Root disease management of ornamentals

Stretton Sugwas Village Hall, Stretton Sugwas, Hereford, HR4 7PT (a.m.)

Wyevale Nurseries, Wyevale Way, Kings Acre, Hereford HR4 7AY (p.m.)

26th November 2024

Contents

Agenda

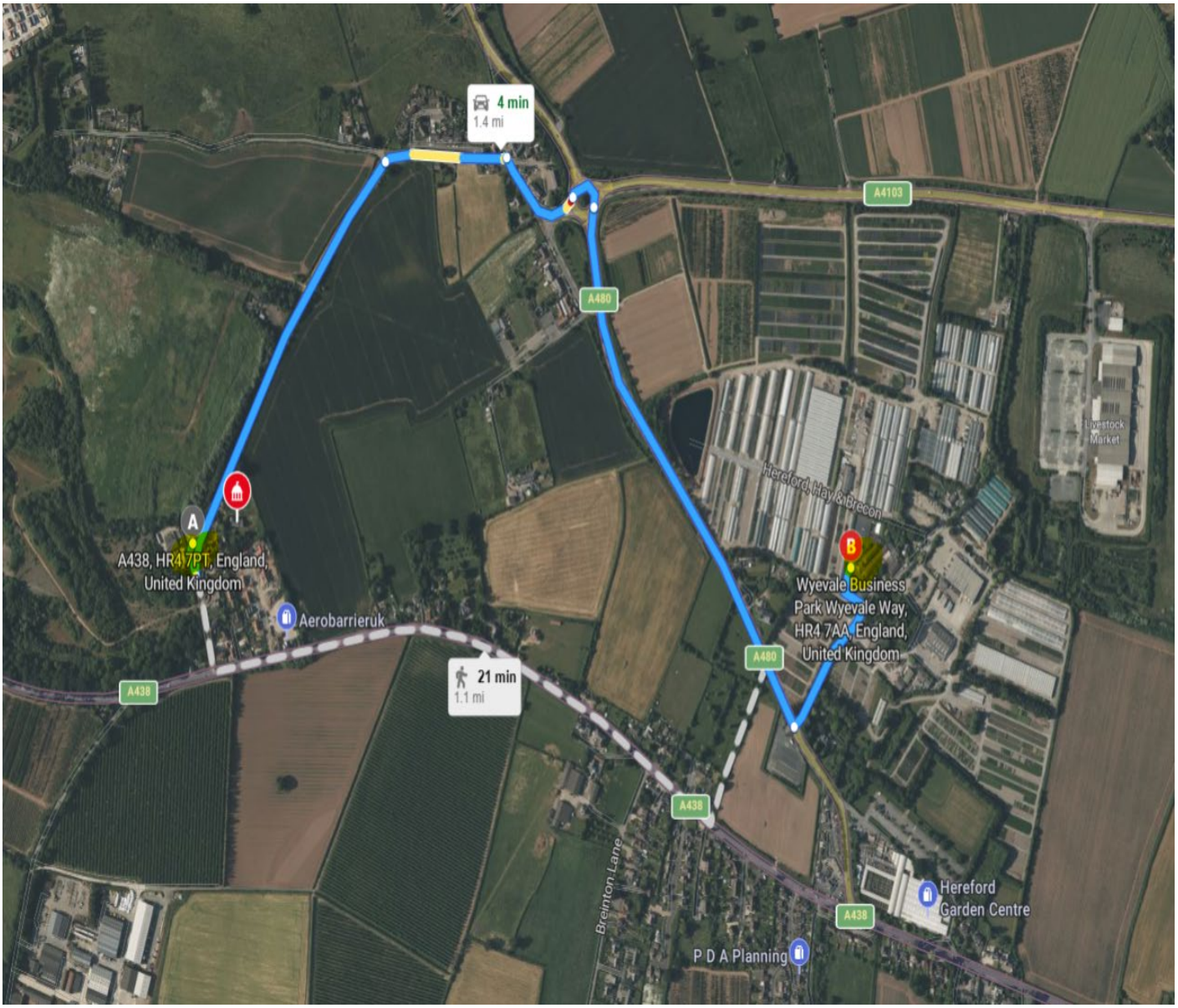
Time	Content	Speaker
Stretton Sugwas Village Hall		
09:00 – 09:30	*Coffee, tea, and refreshments*	
Presentations		
09:30 – 10:10	Root disease challenges in container-grown ornamentals – plant material quality, irrigation water, crop cycles, and growing media considerations.	Selchuk Kurtev, **Zest Sustainable ICM**
10:10 – 10:50	Biology of commonly found root diseases and their diagnosis.	Aiga Ozolina, **Fera**
10:50 – 11:00	*Coffee, tea, and refreshments*	
11:00 – 11:40	Syngenta UK – update on metalaxyl and other developments in the ornamental sector.	Sean Loakes, **Syngenta UK**
11:40 – 12:30	Strategies for root disease prevention and control – crop husbandry and cultural techniques, testing for root pathogens, crop protection options and control programmes.	Selchuk Kurtev, **Zest Sustainable ICM**
12:30 – 13:30	*Buffet lunch*	
Nursery tour (Wyevale Nurseries) and discussion		
14:00 – 14:15	Introduction to Wyevale Nurseries.	Steve Reed/Kyle Ross, **Wyevale Nurseries**
14:15 – 15:30	Nursery tour of Wyevale Nurseries, looking at production facilities, water storage and treatments.	Steve Reed/Kyle Ross/ Selchuk Kurtev
15:30	*Wrap up and depart*	

BASIS and NRoSO continued professional development points will be available on the day of the workshop.

Location

Addresses and locations:

Stretton Sugwas Village Hall, Church Road, Stretton Sugwas, Hereford HR4 7PT (a.m.) (highlighted in yellow on the map) **What3words: ///geology.swerving.bother**	**Wyevale Nurseries, Wyevale Way, Kings Acre, Hereford HR4 7AY (p.m.) (highlighted in yellow on the map)** **What3words: ///bricks.shipped.submerged**



Root disease challenges in container-grown ornamentals.

Selchuk Kurtev, Zest – Sustainable ICM

Notes

PLANTING MATERIAL QUALITY

- Susceptibility to root pathogens
- Changes in the growing media parameters
- Establishment post-planting
- Post-potting care

IRRIGATION WATER QUALITY

- Source of irrigation water
- Irrigation water treatments – see previous workshop
- Irrigation maintenance
- Water storage

IRRIGATION WATER QUALITY

Dear Sirs

The tests on the water sample we received in the laboratory are now complete.

The results can be seen in the table below:

Lab No. & Description	*Pythium spp.* (CFU's/Litre)*	*Phytophthora spp.* (CFU's/Litre)*
TP/7/24 Glasshouse Water	0	0

*CFU = colony forming units

This is the final report from the Bacteriology team, and this completes the work by the team.

A serial dilution was carried out to test for the presence of Xanthomonas arboriocola pv. pruni and Pseudomonas syringae as requested.

Our ref	Your ref	Result	Our comment
2023009240	Reservoir water sample [redacted]	Negative - no pathogen detected	No primary plant pathogenic bacteria isolated.

No primary plant pathogenic bacteria were isolated from the water sample we received. The sample was serially diluted onto semi-selective media and the plates were subsequently examined for growth typical for *Pseudomonas syringae* and *Xanthomonas arboricola pv. pruni*. No growth consistent with either pathogen was observed. As previously stated, this is a non-validated assay and as such a negative result cannot definitively confirm the absence of either pathogen.

I hope this information is of use to you, if you have any queries regarding this report please contact me on the number below.

Once testing is complete we dispose of samples within 10 working days.

Notes

IRRIGATION WATER QUALITY

- pH
- Alkalinity
- Iron
- Sodium and chloride

Determinand	Value	Units	Determinand	Value	Units
pH	7.4		Conductivity	643	uS/cm
Nitrate-N	9.2	mg/l	Chloride	48.5	mg/l
Sulphate as SO4	70.1	mg/l	Phosphorus as P	1.0	mg/l
Boron	0.05	mg/l	Potassium	2.1	mg/l
Copper	< 0.01	mg/l	Magnesium	5.00	mg/l
Manganese	< 0.01	mg/l	Calcium	103.7	mg/l
Zinc	< 0.01	mg/l	Sodium	25.1	mg/l
Iron	< 0.01	mg/l	Carbonate	< 10	mg/l
Alkalinity as HCO3	221	mg/l			

IRRIGATION WATER QUALITY

- pH
- Alkalinity
- Iron
- Sodium and chloride

Sample Point-: Borehole

Test Name	Result	Units	Method No
Colour	Colourless		CHEM001
Clarity	Clear		CHEM001
Odour	None		CHEM001
Taste, Qualitative	Not tested		CHEM001
Solids - Visual	None		CHEM001
pH	8.6	pH Unit	CHEM038
Electrical Conductivity @ 20°C	1300	µS/cm	CHEM038
Total Dissolved Solids - Meter	860	mg/l	CHEM038
Permanganate Value - 4hrs @ 27°C	0.6	mg/l	CHEM006
Ammoniacal Nitrogen as N	1.8	mg/l	CHEM011
Albuminoid Nitrogen as N	0.13	mg/l	CHEM011
Nitrate as N	0.6	mg/l	CHEM028
Nitrite as N	< 0.01	mg/l	CHEM027
Alkalinity, Total as CaCO3	705	mg/l	CHEM038
Alkalinity, Bicarbonate as CaCO3	681	mg/l	CHEM038
Alkalinity, Carbonate as CaCO3	24	mg/l	CHEM038
Alkalinity, Hydroxide as CaCO3	< 15	mg/l	CHEM038
Hardness, Total as CaCO3	120	mg/l	CHEM092
Chloride	65	mg/l	CHEM028
Sulphate	49	mg/l	CHEM028

IRRIGATION WATER QUALITY

- pH
- Alkalinity
- Iron
- Sodium and chloride

Sample Point-: Borehole

Test Name	Result	Units	Method No
Cadmium, Total	< 0.0002	mg/l	CHEM092
Chromium, Total	< 0.0003	mg/l	CHEM092
Copper, Total	< 0.0017	mg/l	CHEM092
Iron, Total	0.031	mg/l	CHEM092
Potassium, Total	2.8	mg/l	CHEM092
Manganese, Total	0.0086	mg/l	CHEM092
Sodium, Total	320	mg/l	CHEM092
Nickel, Total	< 0.0003	mg/l	CHEM092
Lead, Total	< 0.0002	mg/l	CHEM092
Zinc, Total	< 0.0029	mg/l	CHEM092

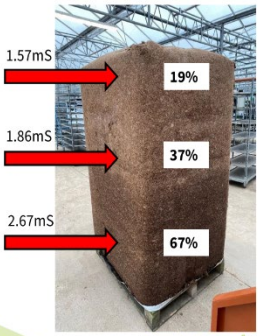
Notes

GROWING MEDIA

- Behaviour of peat-free growing media
- Green waste and bark constituents
- Physical and chemical parameters of growing media
- Storage of growing media

GROWING MEDIA

- Storage of growing media
- EC, moisture percentage and temp.
- Mixing uniformity
- Particle size distribution (PSD)



CROP CYCLES

- Optimum potting times
- Smaller inputs more challenging to establish
- False economy of trying to shorten the crop cycle
- Overwintering in small sized pots is a challenge
- Availability of production beds with different irrigation systems and drainage characteristics
- Influence of pests caused by poor husbandry

Notes

CROP CYCLES

- Potting times are most crucial – which months to avoid!

