AFRICAN CASSAVA MOSAIC
AMONG FARMERS OF THE LOWER IVORY COAST

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Along with yams, cassava is the principal food crop in the lower Ivory Coast. In addition, it provides a useful income to growers living within 100 km from Abidjan. Between 1984 and 1986, an agricultural and economic investigation into the farming practices was conducted relating to food crop, to find out what the technical and economic constraints are and to account for the low cassava yields (10 t/ha on average).

To compare the various growth situations, it was necessary to estimate the effect of African Cassava Mosaic (ACM), which affects all plantations of sweet cassava. Some bitter cassava strains, however, show far fewer symptoms of mosaic; these are grown by certain ethnic groups, for example, the Adioukrou near Dabou.

On the basis of monthly observations of farmers' plots and some experimental tests, three series of questions were initially asked about this endemic disease:

1. What causes the viral disease: The vectors involved, the role of farming techniques and/of the environment, and most important, the role of the peasant farmers themselves when they use any empirical means of control.

2. Its effects on plant growth. In a context of low yields, is mosaic a major constraint ?

3. A control programme: The need for it, how to set it up, and what associated measures may be needed. In the lower Ivory Coast, cassava has specific roles in varied systems of agricultural production.

AFRICAN MOSAIC IN THE LOWER IVORY COAST

The analysis is limited to the varietal group Bonoua Rouge and to three villages between 30 and 90 km from Abidjan, one to the west and the other two to the east, all situated on sandy soils in an equatorial climate with two rainy seasons. In this ecological context, the agricultural situations are quite different, but the levels of mosaic are similar and the village sample can give a representative view of the region.

Table 1. Some systems of agricultural production in three villages of the lower Ivory Coast.

Village	Ethnic group	Typical structure	crops	Surface covered
Béniakré	Baoulé	10 ha reduced family (pioneer)	coffee, cocoa yam-cassava-fallow	7 ha 3 ha
Djimini-Koffikro				
- Land owners	Numerous	20 ha extended family	oil palm yam-cassava-fallow tenanted and other	5 ha 3 ha 11 ha
- Landless farmers	Dioula Burkinabé	3 ha reduced family	cassava-sweet potato or pineapple-cassava	3 ha
Songon-Agban-Attié				
	Attié	20 ha reduced family (pioneer)	coffee-cocoa cassava-fallow	10 ha 10 ha

Three types of observations on peasant plots were made: 1) observation of small patches (40 m2); 2) experimental testing of local cultivars with non-infested cuttings (provided by the laboratory of virology of ORSTOM at Adiopodoumé); 3) observation of pairs of small patches comparing a clean control with the peasant weeding practices. The cassava plants, in all cases, were recorded individually each month. The objective of the experimental test was partly methodological and the 6 blocks, in 3 villages, were measured just once. In order not to overlook possible effects and to prepare more sensitive experiments, we chose a risk threshold of 8%. It was not possible to check for any possible clonal difference between local cuttings and virus-free ones. Because of these restrictions, we consider the results of this test only as hypotheses.

<u>The scale of symptoms</u>

Because we do not have adequate information about the actual mechanism of ACM, and also because our objective was primarily agronomic, we worked on the leaf symptoms, which are liable to produce losses of yield directly (other processes are probably also involved). In addition, it should be simple to record ACM in the peasant setting, and as the yield is obtained per plant (and not per stem), we opted for an overall marking scheme in which the percentage of nongreen surface of the leaves (for which photosynthesis was affected) was estimated. The scores ranged from 1 to 10; 100% represents level 3 on Cours'scale. The subjective character of this marking scheme was reduced, though not eliminated, by regular visits from a reference investigator, to check the work of the observers.

With large cassava plants, this overall marking scheme was no longer sensitive enough to record the effects of different growing conditions. We recorded in addition the last 10 leaves, after examining each stem. This criterion turned out to be pertinent either to the characterization of the overall evolution of the mosaic or to the detection of what determines it.

