HNS 5 MASTER

Research Report

HNS 5

Replant disease

Working for Growers

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HO/5

Replant disease. Project Co-ordinator: B Humphrey Project Leader: B Howard Location: IHR-East Malling, ADAS trials at Knaphill, Luddington EHS and Notcutts Start date: 1.4.87

This HDC project has been set up to build on the existing information available from previous work carried out at IHR-East Malling and elsewhere. This work has demonstrated that the growth of various species is adversely affected, to a varying extent, by the culture of identical or different species in the same soil beforehand; the so called soil sickness or replant effect.

Work at IHR-East Malling has indicated that this effect may be reduced or even totally reversed by the use of slow release sources of Nitrogen as an alternative to the more conventional system of partial sterilisation of the soil by chemicals or heat.

The project sites, species and treatments

Five sites were eventually chosen to carry out further work on the project. Species were somewhat different at each site.

1) IHR-East Malling - at this site work was carried out to incorporate the following species:-

Prunus avium
Fagus sylvatica
Fraxinus excelsior
Acer pseudoplatanus
Sorbus aria
Rosa rugosa
Rosa laxa

The work with these species was carried out in pots, these being placed in glasshouse conditions. The growing medium was based on 30 year old 'cherry soils'.

This trial has already shown some very interesting responses giving improvements so far of up to 200% in growth with the best treatment compared with untreated controls. Generally the slow release nitrogen treatments are performing better than soil sterilisation treatments.

2) Luddington EHS - at this site similar treatments for those in (1) are taking place in open air plots of cherry rootstock Colt.

3) Oakover Nurseries - at this site the following species were lined out into soils with similar treatments to the above:-

Acer plataniodes
Sorbus intermedia
Robinia pseudoacacia (because of unavoidably late planting survival of this species has been poor)

4) ADAS, Surrey are carrying out trials with Robinia pseudoacacia at Knaphill Nursery.

5) Notcutts Nurseries - at this site the following are planted in plots as before:-

Fraxinus excelsior
Crataegus oxycantha

These are planted on a site which has carried two previous crops of Rosaceae trees.

It is too early to draw any firm conclusions regarding optimum responses, but visual inspection is already showing significant differences in foliage colour and size.

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The improved growth of plants after soil partial sterilisation (SPS) is due to the eradication of pathogens and the increased availability of nutrients - especially N. Work with pot-grown apple seedlings indicated that the nutrient effects of SPS could be mimicked by certain N ferilisers, and, although at high application rates, these could equal or exceed the effects of SPS. Funding has enabled these studies to be extended into HONS.

In pot-plant tests (using old soils from under each subject) slow release (SR) N fertiliser amendments resulted in greater growth of *Acer*, *Prunus* and *Rosa* (*laxa*) than did SPS. SRN also resulted in greatly improved growth, but less than SPS, of *Fraxinus* and *Rosa* (*rugosa*). SRN was not effective for *Fagus*, *Pinus* and *Taxus*.

Seven replicated field trials were also established (three under ADAS management) to compare effects of SPS and SRN on the growth of *Acer*, *Crategus*, *Fraxinus*, *Prunus*, *Robinia*, *Sorbus* and *Tilia*. Six trials have yet to be sampled, but in one trial, on old Robinia land, the SRN fertilisers used were comparable with SPS (formalin) for *Acer*, but not for *Robinia* and *Sorbus*. When SRN fertilisers were applied to second-year (initially dazomet-treated) seed beds, growth of *Fraxinus* and *Quercus* was very greatly increased, that of *Aesculus*, *Gleditsia* and *Hamamelis* was not increased.

When seedlings of *Acer*, *Malus*, *Robinia* and *Tilia* were each grown in soils collected from plantations of these four species the growth of each species was most greatly increased in sterilised ex-*Robinia* soil (EMRS/HONS Subject Day 25.9.85). Extensive follow-up work on this experiment has continued. Host-specific effects, not shown in the original experiment, have now been demonstrated in pathogenicity tests. Also, when each untreated soil was added (14% v/v) to a common sterilised soil, ex-*Malus* soil (not ex-*Robinia*) caused the greatest growth reduction (-50%). This result indicates the ex-*Malus* soil to be the most "pathogenic", and the greatest growth increases in sterilised ex-*Robinia* soil were probably due to its greater nutrient release. The growth response to SPS expresses nutrient effects in relation to pathogen effects and gives no indication of the relative strength of either. It is pathogen strength that is most likely to determine the outcome of attempts to ameliorate soil sickness problems with fertilisers.

