THE SUSCEPTIBILITY OF THE SURFACE ROOT SYSTEM OF EUCALYPTUS MARGINATA TO PHYTOPHTHORA CINNAMOMI.

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The gross morphology, detailed structure and anatomy of the surface root system of jarrah (Eucalyptus marginata Sm) trees was examined on a number of sites with different fire and management histories. In all the sites examined, jarrah formed a dense surface root system in the Al horizon. The roots typically occurred in patches, but in some stands formed extensive sheets. This surface root system, on excavation, was found to be composed of pads ranging in size from 10cm to 1-3m in diameter and c 5cm thick. These pads are connected to horizontal root which send vertical risers from the leached soil horizon into the Al horizon where they divide extensively forming the surface pads. The pads are composed of short roots 1-3mm long (which commonly form dense clusters around lateritic pebbles) which arise from small (n-1) order laterals 0.5-1.5cm in length which are connected to (n-2) order laterals 2-5cm long and up to 7mm in diameter. Mycorrhizal roots were common throughout the surface root pads. During the summer drought the short lateral roots die but the main framework of the surface pads ie (n-1), (n-2), (n-3)..... lateral roots are perennial. Following rains or irrigation, new short lateral roots are rapidly formed from the framework of roots in the surface pads. Apparently jarrah has evolved a mechanism by which it can produce a large number of potentially new absorbing surfaces rapidly after rain, without having to develop a new framework of laterals.

Phytophthora cinnamomi could not be recovered from the major (>5 cm) components of the horizontal root systems of c 30 trees located in diseased sites. This suggests that this species, is not subject to systemic infection. The fungus however, was consistantly recovered from short lateral roots and the perennial roots (n-1, n-2), which form the framework of the root pads, on a diseased site where a high density of Phytophthora cinnamomi had been induced in the soil by irrigation.

We suggest that the specialized root pads could account for jarrah's ability to achieve relatively high growth rates on grossly infertile sites. Conversely. the destruction of the perennial components of the root pads, in addition to the short lateral roots, could explain why Phytophthora cinnamomi can cause decline and death of jarrah in an environment which is only marginally favourable for the fungus.

VARIATION IN THE DEVELOPMENT OF PHYTOPHTHORA CINNAMOMI IN SOIL WITH NO CANOPY COVER AND UNDER ACACIA PULCHELLA AND BANKSIA GRANDIS.

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The capacity of Phytophthora cinnamomi to cause mass destruction of the jarrah (Eucalyptus marginata) forest vegetation on freely drained sites can be attributed primarily to : 1) the ability of the pathogen to rapidly increase soil population levels, and 2) the presence of a highly susceptible B. grandis understorey which provides a large food base and reservoir of inoculum (Shea et.al., these proceedings). The object of this work was to determine if replacement of the susceptible understorey, with one dominated by legumes, would inhibit survival and reproduction of the fungus. Open sites were used as controls.

Pieces of B.grandis stem (ca. 1.5 cm diam.) were inoculated with Phytophthora cinnamomi in the laboratory and used to infect plots in the open or under A. pulchella and B. grandis canopies. With regular sampling during the period from September to November, there was no consistent difference between canopy types on the development of Phytophthora cinnamomi in soil sampled greater than 3 cm from the infected stem pieces. When soil 3 cm on either side of the stems and stem pieces were sampled in mid-December, there was consistently less Phytophthora cinnamomi in soil from open sites than that under B. grandis. Development of the pathogen under A. pulchella varied with site, being less than under B. grandis at one site, but not significantly different at another. The greatest survival of Phytophthora cinnamomi in stem pieces occurred under B. grandis, and the poorest survival in the open or under A. pulchella. Soil temperature and moisture fluctuated greatly in the open and was cooler and dryer under A. pulchella than B. grandis.

THE AFFECT OF ACACIA PULCHELLA ROOT AMENDMENTS ON PATHOGENICITY AND SURVIVAL OF PHYTOPHTHORA CINNAMOMI.

