



CENTRO DI SPERIMENTAZIONE E ASSISTENZA AGRICOLA

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CAMERA DI COMMERCIO
RIVIERE DI LIGURIA
IMPERIA LA SPEZIA SAVONA

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Bacterial Disease Outbreaks in Protected Crops and Nurseries: An Emerging Challenge

EPPO Conference on Diagnostics of Plant Pests

Recent developments and future trends

2026-04-22/24, Vienna (AT)

In recent years, **bacterial diseases** have emerged as a significant and increasing threat in nursery production and **protected cultivation systems** in Italy, particularly, **under intensive vegetable production**.

Factors contributing to the spread and establishment of bacterial pathogens in these controlled environments

- **climate change** (increase of relative humidity)
- **intensified production** practices (increase of grower specialization)
- **global plant trade** (propagative material production in “low cost” areas)
- use of **high-density propagation systems** (increase of plant-raisers specialization)
- **pesticide revision** and non approval (dithiocarbamates, copper, other SAR inducers, ...)

Active Substance	Withdrawal Regulation	Authorization Revocation	Final Date for Use (Stock Exhaustion)
Thiram	Reg. (EU) 2018/1480	January 30, 2019	April 30, 2019 (Jan 2020 for treated seeds)
Mancozeb	Reg. (EU) 2020/2087	July 4, 2021	January 4, 2022
Metiram	Reg. (EU) 2023/2455	May 28, 2024	November 28, 2024
Acibenzolar-s-methyl	Reg. (EU) 2024/1696	January 10, 2025	July 10, 2025
Ziram	Under Review*	<i>Decision Pending</i>	<i>Estimated 2025-2026</i>

Component	Primary Role	Effect on Bacteria
Copper (Cu²⁺)	Toxicant	Denatures proteins, destroys membranes, and creates oxidative stress.
Dithiocarbamates	The Catalyst/Synergist	Increases copper solubility and helps transport ions into the cell.
Combined Result	Bactericidal	Rapid collapse of bacterial metabolism and physical structure.

The current approval for copper compounds (including Bordeaux mixture and copper oxychloride) valid until **June 30, 2029**.

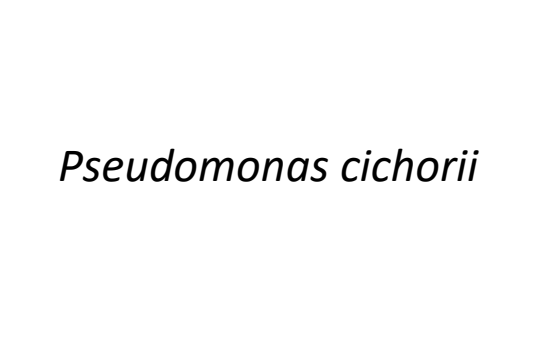
Copper classified as a "**candidate for substitution**".

- Average Annual Limit: **maximum dose is an average of 4 kg** of copper per hectare per year.
- Total Multi-annual Limit: must not exceed **28 kg of copper per hectare** over a period of **7 years**.
- **Member State Flexibility**: Individual Member States have the authority to set stricter annual limits (e.g., Belgium at 2 kg/ha) or specific rules to ensure the 7-year average is respected.
- **Organic Standards**: While EU law allows the **4 kg/ha average**

Causal agent	Common name	Main features	Main hosts	Origin (primary)	Infected organs and tissues	Survival on/in seeds
<i>Pseudomonas syringae</i> pv. <i>tomato</i>	bacterial speck of tomato	Aerobic gram negative, non forming spore	Tomato, eggplant, other non solanaceous plants	Seeds	Cotyledons, leaves, fruits, stems	Survive on seeds 20-30 months (4-5 years)
<i>Pseudomonas cichorii</i>	Bacterial blight / Varnish spot	Aerobic gram negative, fluorescent, oxidase positive	Lettuce, chicory, endive, celery	Infected debris, soil, seed	Leaves, stems, flower heads	Short-term on seed (highly variable)
<i>Xanthomonas</i> spp. (<i>X. euvesicatoria</i> pv. <i>euvesicatoria</i> , <i>X. hortorum</i> pv. <i>gardneri</i> , <i>X. euvesicatoria</i> pv. <i>perforans</i> , <i>X. vesicatoria</i>)	Bacterial spot	Aerobic gram negative, yellow pigment (xanthomonadin)	Tomato, pepper	Seed, infected debris	Leaves, stems, fruits, flowers	Long-term (up to 1 year or more)
<i>Xanthomonas campestris</i> pv. <i>campestris</i>	Black rot	Aerobic gram negative, yellow pigment (xanthomonadin)	Cabbages, broccoli, cauliflower, radish	Seed, infected debris	Vascular system, leaves (V-shaped lesions)	Long-term (up to 3-5 years)
<i>Acidovorax citrulli</i>	Bacterial fruit blotch	Aerobic gram negative, non forming spore	Water melon, melon, squash/zucchini	Seeds	Cotyledons, leaves, fruits, stems	Survive on seed for 5 years or more
<i>Clavibacter michiganensis</i> subsp. <i>michiganensis</i>	Bacterial canker and wilt	Gram positive, aerobic, non-motile	Tomato, (occasionally pepper)	Seed, infected debris	Vascular system, leaves, fruits (bird's-eye spot)	Long-term (up to 5 years or more)



