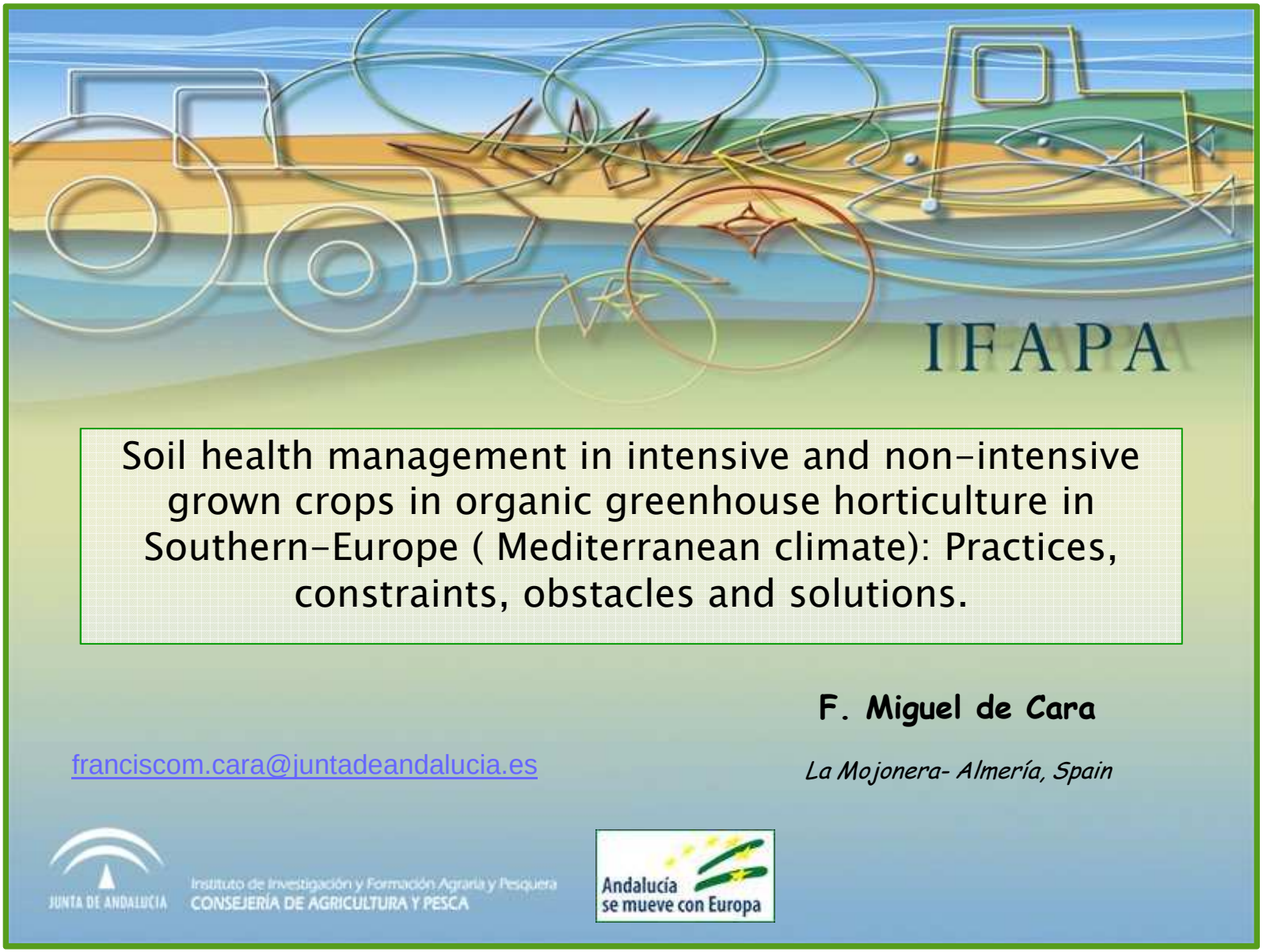

Soil health management in intensive and non-intensive grown crops in organic greenhouse horticulture in Southern-Europe (Mediterranean climate): Practices, constraints, obstacles and solutions.