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Replant disease and soil sickness problems	
Project Co-ordinator:	B Humphrey
Project Leader :	GWF Sewell
Location :	IHR - East Malling, Oakover, ADAS trials at Knaphill, Luddington EHS and Notcutts.
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Results

Most of the pot-plant work during 1987 was summarised in project News No 3. Results from field trials comparing fertiliser amendments and soil partial sterilisation (SPS) have not given the levels of success achieved in the glasshouse. Other work (in which slow release N fertilisers applied to polythene-mulched strawberries resulted in greatly increased yields) indicates that the SRN fertilisers to be effective generally require high temperatures. It was, in one sense, fortunate that 1987 was not a high-temperature season for misleading results might have occurred. The pot-plant work, however, has established the principle that the effects of the insidious pathogens involved in the 'poor growth' diseases can be greatly ameliorated by nutritional approaches. Finding the means to achieve this in the field is the next problem.

Future work

Several of the field trials involve grafting/budding and will continue into 1988. This will provide opportunities to test other fertilisers and fertiliser combinations. A new field trial involving *Rosa* rootstocks has been established near Aberdeen in collaboration with the North of Scotland College of Agriculture.

Since the last Project News, most time has been spent assessing the summer's results and in planning the 1988 programme. This will include: continuing studies on the reciprocal planting experiment (Project News No 3); further screening of fertilisers and fertiliser combinations; interaction effects between N and P; effects of fertilisers on specific host/pathogen inter-relationships; continuing studies on nutrient release following SPS (in collaboration with IHR analytical services); and possible methods of cheapening SPS (by dazomet).

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Introduction

Poor growth problems are often particularly severe in perennial plantation crops when similar species are replanted, they may also be severe in nursery situations with mixed rotations. This poor growth is associated with attacks on roots of primary structure by non-lethal pathogens possessing various degrees of host specialisation. Over the years the problem has been reliably controlled in the field by soil partial sterilisation (SPS) with the fumigants chloropicrin and dazomet, but not apparently by the application of fertilisers. However, studies on the latter aspect have been few and strongly over-shadowed by the consistent success of SPS. Following SPS, soils are not only pathogen-free, but are also nutritionally enriched - particularly by nitrogen in the ammonium form. Failure to relate the 'pathogenicities' of soils to the growth increases following SPS has guided recent research towards studies of nutrient effects on poor growth problems.

Results

Soil partial sterilisation and biomass-N

When soils are partially sterilised N is made available from the killed micro-organisms by the activities of the survivors. Studies on soil N levels after SPS showed that for any one soil different methods or degrees (doses) of partial sterilisation resulted in different amounts of N made available and these amounts were positively associated with sizes of plant growth increases. Studies on a set of different soils revealed a significant association ($P = 0.01$) between the NH4-N released after a standardised SPS method (pasteurisation) and the final sizes of plants grown in the pasteurised soils. There was, however, no association between N levels and the growth increases induced by pasteurisation. This presumably reflected the widely differing effects of the living biomass in non-pasteurised soils.

This work has emphasised the importance of nutritional effects of SPS (as opposed to pathogen eradication), but it does not appear at present that it will lead to a greater understanding of the relative importance of the two factors - each is always expressed only in relation to the other.

Fertilisers and specific pathogens

Attempts to observe the effects of various treatments on specific pathogens in natural (unsterilised) soil are severely restricted because (a) methods do not exist for confidently determining initial freedom from most pathogens (probably there is no natural soil that is free from Pythium spp.), and (b) most pathogens cannot readily be observed and identified with certainty within plant roots. These difficulties do not occur with Thielaviopsis basicola which is the most important poor growth pathogen of Prunus (and probably many other genera including Robinia and Tilia).

Searches of Research Station plots revealed one 50 y-old pear orchard soil that was apparently free from T. basicola. Soil (pH 5.9) was harvested from the herbicide strip (5-20 cm depth), treated (Table 1) and planted with Prunus avium seedlings at late first leaf-pair stage to avoid damping-off problems. The results are given in Table 1.

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Pathogenic fungi in roots of hardy nursery subjects

This work developed from reciprocal planting experiments in which four subjects (Acer pseudoplatanus, Malus sylvestris, Robinia psuedoacacia and Tilia platyphyllos) were each grown in soils collected from 5-6year old commercial plantations of the four subjects. Root samples from each of the 16 plant/soil combinations were examined microscopically and detailed observations and photographic records were made of root parasites. Fungi were also isolated from roots of the 16 combinations using selective and non-selective methods: samples of these isolates were tested for pathogenifc effects on the four subjects.