Annual Weather Averages Near Norfolk

Averages are for Norwich Weather Centre, which is 21 kilometers from Norfolk.
Based on weather reports collected during 1992–2021.

All Year Climate & Weather Averages in Norfolk

High Temp: 22 °C	Precipitation: 42.8 mm	Wind: 17 mph
Low Temp: 3 °C	Humidity: 80%	Pressure: 1015 mbar
Mean Temp: 11 °C	Dew Point: 7 °C	Visibility: 10 km

COMMON ROOT PATHOGENS

- PHYTOPHTHORA SPP.

COMMON ROOT PATHOGENS

- FUSARIUM SPP.

Notes

COMMON ROOT PATHOGENS

- PYTHIUM SPP.

COMMON ROOT PATHOGENS

- RHIZOCTONIA SPP.
- THIELAVIOPSIS SPP.
- OTHERS

SUMMARY

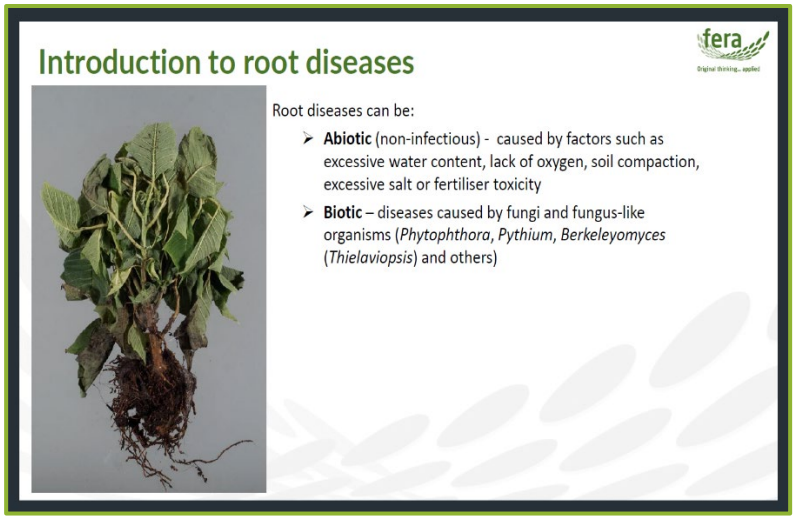
- Stress is the largest contributor to the development of root pathogens
- Crop cycle planning is very important
- Goods-in and plant material quality checks
- Crop husbandry and uniform irrigation
- Mostly reactive approach to root pathogen control in the industry
- Incorporating plant protection products into the growing media is not the solution – addressing the symptoms not the cause!

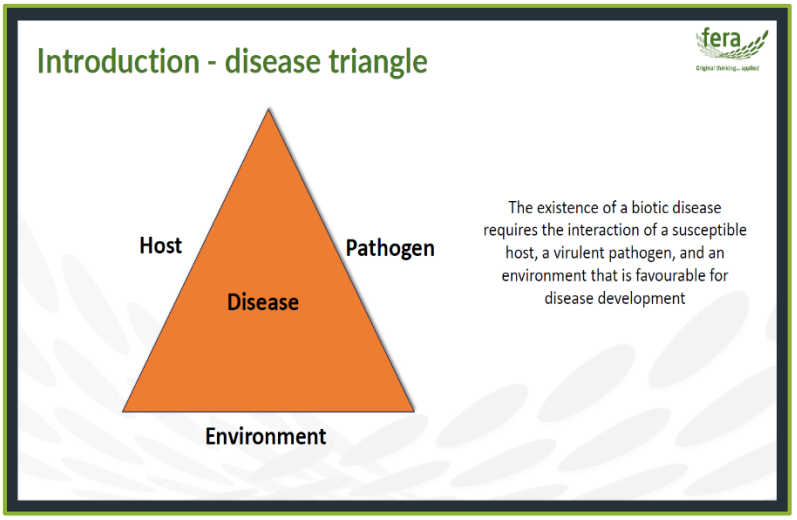
Notes

Biology of common fungal root pathogens and their diagnosis.

Aiga Ozolina, Fera Science Ltd.

Notes

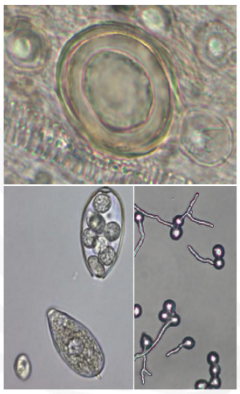




Phytophthora

- Species of *Phytophthora* are among the most significant plant pathogens affecting a broad range of ornamental, horticultural, and forest plant species, including annuals, perennials, trees and shrubs
- *Phytophthora* does not need the host to be weakened and will attack healthy plant tissue
- *Phytophthora* species typically attack the root system and stem base of the plant, but they may also infect the aerial parts of a plant directly
- Symptoms:
  - root and stem base rot, leading to
  - wilt
  - gradual fading of colour from the foliage
  - shedding of leaves
  - dieback

Phytophthora – biology



Phytophthora species produce several types of structures for survival, dispersal and infection:

- Oospores – sexual reproductive spores that are thick-walled, globose or lens-shaped. Oospores enable long-term survival.
- Chlamydospores – thick-walled, long-term survival spores produced asexually by some *Phytophthora* species.
- Sporangia - release short-lived, motile zoospores that can actively swim in water for several hours. When they stop swimming, zoospores form cysts that germinate and form filamentous structures (hyphae).

Phytophthora – life cycle

Oospores or chlamydospores germinate under suitable environmental conditions; hyphae grow though soil and infect roots.

In infected plants, sporangia are produced. Sporangia release motile zoospores that swim in water reaching and infecting new plants.

In infected plants, resting structures (oospores and chlamydospores) are also formed.

As infected plant tissues decay and disintegrate, oospores are released in the environment and can remain dormant for many years.

Notes

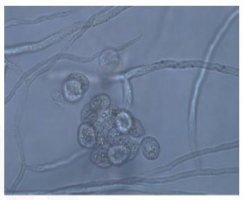
Phytophthora – spread and survival

- *Phytophthora* resting spores can survive in soil and plant debris for many years
- Contaminated soil, compost, water, equipment and footwear may all harbour the pathogen
- Root-rotting species such as *P. citricola* can sometimes affect foliage if spores or contaminated soil are splashed onto it
- Spread can occur via movement of infected plants
- Standing water and waterlogged soil/growing media promote the spread of *Phytophthora*

Pythium

- *Pythium* species are a group of fungus-like organisms, closely related to *Phytophthora*
- Can cause disease in seedlings, cuttings, bedding plants and pot plants
- Larger shrubs and trees usually tolerate *Pythium* infection without adverse effects
- All plant parts can be infected, but *Pythium* usually attacks the roots and stem base
- Symptoms:
  - damping-off of seedlings (pre- or post-emergence)
  - root and stem base rot leading to
  - yellowing, wilting and stunting of aerial plant parts

Pythium – biology



- *Pythium* species produce swimming zoospores, and the disease is therefore more damaging when the growing medium is wet.
- *Pythium* also produce long-lived resting spores (oospores and chlamydospores). These are released from the decaying plant tissue and can contaminate most parts of a nursery such as floors, benches, capillary matting, Danish trolleys, etc. Footwear may also become contaminated, as may re-circulated irrigation water.

Notes

Pythium – life cycle

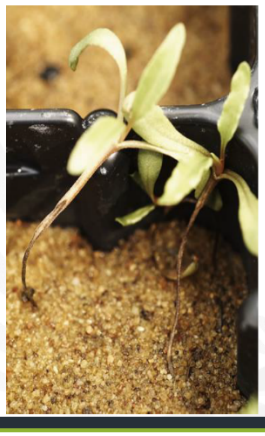
Formation of oospores that can remain dormant in soil for many years.

Oospores germinate under suitable environmental conditions, hyphae grow though soil and infect roots or seedlings.

In infected plants, sporangia and new oospores are produced.
Sporangia release motile zoospores that swim in water reaching and infecting new plants.

As infected plant tissues decay and disintegrate, oospores are released in the environment.

Pythium – spread and survival



- *Pythium* can survive in plant debris and soil for many years
- Contaminated soil, growing media, irrigation water, equipment, tools, surfaces and footwear may harbour the pathogen
- Spread may occur via movement of infected plants
- Sciarid and shore flies can become contaminated with *Pythium* and spread the disease
- Over-watering and excessive fertilizer levels promote the growth of *Pythium*
- *Pythium* damage tends to be more severe when soil moisture is high, and at temperatures between 18-24°C

Phytopythium

- *Phytopythium* is a relatively new group of organisms separated from the *Pythium* genus
- *Phytopythium* species are morphologically intermediate between the genera *Phytophthora* and *Pythium*
- Importance of *Phytopythium* species and their prevalence are not as well known as *Phytophthora* and *Pythium*
- Many *Phytopythium* species are considered to be saprophytic but there are some species which are pathogenic to plants. For example, *Phytopythium vexans* can cause root and crown rot in plants from different families including Camellia, Dianthus, Hydrangea, Lupins and many more.

Notes

Black root rot

Caused by ***Berkeleyomyces basicola*** or ***Berkeleyomyces rouxiae*** (previously ***Thielaviopsis basicola)***

- Common, cosmopolitan disease known since the mid 1800s
- Serious root pathogens, known to infect more than 230 woody and herbaceous plant species worldwide, including ornamentals
- Attacks living roots slowly, causing the following symptoms:
  - rotting roots with black lesions
  - yellowing of leaves
  - wilting and stunting of foliage
  - branch dieback
  - plant death

Black root rot – life cycle

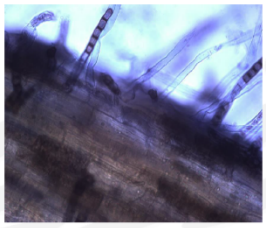
Resting spores in the soil can survive for many years and germinate in the presence of host root exudates

Fine root infection and colonisation of the roots occurs

Spore (endoconidia) production on the infected tissue surface leads to secondary infections

As root tissues start to die off, abundant resting spore (chlamydospore) production occurs, resulting in increased inoculum load in the soil

Berkeleyomyces spp. produce two spore types:
Endoconidia - relatively short-lived, contribute to rapid local spread of infection
Chlamydospores (resting spores) - dark and thick- walled, capable of long-term survival.



Black root rot - survival and spread

- **Soil environmental conditions are critical** for the development of black root rot:
  - Temperatures of 20-25°C are optimal for the growth of the fungus, with little growth at <10°C or >35°C
  - High soil water content increases disease which tends to be more severe in wet, poorly drained soils
  - Neutral to alkaline soil pH favours growth of the fungus. Soil pH below 5.6 has been reported to decrease disease severity
- Chlamydospores can survive in compost, soil or in plant debris as well as inert substrates such as pots, trays, benches, floors and tools
- Local spread during irrigation via water splash, on fragments of old infected plant debris and on infected plants. Spore dissemination by sciarid flies (fungus gnats) has also been demonstrated.
- Longer distance spread by movement of infected plant material or contaminated soil/growing media

Notes

Fusarium

- *Fusarium* species are common in soil, sometimes occur in freshwater, and are found on a wide range of hosts associated with the roots, stems, leaves or seeds
- *Fusarium* species can act as:
  - primary pathogens (especially special forms or *formae specialis* of *Fusarium oxysporum*)
  - secondary invaders of plants weakened by environmental stress or other diseases or pests
  - components of disease complexes together with other fungi or nematodes
- Symptoms:
  - damping-off of seedlings
  - root or stem base rot
  - stunted growth
  - yellowing and wilting of foliage (often along one side of plant)
  - plants may appear water-stressed, foliage may become brown and die

Fusarium - biology

- *Fusarium* forms several types of spores:
  - chlamydospores – thick-walled resting spores for long-term survival
  - Microconidia and macroconidia – short-lived asexual spores, formed in great numbers on infected plant tissues and spread to other plants via water splash, air currents or insect vectors
- *Fusarium* spores are typically formed in a slimy matrix facilitating dispersal by means of water splash
- *Fusarium* colonises the vascular tissues of plants (xylem vessels) and blocks them. This then leads to wilt and other aerial symptoms.