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Andalucía se mueve con Europa

BioGreenhouse

cost
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

COST is supported by the EU Framework Programme Horizon 2020

Greenhouse production in Almería (Spain)

Is THIS system compatible with an agroecological healthy-soil strategy?

>30,000 ha
Eight crops: Tomato, sweet pepper, cucumber, melon, watermelon, eggplant, zucchini, green bean.

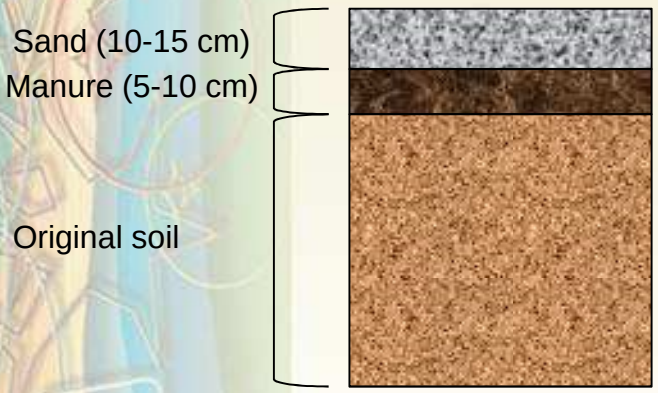
General view of Almería's organic greenhouses.

1.“Suelos arenados” (sandy soils) represents more than 80% of total surface.
2.High number of small producers: concentration and atomization.
3.Agribusiness high pressure.
4.Hybrid varieties are prevalent.
5.Biological control successful for insects and mites but not for microorganisms.

1. “Suelos arenados” (sandy soils) vs. Normal soils.

Disinfection-like?

“Suelo arenado”



- **Sheep, goat manure: fertilizer available to roots**
- **Amendment before summer → manure maduration**
- **Sand: regulation of temperature, use of saline water,**
  Reduction of evaporation, less compactation,
- **Alternatives on cropping line position.**
- **Increase of labour cost.**

General view of Almería's organic greenhouses.

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2. Production concentration

Transmision of information (and problems).

-Different advisors per farm.
-Daily meetings of growers (fruit reception area, warehouses).
-Courses, technical meetings, demostrations…
- Specific media for horticulturists (blogs, journals, radio and tv,...)

Positive

-Sources of inoculum / pest sources:
  -Air
  -Water
  -Environment

Negative

General view of Almería's organic greenhouses.

Soilborne pathogens:

***Meloidogyne* spp.**

-*Meloidogyne* spp.
-Vascular wilt
-Root and crown rot
-Colapse

F. oxysporum* f sp. *lycopersici

Pythium aphanidermatum

***Olpidium bornovanus* + MNSV**

General practices to manage soilborne diseases.

1. **Biodisinfection (biofumigation, solarization, both).**
2. Plant resistance: cultivars and rootstocks.
3. Prevention.
4. Biological control.

1. Biodisinfection.

Biodisinfection/Biofumigation

1. Biodisinfection.

+ 30 days

Water

Organic Matter

Soil

1. Biodisinfection.

Organic matter: Origin and ammount

Crop residues

Food industry residues

-Decreasing doses: 10 → 1 kg/m^2
-Accesible and cheap
-Ratio C/N: 8→20

Brassica and poultry pellets

Weeds

Manure: poultry, sheep, horse

1. Biodisinfection.

Incorporation to the soil

-Homogeneity
-25-30 cm depth

1. Biodisinfection.

Irrigation

-Homogeneity
-Check water distribution
-Repeat several days to reach field capacity

1. Biodisinfection.

Soil covering

-Seal carefully
-Transparent + summer: BioSolarization

Polyethilene

1. Biodisinfection.

Wait…

-Reductive conditions depend on the type of tarping:
-Polyethilene allows lack of oxygen for a few days
- Microbial communities can vary.
-Organic matter is not allways decomposed.
-Plant growth is higher

-Effect of reductive conditions
-Effect of high temperature
-Effect of bio-compounds
-Effect of o. m. mineralisation

1. Biodisinfection.

Results

-Positive results for greenhouse and high value crops:
- -Well documented: Carnation, strawberry, tomato, sweet pepper, cucumber.
- -Control of pathogenic nematodes, fungi and bacteria.

