Organic-PLUS workshop, NORSØK

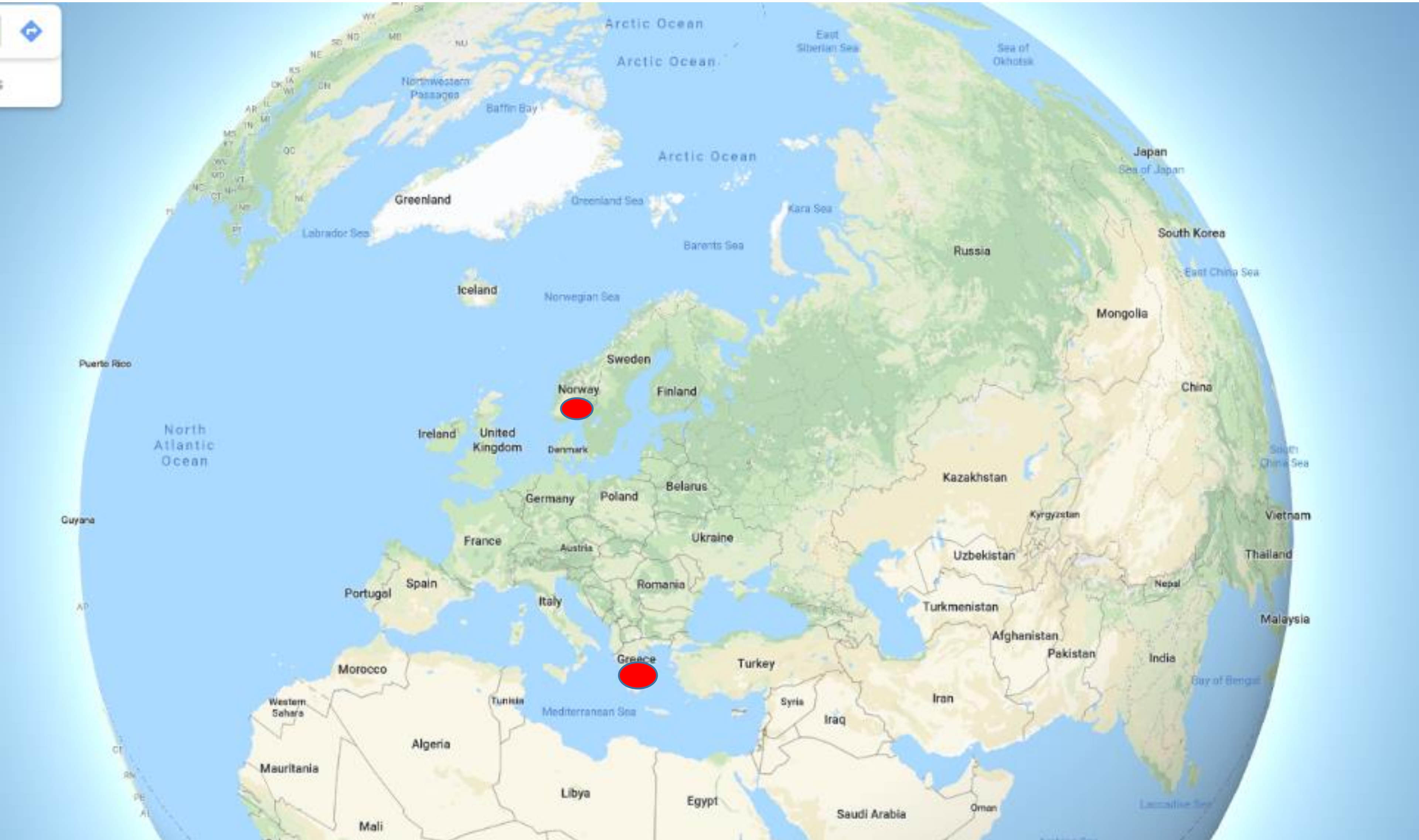
Organic growing in greenhouses under Mediterranean conditions – use of contentious inputs and ways to phase them out

Nikolaos Katsoulas

Associate Professor

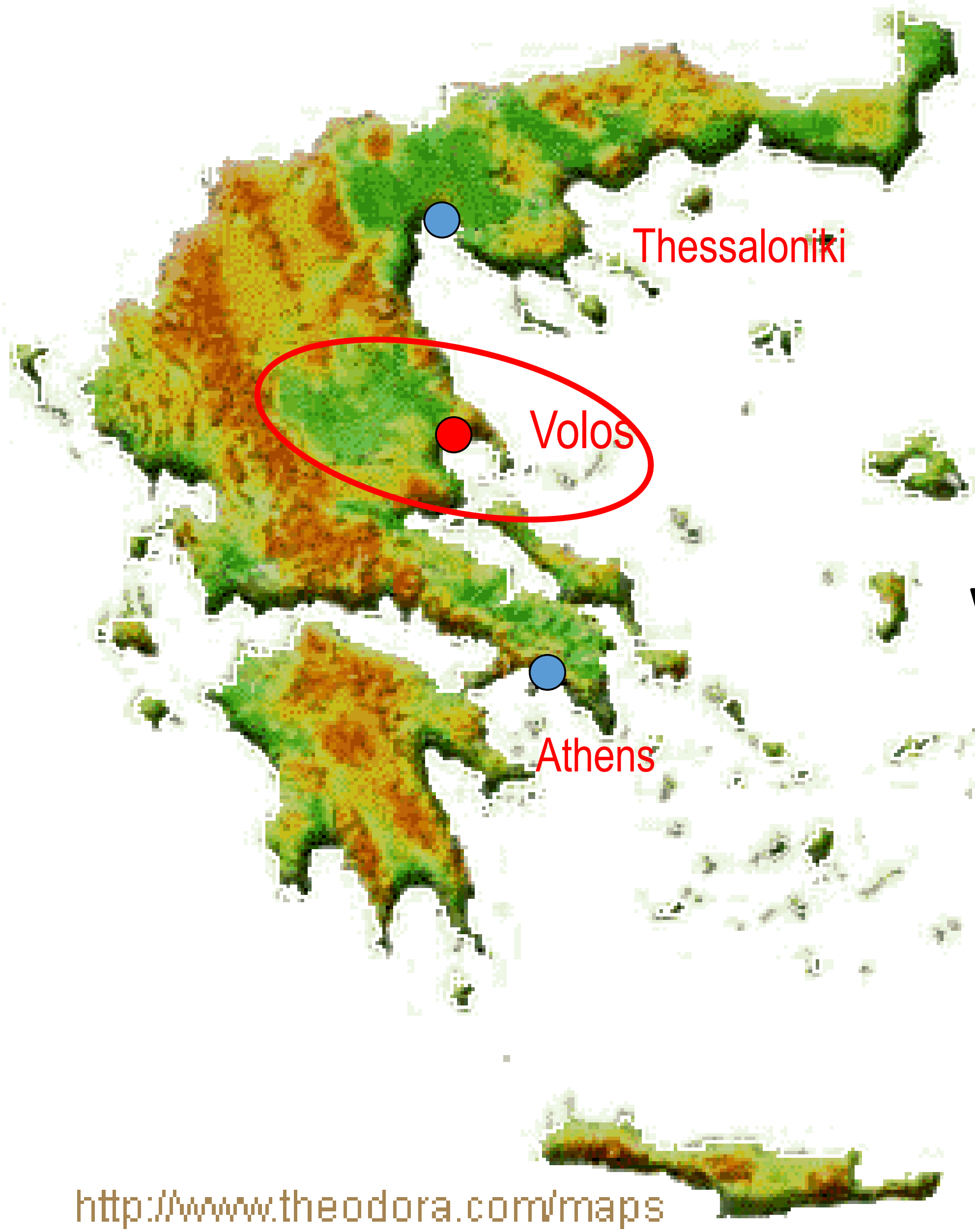
UNIVERSITY OF THESSALY

Fokhol gård, Stange, October 28-29, 2019


Arctic Ocean
East Siberian Sea
Sea of Okhotsk
Arctic Ocean
Northwestern Passages
Baffin Bay
Arctic Ocean
Japan
Sea of Japan
Greenland
Greenland Sea
Kara Sea
Labrador Sea
Barents Sea
Russia
South Korea
East China Sea
Iceland
Norwegian Sea
Mongolia
Puerto Rico
Sweden
Norway
Finland
China
North Atlantic Ocean
Ireland
United Kingdom
Denmark
South China Sea
Kazakhstan
Belarus
Germany
Poland
Guyana
Kyrgyzstan
Vietnam
France
Austria
Ukraine
Uzbekistan
Thailand
Spain
Portugal
Italy
Romania
Nepal
Turkmenistan
Malaysia
Afghanistan
Pakistan
Greece
Turkey
India
Morocco
Bay of Bengal
Western Sahara
Tunisia
Syria
Iran
Mediterranean Sea
Iraq
Algeria
Mauritania
Libya
Egypt
Saudi Arabia
Oman
Mali
Arabian Sea
Guinea


Iceland
Norwegian Sea
Sweden
Norway
Finland
Estonia
Baltic Sea
North Sea
United Kingdom
Ireland
Denmark
Latvia
Lithuania
Moscow
Москва
North Atlantic Ocean
London
Netherlands
Poland
Belarus
Kazakhstan
Belgium
Germany
Paris
Prague
Czechia
France
Vienna
Austria
Slovakia
Ukraine
Moldova
Hungary
Uzbekistan
Portugal
Madrid
Spain
Barcelona
Croatia
Romania
Serbia
Italy
Rome
Black Sea
Georgia
Caspian Sea
Turkmenistan
Azerbaijan
Bulgaria
Tyrrhenian Sea
Istanbul
Greece
Turkey
Morocco
Tunisia
Mediterranean Sea
Syria
Iran
Western Sahara
Lebanon
Iraq
Algeria
Israel
Jordan
Novosibirsk
Nur-Sultan
Нур-Султан

Where we are….



Latitude: 39.22

Longitude: 22.44

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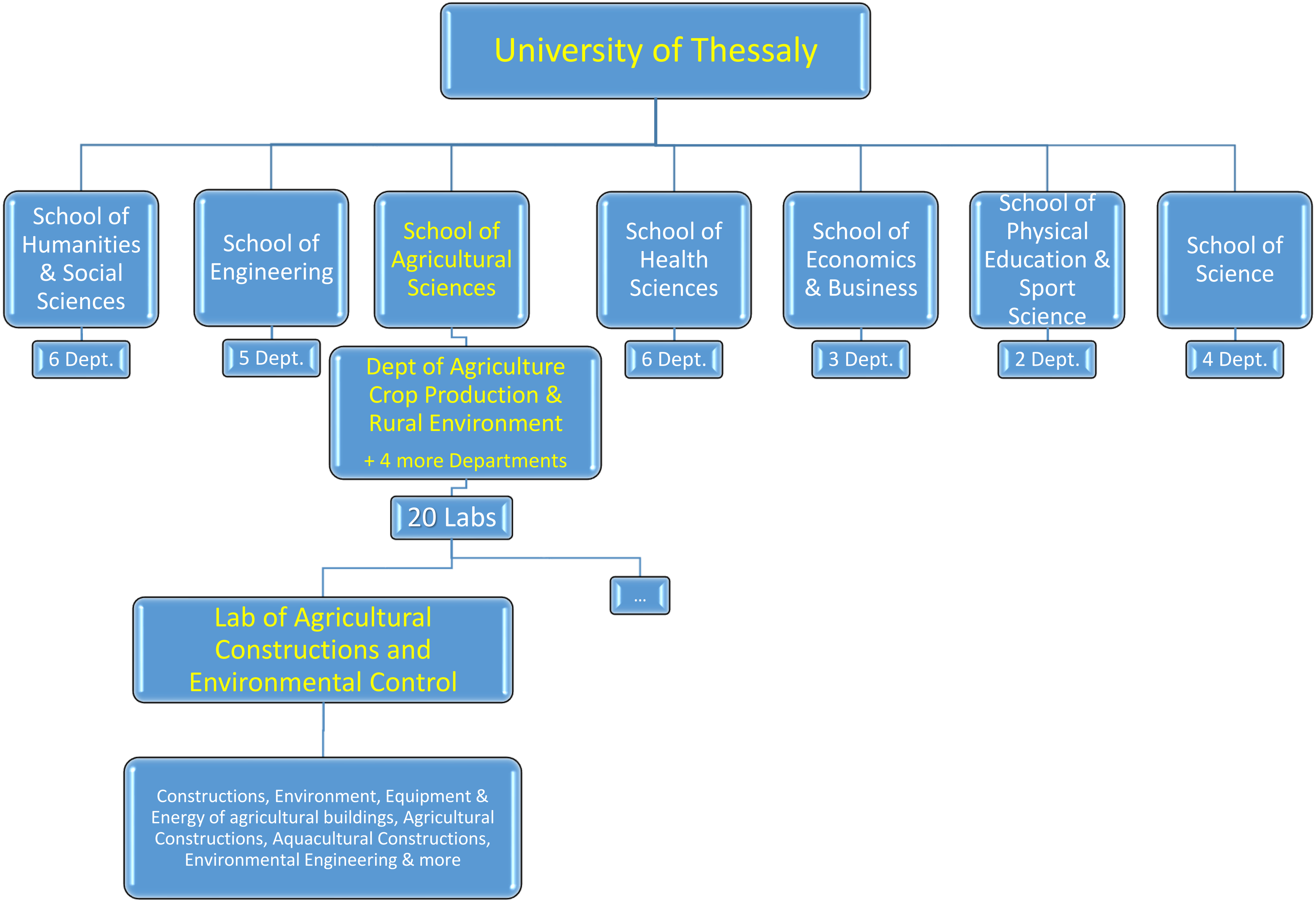
Presentation


University of Thessaly
School of Humanities & Social Sciences
6 Dept.
School of Engineering
5 Dept.
School of Agricultural Sciences
Dept of Agriculture Crop Production & Rural Environment
+ 4 more Departments
20 Labs
Lab of Agricultural Constructions and Environmental Control
Constructions, Environment, Equipment & Energy of agricultural buildings, Agricultural Constructions, Aquacultural Constructions, Environmental Engineering & more
...
School of Health Sciences
6 Dept.
School of Economics & Business
3 Dept.
School of Physical Education & Sport Science
2 Dept.
School of Science
4 Dept.

Lab of Agricultural Constructions and Environmental Control

Team presentation

UNIVERSITY OF THESSALY

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Department of Agriculture Crop Production & Rural Environment,

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MSc S. Bouras

MSc G. Miliokas

MSc P. Xiradakis

MSc st. S. Faliaga

BSc E. Armyra (Secretary)

and

several BSc students

Collaboraors:

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Dr. D. Antoniadis

Dr. D. Papanastasiou

Dr. D. Feidaros

Dr. A. Baxevanou

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)

