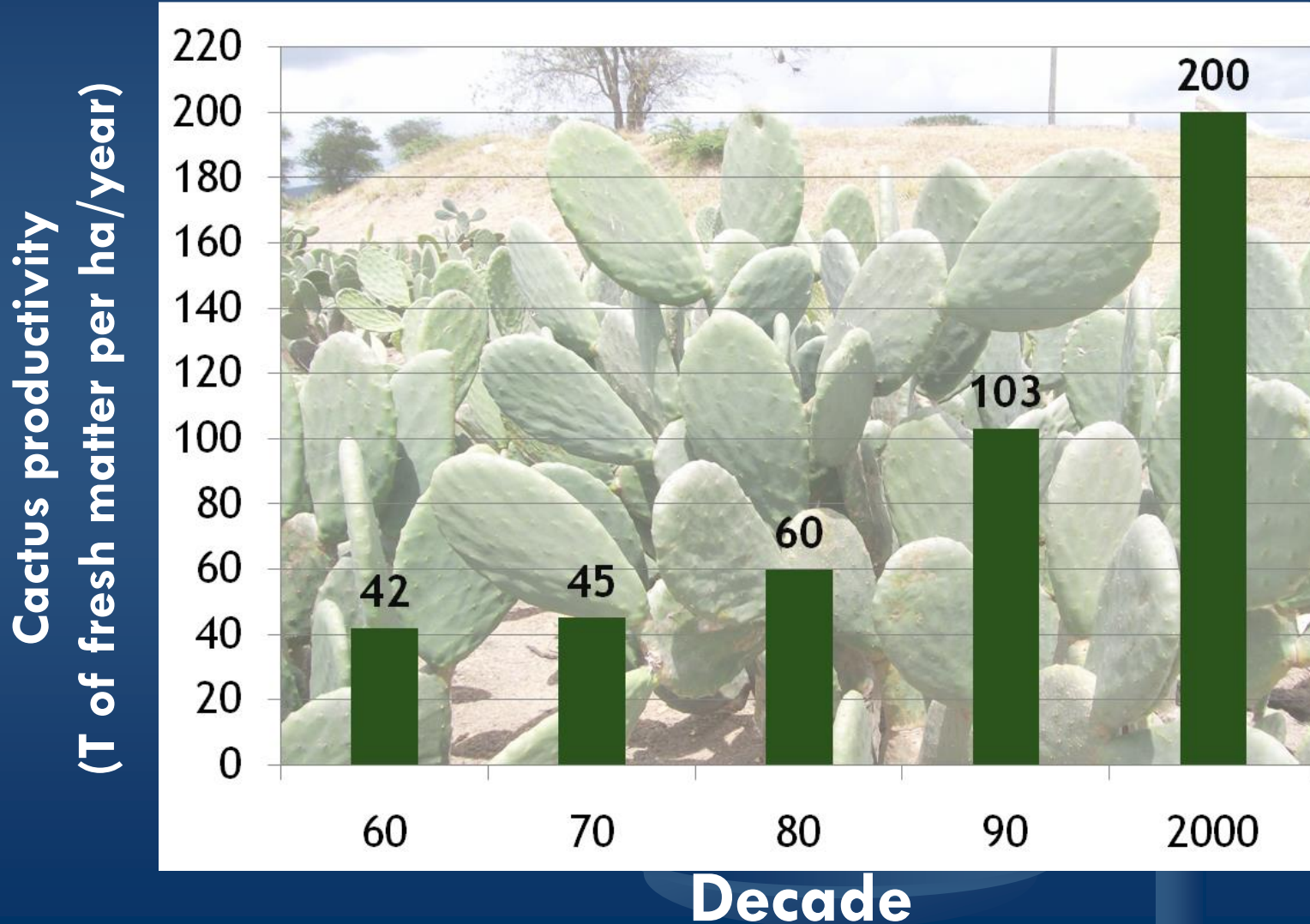
Adapted from Larcher (1986)

Astonishing plants/ Long-life high yielding plant



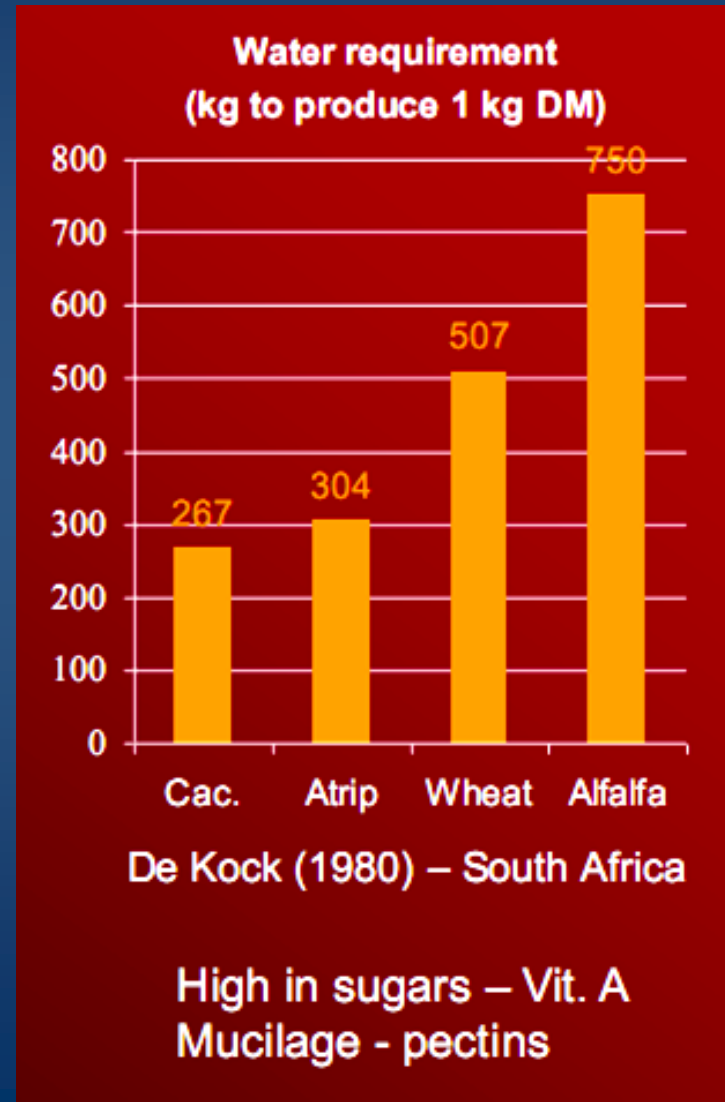
Cactus (*O.F.I. inermis*) yield according to rainfall in Tunisia
(adapted from Montjauze et le Houérou, 1965)

Increment of cactus productivity in experimental areas of NE Brazil in the last 40 years



Astonishing plants/ CAM metabolism and WUE

- Camel of the plant kingdom
- Fodder bank
- Living fodder bank



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How cacti can help developing marginal dry areas and combating desertification?

- Soil and water conservation
- Rangeland and marginal land rehabilitation
- Crop land management: agroforestry

Soil and Water conservation/ Controlling erosion in gullied areas & watersheds



Comparison of **soil losses** under different crops in semi-arid NE Brazil (Romulso et al., 2009) (tons/ha)

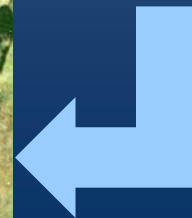
Crop type	Total soil losses
Bare soil	29.10
Cotton	10.91
Maize	5.94
Maize + beans	3.93
<i>Opuntia ficus-indica</i>	1.98
Perennial grass	0.03