After *Clavibacter*

Metan-Na control: diseased plants

1. Biodisinfection.

Composting in situ

F. oxysporum f sp. *lycopersici*

Pythium aphanidermatum

Removed pathogens froms infested plants:

Fusarium oxysporum f.sp. *lycopersici, F. oxysporum* f.sp. *melonis*, *Pythium aphanidermatum*, *Pythium* spp., *Phytophthora* spp., *Thielaviopsis basicola*, *Olpidium bornovanus*, PMMV y MNSV.

After 60 days of composting at Almería, they were not detected. Open piles aerated by flipping.

(Aguilar, 2002)

General practices to manage soilborne diseases.

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4. Biological control.

2. Plant resistance.

2.1. Resistant varieties.

187 millions of plants, that is about 97% of all tomato seedlings produced in Almería, are resistant to one or more viruses (80%), fungi (93%) or nematodes (61%). Most of the fungi-resistant tomatoes are so against Fusarium wilt (*Fusarium oxysporum* f.sp. *lycopersici*) (95%) and Verticillium wilt (*Verticillium dahliae/albo-atrum*) (81%)

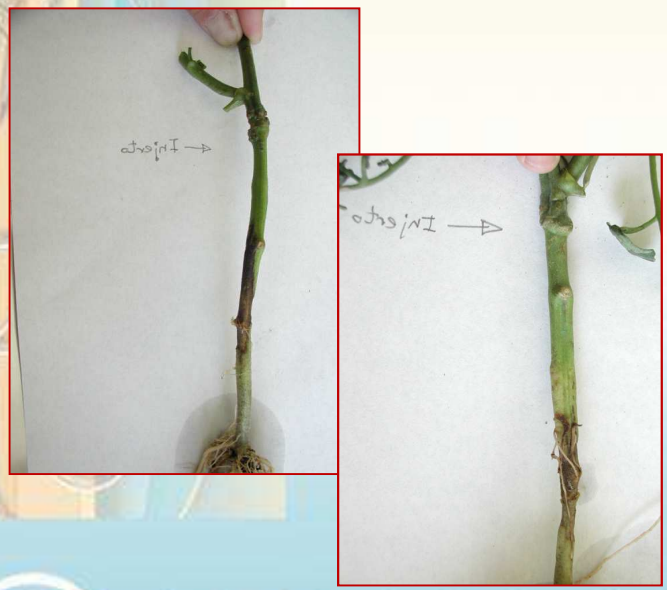
(Janssen et al., on press)

2. Plant resistance.

2.1. Rootstocks.

R = Resistant
S = Susceptible

- More than 100 million tomato plants are grafted in Southern Spain.
- 95% of watermelon is grafted.
- Grafted cucumber is increasing



	P. parasitica	*F. oxysporum* f. sp. *radicis-lycopersici*
Rootstock	**Resistance**	**Resistance**
Mini star	S	R
Katalina	S	R
Montezuma	R	R
Armstrong	R	R
Summer sun	S	R
Root star	S	R
Top-2005	S	R
Spirit	S	R
Beaufort	S	R
Maxifort	R	R
Hpit-0803	R	R
Dro122	R	R
Ar. 97009	R	R
Morgan	S	R
Emperador	R	R
61 071	S	R
19zs913	S	R
19zs912	S	R

General practices to manage soilborne diseases.

1. Biodisinfection (biofumigation, solarization, both).
2. Plant resistance: cultivars and rootstocks.
3. **Prevention.**
4. Biological control.

3. Prevention.

3.1. Water → Drip irrigation.

-Origin for diseases: nematodes, fungi, oomicetes, chytridios, bacteria.

