Organic growing in greenhouses under Mediterranean conditions – use of contentious inputs and ways to phase them out

Nikolaos Katsoulas
Associate Professor

Fokhol gård, Stange, October 28-29, 2019
Where we are....

Latitude: 39.22
Longitude: 22.44

http://www.theodora.com/maps
University of Thessaly

Presentation
Lab of Agricultural Constructions and Environmental Control
Team presentation
University of Thessaly,

Department of Agriculture Crop Production & Rural Environment,

Laboratory of Agricultural Constructions and Environmental Control

**Director:**
Nikolaos Katsoulas
Associate Professor
nkatsoul@uth.gr
T:+302421093249
M:+306948575954

**Members:**
Dr. E. Kitta
Dr. A. Elvanidi,
PhD st. M. Metsoviti
PhD st. E. Karatsivou,
PhD st. A. Bari
PhD st. M. Aslanidou
MSc S. Bouras
MSc G. Miliokas

**Collaborators:**
Prof. C. Papaioannou
Dr. D. Antoniadis
Dr. D. Papanastasiou
Dr. D. Feidaros
Dr. A. Baxevanou

MSc P. Xiradakis
MSc st. S. Faliaga
BSc E. Armyra (Secretary)
and
several BSc students
Laboratory of Agricultural Constructions and Environmental Control

Objectives

Sustainable agriculture production in controlled environment – Greenhouse

✓ Design optimisation of greenhouse structures
✓ Rational management of hydroponic and aquaponic systems
✓ Development and evaluation of greenhouse climate control systems
✓ Plant based greenhouse climate control
✓ Development and evaluation of crop stress indices

Major projects:
➢ Intelligent crop-based environmental monitoring and control of sustainable greenhouse eco-systems (GSRT, Excellence)
➢ Optimisation of greenhouse climate control in high salinity soils using omic technologies (GSRT, Cooperation 2009)
➢ Sustainable use of Irrigation Water in the Mediterranean Region (FP7, KBBE 2009)
➢ Smart Controlled Environment Agriculture Systems (FP7, Marie Curie, IRSES)
➢ Online Professional Irrigation Scheduling Expert System (FP7, KBBE 2013)
Controlled environment growth chamber
Rational use of water resources
Wirelles Systems

Air temp and relative humidity

Leaf temperature
GreenSense

Spatially distributed greenhouse climate control based on wireless sensor network measurements

Temperature - Summer: a) daytime, b) night time
Winter: c) daytime, d) night time

WSN characteristics & sensors
- Zolertia Z1 nodes
- Advantecsys CM3300 for the base-station node
- Olimex Olinuxino A13 computer
- IP65 humidity resistant boxes
- SHT11 sensor for $T_{air}$ & RH
- ZyTemp TN9 sensor for $T_{leaf}$

Transpiration – Spatial variability

- Transpiration estimation: $T_r = a R + b VPD$
  - a) daytime
  - b) night time
  - c) average on entire summer period
Remote sensing in greenhouses for plant reflectance measurement

Different types of effective reflectance sensors can monitor plant water status in real time by monitoring plant reflectance.

The use of GreenSense for reflectance and temperature indices for crop water status assessment.

- Data set group
- Training of CT
- Validation of CT

Predicted N% based on BANI

Measured N%
Running projects

- MED Greenhouses (Interreg MED)  
  https://MEDGreenhouses.interreg-med.eu/
- Organic+ (H2020)  
  https://Organic-Plus.net/
- FoodOASIS (EDK)  
  http://FoodOASIS.eu/
- Alga4Fuel&Aqua (EDK)  
  http://Alga4Fuel-Aqua.eu/
- InGreco (EDK)
- Fotokipia (EDK)
- CasH (Greece-Germany)  
  http://cascade-hydroponics.eu/
- AgriTexSil (Greece-Germany)  
  http://www.agritexsil.eu/
Greenhouses: why?
How to increase circularity in horticulture?
Need for higher productivity

Globally, agriculture needs are expected to rise significantly in the next 35 years.

Current population is 7 billion people

Will be raised to 9.1 billion people

100% of food needs will be raised by 70%

Rise in food needs by 2050 will be disproportionate to the rise of world population.

Source:
1. Food and Agriculture Organization of the United Nations (hereinafter FAO)
2. United Nations
3. International Horticultural Congress
Need for Circularity in Horticulture

- Depletion of natural resources
- Energy
- Land
- Water
- Climate change
Regional suitability needs

Mean air temperature (°C)
Mean solar radiation (MJ m$^{-2}$ day$^{-1}$)
Volos-Greece

Continuous ventilation
Discontinuous ventilation
Closed greenhouse

Heating day/night
Heating night
No heating
Regional suitability-needs

- Continuous ventilation
- Discontinuous ventilation
- Closed greenhouse

Heating day/night
Heating night
No heating
Protected cultivation: why?