O. Ficus-indica planted in countour hedges to control soil erosion

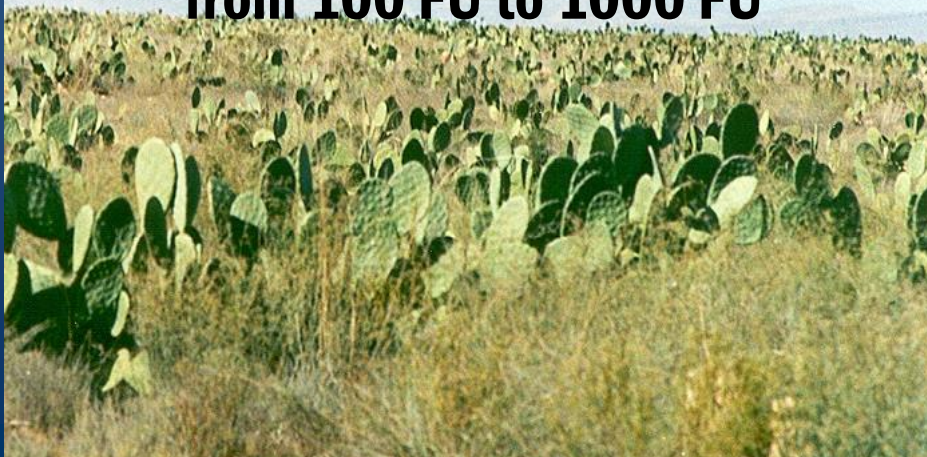


- **Soil retention: 100 tons ha⁻¹ year⁻¹**

Rangeland and marginal land rehabilitation



**Rangeland productivity increases
from 100 FU to 1000 FU**



Desert rehabilitation: Peru

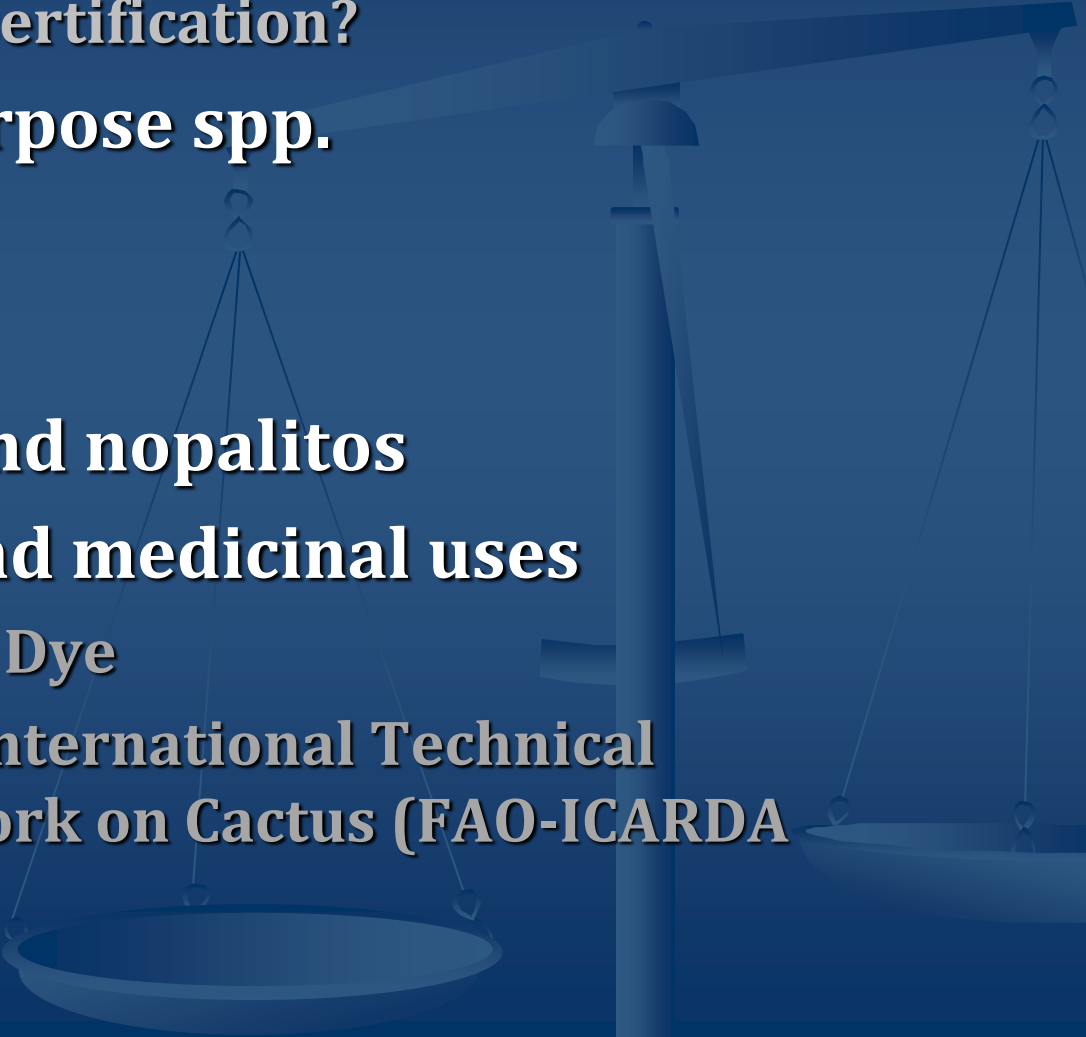


Cropland management: Alley-cropping (Agroforestry)



Treatment	straw+ grain (T/ha)	Grain (T/ha)
Cactus+ barley crop	6.648	2.232
Barley crop	4.24	0.824

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- 



Cactus crop

**Rangeland
improvement**

**Combat
desertification**

**Cash crop with high
value-added products**

Increase plant cover
Carbon sequestration
Livestock feeding
Soil and water
conservation
Wildlife
Food

Fruit & cladodes
(natural
products, high
nutritional value)

Agro-industries
(juice, liquor,
jellies,
colorants)

Cosmetics &
medicinal
uses

Multifunctionality of cactus crop

Cladodes: Nutrients characteristics

High contents in :

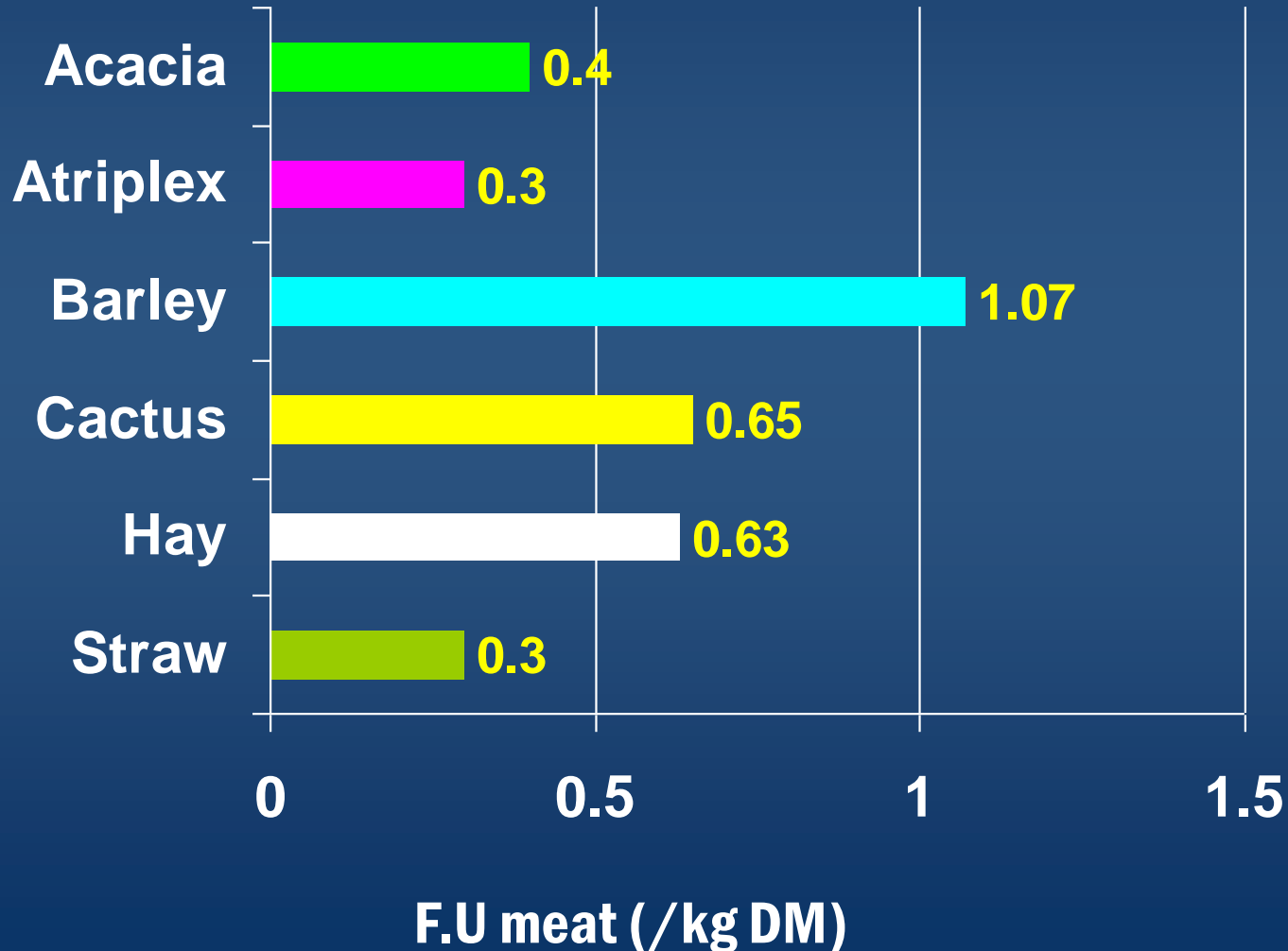
- Water (~ 90 %)
- Ash (~ 20 % DM)
- Ca ($\sim 6-8$ % DM)
- Oxalates (8-13 % DM)
- Soluble sugars (10 % DM)
- Vitamin A
- DOM (d ~ 70 %)

Low contents in :

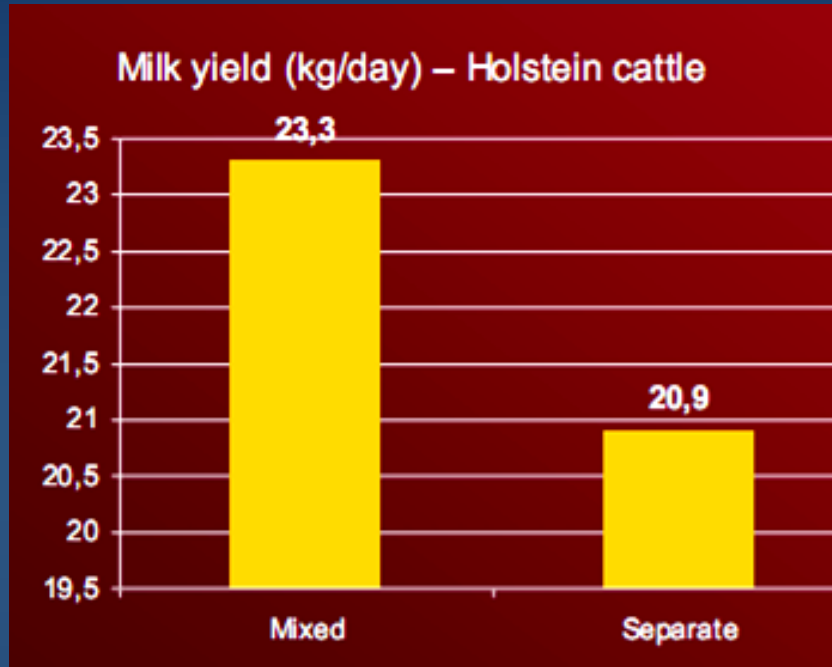
- CP (~ 4 % DM)
- Fiber (NDF < 40 % DM).
- P (0.1-0.2 % DM)



