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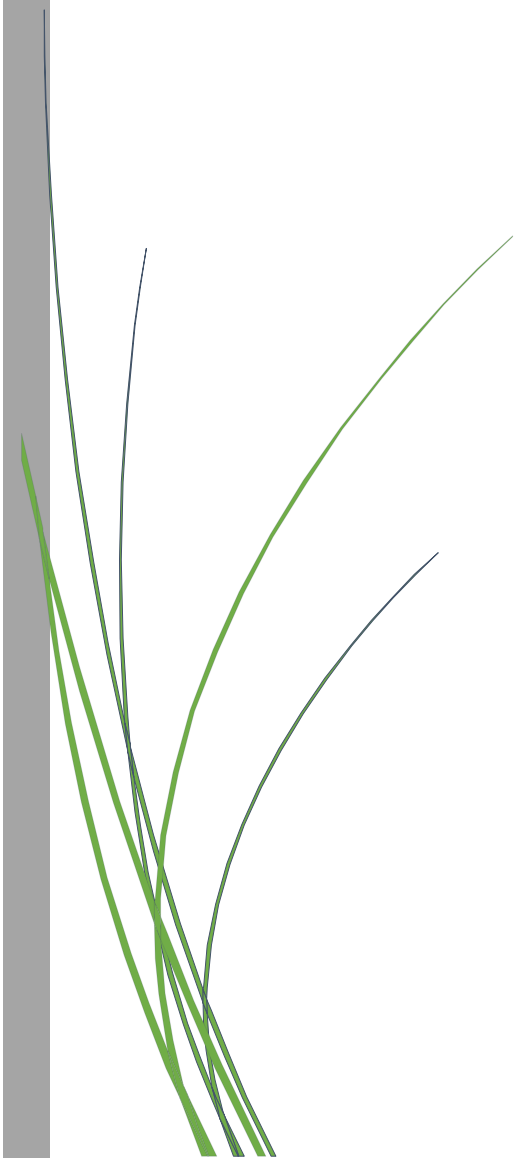
An induction guide for new staff into Welsh commercial ornamental horticulture



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Summary

- The ornamental horticulture industry is a significant part of the UK's horticulture industry.
- A UK plant passport (PP) is an official document needed to move plants and certain regulated wood within Great Britain.
- Every consignment of plants, bulbs or seeds imported to the UK must be accompanied by a phytosanitary certificate which guarantees that the product is free from quarantine pests and diseases.
- There are a number for fungal and bacterial diseases of ornamental plants and knowledge of symptoms caused by these is important in recognising the problem and stop them from spreading.
- Integrated Pest and Disease Management (IPDM) combines cultural, biological, physical and chemical tools to manage diseases, weeds and invertebrate pests in an environmentally sensitive way. With key active substances disappearing from the market and resistance on the rise, IPDM is critical for effective, long-term pest and disease management.
- In order to reduce waste horticulture businesses, need to know where waste happens in their process, the types of waste that arise and the practical steps they can take to prevent or reduce waste happening.
- Better water management can boost resilience in drought or flood situations, ensure nutrient retention and watercourse protection, and result in savings through decreased wastage.

1. Introduction

Ornamental horticulture industry is involved in either breeding, growing and/or marketing of plants for domestic or landscaping purposes. The industry is typically quite specialised with reference to its crops. Flower and pot plant production and sale may occur outdoor, but commercial production is largely performed in greenhouses, where growers exercise exact environmental controls.

Since the demand for the majority of the floral crops is seasonal, precise timing is essential. The perishable nature of the product implies that it must be transported to market efficiently to prevent losses. Ornamental plants are not only attractive, but they also improve the quality of life. They have been shown to improve indoor and outdoor air quality, speed release time of patients from hospitals and improve worker productivity in offices.

Ornamental Horticulture and Landscaping plays a vital role in the UK's economy, culture, health and environment. It is a significant part of the UK's horticulture industry and an important leisure activity for tens of millions of people in the country. In 2018, the Ornamental Horticulture Roundtable Group (OHRG) in partnership with Oxford Economics published a breakthrough report which calculated this sector contributes £24.2 billion to the UK economy via direct, indirect or induced GDP contributions while supporting 568,700 jobs. According to latest statistics, the UK's ornamentals were worth £1.6 billion in 2021, an increase of 16% compared to 2020.

The Government's 25-year environmental plan and its goal to put the UK at the forefront of tackling the climate emergency has given rise to a pressing need to increase the amount of quality habitats throughout the UK. The ornamental horticulture industry can play an important role in the creation of such habitats for example gardens. This technical article focuses on some basics of growing ornamental plants with the aim of serving as a guide to new starters in nurseries, glasshouses or garden centres.

2. Legislation on breeding and plant movement

The legislation governing the horticultural industry is varied and complex. Laws exist to regulate the movement of plants within the UK, with variation for those bred and grown locally and those imported from the EU and beyond.

2.1. Plant breeders' rights (PBR)

This refers to intellectual property rights over plant varieties in the UK and are known as plant breeders' rights (PBR). The Animal and Plant Health Agency (APHA) awards rights for the UK. Plant Breeders' Rights or Plant Variety Rights (PBR – usually written as ^{PBR}) are granted to new plant cultivars to give the breeder exclusive control over the propagating material from that plant for a certain number of years (25 years for plants, 30 years for trees, vines and potato varieties).