- Out-of-season/year round production
- Higher productivity per unit soil surface
- More reliable production (less affected by climate)
- Improved control of pests and diseases
- Higher quality/uniformity of production

Means:

- Improved control of:
  - Temperature; Light; Humidity; CO₂
  - Irrigation and fertilization
  - Pests and fungi

15x more productive

<table>
<thead>
<tr>
<th>Kg fresh product per m² water</th>
<th>Liters water per kg tomato</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Field 3 kg</td>
<td>Outdoor production system 60 liters</td>
</tr>
<tr>
<td>Plastic greenhouse 13 kg</td>
<td>Holland ‘closed’ greenhouse 4 liters</td>
</tr>
<tr>
<td>Modern greenhouse 42 kg</td>
<td></td>
</tr>
</tbody>
</table>

WUR
Worldwide greenhouse areas

Europe

North America

Asia

Top 5 Countries by Area (ha)

China

700,000 ha

United States

8,425 ha

Canada

2,286 ha

57% Ontario

Mexico

11,759 ha

S. Korea

57,444 ha

Japan

49,049 ha

Spain

52,170 ha

France

9,620 ha

Holland

16,370 ha

Poland

7,560 ha

Turkey

33,815 ha

Italy

26,500 ha

Greece

4,670 ha
Almeria - Spain
Low and High-tech greenhouses

- PE covered greenhouses
- Ventilation, shading, evaporative cooling
- Soil grown crops
- Fertigation

- PE or glass covered greenhouses
- Heating, energy shaving systems, ventilation, shading, evaporative cooling, air mixing, insect proof screens
- Soil or soilles crops in open or closed systems, Fertigation
- DSSs and automations
Farm balance for a truss tomato crop under two production strategies

<table>
<thead>
<tr>
<th></th>
<th>Netherlands (Venlo)</th>
<th>Spain (Multitunnel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production (kg/m²)</td>
<td>55</td>
<td>16</td>
</tr>
<tr>
<td>Value (€/kg)</td>
<td>0.93</td>
<td>0.65</td>
</tr>
<tr>
<td>Gross income (€/m²)</td>
<td>51.15</td>
<td>10.40</td>
</tr>
</tbody>
</table>

Affected mainly by product value

Affected mainly by outside climate

(Vanthoor et al., 2011)
Productivity of tomato

Yield \( \text{kg}/(\text{m}^2 \cdot \text{year}) \)

Control of production factors

- open field
- unheated multi-tunnel
- heated multi-tunnel
- high-tech with CO\(_2\)
- high-tech with CO\(_2\) & light
Water and nutrients circularity in greenhouses

Decision support and control systems
Cascade hydroponics

The nitrogen balance for the two combined systems shows an important decrease in N leachate.

The adoption of the ‘cascade’ crop system reduced environmental impact for climate change category by 21%, but increased eutrophication category by 10% because of the yield reduction. 

Muñoz et al. (2012)
Aquaponics

Integration of aquaculture and hydroponics.

Symbiotic growing of fish and vegetables in recirculating water systems – is emerging as one important area of sustainable agriculture.
Organic Plus

Cultivated organic areas in the Mediterranean region and inputs used

What is done in WP3-Plants of Organic Plus
**T3.1: Current use of contentious inputs in organic production**

- Mapping of Cu and mineral oils use. Current policies and legal status

- Countries: Denmark, France, Germany, Greece, Italy, Norway, Poland, Spain, Turkey and UK

**T3.2: Identification of available alternatives to copper and mineral oils for plant protection in organic production in Europe (M1-9)**

- D3.1: Mapping *(available)*

- D3.2a: Available alternatives *(available)*

- D3.2b: Factsheets (4) on transfer/adaptation of alternatives *(available)*
Pathways to phase-out contentious inputs from organic agriculture in Europe

Deliverable 3.1: Version 1.1
Current use and legal status of crop protection inputs

Versions
Version: 1.0 {September 2018} First version

Funding
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No. 774340 — Organic-PLUS
ORGANIC FARMING IN THE EU

ORGANIC AGRICULTURAL LAND* IN THE EU-28 (2016)

11.9 million hectares

6.7% of land used for agriculture

Four countries together account for 54.4% of the EU's total organic area

54.4%

16.9% Spain

15.1% Italy

12.9% France

9.5% Germany
Organic farming area
Share of total organic area in total utilised agricultural area (UAA)

Data refer to 2017.
Norway, Iceland, Switzerland: Non-EU countries.
Estimated data for EU-28, Italy, United Kingdom and Norway.

