STUDIES ON THE MORTALITY OF *CEDRUS DEODARA* (ROXB.) L. DON. IN CHAIL FOREST (H.P.) AND ITS CAUSATIVE FACTORS

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Introduction

Deodar [*Cedrus deodara* (Roxb.) L.Don] a gregarious conifer tree widely distributed throughout Western Himalayas particularly in Himachal Pradesh, India. It occurs abundantly in the districts Chamba, Dalhousie, Mandi, Nahan, Kulu, Chopal, Solan, Kinnaur and Shimla of Himachal Pradesh. The total area of the Deodar forests in Himachal Pradesh is estimated at 69,872 ha (Tewari, 1994). Reports were received about the dying of Deodar in Chail-Banjhani forest area during the year 1998 (Anon., 1998). Later Goraya *et al.* (1998) in a technical report stated that the mortality of Deodar in the forest was caused by root rot disease. The causative organism of the disease was identified as *Phytophthora cinnamomi* Rands, a highly destructive fungal pathogen. Even though the incidence of this pathogen has been reported from the Western Himalayan region for the first time, ample literature is available on this disease and the pathogen from many other countries from across the world. The pathogen, *P. cinnamomi*, has been reported to cause severe damage in tree species including, *Quercus rubra, Castamea sativa* (Robin and Loustau, 1998) *Persea americana* (Cacciola *et al.*, 1998), *Alnus glutinosa* (Brasier *et al.*, 1995) and *Eucalyptus marginata* (Shearer *et al.*, 1987; 1988). This pathogen is recorded as widely distributed fungal pathogen all over the world. In as far as Chail-Banjhani forest is concerned, a preliminary study has been taken with the following objectives :

1. To study the growth characteristics of fungal pathogen causing disease and its mode of infection.
2. Effect of physico-chemical properties of soil of *C. deodara* in diseased area and
3. Assess the frequency and distribution of *P. cinnamomi* over a period of time.

Material and Methods

The study site was selected in the Chail-Banjhani forest, 44 km away from Shimla and located at 77°15' E and 31°28' N at an elevation of 1676 m above msl. The total area of the affected forest is about 26 hectares. The study area was fenced by the State Forest Department with a view to isolate the site and to minimise the chances of further spread of disease through cattle movement. All the trees in the fenced plots

have been enumerated and recorded. These plots are being periodically monitored since December 1998 to know more about the pattern and spread of the disease. Special emphasis during the study was given to the diseased roots and the soils.

For systematic and detailed studies, the site was divided into the following three plots based on the occurrence of completely dead, diseased or healthy trees :

Plot A : all trees in the plot dead
Plot B : comprising of a mixture of totally dead, diseased and healthy trees
Plot C : comprising of all healthy trees except two diseased ones.

Protocol-A : The soil samples were collected from around five randomly selected trees in each plot and the composite soil samples were analyzed as to soil moisture as per method suggested by Jackson (1973) :

$$\text{Soil Moisture (\%)} = \frac{\text{F.W - D.W}}{\text{F.W}} \times 100$$

A constant fresh weighed soil sample (F.W) was kept in the Hot air oven at 120°C for 72 hours, the dry weight (D.W) was measured and the soil moisture was calculated according to the above formula.

Protocol-B : The nutrient analysis of the soil samples has been carried out by the method of Jackson (1973). The nutrients such as N, P, K were analyzed at Himachal Pradesh Agriculture Department, Shimla.

Protocol-C : The root infection has been observed by the method of Phillips and Hayman (1970) and the per cent of infection was calculated by the following formula :

$$= \frac{\text{Total Number of roots - Infected number of roots}}{\text{Total number of roots}} \times 100$$

Protocol-D : Assessment of further spread of disease and the average mortality of *C. deodara* was assessed on the following parameters :

Dead Trees : No green needles/dry branches intact/dry branches fallen off/bark fallen off/rotted.