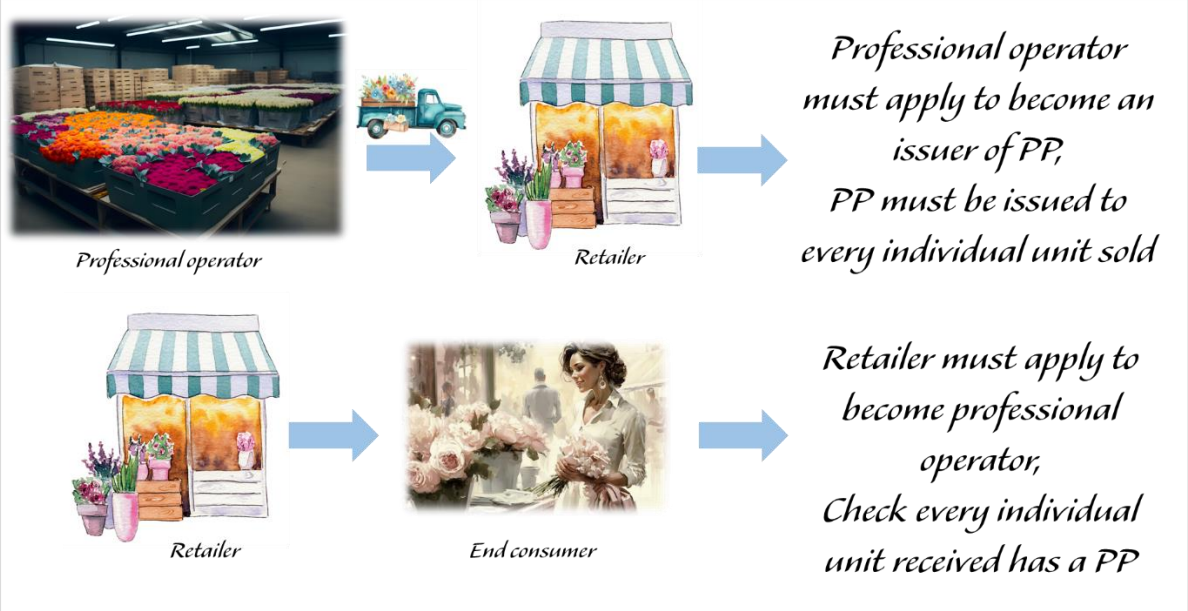
The plant is tested to show that it is Distinct, Uniform and Stable (DUS) before the rights are granted. Distinct implies that the plant variety has at least one important characteristic that is different from other varieties included in the national list. A uniform plant variety has individual plants that share the same important characteristics while stable means that the plant remains unchanged after 'repeated propagation' via either seeds, cuttings, bulbs or other plant parts. DUS testing can take up to one year for ornamental plants. Once a PBR is granted, breeders can bring suit to enforce their rights and can recover damages for infringement.

2.2. Plant Passports for movement within the UK

A **UK plant passport** (PP) is an official document needed to move plants and certain regulated wood within Great Britain. This includes all plants for planting, some seeds, seed potatoes, wood, wood products (include chips, particles, shavings, sawdust, wood waste or scrap and some other types of wood product where there could still be a phytosanitary risk even after processing) and isolated barks.

Any professional operator moving or selling plants, cuttings, bulbs and some seeds and plant products to another professional operator will require authorisation to issue plant passports from APHA Plant Health. The PP will have to be applied to each of the lowest trade units such

as an individual plant in a pot, or tray of plugs. This does not apply to plants sold retail face-to-face to the final user but does apply to plants sold online. Therefore, retailers need not apply to become an authorised issuer of PP (unless selling online), but they do need to apply for official registration as a professional operator. Retailers are also obliged to check for the presence of PP on every individual plant or unit when receiving a delivery from an authorised issuer of PP.



It should be noted that the PP system has 2 pillars: traceability, and assurance. Therefore, a UK plant passport is not just a traceability document but attests that the plants the passport is attached to meet GB Plant Health Standards.

2.3. Importing plants to the UK

Imported plants and plant products can harbour invasive pests and diseases that can be introduced in the country causing devastating loses to native plants and food crops. The highest risk of such pests and diseases comes from imported ornamental trees, pot plants and cuttings. Many pests and diseases that are prevalent in other regions of Europe and abroad do not exist in the UK.

Professional operators importing plants, seeds or bulbs intended for planting, in the UK, need to be registered as an importer on import of products, animals, food and feed system (IPAFFS). This system is also used to pre-notify the APHA Plant Health of the import consignment. Each consignment needs to be accompanied by a phytosanitary certificate issued by the plant health authority in the origin country no more than 14 days before the consignment is dispatched. "*A phytosanitary certificate is a statement from the plant health authority that the consignment: has been officially inspected, complies with legal requirements for entry into Great Britain and is free from quarantine pests and diseases*". This is applicable to plants imported from EU and non-EU countries. Once inside the GB the

imported plants or plant products will require a PP for movement within the UK as discussed above.

3. Growing ornamental plants

Ornamental plants are categorised based on their life span as:

- Annuals - plants that grow and die in a year.
- Biennials – plants that grow in the first year and blossom in the second year.
- Perennials – plants that have a life cycle of more than two years and bloom every year.

Ornamentals also come in a variety of different forms, which can be broadly categorised into trees, shrubs, herbaceous perennials, grasses, herbs and bulbs.

3.1. Growing medium

The term 'growing medium' or 'substrate' refers to the material used in a container to grow a plant. The word compost is also commonly used in the same context, it is however technically a product of composting and can therefore be misleading. Compost may be an ingredient of the growing medium, but growing media are frequently made from a blend of various raw materials to obtain the ideal mix of air and water holding capacity for the plants to be grown. Growing medium has the major role of providing anchorage and nutrients to the growing plant. An ideal growing medium must be available in large quantities, must hold sufficient water and nutrients, be free of pathogens pests and weeds and safe for people to handle.