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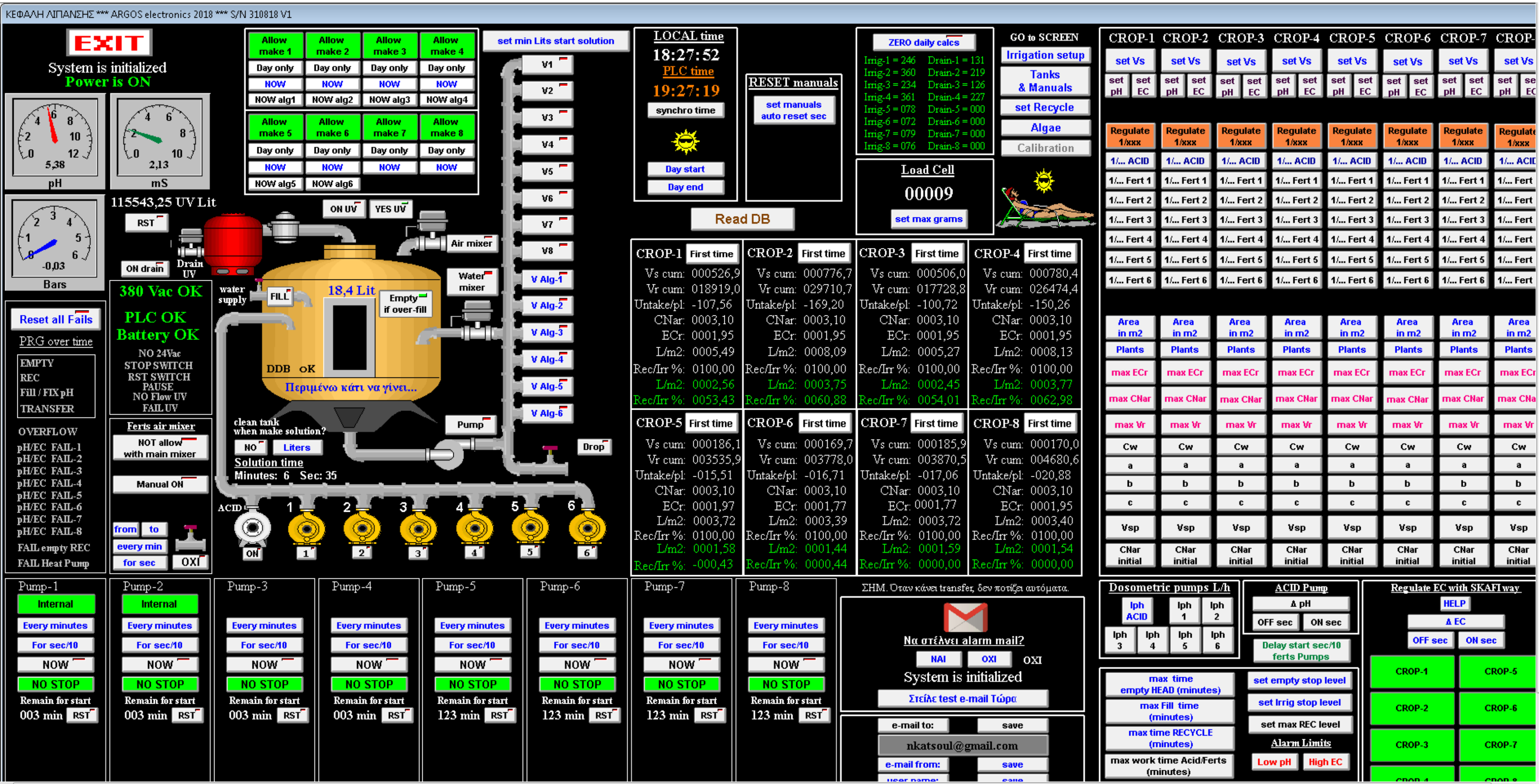
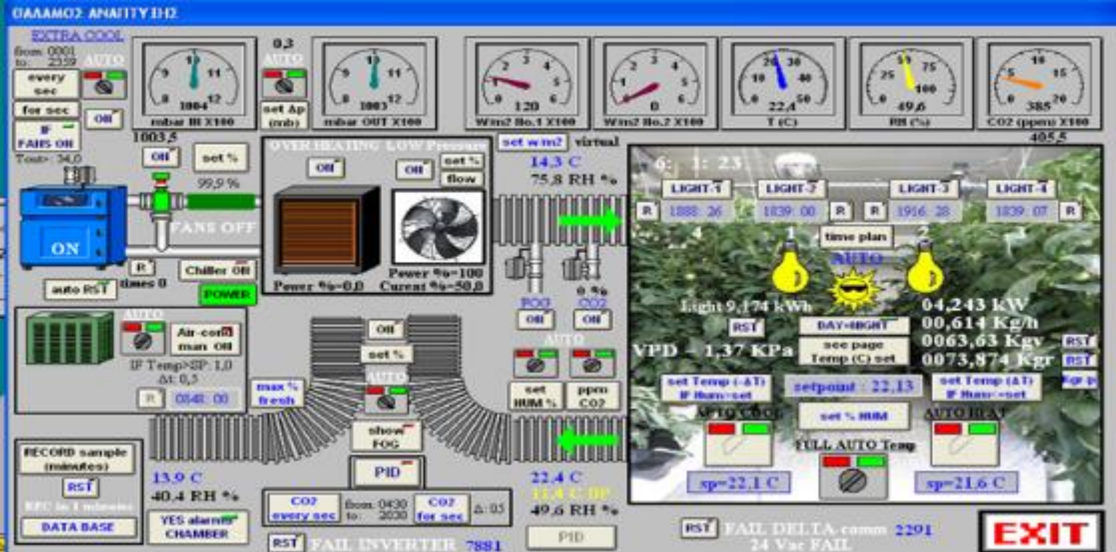
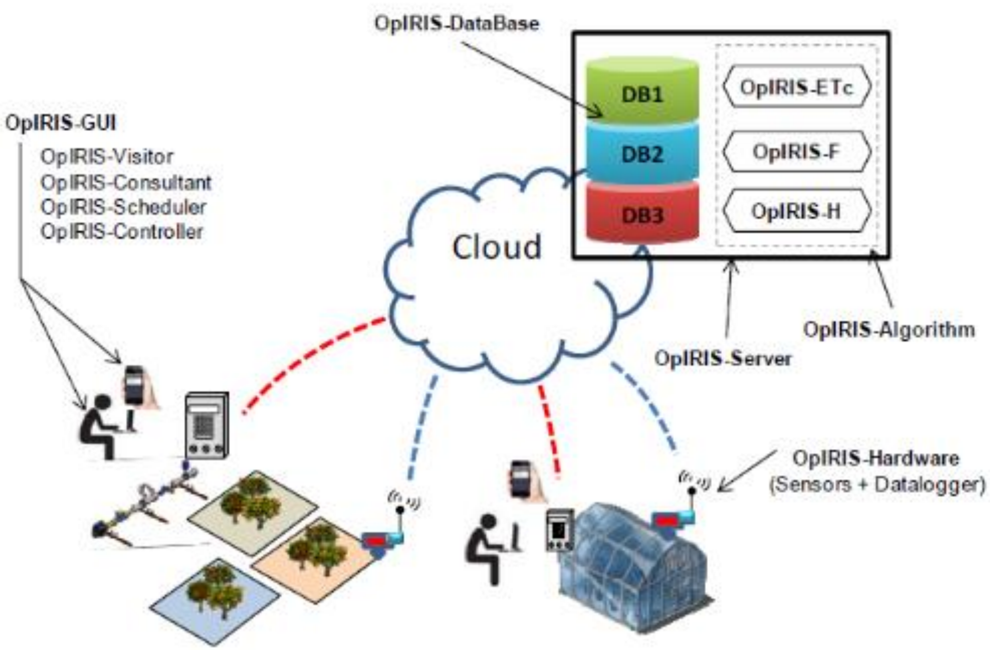
grodan Classic

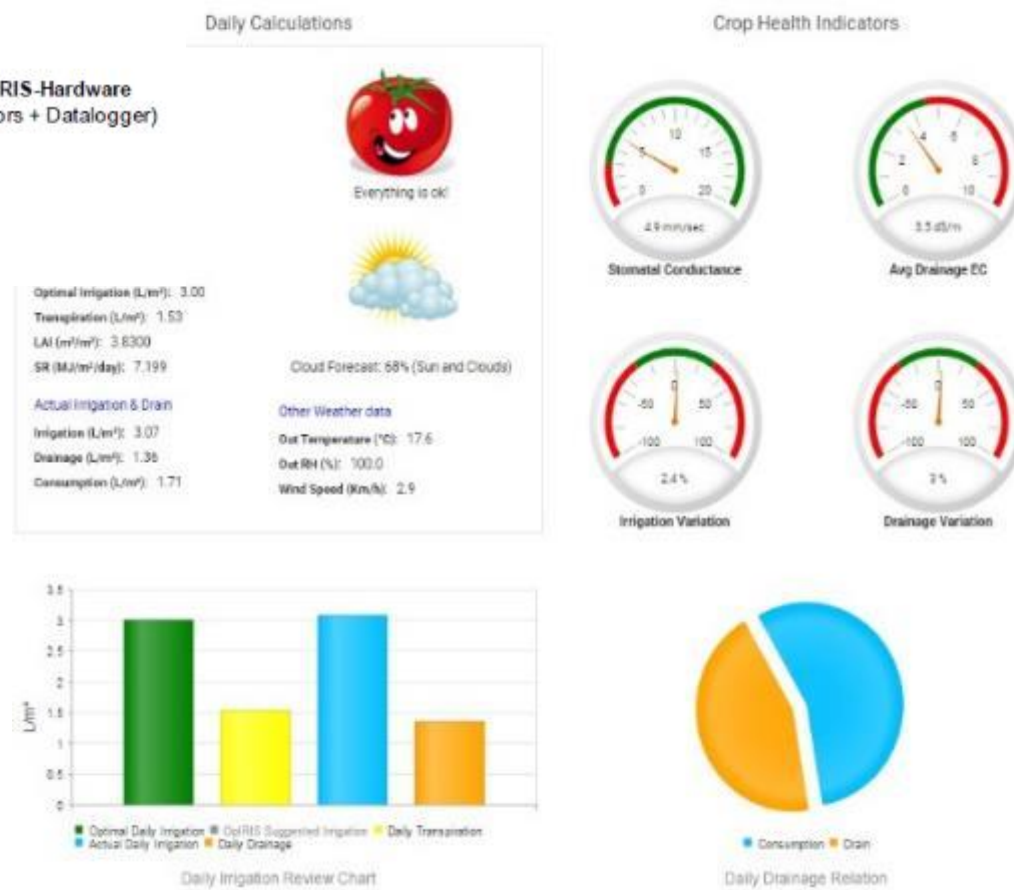

ΚΕΦΑΛΗ ΛΙΠΑΝΣΗΣ *** ARGOS electronics 2018 *** S/N 310818 V1
EXIT
System is initialized
Power is ON
pH
5,38
mS
2,13
Bars
-0,03
115543,25 UV Lit
RST
ON drain
Drain UV
380 Vac OK
PLC OK
Battery OK
NO 24Vac
STOP SWITCH
RST SWITCH
PAUSE
NO Flow UV
FAIL UV
Reset all Fails
PRG over time
EMPTY
REC
Fill / FIX pH
TRANSFER
OVERFLOW
pH/EC FAIL-1
pH/EC FAIL-2
pH/EC FAIL-3
pH/EC FAIL-4
pH/EC FAIL-5
pH/EC FAIL-6
pH/EC FAIL-7
pH/EC FAIL-8
FAIL empty REC
FAIL Heat Pump
Ferts air mixer
NOT allow with main mixer
Manual ON
from
to
every min
for sec
OXI
Allow make 1
Allow make 2
Allow make 3
Allow make 4
Day only
NOW
NOW alg1
NOW alg2
NOW alg3
NOW alg4
Allow make 5
Allow make 6
Allow make 7
Allow make 8
NOW alg5
NOW alg6
ON UV
YES UV
Air mixer
Water mixer
water supply
FILL
18,4 Lit
Empty if over-fill
DDB OK
Περιμένω κάτι να γίνει...
clean tank when make solution?
NO
Liters
Solution time
Minutes: 6 Sec: 35
Pump
Drop
ACID
ON
set min Lits start solution
V1
V2
V3
V4
V5
V6
V7
V8
V Alg-1
V Alg-2
V Alg-3
V Alg-4
V Alg-5
V Alg-6
LOCAL time
18:27:52
PLC time
19:27:19
synchro time
Day start
Day end
RESET manuals
set manuals auto reset sec
Read DB
ZERO daily calcs
Irrig-1 = 246 Drain-1 = 131
Irrig-2 = 360 Drain-2 = 219
Irrig-3 = 234 Drain-3 = 126
Irrig-4 = 361 Drain-4 = 227
Irrig-5 = 078 Drain-5 = 000
Irrig-6 = 072 Drain-6 = 000
Irrig-7 = 079 Drain-7 = 000
Irrig-8 = 076 Drain-8 = 000
Load Cell
00009
set max grams
GO to SCREEN
Irrigation setup
Tanks & Manuals
set Recycle
Algae
Calibration
CROP-1 First time
Vs cum: 000526,9
Vr cum: 018919,0
Untake/pl: -107,56
CNar: 0003,10
ECr: 0001,95
L/m2: 0005,49
Rec/Irr %: 0100,00
L/m2: 0002,56
Rec/Irr %: 0053,43
CROP-2 First time
Vs cum: 000776,7
Vr cum: 029710,7
Untake/pl: -169,20
CNar: 0003,10
ECr: 0001,95
L/m2: 0008,09
Rec/Irr %: 0100,00
L/m2: 0003,75
Rec/Irr %: 0060,88
CROP-3 First time
Vs cum: 000506,0
Vr cum: 017728,8
Untake/pl: -100,72
CNar: 0003,10
ECr: 0001,95
L/m2: 0005,27
Rec/Irr %: 0100,00
L/m2: 0002,45
Rec/Irr %: 0054,01
CROP-4 First time
Vs cum: 000780,4
Vr cum: 026474,4
Untake/pl: -150,26
CNar: 0003,10
ECr: 0001,95
L/m2: 0008,13
Rec/Irr %: 0100,00
L/m2: 0003,77
Rec/Irr %: 0062,98
CROP-5 First time
Vs cum: 000186,1
Vr cum: 003535,9
Untake/pl: -015,51
CNar: 0003,10
ECr: 0001,97
L/m2: 0003,72
Rec/Irr %: 0100,00
L/m2: 0001,58
Rec/Irr %: -000,43
CROP-6 First time
Vs cum: 000169,7
Vr cum: 003778,0
Untake/pl: -016,71
CNar: 0003,10
ECr: 0001,77
L/m2: 0003,39
Rec/Irr %: 0100,00
L/m2: 0001,44
Rec/Irr %: 0000,44
CROP-7 First time
Vs cum: 000185,9
Vr cum: 003870,5
Untake/pl: -017,06
CNar: 0003,10
ECr: 0001,77
L/m2: 0003,72
Rec/Irr %: 0100,00
L/m2: 0001,59
Rec/Irr %: 0000,00
CROP-8 First time
Vs cum: 000170,0
Vr cum: 004680,6
Untake/pl: -020,88
CNar: 0003,10
ECr: 0001,95
L/m2: 0003,40
Rec/Irr %: 0100,00
L/m2: 0001,54
Rec/Irr %: 0000,00
CROP-1 CROP-2 CROP-3 CROP-4 CROP-5 CROP-6 CROP-7
set Vs
set pH
set EC
Regulate 1/xxx
1/... ACID
1/... Fert 1
1/... Fert 2
1/... Fert 3
1/... Fert 4
1/... Fert 5
1/... Fert 6
Area in m2
Plants
max ECr
max CNar
max Vr
Cw
a
b
c
Vsp
CNar initial
Pump-1
Internal
Every minutes
For sec/10
NOW
NO STOP
Remain for start
003 min RST
Pump-2
Pump-3
Pump-4
Pump-5
123 min RST
Pump-6
Pump-7
Pump-8
ΣΗΜ. Όταν κάνει transfer, δεν ποτίζει αυτόματα.
Να στέλνει alarm mail?
NAI
OXI
System is initialized
Στείλε test e-mail Τώρα
e-mail to:
save
nkatsoul@gmail.com
e-mail from:
Dosometric pumps L/h
Iph ACID
Iph 1
Iph 2
Iph 3
Iph 4
Iph 5
Iph 6
ACID Pump
Δ pH
OFF sec
ON sec
Delay start sec/10 ferts Pumps
max time empty HEAD (minutes)
max Fill time (minutes)
max time RECYCLE (minutes)
max work time Acid/Ferts (minutes)
set empty stop level
set Irrig stop level
set max REC level
Alarm Limits
Low pH
High EC
Regulate EC with SKAFI way
HELP
Δ EC
CROP-1
CROP-5
CROP-2
CROP-6
CROP-3
CROP-7

