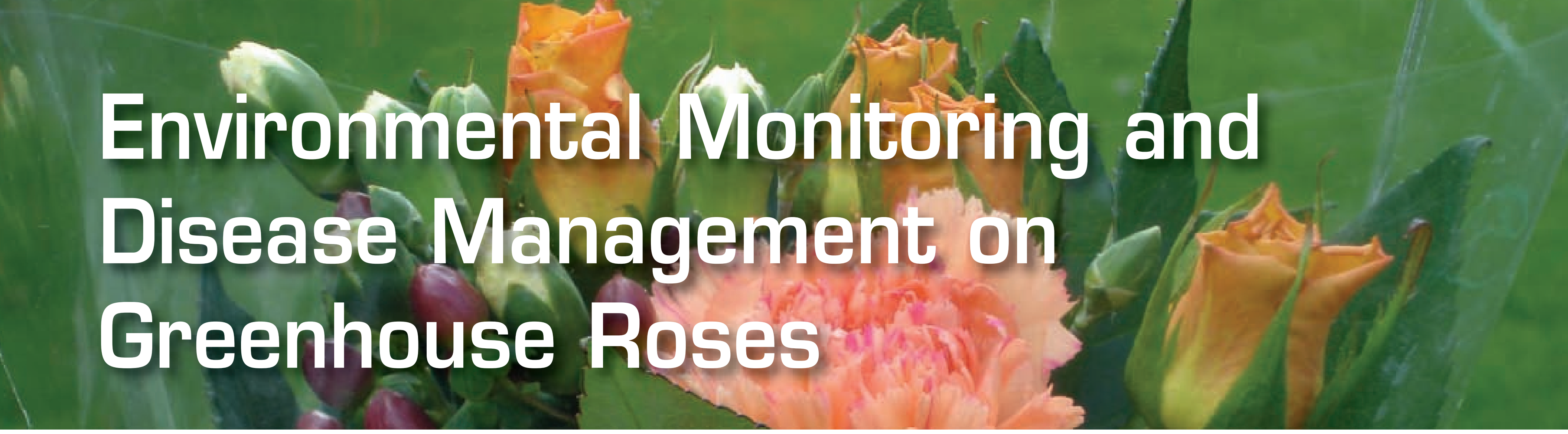


Environmental Monitoring and Disease Management on Greenhouse Roses

Evolutionary plant breeding and production of modern roses for commercial cut flower use traditionally took place in Europe. Commercial production has recently shifted to tropical countries where roses are grown at altitude in unheated polythene greenhouses, rather than heated and environmentally controlled glasshouses. None of this was achievable without a continuous and crucial genetic input from Asia. Earliest introductions from Western Asia comprised Rosa gallica (so-called 'French Rose') from the Middle East and Rosa damascena (the Damask rose) also a red rose and a natural variation of R. gallica from Syria in the thirteenth century. Rosa fatida var persicana (Yellow Rose of Persia) as the name suggests had origins in what is now Iran and was brought in to Europe from Persia in the sixteenth century.

Later but equally essential introductions into Europe were made from East Asia. The semi-double pink 'Tea Rose' (Rosa odorata) from Canton (China) in 1810 followed by the sulphur yellow 'Tea Rose' (another fragrant China garden rose) in 1824 was events without which today's roses grown for commercial cut flowers could not exist.

Countries like Ecuador in South America and Kenya in East Africa may now possess some of the fastest growing production systems, but established high quality cut rose production is also taking place in countries across Asia including Malaysia, Thailand, Philippines, Taiwan, South Korea, China, and Japan.

Disease spread and development

Rapid expansion in cut-rose production has been accompanied by big increases in mildew disease, with type and severity governed by physical factors, (climate and altitude) and growing conditions (greenhouse design and irrigation), and how these impact on temperature, humidity and leaf surface wetness.

Whether roses are infected by downy mildew (Peronospora sparsa) or powdery mildew (Sphaerotheca pannosa), fungicide control is possible. Respective pathogens are taxonomically different (downy mildew is Oomycetes and powdery mildew is Ascomycetes), so fungicides and application strategies will vary.