Cactus cladodes: Feeding value/ Energy



Mixing ingredients vs. separate ingredients (Pessoa et al., 2004 – Brazil)

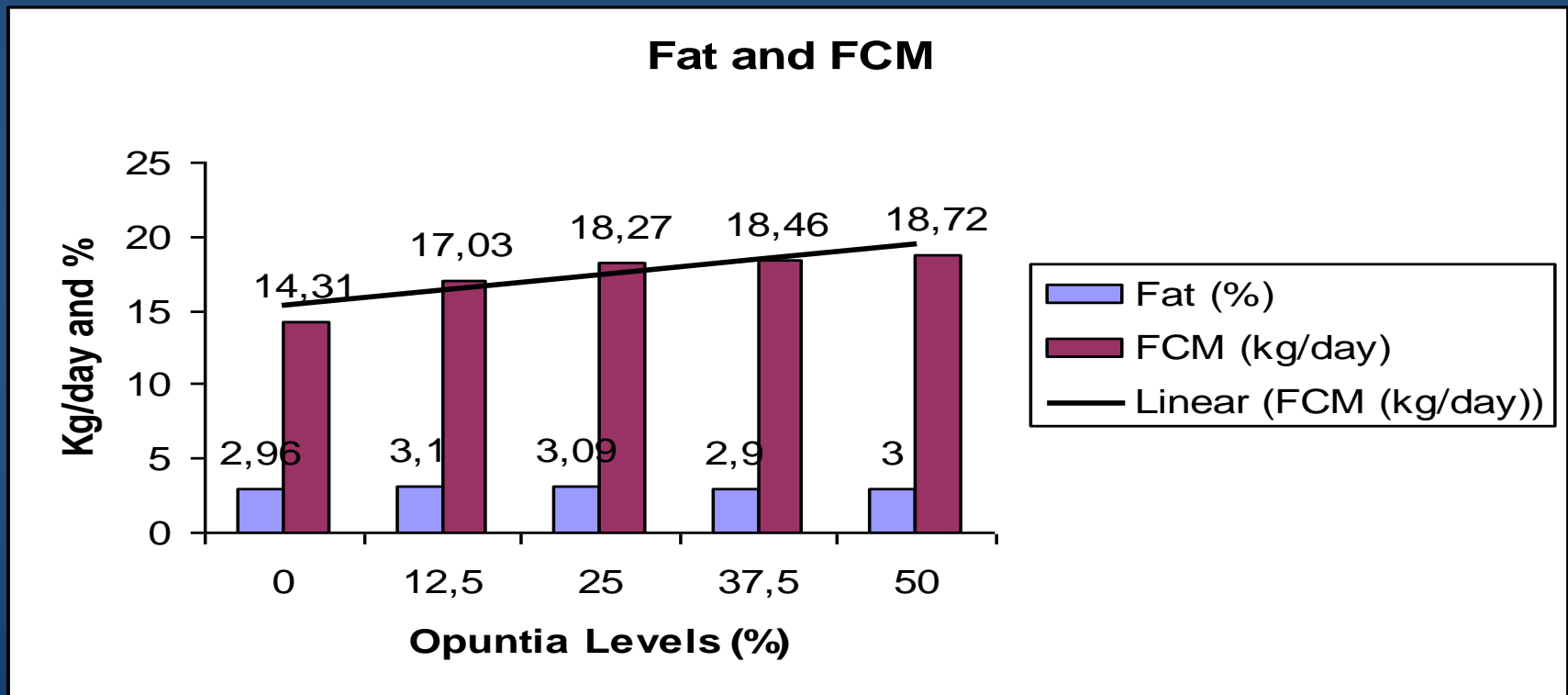


Diet: 39 % cactus + 31 % sorghum silage + 30 % concentrate



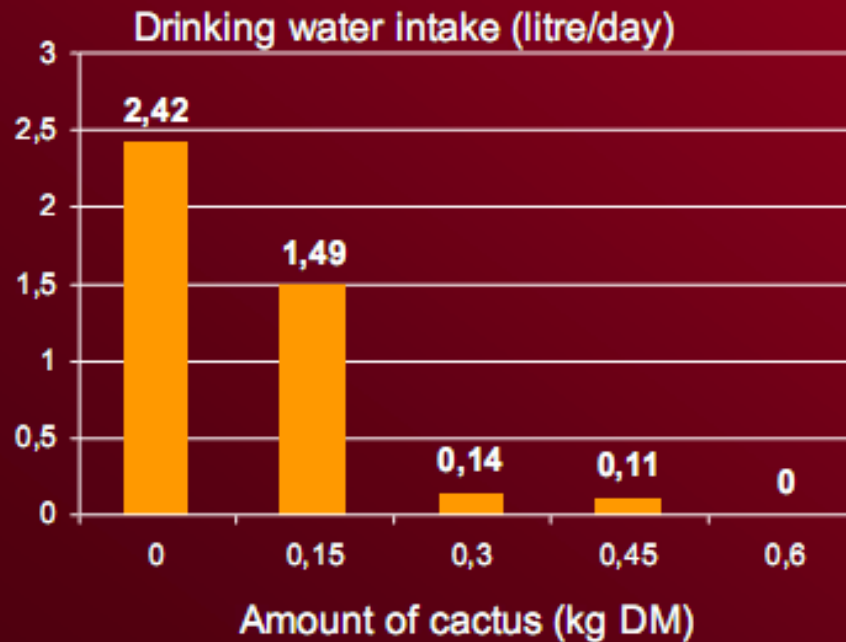
Milk production

Opuntia in replacement of Bermuda grass (Tifton hay) -
Dairy Cows (Cavalcanti, 2005 – Brazil)



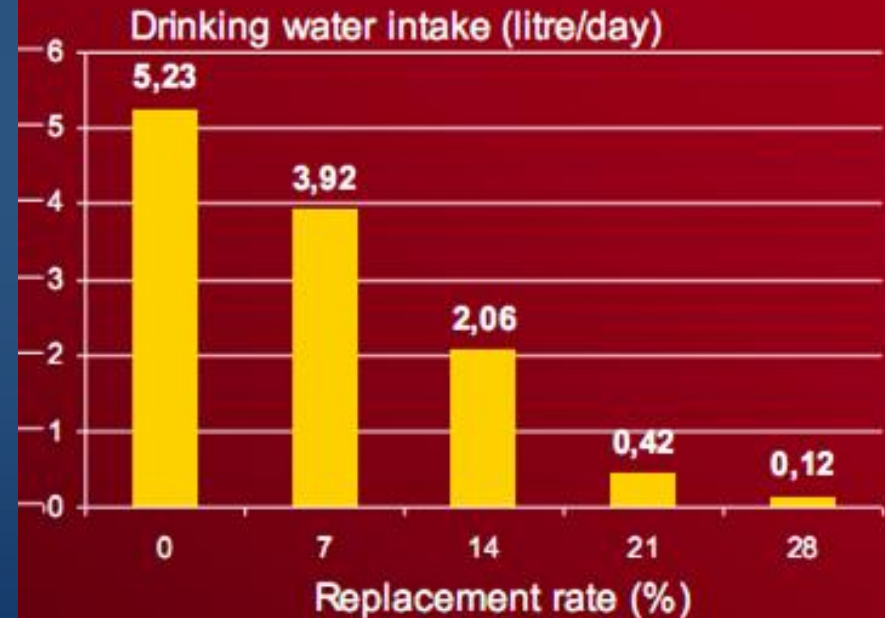
Cactus helps solving watering problems in arid areas

Increasing level of cactus in straw based-diets for **sheep**



Ben Salem et al. (1996) - Tunisia

Replacing corn meal with cactus for dairy **goats**



Roberto Germano Costa et al. (2009) - Brazil

Cactus as fodder/ Feeding fruits

- Large amounts of fruits left on the field (over-ripe)
- Good source of sugars



Wasted fruits in feed blocks

LAMBs (Chermiti & Ferchichi, 2000)

Diets	Daily gain, g
Hay + barley grain	154
Hay + feed blocks (cactus fruit)	163



Cut & Carry

Use of herbaceous plants ?