Controlled environment growth chamber



Rational use of water resources





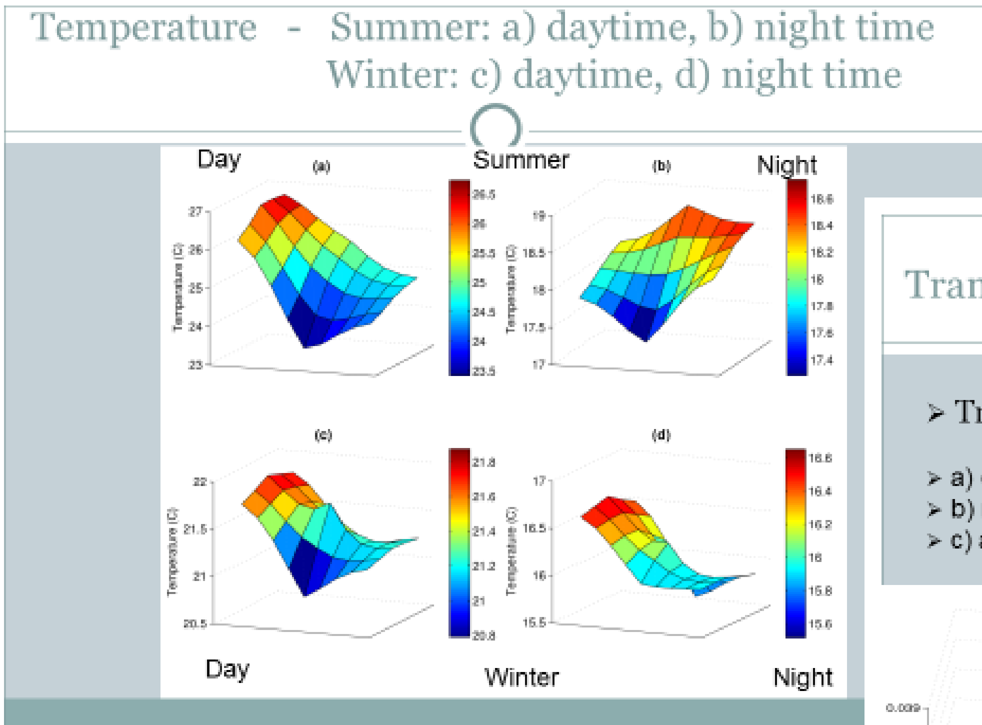
Wirelles Systems

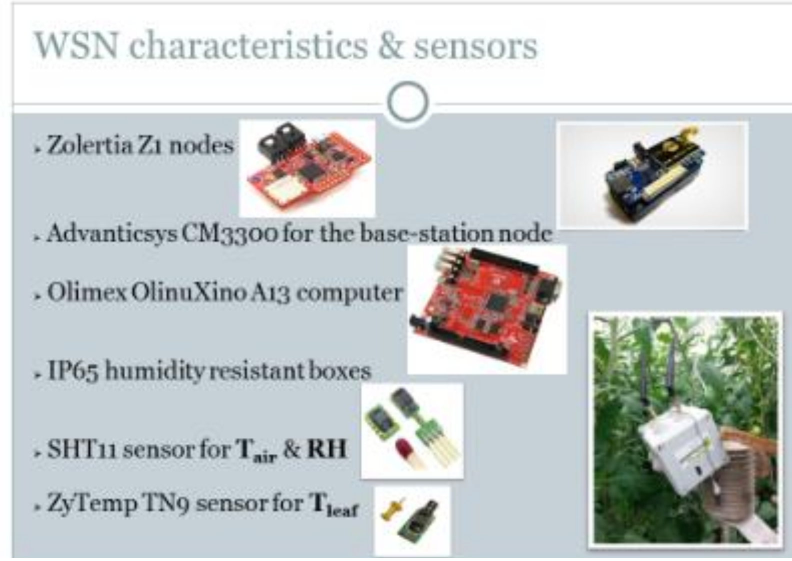
Air temp and relative humidity

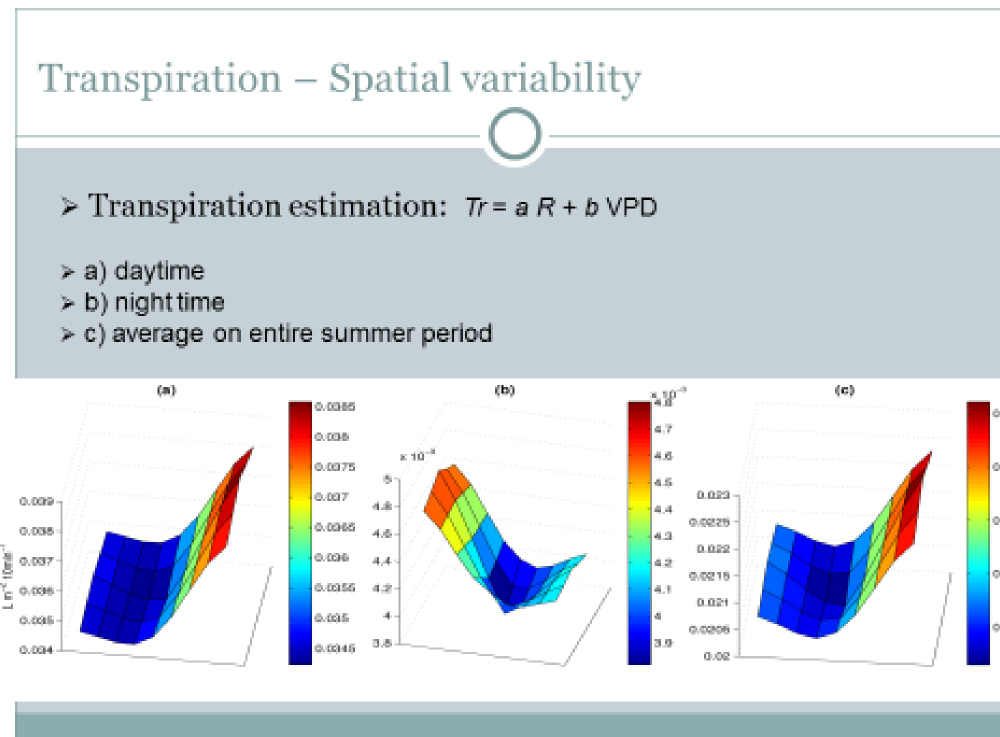
Leaf temperature

GreenSense

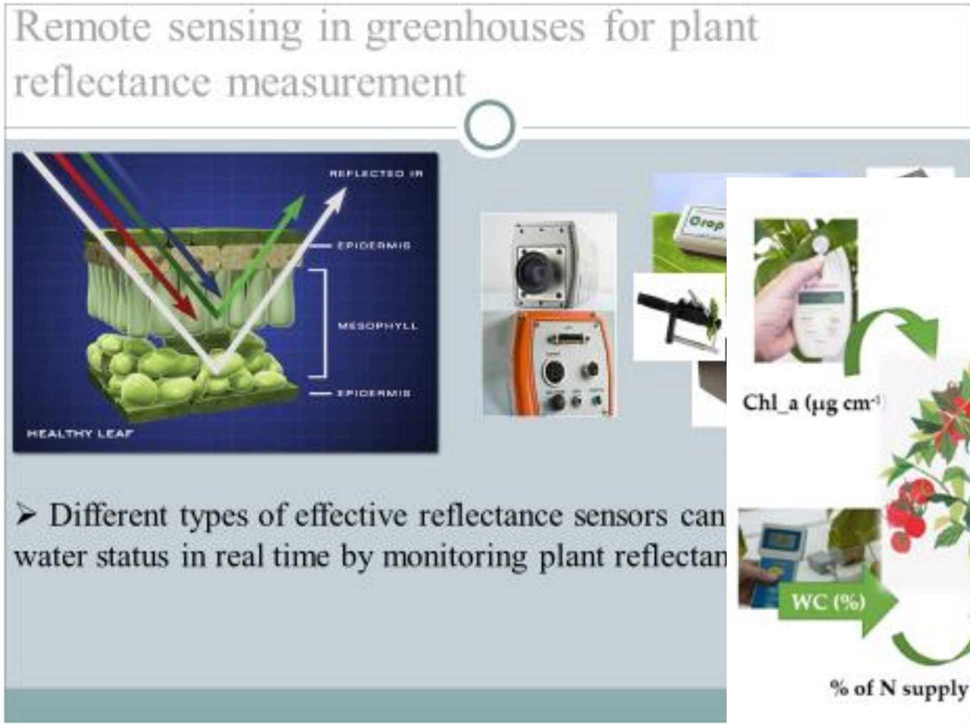
Spatially distributed greenhouse climate control based on wireless sensor network measurements

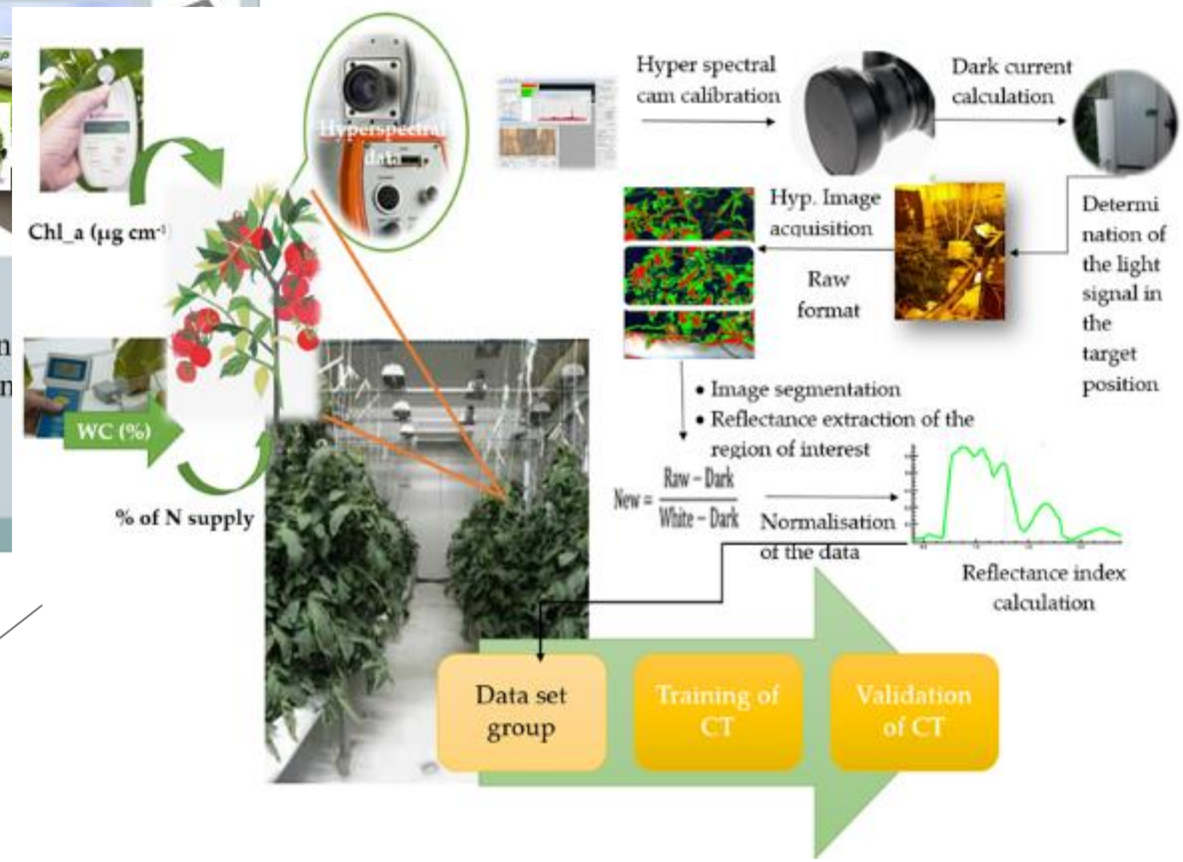


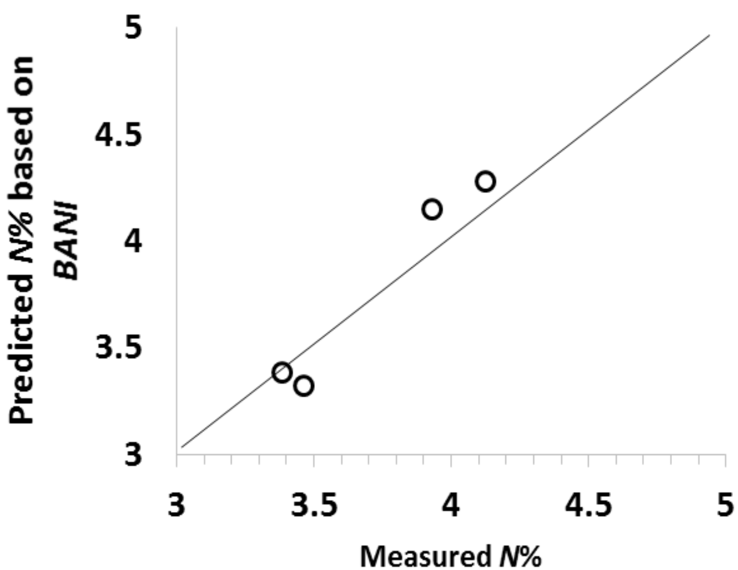




GreenSense Reflectance and temperature indices for ... ıt







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)

Co-financed by Greece and the European Union

- CasH (Greece-Germany)

http://cascade-hydroponics.eu/

- AgriTexSil (Greece-Germany) http://www.agritexsil.eu/

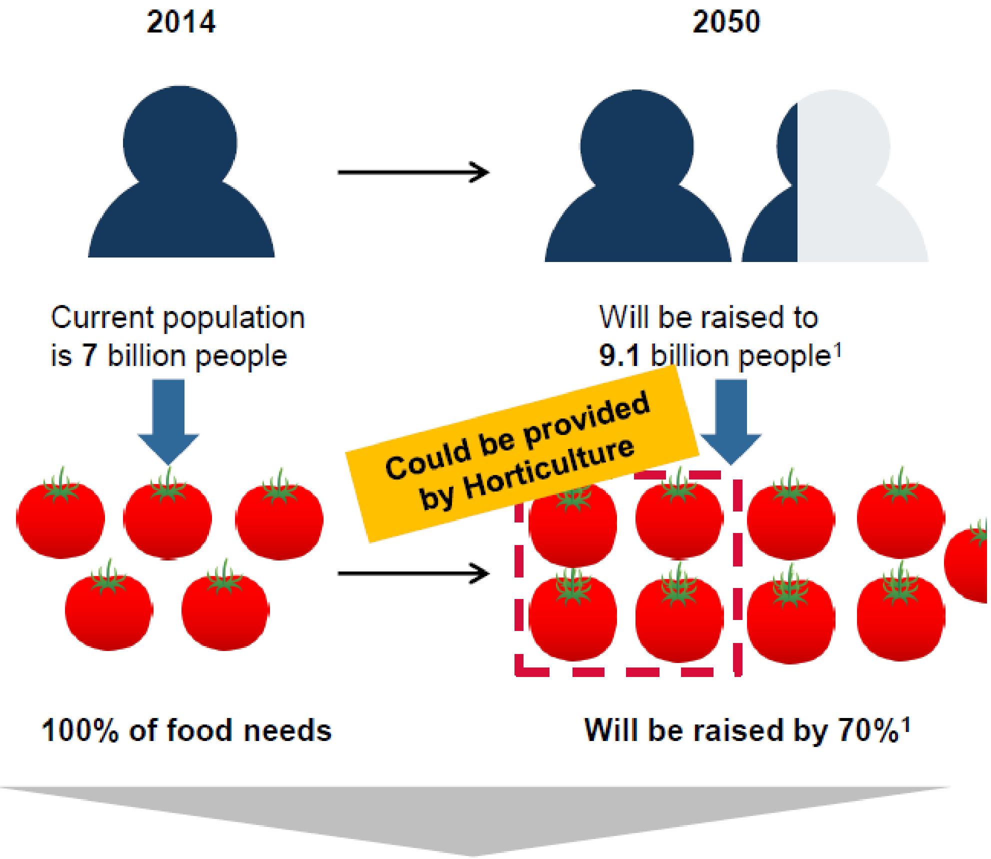
Co-financed by Greece and the European Union

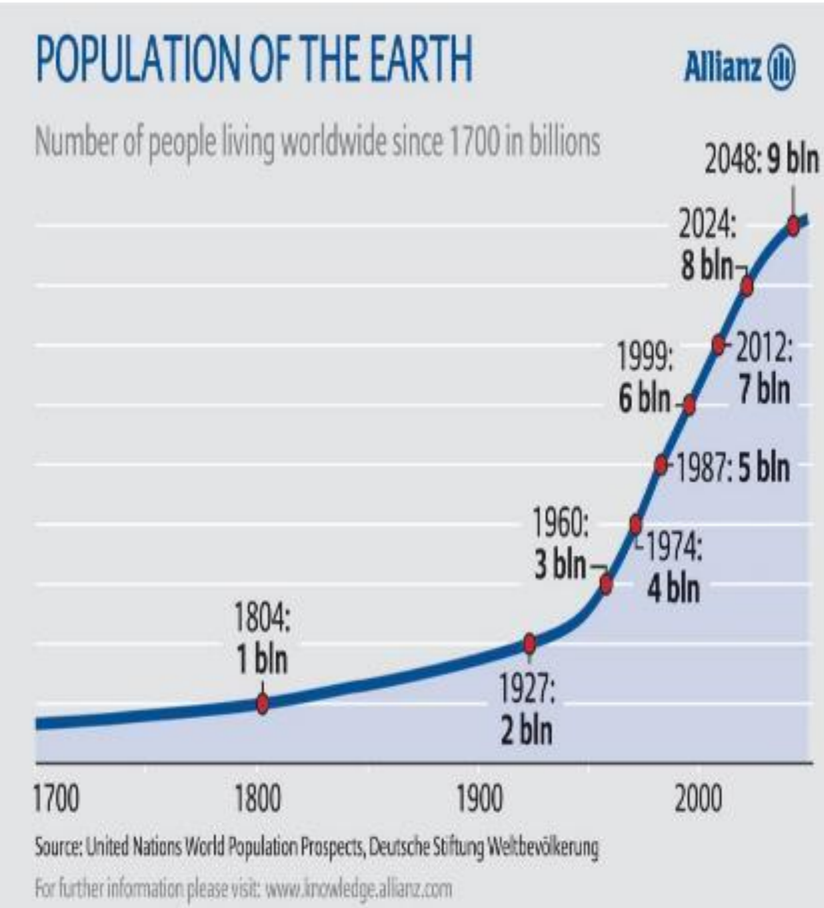
Greenhouses: why?

How to increase circularity in horticulture?

