SOME EFFECTS OF AFRICAN CASSAVA MOSAIC DISEASE ON THE FIRST STAGES OF PLANT GROWTH

RAFFAILLAC, J.P.& NEDELEC, G.
Laboratory of Agronomy
ORSTOM, Adiopodoumé BP. V51
ABIDJAN, IVORY COAST

INTRODUCTION

African Cassava Mosaic is likely to infect cassava in two different ways:

- if the planting material is already infected and consequently the cuttings it produces develop plantlets that are infected from the beginning,

- if a plant that is healthy at the beginning becomes infected by Bemisia tabaci during cultural growth. Periods and pressures of infection in southern Ivory Coast are very unsteady (Fargette, 1985).

This paper aims to determine some effects of the virus at different plant growth levels: cutting, leaves, aerial parts, roots and tuberized roots, and their possible consequences likely to appear both at cycle end and during further cycles.

The results of several agronomical trials made between 1983 and 1986 at the ORSTOM experimental station at Adiopodoumé, are presented here. The CB variety was used in most of them, because the sanitation programme at ORSTOM virology laboratory enabled us to use a well defined planting material and virus-free cuttings. However, an infection was noticed in some plants from the early growth of young leaves, which enabled a comparison with other plants infected at different stages during the first weeks.

Though ACMV was not really studied, it was necessarily taken into account whenever the planting material was checked and all during young plants growth, because of the changes it caused in leaf surface.

The effects of ACMV on cuttings recovery and on planting material quality are first studied, then the evolution of the disease in time and as regards fertilization are presented.

EFFECTS OF ACMV ON THE FIRST STAGES OF PLANT GROWTH

In two trials using the CB variety, it was possible among all plants available to gather similar cuttings as regards their date of virus infection. Thanks to a thorough weekly control, it was possible to record for each plant the date of symptom emergence on 20 cm tall plantlets whose height as well as weight and number of internodes had been controlled from the beginning.

The chosen groups were composed of a minimum of 10 plants:

- plants that remained healthy for the whole period studied (S),
- plants on which virus symptoms were noticed from the early growth of young leaves (V),
- plants on which infection wasnoticed at 3rd, 4th and 5th controls - 2 to 4 weeks - (S-V, 2-4),
- plants on which infection was noticed at 5th, 6th and 7th controls - 6 to 8 weeks - (S-V, 6-8).

Only the first weeks of the growth cycle were studied, when competition between plant is considered unimportant: no competition either for light (incomplete soil cover), or for water (rain recovery or/and irrigation).

Growth measures made at the beginning of the cycle were weight of the different plant parts, number of stems, leaves, roots enabling a comparison between groups as regards their reaction to virus infection.

RESULTS AND DISCUSSION

Two types of results were gathered, on the one hand concerning the number of roots at 33 days (Table 1), and on the other hand those concerning the growth levels of aerial parts and tubers at 76 days (Table 2).

Table 1. Comparison between the number of nodal and basal roots of healthy cuttings (S) and of infected cuttings (V) for two different weights of cassava at 5 weeks.

Group	Cutting Fresh weight (g)	Number of Nodes	Number of roots	
			Nodal roots	Basal roots
S	40-65	6.9a	4.1a	16.7a
V	40-65	7.2a	3.4a	15.2a
S	90-120	10.8b	8.9b	21.4b
V	90-120	11.0b	7.6b	23.1b

a,b: along the columns, the followed values of a given letter are not significantly different for p=0.95.

Table 2. Action of virus infection at the beginning and during the cycle on the growth level of aerial parts (A) and on the initiation of tuberization (B) at 2,5 months.

A	Number of stems	Number of branches*	Leaves Dry weight (g)
V(n=18)	2.1a	2.1a	69.4a
SV.2-4 (n=11)	2.3a	2.6a	77.9ab
SV.6-8 (n=14)	1.9a	3.7b	92.0b
S (n=25)	2.2a	4.7c	127.2c

* = branches that are not caused by flowering.
n = number of repetitions.

B	Roots % Ø > 5 mm	Total of Ø > 5 mm	Maximum M (mm)
V	23a	74.1a	8.7a
S-V.2-4	22a	91.3ab	8.2a
S-V.6-8	49b	126.4bc	13.1b
S	56b	163.6c	17.8c

a,b = The values that are followed by a same letter are not significantly different for p=0.95.

When considering the action of ACMV on rooting (Table 1), only the roots that were complete were counted. The number of roots developed by cuttings of equal weight was the same at the beginning, with the virus or without it. As all roots issued are similar anatomically and are all potentially likely to tuberize, it is the provision level in the cutting that will be able to act first upon the component of the yield number of tubers.