Organic growing medium

i. Soil

Soil is the most abundant available and most traditional option. It is affordable and good quality soil is rich in nutrients. However, it suffers from significant drawbacks such as existence of disease pathogens, unfavourable soil reactions, poor compaction and drainage which can result in poor fertility, poor yield and quality of ornamentals. Due to these inherent issues with soil, a number of soil free alternatives are used by commercial growers.

ii. Peat

Peat is a result of several years of accumulation and decomposition of plant material in poorly drained areas (peat bogs), with low nutrients and pH, under low temperatures and anaerobic conditions. It has high water holding capacity, is easy to handle and is commonly free of pathogens and weeds. Up until the year 2000 most of the

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commercial media in the UK was made of peat. However due to the greenhouse gases released in the mining of peat and its unsustainable nature (grows back just 1 mm a year) the horticultural industry is moving away from peat. A ban of the sale of peat for use in the amateur gardening sector will come into force from 2024. Nowadays more than half of the growing medium is made up of alternative of peat.

iii. Wood residues

A significant source of soilless growth media is wood residues. Usually by-products of the timber industry, these materials are easily accessible and are available in large quantities. Nitrogen depletion by soil microorganisms, during the decomposition process, is one of the primary problems associated with these materials. However, by adding additional N to the growing medium, most wood wastes can become useful supplements.

iv. Coco coir or coco peat

Coco coir is a flexible natural fibre derived from coconut husk. It is natural soilless growing medium with a high water holding capacity about 8-9 times of weight. Its other favourable properties include resistance to bacterial and fungal infections and high aeration that are useful for healthy root development.

v. Compost

Compost is the decomposed organic matter produced from degradation of organic waste by microflora under aerobic or anaerobic conditions. It is a porous and nutrient rich potting material. It often added to soil free growing medium to provide nutrients to the plant. Its disadvantage is that it is not cost effective to transport due the bulkiness and weight of product. **Vermicompost** (also known as worm humus or worn manure) is a type of compost obtained by the breakdown of organic matter by earthworms. It has sufficient amounts of N, P, K but is rich beneficial

microorganisms. It enhances the texture, aeration and water holding capacity of the growing medium.

vi. Biochar

Biologically derived charcoal or biochar is fine-grained porous substance produced by pyrolysis of organic material like wood, animal manure and bones, or waste from the food processing industry at 300 to 500 ^{o}C in the absence of oxygen. It has a high surface area that helps to retain more water, decreases nutrient leaching and improves the physical structure of soil.

Inorganic growing medium

i. Sand

Sand is used in the growing medium to increase the water holding capacity and aeration.

ii. Perlite

Perlite is mined from greyish-white silicaceous volcanic rock. It enhances aeration and drainage in the growing medium. Its greatest advantage is being weed and pathogen free. The pH of perlite is nearly neutral, and it is odourless, clean, and easy to use but on the other hand very low nutrients and cation exchange capacity.

iii. Vermiculite

Vermiculite is a micaceous mineral that expands rapidly when heated. The enlarged, plate-like particles formed have a very high water retention capacity and help with aeration and drainage. Vermiculite can supply potassium and magnesium and has good cation exchanging and buffering properties. Although less durable than sand and perlite, vermiculite nevertheless makes an excellent container media due to its favourable chemical and physical characteristics.

Several combinations of the above-mentioned growing media can be used to produce a medium to match the plant and the economics of its production. It is also important to consider the pH of the growth medium. Most ornamental plants grow well in medium with pH of 6-7 but they differ in their tolerance to change in pH. Having the knowledge of the growth medium and pH limits of individual plants can help to match pH of the growing medium to the requirements of the plant. pH of the growing medium is generally determined by collecting a representative sample, air drying it, mixing it with distilled water and after the mixture equilibrates measuring the pH using a pH meter.

3.2. Environmental controls – temperature, humidity and ventilation

For plants grown under controlled conditions like greenhouses, it is widely acknowledged that temperature and humidity are two of the key environmental elements that affect how effectively plants grow and function in general. The humidity and temperature settings that required for optimal plant growth, depend on the stage of the lifecycle of the plant. Temperature or heating is a top priority for commercial greenhouses, mainly because of the costs associated with heating as well the severe consequences of a poorly built system.

Most ornamental plants prefer **25 ºC** and **60-70%** humidity during the vegetative phase and **28 ºC** and **40-50%** humidity during the flowering phase. Temperatures above or below this range will slow down metabolic and biochemical process, ultimately slowing down the overall development of the plant. Systems or instruments that can continuously monitor temperature and humidity are an important investment in the business. Alerts must be set in the system to notify the concerned staff when temp and humidity have dropped or exceeded the set range.

Ventilation is a crucial element to regulate temperature and CO_2 requirements. Extraction fans installed high inside the grow space can help to remove excess heat. On the other hand, intake fans present close to the ground circulate cooler air to the plant and a continuous supply of CO_2 which is essential for good growth and development.

3.3. Nutrition and water

Maintaining adequate nutrition is among the most critical aspects of producing ornamental crops. The type of fertilizer and frequency of application will depend on the nutritional status of the growing medium and the stage of growth. Most commercial producers adopt a constant feeding programme where soluble feed is supplied at each irrigation or every other

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irrigation. The balance of plant nutrients is important in producing vigorous, efficient plants. Several complete fertilizers are available which provide N-P-K in the desired balance but custom blending of fertilizers from different sources may be required to achieve the best balance. In addition to NPK which are macronutrients, several micro nutrients such as calcium (Ca), magnesium (Mg), sulfur (S), iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), boron (B), molybdenum (Mo), and chloride (Cl) must also be included as a component of the liquid feeding programme

Irrigation of greenhouse plants is an important production practice. Most commercial growers use drip or trickle irrigation to water the majority of greenhouse plants. The physical characteristics of the growing medium and the environmental circumstances play a significant role in determining how frequently irrigation is required. It is crucial to add at least 10-15% more water than the container can hold in places where soluble salts are a concern to ensure adequate leaching. It may be challenging to wet media that is very dry, so care must be used during irrigation to ensure even water distribution. To keep an eye on soluble salts, water quality should be regularly examined.