Need for higher productivity

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

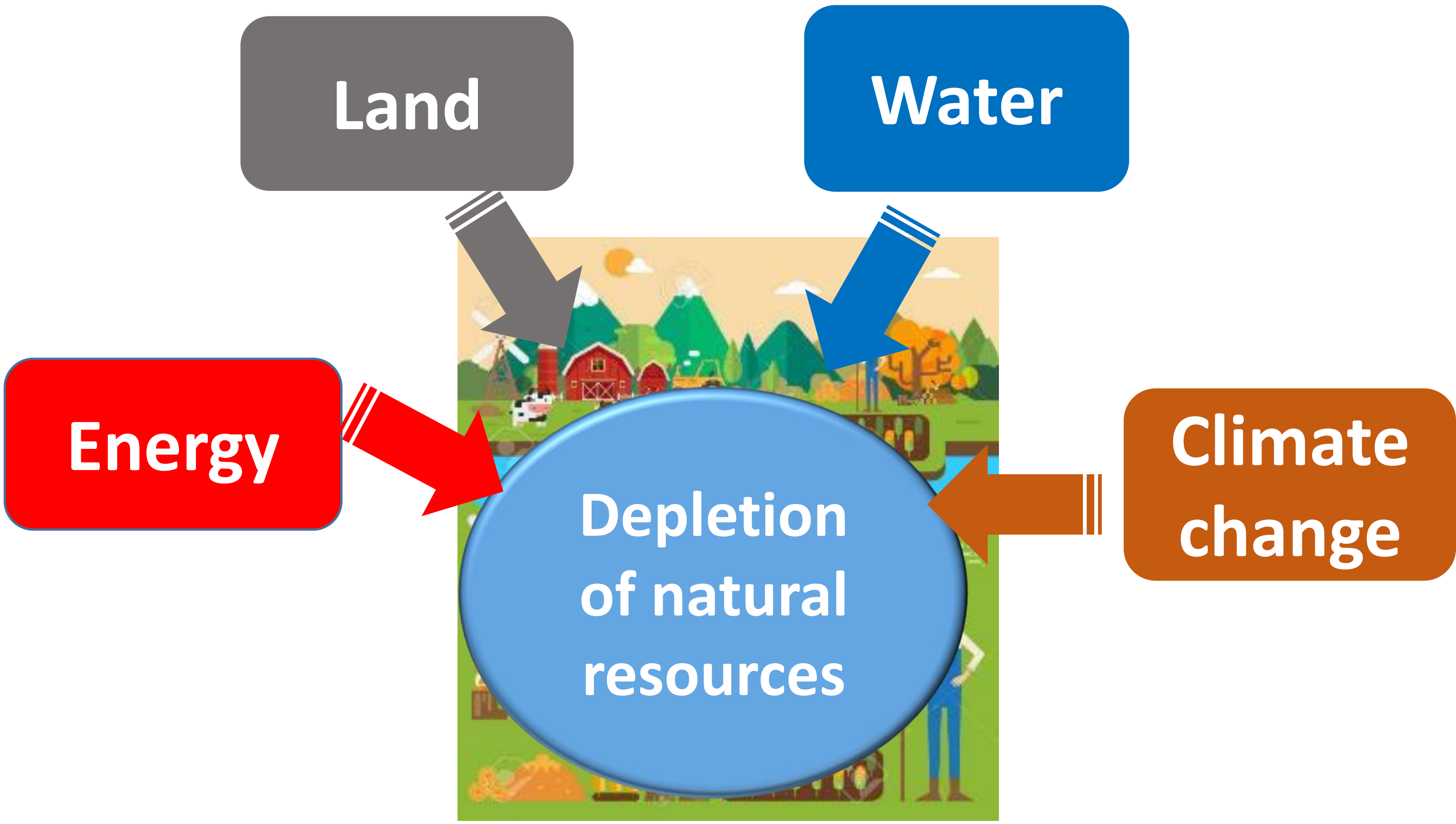




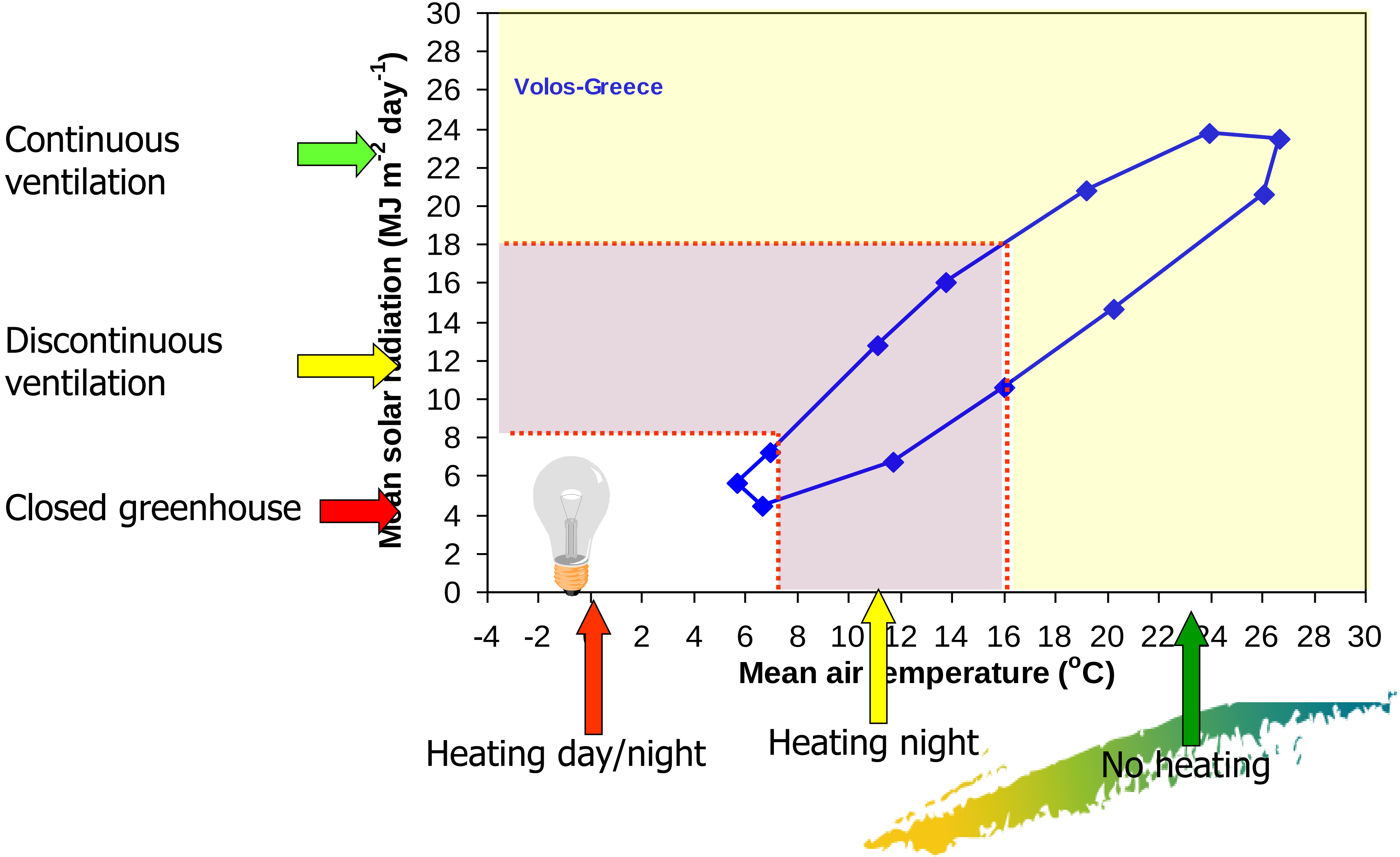
- Rise in food needs by 2050 will be disproportionate to the rise of world population.

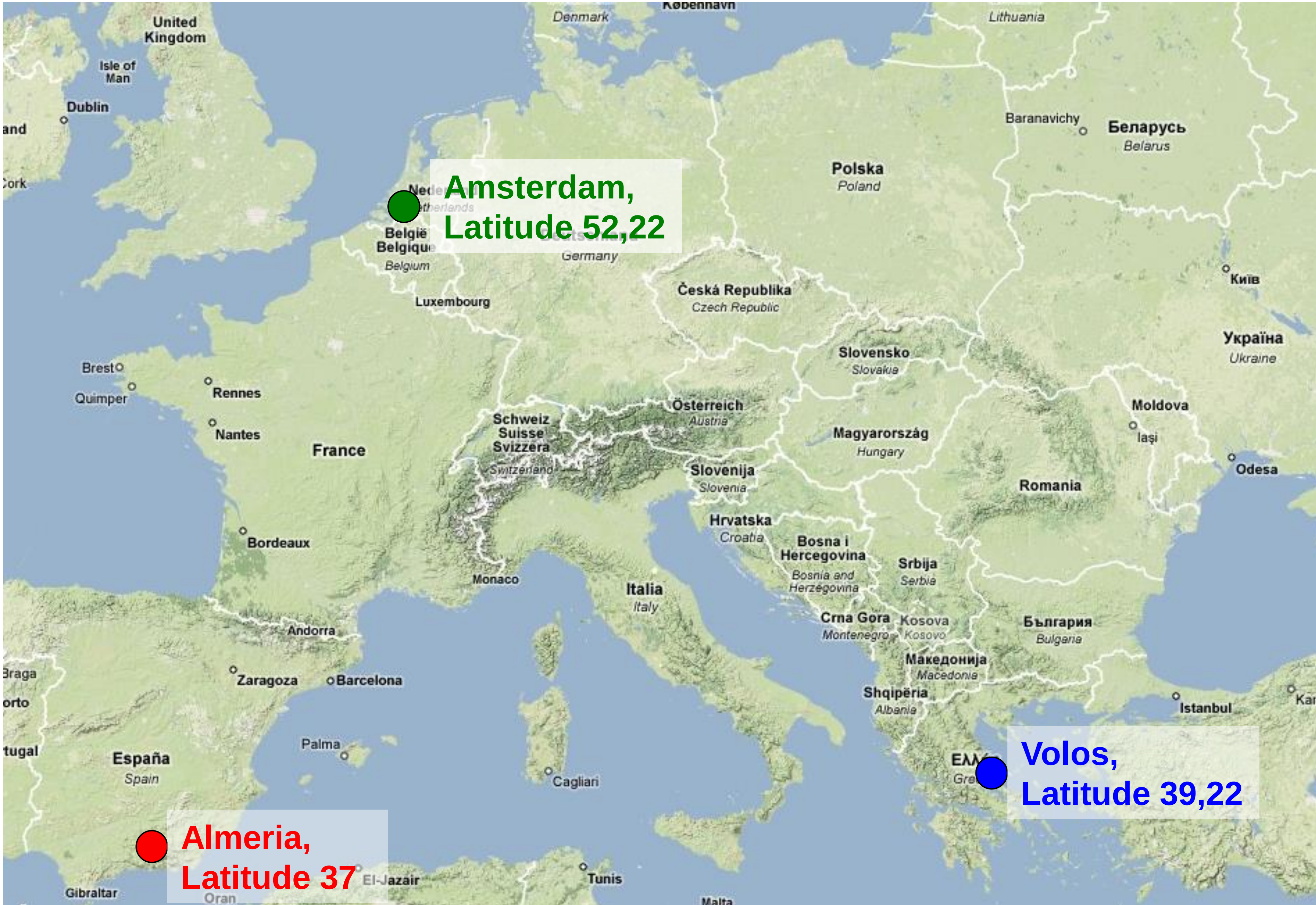
1. Food and Agriculture Organization of the United Nations (hereinafter FAO)
2. United Nations
3. International Horticultural Congress

Need for Circularity in Horticulture



Regional suitability-needs



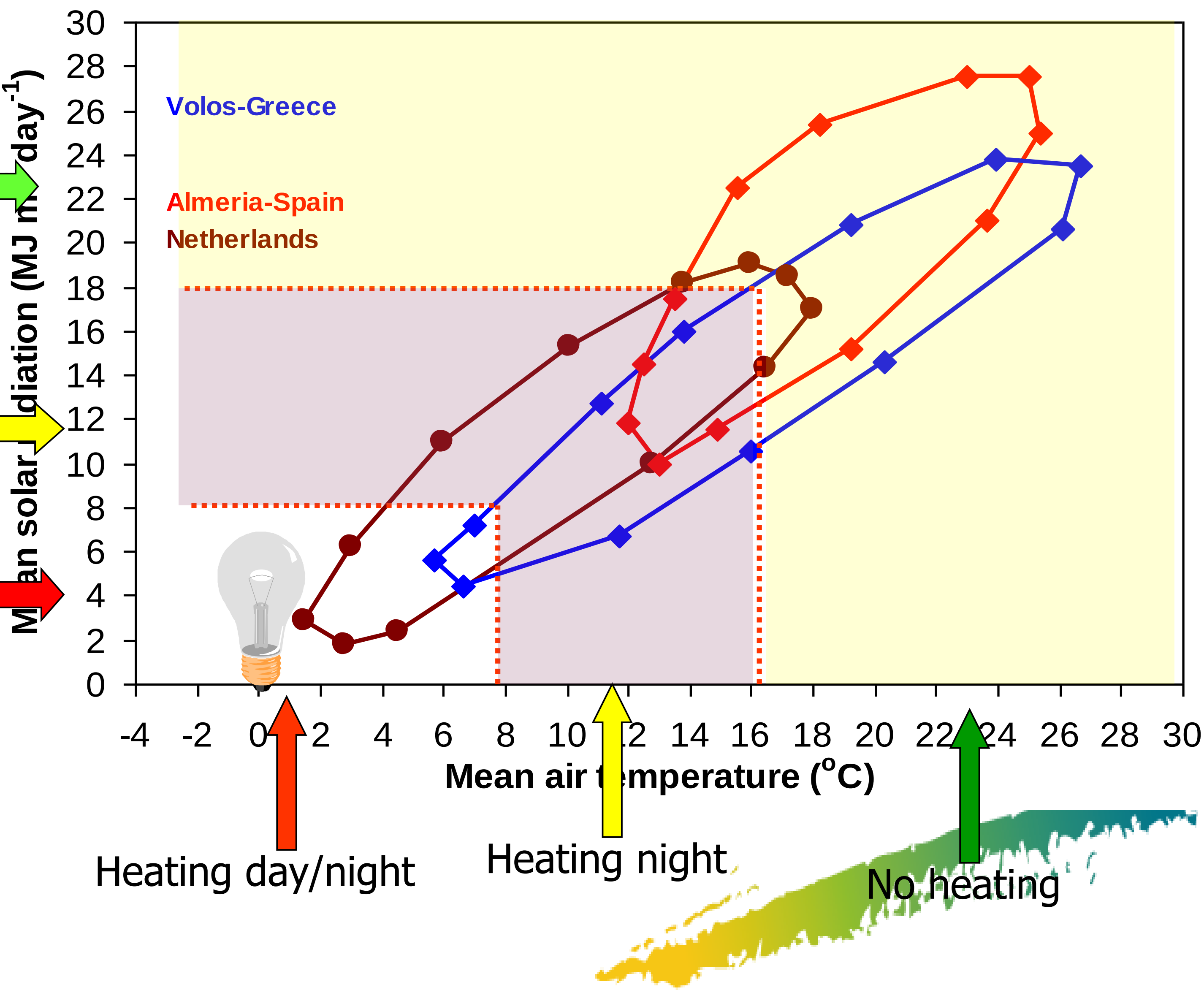

Amsterdam,
Latitude 52,22
Volos,
Latitude 39,22
Almeria,
Latitude 37

Regional suitability-needs

Continuous ventilation

Discontinuous ventilation

Closed greenhouse



Heating day/night

Heating night

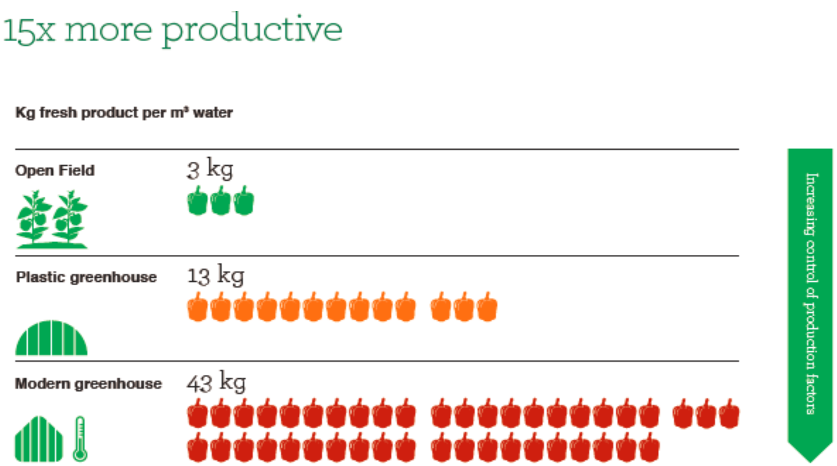
No heating

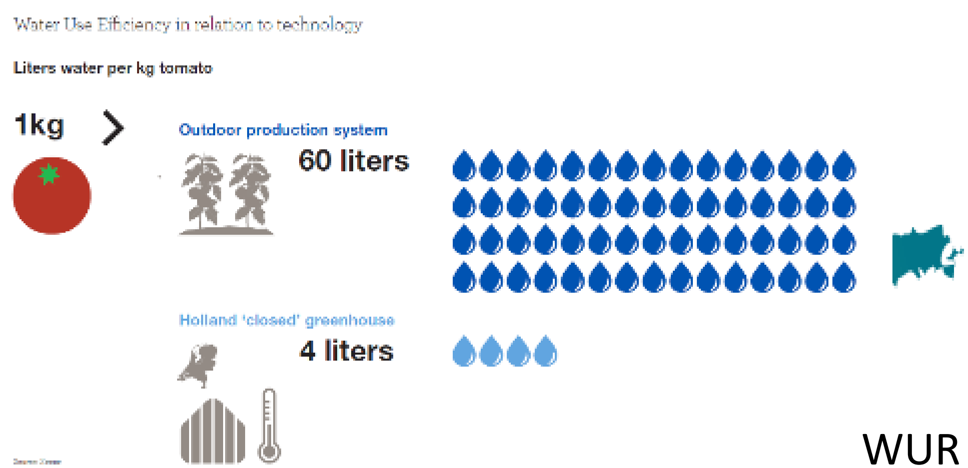
Protected cultivation: why?

