Institute and E.H.S. levels. We are currently interested in extended cold storage of plants and ways of improving winter hardiness by a closer control of nutrition. This is in addition to herbicide screening and other control products. The changes in funding of research in the future is something which will make us look closely at where we get the best value for money, in-house or at a national level. The expansion or contraction of these facilities in therefore under current review.

A pencil in your hand, not a sprayer. How long is a piece of string? I can't answer that question, but I do know where it starts. Crop protection starts by sitting down with a pencil, not a sprayer in your hand! As growers, we know what problems to expect and when they arrive, and are not pushed into crop protection. We strive to be one step ahead. Observation of the weather helps in identifying pending problems such as: aphids after 5-7 days of warm moist humid atmosphere; red spider mites after dry and warm weather for 2 weeks. The Mills and Beaumont period warnings are good reminders for fungal disorders like the mildews and some leaf spots. Wet autumns increase the likelihood of red core, and when controlled-release fertilizers respond to low temperatures like this year's, the addition of liquid feed is necessary to maintain conductivity levels.

We aim to protect the crop from a controlled position. It may seem non-productive to sit down in the winter and work out many of the aspects I've covered but we have learned that it pays off in the end. We have targets in our crop protection programme that we can aim at: labour profiles, chemical costs, and capital requirements. It is said that strategy does not win the immediate battle, but it wins the war. Spending time in planning our crop protection is proving to pay off on the bottom line.

PROGRESS WITH DISEASES AND DISEASE CONTROL

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The temperatures and humidities maintained during propagation are favourable for the development of a wide range of pathogenic fungi. These can reduce very substantially the number of cuttings which produce vigorous, healthy root systems. This paper reviews the fungal diseases most important

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during propagation. It also describes measures for their control.

The origin, age, and location of mother plants and various cultural factors such as nutrition, pruning, and irrigation regimes used, all influence the microflora of cuttings and their susceptibility to disease. Fungi most commonly isolated from decaying cuttings submitted to the ADAS Plant Clinic at Reading are listed below:

Common causes of fungal decay in cuttings of *Azalea, Calluna, Camellia, Chamaecyparis, Erica,* **and** *Juniperus:*

Botrytis	*Glomerella*	*Phomopsis*	*Rhizoctonia**
Colletotrichum	*Monochaetia*	*Phytophthora**	*Thielaviopsis**
*Cylindrocarpon**	*Pestalotiopsis*	*Pythium**	

Some of these fungi are soil-borne (* above) and can be introduced in contaminated compost. Others the so-called water moulds, e.g. *Pythium* and *Phytophthora*, may arrive in the irrigation water. All can be harboured by mother plants and are frequently carried into the propagation unit on cuttings. Thus, the process of producing high quality stock must begin with the selection and maintenance of healthy mother plants.

Mother plants. Ideally mother plants should originate from clonally selected material and be free of major diseases. Where clonal selections are unavailable then the health of any alternative should be verified as far as is possible. This need is now well recognised as is the necessity to establish special isolated stock beds on "clean" land, and their treatment with a rational programme of pesticides to protect against pests and diseases. The programme adopted for any stock area will depend on the subjects grown and their susceptibility to disease. The identification of likely disease problems is essential in formulating a programme of fungicide use for mother plants. Some diseases are readily identified because they produce easily recognisable symptoms. Good examples are: discrete leaf spots produced by *Septoria* (on *Hebe*); *Phyllosticta* (on *Viburnum*); and *Monochaetia* (on *Camellia*). Affected shoots can be pruned out and the remainder treated with a fungicide.

Some fungal pathogens, e.g. *Cylindrocarpon, Pythium,* and *Rhizoctonia* are harboured by mother plants usually without obvious symptoms yet are responsible for extensive losses during propagation.

It is usually worthwhile treating mother plants with broad-spectrum fungicides to reduce inoculum of pathogenic fungi. Fungicide protection is especially important prior to taking a batch of cuttings. Fungicides like benomyl (Benlate), carbendazim + maneb (Delsene M, w.p. formulation), and a

manganese formulation of prochloraz (Octave) are useful in this context. Treatment immediately after removal of cuttings is also worth considering to protect cut surfaces of mother plants against fungal invasion. Flexibility is an essential component of the fungicide programme. Unexplained symptoms should be checked for disease and the programme adjusted to take account of any new development.

Propagation. Fungicide treatment of mother plants reduces but does not eliminate fungal inoculum. Further treatment is usually warranted during propagation. For a fungicide to be of use during propagation it needs to have a fairly wide spectrum of activity. This is essential because the industry produces such a wide range of plant species, each having its own microflora of fungi and bacteria. The successful fungicide also has to be safe in that it has no deleterious effect on rooting.