4. Diseases of ornamental plants

Pathogenic fungi and bacteria that use plants as their host can all cause diseases in ornamental crops. The establishment of a diseases is the result of complex interactions between a susceptible host plant, the presence of a pathogenic organism and the environment. Diseases cause economic loses and diseased plants cannot be exported or sold locally. Viruses are rarely a problem in ornamentals. In fact, some viruses actually increase the desirability of a plant, for example Abutilon mosaic virus, which causes an attractive mosaic pattern in the leaves of variegated forms of the flowering maple, *Abutilon pictum*.

The section below describes some of the **symptoms** of fungal and bacterial diseases and discusses their control options. For section on prevention, control and treatment refer to section 6 on Integrated pest and disease management.

4.1. Fungal Diseases

4.1.1. Leaf spots

Black spots on Rose leaves

Fungal leaf spots can vary in size, shape and colour. The spots have distinct margins surrounded with or without yellow halos. As the spots become abundant the leaves become yellow, die and drop. Infection usually starts on the lower leaves and progress up the plant.

Leaf spots are more common in wet environments as fungi need moisture for growth and infection. The fungi produce infective spores that blow or splash onto health plants. Under the right environmental circumstances, these spores can start a new infection in healthy plants. Almost all ornamental plants develop leaf spots, although not all leaf spot illnesses are harmful to the plants.

4.1.2. Leaf Blight

Leaf blights tend to be larger diseased areas and have less uniform geometries than leaf spots, may have the same impact on plants as leaf spots.

Some may start out as a leaf spot, develop into a leaf blight, and even spread to twigs and branches, resulting in dieback.

4.1.3. Rusts

Rust on grass

Rusts frequently results in pustules, which resemble leaf spots. Both the top and lower leaf surfaces may have pustules. Pustules have spores that are brown, reddish brown, orange, or yellow. Rust pustules are typically elevated above the surface of the leaf and if rubbed leave a dusty rust colour (produced by the spores) on the fingers. Fruit, branches, and twigs can all be harmed by rust fungi. They can be blown from diseased plants to healthy plants by the wind, where they can transmit the disease.

Rust infections frequently need two different hosts to complete their complex life cycles. In such conditions, disabling either host will end the cycle and cease rust. Rusts like cedar-apple rust and others are frequent problems with ornamental plants.

4.1.4. Powdery mildew

Powdery mildew on Rose

The white or grey covering of fungal growth that forms on the surfaces of plant leaves and stems is the most typical symptom. Infected plant buds or young tissue develop into crooked stems or bubbling and twisted leaves.

Powdery mildew spores can be spread to new plants by wind or rain splash. The fungi develop tiny, black overwintering structures in the autumn, which can spend the winter in leaf litter or bark cracks.

Powdery mildew on leaves

Powdery mildew fungi are host-specific. For instance, powdery mildew fungi that infect dogwood will not infect Hydrangea. Powdery mildew typically affects roses, oaks, tulip poplars, lilacs, zinnias, and euonymus.

4.1.5. Leaf Gall

Fungi that cause the gall infections thrive in cool, damp climates. It is important to note that leaf galls are also caused by insects or mites. In fact, vast majority of plant galls are caused due to infestation by insects and mites.

Fungal leaf galls are typically visible as soon as springtime when new growth starts. Parts of leaves become twisted and thickened in a bladder-like pale green to whitish colour. The young, enlarged leaves are covered in white growth. Galls deteriorate with time, becoming brown, dry, and drop to the ground. Leaf loss might reduce plant vigour if the disease is severe. The spores on dead dry leaves that fall to the ground become a source of infection in the following season. Infected plants of Azalea, plum and camellia can develop leaf galls.


Fungal leaf galls on plum tree

4.1.6. Grey mould (Botrytis species)

Grey mould, which caused by the fungus *Botrytis cinerea*, causes soft degradation of plant tissues and the growth of fuzzy, grey-brown mould. It affects many ornamental plants especially those cultivated in glasshouses where the environment is humid.

It usually spreads through wounds or infects stressed plants, although it can also infect healthy plants, especially in humid environments. Any time of year is a good time to expect it.

If humidity is low, infections may be contained within discrete spots, but if it is high they can spread rapidly. Above-ground parts of many plants, particularly buds and flowers, shrivel and die.

Small black seed-like structures form on infected material which are often overlooked.

A closely related fungus *Botrytis galanthina* causes snowdrop grey mould. This fungus only attacks *Galanthus* species (snowdrops) and is most severe on *G. nivalis* in mild winters.

4.1.7. Root Rot and Stem Rot (Stem blight)

The fungi responsible for root or stem rot include *Fusarium*, *Rhizoctonia*, and *Thielaviopsis* as well as the water moulds *Pythium* and *Phytophthora* that resemble fungi The initial symptoms typically manifest as a progressive decline in vigour, leaf yellowing, or wilting on sections of the plant that are above ground. Water and fertiliser solutions to correct the issue (as they may be seen as nutritional deficiencies) typically have negligible or no effect.