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Pathogenicity of Phytophthora cinnamomi to Eucalyptus marginata seedlings was reduced in inoculated soils amended with Acacia pulchella roots, relative to soils amended with Banksia grandis roots or which were not amended. Although overall mortality of seedlings was low (< 5%) and there was no significant difference in mortality between treatments, seedling height and shoot dry weight was greatly reduced in soil amended with B. grandis compared to those amended with A. pulchella. There was greater root rot of E. marginata seedlings growing in soil amended with B. grandis than in soil amended with A. pulchella. Root development of seedlings in soil amended with A. pulchella was not significantly different to that in non-inoculated, non-amended controls. The fungus was recovered from 23% of the root system from soil amended with B. grandis, compared to only 2% of roots from A. pulchella amended soil.

Survival of P.cinnamomi was better in B. grandis than A. pulchella amended soil. The fungus was recovered from soil from only 17% of inoculated pots amended with A. pulchella and at low density (0.1 propagules/gm dry wt). This compared with recoveries from 100% and 84% of inoculated pots not amended or amended with B. grandis, with densities of 53.4 and 3.9 propagules/gm dry wt, respectively.

SEASONAL DEVELOPMENT OF PHYTOPHTHORA CINNAMOMI RANDS IN THE EUCALYPTUS MARGINATA FOREST IN RELATION TO SITE AND ENVIRONMENT.

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The development of methods to control Phytophthora cinnamomi in the jarrah (Eucalyptus marginata Sm) forest has been frustrated by the absence of a rational model of the behaviour of this pathogen in the jarrah forest environment. For example, it has been difficult to reconcile the capacity of this fungus to cause mass destruction of jarrah forest vegetation and its widespread distribution by movement of soil with the low recovery rates recorded from diseased areas: We propose here a tentative description of the epidemiology of the disease based on our studies of the relationship between Phytophthora cinnamomi and the jarrah forest environment.

The soil physical environment on moisture gaining sites favour survival and asexual reproduction by Phytophthora cinnamomi for long periods throughout the year. Using direct plating techniques the fungus has been consistantly recovered at a high propagule density on these sites even in mid-summer. The favourable soil physical environment together with the occurrence of highly susceptible species such as Banksia littoralis, accounts for the rapid spread and intensification of the disease on these sites.

On freely drained sites (which comprise c 60-85% of the forest) survival of Phytophthora cinnamomi is limited by prolonged (c 4-6 months) low soil moisture levels during the summer months. Phytophthora cinnamomi persists for most of the year on these sites in large roots and stumps of highly susceptible species (see Schild et.al. these proceedings).

Phytophthora cinnamomi levels in the soil on diseased freely drained sites have been monitored over a two year period be direct soil plating and baiting. The fungus was present at a very low density in the soil throughout most of the sampling period, except for relatively brief periods in spring when it occurred at a high density. The ephemeral behaviour of the fungus was reproduced by irrigating diseased sites.

The ability of the fungus to rapidly increase soil population levels in spring is attributed to the formation of sporangia and subsequently zoospores. The capacity of Phytophthora cinnamomi to form sporangia on freely drained sites was monitored over a two year period by recording sporangial formation on squares of mycelium inserted into the soil for periods of between 2-8 days. Significant formation of sporangia occurred for relatively brief periods in spring and autumn, corresponding to the periods when there was a coincidence of high soil moisture and temperature levels. The periods, of sporangial formation in spring coincided with the periods when the fungus was recorded at a high density in the soil. Although sporangial production occurred in autumn, no significant increases in soil population levels were recorded. We attribute this to the brevity of the period (in most years) between the onset of heavy rainfall and the depression of soil temperatures to levels at which sporangial formation cannot occur.

Death of highly susceptible jarrah forest species (e.g. Banksia grandis) results from total invasion of the root system and girdling of the stem. Death of less susceptible species (e.g. jarrah) results from destruction of the specialized fine feeder root system during the periods of high fungal activity in spring (see Shea et.al. these proceedings).