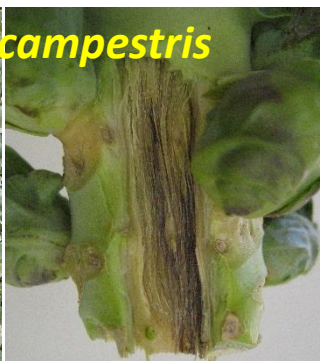
Pseudomonas syringae pv.
tomato



Pseudomonas cichorii



Xanthomonas campestris pv. *campestris*



Xanthomonas euvesicatoria pv.
euvesicatoria





*Acidovorax
citrulli*

*Clavibacter
michiganensis*
subsp.
michiganensis



Pathogen	EPPO Diagnostic Standard (PM 7)	Minimum Seed Sample Size (for PM 7 compliance)	Quarantine Status
<i>Pseudomonas syringae</i> pv. <i>tomato</i>	No specific PM 7	Variable (depends on national/ISTA protocols/literature)	Not Listed
<i>Pseudomonas cichorii</i>	No specific PM 7	Variable (depends on national/ISTA protocols/literature)	Not Listed
<i>Xanthomonas</i> spp. (<i>Xanthomonas euvesicatoria</i> pv. <i>euvesicatoria</i> , <i>Xanthomonas hortorum</i> pv. <i>gardneri</i> , <i>Xanthomonas euvesicatoria</i> pv. <i>perforans</i> , <i>Xanthomonas vesicatoria</i>)	PM 7/110 (2)	10,000 seeds (divided into subsamples)	A2 List
<i>Xanthomonas campestris</i> pv. <i>campestris</i>	No specific PM 7	Variable (depends on national/ISTA protocols/literature)	Not Listed
<i>Acidovorax citrulli</i>	PM 7/127	10,000 seeds (divided into subsamples)	A1 List
<i>Clavibacter michiganensis</i> subsp. <i>michiganensis</i>	PM 7/42 (3)	10,000 seeds (divided into subsamples)	A2 List

Pathogen	Thermal Optimum (Infection)	Seed Infection (Internal/External)	Irrigation Impact (Dissemination)	Quorum Sensing Relevance	Vector Agents (Insects/Mites)	Soil Survival (in crop debris)	Water Survival	Survival on Surfaces/Tools
<i>Pseudomonas syringae</i> pv. <i>tomato</i>	18–24°C (Cool/Humid)	Both (primarily external)	High (Splash dispersal)	High (AHL-mediated)	Rare (Mechanical only)	6–10 months (longer in cold climates)	2–4 weeks (longer in stagnant runoff)	7–14 days (on plastic/steel)
<i>Pseudomonas cichorii</i>	20–28°C (High humidity)	External	High (Overhead irrigation)	Moderate	Not significant	1–3 months (poor competitor)	1–2 weeks	3–5 days
<i>Xanthomonas campestris</i> pv. <i>campestris</i>	25–30°C	Both (Internal in vasculars)	Very High (Runoff/Splash)	Very High (DSF system)	Occasional (Mechanical)	1–2 years (until host tissue decays)	3–6 weeks	15–30 days (protected by xanthan)
<i>Acidovorax citrulli</i>	28–32°C (Warm/Wet)	Both (Strongly internal)	Critical (Nursery misting)	High	Not significant	6–12 months (associated with rinds)	2–4 weeks	10–20 days
<i>Clavibacter michiganensis</i> subsp. <i>michiganensis</i>	23–28°C	Both (Internal/Vascular)	High (Secondary spread)	High (Virulence regulation)	Rare (Mostly human/tools)	2–3 years (highly persistent)	1–3 months	Up to 7–10 months (on dry wood/crates)

Soil Survival vs. "Free" Soil: It is vital to distinguish between survival in **crop debris** (where these bacteria thrive) and free soil. In the absence of host tissue, most of these populations crash within 2 to 8 weeks due to competition with native soil microflora.