Fusarium - life cycle

In favourable conditions, chlamydospores germinate and produce hyphae (mycelium)

Hyphae reach roots and infect via root tips or wounds. Primary infection can also be seed-borne.

Mycelium spreads from the roots to the xylem vessels in the stem base and main stem, symptoms occur

Microconidia and/or macroconidia form on infected plant parts and spread to other plants via water splash, air or insect vectors

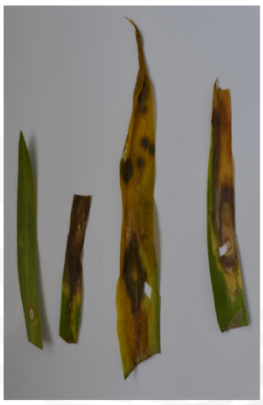
As host plant tissues decay, resting spores are released in the soil where they can survive for many years

Notes

Fusarium - survival and spread

- *Fusarium* is spread in contaminated soil, water and infected cuttings
- Spores formed on an infected crop may become airborne and contaminate greenhouse structures
- *Fusarium* can survive on plant debris, greenhouse floor, tools and machinery, trays, pots, utensils and in irrigation water
- Seed-borne transmission can occur in some plant pathogenic *Fusarium* species
- Insects, especially fungus gnats (sciarid flies) can vector of *Fusarium* spp. in greenhouses and nurseries
- Warm temperatures, high relative humidity, overwatering and poor drainage are favourable conditions for *Fusarium* growth
- Plant density can influence disease severity

Fusarium agapanthi



- *Fusarium agapanthi* is a relatively new species, first described in 2016 causing leaf and stem spots and rots in *Agapanthus* in Italy and Australia
- Detected in UK-grown *Agapanthus* with leaf spots and rots in March 2020
- Since then, there have been several separate findings on *Agapanthus* plants of UK origin, associated with:
  - leaf spots and rots
  - root rots
  - stem base rots

Rhizoctonia root and stem rot

Symptoms:

- damping-off of seedlings
- brown lesions on roots
- brown rot of stems at soil line (e.g. Carnation, Lobelia, Poinsettia)
- neck and bulb rot (e.g. Iris, Gladiolus)
- yellowing and wilting of leaves
- *Rhizoctonia* can also cause aerial blights (web blight)

Excessive soil moisture and high temperatures encourage *Rhizoctonia* infection

Notes

Rhizoctonia - life cycle

Mycelium or sclerotia overwinter in soil, plant debris or host plants

During favourable conditions, new hyphae grow through soil and infect host plant roots

The fungus feeds on the plant's cell resources and produces mycelium and sclerotia (survival structures) in and on the roots/stems

As root tissues start to die off, mycelium and sclerotia are released into soil

Rhizoctonia – survival and spread

- Excessive soil moisture and high temperatures encourage *Rhizoctonia* infection
- The seedling stage is the most susceptible to *Rhizoctonia* infections, and plants become less vulnerable as they age
- *Rhizoctonia* is typically found in the upper layers of the soil and infects plants at stem base, spreading to the root system and stems
- Spreads with infected seed, infected cuttings, growing media, splash from overhead watering, contaminated irrigation water, equipment and footwear, infested trays, tools and equipment
- *Rhizoctonia* rarely forms airborne spores

Aucuba – leaf blackening

If aerial plant parts show disease symptoms, it is important to check the root health. A good example of this is *Aucuba* leaf blackening.

- Causes:
  - Abiotic root stress (e.g. waterlogging)
  - *Phytophthora* root infection (*Phytophthora pachypleura*)
- Symptoms:
  - blackened leaves
  - branch dieback
  - root rot
  - plant death

Notes

Mixed infections

- Mixed infections in plants are not uncommon
- E.g. Lavender can be infected by one or more root pathogens as well as aerial diseases such as:
  - Shab disease (*Phomopsis* or *Phoma lavandulae*) that causes stem dieback and shoot wilt in Lavender, forming globose fruiting bodies on the dying plant tissues. Shab disease spreads by water-splash, air currents or infected plants
  - Grey mould (*Botrytis cinerea*) - a common opportunistic pathogen that can cause dieback in a wide range of hosts

Plant Health at Fera

Over 30,000 samples a year from UK & international customers

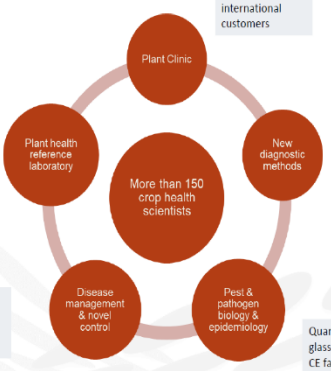
Molecular Technology Unit

Validated assays for both lab & field

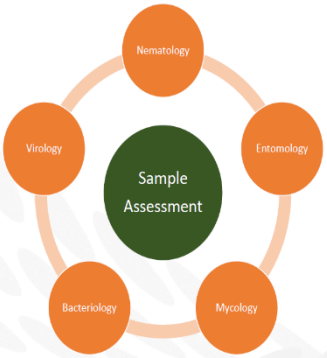
Support & advice to Defra & other overseas governments

Crop protection services: development, evaluation, efficacy & resistance

Quarantine glasshouses & CE facilities



Plant Clinic at Fera



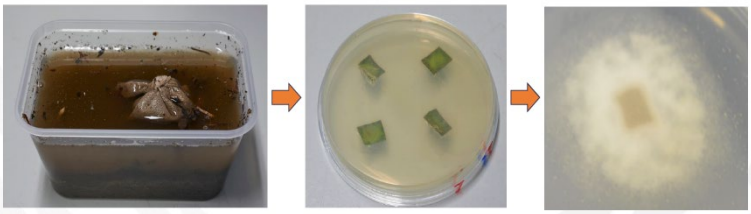
- Fera's Plant Clinic is the largest in the UK. Our work supports healthy plants and crops, increasing sustainable food production and protecting the environment.
- We carry out diagnostics on a range of issues from samples all over the world. We have extensive expertise in fungal, bacterial, viral, insect and nematode identification.
- We can identify plant pests and pathogens found in ornamental plants, arable crops, vegetables, trees, protected edibles, seeds, soft fruit, soil and water.
- "Diagnose my plant" test
  Examination of a sample by our plant pathologists to assess the most probable cause and appropriate method of testing.
- "Diagnose my fungal problem" test
  This test is for symptomatic/diseased plants to confirm the presence of a primary fungal pathogen within a sample. This test involves a visual examination of the plants for the signs and symptoms of a fungal problem and if necessary, incubation and isolation to induce sporulation of any fungi present.

Notes

Root testing for fungal plant pathogens – microscopic examination

Using this method, resting structures (chlamydospores, oospores and microsclerotia) of a range of fungal pathogens can be directly observed in infected fine roots

Soil or water sample testing for *Phytophthora* & *Pythium*– bait tests



Using this soil or water bait test method, a wide range of *Phytophthora* and *Pythium* species can be detected

fera

Original thinking... applied

Thank you for your attention

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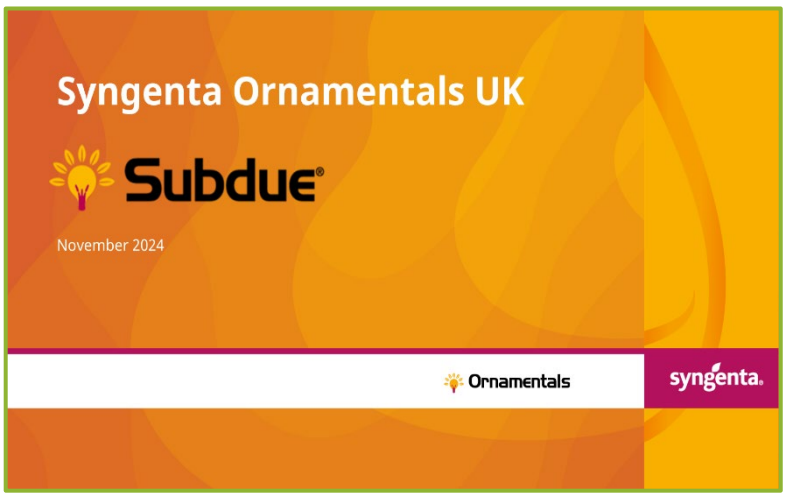
@ferascience
https://www.fera.co.uk/crop-health/plant-clinic

Notes

Syngenta Ornamentals UK – update on metalaxyl and other developments in the ornamental sector.

Sean Loakes, Syngenta UK



Notes

Ornamentals

Syngenta has a dedicated ornamentals business which support the development of products and services for the Ornamental Sector