Cactus choppers



Tunisia



Tigray, Ethiopia

Brazil

Wild population in Mexico

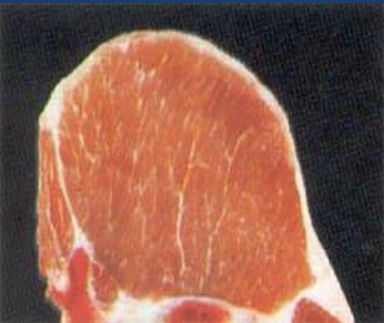




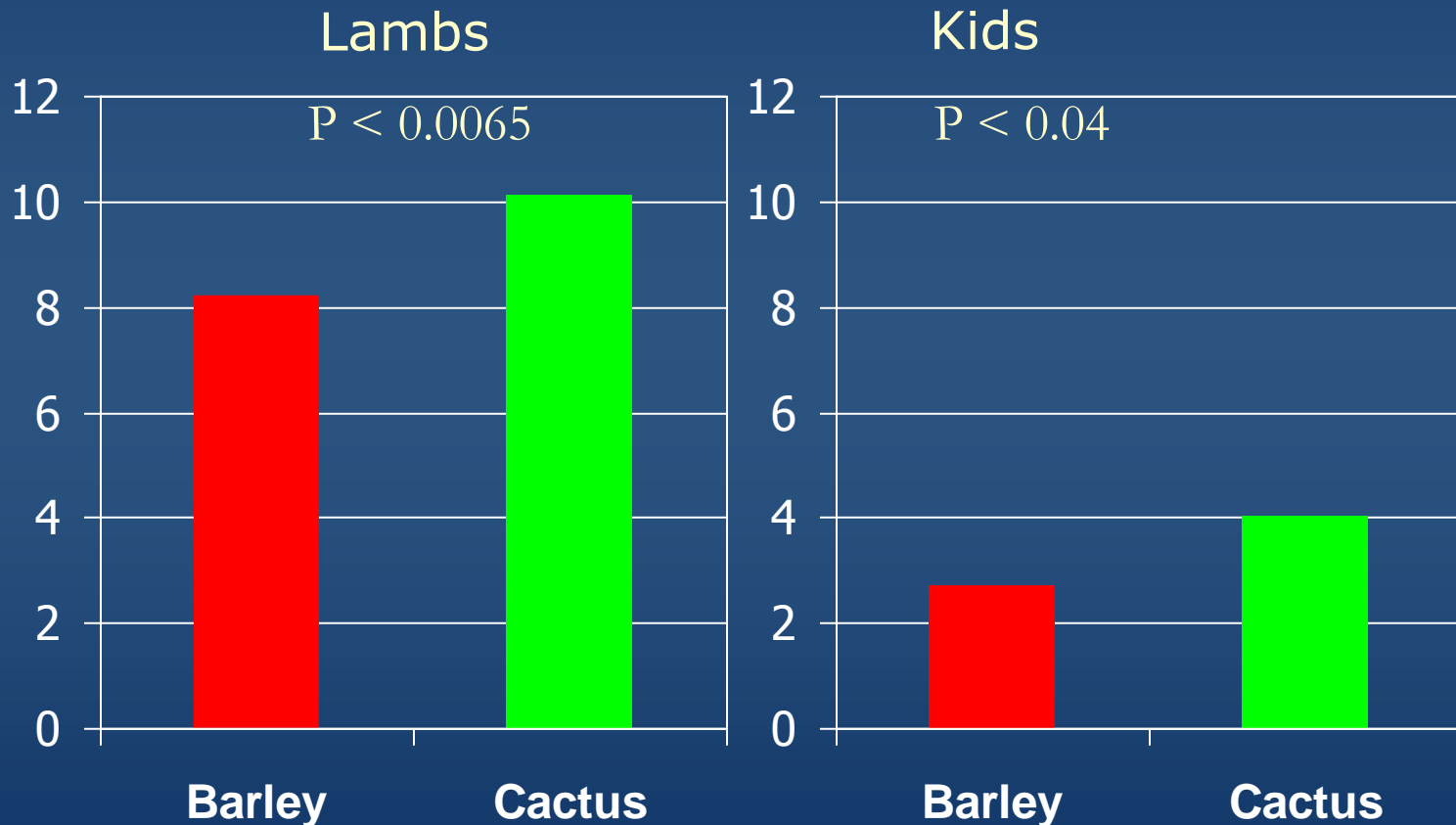
Intensive fodder production, Mexico



Feeding cactus pads improves meat quality : Positive effects of CLA



C18:3 in meat



Fruit production

San Cono (Italy)



South Africa



San Cono (Italy)



Fruit production, Tunisia



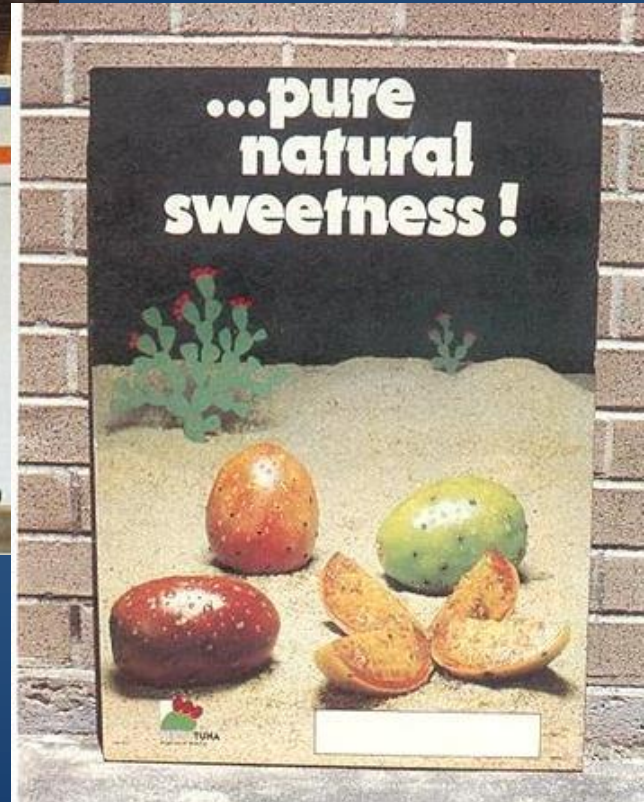
Harvesting



Post harvest and packaging



packaging: a key for success



From wild to seedless fruits...



Agri-food: More than 50 products are marketed....



- Alcoholic beverages
- Marmelades
- Juice
- Nectars
- Candies
- Frosen pulp



- Candies
- Marmelades
- Flower
- Juice
- Brine

Nopalitos production & uses



Nopalitos cleaning



“Nopalitos” in brine and pickled “nopalitos”



Work shop in Chile



Nopalitos production in
Hermosillo, Sonora, México
(A. Rodríguez & L.C. Montoya, CIAD-México)

Pads & fruits: Food



FAO-TCP/ETH/2901

**Training new consumers
(Ethiopia)**



Pads & fruits: Food



“El Bambu” Restaurant in La Havana, Cuba. Dishes based on cactus products



Purple cactus pear colorant



Nopalitos production & uses



Different presentations and trade marks of tender processed cladodes



Different presentations and trade marks of tender cladodes processed in vinegar (pickles)

Marmalades, juices, candies, etc.



Some commercial presentations of candies made with cactus fruit and tender cladodes



Some commercial presentations of marmalades, juices and sauces made with cactus fruit and tender cladodes

Sauces, beverages

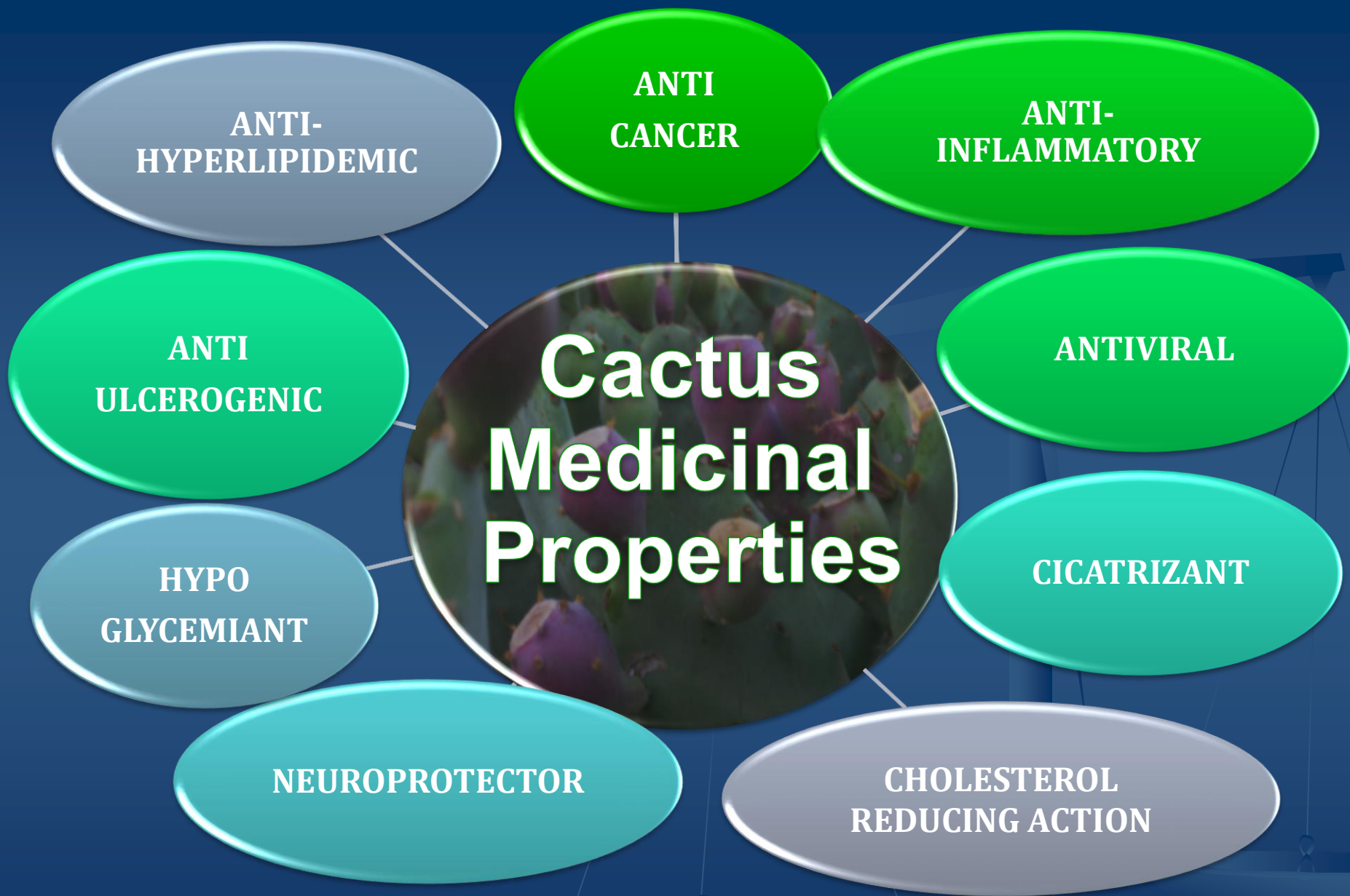


Some commercial presentations and trade marks of beverages made with cactus fruit and tender cladodes

Candies



Figure 8. Some commercial presentations of candies made with cactus pear fruits and tender leaves (nopalitos).



