INFLUENCE OF ENVIRONMENT ON HOST-PATHOGEN RELATIONSHIPS : COFFEE PATHOSYSTEM MODELLING.

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Introduction

Epidemiological research on *Coffea arabica* (var. *Typica* and Bourbon) has been conducted in the Plant Pathology Laboratory at the ORSTOM's New Caledonia Centre since 1991. Its aim is to understand the functioning of the "pathosystem" which comprises coffee, its main pathogenic fungi (*Hemileia vastatrix, Colletotrichum gloeosporioides* and *Cercospora coffeicola*) and the environment, in order to model their inter-relationships. More specifically, the goal is to identify the environmental conditions which influence the dynamics of coffee diseases. Regular epidemiological surveys are carried out in arabica coffee plantations for this purpose. The biometric evaluations of these data take into account the spatial and temporal dimensions of the events occurring. The ultimate objective of this research is to use modelling to devise a decision-making tool, permitting a forecast of the risk of an epidemic in a defined environmental context.

This research programme is mainly performed in New Caledonia, but also includes a regional research dimension with the complementary investigations being carried out in Papua New Guinea (Coffee Research Institute, Kainantu, Eastern Highlands Province) and Vanuatu (Tanna Island).

Materials & Methodologies

The experimental approach is based on monthly epidemiological observation carried out in 20 traditional coffee-growing plots using specific pathological survey methods (leaf-by-leaf inspection, etc.) and environmental characterisation procedures (weather station, soil analyses, etc.).

Management of the pathological and environmental data characterising each site is performed with the ORACLE database through a series of queries which generate synoptic tables. The statistical interpretation of these data is carried out with a software known as ADE-4 for "Multivariate Analysis and Graphic Expression of Environmental Data" (Chessel *et al.* 1996). This software makes it possible to produce complex statistics which are highly relevant to the issues raised by such a spatio-temporal study:

- Three-way ("triadique" in French) analysis of a "data cube" (variables x sites x observation dates) as defined by Kroonenberg (1989). This is a three-stage approach: prior determination of an "interstructure" which proposes an ordering of the sampling dates, establishment of a "compromise" describing common structures at various dates and, thirdly, characterisation of an "intrastructure" describing the divergences from these common compromise structures for each date.
- The costructure of two "data cubes" through analysis of co-inertia (*sensu* Doledec & Chessel, 1994). This approach simultaneously merges "interdate" analyses (temporal effects) and "intradate" analyses (spatial effects). It seeks the combinations of variables (or axes of co-inertia) which express the temporal co-variation and spatial co-structure between clusters of points representing data. The projection of these variables onto these axes defines planes determining the linkages between the two cubes.

Pathological status of coffee growing sites in New-Caledonia

In a given annual cycle, surveys have confirmed the existence of a mosaic of highly diverse pathological situations (disease distributions, infection and mortality kinetics, etc.) within the experimental design (Lamouroux *et al.* 1995). The three-way analysis produces a scatter diagram (cf. Figure 1) on which the plots are located as determined by the vectors characterising either the pathology or the environment.

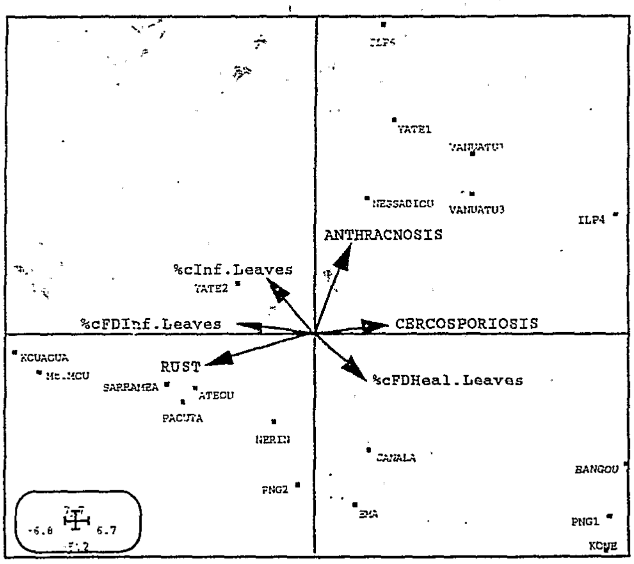

Figure 1: Scatter diagram of sites (NC, PNG) in terms of disease parameters.
{RUST = Sanitary Mark of the rust; ANTHRACNOSIS = Sanitary Mark of the anthracnose; CERCOSPORIOSIS = Sanitary Mark of the cercosporiosis; %cInf.Leaves = cumulative % of infected leaves; %cFDInf.Leaves = cumulative % of Fallen Infected Leaves; %cFDHeal.Leaves = cumulative % of Fallen Healthy Leaves}

Influence of Environment on coffee and fungal pathogens relationships

Analyses of co-inertia between cubes of pathological and environmental data have made it possible to describe the nature of the links between them. In particular, combinations of variables have been identified (Pellegrin *et al.* 1995). These reveal significant trends (cf. Figure 2):

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- Anthracnose emerges as being closely linked to edaphic factors such as high pH values, a good soil structure or low shade.
- High pH and shade values, and to a lesser extent, low altitude are the main factors influencing the behaviour of cercosporiosis.
- Rust differs from the two previous diseases, in that it is more likely to occur in sites featuring low soil pH values, low rainfall, quite high minimum temperatures, high shade and high altitude.