ec.europa.eu/eurostat
Legal status for Cu and Mineral oils

- Cu as fungicide is allowed up to 6 kg per ha per year
  For perennial crops, the 6 kg limit can be exceeded in a given year provided that the average quantity actually used over a 5-year period consisting of that year and of the four preceding years does not exceed 6 kg.
- From 2019 to 2025 the EU limit is 4 kg/ha/year or 28 kg/ha/year in total over 7 years
- From 2026 it may
  - be increased to 6 kg (not likely)
  - stay the same for another 7 years (likely)
  - be reduced to 3 kg or 2 kg (most likely)
  - be reduced to ZERO (not likely)
T3.1: Current use of contentious inputs in organic production (M1-6)

Countries: Denmark
France
Germany
Greece
Italy
Norway
Poland
Spain
Turkey
UK
T3.1: Current use of contentious inputs in organic production (M1-6)

- **Cu:**
  - **Grapes:**
    - Low downy mildew pressure: 2.5 to 3.6 kg/ha/yr
    - High downy mildew pressure: 4.3 to 6.4 kg/ha/yr
  - **Fruits:**
    - Apple: 2.1 kg/ha.yr
    - Peach: 5 kg/ha.yr
    - Apricots: 3 kg/ha.yr
  - **Vegetables**
    - Potato: ware: 3 to 8 kg/ha.yr; earlies: 3.3 tyop 4 kg/ha.yr, according to LB pressure
    - Tomato: 3.6 to 6.1 kg/ha yr according to disease pressure (LB / bacterial diseases)

- **MinOils:** Very little information available (Main target: virus-transmitting aphids/ seed potato)
  - According to the Brittany organisation of organic seed potato growers, mineral oils are now almost entirely replaced by plant oils (rapeseed) > not an issue anymore

- **S:** Not really considered contentious in France
T3.1: Current use of contentious inputs in organic production (M1-6)

Countries: Denmark France Germany Greece Italy Norway Poland Spain Turkey UK

Farming area in Germany (2017):

- Number of farms: 267,651
- Number of organic farms: 29,174
  - Share of organic farms: 10.9%
- Total area: 16,780,085 hectare
- Organic farming area: 1,375,967 hectare
  - Share of organic farmland: 8.2%
Copper application in Germany within Demeters’ farms (2011-2016)
### T3.1: Current use of contentious inputs in organic production (M1-6)

#### Organic and conventional crops of O+ interest in Greece (2016)

<table>
<thead>
<tr>
<th></th>
<th>Olives (in ha)</th>
<th>Citrus (in ha)</th>
<th>Fresh vegetables</th>
<th>Total (agricultural and grazed land)</th>
<th>Total (agricultural land)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic</td>
<td>44752</td>
<td>2300</td>
<td>290</td>
<td>342582</td>
<td>102166</td>
</tr>
<tr>
<td>Conventional</td>
<td>821206</td>
<td>42640</td>
<td>73812</td>
<td>3152600</td>
<td>2432524</td>
</tr>
<tr>
<td>%</td>
<td>5.4%</td>
<td>5.4%</td>
<td>0.4%</td>
<td>10.9%</td>
<td>4.2%</td>
</tr>
</tbody>
</table>

#### Cu use:

- **In conventional olives (worst scenario)**: 1 application in October (CuOH), 2 applications in February (calcium copper sulfate), 1 application in March (CuOH) and 1 application in June-July (oxychloride Cu), **total Cu**: 16.5 kg/ha/year
- **Best scenario**, total Cu: 7 kg/ha/year. (In conventional, concentration of Cu in soil >1.5 ppm)

- **In organic olives**: 1 application in October (CuOH), 1 application in February (calcium copper sulfate), 1 application in June-July (oxychloride Cu). **Total Cu**: 6 kg/ha/year

- **In organic fresh vegetables**: 2-4 kg/ha/year
**T3.1: Current use of contentious inputs in organic production (M1-6)**

### Conventional citrus areas in Italy

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>Var. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>ha</td>
<td>ton</td>
<td>ha</td>
<td>ton</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>150,047</td>
<td>3,151,564</td>
<td>146,000</td>
<td>2,500,000</td>
</tr>
<tr>
<td></td>
<td>138,000</td>
<td>2,900,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Organic citrus areas in Italy

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2016</th>
<th>Var. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>ha</td>
<td>ton</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>31,869</td>
<td>524,990</td>
<td></td>
</tr>
<tr>
<td></td>
<td>36,125</td>
<td>596,000</td>
<td>+13,4%</td>
</tr>
</tbody>
</table>