Affected/Diseased Trees : Chlorotic/Needles fall off on shaking/short needles density of needles very thin/drying from the top.

Unaffected/Healthy Trees : Normal green/ dense tufts of needles/absence of dry branches.

Protocol-E : The diseased roots and soil samples were inoculated in the sterilized Potato Dextrose Agar medium (potato extract 200g, Agar 20 g, Dextrose 20g and Distilled water 1000 ml) in five replicated and stored at room temperature for observing the growth characteristics of the pathogenic fungi. The fungal identifications were made with the help of standard identification manuals (Domsch *et al.*, 1980; Tainter and Baker, 1996).

Frequency distribution of fungal species : The cultures developed in the laboratory were segregated and each fungus was monitored and frequency distribution of each fungus studied. Frequency denotes the number of samples in which a particular fungus was recorded during the period of study and is expressed in percentage of the total number of samples.

Table 1

Physico-chemical properties of the soil samples (mean of 5 replicates)

Plot No.	Soil moisture (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	pH
A	81 a	66 a	83 a	141 a	7.2 a
B	79.2 a	78 b	91 b	138 a	7.3 a
C	40.8 b	81 b	101 b	166 b	5.6 b

Means followed by a common letter are not significantly different at 5% level by DMRT.

$$\text{Frequency} = \frac{\text{Number of samples in which a particular fungus recorded}}{\text{Total Number of samples taken}} \times 100$$

On the basis of frequencies three categories were recognized as follows.

1-40% occasional; 41-80% common; and 81-100% abundant. The distribution of fungi in the samples at each sampling time was expressed in terms of percentage occurrence.

$$\text{Percentage Occurrence} = \frac{\text{Total number of individual fungal species in all samples}}{\text{Total number of fungi in all samples}} \times 100$$

Results

The physico-chemical properties of the soil samples showed that the pH of the soil is moderately alkaline in the diseased plots and acidic in the control plot. The status of nutrients in the control plot was higher than the diseased plots (Table 1). The intensity of root infection showed the diseased plots had higher infection and all healthy trees in control plot showed no infection (Table 2). The assessment of the damaged trees in three plots showed that in the mixed plot (Plot B) eight trees are dying and in the control plot (Plot C) the two already diseased trees had died. In plot 'A' thirty-eight trees were totally dead and only two trees are living (Fig. 1). The most dominant fungus identified from the analysis of root samples matched with description of *P. cinnamomi*. This fungus emerged in the pure culture within 15-17 days at room temperature (19-24°C) and showed the characteristics of (i) coenocytic mycelium, (ii) corolloid hyphae, hyphal swellings, and (iii) lemon shaped zoosporangium. Further, the frequency

Table 2

Assessments of pathogenic infection in diseased roots of Cedrus deodara (mean of 5 replicates)

Plot No.	Rate of infection (%)	SE
A	100	(±5.6)
B	84	(±7.8)
C	0	(±0.0)