www.syngentaornamentals.co.uk

syngenta

Fungicides

PGR

Bonzi® Ornamental growth regulator

Amistar®

Subdue®

Switch®

Insecticide

Mainspring® Insecticide

Bios

Hicure® Biostimulant

Taegro®

Elasto G5® Adjuvant

syngenta

Biologicals

Ornamentals

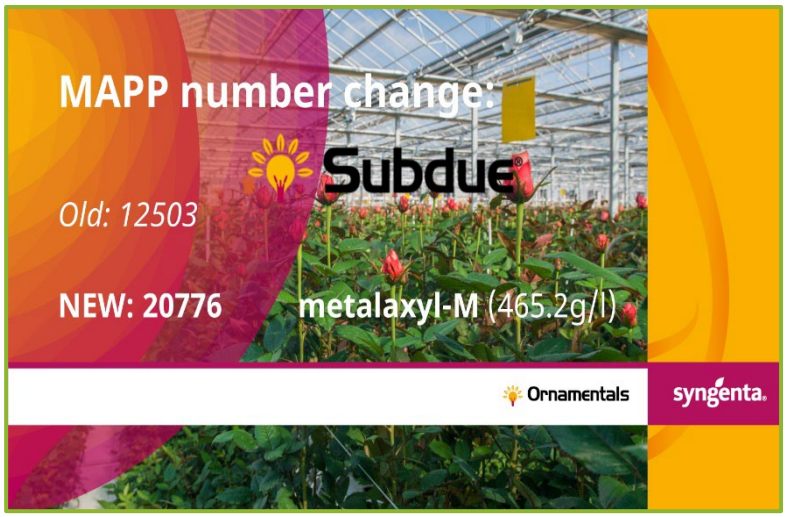
Syngenta development

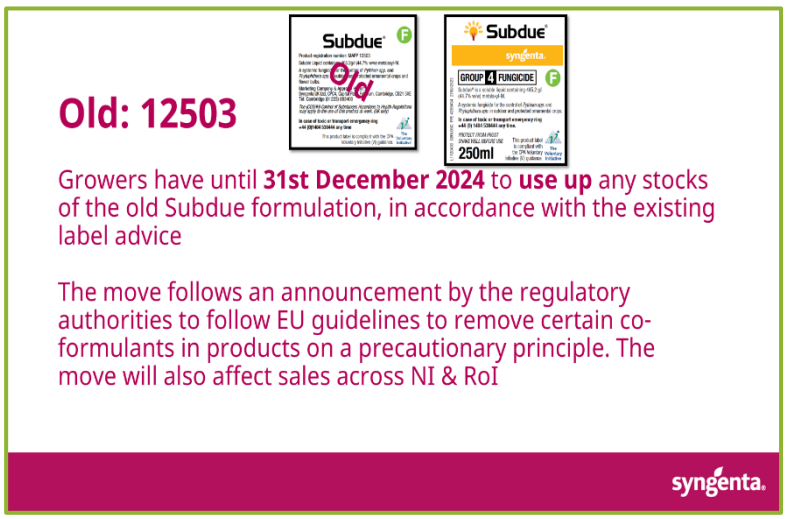
Product type	Research	Early development	Late development	Target
Biofungicide*			2022	Powdery mildew, botrytis
Fungicide			2022	Oomycetes
Bioinsecticide*			2022	Thrips, black vine weevil
Insecticide			2023	Lepidoptera
Fungicide			2023	Botrytis
Biofungicide*		2024		Botrytis
Biostimulant*		2024		Water efficency
Fungicide		2024		Downy mildew
Fungicide		2024		Powdery mildew
Bioinsecticide*		2025		Box tree moth
Biocontrol herbicide*		2025		Broad leaved weeds & grasses
Bioinsecticide*		2025		Mites, sucking insects
Biofungicide *		2025		Botrytis, powdery mildew
Fungicide		2025		Botrytis
Biofungicide*	2025			Powdery mildew, downy mildew
Bioinsecticide*	2025			Pest control
Bioinsecticide*	2026			Black vine weevil
Bioinsecticide*	2026			Lepidoptera
Biofungicide*	2028			Botrytis, powdery mildew
Insecticide	2028			Black vine weevil

A long list of exciting products to come from Syngenta

syngenta

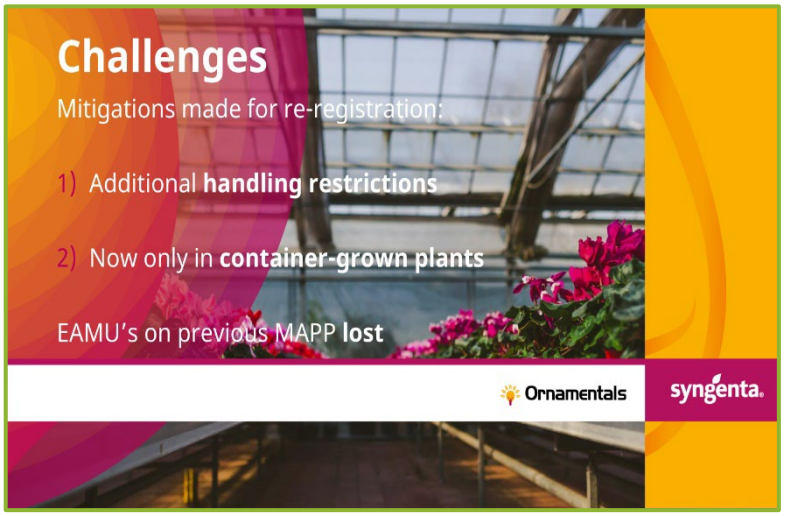
Notes


MAPP number change:
Subdue
Old: 12503
NEW: 20776
metalaxyl-M (465.2g/l)
Ornamentals
syngenta

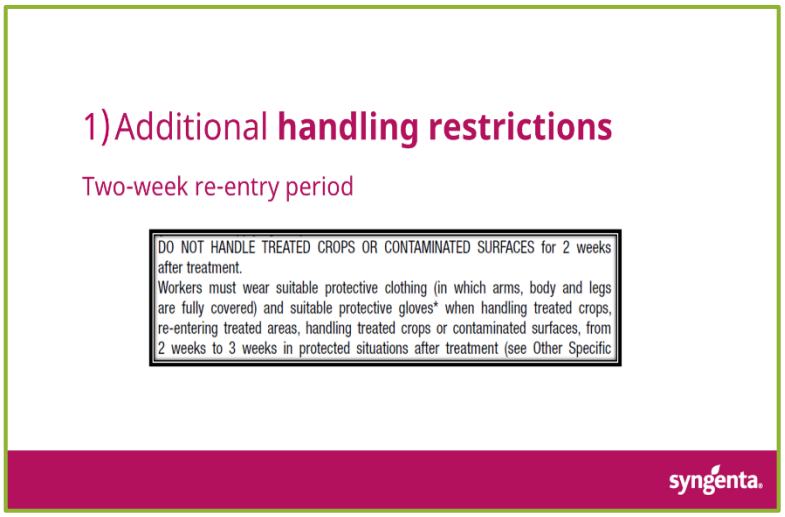

Old: 12503
Subdue
Old
Subdue
syngenta
GROUP 4 FUNGICIDE
250ml
Growers have until 31st December 2024 to use up any stocks of the old Subdue formulation, in accordance with the existing label advice
The move follows an announcement by the regulatory authorities to follow EU guidelines to remove certain co-formulants in products on a precautionary principle. The move will also affect sales across NI & RoI
syngenta


NEW: 20776
Subdue
Re-registered and new label to allow us to retain Subdue for use by UK growers.
Ornamentals
syngenta

Notes


Challenges
Mitigations made for re-registration:
1) Additional handling restrictions
2) Now only in container-grown plants
EAMU's on previous MAPP lost
Ornamentals
syngenta


Positives
New label is more flexible than other EU countries
They only have soil mixtures NOT drench
The rates they have are much lower than UK
Ornamentals
syngenta


1) Additional handling restrictions
Two-week re-entry period
DO NOT HANDLE TREATED CROPS OR CONTAMINATED SURFACES for 2 weeks after treatment.
Workers must wear suitable protective clothing (in which arms, body and legs are fully covered) and suitable protective gloves* when handling treated crops, re-entering treated areas, handling treated crops or contaminated surfaces, from 2 weeks to 3 weeks in protected situations after treatment (see Other Specific
syngenta

Notes

2) Now only in **container-grown plants**

IMPORTANT INFORMATION
FOR USE ONLY AS A PROFESSIONAL FUNGICIDE

Crops/ situations	Maximum individual dose	Maximum total dose	Maximum number of treatments	Latest time of application
Ornamental plant production (outdoor, container grown)	3.125 L/ha (see 'OSR 1')	-	1	-
Ornamental plant production (protected, container grown)	6.25 L/ha (see 'OSR 2')	-	1	-

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Resistance management

We must **rotate** product mode of action (MoA) use to block the development of fungicidal resistance

Download the free **FRAC app** to easily reference the different MoA's

Subdue®
syngenta.
GROUP 4 FUNGICIDE F

FRAC FUNGICIDE RESISTANCE ACTION COMMITTEE

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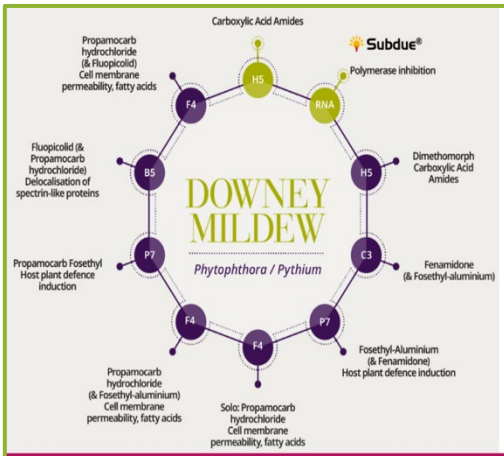

MoA maps, Labels and SDS available on the website

www.syngentaornamentals.co.uk

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Notes

FURTHER REGULATORY UPDATE

- **Paraat MAPP 15445 (dimethomorph) – EAMU 2029/24 – Exp. date 31st January 2030**
  - Downy mildew approval – minimum 600L/ha water volume
  - Other products containing this active substance also at risk (Percos etc.)
  - Anticipated withdrawal earlier than expiry date
- **Promess MAPP 16008 (propamocarb hydrochloride) – EAMU 0796/16 – Exp. date 15th December 2027**
  - Approved for use in propagation area or young plants as drench – not for saleable stock
  - For saleable stock – foliar spray only
  - Medium risk of renewal

FURTHER REGULATORY UPDATE

- **Previcur Energy MAPP 15367 (fosetyl-aluminium/propamocarb hydrochloride) – EAMU 1557/11 – Exp. date 15th September 2027**
  - Drench for root diseases – 3ml/m^2 of product in 2-4L/m^2 of solution
  - 21 days harvest interval, can be used on all stages of crop
  - Low risk of renewal – anticipated to be safe for renewal

HCP ONGOING WORK

- **Ornamentals Committee is looking at EAMUs for drench options:**
  - **Folpet –** exp.date 15th August 2027, multi-site MoA, efficacy on broad spectrum pathogens incl. Pythium, Phytophthora, other oomycetes, Rhizoctonia, Sclerotinia, Fusarium spp (suppression). Renewal is looking very likely with some restrictions
  - **Mefentrifluconazole –** exp.date 20th September 2031, FRAG 3, translaminar and strong persistency, broad spectrum activity including Fusarium (moderate), Thielaviopsis, Phomopsis, Phoma, Alternaria, some rusts species, Ramularia, Sclerotinia. Recently approved active, can have stunting effect and phytotoxicity
  - https://hcpltd.org/

Notes

Strategies for root disease prevention and control.

Selchuk Kurtev, Zest Sustainable ICM

Strategies for root disease prevention and control – crop husbandry and cultural techniques, testing for root pathogens, crop protection options and control programmes

Selchuk Kurtev, Zest Sustainable ICM

WHAT I WILL COVER

- Crop husbandry and cultural techniques
- Testing for root pathogens
- Plant protection product (PPP) options
- The phosphite story
- Control programmes

CROP HUSBANDRY

- Do not re-use pots
- Thorough clean up between crops
- Disinfection of production beds and equipment
- Weekly disposal of dead or dying plants

Notes

CROP HUSBANDRY

- Production beds should be maintained and renewed every 3-5 years – change of sand, capillary matting etc
- Rotate crops wherever possible
- Avoid overfilling pots
- Where mulch is used, reduce spillage
- Overwatering is the largest problem with root pathogens
- Check irrigation system uniformity, address possible leaks and blockages

CULTURAL TECHNIQUES

- Crop densities and ventilation
- Reduce stress/overheating in pots – south/north side of pots
- Potting depth and handling of input material
- Flooding and bed unevenness – pot-in-pot or lift on/in crates
- Care of the planting material pre-potting
- Shading of crops post potting – NOT fleecing!
- Control key growing media parameters – EC, pH and temp.