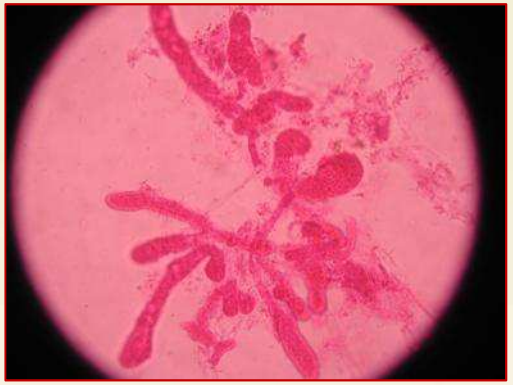
Nematodes

Meloidogyne incognita, M. javanica, M. arenaria

3. Prevention.

3.1. Water → Drip irrigation.

Pythium aphanidermatum, P. ultimum, P. irregulare, ...



Water-borne

3. Prevention.

3.1. Water → Drip irrigation.

1.Root rot, wilt of tomato, pepper, melon.

Phytophthora capsici, P. parasitica

Pools (<100m^3):
Water disinfection

Water-borne

3. Prevention.

3.1. Water → Drip irrigation.

Better than flood irrigation!

3. Prevention.

3.2. Seeds → Seed standard (NO certified).

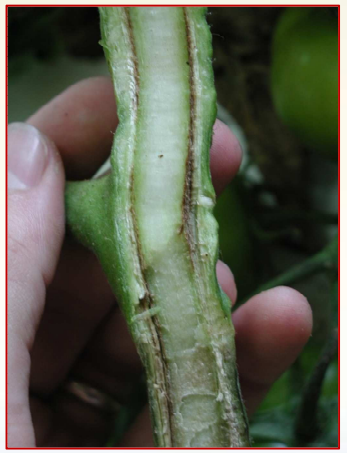
Introduction of pathogens:

- Complaint to the seed company / nursery
- Soil biodisinfectionafter introduction of the pathogen

Fusarium oxysporum f.sp. melonis
Races 0, 1, 2, 1-2 W, 1-2 Y

(Gómez y Tello, 2000)

Clavibacter michiganensis subsp. michiganensis



3.3. Seedlings.

3. Prevention.

3.2. Ourselves.

-Look out for tools!

-Way of contamination and dissemination of pathogens

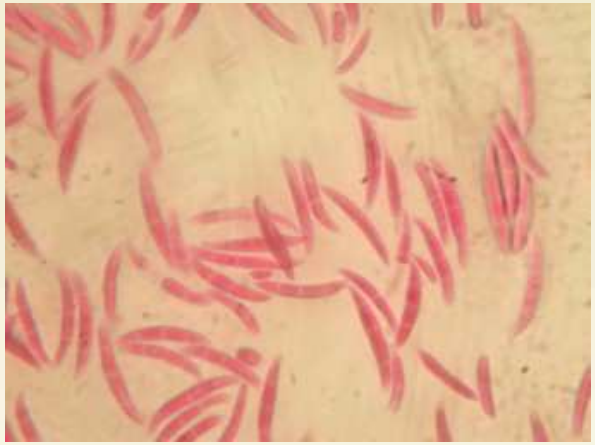
Inoculum sources:
-Kitchen gardens and orchards (38 samples) = 15% *Phytophthora*
-Tracktor wheels and tools (8 tracktors) = 12,5% *Phytophthora*

(de Cara et al., 2011)

General practices to manage soilborne diseases.

1. Biodisinfection (biofumigation, solarization, both).
2. Plant resistance: cultivars and rootstocks.
3. Prevention.
4. **Biological control.**

4. Biological control.
4.1. Evolution.



Baker and Cook (70's, 80's)

↓

Hoitink et al. (90's)

↓

Commercial availability (90's)

↓

¿Results?
(XXI Century)

4. Biological control.

Weaknesses of B.C. in greenhouses

Correct diagnosis → Is there disease in the crop?

B.C. product correctly labeled → What are we going to apply?

Right application → How to apply?

B.C.A. check → Is it established in the soil/crop?

Assesing of control → Is B.C.A. working as it is expected?

Model of B.C. for insects

4. Biological control.

Correct diagnosis → Is there disease in the crop?

