Effects of Cassava Mosaic Disease on Certain Leaf Parameters of Field-Grown Cassava Clones

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The authors are grateful to J. M. O. Eze, Department of Biological Sciences, for guidance in the chlorophyll analysis work, A. O. Ogbimi, of the same address, for the use of his centrifuge, and the Director of the Nigerian Institute for Oil Palm Research (NIFOR) for the use of the Institute's area meter during the study.
Accepted for publication 13 November 1981.

ABSTRACT

Ayanru, D. K. G., and Sharma, V. C. 1982. Effects of cassava mosaic disease on certain leaf parameters of field-grown cassava clones. Phytopathology 72:1057-1059.

Mature leaves of 14 field-grown 8-mo-old cassava clones with (diseased) and without (healthy) symptoms of cassava mosaic disease (CMD) were assessed comparatively for concentrations of chlorophylls (chl) a and b, leaflet surface area, leaflet dry weight, and petiole dry weight. Ratios of chl a and chl b were similar in diseased and healthy leaves (1.76–2.23 and 1.90–2.20, respectively). Concentrations of chl a and chl b were between 1.35–2.38 and 0.67–1.19 mg/g dry wt, respectively, in healthy leaves, and 0.84–1.42 and 0.40–0.72 mg/g dry wt, respectively, in diseased leaves. Concentrations of chl a and chl b, as well as leaflet surface area, leaflet dry weight, and petiole dry weight of diseased leaf samples were reduced significantly ($P < 0.01$) by 32–62, 37–57, 21–48, 25–54, and 27–51%, respectively, compared with corresponding data from healthy leaves. It is suggested that the bulk of CMD-induced heavy yield reductions in cassava can be explained on the basis of the diminished chlorophyll content, leaflet size, and (possibly) other aspects of photosynthetic carbohydrate production.

In Africa, cassava mosaic disease (CMD) is considered to be one of the most important factors limiting increased yields and production of cassava. This poorly investigated and ill-described disease (10) causes characteristic mosaic symptoms on leaves of infected plants, and some leaves also exhibit bright yellow areas separated by normal green tissues (9). These symptoms suggest a reduction in chloroplast and/or chlorophyll content. It is not known to what extent chlorophyll content of chloroplasts varies in leaves of CMD-infected cassava plants.

Losses in cassava yields from CMD range from 20–90% (4,5). Such drastic yield reductions suggest a severe stress on the photosynthetic system and other metabolic pathways affecting enzymatic and hormonal balance. Yields of cassava are directly affected by the photosynthetic efficiency of the canopy, which is reported to be a function of leaflet size, among other factors (16). In addition to the mosaic and chlorotic symptoms, cassava leaves with CMD infections are reduced in size, twisted, and misshaped (10). Consequently, a knowledge of the degree of CMD-induced reduction in leaflet size and chlorophyll content of leaves of cassava clones could be useful in assessing such clones for field resistance to CMD. Hence our study, which reports on the chlorophyll content, leaflet size, and leaflet and petiole dry weight of leaves of 14 field-grown cassava clones with and without CMD symptoms.

MATERIALS AND METHODS

The 14 clones of cassava (*Manihot esculenta* Crantz) used in the study were tropical selections of *Manihot* (TMS) obtained from the experimental substation of the International Institute of Tropical Agriculture (IITA) at Agbarho, Bendel State, Nigeria. All the clones we studied are of the bitter cassava type, except TMS/SA 1001 which is a clone of the sweet cassava type. TMS 30555, TMS 30572, and TMS/W 4488 are among high-yielding CMD-tolerant/resistant elite clones (1) currently being multiplied and distributed widely among local farmers by the IITA, Ibadan, Nigeria. TMS/U 30395, 42046, and 41044 are among low-yielding clones with Umudike (U) accession numbers.

They were propagated by stem cuttings in the field in November, 1980, at Ugbowo, Bendel State, Nigeria, in 14 replicated standard yield plots (7). Ten plants of each clone spaced 1 × 1 m on the square were planted in each plot. There was no fertilizer application, and at monthly intervals the plots were hand-weeded. Eight months after planting, leaves of plants with CMD symptoms (diseased) and without CMD symptoms (healthy) were assayed for concentrations (mg/g dry weight basis) of chlorophyll (chl) a and b and evaluated for leaflet size, leaflet dry weight, and petiole dry weight.