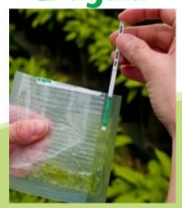
CULTURAL TECHNIQUES

- Use of binding agents to flush excess salinity
- Frost protection
- Soil dwelling pest control
- Do not irrigate overhead after pruning!
- Use of Calcinit (calcium nitrate) to top up and flush excess potassium sulphate

Notes

TESTING FOR ROOT PATHOGENS

- Testing water for pathogens
- In-house water baiting
- Sorbus International and Agdia



TESTING FOR ROOT PATHOGENS (live tissue)

- Tetrazolium salts
- Sigma-Aldrich (Merck)
- Works on any live plant tissue
- Useful in late winter early spring deliveries

PPP OPTIONS – BASAL ROTS

Amistar (MAPP18039)	Azoxystrobin 250g/L	11	2 (4)	(360g a.s/ha)	Gantry sprayer must only be used in PPFE. Resistance management important	No adjuvants, do not apply above 30°C or below 10°C
Amylo-X WG (MAPP17978)	*Bacillus amyloliquefaciens subsp. plantarum* strain D747 250g/kg	BM02	6	-	March to October timing for outdoor crops. Respirator use during application	Can leave light brown spray deposits
Luna Privilege (MAPP18393)	Fluopyram 500g/L	7	2	-	Respiratory equipment must be worn during application. SRSU gloves must be worn for 2 weeks in outdoor situations and protective clothing and SRSU gloves for 5 weeks in protected crops. Managers must carry out a thermal comfort checklist	Very persistent and systemic product, some phytotoxicity possible
Nativo 75 WG (MAPP16867)	Tebuconazole + trifloxystrobin 50g/kg + 250g/kg	3 + 11	2	720g/ha/yr	Container-grown crops only. Protective clothing required for 42 days after treatment. Crop height timing restriction. Managers must carry out a thermal comfort checklist	Efficacious product but check restrictions for handling etc.
Serenade ASO (MAPP16139)	*Bacillus subtilis* strain QST 713 1.015kg/L	BM02	6	-	Respirator use during application	
Signum (MAPP11450)	Boscalid + pyraclostrobin 267g/kg + 67g/kg	7 + 11	2	6.0kg/ha/yr		
Switch (MAPP15129)	Cyprodinil + fludioxinil 375g/kg + 250g/kg	9 + 12	3	-	Max concentration of 80g of product in 100L of water	
Taegro (MAPP16139)	*Bacillus amyloliquefaciens* strain FZB24 130g/kg	BM02	10	-	Latest application 1 day before harvest. Respirator use during application	

Notes

PPP OPTIONS - BLACK ROOT ROT

Amistar (MAPP18039)	Azoxystrobin 250g/L	11	2 (4)	(360g a.s/ha)	Gantry sprayer must only be used in PPFE. Resistance management important	No adjuvants, do not apply above 30°C or below 10°C
Fandango (MAPP17318)	Fluoxastrobin + prothioconazole 100g/L + 100g/L	11 + 3	-	2.5L/ha/yr	Forest nursery only, SRSU gloves for 5 weeks, do not enter crops for 3 days. Must not be applied by handheld equipment	Needle blight EAMU, but will give incidental control of other fungal pathogens
Luna Privilege (MAPP18393)	Fluopyram 500g/L	7	2	-	Respiratory equipment must be worn during application. SRSU gloves must be worn for 2 weeks in outdoor situations and protective clothing and SRSU gloves for 5 weeks in protected crops. Managers must carry out a thermal comfort checklist	Very persistent and systemic product, some phytotoxicity possible
Nativo 75 WG (MAPP16867)	Tebuconazole + trifloxystrobin 50g/kg + 250g/kg	3 + 11	2	720g/ha/yr	Container-grown crops only. Protective clothing required for 42 days after treatment. Crop height timing restriction. Managers must carry out a thermal comfort checklist	Efficacious product but check restrictions for handling etc.
Sercadis (MAPP19716)	Fluxapyroxad 300g/L	7	2	600ml/ha/yr	Handling restrictions for SRSU gloves for 5 weeks for outdoor and 11 weeks for protected crops. Protective clothing for use in treated protected crops for 11 weeks. Apply between 1 April and 30 September to outdoor crops. Must not be used on container-grown crops on non-porous surfaces. Managers must carry out a thermal comfort checklist	Latest EAMU covers narcissus crops
Switch (MAPP15129)	Cyprodinil + fludioxinil 375g + 250g/kg	9 + 12	3	-	Max concentration of 80g of product in 100L of water	

PPP OPTIONS – FUSARIUM SPP.

Amistar (MAPP18039)	Azoxystrobin 250g/L	11	2 (4)	(360g a.s/ha)	Gantry sprayer must only be used in PPFE. Resistance management important	No adjuvants, do not apply above 30°C or below 10°C
Amylo-X WG (MAPP17978)	*Bacillus amyloliquefaciens subsp. plantarum* strain D747 250g/kg	BM02	6	-	March to October timing for outdoor crops. Respirator use during application	Can leave light brown spray deposits
Fandango (MAPP17318)	Fluoxastrobin + prothioconazole 100g/L + 100g/L	11 + 3	-	2.5L/ha/yr	Forest nursery only, SRSU gloves for 5 weeks, do not enter crops for 3 days. Must not be applied by handheld equipment	Needle blight EAMU, but will give incidental control of other fungal pathogens
Prestop (MAPP19458)	*Gliocladium catenulatum* strain J1446 320g/kg	NC	-	-	Min interval between applications of 7 days. Respiratory equipment must be worn during application. Max concentration of 500g/100L must not be exceeded. Growing media incorporation rate 500g product/m3	
Serenade ASO (MAPP16139)	*Bacillus subtilis* strain QST 713 1.015kg/L	BM02	6	-	Respirator use during application	
Signum (MAPP11450)	Boscalid + pyraclostrobin 267g/kg + 67g/kg		2	6.0kg/ha/yr		
Switch (MAPP15129)	Cyprodinil + fludioxinil 375g/kg + 250g/kg	9 + 12	3	-	Max concentration of 80g of product in 100L of water	
T34 Biocontrol (MAPP17290)	*Trichoderma sperellum* strain T34 120g/kg	BM02	1 (2)	-	Respirator use during application, max 10g/L in use concentration. Various application methods	Storage requirement of 4°C, light powder formulation very hydrophobic
Trianum P (MAPP16741)	*Trichoderma harzianum* Rifai strain T-22 10g/kg	BM02	2 (4)	-	Respirator use during application, apply above 10°C, min 4 weeks interval in cultivation and 14 days in propagation	

PPP OPTIONS – PYTHIUM AND PHYTOPHTHORA SPP.

Paraat (MAPP15445)	Dimethomorph 500g/kg	40	2	-	Min 600L/ha water volume	
Prestop (MAPP19458)	*Gliocladium catenulatum* strain J1446 320g/kg	NC	-	-	Min interval between applications of 3 weeks for protected and 7 days for outdoor crops. Respiratory equipment must be worn during application. Max concentration of 500g/100L must not be exceeded	
Previcur Energy (MAPP15367)	Fosetyl-aluminium + propamocarb hydrochloride 310g/L + 530g/L	33 + 28	2	-	Latest application 21 days before harvest. Drench only treatment	
Promess (MAPP16008)	Propamocarb-hydrochloride 722g/L	28	3 (1)	-	Various application methods available including drenches and media incorporation	
Subdue (MAPP20776)	Metalaxyl-M 465.2g/L	4	1	-	Container-grown crops only. Apply at a concentration of 6.25 ml product per 100 litres of water for outdoor crops and 12.5ml product per 100 litres of water for protected crops. Drench volume should correspond to 10% pot volume. Managers must carry out a thermal comfort checklist. No handling restriction for 2 weeks after treatment. Workwear and SRSU gloves for handling crops from 2 weeks to 3 weeks in protected situations	Serious resistance issues, must not be used on its own. Various application methods and rates
T34 Biocontrol (MAPP17290)	*Trichoderma sperellum* strain T34 120g/kg	BM02	1 (2)	-	Respirator use during application, max 10g/L in use concentration. Various application methods	Storage requirement of 4°C, light powder formulation, very hydrophobic
Trianum P (MAPP16741)	*Trichoderma harzianum* Rifai strain T-22 10g/kg	BM02	2 (4)	-	Respirator use during application, apply above 10°C, min 4 weeks interval in cultivation and 14 days in propagation	

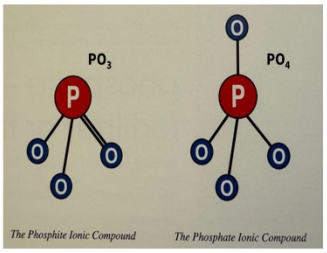
Notes

PPP OPTIONS - OTHERS

- **LALSTOP K61** – relatively new on the market, early indications don't show much of a different efficacy to other bio-fungicides
- **BIOSTIMULANTS**
  - **Plant stress relief options and many others – Zonda, Kelpak, Megafol, Quantis and many others**
  - **Frost protection – ProAct, CropAid, Intracell and many others**
  - **Enhanced root development – HortiPhyte, HortiBoost, VidiParva and many others**

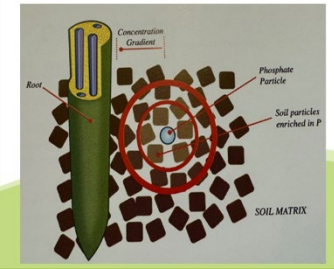
THE PHOSPHITE STORY

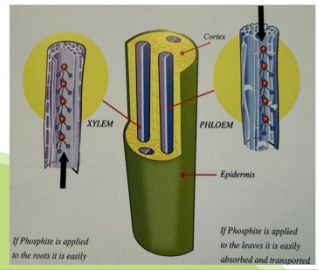
- Fertiliser or a fungicide?
- Developed in the 1980s in Australia
- Registered in 1991 in Australia
- Both fertiliser and as fungicide solo or in co-form
- Challenges with registration and traceability in fresh produce
- In EU arrived in early 2000s
- UK one of the last countries to register fosetyl-aluminium (Aliette)
- PO_3 – liquid
- PO_4 – solid



THE PHOSPHITE STORY

- Often locked up in soil and only small amounts available
- PO_3 – easily absorbed by all plant parts and mobile within the plant
- **Since phosphorus takes part in the bioenergetic plant processes, it triggers Induced Systemic Resistance (ISR) process easily**

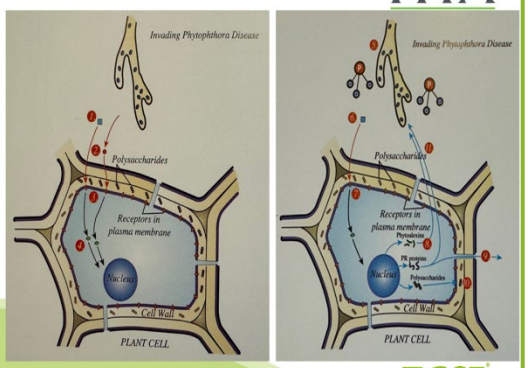




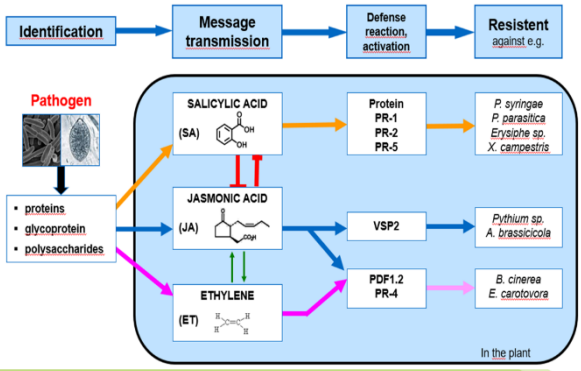
Notes

HOW DOES PHOSPHITE WORK

1. Recognition of pathogen
2. Pathogen masks recognition with suppressors
3. Recognition fails by host cell
4. **Weak signal = delay in defence response**
5. Pathogen affected by phosphite
6. Suppressors under or not produced
7. Recognition of pathogen by host
8. Triggered phytoalexin production
9. Signalling to other cells
10. Polysaccharides strengthen the cell
11. Disease is limited or controlled