Root rot in Orchid

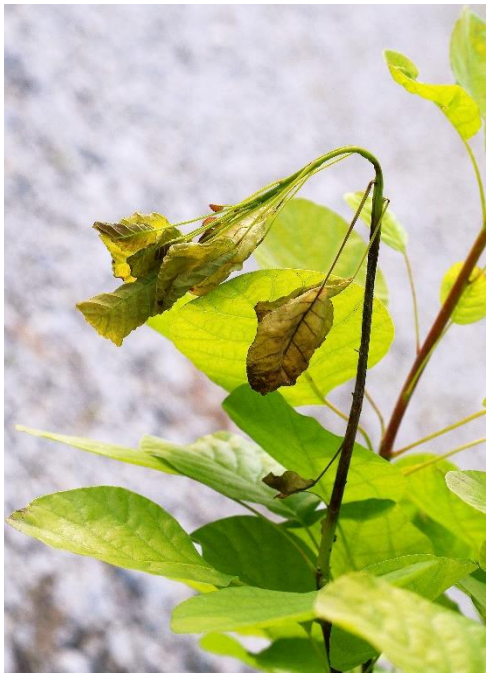
Rose stem blight

Plants must be carefully dug out and the dirt around the roots must be removed in order to diagnose root rot infections. Infected roots have a decaying appearance, are typically brown to black, and can be mushy or spongey. In ornamental plants, root rot disease is encouraged by excessive soil moisture. Once soilborne fungi accumulate in a landscape and it is challenging to eradicate the infestation.

Plants with stem rot fungi commonly display pre-wilt signs. Advanced illness causes plants to wilt more severely and eventually die. At the soil line, the stems could be brown and shrivelled. The surface of the stem may be covered in the white, cottony mycelium of the fungus under particularly damp conditions. Chrysanthemums, geraniums, petunias, and other herbaceous ornamental plants are very susceptible to stem rot.

Damping-off, a similar disease of seedlings, kills ornamental seedlings during the first few weeks after seed germination.

4.1.8. Vascular Wilt Disease



Wilt disease in smoketree

Fungi like *Fusarium*, *Verticillium*, and *Ophiostoma* can cause the wilting of many ornamental species by limiting the water supply to leaves and stems. The toxins these fungi produce are responsible for the wilting. When fungal growth plugs water-conducting vessels, other infections can accumulate there. Individual branches will often wilt and die back on one side of the plant first as a result of vascular wilt infections. Infections with Fusarium and Verticillium typically start in the roots and progress internally throughout the affected plant. One example is maple verticillium wilt.

Other wilt fungi infect via upper plant tissues. Discoloured streaks in the wood of affected branches, which are discernible upon cross-sectioning, are among the signs of the vascular wilt disease.

4.1.9. Cankers

Cankers on a rose stem

Cankers are small, localised patches of sunken lesions on the trunks, stems, or branches of woody plants. Bark tissues shrink and die as a result of canker illnesses. The wood beneath is frequently visible as the dead tissues break open.

Although some canker diseases are not visible outside of the bark, cankers usually start as small, discoloured yellow, brown, or red spots that occasionally look as though they are drenched in water. Cankers' centres may turn tan or grey as they enlarge. The canker may develop little, black, pimple-like structures that are fungal fruiting bodies that carry spores. Cankers have a tendency to grow huge and encircle stems, killing the sections of the plant above them.

Canker-causing fungi typically spread through a wound or other damage to the bark or wood. Rose canker is a common example of a disease showing this symptom.

4.2. Bacterial diseases of ornamental plants

Plant pathogenic bacteria typically persist in infected plants, in plant waste, and occasionally in infected soil. Most need a wound or other naturally occurring entrance in the plant to enter,

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and need warm, moist conditions to spread disease. Bacteria flourish on the nutrients that seep into spaces between plant cells or inside the vascular tissue of the plant. They release enzymes that break down cell walls, toxins that digest cell membranes, growth regulators that interfere with normal plant growth, and complex carbohydrates that clog water conducting vessels depends on the kind of bacteria involved and the tissue afflicted.

The majority of bacterial infections substantially disrupt photosynthesis and respiration to the disadvantage of the plant. **Symptoms of bacterial diseases in plants can be divided into those causing distinct leaf symptoms (leaf spots or leaf wilting) and those causing more general soft rots** (caused by breakdown of pectin by bacteria). Few examples are described below.



Chrysanthemum, geranium, impatiens, and many other attractive plants are susceptible to **leaf blights and spots** caused by *Pseudomonas cichorii*. The spots are often dark brown to black and appear to be moist with water and some may have a yellow halo. *P. cichorii* has been reported as a cause of leaf spots on lavender, parsley and basil. In herbs such as coriander and parsley the most common disease is leaf spots caused by *Pseudomonas syringae*.

Another bacterial genus that has significant plant harmful species is *Xanthomonas*. Geraniums become infected with bacterial blight or wilt due to *Xanthomonas campestris* pv. pelargoni. Other Xanthomonas species prey on foliage plants as Dieffenbachia, Philodendron, Syngonium, Aglaonema, and others.

Numerous herbaceous ornamentals, including geraniums, become vascularly wilted by *Ralstonia solanacearum*. Geraniums exhibit unpleasant symptoms that resemble the bacterial blight brought on by *Xanthomonas campestris* pv. pelargoni. *Ralstonia solanacearum* is difficult to eradicate once it has infected a greenhouse. Symptoms of infection including leaf withering, vascular tissue browning, leaf yellowing, and plant mortality.

Dickeya dadantii and *Pectobacterium carotovorum* infect a variety of greenhouse plants. It has been demonstrated that *Dickeya dadantii* can survive on plants that it does not truly infect. This may result in leaf patches or a mushy, stinky, squishy rot.

