DISTRIBUTION AND SPREAD OF AFRICAN CASSAVA MOSAIC IN A CASSAVA FIELD

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INTRODUCTION

Our investigation of the spatial development of African Cassava Mosaic aims to characterize and understand the factors that govern the development of the disease at the field level. The distribution of the disease in a field is rarely completely random or totally homogeneous. Most of the time, the characteristics are related to the position of the sources of infection, the movements of the insect vector, and the ecological site of the field. The disease is characterized by some regions where the frequency of infection is high and others in which it is low, and investigation should reveal the gradients thus created. The observed infection gradients (or disease gradients) may have two different bases. They may be due to variations, across the field, of factors such as soil, vegetation, or microclimate; these are called environmental gradients. Or they may be due to spatial variations in the quantity of inoculum. These are called dispersal gradients.

These two types of gradients are closely related to the various movements of the whitefly and to climatic conditions. Consequently, the results concerning the dispersal of the disease have to be related to the knowledge available about the microclimate in a cassava field and the movements of *Bemisia tabaci*; information about these has been presented earlier. A model of dispersal is proposed here.

At the same time, we have sought to distinguish the contamination arising from outside the field from that arising within it. Distinguishing between these two types of contamination is essential for the establishment of methods to control the disease.

RESULTS

Trapping of whiteflies

The trapping was done in a field of 1 ha in area from September to December 1982 inclusive. During this whole period, there was a prevailing wind from the southwest; this prevails throughout most of the year. The spatial distribution of the captures in water traps during the first two months of cultivation (October-November 1982) was mapped. The distribution was not homogeneous within the field: there were more captures along the south and west edges. During the third month of cultivation (December 1982) the traps were no longer placed in the center of the blocks, but at the junctions of the paths. The greatest number of captures were, again, recorded in the southwest section of the field.

Distribution of the disease within the fields

Contamination of each block of one hundred plants in a 1-ha cassava field after 3 months of cultivation was measured. Certain characteristics of the disease's distribution can be seen. The infection was not uniformly distributed throughout the field; instead, the incidence of the disease was higher along the south and west edges than along the north and east edges. This particular distribution shows up as a curved contamination gradient along the diagonal running southwest. This gradient occurred in all the fields investigated, despite very different surfaces and exposure conditions.

Dispersal of the disease from the focus

The figure shows the dispersal of the disease five and a half, and six and a half months after planting, upwind and downwind of a source consisting of 50 plants (F 50) derived from diseased cuttings. The dispersal of the disease was noticeable on both dates, but its range remained very limited, not more than a few metres. It shows up as a dispersal gradient. Unlike the gradients investigated previously (where there was no direct contact with a defined source of incoulum), the dispersal of the disease took place in all directions. It nevertheless seems that there was a more marked dispersal in the direction facing into the wind.

The environmental gradients

The environmental gradients are related to the passive movement of the whitefly. The whiteflies caried by the wind gathered preferentially on the first edges of the plot that they came to, that is, the upwind edges. Several hypotheses have been proposed to account for the mechanism of this accumulation. For example, it could be related to phenomena of turbulence and/or reduction of wind speed at the edges of the field. Whatever the underlying mechanism, this distribution of the vector results in a greater contamination in the upwind part of the field, and the environmental gradients thus appear. Many observations based on the captures in insect traps remote from all sources of whiteflies suggest that distances of several kilometres may be covered in this way.

Dispersal gradients

Dispersal gradients, by contrast, are related to the presence of well-defined sources of diseased plants. With African Cassava Mosaic, these gradients are limited in extent, do not exceed several metres, and do not show any particular orientation relative to the wind. It cannot be excluded, however, that in certain conditions this local dispersal faces the prevailing wind. This limited dispersal is probably the consequence of active movements of the whiteflies within the boundary layer, which seem to take place more obviously against the prevailing wind, but does not exceed several metres, whatever their direction.

The dispersal of the disease from foci of diseased plants shows that cassava plants within the plot do indeed contribute to its contamination. In the following experiment, we sought to quantify the fraction of the contamination that was external to the field (primary spread) and the fraction due to interior sources, consisting of plants that became diseased with the passage of time (secondary spread). We therefore followed the contamination in fields from which the diseased cassava plants were rogued as soon as the symptoms appeared. We have no evidence to suggest that the cassava plants were the source of the virus before the appearance of symptoms. Even if that was the case, the systematic roguing of the virus-infected plants should reduce to a minimum any secondary spread. So, the disease progress curves in this type of plot reflect mainly the the contamination arising from outside the field. This spread is important and results from the influx of virus-carrying whiteflies throughout the year. Detailed analysis of the inoculum pressure and the factors that govern its fluctuations will be given in a subsequent communication ("Temporal development of African Cassava Mosaic").

We compared the kinetics of contamination in plots where a 4% source of inoculum was available, with fields which had none. It was clear that initial sources did contribute to the contamination, since the disease progress curves in the two conditions differed. The difference was limited, however, to not more than a few per cent.

Development of the disease and distribution of host plants

It is known that, as with many viral diseases, the distribution of the host plants influences the development of the disease. We investigated the influence of the planting density on the incidence. It appears that the plots in which the density was lowest were contaminated the most rapidly, whereas those in which the density was greatest had the lowest incidence of the disease. These differences in the spread of the infection may be related to differences in the size or behaviour of the insect vector.

CONCLUSION

These results show the close dependence that exists between the dispersal of the disease and the movements of the whiteflies which themselves are largely dependent on the characteristics of the wind. They emphasize the usefulness of an interdisciplinary approach to the epidemiology of a viral disease. However, we stress that the main objective of this investigation was to understand the mechanisms that govern the progress of the disease, on the scale of the individual field. These basic relationships between virus, vector, plant, and environment are probably valid whatever the agronomic situation. In practice, however, the fields used in the investigation were homogeneous and were large in area. Judging from the responses to the questionnaires by representatives of each country, we see that in the great majority of cases cassava is grown in very small plots, and in association with other crops. We have therefore sought to establish how the disease behaves when cassava is grown with other plants. We chose the combination of cassava and maize, with various densities and various dates of planting of the maize. The infectious processes in the various combinations did not appear fundamentally different from that in cassava grown on its own. A major study of how the disease behaves in the conditions of peasant farms remains to be carried out, but a number of methodological obstacles must be overcome first.

In practice, the heavy primary contamination which exists at Adiopodoumé makes it somewhat uncertain whether healthy fields can be maintained with the current varieties. Though such agricultural methods as eliminating diseased plants, changing the density of planting, or trying to achieve some isolation may reduce the incidence of the disease, the inoculum pressure is such that this control strategy remains risky with the varieties in use now. This situation has been confirmed in the coastal region of the Ivory Coast. It does not seem impossible, however, to be able to maintain healthy fields in such regions so long as varieties are used that are highly resistant in the field (see the accompanying paper "The resistance of cassava to African Cassava Mosaic"). This situation is not, however, characteristic of the entire Ivory Coast. These are regions where healthy fields of relatively susceptible varieties can be maintained healthy because of the low inoculum pressure there (see "Development of the disease on a regional scale").

Fargette Denis, Fauquet Claude, Thouvenel Jean-Claude. (1987)

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In : African cassava mosaic disease and its control. Wageningen : CTA, 109-112. International Seminar on African Cassava Mosaic Disease and its Control

Yamoussoukro (CIV), 1987/05/04-08