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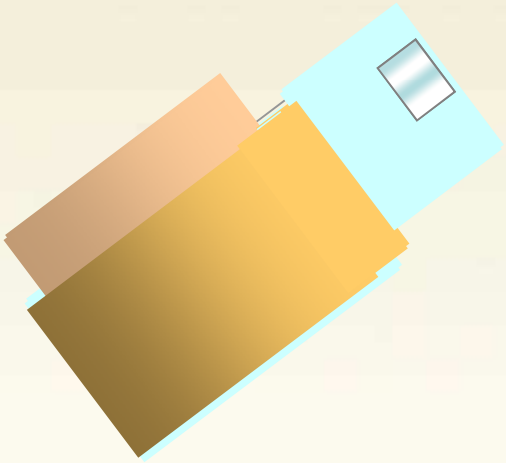
4. Biological control.



-Biofertilizer
-Phytofortificant
-Biostimulant
-Fungicide

Correct diagnosis → Is there disease in the crop?

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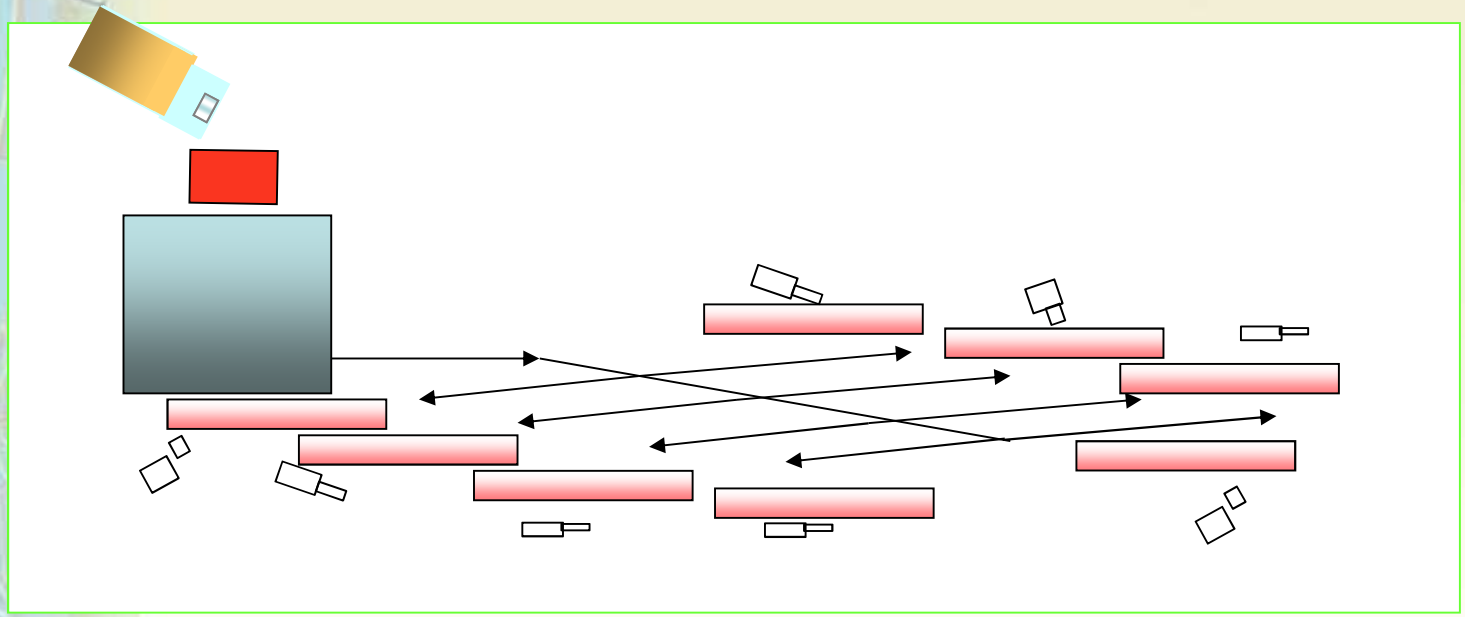
4. Biological control.