Pattern of development of the mosaic

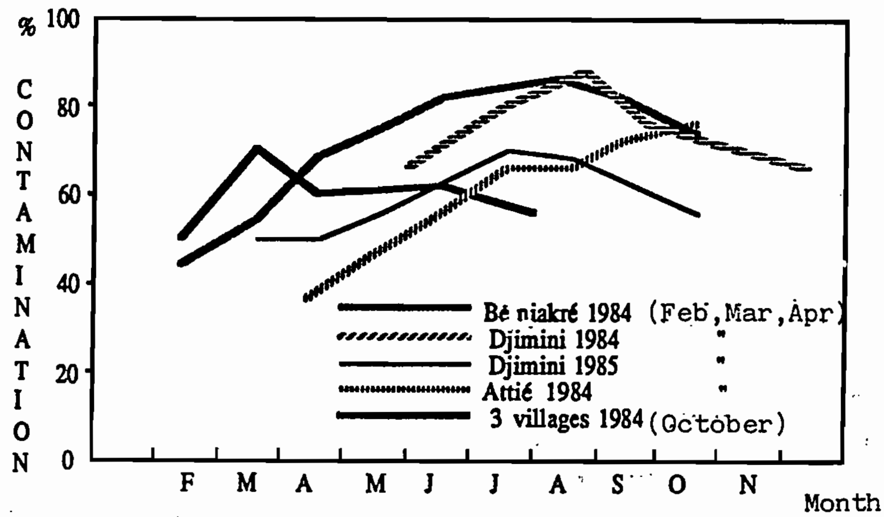
The contamination of the crop arises from cuttings. The farmers were not recorded as performing any empirical selection, except that they eliminated weak stems as they weeded. The need for many cuttings at planting time leads to indiscriminate use, to the point where during the cassava "boom" of 1984 several plots had to be replanted. From the first month, the cassava showed a mean level of 40% to 50%, whatever the date of planting. The variability between plants within a plot and between plots was large, whereas certain villages (Djimini for example) showed less initial variability of ACM.

Table 2. Mean coefficient of variation of ACMV in the first month (%).

	Between plants in a patch (40 m2)	Between groups of 4 plants within a plot
Bêniakrê,		
- beginning of 1984	58	42
Attiê		
- beginning of 1984	54	41
Djimini		
- beginning of 1984	33	33
Djimini		
- beginning of 1985	28	-

The patterns of development of the symptoms varied from one village to another, depending on the year and date of planting, showing that the expression of ACM was clearly related to the growing conditions (Fig.1). In two villages, ACM stabilized and even subsided slightly, from the 6th month. The mean maximum lay around 80% in the various situations (which does not signify an actual 80% loss of photosynthetic capacity, since our scale is above all comparative and relative).

Fig. 1: Evolution of the symptoms in the lower Ivory Coast



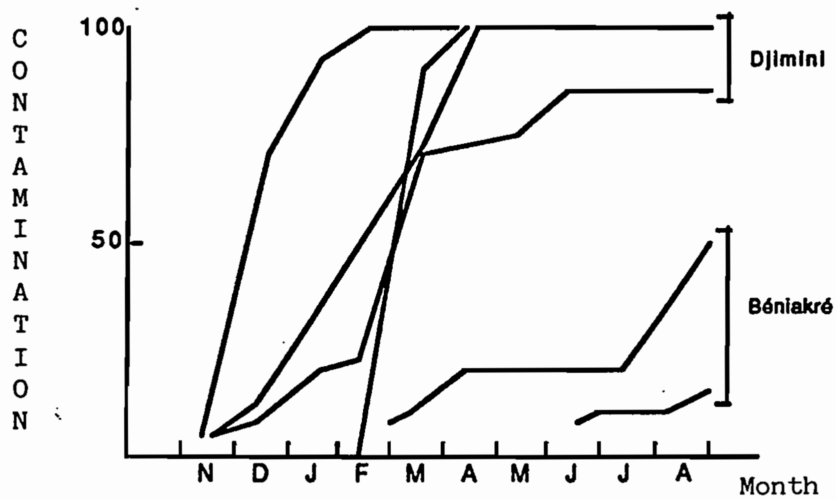
Some causes involved

Though contamination occurs mostly through cuttings, other vectors are likely to play a role. After analyzing the latter, we will discuss whether the expression of symptoms was related to certain growing conditions:

- Contamination of healthy cutting

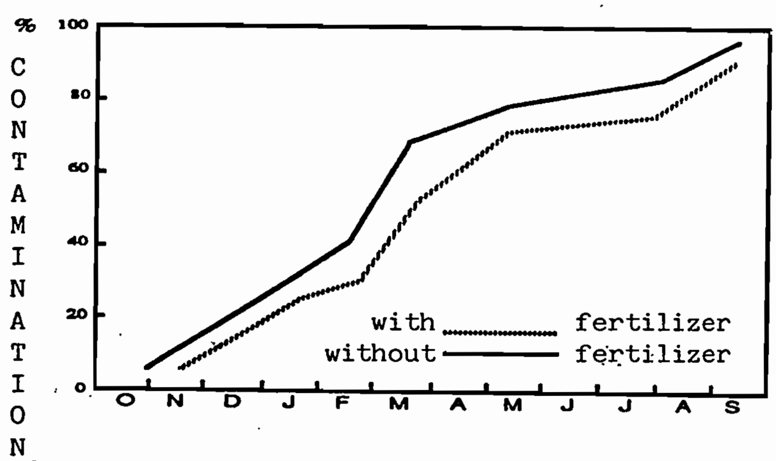
Although issued only from a single experimental test, the results are convincing: virus-free cuttings, planted in contaminated plots, showed dynamics of contamination that differed among villages (Fig. 2). It seems that the outcome may be related to the level of subdivision of the land and to the relative amount of cassava in the village: Béniakré, where contamination was slow, has mainly coffee and cocoa fields, broken by a few clearings for food crops; Djimini is much more open, with wide diversification (trees, food crops, and pineapples); Attié has the largest amount of cassava (although one case is hardly significant). There are several limitations applicable to these hypotheses: the contamination is measured by the appearance of symptoms, perhaps related to different growing conditions. The village effect is not independent of the climatic effect.

Fig. 2: Changes in the level of contaminated plants between blocks and villages.



For the plants whose virus disease is derived from secondary contamination, the level of symptoms is clearly lower: 30% versus 60% for the 6th and 7th month. It seems that the NK fertilizer had no effect on the expression of the symptoms, because the shift on the figure appeared before the application.

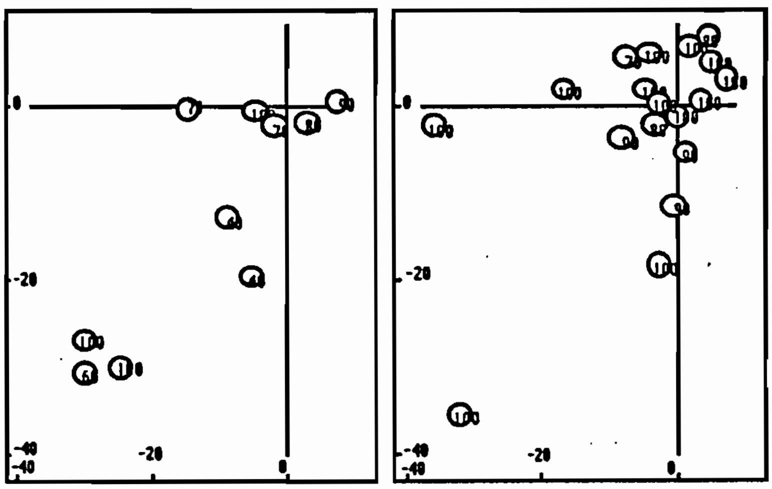
Fig. 3: Changes in the level of contaminated stalks (mean of the 3 villages).



- Weeds and ACM

The expression of ACM might depend on the conditions in which the plant population is growing. Two examples are analysed from the tests in the peasant environment: the effect of the NK fertilizer (in the following section) and the effect of a lot of weeds on the expression of the mosaic. From pairs of cassava patches, we chose the most unfavourable situations (infestations 80% and height of the weeds > 30cm). To avoid the poor sensitivity of the criterion "overall mosaic of the plant", we distinguished plantings less than 3 months old from those more than 3 months old (Fig. 4). However, in neither case did the pattern of the changes seem related to the unfavourable weed conditions (the different situations did not diverge significantly from the bisector).

Fig. 4: Changes in the symptoms of ACM with heavy weed infestations. a. First 3 months. b. Following months.



Each number represents the level of infestation of a weed-infected patch compared with a clean control. The displacement between mosaic in the control and that in the patch is given by the X-axis position for the month M, versus the month M + 1 on the Y-axis.

THE CONSEQUENCES OF AFRICAN CASSAVA MOSAIC

Effects of ACM on the harvest

In the experimental test and for the treatments without fertilizer, the non-infected cuttings doubles the yield on fresh roots (14 to 27 t/ha). With fertilizer, the gain was not more than 74%. In contrast with the NK fertilizer, which acts preferentially on the above-ground parts, the mosaic acted preferentially on the weight of the roots (Table 3).

Table 3. Analysis of variance of the experimental test.