The "Biofilm" Factor on Tools: On greenhouse benches, wooden stakes, or pruning shears, these bacteria form biofilms. Under these conditions, *Clavibacter michiganensis* has been recorded to survive for an entire off-season (approx. 8–10 months), allowing for re-infection in the following spring.

High-Risk Production Scenarios

- Nursery: production of grafted plants (solanaceous, cucurbits)
- Nursery: continuous coexistence of staggered sowing lots
- Field: cultivation in mini-tunnels (non-walk-in tunnels)
- Field: contemporaneous transplant events coexisting on the same farm



Germination chamber



Grafting



Grafting



Healing chamber



Irrigation

Disease control options during the nursery propagation phase.

Direct

- bacteriophage-based biocontrol
- copper based formulations

Indirect

- strict hygiene procedures
- disease resistance inducers
- keep down population density
- *Bacillus amyloliquefaciens* strains (lipopeptides)
- *Bacillus subtilis* strains (lipopeptides)
- *Bacillus velezensis* strains (lipopeptides)



Disease control option in field scenarios

Direct

- Copper based formulations
- Disease resistance inducers

Indirect

- Bacillus based formulations spray
- Hygiene and preventive measures
- Separation of crops
- Avoiding overhead irrigation
- Destruction of infected plants and fruits, avoiding incorporation of discarded seeds into the soil



Final considerations

Plant extracts - botanicals

- Polyphenolic extracts, terpens, terpenoids
- Neem (*Azadirachta indica*) extracts
- Pepper (*Piper nigrum*) and geranium (*Pelargonium graveolens*) leaf oils, active against Gram-positive and negative bacteria

Biological Control Agents (BCAs)

- Approximately 250 microbial strains, 94 of which are used for disease control, including bacterial ones.

Meeting point: “Prevention avenue”

DISINFESTATION OF GROWING ENVIRONMENTS

SANITATION in absence of the
crop
EPPO PP1/261(1) - Disinfection in
plant production (2008)



Crop protection sector (Reg.
1107/2009) which deserves
greater attention from a regulatory
point of view



Difficulties

- **Chlorine based compounds** (NaClO, HClO, ...): risk of contamination of chlorate and perchlorates (regulated in food crops).
- **Quaternary Ammonium Compounds**: risk of contamination of Benzalkonium Chloride e/o Didecyl Dimethyl Ammonium Chloride (regulated in food crops).