### Organic citrus area in Italy in conversion and converted (ha)

<table>
<thead>
<tr>
<th>Organic citrus area</th>
<th>In conversion</th>
<th>Converted</th>
<th>Total organic area 2016 (ha)</th>
<th>Var.% 2016/15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oranges</td>
<td>5.321</td>
<td>12.897</td>
<td>18.218</td>
<td>15</td>
</tr>
<tr>
<td>Lemons</td>
<td>1.990</td>
<td>5.353</td>
<td>7.343</td>
<td>14,4</td>
</tr>
<tr>
<td>Grapefruits</td>
<td>22</td>
<td>105</td>
<td>127</td>
<td>32</td>
</tr>
<tr>
<td>Others</td>
<td>3.150</td>
<td>7.287</td>
<td>10.437</td>
<td>9,7</td>
</tr>
<tr>
<td>Total</td>
<td>10.483</td>
<td>25.642</td>
<td><strong>36.125</strong></td>
<td>+13,4</td>
</tr>
</tbody>
</table>

**Organic citrus area in Italy (ha) = 36 kha/146 kha =25%**

Among the investigated crops (citrus, olive, tomato and potato), high amounts of copper are used by Sicilian growers in lemon orchards and potato. For these two crops the limit of 6 kg per ha and per year is generally not respected. In olive orchards in Calabria the amount of copper applied exceeds greatly 6 kg/ha per year.
In 2016, certified organic agricultural area, including area under conversion, =4.8% of the total agricultural area in use. Number of holdings with organic farming was 2 100 = 5.0% of the total agricultural holdings in Norway.

- **Cu:** Up to 6 kg copper per ha per year. Was approved as a pesticide in organic growing in March 2017.
- **Mineral oil:** Commercial product containing >94% parrafin oil, approved for use in OF in Norway: Fibro (Belchim Crop Protection).
- **Sulphur and Lime sulphur (calcium polysulphide)** allowed without thresholds or other limitations.
### T3.1: Current use of contentious inputs in organic production (M1-6)

**Countries:**
- Denmark
- France
- Germany
- Greece
- Italy
- Norway
- Poland
- Spain
- Turkey
- UK

<table>
<thead>
<tr>
<th>SPAIN (2016)</th>
<th>SURFACE (Ha) ORGANIC</th>
<th>SURFACE (Ha) TOTAL</th>
<th>% organic SURFACE</th>
<th>% organic PRODUCTION</th>
<th>Yield Organic (kg/Ha)</th>
<th>Yield Conventional (kg/Ha)</th>
<th>Yield difference (organic/conventional)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>216.481</td>
<td>6.240.000</td>
<td>3,5%</td>
<td>0,7%</td>
<td>757</td>
<td>3.865</td>
<td>20%</td>
</tr>
<tr>
<td>Dried legumes</td>
<td>38.057</td>
<td>460.000</td>
<td>8,3%</td>
<td>2,0%</td>
<td>337</td>
<td>1.409</td>
<td>24%</td>
</tr>
<tr>
<td>Tubers</td>
<td>639</td>
<td>74.584</td>
<td>0,9%</td>
<td>0,4%</td>
<td>13.323</td>
<td>30.912</td>
<td>43%</td>
</tr>
<tr>
<td>Industrial crops</td>
<td>16.522</td>
<td>952.806</td>
<td>4,6%</td>
<td>1,9%</td>
<td>16.649</td>
<td>40.202</td>
<td>41%</td>
</tr>
<tr>
<td>Arable crops</td>
<td>24.144</td>
<td>1.064.379</td>
<td>2,4%</td>
<td>1,3%</td>
<td>31.113</td>
<td>54.987</td>
<td>57%</td>
</tr>
<tr>
<td>Vegetables</td>
<td>17.182</td>
<td>375.073</td>
<td>15,4%</td>
<td>2,4%</td>
<td>729</td>
<td>4.623</td>
<td>16%</td>
</tr>
<tr>
<td>Strawberries</td>
<td>163</td>
<td>6.867</td>
<td>3,4%</td>
<td>2,0%</td>
<td>13.986</td>
<td>23.993</td>
<td>58%</td>
</tr>
<tr>
<td>No citrics fruits</td>
<td>144.957</td>
<td>939.066</td>
<td>11,4%</td>
<td>3,5%</td>
<td>1.983</td>
<td>6.515</td>
<td>30%</td>
</tr>
<tr>
<td>Citrics</td>
<td>10.183</td>
<td>295.331</td>
<td>7,8%</td>
<td>2,3%</td>
<td>835</td>
<td>2.809</td>
<td>30%</td>
</tr>
<tr>
<td>Grapevine</td>
<td>106.720</td>
<td>936.788</td>
<td>7,8%</td>
<td>2,3%</td>
<td>835</td>
<td>2.809</td>
<td>30%</td>
</tr>
<tr>
<td>Olive</td>
<td>196.567</td>
<td>2.521.694</td>
<td>1,9%</td>
<td>0,4%</td>
<td>13.986</td>
<td>23.993</td>
<td>58%</td>
</tr>
<tr>
<td><strong>TOTAL SURFACE</strong></td>
<td><strong>771.615</strong></td>
<td><strong>13.866.588</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Olive is the main organic crop in Spain (>39% surface of permanent crops)
Contentious inputs limits:
Copper: max. 6 kg/ha/year
Mineral oil: authorised only for trees.