Treatment	Level of significance (risks)			
	<0.001	<0.01	<0.05	<0.08
Mosaic	Number of tubers (-)	% Abnormal plants (+)	Dry matter, roots (-)	
NK fertilizer			Dry weight, above ground (+)	Total dry weight (+) Number of tubers (+)
Interaction	-	-	-	-

The mean weight of a tuber did not differ detectably with the different treatments (approximately 0.16 kg dry weight), so yield was strongly correlated with the number of tubers. The level of plant destruction also did not differ, but there was a higher percentage of atypical plants in the case of virus-infected cuttings: these were vigorous plants (above-ground part > 1000 g wet weight), but without any tubers, detracting from the linear regression between weight of roots and weight of above-ground parts. This correlation would be even more marked if it had integrated the plants with many roots and reduced tuber formation. Some cases of root rot were observed, but they were not attributable to a particular treatment. In this test, the fertilizer did not significantly affect the weight of the roots. Nevertheless, it produced a non-negligible mean gain, of 53 and 32% respectively, depending on whether the cuttings used were the local or the virus-free ones.

Table 4. Action of fertilizer on the cuttings.

	Local cuttings		Virus-free cuttings	
Fertilizer	without fertilizer	With NK fertilizer	Without fertilizer	With NK fertilizer
% Atypical plants	7	16	0	0
Root dry wt/plant (kg)*	0.53	0.81	1.07	1.41
Above-ground dry wt/plant (kg)*	0.58	0.91	0.86	1.39
Number of tubers**	2.8	4.3	6.8	8.2

* all the plants present at the harvest
** on 5 blocks

The use of diverse growing conditions made it possible to contrast the common functioning better, in particular to weight the effects of the treatments. Two blocks showed a clear effect of the mosaic on the weight of the above-ground parts, or, rather in one village there were marked interactions between fertilizer and mosaic.

ACMV: Planting and harvest

As the cassava grows continuously, and its phases of development induce hardly any break in growth, it is legitimate both to monitor the effect of ACM from the first month of planting and to analyse how this period explains certain components of the yield. As the cycle lasts 12 months, the low correlations (>0.4) will be preserved initially.

The farmers'virus-infected cuttings produced taller plants in the first month, a phenomenon which fell off thereafter (Table 5). These plants branched sooner. From the second month, the mosaic decreased the leaf cover on the ground.

Table 5. Analysis of variance (2 fixed, crossed factors).

(Risk)	Mosaic	Fertilizer	Interaction
1st month: height	0.006 (+)	-	-
2nd month: area	0.02 (-)	-	-
3rd month: height	-	0.04 (+)	-
3rd month: competition	0.03 (-)	0.015 (+)	-
3rd month: % branched plants	0.04 (+)	0.003 (+)	-

In addition, the components of the yield were correlated with the state of growth at 3 months. Thus, the dry weight of tubers at 12 months was positively correlated both with an estimator of the leaf cover on the ground ($r = 0.65$) and with the depth of fallen leaves ($r = 0.70$). The following figure summarizes some elements that may determine the plant's growth, which are then specified by the multiple regressions.

Fig. 5: Factors affecting plant growth, specified by multiple regressions.

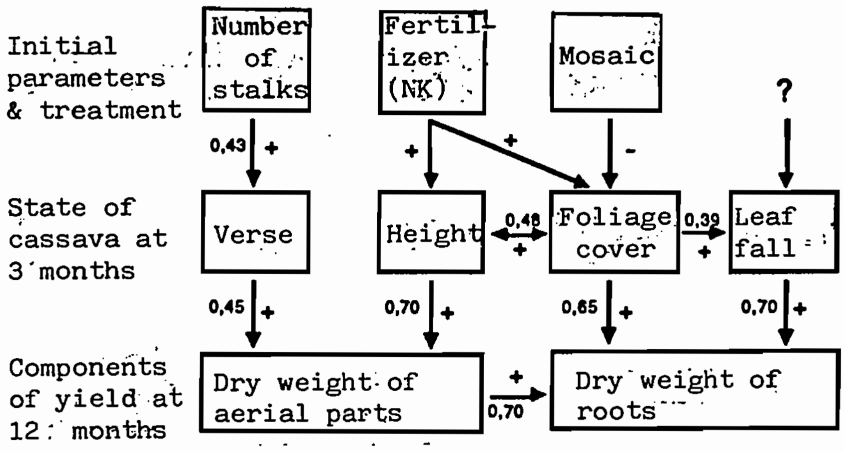


Table 6. Approach of correlations between treatments, plantings, and the components of yield, on the basis of experimental tests.