Evolution, from year to year, of the epidemics.

This original correlation between environment and pathology was taken further by also considering results recorded over four successive survey years. In fact, the comparative analysis of the distribution of pathogens and epidemiological kinetics, on an annual basis, reveals that, depending on the site, the pest situation may or may not remain similar from year to year:

- From an epidemiological point of view, almost 40% of these sites show individual characteristics of "temporal stability", whereas the weather conditions are very varied. In such cases, taking into account previous co-inertia results, it is legitimate to think that the epidemiological diversity observed between sites in any given year is, basically, a reflection of edaphic diversity (e.g. pH, relief, fertility, etc.) because only these factors remain stable over the time-scale of the study.
- On the other hand, there are other sites which show "instability", expressed from one year to the next in major differences in severity for the same pathogen. Such inter-annual variations support the idea that disease diversity in these sites is dependent on climatic characteristics, which in New Caledonia varied greatly between 1992 and 1995.

Pathosystem modelling.

The characterisation of sites where pathological determinism is highly different is used to detail the influence of soil and climate respectively on the disease. The major trends resulting from the above interpretations were used as a basis for modelling the risk of disease attributable either to rust or to anthracnose (cercosporiosis being insufficiently represented *in situ* to permit an analysis of this kind). Significant forecasts of the level of infestation of each plot at the end of the crop cycle were made, taking into account only the environmental parameters selected for each of the years studied (Lamouroux *et al.* 1995). Although significant correlations have already been obtained, work is continuing to further improve this specific statistical approach.

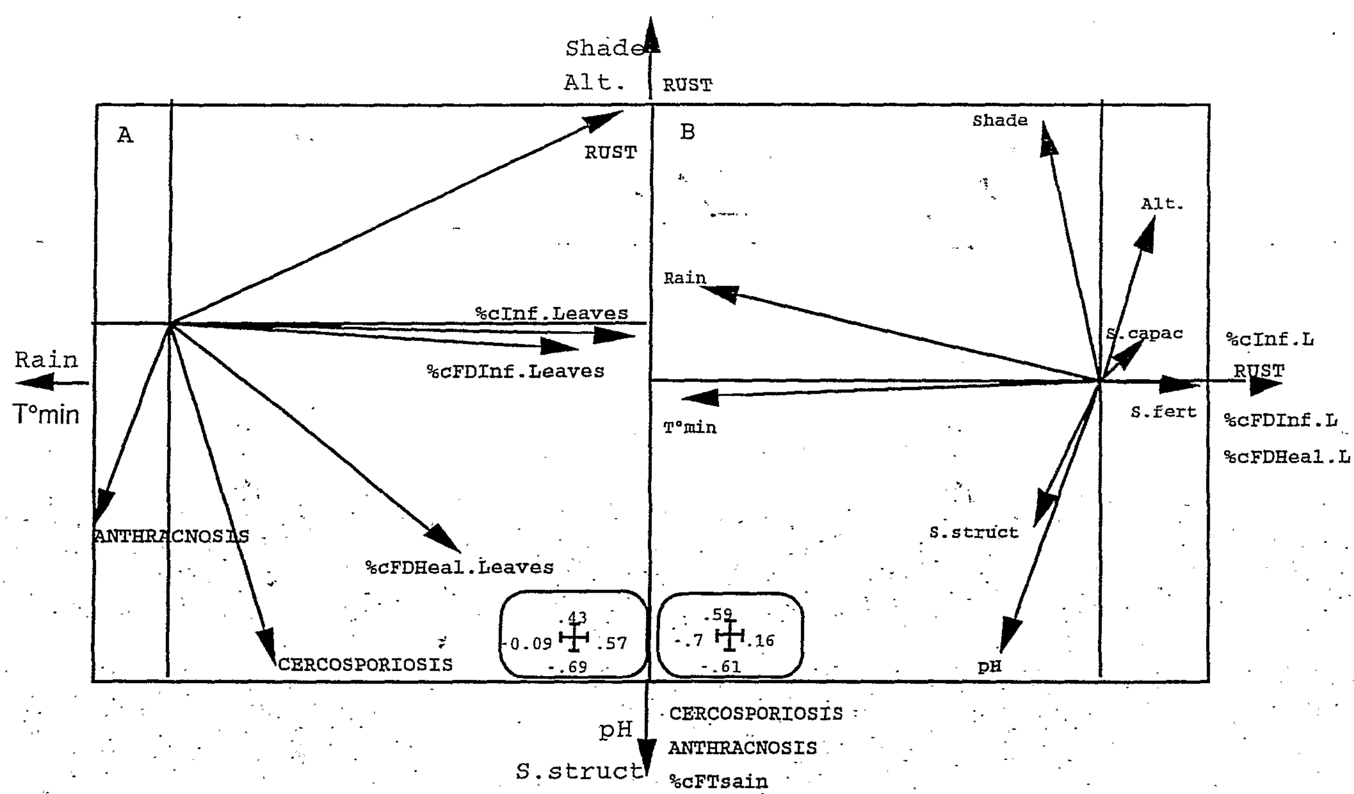

Figure 2: Co-structure of pathological data (A) and environmental data (B).
{Rain = cumulative rainfall over one month; T_ min. = mean minimum temperatures; S.fert = soil fertility; S.struct = soil structure; S.capac = Soil water capacity; pH = soil pH; Alt = altitude of site; Shade = amount of shade}