Cu consumption per ha and year (kg) - season 2012/2013
WHAT ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN CITRUS ORGANIC FARMING?

CITRUS

The citrus industry is one of the most important fruit industries worldwide. The Mediterranean countries are second only to China for fruit production, and are the largest fruit exporter after South Africa (FAO 2015).

The citrus crop is continually threatened by pathogens and pests, which limit the citrus productivity in the field and the commodity itself. For instance, in addition to common and often devastating phytopathogens, fungi, and bacteria (Pseudomonas, Fusarium, Phytophthora, Xanthomonas), the citrus fruit is very sensitive and heavily damaged by insect pests, which can be very damaging to the citrus-growing industry. The mycotic infection produces serious losses. Many alternative approaches to reduce or replace the use of copper compounds are under development, but few are already available on the market.

Visit our website: www.organic-plus.net
Follow us on Twitter: @OrgPlusResearch
Judith Conroy@conroy.co.uk
Project Manager
Ulster University/University of Birmingham
Floral Research Institute

Pathways to phase-out contentious inputs from organic agriculture in Europe

OrganicPLUS is a new EU Horizon 2020 project for which 25 partners from 12 countries (EU and non-EU) are working to find alternative solutions to some of the contentious inputs currently permitted in certified organic production, including copper fungicides, mineral oils and sulphur, with a special focus on perennial Mediterranean crops like olives and vines and green technologies like tomatoes and alfalfa.

The citrus crop is threatened by several pests and diseases, which can severely impact its productivity. The citrus industry is second only to China in terms of fruit production and is the largest exporter after South Africa (FAO 2015). The citrus crop is particularly sensitive to insect pests, which can cause significant damage to the industry. Alternative approaches to replace or reduce the use of copper compounds are under development, but few are currently available on the market.
Pathways to phase-out contentious inputs from organic agriculture in Europe

Organic-PLUS is a new EU Horizon 2020 project for which 25 partners in 12 countries (EU and non-EU) are working to find alternatives to some of the contentious inputs currently permitted in certified organic production, including copper fungicides, mineral oils and sulphur, with a special focus on perennial Mediterranean cropland such as citrus and olives and greenhouse crops like tomato and aubergine.

WHAT ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN OLIVE ORGANIC FARMING?

OLIVE

This factsheet provides an overview of some alternatives for the replacement/reduction of contentious inputs (namely copper, mineral oil, sulphur) used for control of diseases and pests in olive crops. Alternative compounds cannot be considered as one-for-one substitutes of contentious inputs, but they should be integrated within more complex strategies for crop protection. In general, plant health should rely on preventive and indirect care measures more than off-farm inputs. The choice of varieties adapted to the local conditions, the use of resistant varieties and, in general, all measures which ensure a resilient agricultural system, strongly contribute to reduce the dependency on external inputs to control pests and diseases.

The olive tree is an identifying element of the Mediterranean basin’s landscape and intensive olive plantations. Ancient olive groves and even monumental olive trees are emblematic of the cultural heritage and culinary traditions. European producing countries, with about 5 million hectares of plantations, account for 70 to 75% of world production of olive oil and more than one third of table olives. The olive yield is threatened by pathogens and pests, which limit the olive productivity in the field and the commercial life of products post-harvest. Common phytopathogenic fungi and bacteria (Colletotrichum gloeosporioides, Xylella fastidiosa, Phytophthora cladosporioides, Verticillium dahliae, Pseudomonas savastanoi) commonly found in all Mediterranean regions, compromise olive production in different Mediterranean countries. The olive oil sector is going through a very critical phase due to the spread of the devastating quarantine bacterium Xylella fastidiosa in the Salento area (south of Italy), becoming an emerging disease which represents a serious limiting factor in the olive sector.

Visit our website www.organic-plus.net
Follow us on Twitter @OrgPlusResearch
Judith.Conroy@coventry.ac.uk
Project manager: Ulrich.Schmidt@coventry.ac.uk
P.I. (Principal investigator):

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No. 774340.

ALTERNATIVES TO COPPER

In olive crops of Mediterranean countries the limit of 8 kg/ha/year is generally respected.