DISTRIBUTION OF PHYTOPHTHORA CINNAMOMI RANDS. IN BANKSIA GRANDIS WILLD. IN THE JARRAH FOREST IN WESTERN AUSTRALIA.

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For most of the year it is difficult to detect *Phytophthora cinnamomi* Rands. in soil and fine roots on freely drained sites in the Jarrah forest in Western Australia, yet the destruction of the forest flora caused by the organi is considerable. *Banksia grandis* Willd. is highly susceptible to *P. cinnamomi* and is a dominant understorey species in the forest and is considered a major source of inoculum for the fungus.

Eight *B. grandis* trees in different stages of death, across a disease front, were excavated in late summer and intensively sampled for the presence o *P. cinnamomi*. The fungus was detected in recently killed trees and in those tl had been dead for approximately one year, but not in healthy trees and those tl had been dead for over two years. *P. cinnamomi* was present in the fine roots, large roots, and the stump and lower stem region of the trees but was not recovered from soil samples taken in the diseased site.

A recently killed *Banksia* and a *Banksia* that had been dead for approximat ly one year were excavated from other diseased areas and were dissected and intensively sampled for the presence of *P. cinnamomi*. It was found that in the recently killed *Banksia*, *P. cinnamomi* can invade the stump and stem except for the pith, and all of the large roots. In the older dead *Banksia*, *P. cinnamomi* was detected in the large roots and the stump but not in the stem region. The presence of the fungus was less extensive in the older dead *Banksia*, than in the recently killed *Banksia*. Infected root and stump pieces were sectioned and scanned under the microscope and no chlamydospores were observed. The results indicate that *B. grandis* acts as a reservoir for *P. cinnamomi* over the harsh summer months, enabling the fungus to re-infect the soil when conditions become conducive.

In field studies the movement of *P. cinnamomi* from naturally infected *Banksia* stumps into the soil has been shown to occur primarily in spring. This phenomenon has been simulated in glasshouse studies and these indicate that movement into the soil around infected stumps is localized, and spread downslop is dependent on movement of propagules carried in overland or subsurface water-flows. Further studies regarding this aspect are being continued.

MECHANISMS OF ACTION OF CGA 48988 FUNGICIDE ON *Phytophthora cinnamomi*

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Phytophthora cinnamomi hyphae growing on 1 cm^2 squares of cellophane were incubated at 25°C in 1:2 soil:water extracts or de-ionised water containing a range of concentrations of the fungicide CGA 48988. A preliminary experiment compared the activity of the fungus in de-ionised water and non-sterile soil extract. Sporangial production occurred at 0 $mg \cdot l^{-1}$ CGA 48988, was reduced at 10.0 $mg \cdot l^{-1}$ a.i., and was prevented at 25.0 $mg \cdot l^{-1}$. Lysis of the hyphae occurred in all test solutions. Increasing CGA 48988 concentrations accelerated the breakdown in both de-ionised water and soil extracts. In soil extracts, complete lysis of hyphae occurred within 6 days at 10 $mg \cdot l^{-1}$ CGA 48988, without fungicide 97% lysis occurred in 12 days.

In a second experiment using a different soil extract and *P. cinnamomi* isolate, sporangia were produced in non-sterile soil extracts but not in de-ionised water or filter-sterilised de-ionised water and soil extracts. Mean numbers of sporangia produced after 2, 4, 6 and 10 days incubation at 0 $mg \cdot l^{-1}$ CGA 48988 were 72, 318, 903 and 1138 per cm^2 respectively. Fungicide concentrations of 5.0, 10.0 and 25.0 $mg \cdot l^{-1}$ prevented formation of sporangia. An insignificant number of sporangia, a mean of 1 per cm^2, were produced in the 2.5 $mg \cdot l^{-1}$ extract after 6 days. CGA 48988 had no effect on the formation of chlamydospores.

These results suggest that CGA 48988 reduces the activity and survival of *P. cinnamomi* by suppressing sporangial formation and affecting microbial degradation of hyphae.