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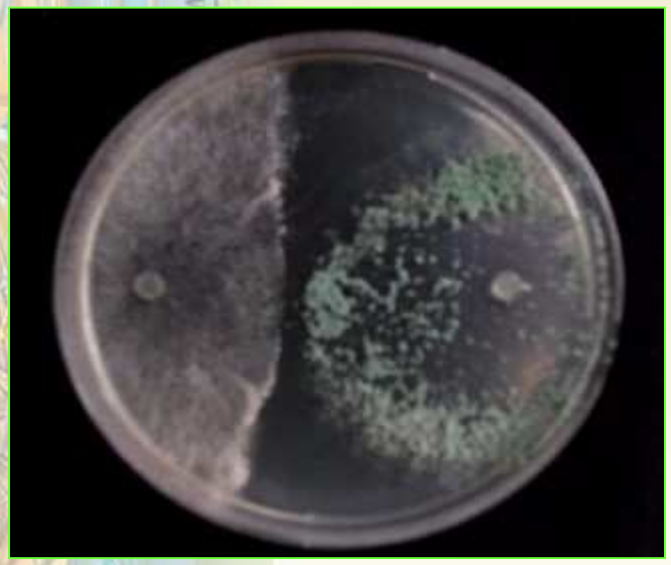

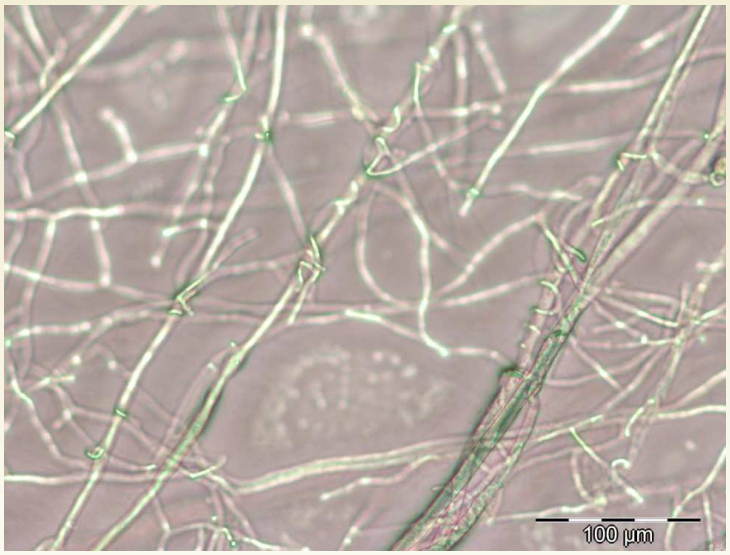

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Right application → How to apply?

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4. Biological control.

There are not clear successes for B. C. in Almería's greenhouses

There are Plant Promoting effects on plants (nursery level) when some B. C. Organisms are applied, such as *Trichoderma* spp. (Systemic Resistance Acquisition?, Increased availabilivty of nutrients?)

More need to be done...

General practices to manage soilborne diseases.

1. Biodisinfection (biofumigation, solarization, both).
2. Plant resistance: cultivars and rootstocks.
3. Prevention.
4. Biological control.

COMBINATION

~~**ROTATION**~~

General practices to manage soilborne diseases.

1. **Biodisinfection (biofumigation, solarization, both)**.
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3. Prevention.
4. Biological control.

Allow management of plant residues
In summer fast decomposition of organic matter
Compatible with other practices

Difficult to make it compatible with "suelo arenado"
In winter not enough to disinfect soils
Labourious task

General practices to manage soilborne diseases.

1. Biodisinfection (biofumigation, solarization, both).
2. **Plant resistance: cultivars and rootstocks.**
3. Prevention.
4. Biological control.

Safer than other practices
As simple as buy them
Rootstocks allow cropping local varieties

Expensive
Highly dependant on seed companies
Resistances to all pathogens are not present

General practices to manage soilborne diseases.

1. Biodisinfection (biofumigation, solarization, both).
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3. **Prevention.**
4. Biological control.

Water disinfectants need to be allowed/developed
Seed coating protective products need to be developed
Fungicides and bactericides for nurseries need to be developed
Certified horticultural seeds are desiderable

General practices to manage soilborne diseases.