Downy and powdery mildew diseases can move rapidly into disease epiphytotics (epidemics) to devastate blooms. Either mildew disease may spread out of control in a short space of time, especially in greenhouses and the ideal conditions of temperature, humidity and surface wetness they create.

Growers have three options when considering the use of fungicide control:

- Apply fungicide on a routine basis.
- Determine environmental conditions for infection, and only spray when these occur.
- Monitor disease and environmental conditions in tandem using spore traps linked to sensors for temperature and humidity.

Routine Spray Regimes

In today's cost and safety conscious environment, routine application of fungicides to commercial cut roses is fraught with all kinds of difficulty and danger. Prophylactic insurance sprays are generally considered a waste of resources and increase risk of pathogen insensitivity (resistance) to groups of products with similar fungicide chemistry.

Furthermore, unnecessary application of agrochemicals generally disrupts the rose growing environment with adverse effect on natural enemies of insect pests, 'friendly' microbes in the soil and the workers looking after the crop.

Big cut-flower importers like European Union (EU) have strict rules and regulations regarding pesticide use in exporting countries and residue levels on cut rose blooms. No-one is likely to 'eat' cut-flowers but they are still handled by packers and consumers and the latter will instinctively smell the blooms, even if not scented which is the case for most contemporary cut-rose varieties.

Decision Led Control - Environment

Spraying only when temperature, humidity and leaf surface wetness come together to create optimum conditions for infection, spread and development of a disease is another option. This is a major step forward but clearly not the ideal solution because there is no way of knowing whether the pathogen is present.

SporeWatch

Decision Led Control – Disease and Environment

The most logical way forward is to monitor presence/absence of fungal pathogens alongside the environmental conditions for spore germination, infection, tissue colonisation by mycelium and spore production and spray accordingly.

Spore traps are linked to sensors which monitor environmental conditions during the spore trapping period. This is an integrated system used indoors or outdoors although clearly easier to control and manage inside the greenhouse. Downy and powdery mildew diseases on roses are spread mainly via air-borne spores and therefore ideal for disease forecasting using spore traps and sensors for temperature and humidity.

With fungal pathogen identified and quantified by trapping air-borne spores, and sensor readings showing ideal conditions for infection, fungicide sprays can be synchronised with those periods then the crop is at risk. Prompt and accurately timed spraying is crucial, especially when using protectant (preventative) fungicides. Preventative fungicides must be deposited on the plant surface before fungal spores arrive. Preventative fungicides will not control established infections.

Spore Sampling and Environmental Monitoring

The instrumentation will use dedicated spore traps inter-linked and integrated with a range of sensors for temperature, relative humidity, leaf surface wetness and any other environmental parameters that affect infection and disease development.

Novel tried and tested approach is provided by Burkard Scientific a United Kingdom (UK) company based in Uxbridge with decades of experience and expertise in instrumentation and equipment for monitoring fungal pathogens and environmental conditions for disease forecasting and decision-led control.

The 'SporeWatch' spore and pollen sampler from Burkard Scientific uses state-of-the-art electronic technology to drive definitive methodology with precise specification based on the original 'Hirst Spore Sampler'. SporeWatch provides users with the same precise methodology underpinning contemporary spore sampling procedure, with more flexibility, reduced size and at a lower cost through benefits of modern technology.

SporeWatch uses the 'original' drum and tape principle to trap and secure spores. Orifices and air throughput are identical to those on the Hirst spore sampler, but with interchangeable orifices improving the trapping efficiency of particles in the 1-10 μm diameter size range.

Units have been tested and evaluated under field conditions by independent accredited scientists. They report 'SporeWatch' providing equal performance as a modern replacement for its predecessor the Hirst spore trap.