Scientific Research Concerning Medicinal Properties

HIGH-VALUE-ADDED CACTUS PRODUCTS

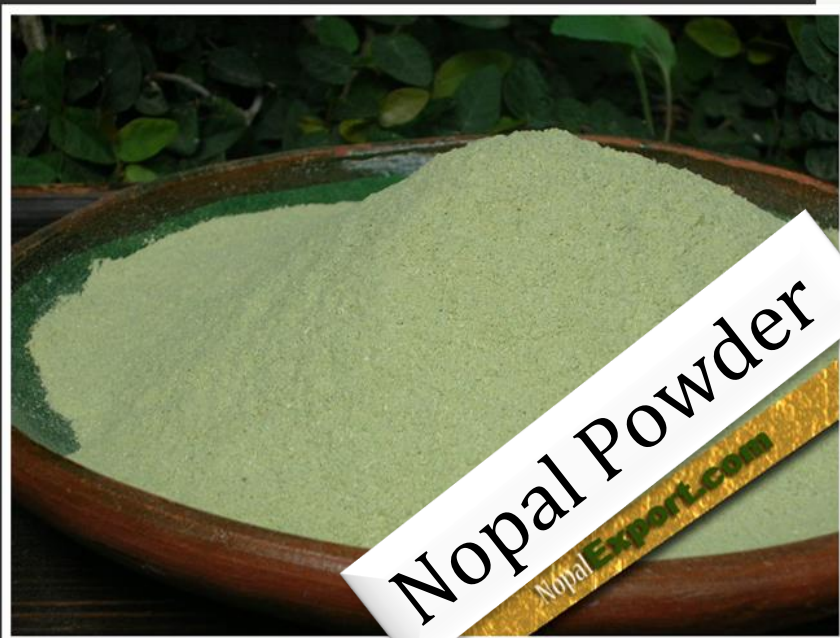
✓ **NUTRACEUTICS**

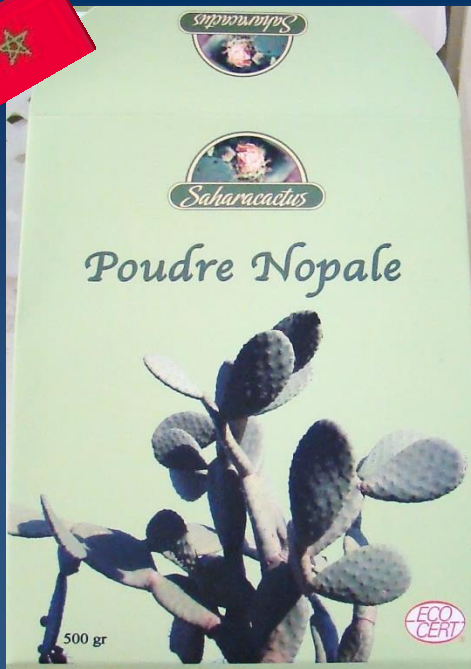
✓ **FUNCTIONAL FOODS**

✓ **COSMETICS**



Dehydrated Nopal





Nopal powder

It can be used as food additive to take benefits from its functional properties

Prepared by solar dehydration from mature nopal pads.

US \$ 5-10/Kg



Nopal pills and capsules



FUNCTIONAL FOODS



Nopaltilla(TM) The Healthy Green Cactus Tortilla



FUNCIONAL FOODS

Healthy drinks and Juices



Cahill Prickly Pear Thirst Quencher
Rich in Vitamin C, Flavonoids & Antioxidants
100% Natural



- Protect against premature aging
- Reduce inflammation
- Promote optimal cellular health
- Detoxify the body

CACTUS FRUIT FUNCTIONAL PRODUCTS



Syrup



Solar dried fruits

JAM & JELLYS

Hangover Terminator



Prickly Pear Fruit Spread



DRIED FLOWERS FOR MEDICINAL TEAS OR INFUSIONS





Maceration of dried flowers in argan oil

SEED MEAL



- ✓ *Opuntia ficus indica* seed meal contains 16.5% protein and 48% fiber.
- ✓ The flour is used as a food supplement thanks to its high nutritional value, due to its richness in essential fatty acids, sterols and vitamin E.
- ✓ This powder is also used in cosmetics as exfoliant, anti-aging and antioxidant. It is also used to produce a precious maceration.

COSMETIC PRODUCTS



Seed Oil



Cactus seed oil 100 %
organic from morocco



anti-wrinkle cactus seeds oil





550 € / L



Seed Oil



10 mL x 29 €



350 € / L



Soap and Shampoos



Cosmetics: creams and make up



Carminic acid from cochineals



Cooperative for cactus processing, beekeeper union and green technology = will be presented in a short movie



Fruit processing unit =

- Taking advantage of 60,000 Ha of plantation close to Guelmim
- Almost six month of fruit production (Aissa & Moussa)
- Spineless fruit sold in supermarket, nationally and internationally



Futuristic vision = the cactopole

- Industrial quarter devoted to cactus transformation on 25 Ha
- Close to the national road, close to Guelmim, close to the provincial water treatment plant





Outline

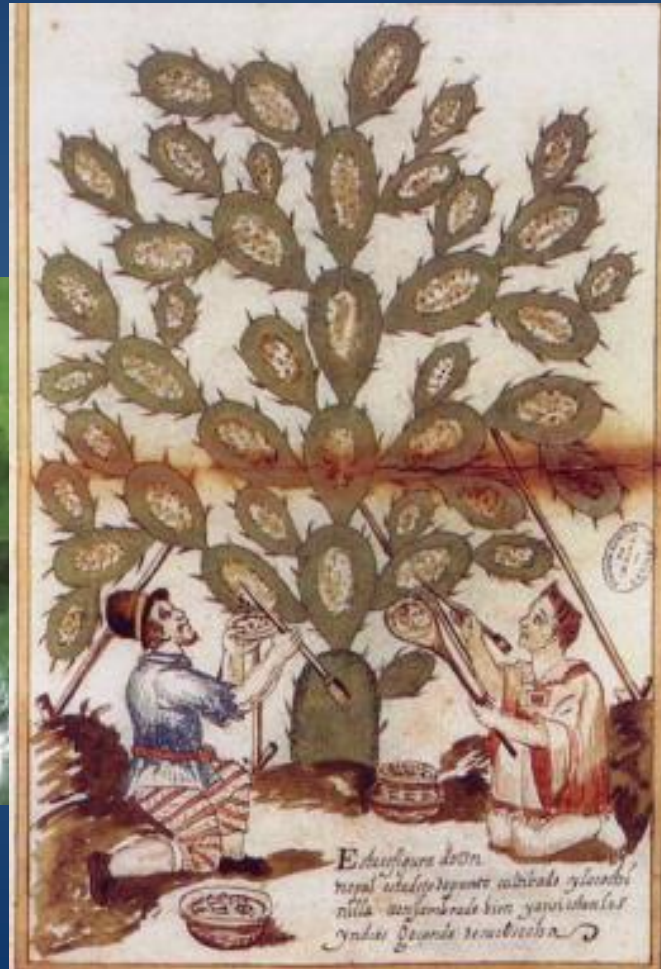
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- 

Cochineal and Red Dye

Empire, Espionage,
and the Quest
for the Color
of Desire

*A Perfect
Red*

AMY BUTLER
GREENFIELD



The good and the bad cochineal

***Dactylopius* Costa** (Hemiptera: Dactylopiidae)

D. confusus Cockerell
D. opuntiae Cockerell
D. tomentosus Lamarck

***D. coccus* Costa**

D. ceylonicus Green
D. austrinus De Lotto
D. confertus De Lotto
D. salmianus De Lotto
D. zimmermanni De Lotto
D. bassi Targioni Tozzetti

→ Mexico

→ South
America

Feeding exclusively on cacti
~80 species hosts worldwide
22 in Mexico.



Dactylopius opuntiae



Dactylopius coccus



$2n = 16$



Fine cochineal

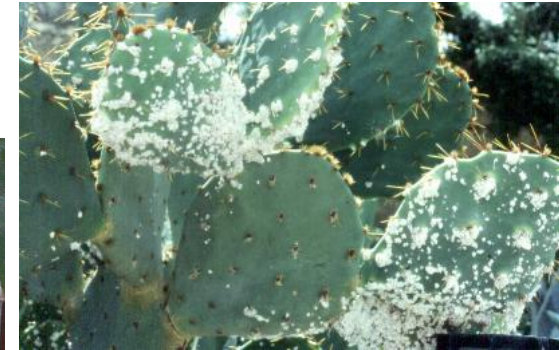


Chromosomes

$2n = 10$



Dactylopius opuntiae



Wild cochineal

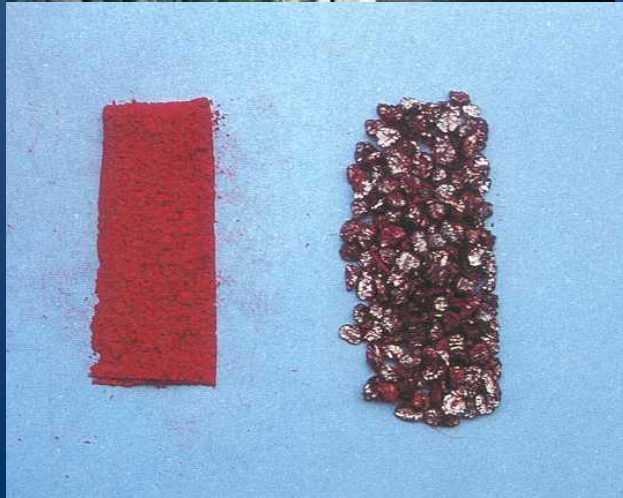




Paracas, Peru
(millenary)