5. Pests of ornamental plants

Given the variety of species produced by nurseries or the ornamentals in a landscape, it is not unexpected that the plants in these spaces can be impacted by a large variety of pests capable of attacking several different crops. The common pests of herbaceous and ornamental plants in the UK are listed in the table below.

Table 1. The most common pests of ornamental plants in the UK

Insect	Host range	Scouting
Aphids 	Most ornamental plants	Check for heavy infestations on leaves and stems, especially in spring and autumn. Causes wilting of terminals.
Wooly aphids 	Edible and crab apples, pyracantha and *Cotoneaster horizontalis*	Between spring and early autumn, affected parts of the trunk and branches are covered with a fluffy white waxy material. Check susceptible plants frequently from spring onwards so action can be taken before a damaging population has developed 
White flies 	Most house-plants and greenhouse plants	Be alert for honeydew or sooty mould. Clouds of small, white, moth-like adults fly out when foliage is disturbed. Scale-like immatures occur on undersides of leaves.

Insect	Host range	Scouting

Vine weevil 	Most ornamental plants	Check susceptible plants frequently so action can be taken before a damaging population has developed. Look for notched leaves particularly on thick leaved evergreen plants.
Box tree caterpillar 	Box (Buxus)	Check box plants frequently from early spring onwards so action can be taken before a damaging population has developed. Check for pale yellow flattish eggs laid sheet-like, overlapping each other, on box leaves. The caterpillars eat box leaves and produce webbing over their feeding area. 
Leaf miners (insects that complete at least a portion of their life by living and feeding inside plant leaves) 	*Alstroemeria, Aster, Calendula, Centaurea, Chrysanthemum, Dahlia, Gazania, Gypsophila, Lathyrus, Malva Oxalis, Petunia, Phlox, Verbena and Zinnia*	Check for mines, leaf tying, and tattered defoliation of leaves at tips of branches. 
Thrips 	Thrips occur on many plants but are most important on roses, tropical hibiscus, and laurels.	Check for feeding injury and distortion on flower petals, especially on light-coloured blooms. Large numbers of thrips may move to roses as wild hosts dry in spring. Often found at base of flower petals.

Red spider mites 	Many greenhouse and garden plants, and houseplants	Be alert for stippling, yellowing, or bleaching of leaves. Use a hand lens to check for mites. 
Fuchsia gall mite (microscopic sap-sucking mite that is specific to fuchsias) 	Garden and greenhouse fuchsias.	Check for extensive galling and distortion affecting the appearance of fuchsias
Glasshouse mealybug 	Many houseplants and greenhouse plants	Concentrations of white, cottony or powdery material in crotches of twigs and terminals may indicate mealybugs. Check for small, oval, soft-bodied insects. 
Capsid bugs (sap sucking bugs with over 200 species found in Britian)	*Caryopteris, Chrysanthemum, Clematis, Dahlia, Forsythia, Fuchsia, Hydrangea, Phygelius*, roses and *Salvia*	Tattered foliage with distorted appearance and aborted flower buds
Slugs and snails	Many ornamental plants	Be alert for feeding injury on leaves, especially as leaves are emerging in spring.

6. Integrated Pest and Disease Management (IPDM) for ornamental plants and landscapes

Pesticides have been an integral part of agriculture and food security, facilitating the production of safe and high-quality food, feed and ornamental plants. The use of pesticides has allowed more production per given area of land, increasing yields and farm revenue. However, after application pesticides may leach into the surrounding environment, particularly watercourses, causing damage to non-target species. This in turn, has the potential to decrease biodiversity and destabilise ecosystems. In addition to the environmental implications, some pesticides can also have adverse effects on humans. Finally, incorrect or prolonged use of a pesticide causes it to become ineffective in the target species. Therefore, Integrated Pest and Disease Management (IPDM) approaches have been developed which rely on controlling, preventing or suppression of pests and diseases and reducing the use of chemical pesticides.

6.1. Principles of IPDM

Integrated Pest and Disease Management, or IPDM, is a broad approach to maintaining nurseries or commercial greenhouses in which pests, diseases and weeds are either prevented or suppressed using a combination of practices (cultural, mechanical, biological or chemical) and reducing chemical use. These practices are based on the 8 principles of IPM documented in the suite of 2009 European Union legislation known as "The Pesticides Package".

Principle 1. Prevention and Suppression

This refers to practices that prevent the pathogen or pest from becoming dominant or damaging the system.

Examples

- Where appropriate, using resistant or tolerant varieties.
- Hygiene measures – cleaning equipment and machinery.
- Crop rotation

Principle 2. Monitoring harmful organisms

Regular inspection can detect and identify pathogens, insects and other arthropods and determine which ones are truly causing harm.

Examples

- Observation in the field for signs of infestation
- Forecasting an infestation from history or previous experience
- Early identification of pest based on signs of infestation.

Principle 3. Decision making based on monitoring and threshold

This is challenging as thresholds for many pests are not established. Seeking professional advice is recommended.

Principle 4. Nonchemical methods

Sustainable biological, physical and other non-chemical methods must be preferred to chemical methods if they provide satisfactory pathogen and pest control.

Examples

- Promoting insects which prey on pest species.
- Using natural deterrents of pests like plant essential oils
- Attracting birds which feed on insects by providing safe nesting sites (trees & hedgerows)

Principle 5. Pesticide selection

The pesticides, fungicides or bactericides applied must be specific as possible for the target pest and have the fewest side effects on human health, non-target organisms and the environment.

Principle 6. Reduced chemical use.