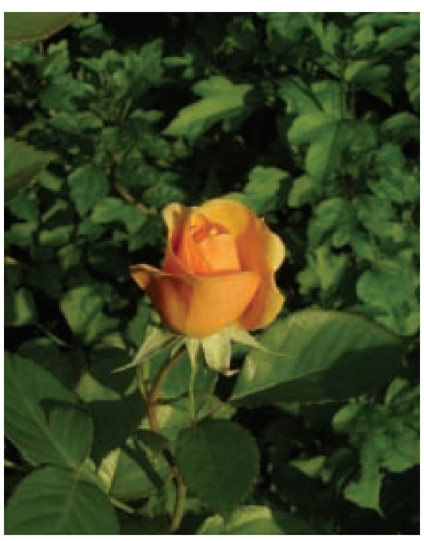
Modern electronics enhance performance and control with advanced features including 16 pre-selectable sampling periods, automatic shutdown to avoid over-impacted spore load and a simple stop/start control.

Spores are impacted on adhesive coated transparent plastic tape (Melinex) stored and supplied on a drum of fixed circumference, with specification and operation identical to the Hirst spore sampler. Integral vane makes the sampler sensitive to very small variations in wind direction, and adjustment of the 10-litre/min throughput is made by simply adjusting the metering screw easily and conveniently located on the underside of the unit.

SporeWatch may be powered by mains or battery via an external encapsulated power unit or 12V battery, respectively. A highly efficient solar power option increases flexibility of SporeWatch in remote operational areas under all normal weather conditions worldwide. The standard solar panel at only 360mm x 250 mm x 35 mm is highly compact but still provides 10 watts of power. Panels are of an aluminium frame construction which allows for a range of mounting options on the floor, roof or a pole. The solar power kit includes a battery and controller facilitating overnight operation from charge received during daylight hours, thus providing continuous 24-hour operation. Users say the SporeWatch solar power kit provides an easy economic answer to stand-alone operation in remote locations.

Use of aluminium in the design and construction of SporeWatch provides a light weight and entirely portable unit for use anywhere in the field and all parts are finished and protected by hard stove enamel or anodised coat to prevent corrosion under normal weather conditions. Drums are changed on site in a quick, simple and no fuss operation via a lockable instrument side panel cover opened for easy access to the drum and all controls. The unit is supplied with a tripod for stand-alone, on-ground operation or an optional and complementary support arm so that SporeWatch may be fitted to an environmental monitoring station or other mounting sites. An integral setting level simplifies instrumentation set up to avoid biased rotation.

Burkard Scientific have taken the operational scope of SporeWatch one stage further by design of an 'aerobiological monitoring station' so users can simultaneously monitor air temperature and relative humidity over the spore sampling period. Data is logged and can be downloaded for laboratory analysis if required. A stable platform provides secure mounting for the sampler and solar panels and the battery is conveniently housed in the control cabinet. A guy rope set is available for additional stability in windy conditions.



Cut Rose

Rose Powdery Mildew

Powdery mildew disease can be expected when high daytime temperatures give way to cool humid nights as in roses under cover in the tropical highlands of Africa. Conditions ripe for development of powdery mildew are defined as night-time relative humidity rising from 40-70 per cent during daylight hours to exceed 90 per cent at night. This humidity profile, in tandem with at least six hours in the 20–30ºC temperature range, sets off spore (conidia) germination and a spiral of irreversible crop damage as disease rapidly moves into epidemic proportions. Failure to spot the first signs of infection and take remedial action is central to control failure of powdery mildew on roses.

Life cycle can be complicated by type of growing system and whether roses are grown outdoors in temperate climates or in unheated glass or plastic greenhouse (e.g. equatorial highlands of countries like Kenya and Ethiopia).

In rose producing countries where growing season is not punctuated by a cold winter period the fungus reacts in an equally unbroken fashion, with continuous production of asexual spores (conidia) on the leaves, young shoots and green scales of flower buds. Optimum temperature for germination of conidia is around 22ºC with minimum and maximum at 5 and 35ºC, respectively. Spore germination occurs over a wide range of relative humidity, although free moisture (surface water) inhibits the process.

Under optimal conditions the powdery mildew disease cycle proceeds at phenomenal speeds, conidia germinating within 2 to 4 hours of landing on the surface. The entire disease cycle of spore release, germination, fungal infection and production of more conidia may take as little as 72-96 hours. Net result is several million spores produced and released from just 6.25 cm of infected leaf surface.

With high value cut rose crops at risk from total destruction in days if not hours, powdery mildew disease demands 24 hour monitoring throughout the year to identify onset of high risk periods and accompanying spore release, so that timed preventative sprays may be applied.