- 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; CO_2
  - Irrigation and fertilization
  - Pests and fungi

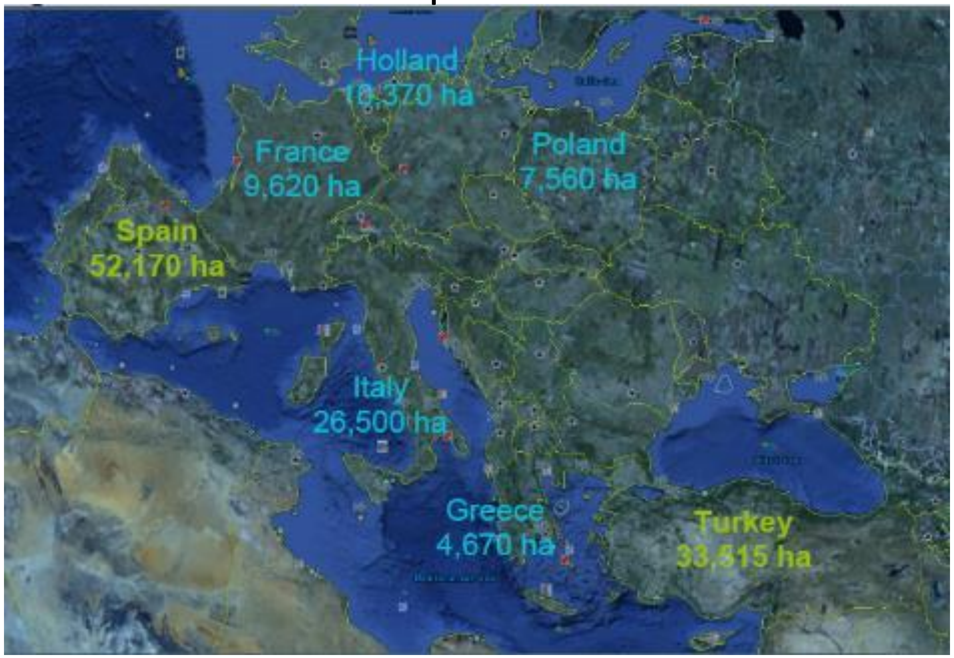




WUR

Worldwide greenhouse areas

Europe



North America

Asia

Top 5 Countries by Area (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

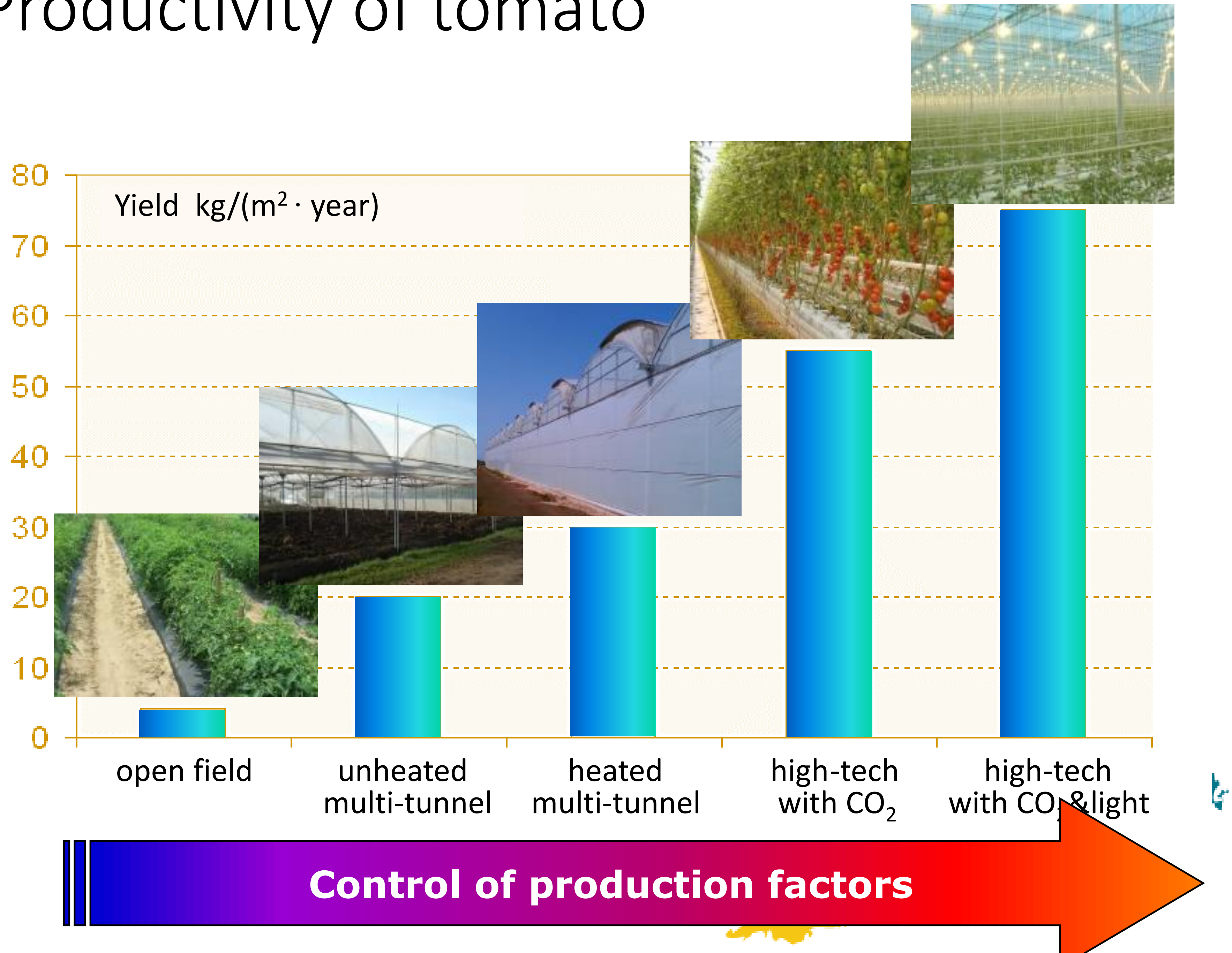
	Netherlands (Venlo)	Spain (Multitunnel)
Production (kg/m^2)	55	16
Value (€/kg)	0.93	0.65
Gross income (€/m^2)	51.15	10.40

Affected mainly by product value

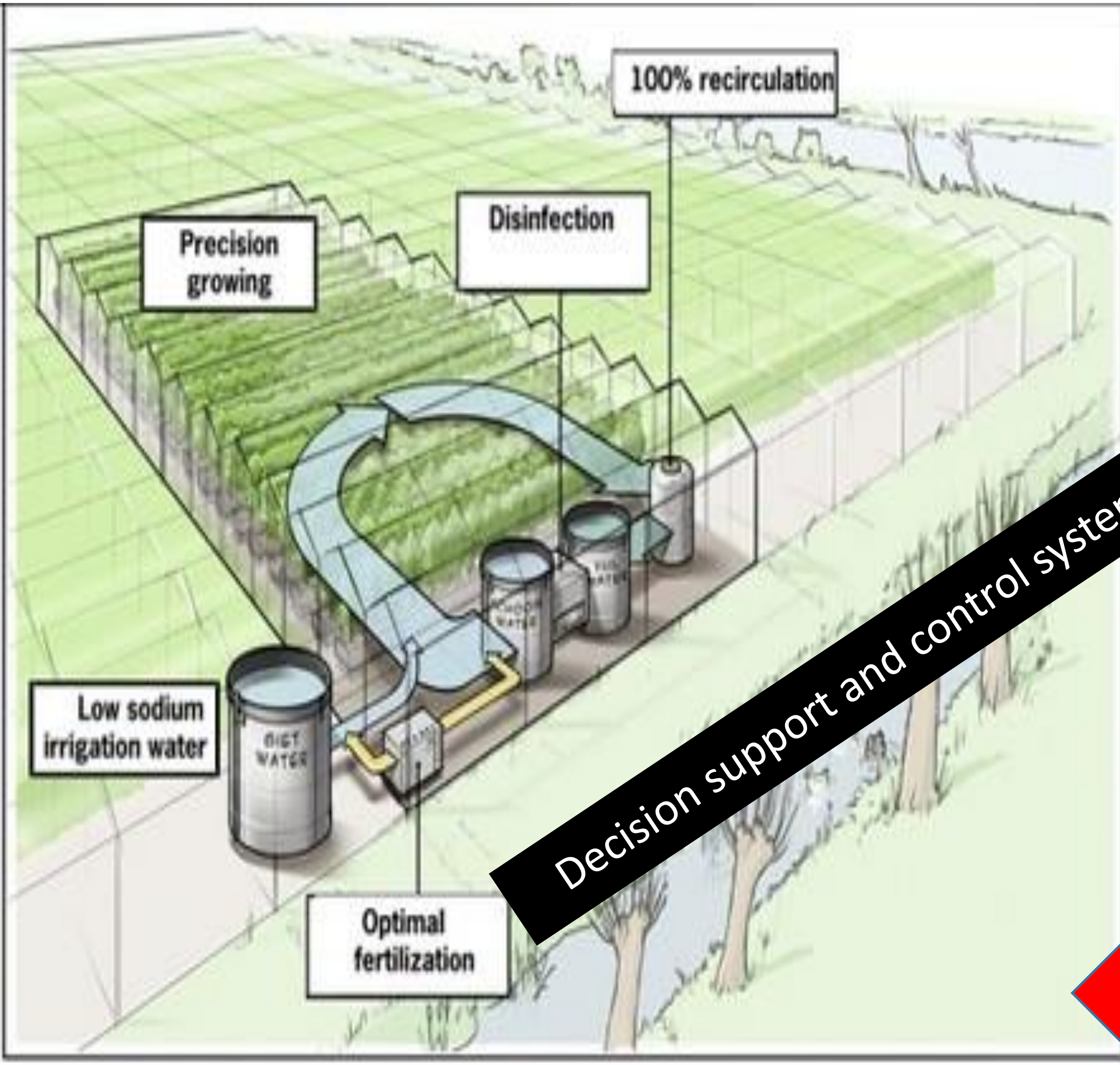
Affected mainly by outside climate

(Vanthoor et al., 2011)

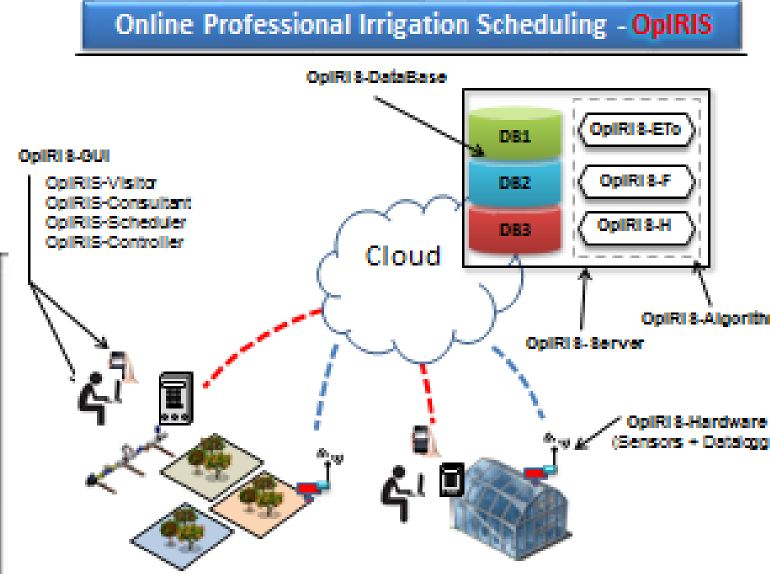
Productivity of tomato



Water and nutrients circularity in greenhouses



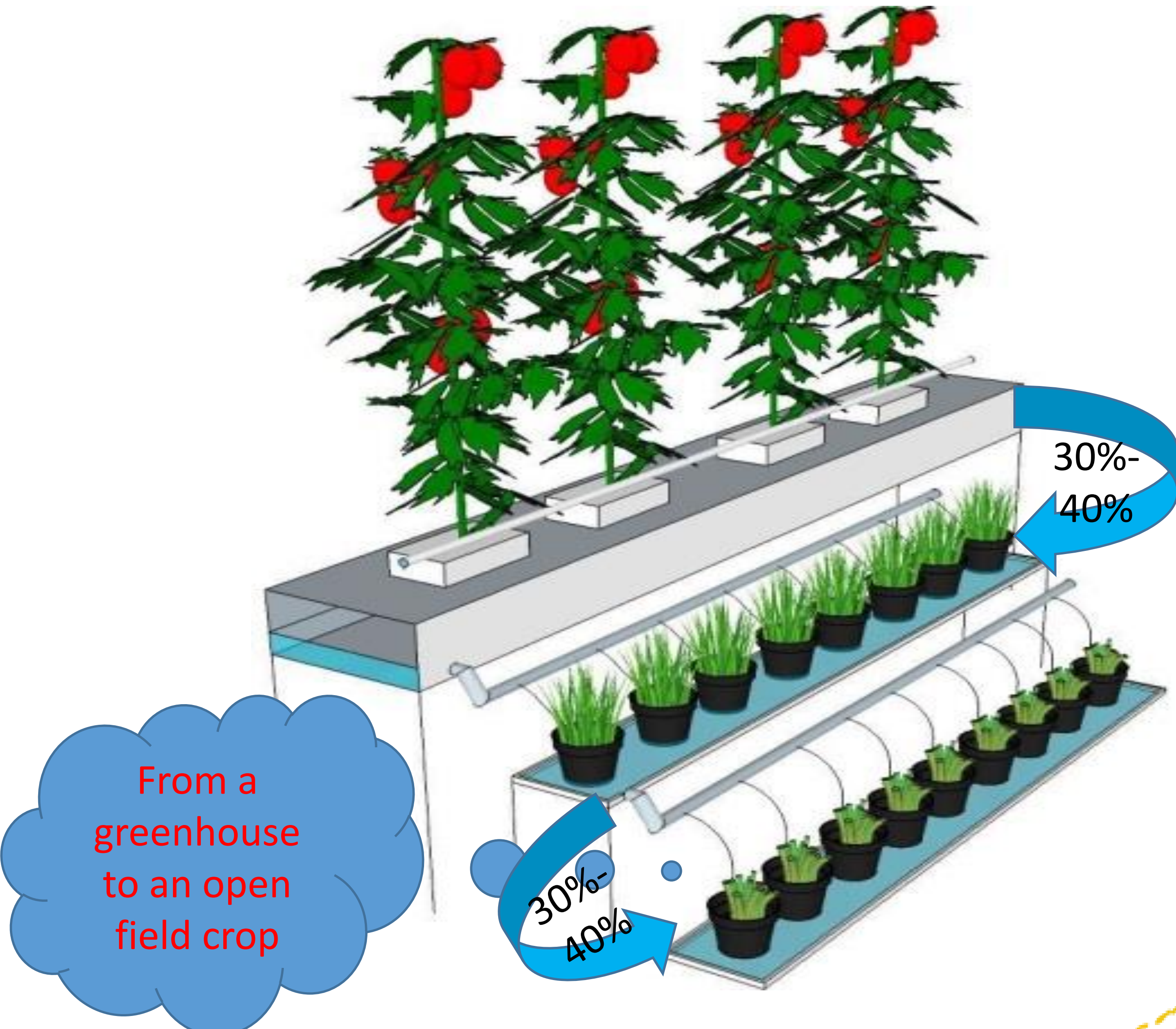
Decision support and control systems



DB1: Data from previous IP projects; DB2: Users' archive; DB3: Historical ETo records and crop coefficients (Kc); OpIRIS: Online Professional Irrigation Scheduling ( ) Irrigation Programmer; ( ) Sensors + device-to-web datalogger; ( ) Smart_Phone application