The professional user must keep the use of pesticides and other forms of interventions to levels that are necessary.

Examples:

- Reducing application frequency once the level of risk in vegetation is below threshold and then managing with non-chemical interventions.
- Using combination of pesticide and non-chemical methods

Principle 7. Anti resistance strategies

Where the risk of resistance against a plant protection measure is known and where the level of pest requires repeated application of cidal agents, available anti resistance strategies should be applied to maintain the effectiveness of the product.

Example

- use of chemicals with different modes of action.

Principle 8. Evaluation

Based on the records on the use of chemicals and on the monitoring of harmful pests the professional user should check the success of the applied plant protection measure applied.

6.2. Prevention and control of diseases and pests using cultural practices.

Healthy plants are more resistant and more tolerant to diseases and pests. Practices that promote good growth and plant health are key. While there is no guarantee that you won't have pest or disease problems, there are some low effort disease control methods.

i. Good air flow

Provide good air circulation around the plants by not planting the individual plants or not placing plant pots too close to one another. Bacteria and fungi will have a harder time spreading if plants are reasonably spaced out. Tightly packed plants invite feeding insects that enjoy both the shelter from the heat and the cover from predators.

ii. Proper watering

Avoid getting the whole plant wet and focus water directly to the plant roots. Avoid overhead sprinklers and use drip systems instead. Microbial pathogens and spoilage causing organisms thrive on moist plants. Water in the morning especially on hot sunny days. This offers two benefits. First, your plants will be well hydrated when the hottest part of the day comes around making them less apt to wilt and stress and therefore less appealing to insect pests who prey on stressed plants. Secondly, the leaves will have time to dry off before the evening. Damp plants especially if they are close and densely planted, are ideal hangouts for many pests, like slugs, snails, and earwigs.

iii. Disease resistant cultivars

The use of disease and pest disease resistant cultivars is the most efficient and cost-effective means of disease control. There is little additional operating expense and no hazard to the producer or the environment. Equally important is the fact that plant residue of resistant cultivars constitutes less of a disease inoculum problem for future plants. Use of resistant varieties is particularly beneficial when the disease organism has a wide host range, persists

in the soil for long periods, has a high rate of spread (eg powdery mildew), spreads over long distances via spores or insects and is seed-borne.

iv. Crop rotation

You should also include rotation planning, avoiding planting by family to minimise disease and weed build up and aim to plant by harvest time to improve ease of harvest. You can also include cultivation approaches to help schedule plants. Plants grown in pots or modules can be moved in/out of protection as the season requires it, helping you to extend the season where required. Chilling of bulbs or corms (e.g. Gladioli) and successive plantings can give a good spread of flowers.

Cutting back perennials between May and June (the "Chelsea Chop") can be suitable for many flower types such as Helenium and Echinacea can push back flowering, encourage side shoot development and will have a bigger effect the closer you come to flowering. For large stands this can be done in blocks to give waves of flowers over a period of time to avoid gluts.

v. Sanitation

Remove diseased plants or weeds promptly. Do not put diseased plants or weeds in the compost pile. Some pathogens form resistant structures that can tolerate unfavourable conditions; therefore, incineration or council composting facilities are ideal for diseased plant disposal. Follow strict biosecurity measures for greenhouses.

6.3. Physical control of pests and diseases

i. Physical barriers

Insect nets – greenhouses require sufficient ventilation, and it is never worthwhile to totally seal them off to keep out incoming pests. But simply covering open windows or other vent points with netting, you may easily reduce the number of large flying insects that enter.

ii. Sticky traps

Insects often enter greenhouses when these are being accessed and rapidly multiply inside the warmth of these structures. Sticky traps these are ideal for detecting, monitoring and controlling insects in greenhouses.

iii. Removal

Hunting down slugs and snails after dark using tongs can be an effective method of keeping a check on their population. You can also use baits or put down a flat slate on the soil near your plants and check underneath it every day to remove the slugs and snails which have congregated.

6.4. Biological control and treatment pests and diseases

Biological control involves use of predators and parasites that feed on insects or organisms that inhibit the growth of pathogens or use of botanical extracts to deter pests. Salts of copper and iron are found in nature, processed for use, and termed 'synthetic' also allowed to be used with some restrictions (used in a manner that minimizes accumulation in the soil) in organic production systems. It is the most promising alternative to chemical plant protectants. Advantages of biological control are,

- They usually target a specific group of pathogens and therefore have fewer negative impacts on the ecosystem.
- They can sustain themselves and keep in place for a longer time without additional efforts.

Table 2. Examples of organic control material and their target plant pathogens

Organic material	Target pathogen or disease
Copper	*Alternaria, Erwinia, Pseudomonas, Xanthomonas, Powdery mildew, Downy mildew, Phytophthora, Pythium, Botrytis*
Neem oil	Powdery mildew
Potassium bicarbonate	Powdery mildew
Potassium silicate	Powdery mildew, *Pythium, Botrytis, Fusarium*
Sulfur	Powdery mildew

Table 3. Examples of biological control agents approved in the UK and their target plant pathogens

Biological control organism	Target pathogen or disease
Ampelomyces quisqualis (fungus)	Powdery Mildew
Gliocladium catenulatum (fungus)	*Pythium, Rhizoctonia, Botrytis*
Trichoderma harzianum (fungus)	*Pythium, Fusarium, Phytophthora, Rhizoctonia, Botrytis, powdery mildew, downy mildew, Sclerotinia*
Bacillus amyloliquefaciens (bacterium)	Grey mould (*Botrytis* spp.)
Pseudomonas chlororaphis strain (bacterium)	A seed treatment for the control of seed-borne fungal diseases