Low copper grade formulations, with reduced copper content (2-5%), allow a smaller amount of copper distributed per hectare.

“Natural” alternative formulations, applied to replace or reduce copper usage, used alternatively or in combination with copper. Some of them are included in Annex II to Commission Regulation (EC) 881/2008, permitted for plant protection in organic crop production:

• Inorganic substances: sprayable zeolite and kaolin for abiotic stress protection and olive fruit fly protection; K2SO4
• Plant defence stimulators including calcium and silicon.
• Biological control agents, with a variety of mechanisms of action against fungal and bacterial pathogens and stimulating effects on plant defenses. Trichoderma spp., Bacillus subtilis strains, Streptomyces spp. are some example of BCAs available on the market.
• Chitosan, natural polymer obtained from chitin, repared active against a variety of microorganisms, with a good direct activity coupled with stimulation of plant defense mechanisms.
• Compost: compost tea (enrichment with platanius orientalis leaves), vermicompost, vermicompost tea.
• Lime-sulphur.

Authors: Andrew P, Cotter B, Chaillet G, de Cao M, Koutsos K, K, K, A

ALTERNATIVES TO MINERAL OILS

Mineral oils are applied to exclusively control insects and mites. Their use ranges between 30-90 litres/ha/year. The wide spectrum of activity of mineral oils makes them more versatile than other alternatives.

• Organic oils (e.g. from neem)
• Zeolite and Kaolin for olive fruit fly protection
• Beneficials

ALTERNATIVES TO SULPHUR

Mineral sulphur is used in Mediterranean olive groves.

Main goals of O+ project related to olive

Aim

To assess the efficacy and acceptability of five main alternatives to copper fungicides in Mediterranean olive orchards, and to compare their impact on soil and water quality, pollinators and overall plant health.

Main results

Possible reduction of copper fungicides by 85%,

Mineral oils can replace copper fungicides in olive orchards,

Plant growth promoter (PGR) in control of olive moth (Eueides sp.)

Better alternative to copper fungicides:

• Inorganic substances
• Plant defence stimulators
• Biological control agents
• Compost
• Lime-sulphur

Main conclusions

There are effective alternatives to copper fungicides that can be used in Mediterranean olive orchards.

Further research is needed to assess the impact on crop productivity and fruit quality, as well as the potential for use in larger areas.

Acknowledgments

The project was funded by the European Union’s Horizon 2020 research and innovation programme.
WHAT ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN TOMATO ORGANIC FARMING?

TOMATO

This fact sheet provides an overview of some alternatives for the replacement/reduction of contentious inputs (namely, copper, mineral oil, sulphur) used for control of diseases and pests in tomato crops. Alternative compounds cannot be considered as one-for-one substitutes of contentious inputs, but they should be integrated within more complex strategies for crop protection. In general, plant health should rely on preventive and indirect control measures rather than off-farm inputs. The choice of varieties adapted to the local conditions, the use of resistant varieties and, in general, all measures which promote a resilient agriculture system, strongly contribute to reduce the dependency on external inputs to control pests and diseases.

In organic tomato cultivations, pathogens are generally controlled by regular sprays with copper-based products. The demonstrated toxic effect of copper on soil microbial communities and other soil fauna has led to regulatory restrictions in its use. The use of copper for crop protection purposes has been restricted in the EU to a maximum amount of 5 kg ha⁻¹ of metal Cu as to the end of 2018 but is now reduced to 4 kg ha⁻¹ starting from January 2019.

According to the data collected by interviewing experienced advisors in the first 6 months of this research activity, this limit is too the severe requested by Mediterranean tomato growers. Many alternative compounds to replace or reduce copper inputs are under development, but few are already available on the market.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No. 779580.

Organic PLUS is a new EU Horizon 2020 project for which 25 partners in 12 countries (EU) and Norway are working to find alternatives to some of the contentious inputs currently permitted in organic farming, including copper fungicides, mineral oils and sulphur, with a special focus on perennial Mediterranean crops like citrus and olives and greenhouse crops like tomato and asparagus.

WHAT ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN TOMATO ORGANIC FARMING?

ALTERNATIVES TO COPPER

Copper use in Mediterranean countries rarely exceeds the limit of 6 kg ha⁻¹ per year. The highest amounts of copper are generally applied on greenhouse tomatoes during the winter season. Alternatives to copper are currently represented by:

- Low copper grade formulations, with reduced copper content (2-6%), allow a smaller amount of copper distributed per hectare.

- “Natural” alternative formulations, applied to replace or reduce copper dosage, uses alternately or in combination with copper. Some of them are included in Annex II to Commission Regulation (EC) 889/2008, permitted for plant protection in organic crop production.