Equations	Correlation r	Total	Risks Partial	Partial
Dry wt.roots (kg) = 0.014 Comp3 (%) + 0.019 LF 3 (cm) + 0.29	0.81	0.048	0.004	0.001
Dry wt. above ground (kg) = 0.011 Height3 (cm) + 0.445 T 3 - 0.76	0.78	0.059	0.0001	0.006
Leaf fall (cm) = 0.21 Area3 (dm2) + 14.9 T 3 + 0.21	0.53	0.22	0.041	0.027
B1-3 = 0.45 Height3 + 0.52 M3 (%) - 55.9	0.61	-	0.013	0.007

Note: Dry wt. of roots and above-ground parts at 12 months; and Comp, competition (leaf-cover index), leaf fall (LF), height, toppling (T) (scored from 0 to 0.5)% of branched plants (B), area and mosaic (M) at 3 months.

At 3 months, the percentage of branched plants was not much correlated with the height nor with the mosaic (r = 0.33 and 0.59). It was, however, clearly related to the two of them at a given height, the effect of the mosaic interacted with branching (there might be a clonal difference, but none of the treatments showed a simple regression of height versus percentage of branched plants). The weight of roots at 12 months was clearly correlated with the leaf cover on the ground (expressed as a criterion of competition) and, more surprisingly, with the amount of fallen leaves. In summary, the absence of mosaic in a cutting is translated mainly into a greater ground area from the first month. With no change in the weight of the parts, this greater effectiveness of light capture shows up in the root yield.

As for the components of yield, we did not see any interaction between mosaic and fertilizer on the criteria of cassava planting. Nevertheless, to eliminate partially a strong initial variability between plants, we calculated the difference between the mosaic at the 3rd and the 1st months. It turned out that fertilizer had a significant effect (risk = 4%), which could signify that the mosaic is expressed more in the presence of fertilizer.

AFRICAN CASSAVA MOSAIC AND FARMERS

Although the experiment lasted only one year and covered only one particular period, the gain of nearly 100% provided by the virus-free cuttings gives an idea of the impact of this disease. It would be necessary to clarify this relation further, first to specify the actual gain, according to years and dates of planting, provided by the non-infected cuttings. In this respect, it is also necessary to evaluate the real effect of ACM for the sake of knowledge (and therefore of improvement). In fact, there is a possibility that there is some varietal difference within the Bonoua Rouge group, and it would be desirable to be able to work in a non-experimental setting with a genetically characterized and virus-free cassavas. Finally, it is not enough to have shown a gain for a given year if the increase will not persist without a longer fallow period. Therefore, it is advisable to determine it in terms of the cropping system, and particularly when cassava follows a fallow period. If the gain were to be confirmed experimentally, it would then be possible to go on to analyse the conditions for setting up a possible programme of combative action.

At present, no structural shortage of cassava is recorded in Abidjan, though there are substantial fluctuations in supply and price. Controlling ACM would serve mainly to free farmland and to lower the price to the consumer. To achieve these objectives, it will be necessary to ensure a clear gain to the producer, despite foreseeable reduction in the price. In addition, the release of land will be an opportunity that is put to use differently by the various systems of production in the lower Ivory Coast. One must not forget that two nearby villages, even two contiguous stretches of farmland for some villages (Djimini for example) operate differently, under different constraints. Cassava plays different roles there, depending on whether it is all consumed in the village, or is sold, either the total production or just the surplus.

This release of land will be felt in different ways, depending on the pressure to diversify, which combines two opposing factors:
i) the systems of production in which the food crop is imposed;
ii) those for which cassava is a sideline. In the first case, we have the indigenous Adioukrou, whose social system is largely based on cassava monoculture. There are also landless farmers who have only temporary access to a plot, often planted with cassava, which will be sold. In the second case, the small and medium planters of Bėniakrė may respond circumstantially to a rise in price, but to the detriment of their small reserve of fallow land.

In the Congo, the virus may even represent an advantage, since the consumption of the young cassava leaves shows that there is a preference for virus-infected leaves. Whatever programme of combative action is envisaged, it is necessary to avoid marginalizing the most specialized and most fragile systems of production; a prudent, gradual action is necessary to allow each of them to adapt themselves. In addition, the provision of healthy cuttings may lend itself to the organization of profitable cassava production, for which a knowledge of differentiated and original systems of agriculture is essential.

Mollard Eric. (1987)

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