Table 4. Examples of biological control agents approved in the UK and their target insect pests

Biological Control	Target insect pest
Ant nest nematode - *Steinernema feltiae*	Ants
Various products containing – *S. feltiae* and *S. carpocapsae* including Nemasys Fruit and Veg protection nematodes Predatory bug – *Macrolophus pygmaeus*	Caterpillars
Lacewing larvae – *Chrysoperla carnea* Mealybug ladybird – *Cryptolaemus montrouzieri* Mealybug parasites – *Leptomastix* & *Leptomastidea* sp., combined with *Cryptolaemus* Mealybug parasites – *Leptomastix* & *Anagyrus* species	Glasshouse mealybugs
Predatory mites – *Amblyseius species* Glasshouse red spider mite predator – *Phytoseiulus persimilis* Rove beetle – *Atheta coriaria* Predatory bug – *Macrolophus pygmaeus*	Glasshouse red (two spotted) spider mite (*Tetranychus urticae*)
Glasshouse whitefly parasitoid – *Encarsia formosa* Predatory mite *Amblyseius andersoni as* whitefly egg predator Predatory bug – *Macrolophus pygmaeus*	Glasshouse whitefly *(Trialeurodes vaporariorum*)
Slug nematode – *Phasmarhabditis hermaphrodita* Slug nematode – *Phasmarhabditis californica*	Slugs

The biological control products mentioned above are commercially available and suppliers will usually provide advice on suitable products depending on the size of the greenhouse or the area to be treated, the main type of plant and the extent of the problem. Biological products are often compatible with each other but incompatible with most pesticides.

Commercially bought biological control agents incur additional costs to the growers. But growers can adopt certain practices to naturally attract predatory species.

- **Introducing beneficial insects to control insect pests**

Not every insect is a pest. Some are carnivores who will quickly reduce pest population. Eg The ladybug nymph is a voracious eater of aphids. This reputation has led gardeners to release ladybirds into their greenhouses and polytunnels. Beneficial insects do feast on pest insects, but there may be certain points in their life cycles when their diets are confined to nectar and pollen. Ladybirds like a mixture of lower herbaceous planting to larger shrub borders. They particularly love flowering plants with loads of pollen and scented herbs. Well established

flower borders with plants of varying sizes are very beneficial for ladybird populations to thrive.

6.5. Pesticide use

IPM does allow the use of chemical plant protectants if non – chemical methods of pest and disease control fail to provide satisfactory control or treatment. The decision to apply pesticide should not be taken lightly and should be done after a thorough risk assessment. You may need expert advice and find it helpful to supplement any initial training you have undertaken with continuing professional development programmes. Failure to use pesticides correctly can put people and the environment at risk.

More information on safe use of pesticides can be found on

https://www.hse.gov.uk/agriculture/topics/pesticides.htm#:~:text=Make%20sure%20you%20use%20any,avoid%20walking%20through%20treated%20areas

6.6. Resistance management

Severe infestations may require frequent and prolonged use of pesticide which can increase the risk of the pest becoming resistant to the pesticide i.e no longer effective in killing the pest. Pesticides are grouped into different classes depending on their chemistry. Effective resistance management requires rotation among the various classes of pesticides specific to the target pest. Often when one insecticide in a chemical class fails because of insecticide resistance, other insecticides in the same class will also become ineffective. Selection of a combination of insecticides from different classes will improve the chances of obtaining control. Therefore, it may be very useful to be aware of the class of pesticide being used which is mentioned on the label or the safety data sheet.

Consult an advisor for insecticide resistance management and IPM strategies. Consider the pest management options available and map out a season-long plan to avoid unnecessary applications of insecticides.

Select insecticides with care and consider the impact on future pest populations. Avoid broad-spectrum insecticides when a narrow or specific insecticide will suffice.

Timing of applications: Applications of insecticide should be made against the most vulnerable life stage of the pest. Care should be taken to follow the recommendations of the manufacturer and advisors.

At the end of the season remove crop residues and over wintering habitats for pests. Consider next year's IPM/ Insecticide Resistance Management plans while planning and preparing for next year's crops.

7. Waste reduction in ornamental plant production and maintenance

There is growing pressure on all business to reduce their waste and make their practices more sustainable. This not only benefits the environment by lowering the greenhouse gas emissions but also the business itself considering the rising cost of waste disposal and compliance with new legislations. Horticulture Wales have developed a practical guide for the industry which based on having the knowledge of the **type** (metal, wood, plastic, glass, paper/cardboard, rubber and plant waste) and **source of waste** (supply, growing and processing or packaging and distribution) and then creating an **action plan** to determine how to deal with the waste. In addition to the three fundamentals, Reduce, Recycle and Reuse, of Waste Management, Repairing and Maintaining tools and Reinvesting in items made from recycled materials or that can be recycled will help to further reduce waste (5 R).

Some practical examples of waste management are avoiding and moving away from single use packaging, using waste wood as mulch and of course composting green waste which can be used within the business as growing medium. Buying peat free compost is a great example of Reinvesting in responsibly sourced and recycled products. Operating the business as a Circular Economy can keep the materials in use for as long as possible and thereby reducing waste.

The necessity of better water management in horticulture operations is also increasing.


- Greenhouses and protected environments can collect rainwater and store appropriately to reduce water demand for at least some parts of the year.
- Appropriate ventilation can reduce the impact of evapotranspiration loss from protected environments.
- Drip irrigation for hanging baskets and other container-grown plants in nurseries can ensure more effective water use (water goes directly to roots)
- Setting the irrigation to occur in the early mornings or late evenings can reduce evaporation losses thus improving water efficiency.