PHOSPHITE MECHANISM



- **Previcur Energy**
- **Frutogard**

CONTROL PROGRAMMES – CURRENT

Week 1	Week 2	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 12
Potting	Root growth	Vegetative growth extension			Bud formation			Start of flowering	
T-34 incorporated	**Subdue + HortiPhyte**		**Promess + HortiPhyte**			**Paraat + HortiPhyte**			

- Growing media incorporation of T-34 as standard for susceptible crops
- Subdue + phosphite as standard treatment
- All others have varying degrees of implementation in programmes

Notes

CONTROL PROGRAMMES – FUTURE 1

Week 1	Week 2	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 12
Potting	Root growth	Vegetative growth extension			Bud formation			Start of flowering	
T-34 incorporated	**LalStop K61 + HortiBoost**	**Previcur Energy + HortiBoost**			**Frutogard X2**			**Promess + HortiPhyte**	

- Possibly Lalstop/Prestop likely to become more widely used
- Previcur Energy is likely to become more of a mainstay
- Frutogard is newly registered but rarely used
- Promess remains a propagation/young plant option

CONTROL PROGRAMMES – FUTURE 2

Week 1	Week 2	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 12
Potting	Root growth	Vegetative growth extension			Bud formation			Start of flowering	
T-34 incorporated	**Vidi Parva + HortiBoost**	**Vidi Parva**	**Previcur Energy + HortiBoost**		**Frutogard X2**			**Promess + HortiPhyte**	

- Mixture of reliance on biostimulants and currently approved products
- Most likely we will see use of elicitors and fertilisers applied as foliar or liquid feeds
- Handling restrictions and possible MRL implementations will play a key role

SUMMARY

- **Most likely cultural/crop husbandry measures will be vital**
- **Attention to good nutrition is likely to increase**
- **Supplemented by biostimulants and remaining active substances**
- **Future restrictions on PPPs inevitable**
- **New active substances likely to be more difficult to approve for high volume sprays**

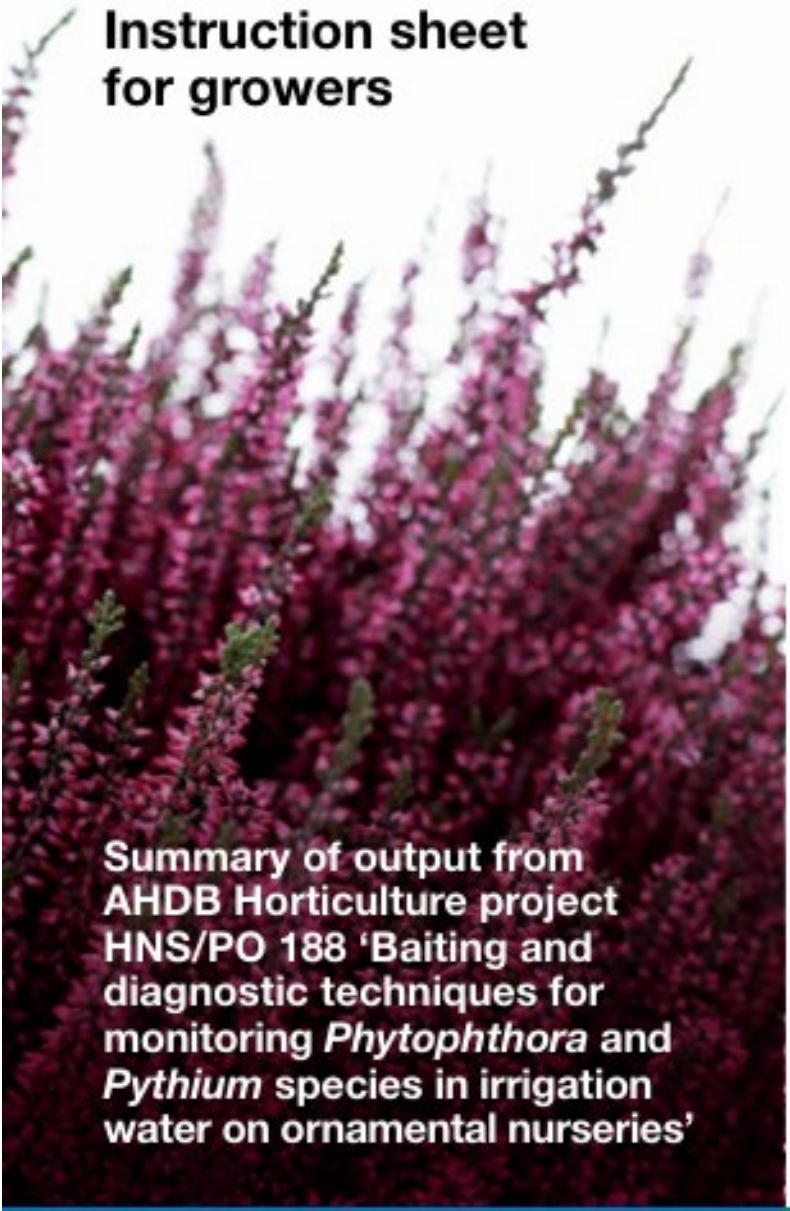
Notes

Appendix

1. Oomycetes: their impact on your business, and the testing and control methods for their elimination - https://horticulture.ahdb.org.uk/oomycetes
2. Testing water for plant pathogens - https://projectblue.blob.core.windows.net/media/Default/Horticulture/Oomycetes/21_15%20Testing%20water%20for%20plant%20pathogens.pdf
3. Methods of water treatment for the elimination of plant pathogens - https://projectblue.blob.core.windows.net/media/Default/Horticulture/Oomycetes/22_15%20Methods%20of%20water%20treatment%20for%20the%20elimination%20of%20plant%20pathogens.pdf
4. Hygiene and disease avoidance underpin the management of Oomycete stem and root rots - https://projectbluearchive.blob.core.windows.net/media/Default/Horticulture/Publications/23_15%20Hygiene%20and%20disease%20avoidance%20underpin%20the%20management%20of%20Oomycete%20stem%20and%20root%20rots.pdf
5. Use of chemical disinfectants in protected ornamental plant production - https://projectblue.blob.core.windows.net/media/Default/Horticulture/Diseases/03_14%20Use%20of%20chemical%20disinfectants%20in%20protected%20ornamental%20plant%20production.pdf
6. Guidelines on nursery hygiene for outdoor and protected ornamental crops - https://projectblue.blob.core.windows.net/media/Default/Horticulture/Publications/Guidelines%20on%20nursery%20hygiene%20for%20outdoor%20and%20protected%20ornamental%20crops.pdf
7. Control of Pythium, Phytophthora and Rhizoctonia in pot and bedding plants - https://projectblue.blob.core.windows.net/media/Default/Horticulture/Publications/Control%20of%20Pythium,%20Phytophthora%20and%20Rhizoctonia%20in%20pot%20and%20bedding%20plants.pdf
8. Control of Phytophthora, Pythium, and Rhizoctonia in container-grown hardy ornamentals - https://projectblue.blob.core.windows.net/media/Default/Horticulture/Publications/Control%20of%20Phytophthora,%20Pythium%20and%20Rhizoctonia%20in%20container-grown%20hardy%20ornamentals.pdf
9. Baiting stored irrigation water to test for the presence of Pythium and Phytophthora - https://projectblue.blob.core.windows.net/media/Default/Horticulture/Publications/Baiting%20stored%20irrigation%20water%20to%20test%20for%20the%20presence%20of%20Pythium%20and%20Phytophthora%20Instruction%20sheet%20for%20growers%20Summary.pdf

Baiting stored irrigation water to test for the presence of *Pythium* and *Phytophthora*

Instruction sheet for growers



Summary of output from AHDB Horticulture project HNS/PO 188 'Baiting and diagnostic techniques for monitoring *Phytophthora* and *Pythium* species in irrigation water on ornamental nurseries'

Pythium and *Phytophthora* water baiting – a quick guide

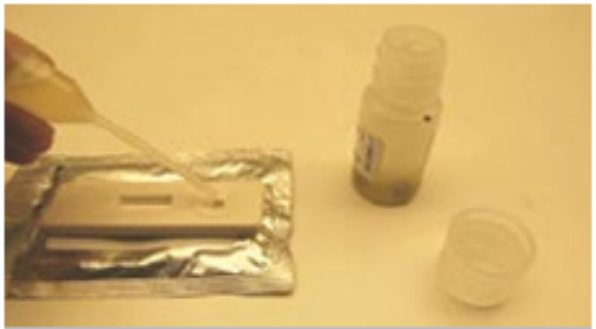
1 Components needed for the bait bag: 7–10g boiled stones, polystyrene, apple pieces, length of string, and fleece (size approximately 28x28cm).

2 To obtain the apple pieces, cut a slice of 'Golden Delicious' apple 7mm thick. From this cut out eight squares approximately 7x7mm from the centre of the apple slice using a clean knife.

3 Place the apple pieces in the centre of the fleece with the stones and polystyrene. Tie up with the string to produce a loose bag.

4 Place the bait bag in the reservoir. Once the fleece is wetted the bag should float below the water surface. Tether the string to the baiting location for 48 hours.

5 Untie the collected bag. With washed hands, place the apple pieces in the buffer bottle. Shake the buffer bottle vigorously for at least one minute until the buffer becomes coloured by the apple.



6 Draw up the apple solution from the buffer bottle and pipette 2–3 drops into the well on the Lateral Flow Device (LFD) test kit. A vertical line should appear next to the C (control), if the test is positive a vertical line should also appear next to the T (test) within 10 minutes.

Instructions for using a Lateral Flow Device

Store test kits at room temperature (up to 40°C), do not refrigerate or freeze.

Step 1: Plant material selection

- Undo or cut open the bait bag and find all eight apple pieces.
- Unless the pieces look soft then break up the apple pieces a little (handle with washed hands or knife) before adding to the buffer bottle (see step 2), or add to the bottle and squash the apple a little with a suitable washed item.

Step 2: Extraction in buffer

- Unscrew the extraction bottle lid and add all the plant material pieces from one bag. Replace the lid tightly. One extraction bottle per bait bag should be used.
- Label the bottle with the sample identity if there is more than one sample.
- Shake the bottle vigorously for 60 seconds so that the ball bearings break the plant cells apart. Shake until the extraction buffer is no longer colourless.
- The buffer should start to become green or brown as the tissue is broken down. If this does not happen the plant pieces may have been too big, or the shaking not vigorous enough.
- Grasping the entire bottle during the process of shaking will normally warm it to above 10°C to enable the extraction process to work.