Results in Table 2 were obtained from the observation of plants whose original cutting weighed between 60 and 130 grammes for each group. No effect was noticed upon the number of stems produced per plant. Leaves' growth level was affected most as the virus was present early on the plant. The dry weight of leaves, grossly comparable to the photosynthesis surface, decreased by 45% as compared to the sample, in the extreme case of a plant infected from the beginning. This decrease was partly caused by a reduction in the number of branches that normally develop from side buds off the principal stems. This foliage limitation entails a limitation of the occupied space and the intraspecies competition for light, and/or with weeds and plants grown in association will occur at the expense of a given plant.

Taking into account the two yield component "number and weight" (represented here by diameter) of tuberized roots, infection is effective very early on tuberization, delaying the growing of primary axis both in number and on each root (Table 2B). For a tuberized root whose diameter is over 5 millimeters, the percentage of this type of root compared with the total number of roots is significantly decreased in plants infected in the first 5 weeks after planting. In other respects, the maximum diameter of the biggest tuberized root on the plant decreases from 26 to 51% as compared with control. Whatever the phenomenon likely to arise after 2.5 months, the early disease occurrence causes a decrease in the accumulation of weight and in the number of tuberized roots on the individual plant.

ACTION OF ACMV UPON CUTTING QUALITY

When a 17 months old trial was harvested, a study was made to compare the stems of plant (CB variety) whose virus infection during the growth cycle had been recorded. In order to gather an adequate number of repetitions, the dates when the disease appeared on the last leaves were recorded during periods of 21 days for all plots with no significant difference. Only plants with two stems were included.

The diameter of the lowest part of each plant's biggest stem was measured about 5 cm above its insertion on the cutting. A single 20 cm long cutting was made from the stem's lowest part and its dry weight determined.

RESULTS AND DISCUSSION

Table 3. Action of ACMV infection on a cassava stem at harvest and on a basic cutting provided by this stem.

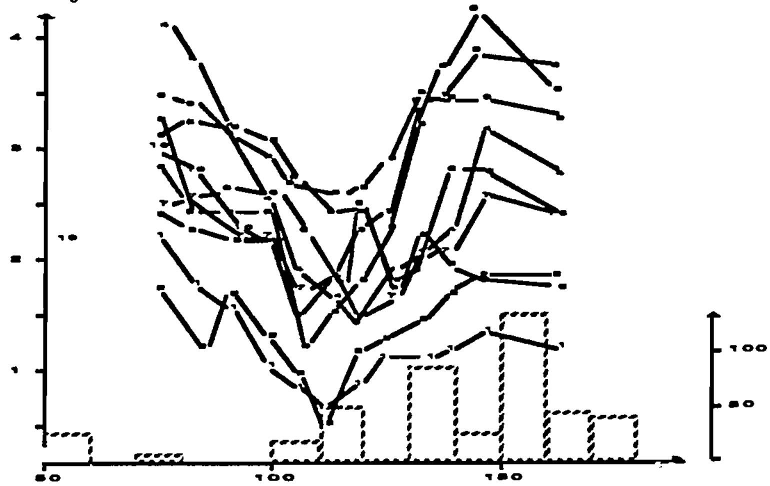
Date of symptoms	Number of observations	Stem basal Ø	Basic cutting weight
2-4 weeks	17	25.9a	67.4a
6-8 weeks	25	26.3a	79.8a
10-12 weeks	27	31.4bc	109.8b
14-16 weeks	19	35.3c	117.4b

a,b = The values that are followed by a same letter are not significantly different for p=0.95

The early infection of a cassava plant causes a decrease in stem diameter, which is in part the expression of an intraspecific competition in plant structure: healthy plants situated around an infected plant very early in the cycle bring shade for the latter. The reduction of limb surface of the plant itself may have caused a decrease in dry matter production. This has consequences on cuttings they will provide. In this manner the planting material quality is not as good and the number of roots decreases (cf. first part). A plant infected early in the cultivation cycle will, at harvest, provide cuttings which are likely to be more susceptible to climate changes (water stress for instance). The root number decreases, which is likely to change the first yield component, i.e. the number of tuberized roots.

Fig. 1: Evolution with time of the average intensity of the viral disease on the youngest completely developed leaf of 10 cassava clones infected at planting.