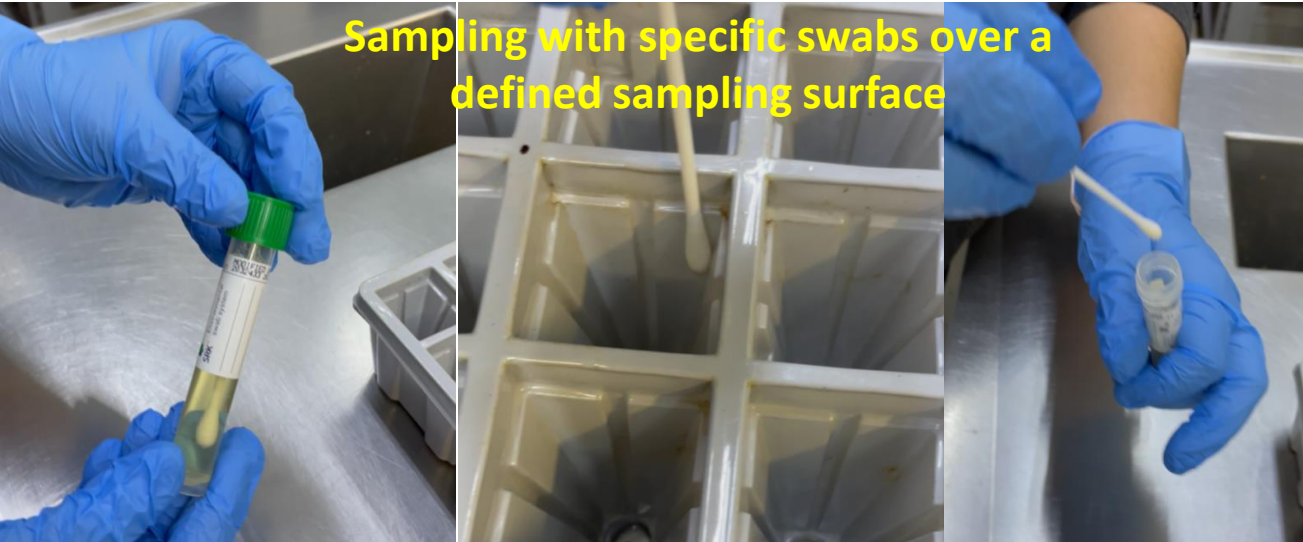
Perspectives

- Need to reconsider "SANITATION" as a **defense technique**.
- Introduction of **diagnostic tools** to evaluate **epiphytic** and or **endemic** bacterial disease agent presence
- **RATIONAL** adoption of **biostimulation** systems and techniques

Case study: *Pseudomonas syringae* pv. *tomato* (PST)

Monitoring of presence of PST aimed at

- identify endemism in a nursery scenario (critical areas and tools)
- verify efficiency of sanitation practices
- verify presence on leaf surface before final delivery to cultivation areas

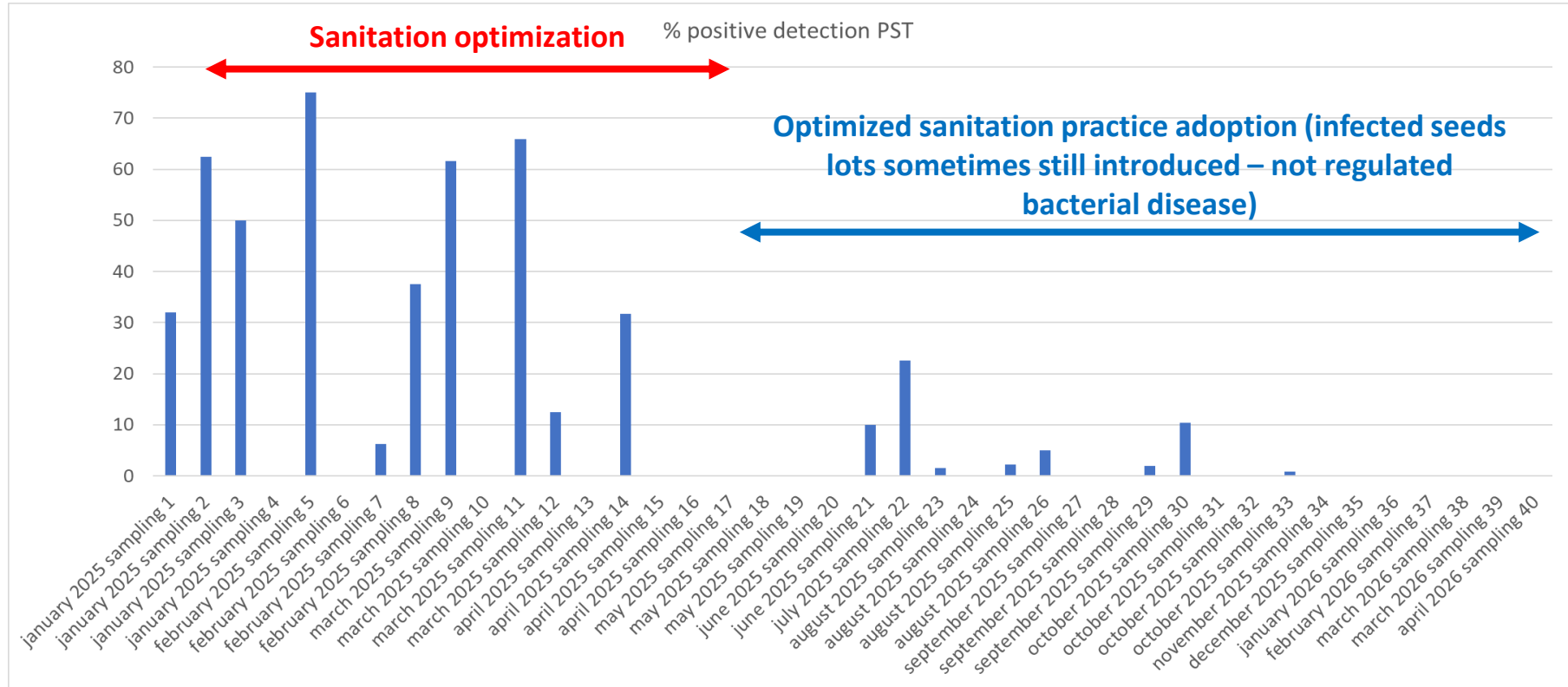


Analytical phase

Direct plating + PCR
(Zaccardelli *et al.* 2005)