N. Katsoulas et al./Computers and Electronics in Agriculture 113 (2015) 61–71

Cascade hydroponics



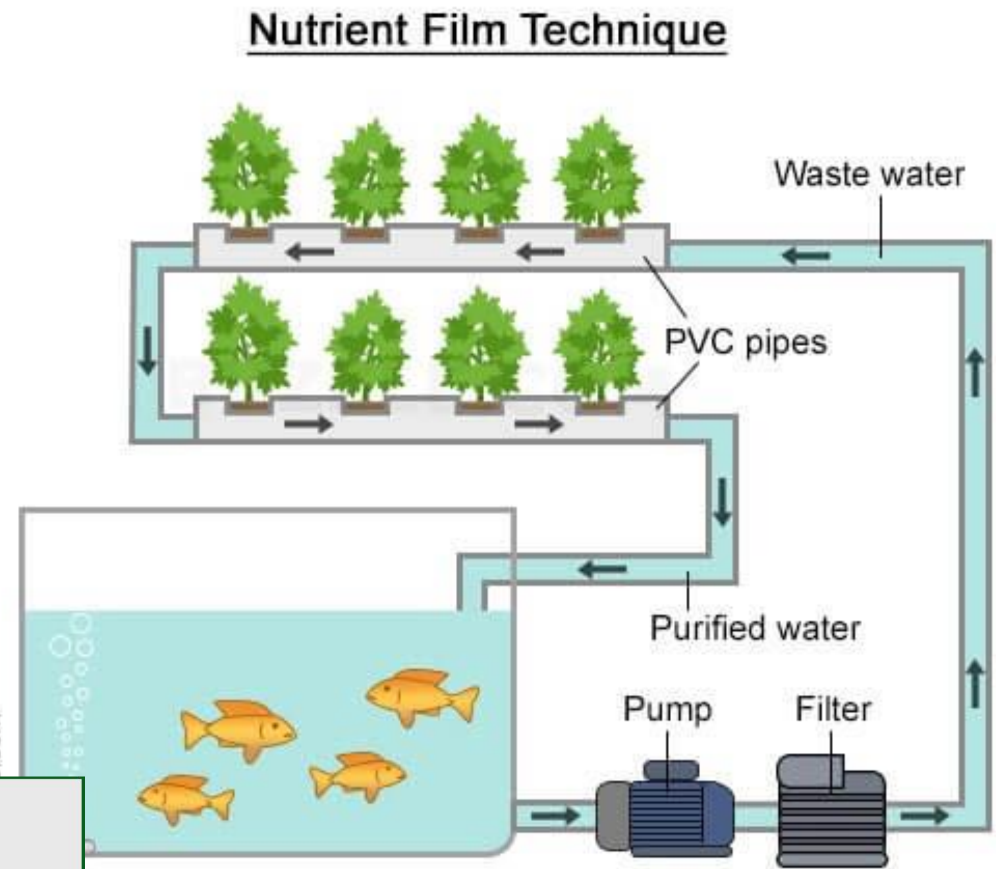
The nitrogen balance for the two combined systems shows an important decrease in N leachate.

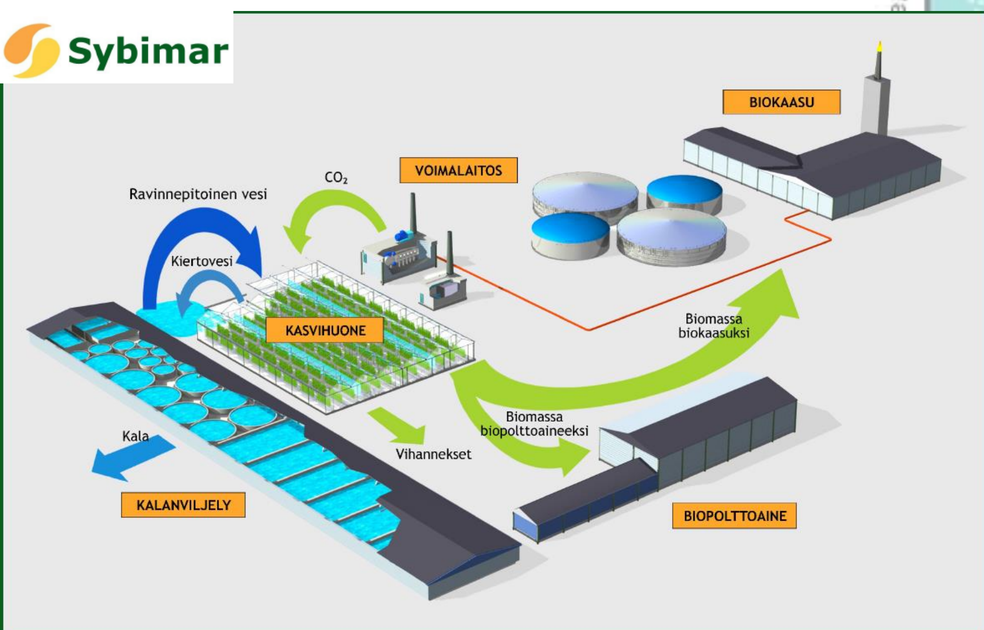
The adoption of the ‘cascade’ crop system reduced environmental impact for climate change category by 21%, but increased eutrophication category by 10% because of the yield reduction.
Muñoz et al. (2012)

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.

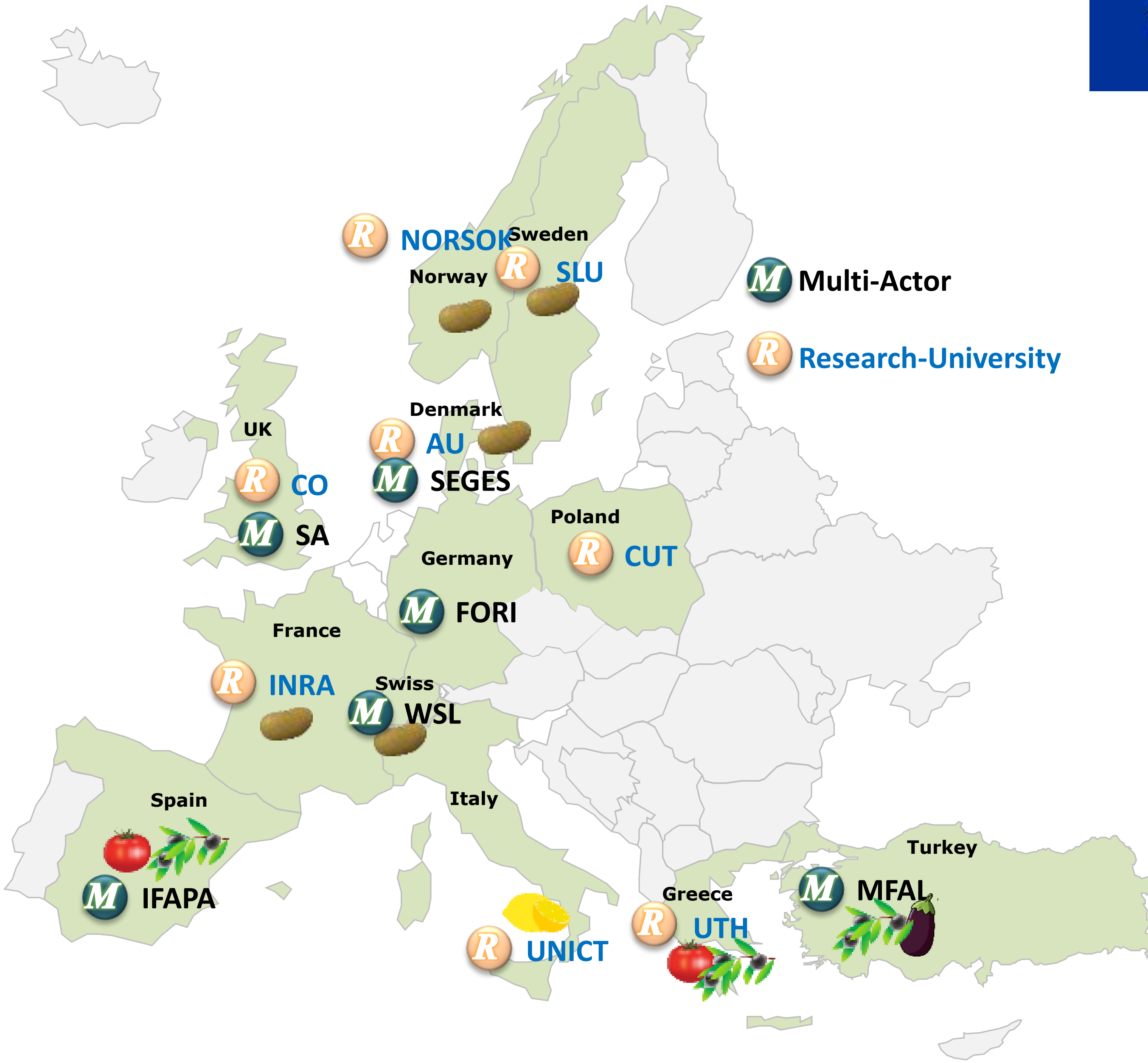




Organic Plus

Cultivated organic areas in the Mediterranean region and inputs used

What is done in WP3-Plants of Organic Plus


Multi-Actor
Research-University
NORSOK
Sweden
Norway
SLU
UK
CO
SA
Denmark
AU
SEGES
Poland
CUT
Germany
FORI
France
INRA
Swiss
WSL
Italy
Spain
IFAPA
UNICT
Greece
UTH
Turkey
MFAL

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

Version: 1.1 (31 October 2018) Text updated with latest information.

Funding

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No [774340 — Organic-PLUS]

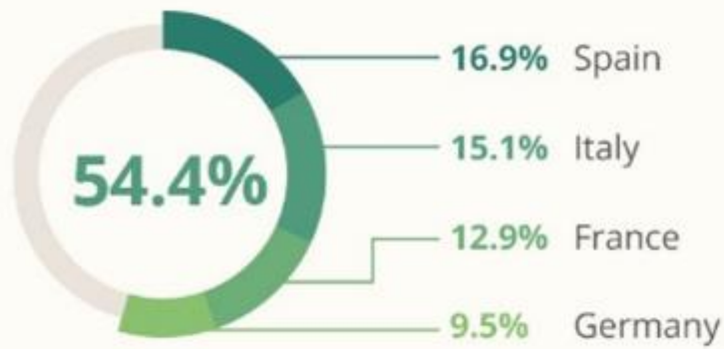
ORGANIC FARMING IN THE EU

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

11.9 million hectares

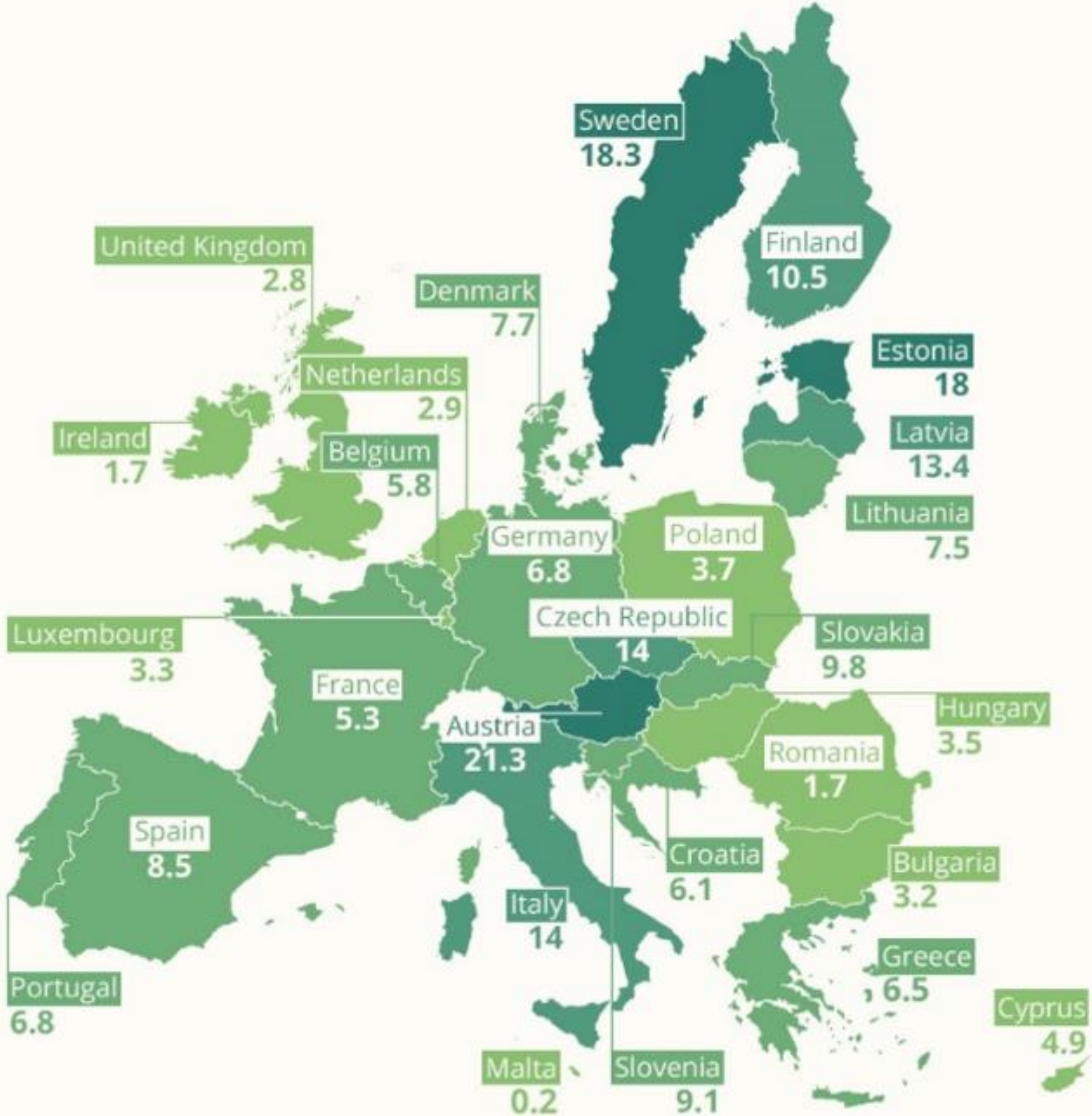
6.7% of land used for agriculture

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



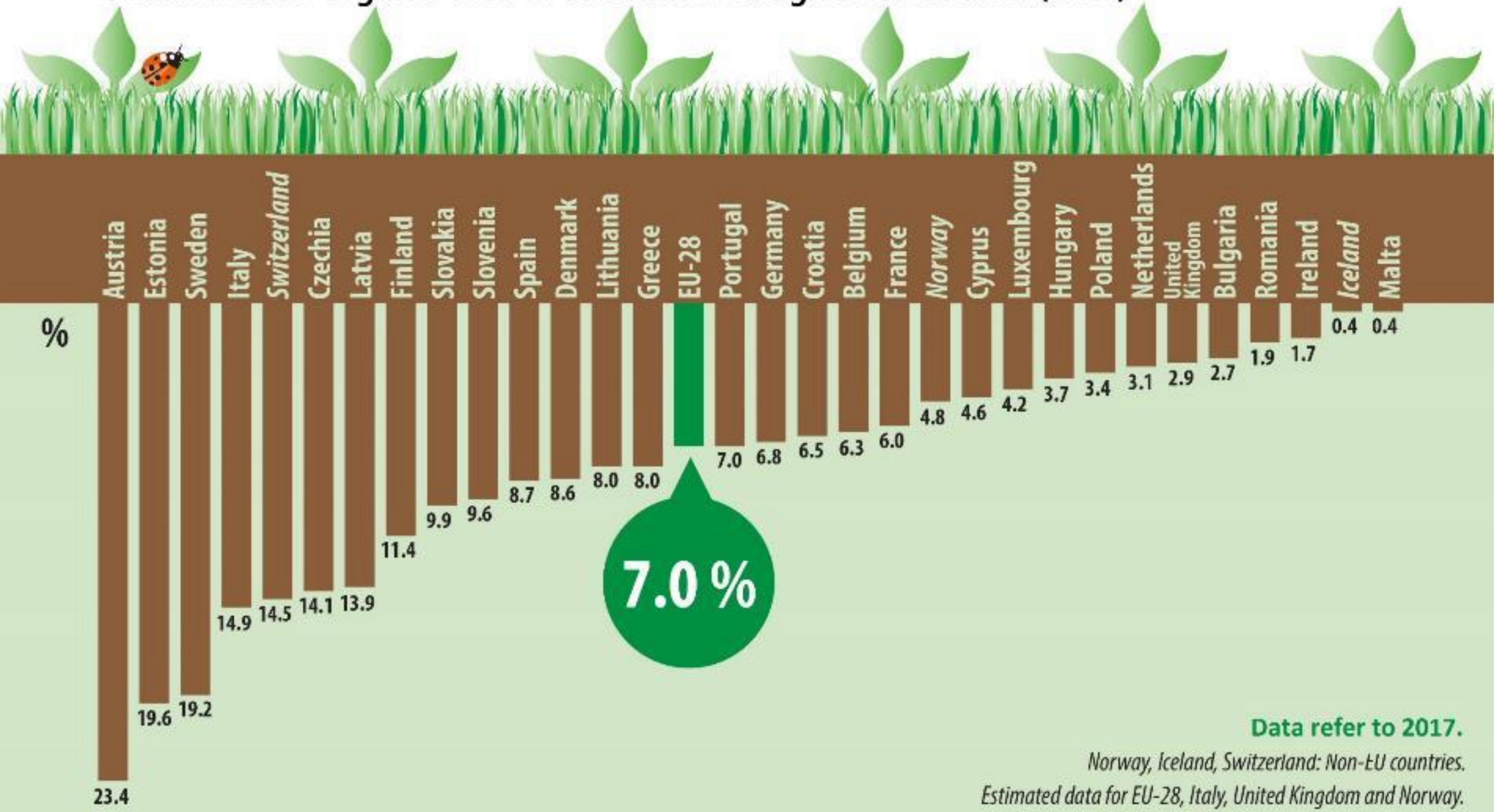
ORGANIC FARMING IN EU COUNTRIES

Proportion of organic agricultural land in 2016 (in %)*



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.