Severity of virus



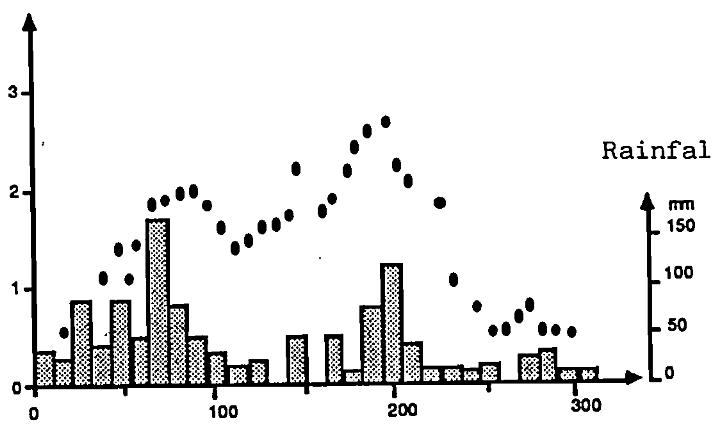
EVOLUTION OF ACMV DURING THE CULTIVATION CYCLE

Two trials enabled us to monitor the fluctuations of disease symptoms over time: one trial involved the comparison between 10 clones whose 20cm long cuttings had all been infected from planting, the other involved field preparation with the virus-free CB variety.

In both cases, a weekly control of leaf production rythm was carried out by marking the youngest completely developed leaf from 0 (no symptom) to 5 (most severe symptoms), following the symptom scale of Cours (1951).

Fig. 2: Evolution of the average intensity of the viral disease on the youngest completelyt developed leaf in a plot of healthy cassava at planting (CB variety).

Severity of virus



RESULTS AND DISCUSSION

Figures 1 and 2 show the evolution of symptoms on the youngest completely developed leaf during 3.5 months and the whole cultural cycle, and present the amount of rainfall during the same period.

For the 10 clones considered, a general tendency of a decreasing severity of symptoms was recorded, coinciding with the end of the rainy season. Symptoms are minimum when the first rain recover and become more severe later on.

Figure 2 represents a different situation as plants were healthy from the beginning, and a first increase of symptoms can be seen on the trial, caused by the infection of a greater number of plants over time. At the end of the rainy season when contamination reached 100%, symptoms decreased then recovered with the arrival of the second rainy season. From the 7th month, after planting, the average mark heavily decreased.

The seasonal changes globally registered during the two trials are difficult to explain as the age of the plant must be considered. Nevertherless, it is interesting to note the effect of recovery of rains on symptom increase. Further experiments and a plant physiological control (nutritional state), coupled with the results of Fargette (1985) on whitefly population fluctuation, might give some explanation.

EFFECTS OF ACMV ON CASSAVA LEAVES

To assess the nutritional levels of cassava plants by Foliar Diagnostic, a distinction was made between healthy and infected leaves. The reference leaf is the youngest completely developed leaf on each stem. Apart from the analysis of principal elements, area measures by planimetry and dry weight made it possible to record some effects of the disease on this type of leaf of the CB variety.

In a fertilization trial (Van Hanja, 1984, Raffaillac, 1984-b) with a local Bonoua-BR1 clone, the infection dynamics at cycle beginning could be analysed for the whole trial. For this purpose, three treatments were distinguished: N 0 = non fertilized sample, N 100 = 100 N units (urea) and N 200 = 200 N units (urea) applied at planting. Weekly recordings for infected plants were taken from the youngest completely developed leaf, whose median lobe length was measured, as an indication of limb surface.

RESULTS AND DISCUSSION

Table 4: Effect of nitrogen fertilization upon ACMV cassava infection between 42-70 days of cycle and on a healthy leaf at 42 days.

Treatment	% of infected plants	Median lobe length of a healthy leaf (cm)	% N	% K
N 0	54.3a	16.6a	5.23	1.81
N 100	69.0b	17.5b	6.29	1.82
N 200	75.1c	17.6b	6.22	1.87

a,b,c = The values that are followed by a same letter are not significantly different for p=0.95

Nitrogen fertilization increased the contamination of the plants in this trial. This viral disease increase on fertilized plots must be compared to the healthy leaf's limb surface increase and to a tendency to concentrate, related to the total amount of nitrogen.

Table 5: Comparison at 72 days of the youngest completely developed leaf of healthy and infected cassava plants.

Group of plants	S (Healthy)	SV. 6-8 (Infected) V3*	V5
Surface (cm2)	386a	208b	119c
Dry weight/ Surface (mg/cm2)	3.5a	3.9b	4.4c
% N	5.19a	5.85b	
% P	0.42a	0.50b	
% K	1.74a	2.07b	
% Ca	0.66a	0.68a	
% Mg	0.26a	0.31a	

a,b,c = The values that are followed by a same letter are not significantly different for p=0.95.
* = V3, V5 = Gravity index of Cours (1951).