To clearly perceive the mechanisms studied, it is first necessary to evaluate the proportion of variability due to the genetic diversity of the populations of pathogens and to the possible host diversity.Two further studies are under way in this connection:

- a biomolecular analysis of the *H. vastatrix* populations is going ahead in order to compare the various rust isolates through PCR-RFLP; in addition, existing rust races at the survey sites are being identified (Kohler *et al.* 1995). An appraisal of *C. gloeosporioides* populations (isolated on the survey sites) is also being carried out using molecular markers (RAPD). These evaluations of genome diversity are complemented by quantification of the pathogenicity.the intraspecific homogeneity of *arabica* plants studied is also being studied under a more general programme dealing with the genetic diversity of coffee in New Caledonia (study of natural hybrids).

Conclusions and perspectives

These results on the diversity of pathogens and of the host, as well as the deletion of irrelevant information from data files (e.g. selection of trees and branches, and distinction between "stable" or "unstable" plots, etc.) are clarifying factors which, once included in the statistical model, will make it possible to increase the correlation coefficients between pathological and environmental characteristics and therefore the accuracy of disease risk forecasts.

The concepts and methodologies developed under this programme are now being disseminated in the region and training programmes are currently conducted for our partners (e.g. PNG-CRI) in coffee disease work. These tools may be also of interest to teams working on other crops for which pathogen incidence has become a serious source of concern.

References

Thiolousse, J., Chessel, D., Doledec, S., Olivier, J.M. (1996). ADE-4 : a multivariate analysis and graphical display software. *Statistics & Computing* 7(1):75-83.

Doledec, S. & Chessel, D. (1994). Co-inertia analysis: an alternative method for studying species-environment relationships. *Freshwater Biology* 31:277-294.

Kohler, F., Lourd M., Bresson E., Fernandez D., Nandris D., Pellegrin F., 1995 : Investigations on the diversity of coffee fungal pathogens using molecular, enzymatic and morphological tools. 16th International Scientific Colloquium on Coffee, ASIC, Kyoto, Japan, 9-14 April 1995. *in* Proc. 845-852.

Kroonenberg, P.M. (1989). The analysis of multiple tables in factorial ecology. III Three-mode principal component analysis:"analyse triadique complète". *Acta Œcologica, Œcologia Generalis* 10(3):245-256.

Lamouroux N., Pellegrin F., Nandris D., Kohler F., (1995). The *Coffea arabica* fungal pathosystem in New-Caledonia : interaction at two different spatial scales. *Journal of Phytopathology* 143:403-413.

Pellegrin F., Nandris D., Westrelin S., Kohler F., (1995) : Pathological status of *arabica* in New-Caledonia, correlations between epidemics and environment. 16th International Scientific Colloquium on Coffee, ASIC, Kyoto, Japon, 9-14 April 1995. *in* Proc. 690-698.

SOOTY MOULD OF DENDROBIUM ORCHIDS ASSOCIATED WITH SEVERE BREVIPALPID MITE DAMAGE

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This paper reports on an unusual occurrence of sooty mould on Dendrobium orchids in the Northern Territory of Australia. Sooty mould is a superficial growth of saprophytic fungi on the surface of plants. The sooty growth can be easily rubbed off. Sooty moulds are caused by several species of fungi of various types, but primarily dark-coloured Ascomycetes of the order Dothideales (Agrios 1988). Normally sooty moulds are associated with the sugary excretions called "honey dew" produced by Homopteran insects (order Hemiptera, sub-order Homoptera) such as scale insects, mealy bugs and aphids. Sooty moulds can also grow on the sugary secretions from the nectaries of plants.

Hamon (1986) in the American Orchid Society's "Handbook on Orchid pests and diseases" indicates that sooty moulds also occur on orchids infected by scale insects. Further, there has been one case of a commercial grower spraying orchids with a sugar solution and sooty moulds growing on the sprayed plants.

In the 1997 dry season a commercial orchid grower reported a large number of orchid plants in a shadehouse had severe sooty mould. The cultivar Dendrobium Kasem White had particularly severe sooty mould. Both leaves and flowers were affected by the black sooty mould. The affected orchids were thoroughly examined and no Homopteran insects could be found. We and the grower had noticed sticky patches under the leaves. There was a thought that the sooty mould was growing on fertiliser applied to the plants. The grower had used Rovral ® fungicide (Iprodione) in the wet season but not in the dry season so there was the possibility that the fungicide had