Step 3: Using the LFD

- If the test is being performed in conditions below 10°C then warm the packaged LFD before opening.
- Remove the test device from its foil packet just before it is needed. **DO NOT TOUCH THE VIEWING WINDOW.**
- Label the front or back of the device with the sample identification and date. The same extraction bottle containing the apple bait can be used with both a *Pythium* and *Phytophthora* lateral flow device.
- Place on a level surface, or in the hand, with the viewing window upwards. Holding the device is recommended if the temperature is below 10°C.
- Allow the plant material a few seconds to settle in the extraction bottle.
- Remove the lid from the extraction bottle, tilt the bottle and draw some of the liquid into the clean pipette from above the apple bait material.
- Gently squeeze two large or three smaller drops of the sample liquid into the sample well of the test device (so the liquid is below the rim of the well). Aim to release the liquid without air bubbles as these can break the flow of the liquid across the device.
- After about 30 seconds a pale blue or pink line* will appear in the viewing window as liquid flows along the test device.
- If no line becomes visible in the viewing window after 30 seconds, another drop of sample can be added to the sample well. Using too much liquid however will flood the strip and will cause the test to run incorrectly.
- If the test still runs very slowly tap the device gently to remove any air bubbles.
- If too much debris has been added with the sample liquid the test will run slowly. It may be necessary to use a new device with clearer liquid from the extraction bottle.

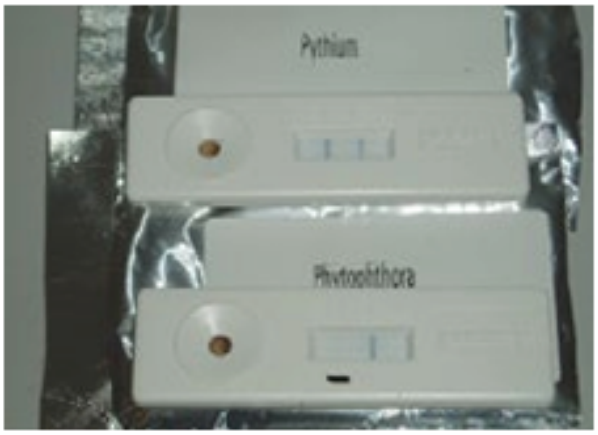
*The colour of the line depends upon the LFD used, with Forsite Pocket Diagnostic test kits the line will be blue, in the case of Neogen Alert-LF kits the line will be pink.

Step 4: Examining the results

- A vertical line (the 'Control' line) will appear next to the letter 'C' on the device. This line confirms the test is working properly.
- If the test is positive, a second line, the 'Test' line (next to the letter 'T'), will appear. Even a faint line means the result is positive and so the test should be examined in a location that is well illuminated.
- The lines can appear in *Pythium* and *Phytophthora* kits within 3–4 minutes of adding the sample to the device, but may take up to 10 minutes.
- Read the result within 10 minutes of adding the sample to the device. Ignore any changes that happen after 10 minutes. For future reference (if required), an image of the LFD can be taken, ensure the front is appropriately labelled with any sample details.
- Where comparison of the strength of the line between samples is being sought for research purposes the LFD should be placed against a similar coloured background and read under the same light level.
- After use, if a secondary confirmatory test is required on DNA extracted from the LFD, the test devices should be returned to the foil packet with the silica gel sachet provided.

Step 5: Interpretation of the results

- A positive result indicates that the plant material sampled contains the pathogen under test.
- Under some circumstances, laboratory confirmation of an on-site test result may be necessary.
- A negative result indicates that the target pathogen was not detected in the test sample. As with all diagnostic testing, a negative result does not confirm that the location is free from the pathogen under test.
- A faint or absent line may indicate a low concentration of the pathogen, uneven distribution in the host, or recent infection.



Problems with the readings

- Faint test lines are caused by either low pathogen concentration, uneven distribution, too small a sample, sample not broken up enough, or sample not shaken for long enough. If in doubt, repeat with a new device using a fresh sample, or repeat again in a few days time.
- 'T' line visible, but no 'C' line may be due to a high level of pathogen in the sample, preventing the test from working properly. Dilute the sample 1 in 10 and 1 in 100 with fresh buffer and retest with a new device.
- No 'T' line, no 'C' line can occur when too much sample material is added. Retest with a new device.

Want to know more?

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FACTSHEET 21/15

Cross Sector

Dr Tim Pettitt, University of Worcester

Testing water for plant pathogens

Water for irrigation can easily become contaminated with potential plant pathogens and, whether a new source of water is being considered or there are concerns with the current supply such as possibly contaminated storage tanks or the occurrence of suspicious disease outbreaks, water testing is essential for guiding management decisions.

However, the approach to testing can strongly influence the value of the results. This factsheet explains the appropriate testing that is currently available to properly assess the disease risks and outlines interpretation of results, together with the questions to ask a prospective test provider.

Figure 1. Water testing equipment

Figure 2. Water filter

Action points

Why test water for plant pathogens?

- Water can easily be contaminated with plant pathogens and rapidly initiate and spread plant diseases – testing will detect contamination.
- Tests help identify the source of contamination – allowing effective treatment.
- Monitoring the efficacy of water treatment systems.
- Compliance with accreditation.
- There is no reliable way of visually assessing the level of pathogen contamination as water containing large numbers of infective pathogen spores can still appear 'crystal clear'. A true and reliable measure of the risks can only really be obtained by carrying out microbiological tests.

Types of water tests available for plant pathogens

The reasons for needing to test water for potential plant pathogens vary and are summarised in figure 3, which also indicates the most appropriate testing approach for each situation. Tests can either be 'specific', focusing on one genus or even species of pathogen or one particular disease problem, or more 'general', screening for a wider range of pathogens and attempting to use certain, more commonly seen, non-pathogens as indicators.

Specific testing

- Specific testing is very useful when dealing with a known disease problem, especially within a closed irrigation system under protection. It also has a vital role in the detection of notifiable pathogens (eg *Phytophthora ramorum*) and the Animal and Plant Health Agency (APHA) has an array of sophisticated tests available to their inspectors for this purpose.
- In certain circumstances, general tests can identify situations when a specific test is needed as a follow on, especially when testing potential new sources of irrigation water.
- The main potential pitfall to specific testing for single species or genera is the danger of getting a false sense of security from regular negative test results, while actually missing other pathogen species that might be present. Using specific tests as the sole assessment of water-borne disease risks on a nursery is very unwise.

General testing

- General testing is the most appropriate approach for testing the efficacy of water treatment systems on nurseries, where specificity to genus/species is not necessary. Pathogen propagules are usually relatively rare. More commonly occurring non-pathogen relatives can be detected and used as indicator species. For example in the case of *Pythium* and *Phytophthora*, related Oomycete species such as *Saprolegnia ferax*, which lives on debris and insect remains, is very common in untreated irrigation water. An effective water treatment system will remove these propagules in the same way it would remove pathogen spores and so, if they are detected in treated water, this gives an early warning of possible treatment failure.
- General testing is also effective for regular assessments of clean irrigation systems for early signs of contamination.
- The most common causes of system contamination are flooding (eg increased disease risks associated with contamination of boreholes by flooding – table 1) and the damage or removal of storage tank covers.
- Currently, the most economic general testing method is membrane filtration, followed by selective agar plating. General tests normally will include media for total Oomycete propagule counts (this includes many non-pathogens as well as *Pythium*, *Phytophthora* and *Aphanomyces*), for total filamentous fungus counts and for total bacteria counts.
- General tests can be tailored to specific situations, for example, if a nursery has a concern about *Fusarium*, semi-selective agar media for this group can easily be included in the test. Tests can be made specific by subculture of selected colonies and identifications by morphology or molecular methods (although this generally takes more time and incurs greater costs).