Effect of sanitation optimization in a professional nursery area after sudden and unexpected introduction of *Pseudomonas syringae* pv. *tomato* (PST) through infected seeds

- Infection event: August-September 2024
- Epidemic spread: October-November 2024
- Sanitation optimization: January-May 2025



Prodotti biostimolanti ed effetti sulle colture ortofloricole

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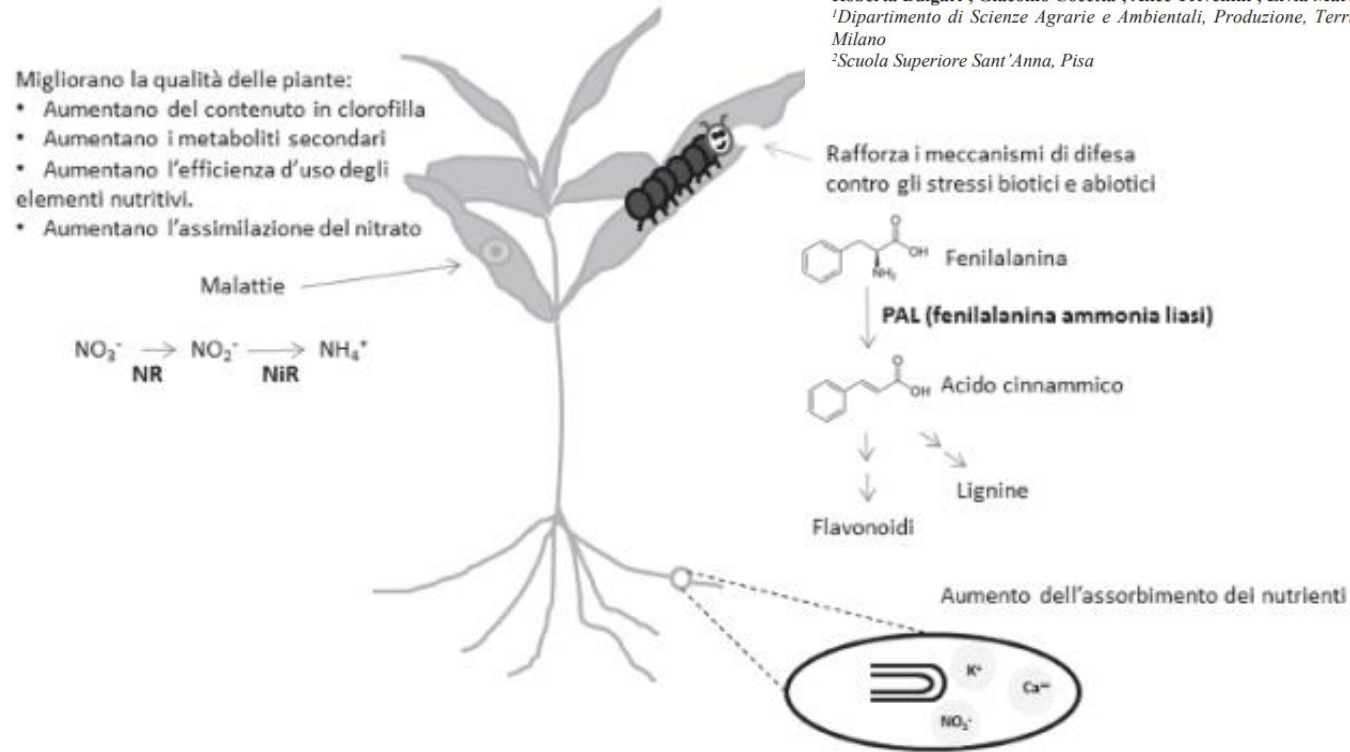
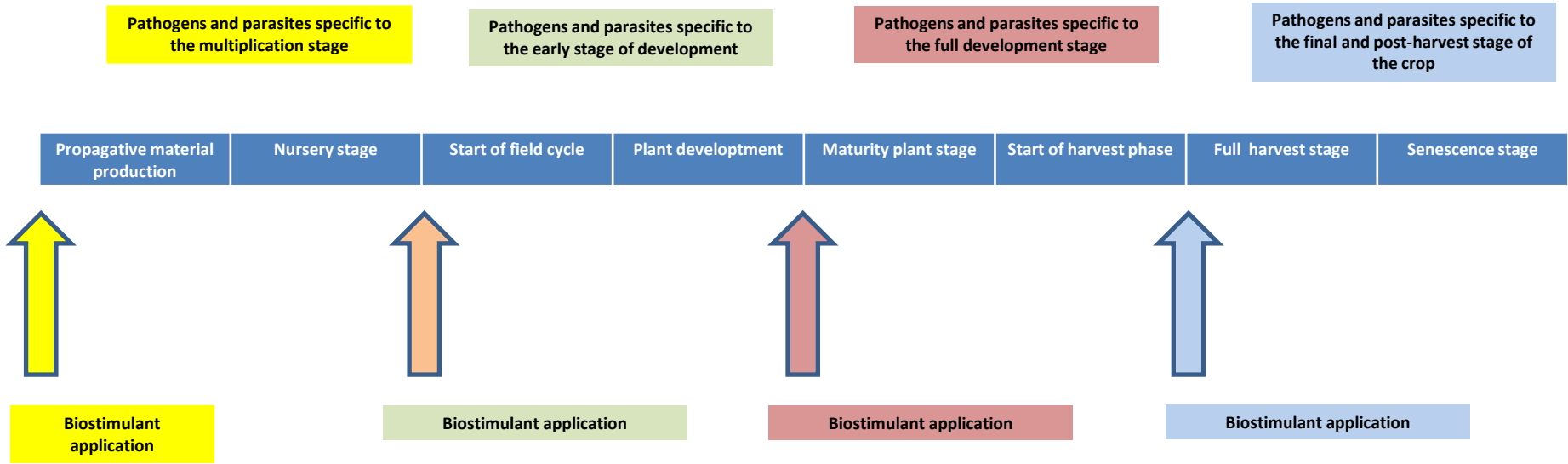