For the determination of chl content of leaflet samples, four fully expanded (mature) leaves were detached randomly from about the sixth node from the top of four selected plants in each plot during daytime periods, and analyzed for chl content immediately after harvest. Two 1-cm diameter disks were punched (the midrib was avoided) from two leaflets of each leaf, weighed, ground in a mortar with a pestle, and chl was extracted in 10 ml 80% acetone. The extract was centrifuged (1,400 *g*) for 2 min, and a Corning 253 colorimeter was used to determine its absorbance at selected wavelengths. The concentrations of chl a and chl b were then computed by the method of Hiscox and Israelstam (8) by using absorbance values measured at 645 and 663 nm wavelengths.

From a sample of 100 leaves harvested randomly from varying positions on stems of plants in each plot, the surface area of a 100-leaflet sample was determined with a model LI-3000 LI-COR portable area meter. After this, the leaflets and petioles from them were dried in an oven at 55 C to a constant weight, and values were recorded. For each clone, statistically significant differences between pairs of means of chl concentrations, leaflet area, and dry weight data from diseased and healthy leaves were analyzed and recorded as means of two independent samples (12). To detect significant differences between means of all test clones, analysis of variance as a completely randomized design was performed on the chl concentrations data, and Fisher's least significant difference (LSD) was then computed.

RESULTS

Leaves of clones TMS 30572, TMS/W 4488, TMS/A 3001, and TMS/U 30395 remained free from CMD symptoms during the study. Chl a and chl b contents of healthy leaves of all test clones ranged from 1.35–2.38 and 0.67–1.19 mg/g dry weight, respectively (Table 1). On the other hand, the concentrations of these pigments in diseased leaves were from 0.84–1.42 and 0.40–0.72 mg/g, respectively. Chl a and chl b contents of leaves of each clone with

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0031-949X/82/08105703/$03.00/0

CMD symptoms were significantly lower ($P < 0.01$) than those of healthy leaves of the clone. The highest reduction in chl a and chl b concentrations occurred in diseased leaves of TMS/U 42046, and the lowest reduction in chl a and chl b concentrations occurred in diseased leaves of TMS/U 4044.

The ratios of the concentrations of chl a and chl b in healthy leaves of all test clones were similar, and similar ratios were obtained in diseased leaves of all clones with CMD symptoms.

Leaflet size, leaflet dry weight, and petiole dry weight of leaves of all clones with CMD symptoms were significantly lower ($P < 0.01$) than those of leaves of the same clone without symptoms (Table 2). The reduction in leaflet size varied from 48 ± 16% for diseased leaves of TMS/U 42046 to 21 ± 11% for those of TMS/MANR 60447. Similarly, the reduction in leaflet (lamina) dry weight varied from 54 ± 14% for diseased leaves of TMS/U 30568 to 25 ± 16% for those of TMS 30555. The reduction in dry weight of petioles from leaves with CMD symptoms ranged from 51 ± 23% for petioles of TMS 4092 to 27 ± 10% for those of TMS 30555.

DISCUSSION

The drastic reduction in the concentrations of chl a and chl b in diseased leaves of the tested cassava clones reported here could have very detrimental consequences for growth, yield, and other physiological processes. For example, in diseased leaves of TMS/U 42046, where chlorophyll reduction was most severe, 62 and 57% reductions in chl a and chl b concentrations, respectively, were accompanied by 48, 51, and 44% reductions in mean leaflet area, leaflet dry weight, and petiole dry weight, respectively. Similar results were found for all other test clones with CMD symptoms.

Reduction in chl content in leaves of virus-infected plants has been attributed to underdevelopment and degradation of chloroplasts (3,6). Although it is not the only measure, reduced chlorophyll content of virus-infected leaves can cause decreased and less efficient photosynthetic activity (11,15). Less photosynthate due to decreased chlorophyll content is reported to account for most of the dwarfing and decreased yields in virus infections (14). Consequently, the severe reduction in chlorophyll content in leaves of all clones with CMD infections may be a partial explanation for reduced leaflet sizes, leaflet dry weight, and petiole dry weight.