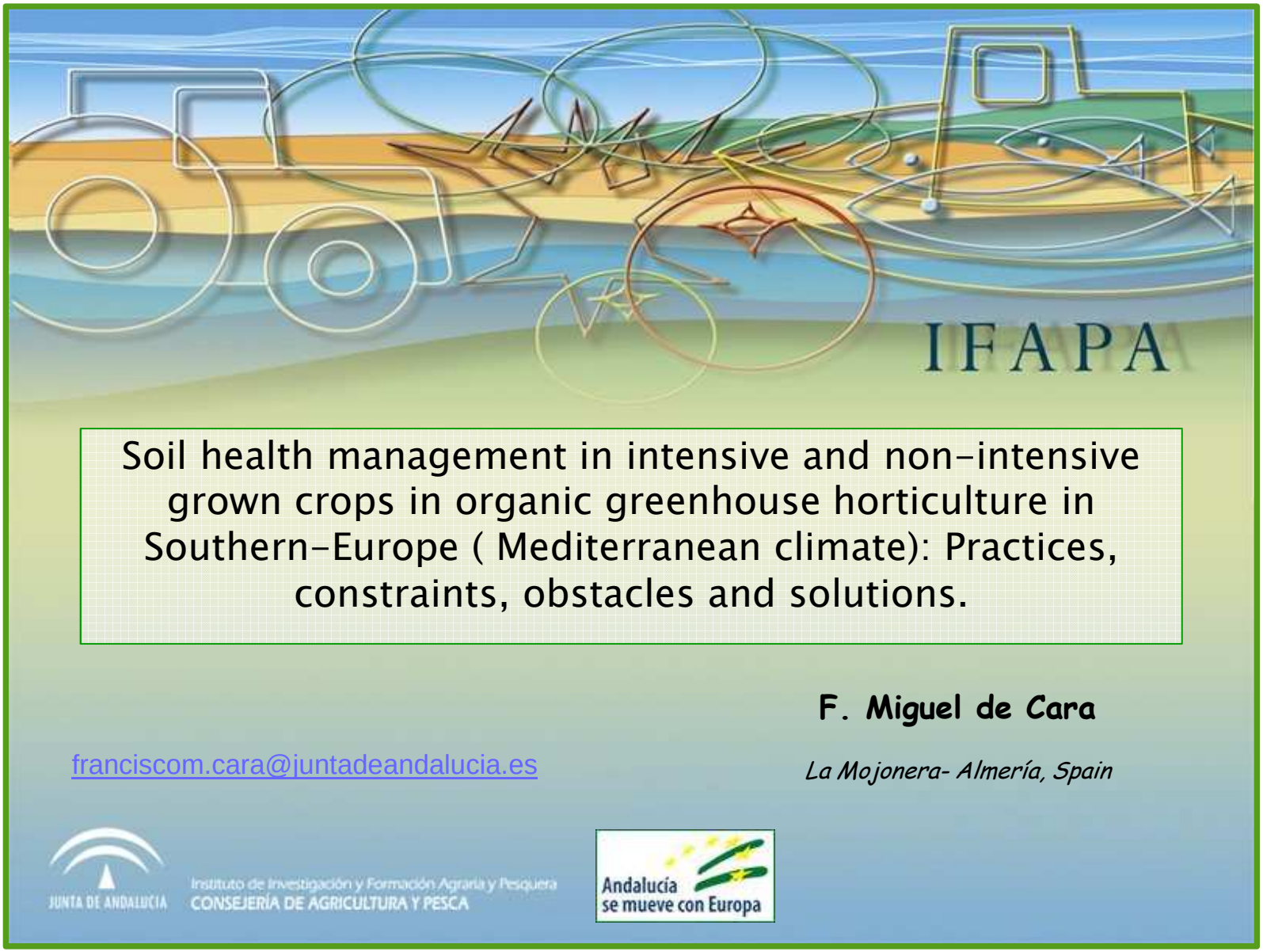
1. Biodisinfection (biofumigation, solarization, both).
2. Plant resistance: cultivars and rootstocks.
3. Prevention.
4. **Biological control.**

Rational method
Easy to use

Not as effective as needed
Specific application instructions needed
Low availability for the whole spectrum of pathogens

Greenhouse production in Almería (Spain)

Is THIS system compatible with an agroecological healthy-soil strategy?



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