This decrease in individual leaf area is nevertheless not constant in time and leaves infected differently may be observed on the same stem. This will not necessarily cause a photosynthesis decrease. The absorption of light is made easier by the canopy area decrease: an increased quantity of light was thus measured at mid-length of stems on a 3 month old plot of infected plants. This increase was between 20 and 65% depending the situation: one or two plants with 1 or 2 stems showed greater viral intensity than youngest leaves. In such situations, more leaves can work more efficiently; measurement of the efficiency of different types of leaves for the production of dry matter and its migration towards roots might bring some complementary information in this field.

The amounts of N, P and K elements in an infected leaf are significantly increased: the distinction between healthy and contaminated leaf must be made to estimate the nutritional level of cassava plants by "Foliar Diagnostic".

Intensity of infection depends upon how early infection takes place in the cultivation cycle, leaf level, ratio of healthy to infected plants in the plot and environmental factors. The prediction of yield loss from measurements of the decrease in limb area is likely to be inaccurate. Compensation takes place (Raffaillac, 1984-a), therefore individual yield loss must be distinguished from plot yield loss.

Loss of above ground vegetation caused by the disease does not necessarily imply yield loss in tuberized roots. As a matter of fact, an optimal level of Leaf Area Index (LAI) is known for each variety above which competition between aerial parts will limit tuberization (Cock et al, 1979). A small infection on vegetation where such a competition exists between aerial parts of plants will decrease competition for light and change the aerial/roots growth rate to the benefit of roots. Cours (1951) records such a phenomenon on a rich soil with an important foliar growth where increases reaching 20% from healthy plants to plants infected up to an intensity of 2 are recorded.

GENERAL CONCLUSION

The level of yields loss through ACMV varies for the different parts of the plant, and depending on whether the individual plant or tôtal plant population is being considered.

The presence of the virus in the cutting is not the only factor which limits root tuberization. A decrease in stem growth leads to a decline in bulk (wet and dry weights). Propagation using infected plant material may lead to a cumulative decline in quality over a few generations.

Infection during a cultural cycle becomes less and less prominent on tuberization, as regards number and weight, as it occurs late in the season. The subsequent decrease in limb area will not necessarily imply a yield loss: the interaction between disease and competition must be taken into account.

Cassava's ability to compensate may conceal the effects of the disease on the individual plant, and therefore plant density on the trial plot becomes an important factor. The role played by environmental factors which encourage vegetation growth (e.g. nitrogen) must also be taken into account in the analysis of yield loss through ACMV. In the case of nitrogen fertilization, on the one hand plants are more rapidly infected but on the other hand an increased growth in aerial parts is likely to take place at the expense of the tubers (Raffaillac, 1984-b). In such a case leaf fall is likely to benefit tuberization if the Foliar Area Index already exceeds optimum value. Numerous experiments are still needed to confirm this.

REFERENCES

COCK, J.H., FRANKLIN, D., SANDOVAL, G.& JURI,P. (1979). The ideal cassava plant for maximum yield. Crop Science 19 (3-4), 271-279.

COURS, G. (1951). Le manioc à Madagascar. Mémoire de l'Institut Scientifique de Madagascar, série B III (2), 203-400.

FARGETTE, D. (1985) Thèse: Epidémiologie de la Mosaïque Africaine du Manioc en Côte d'Ivoire. USTL, Montpellier, 203p.

INDIRA, P.& SINHA, S.K. (1970). Studies on the initiation and development of tubers in Manihot esculenta Crantz. Indian Journal of Plant Physiology 13, 24-39.

RAFFAILLAC, J.-P. (1984-A). Comportement du manioc pour différentes densités de plantation. Documents ORSTOM, Centre ORSTOM d'Adiopodoumé, Abidjan, 15p.

RAFFAILLAC, J.-P. (1984-B). Fertilisation du manioc en basse Côte d'Ivoire - Etude de cas. Communication au séminaire IMPHOS sur la production agricole et le maintien de la fertilité des sols en zone tropicale. Yamoussoukro, Côte d'Ivoire, IMPHOS, éd., 12p.

VAN HANJA, N. (1984), Rapport de stage d'Ingénieur d'Agronomie Tropicale de l'Université de Wageningen, Laboratoire du Centre ORSTOM d'Adiopodoumé, 64p.

Raffaillac Jean-Pierre, Nedelec Gabriel. (1987)

Some effects of african cassava mosaic disease on the first stages of plant growth

In : African cassava mosaic disease and its control. Wageningen : CTA, 277-285. International Seminar on African Cassava Mosaic Disease and its Control

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