Trials during recent years have been designed to evaluate the benefits of fungicides as pre- and post- insertion treatments. The most comprehensive exercise of this sort was conducted by Dr. P. Smith of the Glasshouse Crops Research Institute. She determined the efficacy of fungicides during the propagation of four cultivars of hybrid *Rhododendron*. Initially she identified the microflora of cuttings and found that 39% were contaminated by *Cylindrocarpon destructans*, 16% by *Pestalotiopsis sydowiana*, and 8% by *Botrytis cinerea*. The cuttings were immersed in suspensions of a range of fungicides and stem bases dipped in IBA hormone powder before insertion in a 50% peat: 50% grit rooting medium. This was then drenched with the same fungicide. Cuttings were covered with polythene sheeting and the base temperature maintained at 20°C. Cuttings were assessed 3½ months later. The following results were obtained:-

(i) *Cylindrocarpon destructans* was the main cause of decay.
(ii) Prochloraz (Octave 50% w.p. at 0.5 c.p./litre) or benomyl (Benlate 50% w.p. at 1 g c.p./litre) when applied to both cuttings and compost gave the best control of decay, the lowest incidence of C. *destructans* and the highest percentage of rooted cuttings. They were superior to captan (Captan 50% w.p. at 2 g c.p./litre)
(iii) Carbendazim + maneb (Delsense M 10% + 64% w.p. at 0.5 g c.p./litre) gave results similar to benomyl but was inferior to prochloraz.
(iv) Benomyl was not effective when applied only to cuttings. Similar trials have been conducted on cuttings of ericaceous plants (*Calluna*, *Erica* and *Daboecia*), and of *Juniperus* under mist. Prochloraz manganese (Octave 50% w.p. at 0.5 - 1.0gc.p./litre), gave good results in both instances. Iprodione (Rovral, 50% w.p. at 0.5g c.p./litre) on erica-

ceous subjects, and benomyl on all subjects except *Daboecia* also improved the percentage of well-rooted cuttings. In these trials, species of *Pestalotiopsis Botrytis, Phomopsis, Fusarium* and *Glomerella* restricted the rooting of untreated plants.

In the series of trials neither *Pythium* nor *Phytophthora* were a problem. These fungi are sometimes a cause of decay in the propagation unit. *Pythium* is more commonly found than *Phytophthora*. Where *Pythium* is recovered from decayed roots it may be the primary cause of damage, or secondary in so far as it is invading roots weakened due to adverse growing conditions. Nutrient imbalance, high pH, or poor drainage of the compost can all predispose roots to invasion and decay by *Pythium* spp.

Pythium and *Phytophthora* are often introduced in contaminated irrigation water. This is especially a risk where mains water is stored in an uncovered tank prior to use or where growers are forced to make use of non-mains supplies. Recent joint work by ADAS and G.C.R.I. has shown that surface water can be freed of water moulds by chlorination. Two parts per million of free chlorine for a minimum exposure period of one minute is sufficient to kill the motile spores (zoospores) of *Phytophthora cinnamomi*. Surface water often requires coarse filtration to remove suspended organic matter prior to chlorination. The chlorinated water needs to be stored in a covered tank to prevent re-contamination before use for irrigation.

On nurseries where there is a recurring problem with *Pythium* or a high risk of *Phytophthora*, fungicide treatment of the compost may be necessary. Fungicides with label recommendations for control of these fungi are listed below:

In Compost or as a Drench

etridiazole - AAterra W. P., furalaxyl - Fongarid, 25 wp

As a Drench

propamocarb hydrochloride - Filex

fosetyl aluminum - Aliette (effective against *Phytophthora* but does not control most species of *Pythium*)

Recommendations for the control of diseases during propagation are listed below:

— Maintain a high standard of hygiene in the propagation unit
— Encourage growth with a well balanced and drained compost

— Use clean uncontaminated water
— Identify target diseases
— Dip cuttings and drench the compost with a fungicide, e.g. prochloraz, benomyl, or captan
— Repeat drenching sprays at 14 day intervals alternating fungicides to minimise the risk of fungicide resistance
— Avoid trimming leaves of large-leaved subjects, e.g. *Camellia* and *Rhododendron*; (cut surfaces rapidly become invaded by wound pathogens notably *Monochaetia*, *Botrytis*, and *Pestalotiopsis*).
— Where necessary consider the use of etridiazole or furalaxyl to protect against *Pythium* and/or *Phytophthora*

Two specific diseases are worthy of mention as they are currently troublesome:

(a) **Rhododendron powdery mildew.** Symptoms may be apparent throughout the year but are most obvious from June onwards. They appear as faint yellow blotches on the upper surfaces of leaves. As leaves age these blotches may develop a purple margin. With some *Rhododendrons* e.g. 'Seta' the purple margins appear early and the lesions turn brown or purple to resemble a leaf spot. Occasionally in very shaded situations a white powdery fungal growth develops on upper surfaces. Usually, however, this sparse growth is more common on the lower sufaces of leaves.