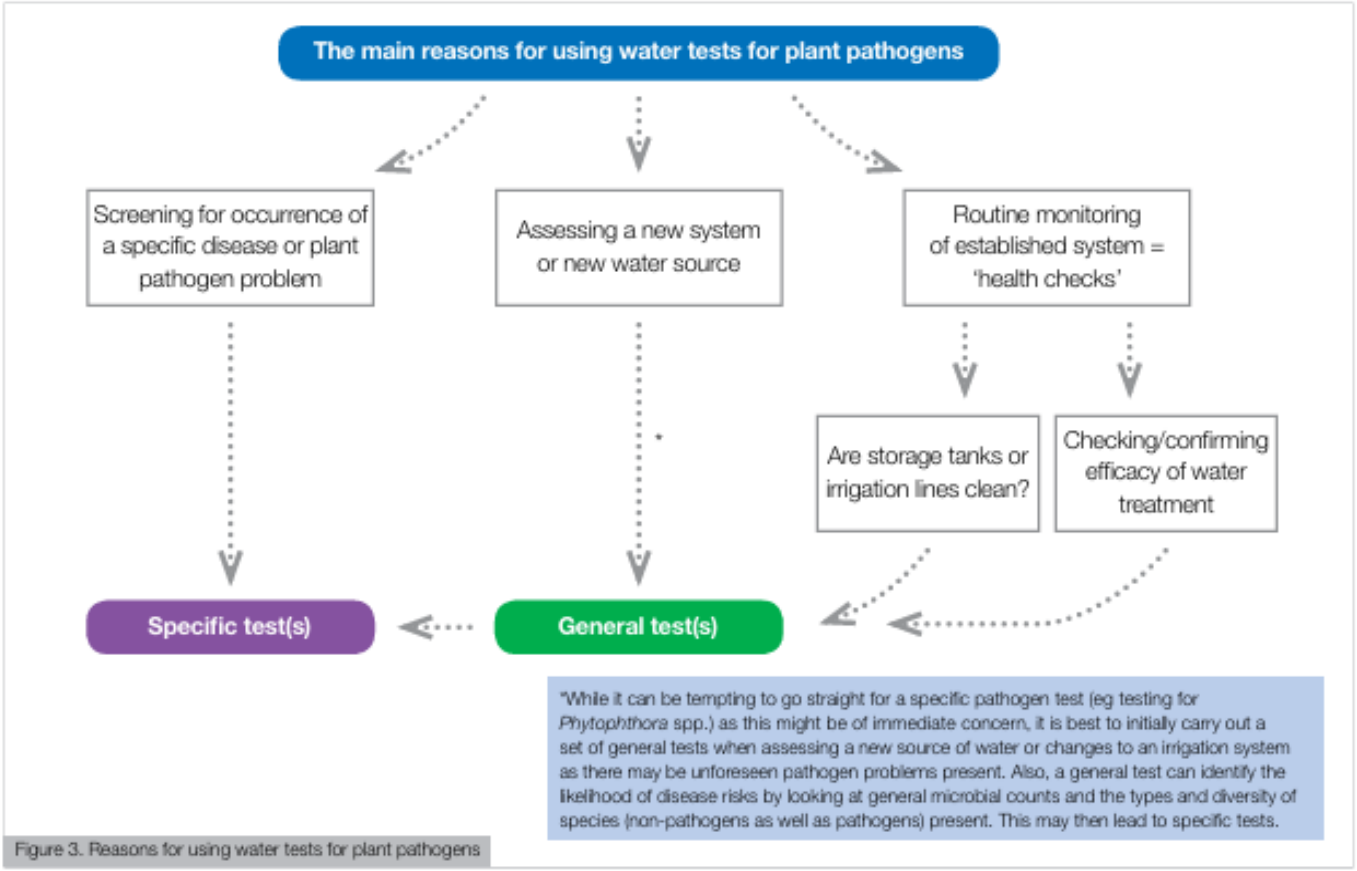

Figure 3. Reasons for using water tests for plant pathogens

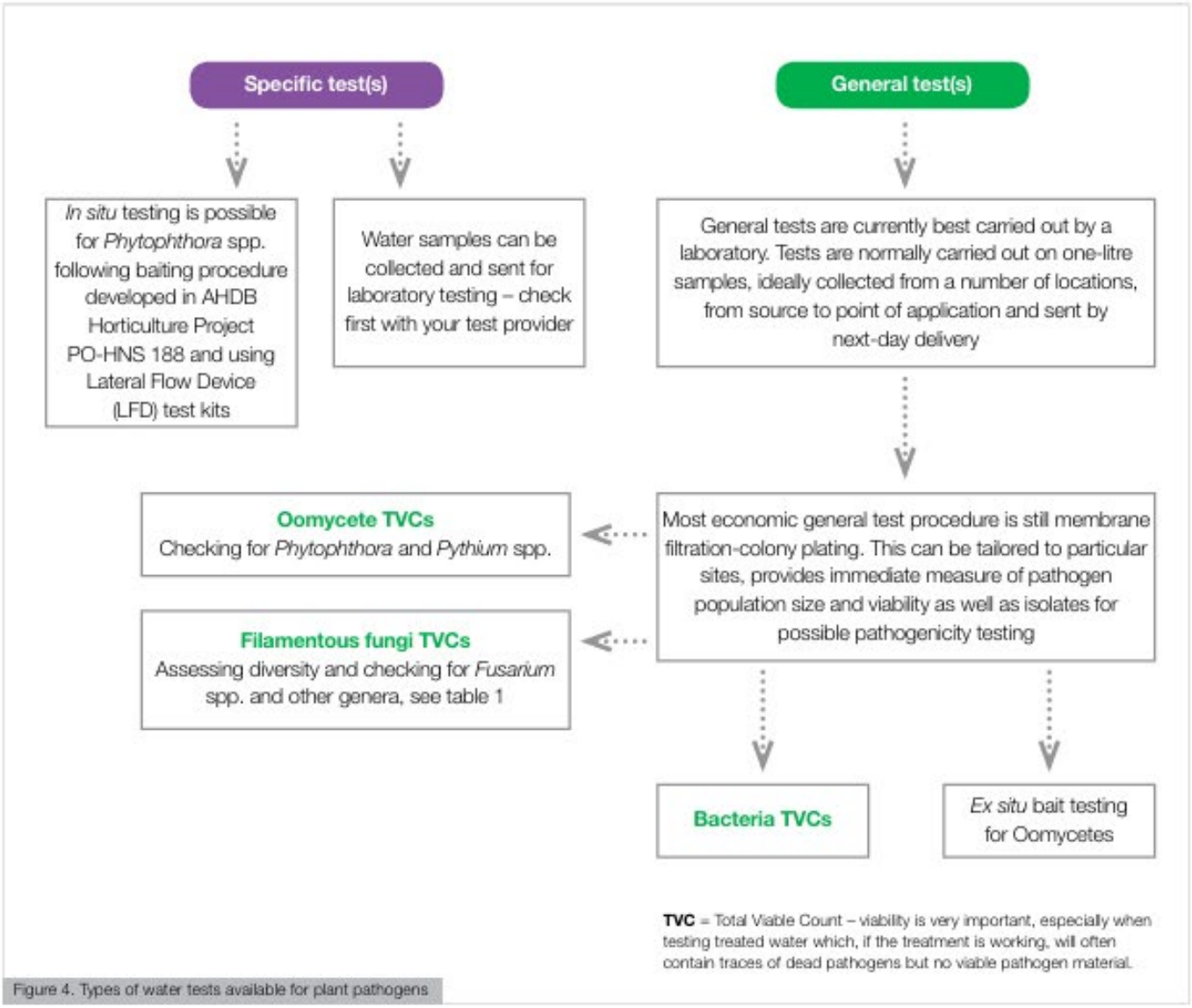

Figure 4. Types of water tests available for plant pathogens

Figure 5. Water samples should be sent to a laboratory by courier in empty sparkling water bottles – clearly marked with sample numbers on both the lid and the bottle

Figure 6. Filling water bottle from hose

Table 1. Plant disease risks associated with different sources of water for irrigation

Rivers, streams and ditches, as well as outdoor reservoirs and ponds, carry a very high risk of contamination with plant pathogens, as do uncovered storage tanks, especially those positioned out of doors. Often appearing very clean, greenhouse roof water can also be contaminated, especially by species of *Pythium* and *Fusarium*, largely depending on the cleanness of the roofs and the gutters. Mains water and water abstracted from boreholes is generally free from plant pathogens.

Water source		Disease risk
Mains	1) Used directly	Very low–none
	2) Stored in covered tanks	Very low–moderate
	3) Stored in uncovered tanks	Moderate–high
Borehole/well		
A) Clean, uncompromised borehole and extraction equipment	1) Used directly	Low–none
	2) Stored in covered tanks	Low–moderate
	3) Stored in uncovered tanks	Moderate–high
B) Flooded borehole, dirty extraction equipment		High–very high
Open reservoirs/ponds/lakes		High–very high
Rivers/streams/canals/ditches		High–very high
Collected from roofs or paved areas		Moderate–high
Run-off from fields or production beds		Very high
Recirculating nutrient solution		Moderate–very high

Plant pathogens frequently found in water

A wide range of microorganisms are regularly detected in water samples and potential plant pathogens represent only a small proportion of these. In table 2, all of the important Oomycete genera and a selection of other key pathogen groups spread by contaminated irrigation water are listed, together with some frequently encountered non-pathogen species that can be useful as 'indicators' of both pathogen risks and water treatment efficacy (see 'General testing' page 2). Some examples of naturally occurring genera with known disease suppressive qualities (eg *Trichoderma*), that are often recorded in horticultural water samples, are also mentioned. Growers are often interested in their presence and populations, although we unfortunately still know too little of their complex interactions with plant pathogens in water to draw much useful information for disease management purposes from such observations.

Table 2. Examples of pathogenic genera known to be spread in irrigation water

Genera demonstrated to be spread by water	Other genera that might be spread in water [those in brackets are not generally pathogens but are either useful indicator species or potential disease-suppressive agents]
Oomycetes	
Aphanomyces	[*Saprolegnia*]
Phytophthora	
Pythium	
Plasmodiophorids	
Plasmodiophora	

Table 2. *(continued)*

Genera demonstrated to be spread by water	Other genera that might be spread in water [those in brackets are not generally pathogens but are either useful indicator species or potential disease-suppressive agents]
Fungi	
Fusarium	*Alternaria*
Phoma	*Ascochyta*
Thielaviopsis	*Botrytis*
Verticillium	*Colletotrichum*
	Didymella
	Rhizoctonia
	[*Coniothyrium*]
	[*Gliocladium*]
	[*Trichoderma*]
Bacteria	
Erwinia	
Pseudomonas	
Xanthomonas	
Viruses	
Cucumber green mottle mosaic virus (CGMMV)	
Pelargonium flower break virus (PFBV)	
Pepino mosaic virus (pepMV)	
Tobacco mosaic virus (TMV)	
Tomato mosaic virus (ToMV)	

Taking samples

The following procedure is straightforward and very effective:

- The optimum sample volume is one-litre. This is a trade-off between the need for water volume to improve test sensitivity and the economics of sample handling and delivery.
- Sample bottles need to be robust for delivery to the test lab. PET (polyethylene terephthalate) bottles for carbonated soft drinks make ideal containers, and bottles used for supermarket economy-branded carbonated water, if used immediately after decanting their fizzy contents, are ready and clean enough for the purpose of collecting samples for Oomycete and fungus testing (see figure 5).
- Each sample bottle needs to be clearly identified and labelled before packing and dispatch to the testing lab, and samples need to arrive at the lab by the day following collection (see figure 5).
- Single water samples carried out in isolation rarely mean very much, even testing water treatment efficacy requires a minimum of one pre and one post-treatment sample to be certain that the treatment is working. Water-borne plant pathogen inoculum is dynamic, changing over time and with movement within a system. It is, therefore, wise to take several samples from different parts of an irrigation system, from the 'raw' water source, its storage, and from the point of delivery to plants.

Frequency of testing

From a strictly disease-management perspective, the more frequently testing is carried out, the better. Even very infrequent testing is better than none.

The frequency at which water sampling is carried out is, ultimately, a question of economics. With an average outlay for a full test of between £100–£150 plus nursery staff time in collection and packing, and sample carriage, it is important to get best value for money. It is difficult to put a cash value on timely disease intelligence or on the peace of mind provided by testing. In certain situations, for example, when accreditation schemes recommend routine storage tank clean-ups, microbiological tests demonstrating that tanks are clean can achieve significant cost savings in avoided disruption and cleaning.

Timing of testing

Sampling times may be dictated by the scheduling of crops or by the availability of staff to complete the task, however, an optimum arrangement would be to carry out tests four to six times per year, at regular intervals. The numbers of pathogen propagules in water do vary significantly with season. For example, Oomycete numbers peak in late spring and again in early autumn while genera such as *Fusarium* peak in late summer/early autumn. If a single test is carried out per annum, the best time to do so would appear to be in late summer/early autumn.

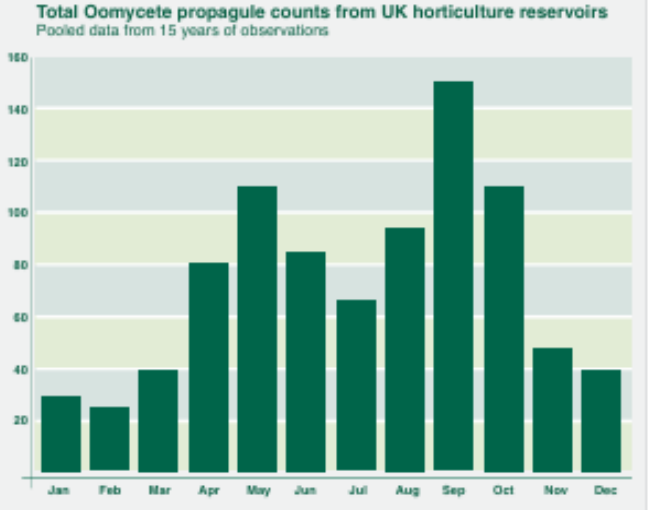

Figure 7. Total Oomycetes propagule counts from UK horticultural reservoirs

Future developments

The techniques available for practical disease diagnostic testing are currently evolving fast with a number of new developments that have recently been reviewed for AHDB Horticulture Project CP 099b. Lower-cost portable DNA-based technologies provide exciting prospects for the future although there is still much development work needed. Meanwhile, further development of immunodiagnostic techniques is underway in AHDB Horticulture Project CP 136 to provide a new range of test kits. The kits will hopefully have the capacity to differentiate between viable and dead pathogen propagules and, thus, be useful in combination with membrane filtration for rapid on site testing of water treatment systems and possibly reducing the need to send samples away to laboratories for analysis.

Further information

AHDB Horticulture factsheets and publications

AHDB Factsheet 22/15: Methods of water treatment for the elimination of plant pathogens.

AHDB Factsheet 23/15: Hygiene and disease avoidance underpin the management of Oomycete stem and root rots.

Instruction sheet for growers: *Pythium* and *Phytophthora* water baiting.

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All of the images contained within this factsheet were provided by Dr Tim Pettitt, University of Worcester.

Want to know more?

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