Results

Observations and isolations

As is usual with this type of study, many fungi that were observed in roots could not be identified and many fungi that were isolated into pure culture were not knowingly observed in roots. Even so some host/parasite associations were evident. The fungus Thielaviopsis basicola (cause of cherry and plum replant disease) occurred only in soil from plantations of Robinia and Tilia and only infected these two subjects: Acer and Malus were immune to Thielaviopsis. The chytrid Olpidium brassicae also occurred only in ex-Robinia and ex-Tilia soils and infected Robinia, Tilia and Malus. (This fungal virus-vector has never been observed in Malus roots from fruit plantations). Pythium spp occurred in all soils and were isolated from all four subjects with frequencies of 53-64%. P sylvaticum (of major importance in apple replant disease) was the most frequently occurring species in each subject. Roots of Tilia were frequently ensheathed by an ectomycorrhizal fungus and these roots were protected from invasion by other fungi: strong antibiotic effects were evident.

Pathogenicity tests

From more than 500 fungal isolations, 21 isolates of 9 Pythium spp, and 31 isolates of 23 non-Pythium spp were selected for inclusion in pathogenicity tests. The selected fungi were from known potentially pathogenic genera, or were spp with morphological features resembling those of fungi observed in roots, or were fungi that were frequently associated with certain subjects.

The selected fungi were individually added to sterilised composts (often acidic or alkaline, according to fungus 'preference') and their effects on growth of the four subjects were observed during 12-14 week. A summary of the maximum growth reductions is given in Table 1.

TABLE 1 - % GROWTH REDUCTIONS CAUSED BY INFESTATION OF COMPOSTS WITH FUNGI ISOLATED FROM ROOTS (MAXIMUM RECORDS FROM INDIVIDUAL HOST/PATHOGEN TESTS)

Pathogen	Subject			
	Acer	Malus	Robinia	Tilia
Cylindrocarpon spp	0	0	51	25
Fusarium spp	0	0	37	43
Thielaviopsis basicola	NH	NH	48	74
Pythium intermedium	21	15	90	49
P sylvaticum	16	0	72	45
P ultimum	33	38	75	78
P (homothallic) spp	0	32	78	23

NH = Non host (Not tested)

This summary includes effects of 14 fungal species from four genera: 38 other fungal isolates did not significantly reduce plant growth. While none of the pathogenic fungi was lethal, or associated with specific host symptoms, some of their effects on growth were very severe.

Discussion

Robinia and Tilia were affected by a wider range of pathogens, and more severely, than were Acer and Malus: this result is consistent with the greater growth increases observed in Robinia and Tilia in other tests when the plantation soils were sterilised.

Robinia was more affected by Thielaviopsis isolates from ex-Robinia soil than from ex-Tilia soil, and Tilia was more affected by its 'own' isolates than those from Robinia soil. Apart from this (and the generally greater sensitivity of Robinia and Tilia) there were few indications of pathogen adaptation to a particular host which might result in 'specific replant' problems.

It is noteworthy that the Pythium spp (especially P sylvaticum) from these HNS soils were of relatively low pathogenicity to Malus (compared with Robinia and Tilia) and were of much lower pathogenicity than has been found amongst isolates of similar species from apple orchards. The result suggests that Pythium strains, or pathotypes, aggresive to Malus may develop and accumulate only slowly, and in longer term plantings than normally occur in mixed ornamental nursery soils.

Perhaps the most striking feature of the results is the fact that, despite strenuous efforts to select pathogenic forms from many root isolates, few were found and these mainly included the known cause of tree fruit replant disease (Pythium and Thielaviopsis). Although Cylindrocarpon and Fusarium spp caused marked growth reduction in Robinia and Tilia, these fungi were not frequently isolated from roots - their selection for testing was based on the known pathogenic potential of these two genera.

Pythium spp generally are not host-specific although host-adapted pathotypes may occur (as already suggested). Thielaviopsis differs from Pythium in that certain host genera are immune to attack and soil populations of Thielaviopsis fluctuate greatly in response to cropping. Lists of hosts and non-hosts to this harmful pathogen might be of value in guiding nursery rotation sequences.

Future work

Experimental work within this project is virtually concluded. Time will be allocated to consolidating and preparing past work for publication. It will be extended by relevant studies, with emphasis on nutritional aspects of plant establishment in the new (MAFF funded) Farm Woodland Project.