Losses in yields of field-grown cassava plants due to CMD infections vary from 20–90% (4,5,10). We did not determine the association between yield losses and the 32–62% chlorophyll reduction or the 21–48% reduction in leaflet sizes. It is true also that decreased photosynthetic activity is not a measure only of reduced chlorophyll content of a virus-infected leaf (13). Nevertheless, the magnitude of the diminished photosynthetic capacity reported for cassava in this study strongly suggests that major portions of CMD-induced yield reductions in cassava can be explained on the basis of depleted chlorophyll content, reduced leaflet size, and possibly other features associated with carbohydrate production.

TABLE 1. Comparison of concentrations of chlorophylls (chl) a and b and the ratio chl a/chl b in leaves of cassava clones with (diseased) and without (healthy) symptoms of cassava mosaic disease

Clones	Chl a[a]			Chl b[a]			Ratio chl a/chl b	
	Healthy leaves	Diseased leaves	% of healthy	Healthy leaves	Diseased leaves	% of healthy	Healthy leaves	Diseased leaves
TMS 30555	1.65	0.87**[b]	53	0.83	0.49**[b]	59	1.99	1.78
TMS 5814	1.35	0.84**	62	0.67	0.42**	63	2.01	2.00
TMS 30572	2.08	–[c]	–	1.05	–[c]	–	1.98	–[c]
TMS/SA 1001	1.96	1.11**	57	0.89	0.55**	62	2.20	2.02
TMS 1095D	1.99	0.99*	50	0.96	0.55**	57	2.07	1.80
TMS/U 30395	1.99	–	–	0.94	–	–	2.12	–
TMS/A 3001	2.37	–	–	1.15	–	–	2.06	–
TMS/W 4488	1.79	–	–	0.92	–	–	1.95	–
TMS/U 30568	1.82	1.01**	55	0.96	0.57**	59	1.90	1.77
TMS 4092	2.38	1.42*	60	1.19	0.72	61	2.00	1.97
TMS/U 42046	2.20	0.84**	38	1.09	0.47**	43	2.02	1.79
TMS/MANR 60447	1.55	0.89**	57	0.82	0.40**	49	1.89	2.23
TMS/U 4044	1.52	1.04**	68	0.75	0.59**	79	2.03	1.76
TMS 1526	2.35	0.97**	41	1.17	0.55**	47	2.00	1.76
LSD ($P = 0.05$)	0.26	0.16		0.16	0.10			

[a] Mg/g dry weight; means of four replications.
[b] ** indicates highly significant difference ($P = 0.01$) between healthy and diseased leaf samples of each clone.
[c] – Indicates clones without CMD symptoms in field stands.

TABLE 2. Comparative mean leaflet area, leaflet dry weight, and petiole dry weight of leaves of cassava clones with (diseased) and without (healthy) cassava mosaic disease symptoms

Clones	Leaflet area (cm^2)[a]			Leaflet dry wt (mg)[a]			Petiole dry wt (mg)[b]		
	Healthy leaves	Diseased leaves	% of healthy	Healthy leaves	Diseased leaves	% of healthy	From healthy leaves	From diseased leaves	% of healthy
TMS 30555	27	19**[c]	70	137	103**	75	48	35**	73
TMS 5814	47	30**	64	184	132**	72	91	61**	67
TMS/SA 1001	41	31**	76	217	149**	69	133	74**	56
TMS 1095D	22	14**	64	81	56**	69	30	22**	73
TMS/U 30568	30	16**	53	184	84**	46	58	39**	67
TMS 4092	49	32**	65	315	207**	66	145	71**	49
TMS/U 42046	27	14**	52	140	68**	49	34	23**	68
TMS/MANR 60447	38	30**	79	190	133**	70	133	90**	68
TMS/U 41044	38	23**	61	160	106**	66	85	46**	54
TMS 1525	32	19**	59	161	96*[c]	60	92	52**	57

[a] Means of 100 leaflets.
[b] Means of 100 petioles.
[c] Asterisks indicate significant (*) and highly significant (**) difference ($P = 0.01$) between means of healthy and diseased samples.

This view is supported by the fact that reduced levels of carbohydrates are known to be characteristic of mosaic diseases (2). Also, leaflet size is among other functions that can affect the photosynthetic efficiency of the canopy and thus reduce yields of cassava plants (16).

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