Rational and optimized control of coffee leaf rust in Honduras

The research described below was conducted under cooperation between CIRAD and IICA-PROMECAFE in Honduras, with the assistance of the Honduran coffee institute (IHCAFE).

A decline can currently be seen in the economic viability and ecology of Central American coffee cultivation. In such a context, it is essential to reduce inputs and production costs. In crop protection terms, a reduction in production costs means more effective management of the main fungal disease on Arabica coffee in the region, leaf rust caused by *Hemileia vastatrix*, against which control methods are still highly stereotyped. However, rational and optimized control of leaf rust requires better knowledge of the disease and of factors propitious to its development.

Coffee leaf rust survey-diagnosis

We conducted an integrated study, based on a survey, of all the physical (climate and soil), phytotechnical (crop management sequences and plantation structures) and biological (production variables and leaf mass) factors propitious to the disease in six coffee growing regions of Honduras. The survey covered 73 plots. Observations were carried out over three consecutive years in 25 of the plots, over two years in 10 of the plots and over just one year in the remaining 38 plots. Different types of multivariate analyses revealed that local characteristics, specific to each plantation, mainly determined the development of coffee leaf rust epidemics. Regional factors such as rainfall ranked second. The local factors linked to epidemic development were primarily the production and leaf mass characteristics of the coffee trees, nutritional characteristics, such as soil acidity and fertilization, along with the height above sea level and percentage of shading. The production and leaf mass of the coffee trees were positively linked to epidemic development. Conversely, soil pH and fertilization were negatively associated to epidemic development. Fertilization was a variable that had never been included so far in prediction models for this disease. The same applied for shading which, whilst not limiting production, probably affects the microclimate in such a way that leaf rust incidence increases. Lastly, height above sea level played a substantial role in restricting epidemic development.

A decision support tool

A segmentation analysis of all the variables mentioned above resulted in a leaf rust management tool adapted to conditions in Honduras. It is the first management tool for this disease to be proposed in the Central American region. It can be used to measure the predisposition of a given plot to the development of a leaf rust epidemic, depending on certain plantation characteristics (table) and to suggest to producers what action to take in line with the epidemic risks incurred. In other words, this tool defines recommendation domains. The control measures to be recommended will be all the more stringent, the higher the risk probability. This thereby helps to reduce production costs and protect the environment in certain cases with a low epidemic risk.

Table. The risks of coffee leaf rust epidemics in Honduras.

Plantation characteristics	Epidemic risk
Fewer than 230 fruiting nodes per coffee tree	Low
At least 230 fruiting nodes per coffee tree Fertilized plot Height above sea level over 1,100 m	Low
At least 230 fruiting nodes per coffee tree Fertilized plot Low Height above sea level under 1,100 m Soil pH over 6	
At least 230 fruiting nodes per coffee tree Unfertilized plot Under 56% shade	Average
At least 230 fruiting nodes per coffee tree Fertilized plot Height above sea level under 1,100 m Soil pH under 6 Mean leaf mass under 7.6 young leaves per branch	Average
At least 230 fruiting nodes per coffee tree Fertilized plot Height above sea level under 1,100 m Average Soil pH under 6 Mean leaf mass over 7.6 young leaves per branch Mean fruit crop under 1.6 fruits per young leaf	
At least 230 fruiting nodes per coffee tree Unfertilized plot Under 56% shade	High
At least 230 fruiting nodes per coffee tree Fertilized plot Height above sea level under 1,100 m Soil pH under 6 Mean leaf mass over 7.6 young leaves per branch Mean fruit crop over 1.6 fruits per young leaf	High

Effects of fertilization and of soil acidity on coffee leaf rust

An additional factorial experiment confirmed the effects of fertilization and soil acidity on leaf rust levels; these two factors figure in the definition of recommendation domains (table). In the short term, and this is a new fact, nitrogen fertilization only, based on urea, causes early disappearance of leaves affected by coffee leaf rust, which may explain the negative effect of fertilization on epidemic development. This type of fertilization is probably inappropriate, as no effect has been seen on yields, but it is widely practised. In addition, soil acidity is clearly and positively associated with disease development, so long as the life span of the leaves is sufficient. However, in the long term, extreme soil acidity becomes detrimental to coffee tree development and is antagonistic to epidemic development. In addition, adequate compound fertilization (NPKMgS), leading to an increase in the life span of leaves and higher yields, also leads to an increase in disease levels.

Effects of intensifying coffee cultivation on leaf rust

The results of the survey, and of this experimental work, provide an understanding of how intensifying coffee cultivation affects leaf rust epidemics. The intensification of coffee cultivation primarily involves reducing shading and resorting to fertilization. In the short term, i.e. probably on the scale of a production year, fertilization and shade reduction have negative effects on leaf rust development. However, in the medium term (probably less than five years), these practices cause an increase in leaf mass and yields, which are factors that increase the risks of leaf rust epidemics. The effects of increasing yields and leaf mass on leaf rust seem to increase in line with soil acidity. Indeed, carrying out fertilization and shade reduction contributes to soil acidification, which consequently favours disease development. In the long term (more than five years), it is to be feared that the cumulated effects of soil acidification and leaf rust attacks will lead to irreversible low yields. Leaf rust would therefore play a part in the decline of intensified coffee cultivation. To our knowledge, this study is one of the rare illustrations of the link between agricultural intensification and an increase in epidemic risks for a perennial plant.

A control method

After defining the recommendation domains making it possible to decide on whether or not to take control measures against leaf rust, emphasis was placed on the control method to be applied. Leaf rust control in Central America relies on the use of copper-based fungicides, which have recognized long-term pollutant effects. This sole means of control is also intended to protect leaves from an exogenous or secondary inoculum. The existence of an endogenous inoculum at the beginning of the rainy season on old coffee tree leaves, a residue from the previous year's epidemic, is therefore not taken into account in the current control strategy.

A factorial trial, in which old leaves were removed by hand before the beginning of the rainy season, showed that this residual inoculum was responsible for initial development of the epidemic. It also showed that using a curative fungicide on the first spraying reached primary infections and therefore slowed down the development of the epidemic. The number of cuprous applications required to control the epidemic could thereby be reduced. This strategy seems all the more important in that spraying fungicides increases the quantity of residual inoculum, subsequently leading to early epidemics in the case of an inappropriate control programme. Sometimes, such programmes lead to disease levels at the end

of the campaign that are no better than those obtained if no control measures are taken.

Conclusion

The outcome of the research conducted in Honduras was a decision support tool for coffee leaf rust control, and a new, less polluting control strategy based on the control of primary infections. It should therefore help in improving the profitability and sustainability of Central American coffee plantations. ■

List of publications

AVELINO J., SEIBT R., ZELAYA H., ORDOÑEZ M., MERLO A., 1998. Enquête-diagnostic sur la rouille orangée du caféier Arabica au Honduras. *In* : 17th International Scientific Conference on Coffee, Nairobi, Kenya, 20-25 July 1997. France, ASIC, p. 613-620.

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AVELINO J., 1999. Contribution à la gestion du pathosystème *Hemileia vastatrix* et *Coffea arabica* au Honduras : influence des principaux facteurs physiques, phytotechniques et biologiques. Thesis, University of Paris XI, Orsay, France, 127 p.