The trick is to intercept airborne spores by trapping and then analyse results with utmost speed so that fungicide can be applied before spores germinate. Indeed protectant fungicides will only control the disease if they are on the crop surface and active prior to spore germination. Otherwise, growers are forced to use systemically acting eradicant (curative) fungicides which penetrate the leaves to kill established infections, but take longer to work and are more expensive.

Where growing season is broken by a definite low temperature winter period the fungal pathogen responds by surviving as mycelium inside rose bud scales and young leaves, conidia production resuming when the right conditions return. Alternatively it may move into its sexual reproductive phase by producing resting bodies called cleistothecia. When warm humid spring weather returns the cleistothecium absorbs water and ruptures to release a sac (ascus) containing eight ascospores, which are carried by air currents onto the leaves where they germinate. Whether the airborne spores are conidia or ascospores they can be trapped, identified and quantified using SporeWatch.

First signs of powdery mildew appear on the upper (adaxial) surface of expanding leaves as irregular shaped blistered areas light green to reddish in colour. These are quickly followed by typical powdery mildew symptoms caused by a combination of white mycelium of vegetative hyphae and reproductive aerial hyphae (conidiophores) bearing the conidia.

Failure to control early infections leads to distortion of young leaves that are completely covered with white felt-like lesions and stunted shoots that fail to recover. Advanced infections show young leaves becoming more red and purple under the powdery layer, before yellowing and dropping off. Infected flower buds produce deformed flowers with discoloured petals and blooms with a much shortened shelf-life.

Rose downy mildew

'Downy' mildew like the 'powdery version' needs a high humidity of around 80 per cent for uninhibited spore germination, although optimum temperature for spore germination is on the cooler side at 15 to 20ºC. Colonisation of rose leaf tissue moves most rapidly within a higher range of 20 to 25ºC. In common with other downy mildew pathogens leaf surface wetness is crucial for spore germination. At optimal temperatures only 2 hours of leaf wetness is required for spore germination. More detailed predictive models show the critical leaf wetness period for disease development is an average 8.4 hours per day over a 10 day period. At optimal temperatures for leaf colonisation (20 to 25ºC) disease cycle is short with symptoms appearing just 4 days after spore germination and spore producing lesions several days later.

Potential losses are huge with growers traditionally spraying fungicide on a routine 7 or 14 day basis, but as with powdery mildew this fungal pathogen is apparently limited by some environmental conditions. Therefore like powdery mildew it is a good candidate for disease forecasting via spore trapping and environmental monitoring. The short rapid cycle of rose downy mildew helps to explain why growers often fail to control the disease even with application of protectant fungicides at 14 day spray intervals.

Leaf disease on Rose

All above-ground plant parts are affected. Typical symptoms on roses include irregular shaped leaf spots that are purple red to dark brown in colour. Major leaf veins may restrict spread of lesions which therefore become angular as they enlarge. Shoots are distorted and flowers deformed by infection of flower bud scales.

During periods of sustained humidity grey coloured spore masses develop on the underside (abaxial surface) of leaves which eventually die and abscise resulting in severe defoliation, if the disease is left uncontrolled. Small spots or elongated purple coloured areas may form on the rose bush canes with eventual die-back caused by secondary Botrytis fungal attack.

Downy mildew control with fungicide is all the more difficult due to development of resistance (insensitivity) to some chemical groups. This is all the more reason to develop decision-led spray regimes based on disease forecasting through combined spore trapping and environmental monitoring.

One major rose growing area of the world where moves towards downy mildew disease monitoring using spore traps are already being made is Colombia. At the present time monitoring is carried out by direct inspection of the plants for infection and damage. This is slow and cumbersome and invariably not quick enough to pin-point infection and spray before this fast moving pathogen and disease takes off and ruins the crop.

Research plans are being laid to locate spore traps in greenhouses to record airborne spore numbers on an hourly basis, thus enabling operators to determine exactly when spore liberation occurs. Spore concentration will be established and statistically correlated with infection of rose plants, to build an accurate disease forecasting model that allows growers to develop decision-led spray application programmes.

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