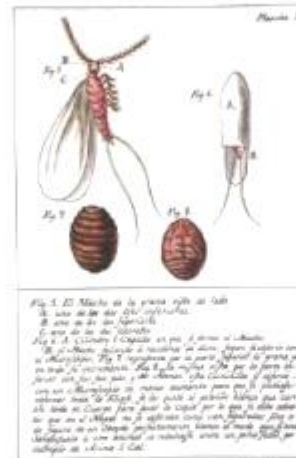
Cactus plantation for cochineal. San Mateo,
Guatemala (1875) Sidney D. Markman



Red dye



Opuntia and Dactylopius production and marketing



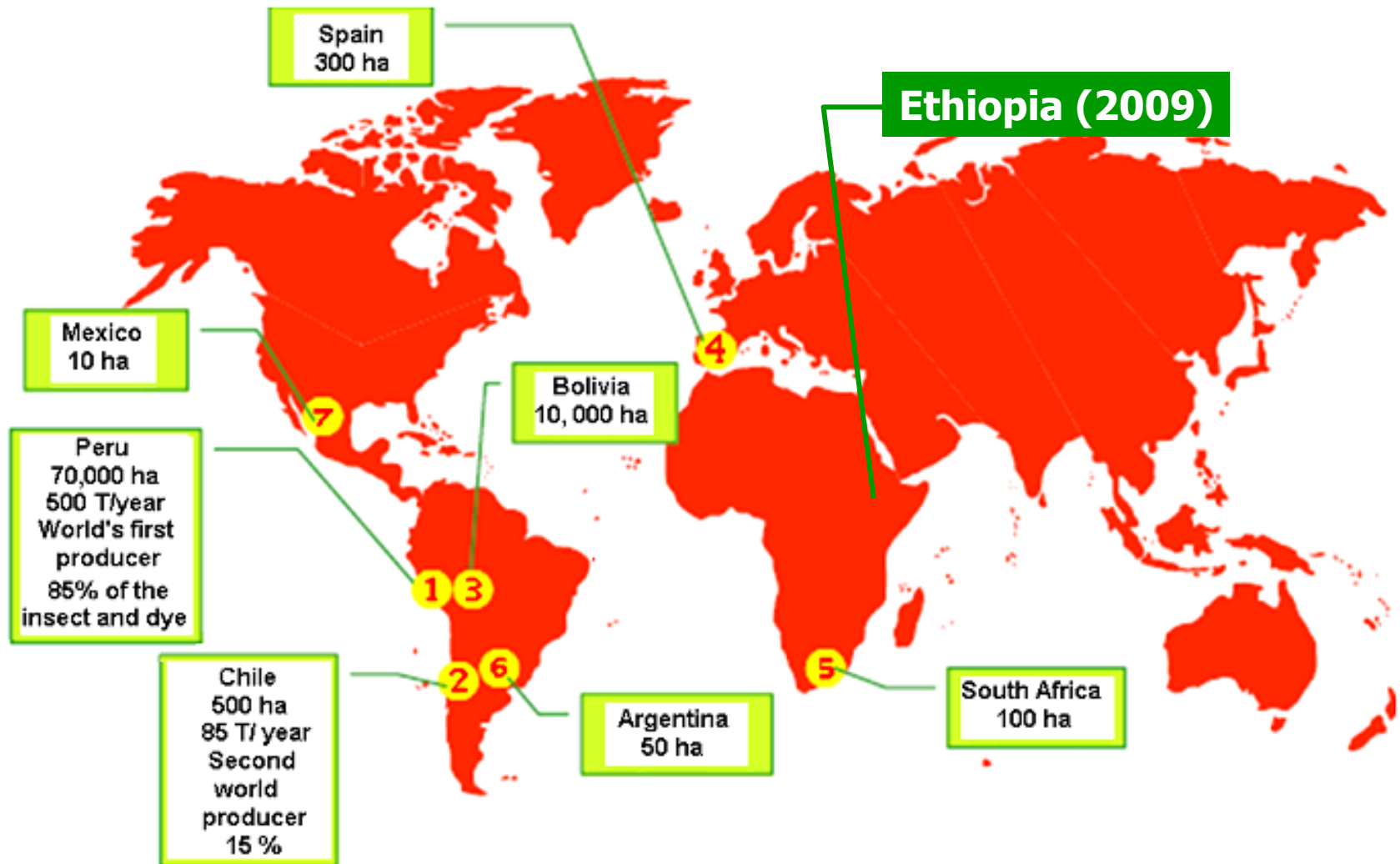
Moctezuma Ilhuicamina



Tribute to Aztecs, 394 communities Mixtec/4,400 kg/year

Red dye

Dactylopius coccus



Market: Local, France, England, Italy, Japan, United States and Argentina

CHINA

10-15 ton/yr

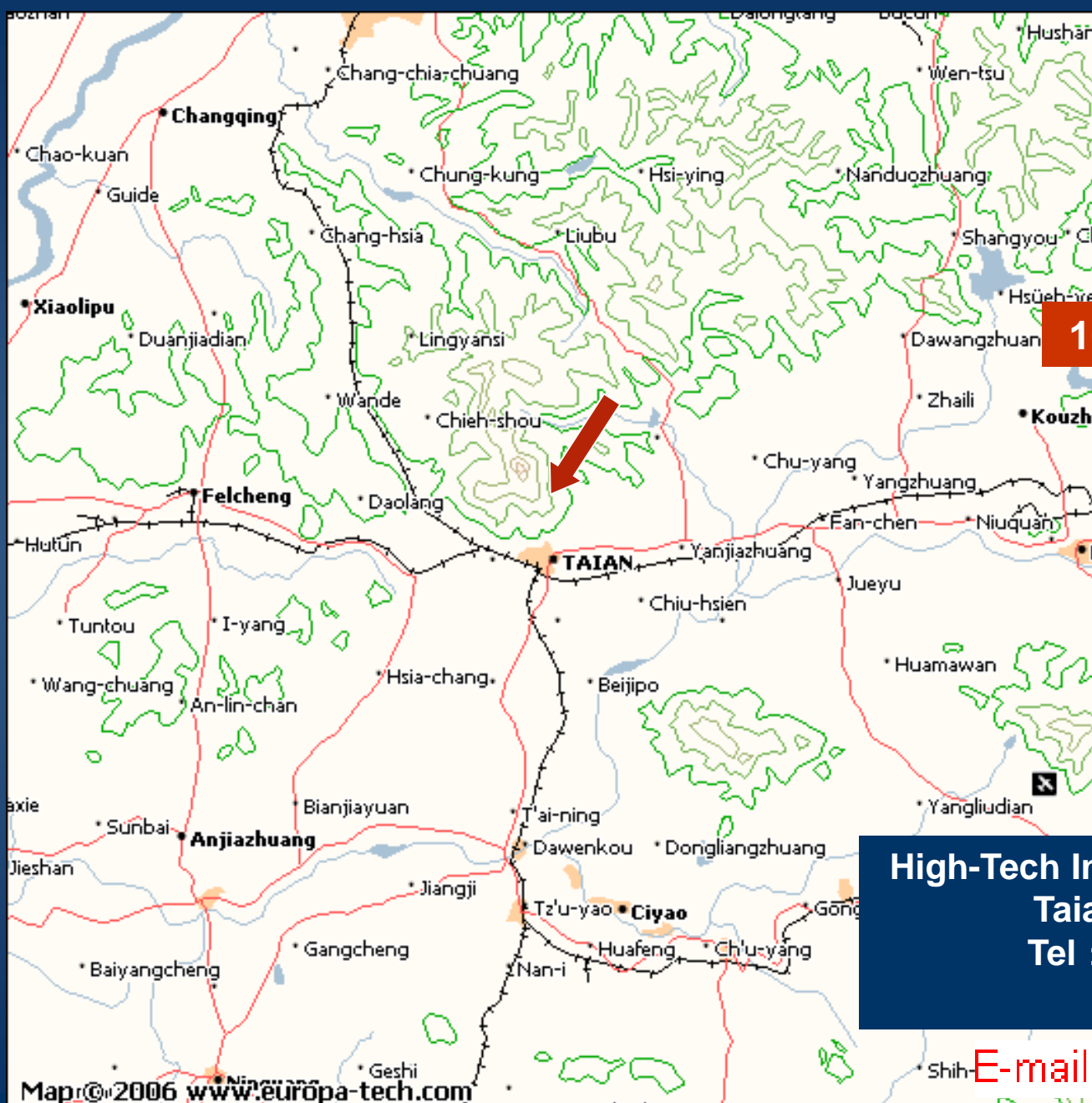


? !