The disease spreads rapidly when mild, humid weather coincides with a growth flush in early to mid-summer. Powdery mildew was first recorded on outdoor rhododendrons in the U.K. in 1980. It is now widely distributed in southern and eastern counties of England and has spread as far distant as Cornwall, Gwynedd, and Argyll. Severe attacks can defoliate susceptible species, e.g. *R. abeconwayi*, *R. griffithianum*, *R. ponticum*, and *R. cinnabarinum*. Many hybrids are also susceptible.

If only a few rhododendron plants are affected by powdery mildew it is probably wise to remove and destroy them. If, as is more likely, infection is widespread remove worst affected shoots and deploy a regular programme of fungicide sprays. The fungicide should be applied at 7 to 10 day intervals when growth is rapid and conditions favour the disease; at 14 to 21 day intervals at other times. The programme should continue until temperatures fall during October or early November. Imazalil (Fangaflor) and triforine + dimethylformamide (Funginex) have label recommendations for control of this disease.

(b) **Botrytis grey mould:** *Botrytis* is probably the most com-

mon fungal pathogen on ornamentals.

It is an increasing problem on many nurseries causing leaf spot and die-back symptoms. Grey mould is especially a problem on thin-leaved evergreens grown under protection during autumn and winter. In the past, *Botrytis* has been well controlled by the use of fungicides but this is now less successful due to the occurrence of fungicide-resistant strains. The fungi*cides** *available for control of Botrytis on various ornamentals* are listed below:

Group 1: Benzimidazoles, e.g. benomyl - (Benlate); Carbendazim-Focal Flowable

Group 2: Dicarboxamides, vinclozolin - (Ronilan); iprodione - (Rovral)

Group 3: Pthalonitriles, chlorothalonil - (Repulse)

Group 4: Dithiocarbamates, thiram zineb captan

* all fungicides listed are not necessarily recommended for hardy or ornamental nursery stock.

Fungicides from other groups, e.g. dichlofluanid (Elvaron) *and prochloraz (Octave) are currently being evaluated for Botrytis* control on hardy ornamentals.

ADAS surveys have monitored the extent of fungicide resistance in *Botrytis* taken from protected ornamentals. Survey *results have shown that resistance to the benzimidazole* (mbc) fungicides increased between 1980 and 1984 but that resistance to the dicarboximide materials has increased even more dramatically. Many isolates of *Botrytis* from nursery stock in South East England during 1984 and 1985 exhibited resistance to both groups of fungicides, thus limiting choice of effective materials.

Guidelines for Control of Botrytis

— Avoid damage which provides an entry point for *Botrytis*
— Remove and destroy any dead or dying plants and senescing leaves which provide an ideal substrate for *Botrytis*.
— Avoid as far as is possible conditions of high humidity (over 93% R.H.) by ventilation, Sub-irrigation is preferable to overhead watering.
— Where resistance is suspected, contact ADAS for advice on the use of alternative fungicides to benzimidazole and/or dicarboximide materials
— Where resistance is not yet a problem, risk of it developing is reduced by alternating fungicides from different chemical groups.

This paper has attempted to highlight some of the current disease problems of hardy ornamentals. It shows that there are many threats to the health both of mother plants and cutting

material. Within the scheme of things the prophylactic use of fungicides correctly integrated into the production system can substantially decrease crop losses and improve quality and health of those that survive.

ALPINES AND HERBACEOUS PLANTS FROM SEED PRODUCED IN LOW COST FILM PLASTIC STRUCTURES

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Herbaceous and alpine subjects can be produced in fully ventilated low cost film plastic structures and will fit into the schedule of the traditional bedding plant producer. The material can be satisfactorily grown in these structures without heat although hardening off and control of growth by growth regulants may be necessary. The production of herbaceous and alpine subjects from seed has been part of the "Bedding Plant Programme" at Lee Valley EHS for the last four years. The objective set was to establish sowing schedules which would fit in with the traditional bedding plant season. Also to establish new subjects which may have not been grown by the traditional bedding plant producer.

Structures. The experiments were carried out in prototype 5 m side and end ventilated film plastic structures, all single clad with 150 micron UV inhibited EVA polyethylene. These structures are more fully described in the Station Leaflet "Low Cost Plastic Structures for Vegetables, Flowers, and Nursery Stock Production". An additional aid to seed germination and summer establishment has been the use of an internal thermal/shade screen which is fully described in Station Leaflet No 24. This screen can easily be replaced by a shade screen only.

A side "baffle" at floor level to approximately 20 cm as shown in Figure 1. This has helped in the reduction of the "edge effect" commonly found in single span side and end ventilated film plastic structures. The skirt successfully redirects the air flow above the plant material but does not adversely affect the ventilation capacity of the side ventilation. In addition, during winter, in periods of driving snow and rain, the outside rows of plants nearest the ventilation skirt were protected.

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