Legal status for Cu and Mineral oils

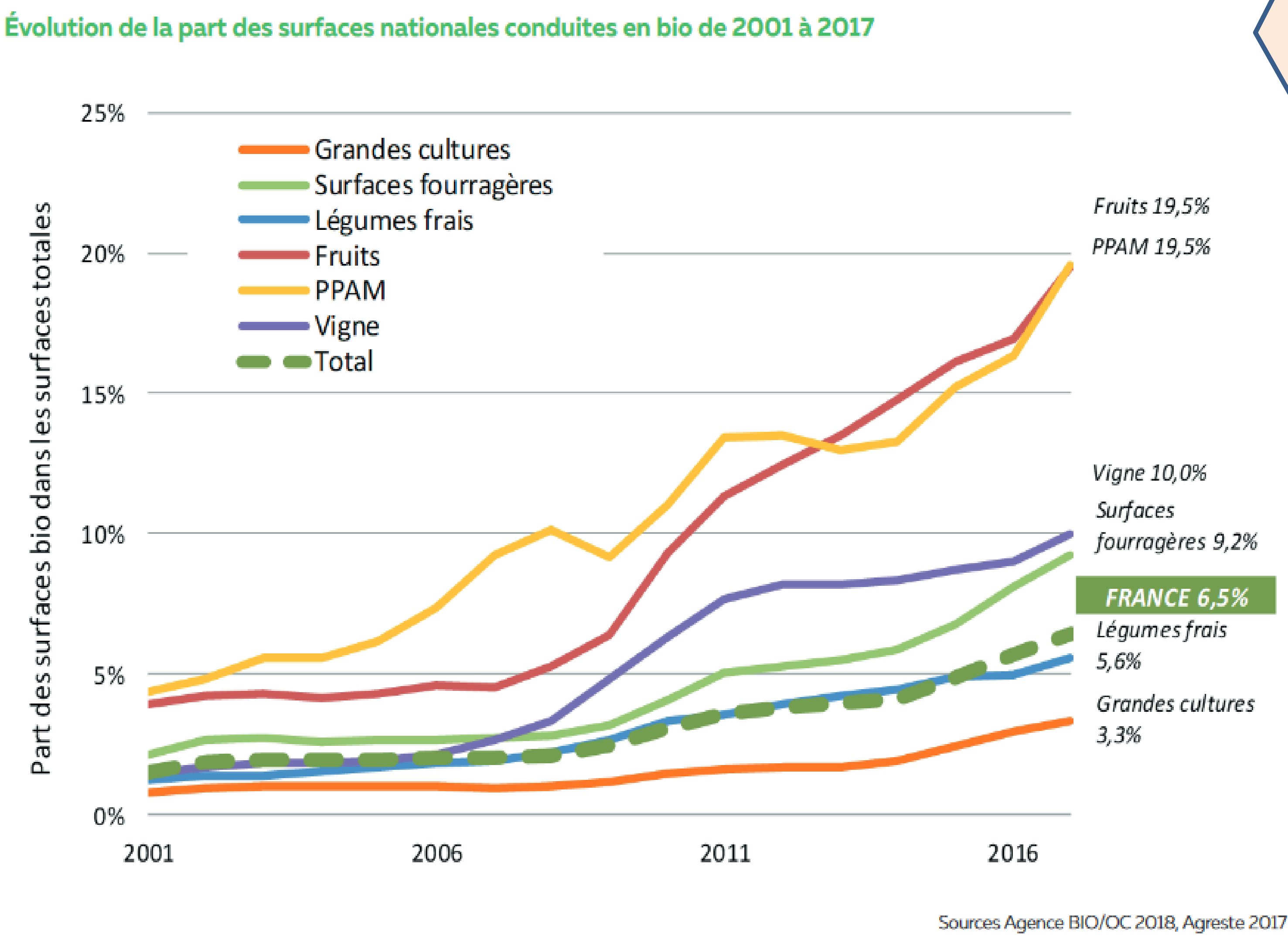
- The legal status of Cu, S and mineral oils in the EU is regulated by the European Commission regulation (EC) No 889/2008 of 5 September 2008
- Cu as fungicide is allowed up to 6 kg per ha per year

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 typo 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

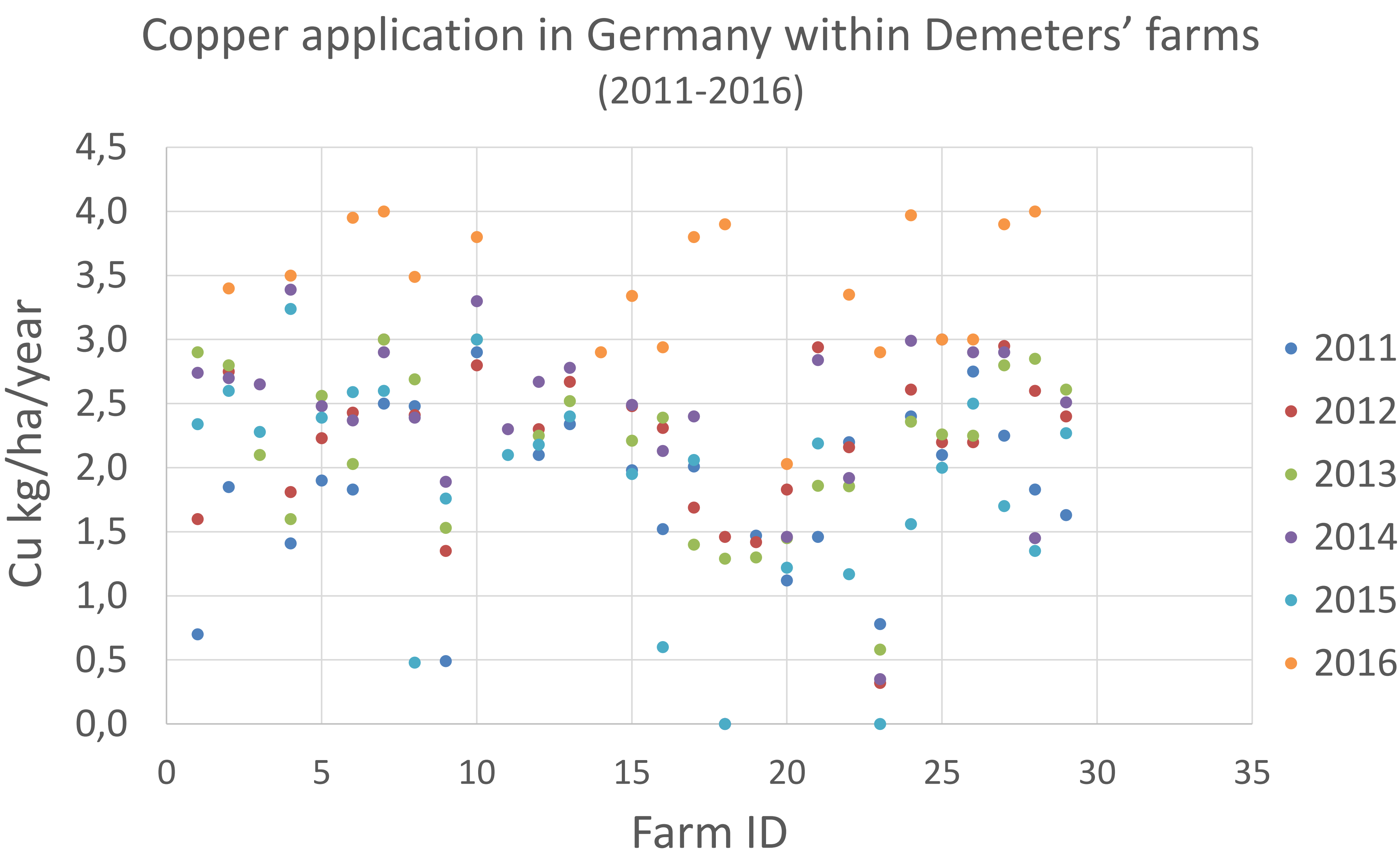
Countries:
Denmark
France
Germany
Greece
Italy
Norway
Poland
Spain
Turkey
UK

T3.1: Current use of contentious inputs in organic production (M1-6)

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%

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



Copper application in Germany within Demeters' farms
(2011-2016)
Cu kg/ha/year
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
0
5
10
15
20
25
30
35
Farm ID
2011
2012
2013
2014
2015
2016

T3.1: Current use of contentious inputs in organic production (M1-6)

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

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

(in ha)	Olives	Citrus	Fresh vegetables	Total (agricultural and grazed land)	Total (agricultural land)
Organic	44752	2300	290	342582	102166
Conventional	821206	42640	73812	3152600	2432524
%	5.4%	5.4%	0.4%	10.9%	4.2%

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)

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

Conventional citrus areas in Italy

		2015	2016	2017	
Italy	ha	150,047	146,000	138,000	- 3%
	ton	3,151,564	2,500,000	2,900,000	+ 6%

Organic citrus areas in Italy

		2015	2016	
Italy	ha	31,869	36,125	+ 13,4%
	ton	524.990	596,000	

Organic citrus areas in Italy in conversion and converted (ha)

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

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.

T3.1: Current use of contentious inputs in organic production (M1-6)

Countries:
Denmark
France
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Greece
Italy
Norway
Poland
Spain
Turkey
UK

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 tresholds or other limitations.

T3.1: Current use of contentious inputs in organic production (M1-6)

SPAIN (2016)	SURFACE (Ha) ORGANIC	SURFACE (Ha) TOTAL
Cereals	216.481	6.240.000
Dried legumes	38.057	460.000
Tubers	639	74.584
Industrial crops	16.522	952.806
Arable crops	24.144	1.064.379
Vegetables	17.182	375.073
Strawberries	163	6.867
No citrics fruits	144.957	939.066
Citrics	10.183	295.331
Grapevine	106.720	936.788
Olive	196.567	2.521.694
TOTAL SURFACE	**771.615** 5.5%	**13.866.588**

SPAIN (2016)	% organic SURFACE	% organic PRODUCTION	Yield Organic (kg/Ha)	Yield Conventional (kg/Ha)	Yield difference (organic/conventional)
Cereals	3,5%	0,7%	757	3.865	20%
Dried legumes	8,3%	2,0%	337	1.409	24%
Tubers	0,9%	0,4%	13.323	30.912	43%
Vegetables	4,6%	1,9%	16.649	40.202	41%
Strawberries	2,4%	1,3%	31.113	54.987	57%
No citrics fruits	15,4%	2,4%	729	4.623	16%
Citrics	3,4%	2,0%	13.986	23.993	58%
Grapevine	11,4%	3,5%	1.983	6.515	30%
Olive	7,8%	2,3%	835	2.809	30%

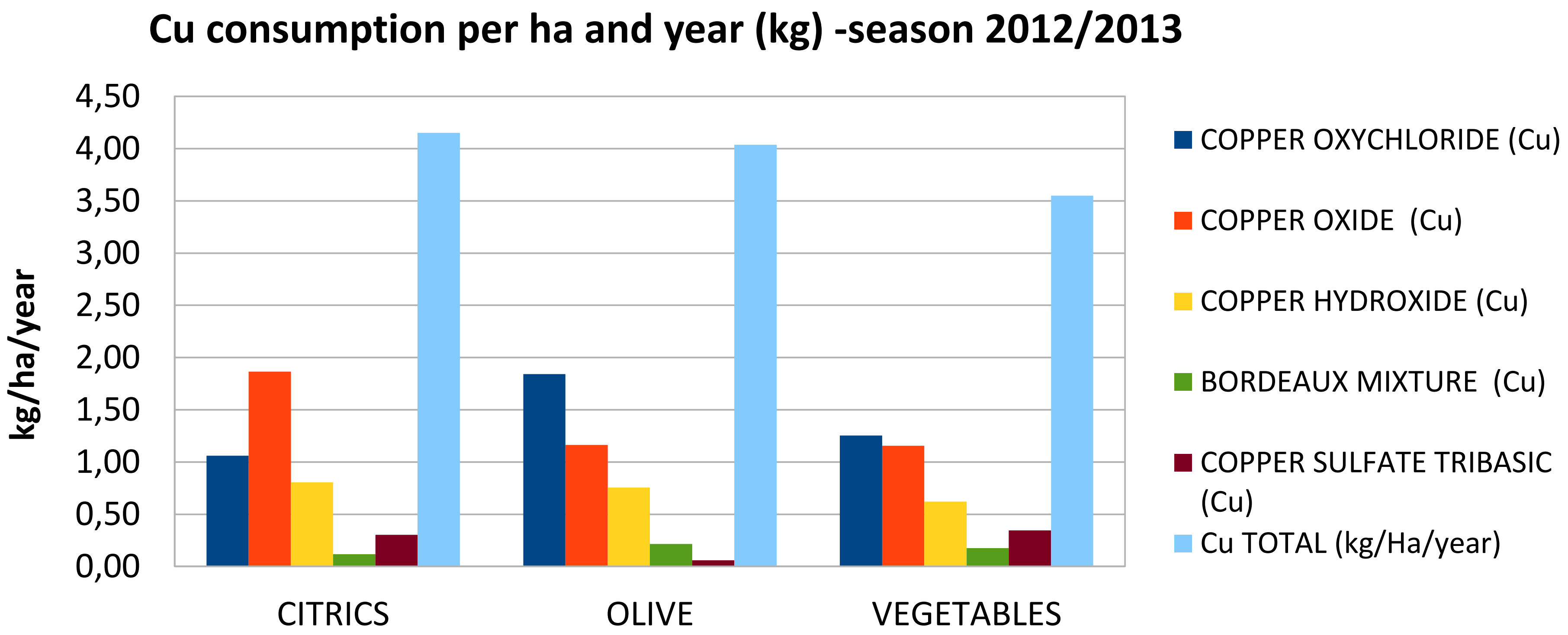
Countries:
- Denmark
- France
- Germany
- Greece
- Italy
- Norway
- Poland
- Spain
- Turkey
- UK

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.



ORGANIC PLUS

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 crops like citrus and olives and greenhouse crops like tomato and aubergine

WHAT ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN CITRUS ORGANIC FARMING?

CITRUS

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 citrus 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.

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 2016).

The citrus yield is continually threatened by pathogens and pests, which limit the citrus productivity in the field and the commercial life of fruit in post-harvest. In addition to common and often devastating phytopathogenic fungi and bacteria (*Plenodomus tracheiphilus*, *Phytophthora* spp., *Fusarium* spp., *Penicillium* spp., *Pseudomonas syringae*) commonly found in Mediterranean regions, recent infections caused by *Colletotrichum* spp. and *Alternaria* spp. strongly compromise citrus production in different Mediterranean countries, and they can be considered emerging diseases that could become a serious limiting factor in citrus groves.

In organic citrus orchards pathogens are mainly controlled by regular sprays of copper-based products. The demonstrated noxious effect of copper on 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 metal Cu up to the end of 2018 but is now reduced to 4 kg/ha/yr 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, on the whole, respected by Mediterranean citrus growers. The only exception may regards lemons. Many alternative compounds to reduce or replace 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 Impact and Innovation programme under grant agreement No. 774340

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ORGANIC PLUS

WHAT ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN CITRUS ORGANIC FARMING?

ALTERNATIVES TO COPPER

The limit of 6 kg/ha/year of metal copper is generally respected in organic citrus farms of Mediterranean countries. The only exception may regard lemons which are particularly susceptible to Mal secco disease. Since no effective alternatives to copper are available against this disease, in years with adverse weather conditions, the given limit may be exceeded by organic growers.