- Biological control agents, with a variety of mechanisms of action against fungal and bacterial pathogens and stimulating effects on plant defences. Biocontrol agents, dissolved metals, e.g., ampicillins, pseudomonas ssp., trichoderma ssp., streptomyces ssp., are some example of BCA available on the market.

- Seaweed extracts, such as Ascosphaera odonnov and Laminaria digitata. Laminar, extracted from L. digitata, has not a direct bactericidal or fungicidal activity, but enhance plant resistance to pathogens.

- Chitosan, natural polymer obtained from chitin, is reported to be active against a variety of microorganisms, with a good direct activity coupled with stimulation of plant defense mechanisms.

- Herbal preparations (dieses, hirtella, neskład, hoentchel).

ALTERNATIVES TO MINERAL OILS

Mineral oil is occasionally applied in tomatoes. The maximum use is 10-13 litres ha⁻¹ per year as a repellent effect on insects or mites. Alternatives may rely on:

- Organic oils (e.g., from rapeseed)
- Plant defence stimulators
- Diatomaceous earth
- Potassium salts of fatty acids
- Beneficials

ALTERNATIVES TO SULPHUR

Sulphur is applied in organic greenhouses against pests and powdery mildews. Its use can range from 2 kg ha⁻¹ per year to, in the rare and highest case, 55 kg ha⁻¹ per year depending on the production system and the incidence of powdery mildews. It is not selective and has harmful effects on beneficial arthropods. Alternatives, not widely applied for economical reasons, are essentially represented by:

- Maldextrins
- Potassium hydrogen carbonate
- Apamolaces quisquiliaes

Main goals of O’ project related to tomato

Based on 슈리를 발전시켜내는, we all know to the growing behaviours. Formulations alternative to copper will be screened in the lab for their efficacy against pathogens sensitive strains of Botrytis cinerea and powdery mildews. The effective formulations will be checked for persistence of their effect. The best selected alternative will be grown in three representative sites carried out in Mediterranean greenhouses.
WHAT ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN AUBERGINE ORGANIC FARMING?

AUBERGINE

Aubergine is a plant cultivated in southern European countries. Cultivation is practiced both in open fields and in greenhouses, based on the area and the season. The aubergine yield is threatened by fungal and bacterial diseases which limit the productivity in the field and the commercial life of product in post-harvest. Fungi and bacteria (nobody minds, *Phytophthora infestans*, *Botrytis cinerea*, *Verticilllium spp.*, *Rhizoctonia solani*, *Alternaria solani*, *Rhizoctonia solani*) found in the Mediterranean region compromise aubergine production in different producing countries.

In organic aubergine cultivations, pathogens are generally controlled by regular sprays with copper-based products. The demonstrated various effect of copper or soil microbial communities and other soil fauna has led to regulatory restrictions in its use in the EU. The use of copper for crop protection purposes has been permitted in the EU to a maximum amount of 6 kg/ha/yr of copper for the end of 2019 but is now reduced to 4 kg/ha/yr starting from January 2019. According to the data collected by intervening experienced advisors in the first 6 months of this research activity, this limit seems to be respected by Mediterranean aubergine growers. Many alternative compounds to reduce or replace copper amounts are under development, and few are already available on the market, and fewer are currently used by growers to any substantial extent.

Visit our website [www.organic-plus.net](http://www.organic-plus.net)
Follow us on Twitter @OrgPLUSResearch
[Healthльнorway@cowenry.ac.uk](mailto:Healthльнorway@cowenry.ac.uk)
Project manager: [Ulrích.Schmutz@coventry.ac.uk](mailto:Ulrích.Schmutz@coventry.ac.uk)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 775600

ALTERNATIVES TO COPPER

Low copper grade formulations, with reduced copper content (2-4%), allow a smaller amount of copper distributed per hectare.

- "Natural" alternative formulations, applied to replace or reduce copper dosage, used alternatively or in combination with copper. Some of them are included in Annex II to Commission Regulation (EC) 288/2008, permitted for plant protection in organic crop production.
  - Plant extract with biocidal activity and stimulating effects on plant defenses.
  - Inorganic substances: fatty acid and potassium salts, potassium hydrogen carbonate.
  - Biological control agents, with a variety of mechanisms of action against fungal and bacterial pathogens and stimulating effects on plant defenses: *Ampelomyces quisqualis*, *Kocuria rosea*, *Amylomyces rouxii*, *Pseudomonas sp.*, *Trichoderma sp.*

ALTERNATIVES TO MINERAL OILS

Rarely applied in aubergines and only for resistant effect on insects or mites. Alternatives to mineral oils may be:

- Potassium salts of fatty acids
- Plant defence stimulators

ALTERNATIVES TO SULPHUR

Sulphur is applied in organic greenhouses against pests and powdery mildew.