Fig. 1 - Rappresentazione schematica dell'azione dei biostimolanti sulla pianta.

Fig. 1 - Schematic representation of the biostimulants effect on plants.



QUESTION: Do we always have complete knowledge of the interactions between host/environment/parasitic complexes/cultivation technique/FARMER?

The challenges ahead

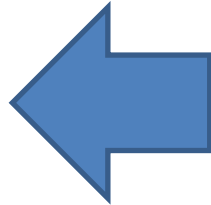
Reconsidering the nursery production scenario within the framework of plant protection product registration regulations

ANNEX III

General principles of integrated pest management

1. The prevention and/or suppression of harmful organisms should be achieved or supported among other options especially by:
 - crop rotation,
 - use of adequate cultivation techniques (e.g. stale seedbed technique, sowing dates and densities, under-sowing, conservation tillage, pruning and direct sowing)
 - use, where appropriate, of resistant/tolerant cultivars and standard/certified seed and planting material,
 - use of balanced fertilisation, liming and irrigation/drainage practices,
 - preventing the spreading of harmful organisms by hygiene measures (e.g. by regular cleansing of machinery and equipment),
 - protection and enhancement of important beneficial organisms, e.g. by adequate plant protection measures or the utilisation of ecological infrastructures inside and outside production sites.

**Healthy propagating material
= pillar of integrated
agriculture (Directive
2009/128/EC)**





NURSERY



IS THE OPERATIONAL SCENARIO THE SAME?




FIELD

Advantages (A) and disadvantages (D) under nursery scenario

1. Highly specialized farms **A**
2. Highly technologically advanced protected cultivation systems **A**
3. Non-exhaustive application labels for applications in the horticultural plant propagation sector **D**
4. Maximum number of applications per year (or per crop cycle) **D**
5. Need of introduction of the concept of application rate per plant for biological pest control **A**
6. Crops "not in contact with the soil" Very high crop density - example tomato
 - Field 20.000 - 40.000 plants/ha
 - Nursery standard plants 4.000.000 – 7.500.000 plants/ha
 - Nursery grafted plants 6.000.000 – 10.000.000 plants/ha

Lack of specific guidelines (evaluation of effectiveness, residues,) dedicated to the scenario "production and multiplication of propagative material" and specifically to pest and disease control

Adoption of the same application GAPs (technical means, application dosages, application intervals, application limitations) of the field production scenario for the "production and multiplication of propagating material"



Objective difficulty – impossibility of producing healthy propagating material (Directive 2009/128/EC)



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Thank You for Your attention