High-Tech Industrial Development Zone
Taian Shandong China
Tel : +86-135 838 73996

E-mail: info@cochineal.net



Red dye

- Food



- Cosmetics

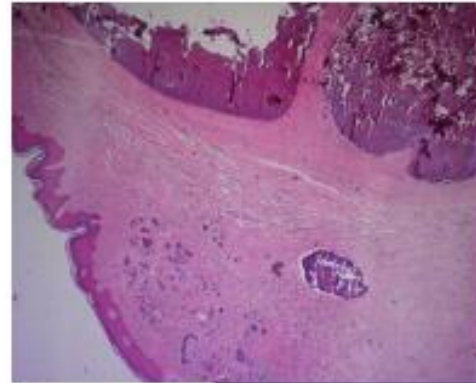


Red dye

- Medicines



- Antibacterial, antiviral, and insecticidal



- Textiles



FAO-TCP/ETH/2901 (A)/ Ethiopia

Man, cactus and cochineal



CACTUS PEAR (*Opuntia ficus-indica*):
PRODUCTION AND UTILIZATION
H. G. Zimmermann (team leader)

Tigray: +355 000 ha
with cactus pear

Cochineal nursery
ca. 40.000 plants

Infestation: 25 ha

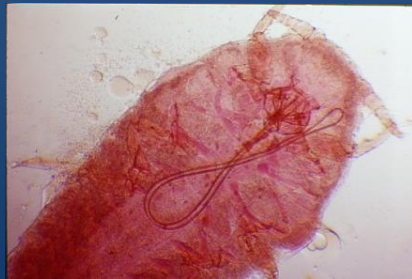
Good future! Or
Nightmare



Considerable time was spent
to look for the wild cochineal,
Dactylopius opuntiae, which
could have arrived as a
contaminant with the original
consignment.



Dactylopius opuntiae



Dactylopius opuntiae



Total destruction
achieved in very
short time



Main pathways of dispersal of cactus insect pests

1. Accidental

- Climatic events (wind)
- Birds, livestock, trade and transit

2. Human induced

- Trade (mainly the nursery trade)
- Biological control of cactus weed
- Research
- Illegal cactus collectors

Main pathways of dispersal of cactus insect pests

Birds



Wandering animals



Trade and transit of livestock



Trade and transit of infected material



Human induced

- Trade (mainly the nursery trade)

Dactylopius spp. and *Cactoblastis cactorum* are very easily overlooked and can spread very effectively through nursery stock.

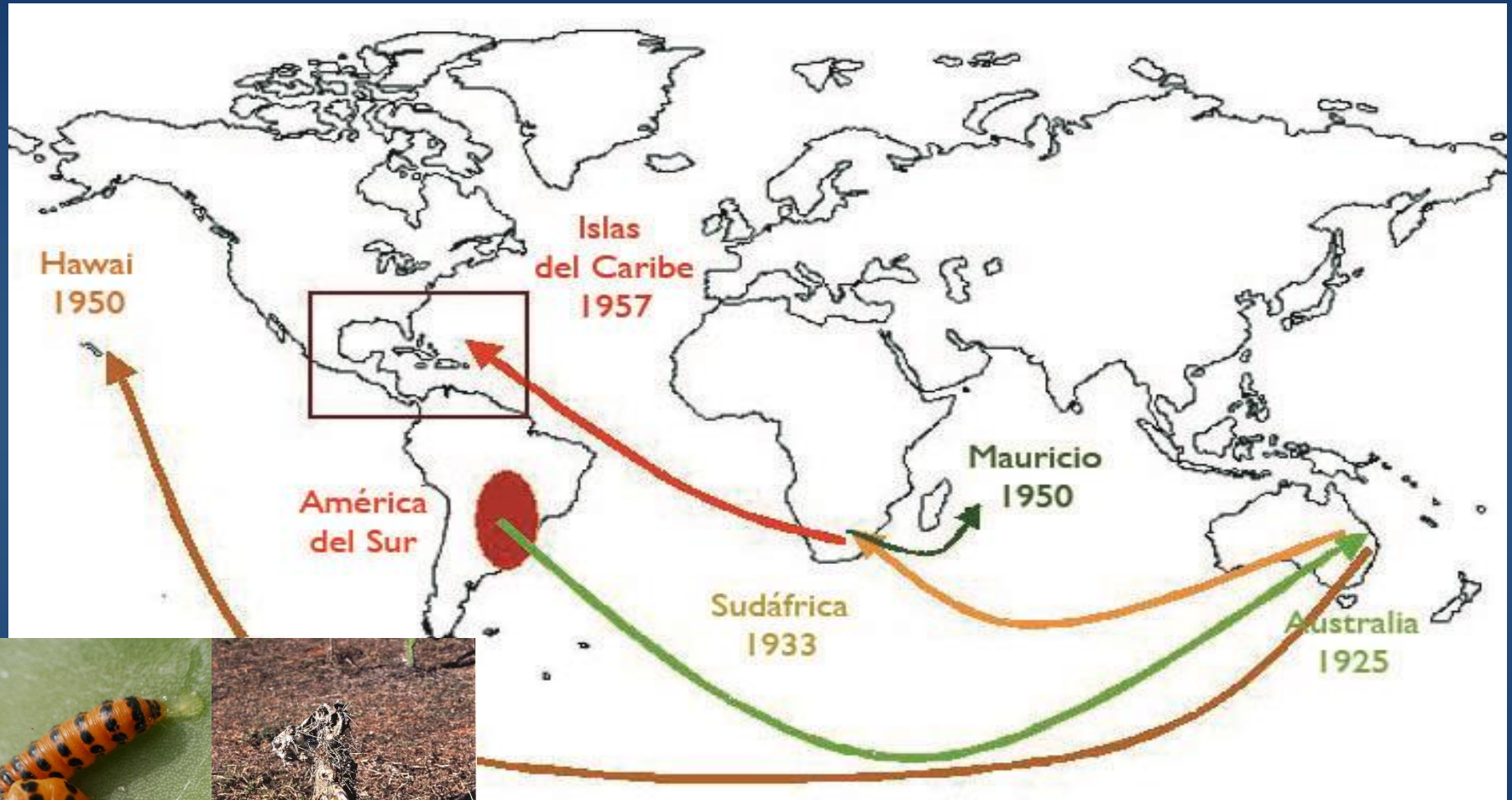


Human induced (cont.)

Biological control of cactus weeds

- 23 cactus insects have been exported from the Americas for biological control of cactus invaders outside the Americas (example: Australia, South Africa). Some have become serious pests including
 - ✓ *Cactoblastis cactorum*
 - ✓ *Dactylopius opuntia*

The spread of *Cactoblastis cactorum* for biological control



.....and its accidental spread towards Mexico and the USA



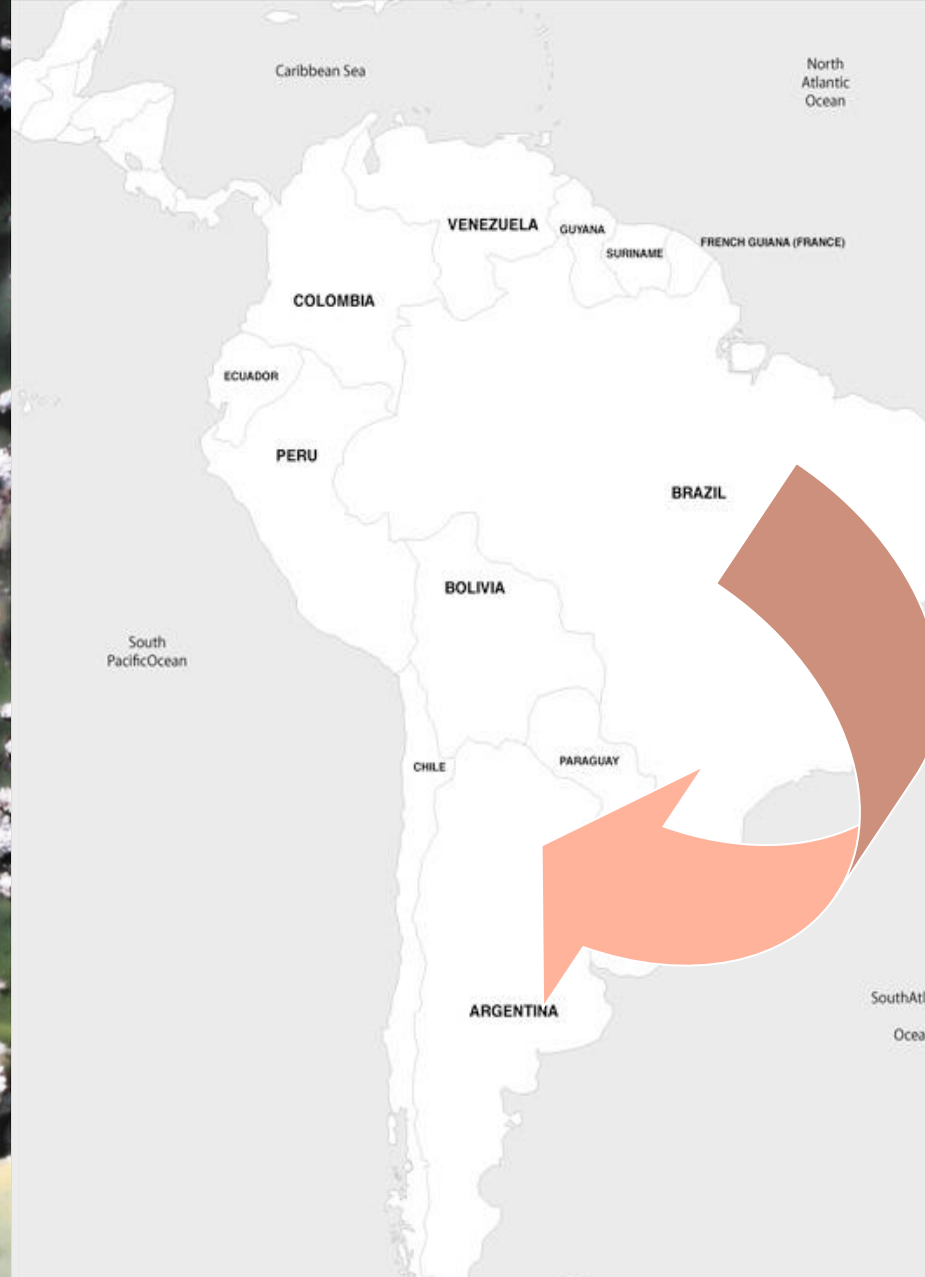
The spread of *Cactoblastis cactorum* towards Pernambuco



Cactoblastis cactorum



51 endemic, 6 cultivated and 18 wild-growing species



Spread of *Dactylopius opuntiae* in South America

Dactylopius opuntiae: Every country should manage the situation locally But global action must be considered



Human induced (cont.)