It is not selective, and has harmful effects on beneficial anthropes. Alternatives, not currently applied for economical reasons, are essentially represented by:

- Maldextrins
- *Ampelomyces quisqualis*

Main goal of O project related to aubergine

60 eggplant (*Solanum melongena* L.) landraces will be screened for early blight fungal disease. Seedings of the landraces will be tested for resistance to *Alternaria solani* f.sp. *Solanum* under controlled conditions. After the inoculation step, resistant or moderately resistant entries will be selected.
**T3.3: Generation of additional knowledge required for optimal use of alternatives (M1-20)**

Alternatives work well in the lab but not in the field. Knowledge on the modes of action and interactions between different alternatives is missing. Knowledge gaps are addressed by coupling field trials with mechanistic and ecological investigations of potential key innovations.

**Field and lab trials (M1-20)**

- early & late blight (INRA, SLU): BCAs & PDSs
- *Botrytis c.* & *Fulvia f.* (IFAPA): Alternatives
- *Alternaria s.* (MFAL): evaluation of landraces
- *Cycloconium o./Spilocaea o.* (MFAL-UTH), & *Mycocent. cladosp.* (UTH), *Colletotrichum sp* (IFAPA): BCAs & PDSs
- *Colletotrichum sp* (UNICT): BCAs & PDSs, fertilisers, vegetable extracts, GRAS

D3.3: Evaluation of alternatives (lab and field trials) (M20)
T3.4: *Design of phase-out scenarios* through substitution, combination or plant protection systems redesign (M1-20)

- Simple substitution strategies, combination & complete redesign.
- Determination of the need for specific experimental work.
- Data transfer to MODEL and IMPACT WPs.
- Preventive farm management methods for disease control in greenhouse and open field will be identified and developed.

**Field trials**

- late blight (INRA, SLU): epidemiological simulation model, (AU) evaluation of scenarios for use of alternatives by IPMBlight2.0
- *Botrytis c.*, *Alternaria spp* & *Leveillula t.* (UTH): DSS
- (UNICT): Alternatives to Cu

D3.4a: Design of phase-out scenarios for field evaluation (M20)
D3.4b: Analysis-modeling of disease dynamics in potato blight (M20)
D3.4c: Web-based DSS for disease risk in greenhouses (M20)
Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

**Organic-plus Locations**

**Owner:** Organic, Dimitrios  
**Location:** Velesino organic  
**Serial:** 049H0568

**Organic Plus World**  
**RTU Type:** OpIRS  
**Country:** Greece  
**Status:**

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**Time:** 2019-06-26 17:25:00  
**Crop:** Grapes  
**Substrate:** Other Variety  
**Period Start:** 2019-06-09 18:05:49 (+16 days until the last sensor reading)

- **5** Wind Speed(Km/h)  
- **3.25** VPD OUT(KPa)  
- **31.4** Dew Point OUT(C)  
- **14.9** RTU Temperature(C)  
- **11.3**

**Temperature OUT**  
**Humidity OUT**  
**Solar Radiation OUT**  
**Solar Radiation IN**  
**Pressure IN-UP**  
**Temperature IN-DN**  
**Hum**
T3.5: Field evaluation of system solution scenarios to foster the application of available alternatives based on best practice examples (M7-43)

Field evaluation
- system approach: across EU with focus on North
- across EU with focus on South
- Mediterranean

D3.5: Field evaluation of system solution scenarios (M48)
**T3.6: Evaluation of the acceptance of alternative solutions and barriers to further reduction of contentious inputs (M13-46)**

**T3.7: Stakeholder interaction and dissemination (M13-46)**

- 10 workshops with growers, advisors and policy makers in: Volos-Greece (UTH), Catania-Italy (UNC), Almeria and Cordoba-Spain (IFAPA), Angers-France (INRA), Izmir-Turkey (MFAL);
- 8 open field days for growers and advisors in the field trials in: Volos-Greece (UTH), Catania-Italy (UNC), Almeria and Cordoba-Spain (IFAPA), Izmir-Turkey (MFAL);
- 6 publications in high-ranking peer-reviewed by: UTH, INRA, SLU, IFAPA, UNC, MFAL;
- 12 presentations in international conferences;
- Stakeholder briefing papers (7); project leaflets; press releases; and other

D3.6a: Evaluation of alternatives and design of complete systems. Cost/benefit analysis (M46)
D3.6b: Barriers to further reduction of inputs (M46)
D3.7: 3 set of factsheets for stakeholders and dissemination (M30 & M46)
Thank you for your attention