Alternatives to copper currently rely on:

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, used 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.

- **Plant extracts** with biocidal activity and stimulating effects on plant defences.
- **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 (as *Trichoderma* spp.).
- **Seaweed extracts**, such as *Ascophyllum nodosum* and *Laminaria digitata*.
  Laminarin, extracted from *L. digitata*, has not a direct bactericidal or fungicidal activity, but enhance plant resistance to pathogens.
- **Chitosan,** natural polymer derived from chitin, reported active against a variety of microorganisms, with a good direct activity coupled with stimulation of plant defence mechanisms.
- **Essential oils.** Commercial formulations made from essential citrus oils are approved for use in OA.

Authors: Andrivon, D., Orsilleri, G., de Cara, M., Katsoulas, N., Kir, A.

ALTERNATIVES TO MINERAL OILS

Mineral oils are applied in citrus orchards to exclusively control insects and mites. Their use ranges between 30-100 litres/ha/year. The wide spectrum of activity of mineral oils makes them more versatile than other alternatives which currently are:

- **Soft potassium soaps 28%**
- **Plant defence stimulators**
- **Beneficials:** *Aphytis melinus, Cryptolaemus montrouzieri, Leptomastix dactylopii, Amblyseius andersoni, Phytoseiulus persimilis*

ALTERNATIVES TO SULPHUR

The use of sulphur in Mediterranean citrus groves is generally low and restricted to certain circumstances. Its use ranges between 3-6 kg/ha/year.

No alternatives are currently adopted.

Main goals of O' project related to citrus

In laboratory and growth chamber tests, biological control agents, resistance inducers, innovative formulations, vegetable extracts, GRAS (hydrogen peroxide; potassium bicarbonate; calcium polysulphide) will be evaluated as alternatives to Cu against *Colletotrichum* spp., *Alternaria* spp., *Penicillium* spp. and *Pseudomonas syringae*.

The best products will be tested in open field trials, and monitored for 2 years. Field trials will evaluate: (a) reduced incidence/severity, (b) reduced susceptibility to diseases, (c) impact on crop production, (d) best application strategy (e) synergic activity of products, and (f) phytotoxicity.

ORGANIC PLUS

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 crops like 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 for 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*, *Spilocaea oleaginea*, *Mycocentrospora cladosporioides*, *Verticillium* spp., *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.

In organic olive orchards, pathogens are mainly controlled by regular sprays with copper-based products. The demonstrated noxious effect of copper on 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 metal Cu up to the end of 2018 but is now reduced to 4 kg/ha/yr 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 generally respected by Mediterranean olive growers.

Many alternative compounds to reduce or replace copper amounts are under development, but few are already available on the market, and fewer are currently used by growers to any substantial extent.

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

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ORGANIC PLUS

WHAT ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN OLIVE ORGANIC FARMING?

ALTERNATIVES TO COPPER

In olive crops of Mediterranean countries the limit of 6 kg/ha/year is generally respected

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, used alternatively 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.

- **Inorganic substances**: sprayable zeolite and Kaolin for abiotic stress protection and olive fruit fly protection: K_2SiO_3
- **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, *Glomus* spp. are some example of BCAs available on the market.
- **Chitosan**, natural polymer obtained from chitin, reported active against a variety of microorganisms, with a good direct activity coupled with stimulation of plant defence mechanisms.
- **Compost**: compost tea (enrichment with platanus orientalis leaves), vermicompost, vermicompost tea.
- **Lime-sulphur.**

Authors: Andrivon, D., Cotinet, B., Civillari, G., de Cara, M., Katsoulas, N., Ki, 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 rapeseed)
- **Zeolite and Kaolin** for olive fruit fly protection
- **Beneficials**

ALTERNATIVES TO SULPHUR

The use of sulphur in Mediterranean olive groves is generally low, approximately 15-20 kg/ha/year.

NO alternatives are currently adopted.

Main goals of O' project related to olive

Alternatives to Cu (lime sulphur, plant defence stimulators products based on Ca and Si, natural extracts) will be tested in open field trials and monitored for 2 years.

Field trials will evaluate: (a) reduced incidence/severity, (b) reduced susceptibility to diseases, (c) impact on crop production and fruit quality, (d) best application strategy, and (e) phytotoxicity.

Effectiveness of other alternatives to Cu (*Glomus intraradices*, K_2SiO_3, *Bacillus subtilis* EU007, compost tea enriched with *Platanus orientalis* leaves, Maxicrop, moldy bread pieces) will be evaluated in comparison with $CuSO_4$ both in growth chamber and, for promising ones, in open field. Timings of promising alternative applications will be determined by means of a disease forecasting system that will be established on the field trial area.

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

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WHAT ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN TOMATO ORGANIC FARMING?

TOMATO



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 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 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.

Tomato is a plant widely cultivated in European countries, both as table tomato for fresh consumption and as industrial tomato for processing.

Cultivation is practiced both in open fields and in greenhouses, based on the area and the season.

The tomato yield is continually threatened by pathogens and pests which limit the tomato productivity in the field and the commercial life of product in post-harvest. Common and often devastating phytopathogenic fungi and bacteria (powdery mildews, *Phytophthora infestans*, *Cladosporium* spp., *Botrytis cinerea*, *Alternaria* spp., *Pseudomonas* spp., *Xanthomonas* spp.) found in all the Mediterranean regions strongly compromise tomato production in different Mediterranean countries.

In organic tomato cultivations, pathogens are generally controlled by regular sprays with copper-based products. The demonstrated noxious effect of copper on 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 metal Cu up to the end of 2018 but is now reduced to 4 kg/ha/yr 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 on the whole respected by Mediterranean tomato growers.

Many alternative compounds to reduce or replace copper amounts 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. 774340

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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/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, used 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.

- **Plant extracts** with biocidal activity and stimulating effects on plant defences.
- **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*, *Bacillus subtilis*, *B. amyloliquefaciens*, *Pseudomonas* spp., *Trichoderma* spp., *Streptomyces* spp., are some example of BCAs available on the market.
- **Seaweed extracts**, such as *Ascophyllum nodosum* and *Laminaria digitata*.
  Laminarin, 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 defence mechanisms.
- **Herbal preparations** (decoctions, nettle maceration, horsetail).

Authors: Andrivon, D., Cirvilleri, G., de Cara, M., Katsoulas, N., Kir, A.


ALTERNATIVES TO MINERAL OILS

Mineral oil is occasionally applied in tomatoes. The maximum use is 10-13 litres/ha/year as 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 move from 2 kg/ha/year to, in the rare and highest case, 95 kg/ha/year depending on the production system and the incidence of pests/diseases. It is not selective and has harmful effects on beneficial arthropods. Alternatives, not widely applied for economical reasons, are essentially represented by:

- **Maltodextrins**
- **Potassium hydrogen carbonate**
- ***Ampelomyces quisqualis***

Main goals of O+ project related to tomato

Based on practitioners experience, ten different available-to-growers formulations alternative to copper will be screened in the lab for their efficacy against pathogenic tomato strains of *Botrytis cinerea* and *Fulvia fulva*. The effective formulations will be checked for persistence of their effect. The best selected alternative will be tested out in three demonstrative trials carried out in Mediterranean greenhouses.

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WHAT ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN AUBERGINE ORGANIC FARMING?

AUBERGINE

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 aubergine 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.

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 (powdery mildews, *Phytophthora infestans, Botrytis cinerea, Verticillium* spp., *Rhizoctonia solani, Alternaria solani, Xanthomonas* spp.) found in the Mediterranean regions compromise aubergine production in different producing countries.

In organic aubergine cultivations, pathogens are generally controlled by regular sprays with copper-based products. The demonstrated noxious effect of copper on 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 metal Cu up to the end of 2018 but is now reduced to 4 kg/ha/yr starting from January 2019.
According to the data collected by interviewing 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, but few are already available on the market, and fewer are currently used by growers to any substantial extent.

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WHAT ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN AUBERGINE ORGANIC FARMING?

ALTERNATIVES TO COPPER

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, used 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.

- **Plant extract** with biocidal activity and stimulating effects on plant defences.
- **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, Bacillus subtilis, B. amyloliquefaciens, Pseudomonas* spp., *Trichoderma* spp., are some example of BCAs available on the market.
- **Seaweed extracts,** such as *Ascophyllum nodosum* and *Laminaria digitata*.
  Laminarin, extracted from *L. digitata*, has not a direct bactericidal or fungicidal activity, but enhance plant resistance to pathogens.
- **Chitosan,** natural polymer obtained from chitin, reported to be active against a variety of microorganisms, with a good direct activity coupled with stimulation of plant defence mechanisms.
- **Compost:** compost tea, vermicompost, vermicompost tea.
- **Resistant variety:** some native aubergine varieties can be resistant or moderately resistant to fungal diseases such as early blight (*Alternaria solani*).

Authors: Andrivon, D., Cotine, B., Civitelli, G., de Cara, M., Katsoulas, N., Kir, A.

ALTERNATIVES TO MINERAL OILS

Rarely applied in aubergines and only for repellent 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 arthropods. Alternatives, not currently applied for economical reasons, are essentially represented by:

- Maltodextrins
- *Ampelomyces quisqualis*

Main goals of O+ project related to aubergine

60 eggplant (*Solanum melongena* L.) landraces will be screened for early blight fungal disease. Seedlings of the landraces will be tested for resistance to *Alternaria solani* fungal spores in climate room conditions. After the inoculation step, resistant or moderately resistant native races 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)

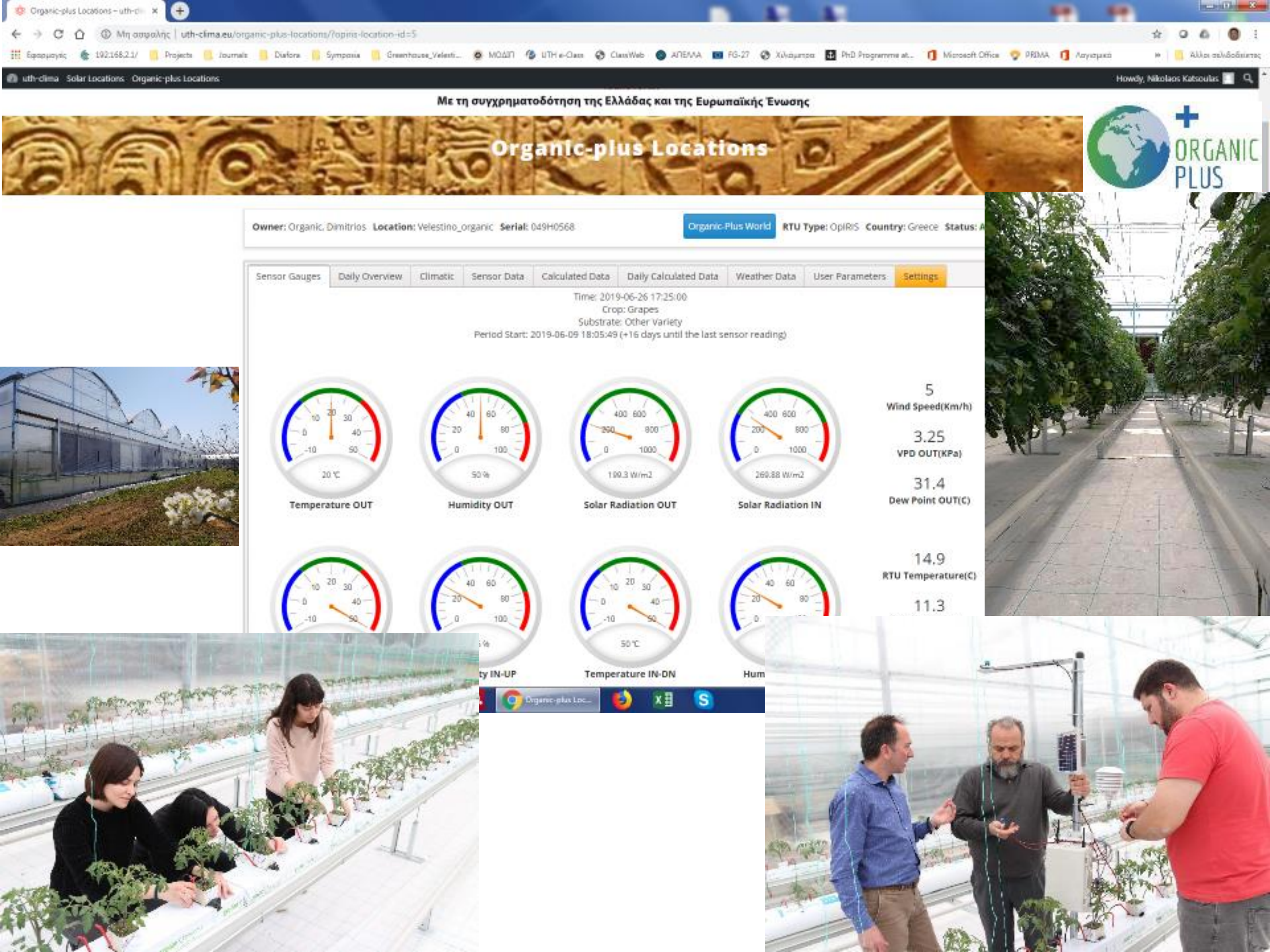
T3.4: *Design of phase-out scenarios* through substitution, combination or plant protection systems redesign (M1-20)

-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)

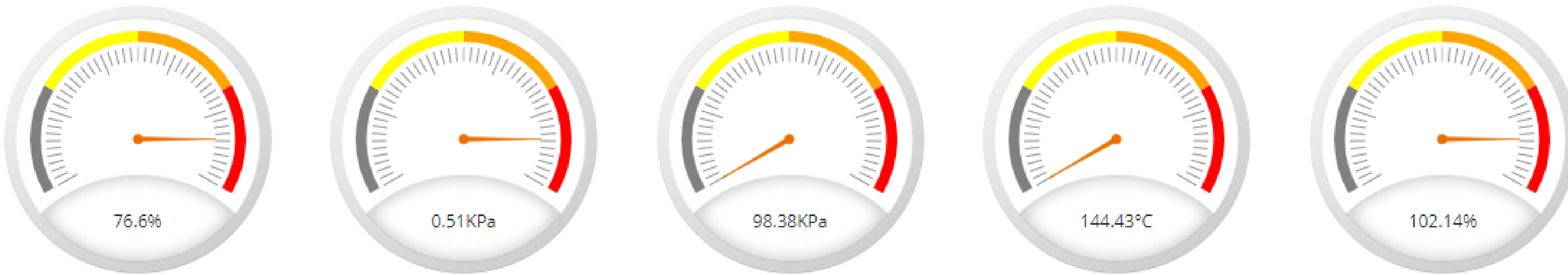


Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης
Organic-plus Locations
ORGANIC PLUS
Owner: Organic, Dimitrios
Location: Velestino_organic
Serial: 049H0568
Organic-Plus World
RTU Type: OpIRIS
Country: Greece
Sensor Gauges
Daily Overview
Climatic
Sensor Data
Calculated Data
Daily Calculated Data
Weather Data
User Parameters
Settings
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)
Temperature OUT
Humidity OUT
Solar Radiation OUT
Solar Radiation IN
5
Wind Speed(Km/h)
3.25
VPD OUT(KPa)
31.4
Dew Point OUT(C)
14.9
RTU Temperature(C)
11.3
Temperature IN-DN

Owner: Organic_Plus **Location:** Velestino_organic **Serial:** 049H0568 Organic-Plus World **RTU Type:** OpIRIS **Country:** Greece **Status:** **Active**

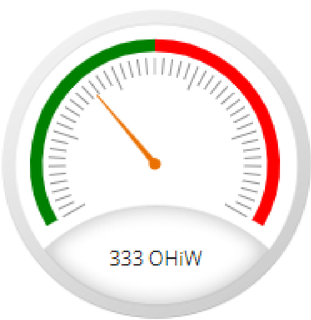
Sensor Gauges | Daily Overview | Climatic | Sensor Data | Calculated Data | Daily Calculated Data | Weather Data | Alarm Indexes | User Parameters | Settings

Current health indexes status

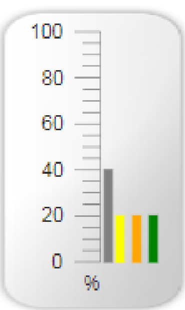


RH **VPD Air** **VPD Crop** **T Leaf** **Wetness**

Running Time:	Running Time:	Running Time:	Running Time:	Running Time:
Caution:0 min	Caution:0 min	Caution:0 min	Caution:0 min	Caution:5 min
Medium: 0 min	Medium: 0 min	Medium: 0 min	Medium: 0 min	Medium: 20 min
Critical: 0 min	Critical: 0 min	Critical: 0 min	Critical: 0 min	Critical: 5 min
High: 0 min	High: 0 min	High: 0 min	High: 0 min	High: 30 min



Last day Spore Pressure



Total Alarms (%)

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)

Conferences

Seminars/workshops:

- 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