■ Research

1. Taxonomic confusion
2. Inadequate quarantine procedures when introducing vegetative material

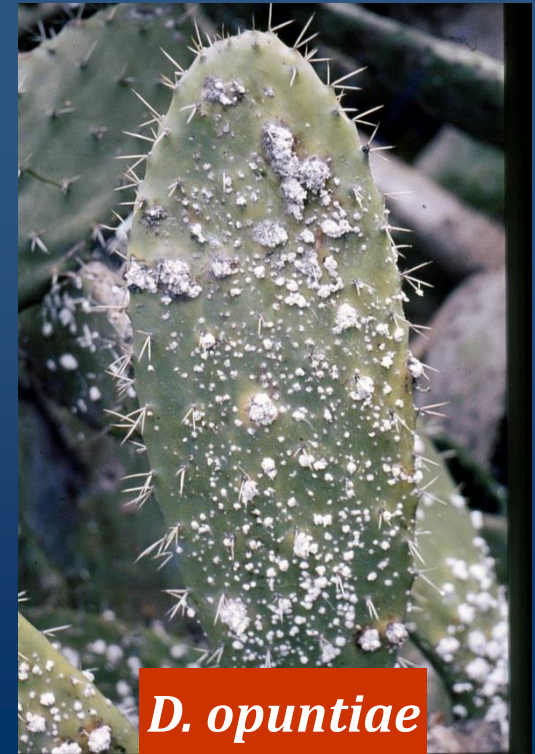


Research: Taxonomic confusion within *Dactylopius* (cochineals)

- 1) **India 1795:** Total destruction of *O. monacantha*
 - 2) **Madagascar 1924:** Total destruction of the “Malagasy Cactus”?
 - 3) **Brazil 1998:** Known as the “carmine cochineal” ???
- Now a serious pest on cultivated cactus pear.



D. coccus



D. opuntiae

What to do?

Inspired from the Brazilian experience

1. Initial action: To study its biology and control
2. Emergency action plan
3. Agroecological research
4. Informative action: Elaboration of leaflets and of control manual illustrated with pictures
5. Training: extensionists and producers
6. Proposals for the management of *D. Opuntiae*
 - **Exclusion**
 - **Erradication**
 - **Therapy**
 - **Escape**

What to do?

Inspired from the Brazilian experience

■ **Exclusion:**

- ✓ Keep the cochineal away

■ **Erradication:**

- ✓ To destroy the first clusters of infested plants
- ✓ To collect fallen cladodes
- ✓ To burn abandoned cultivations

■ **Therapy:**

- ✓ To spray with alternative products, with no hurry

■ **Escape:**

- ✓ Resistant variety: *Nopalea cochenillifera*

What to do?

Inspired from the Brazilian experience

TREATMENTS	EFFICIENCY
MINERAL OIL + SALT	30%
QUEROSENE + SALT	30%
HOUSEHOLD BLEACH + DETERGENT	90%
METHYL PARATHION	90%
METHYL PARATHION + DETERGENT	90%
ENDOSULFAN + DETERGENT	90%
DELTAMETHRIN + DETERGENT	80%

What to do?

Inspired from the Brazilian experience

EFFECT OF PRODUCTS FOR THE CONTROL OF COCHINEAL *D. OPUNTIAE* ON CACTUS PEAR

TREATMENTS:	Product efficiency (%)
1. CONTROL	0
2. POWDERED SOAP 2%	100
3. NEUTRAL DETERGENT 5%	100
4. NEUTRAL DETERGENT 5% + HOUSEHOLD BLEACH 5%	100
5. SULPHONIC ACID 2%	100
6. LAURYL 5%	100
7. LAURYL 5% + CHLORINE 0.5%	100

Suggested solution

- ✓ Powdered soap: 400 g/20 L
- ✓ Detergent: 1 L/ 20 L
- ✓ Close (20 cm) on both sides



Resistant variety: *Nopalea cochenillifera*



Biological control: Natural enemies



Chilocorus cacti



Hyperaspis trifurcata



**FAO-ICARDA
INTERNATIONAL TECHNICAL
COOPERATION NETWORK ON
CACTUS**

www.cactusnet.org

FAO-ICARDA CACTUSNET

Creation of FAO- CACTUSNET: 1st August 1993, Mexico

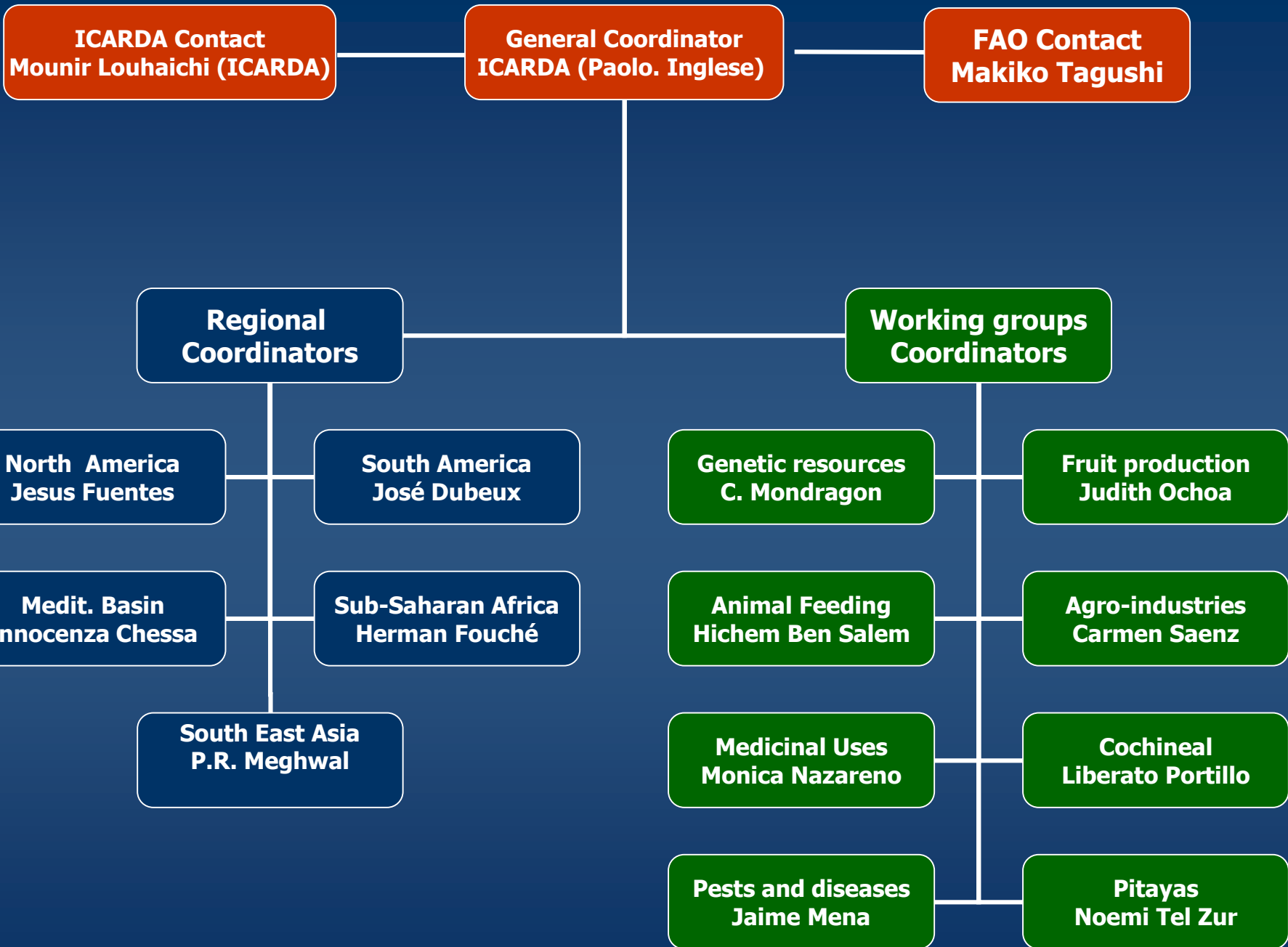
Objectives:

- To collect and disseminate information on production and planting, trade and markets, crop research, postharvest and processing and cochineal;
- To cooperate in the collection, conservation, exchange, evaluation and utilization of germplasm and monitor progress and usefulness of such exchanges.
- To promote the ecological and social benefits of cactus pear;
- To develop new food and carminic acid uses;
- To exchange expertise and organize training courses, workshops and meetings of experts in order to improve technical capability in the individual institutions.

Participating Countries



Angola, Algeria, Argentina, Bolivia, Brazil, Chile, China, Cuba, Egypt, Eritrea, Ethiopia, Germany, Greece, India, Iraq, Iran, Israel, Italy, Jordan, Mauritanian, Morocco, Mexico, Mozambique Pakistan, Peru, South Africa, Syria, Tunisia, Turkey, United States, Zimbabwe.



Highlights Network activities

Congresses / General Meetings + many country workshops

- 1st August 1993, Mexico - Creation of CACTUSNET
- 2nd December 1994, Italy
- 3rd January 1996, South Africa
- 4rd October 2000, Tunisia
- 5th August 2004, Mexico
- 6th October 2007, Brazil
- 7th October 2010, Agadir (Morocco)
- 8th October 2013, Palermo, Italy
- 9th March 2017, Chile

Highlights Network activities

Publications : Technical reports, Newsletter,...

