THE RESISTANCE OF CASSAVA TO AFRICAN CASSAVA MOSAIC

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The first programme of selection of cassava (Manihot esculenta) for resistance to African Cassava Mosaic Virus (ACMV) was carried out by Storey in East Africa in 1938 (Nichols, 1947). Initially, he produced intraspecific hybrids, using African clones and a Javanese clone (F279), which led to the creation of the hybrid 37244E. Then he created intraspecific hybrids, in particular M. esculenta x M. glazovii, followed by three backcrosses with M. esculenta, in this way selecting a resistant clone, 46106/27.

The same source of resistance was then used by Jennings in 1951 (Jennings, 1957), leading to the selection of the hybrid 5318/34. In 1958, Ekandem, working in Nigeria with seeds from this hybrid, bred a resistant hybrid, produced the clone 58308 which became the source of resistance to ACMV used in the IITA selection programme.

Hahn et al. (1980) concluded that the resistance of cassava to ACMV is:

i) multifactorial and recessive,

ii) A resistance to inoculation and diffusion of the virus,

iii) not a resistance to the vector itself.

In order to test the resistance of the selected clones in comparison with local clones in the conditions of the Ivory Coast, and in order also to determine their various levels of resistance, we investigated the various components of resistance to ACMV.

We distinguished six different types of resistance:

- RF in the field,
- R1 to the vector,
- R2 to inoculation,
- R3 to multiplication of the virus,
- R4 to the symptoms,
- R5 to diffusion.

MATERIALS AND METHODS. COLLECTION OF CLONES

In order to test a small collection of 54 clones, as representative as possible of the genetic variability of cassava, we chose clones of different geographic origins and resulting from different selection procedures. They originated from 9 different sources: The Ivory Coast, Togo, Nigeria, Central Africa, Zaire, Kenya, Madagascar, India and South America. Likewise, we have succeeded in asembling the clones described as resistant by the authors cited above and derived from either intraspecific or interspecific hybrids, selected in Kenya and Nigeria.

The experiment itself was performed in two stages: first, in 1984 we tested 28 clones, including among others the resistant ones from East Africa; then in 1985, we tested all the resistant clones, both East African and Nigerian.

TECHNICAL EVALUATION OF RESISTANCE

The investigation was based on two principles:

- First, the variables chosen were recorded without any a priori classification of their value for describing the biological phenomenon studied.

- Then each was measured, many times if possible (1 to 25), so that the results might be as independent as possible from any climatic, agronomic, or experimental effects.

The curves representing the changes of these variables over time were reduced by transformation into one characteristic figure.

The six different types of resistance are represented by:

- RF: rough estimate of the area of the curve of the cumulative percentage of contamination over time,

- R1: cumulative number of whiteflies counted on the plants,

- R2: regression line of the changes in the cumulative number of whiteflies versus the cumulative percentage of contamination,

- R3: concentration of virus in the diseased plants (only one measurement in 1984),

- R4: intensity of the symptoms (mean of 3 different counts),

- R5: regression line of the intensity of symptoms versus time (1985 only).

Analysis: We analysed the correlations between the variables, then performed principal component analyses, hierarchical classifications, and finally multiple regressions.

RESULTS AND DISCUSSION

A correlation matrix was established for these components of the resistance, which shows that the resistance in the field (RF) was significantly correlated with the other resistance (r 0.48 to 0.80). The most independent type of resistance was that to the vector (R1); R2, R3, and R4 were also significantly correlated with one another.

The object of the principal component analysis was to describe the cassava clones with regard to the five different components of their resistance to ACMV (R5 could not be taken into account). The results may be visualized in the form of three-dimensional diagrams representing, in the present case, 93% of the total variability. The coefficient of correlation of each type of resistance, with its three axes, ranged between 0.75 and 0.95. Axis 1 was especially represented by RF and R4, whereas axis 2 was represented only by R1, and axis 3 was more linked to R2 and R3. The same analysis done in 1985 with another collection of cassava led, except for some details, to essentially the same diagram. All the components of the resistance lay at practically the same place in the diagram. except the virus concentration, but it must be noted that there was only one estimation, which could not be done at the same time during growth in the two cases. This difference therefore probably accounts for the recorded change.

