Factors affecting the distribution of pitch canker of pine in Northern Spain

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Introduction- *Fusarium circinatum* (teleomorph=*Gibberella circinata*) is the causal agent of Pine pitch canker, an important disease that is causing serious economical, ecological and social impacts in various parts of the world. It has also been recorded on more than 30 pine species, including *P. radiata*, the European and Mediterranean species Aleppo pine (*P. halepensis*), Maritime pine (*P. pinaster*) and Scots pine (*P. sylvestris*); various North American species planted in Europe, such as Lodgepole pine (*P. contorta*) and Eastern white pine (*P. strobus*) and various Asian species e.g. Japanese red pine (*P. densiflora*) and Japanese black pine (*P. thunbergii*). There are occasional records on Douglas fir, but only associated with limited damage, although it can act as a pathway for spreading the disease (Wingfield et al, 2008).

Pitch canker of pine is worldwide distributed disease (Fig. 1). It occurs in 12 south-eastern states of the USA, and in the Monterey Peninsula and coastal areas of California, in Mexico, Haiti, Chile and South Africa (but only in nurseries) in Japan, Korea and possibly Iraq. In Europe Pitch canker of pine has been reported in nurseries and forests in several countries, namely France and Italy (from where it is now considered to have been eradicated), and Spain and Portugal. In Spain it has been recorded for the first time in 1995 in nurseries in Galicia where it infected *P. radiata* and *P. halepensis*. In 1998 pitch canker was reported in north-west of Spain in the Basque Country and later in Asturias.

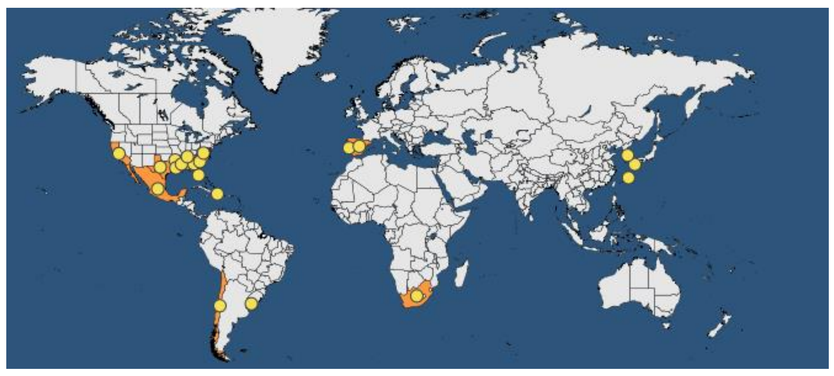

Figure 1-Distribution map of *F. circinatum* (source: EPPO)

The main symptom are large resinous cankers on trunks and branches of pine trees. Pitch canker can also reduce seed germination, and cause seedling blight and canopy dieback. These symptoms spoil the trees, and together with the premature trees' death, result in economic loss to the affected regions. The pathogen is also an agent of severe root diseases of nursery seedlings. Consequently *F. circinatum* may be considered a serious threat to pine forests and in nursery throughout the world.

Several environmental factors may contribute to pitch canker severity such as drought, physical damage or other environmental stresses. In this study pine forests were surveyed in the Cantabria region, North of Spain, in order to evaluate the environmental and biotic elements that influences the epidemiology of pitch canker and the development of different symptoms associated with the disease.

Methods- Data were collected from *P. radiata* plantations distributed throughout 50 plots , randomly selected among 16 sites affected by *F. circinatum* in the region of Cantabria (northern Spain) (Fig. 2).
Climatic and edaphic parameters were collected in each sites. Dasometric and dendrometric (e.g. and and forest health) variables were evaluated for 25 trees per plot, selected according a statistical design . A total of 1250 trees were measured against the below variables. The plant health variables included number and position on the trees of cankers, flow of resin on the cankers (from 1 to 3 where 1 = light, 2 = medium, 3 = abundant), percentage of trunk perimeter affected by the canker (< 33%, 33-66% or > 66%), five degrees of defoliation (1 = 1-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80%, 5 = 81-100%), presence of trickles of resin outside the cankers (from 0 to 3, where 0 = absence, 1 = light, 2 = medium, 3 = abundant), presence of red shoots in the crown (from 0 to 3,where 0=absence,1=on1/3 of the crown, 2 = on 2/3 of the crown, 3 = on all the crown), dieback (from 0 to 3, where 0 = absence, 1 = on 1/3 of the crown, 2 = on 2/3 of the crown, 3 = on all the crown) and mortality.

Univariate and multivariate statistics were used to evaluate the importance of local (e.g. trees height, soil) and landscape (e.g. distance to the sea) scales.

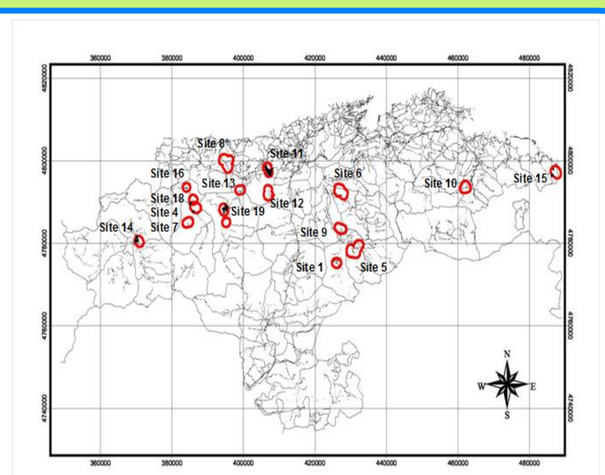

Figure 2- Location of the study sites in Cantabria , Spain

Results- Symptoms included yellowing of the needles, which turned red in time and finally dropped (Fig. 3A), and dieback of the crown (Fig. 3C). About 54% of the pine trees in the filed displayed resin-soaked cankers in the bark (Fig. 3B), sometimes located in wounds caused by pruning, and tree trunk deformation (Fig. 3D)