A : Dead trees, B : Dying and dead trees, C : Control

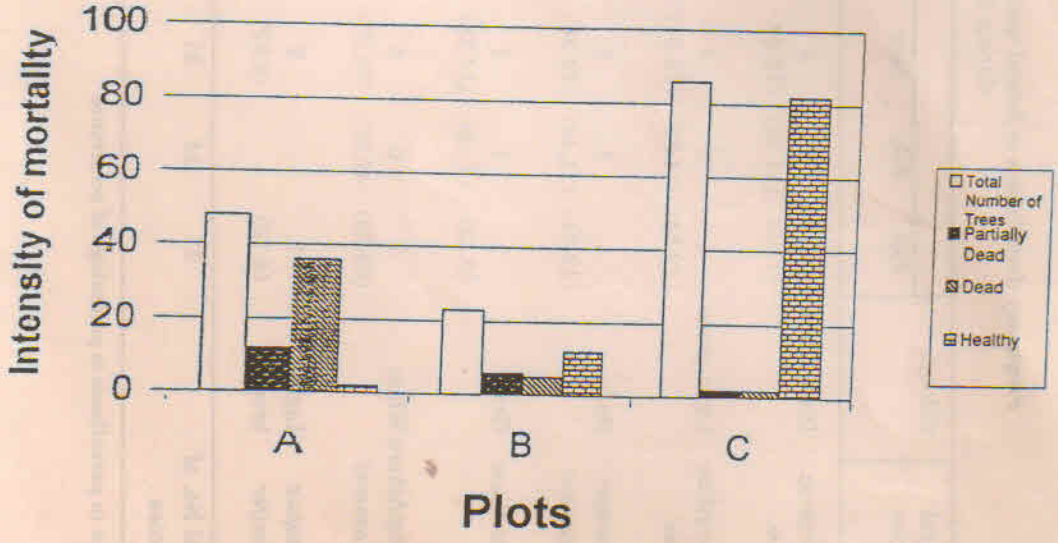
distribution of fungal population showed that *P. cinnamomi* is the abundant pathogen affecting the roots whereas *Fusarium oxysporum, Alternaria solani, Aspergillus, flavus, Penicillium* sp were common and *Rhizopus stolonifer* is occasional (Table 3).

Discussion

The symptoms of the root rot disease include yellowing of the needles, shortening of the needles, easily falling needles and total chlorotic appearance. All the needles of infected trees fall within three to four months of showing the first symptoms of the disease and the tree dies completely soon after. It is assumed that the pathogen *P. cinnamomi* causes the root rot disease and infects the secondary phloem of roots (Dell and Malajczuk, 1989) resulting in water stress in the trees and chlorotic appearance. The trees in Plot 'A' have been reported to be dying/standing dead for the past more than ten years. It seems that this patch showing all dead trees could be the patch getting first infection from where the infection has spread to the adjoining trees. Moreover, Plot 'A' is in depression having the highest moisture percentage. Whereas Plot 'B' is on the slopes along Plot 'A', the Plot 'C' covers the spur with very less moisture percentage. Spread of disease through dissemination of spores up the slopes to plots 'B' and 'C' might be through inoculum transportation by animals and human activity (Shearer and Tippett, 1989). Another way of spread of this disease to the trees in plots 'B' and 'C' seems to the through hyphal contact.

The soil moisture (%) in these three plots showed less soil moisture (%) in the control plot than in diseased plot. The soil moisture favours the sporulation, survival and dispersal of *P. cinnamomi*. Furthermore the impact of environment such as summer rain influences the disease

Fig. 1



Mortality of *Cedrus deodara*

Table 3

Frequency distribution of fungal species presented in the rhizoplane of diseased Cedrus deodara during the period of study (1999-2000)

Fungal species	Colour	1999									Mar. 2000	Frequency (%)	F. Class
		Jan.	Feb.	Mar	Apr	Aug	Sep.	Oct.	Nov.	Dec.			
Alternaria solani	Dirty white	3 (14.2)	2 (14.28)	3 (14.28)	2 (9.52)	2 (8.69)	-	-	-	1 (12.5)	2 (12.5)	70	Common
Aspergillus flavus	Light green	4 (19.04)	2 (14.28)	4 (19.04)	5 (23.80)	5 (21.73)	1 (10.00)	-	-	2 (25.00)	2 (12.5)	80	Common
Fusarium oxysporum	Pink	4 (19.04)	3 (21.42)	3 (14.28)	3 (14.28)	2 (8.69)	-	-	-	2 (25.00)	5 (31.5)	70	Common
Penicillium sp.	Grey	2 (9.52)	1 (7.14)	3 (14.28)	4 (19.04)	5 (21.23)	-	2 (20.00)	-	1 (12.5)	1 (6.25)	80	Common
Phytophthora cinnamomi	White	7 (33.33)	6 (42.85)	8 (38.09)	7 (33.33)	8 (34.78)	9 (80.00)	8 (80.00)	8 (88.88)	2 (25.0)	6 (37.5)	100	Abundant
Rhizopus stolonifer	Light brown	1 (4.76)	-	2 (9.52)	-	1 (4.34)	-	-	1 (11.11)	-	-	50	Occasional
Total No. of colonies		21	14	21	21	23	10	10	9	8	16	-	-