A hierarchical classification of the cassava clones according to the various type of resistance classifies them into several groups ranging from the most susceptible to the most resistant. The resistant groups contain all the hybrids from East Africa and Nigeria, but also the local clones from Kenya, two clones from India, and the clone Aipin Valenca, which was the one most widely used in the selection programmes.

The use of the multiple regressions allowed the resistance in the field (RF) to be related to all the other types of resistance, with a high level of correlation (r=0.85).

Consequently, in the collection of 54 clones used, RF is a good evaluator of the general resistance of cassava to ACMV, with no distinction among components of the resistance.

TEMPORAL STABILITY OF RESISTANCE

We tested the same collection of 10 resistant clones with the same technique for evaluating resistance in the field, at different times of year, that is, subject to high inoculum pressure in April and low inoculation pressure in July. The correlation between two experiment was of the order of 0.75, which is highly significant.

Likewise, we compared the resistant in the field, during several successive years, on collections of about 30 to 50 clones of very diverse susceptibility, but at the same time of year, so they were subject to a similar inoculum pressure. The correlations obtained ranged from 0.58 to 0.69 and where highly significant.

Similarly, we compared the stability of the other components of resistance, such as R1, R3, and R4, for the same collection of 14 resistant clones between two successive years. The correlations obtained were of the order of 0.80 and were therefore significant.

SPATIAL STABILITY OF RESISTANCE

We compared the behaviour of a collection of 54 cassava clones in two very different regions in the Ivory Coast, one in a forest with two rainy seasons with 2000 mm of annual precipitation, and the other in a savanna region with one rainy season and 1000 mm of precipitation. In the first case, the resistance in the field for 1984 ranged from 220 to 1669, and in the second case it ranged from 0 to 168. For 1985, we obtained respectively 0 - 450 and 0 - 248 as a quantification of the resistance in the field. There is therefore some variation from one year to another, but the correlation between the two places was 0.49 and 0.46 respectively for the two years, a result significant at the 5% level.

DISCUSSION

Cassava has been selected for resistance to African mosaic using symptoms as the sole criterion, and in fact this component turns out to be dominant in the scheme that we have drawn up. All the resistance components that we tried to identify tend to point in the same direction. That is, the more vectors there are and the more virus-infected plants there are, the more symptoms there will be and the more virus there will be, considering all 54 clones together.

The resistance of cassava is not a single entity; there is a clearly pronounced resistance to the vector, which is practically independent of the other components. The resistance to the virus is more difficult to investigate, but it does exist and is strongly correlated with the expression of symptoms. Resistance to inoculation, which was investigated directly in the field and not in the laboratory, is sufficiently independent to suggest that it is different from the resistance in the field and particularly from the resistance to the vector. The resistance in the field, expressed as the percentage of virus-infected plants, is ultimately the best indicator of the resistance of a cassava strain. By multiple regressions, the other components of the resistance accounts for approximately 80% of the variability of resistance in the field.

The components of resistance investigated in two different collections had quite similar relationships, except for the virus concentration, which suggests that the system is relatively stable and reproducible, even though in the second year the vector populations were much lower. From one year to the other there were good correlations between the various components of resistance. It seems that there may also be a good stability of cassava's resistance in the field to African cassava mosaic, both

in time and space; we observed this in two different ecotypes and over several years.

The clones which result from selection for resistance itself obviously are classified in the group of resistant clones, but it is surprising to find in this group local clones also, such as those from the East Coast of Kenya and those from India. We did not test many South American clones, but all those tested were very susceptible. It appears therefore that cassava, or at least the clones that we studied, has certain resources of resistance. This store of resources has not yet been fully exploited, notably in respect of resistance to the vector and especially in respect of resistance to diffusion of the virus.

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