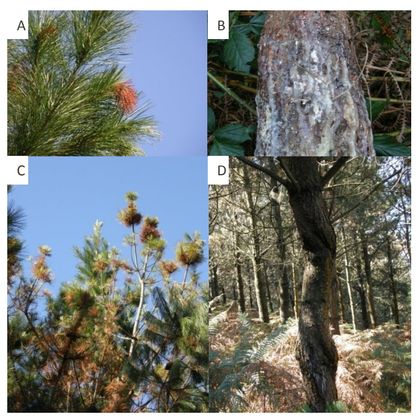

Figure 3- Symptoms of Pitch resinous canker

The content of Mg^{++} and Na^{+} significantly influences the development of red shoots, while plots with high levels of defoliation have scarce Mg^{++} and Na^{+} resources in the soil (Fig. 4)

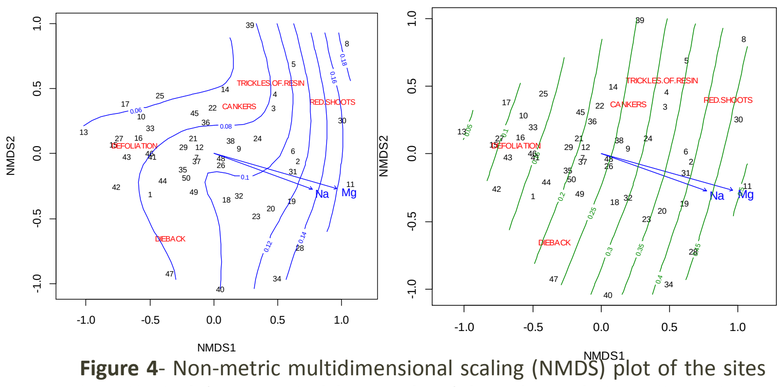

Figure 4- Non-metric multidimensional scaling (NMDS) plot of the sites investigated (represented by numbers) based on phytosanitary status and edaphic condition of the plots. The blue arrows indicate the significant correlation with the ordination. Na^{+} (blue curves) and Mg^{++} (green curves)

The underlying gradients were detected by fitting the different dasometric and dendrometric variables onto the ordination scores. Among the parameters considered, five variables (Live crown index-ICOPA, Diameter-D; Dominance-DO; Perimeter-P; Total height of the tree-A) were significant vectors (Fig. 5). Dominance and Live crown index appear to represent two gradients well differentiated from perimeter, total height of the tree and diameter indices .

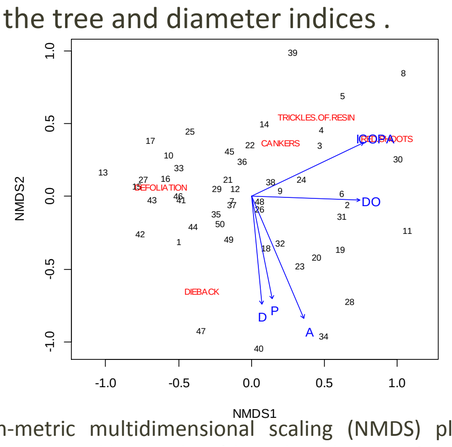

Figure 5- Non-metric multidimensional scaling (NMDS) plot of the sites investigated (represented by numbers) based on dasometric and dendrometric variables of the plots. The blue arrows indicate the significant correlation with the ordination

<u>Landscape scale variables</u>- The mean resin cankers per plot was related to distance to the coast in kilometers (n = 50, S = 26522.74, p-value = 0.05). The ρ obtained was -0.27 meaning that as the distance to the coast increases, the average resinous chancres per plot decreases. The mean infected branches per plot was related to the distance to the Basque country, albeit not significant (n = 50, S = 25936.59, p-value = 0.08) . The ρ obtained is -0.24 meaning that the distance from Basque country to Asturias increases, the average number of infected branches decreases.

Discussion- Several abiotic and biotic actors are known to contribute to pitch canker disease establishment and severity. In USA many of the outbreaks of pitch canker have been associated with hurricanes (Kelley and Williams 1982; Dwinell et al. 1985). High levels of nutrients, both in soil and foliage, have been found to increase disease severity (Blakeslee et al. 1999; Lopez-Zamora et al. 2007). The preliminary results of this study showed that the appearance of different symptoms is influenced by the interaction of several environmental variables, in particular the symptom of the resinous cankers. The areas with low micronutrients (Mg^{++} and Na^{+}) in the soil facilitate the presence of high levels of defoliation in the plot. Generally, defoliation is more evident in those trees that are dominated and do not have a wide crown surface.
Previous studies concluded that the survival and infection of *F. circinatum* is influenced by environmental humidity (Gordon, 2006). We found that the distance to the coast was a factor that affects the incidence of the disease, indicating the importance of environmental humidity for the disease. The influence of the coast, where the environmental conditions are more favorable for the infection, was previously observed in California (Wikler et al., 2003).
The results of this study should be taken into account for future management of pine plantations.

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