Given in parenthesis is percentage of occurrence.

development (Shearer and Tippett, 1989). The major and essential soil nutrients showed that in the control plot is higher than the diseased and infected plots. Available soil nutrients in the plots A&B influences the development and growth of *P. cinnamomi*. As a soil borne fungus belonging to the evolutionary primitive group called the oomycetes or water moulds *P. cinnamomi* completed its life cycle in moist and nutrient enriched soils. As the name "water mould" suggests the life cycle of *P. cinnamomi* depends on moist conditions, which favour its survival, sporulation and dispersal. In autumn season (September and October) and early winter season (November) the percentage of occurrence of *P. cinnamomi* are more than other seasons. It is resulted that when conditions are warm and moist, microscopic spore sacs called sporangia and thick walled chlamydospores are produced vegetatively from mycelial strand in the soil or host tissue. The sporangia release the motile zoospores in free water to infect the host tissue. The pH of the soil is acidic in the control plot and alkaline in the diseased plot indicating that the pathogen influences the soil pH also.

The disease causes severe damage of the entire plant body due to blockage of water conductivity and suppressing the photosynthesis of the needles. The spread of the disease is definitely by root to root contact process, dispersion of spores by cattle and higher soil moisture.

Conclusion

The present study concludes that root rot disease results water stress in *C. deodara* at Chail-Banjhani forest by *P. cinnamomi*, however further studies are needed to develop site specific control measures for the disease.

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SUMMARY

A study has been undertaken in the diseased *Cedrus deodara* (Roxb.) L.Don (Deodar) forests at Chail (Himachal Pradesh) to find out the causative factor of the disease and their mortality. The infected trees showed yellowing, shortening needles and the causative pathogen was identified as *Phytophora cinnamomi* which is causing root rot disease. The rhizosphere soil samples of the disease-affected trees showed higher soil moisture due to blockage of water conductivity. The results of the study explicit that the fungus causes water stress in the diseased trees because of root rot. Under favourable moisture conditions the activity of the pathogen becomes vigorous. However, studies are under investigation to control the disease.

चैल वन (हि०प्र०) में *सिडरस डिओडारा* (राक्स०) लूड० का मरण और उसके कारणभूत कारकों का अध्ययन

ए० कार्तिकयन, जी०एस० गोरय्या, शैलेन्द्र कुमार व एस० कालिया

साराशं

चैल (हि०प्र०) के रुग्ण देवदार (*सिडरस डिओडारा*) (राक्स०/लूड०) वनों के मरण और उनके कारणीभूत कारकों

का पता लगाने के लिए एक अध्ययन किया गया । संक्रमित वृक्षों का पीला पड़ जाना, पत्तियों का छोटा रह जाना होता देखा गया तथा उसके कारणीभूत रोगजन *फायटोरफोरा सिन्नेमोमी* पहचाना गया जिससे वृक्षों की जड़ें सड़ जाने का रोग हो रहा है । रोग प्रभावित वृक्षों से लिए गए राइजोमण्डल के मृदा नमूनों में जल संवाहन रुद्ध हो जाने से उनमें नमी की मात्रा अधिक पाई गई । अध्ययन के परिणाम स्पष्ट करते हैं कि कवक ग्रसित वृक्षों में जल की कमी ला देते हैं क्योंकि वे जड़ों को सड़ा देते हैं । अनुकूल दशाएं रहने पर रोगजनों की क्रियाशीलता बहुत ओजस्वी बन जाती है । तथापि इस रोग का नियन्त्रण करने के उपायों का अन्वेषण कार्य अभी चल रहा है ।

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