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AFRICAN CASSAVA MOSAIC VIRUS: THE ROLE OF HOST-PLANT RESISTANCE IN SUSTAINABLE CONTROL

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Abstract

The African cassava mosaic virus (ACMV) has, for many years, caused a serious, yield-limiting, disease of cassava in Africa. Breeding for resistance took advantage of resistant material obtained through interspecific hybridization in East Africa. A resistant backcross derivative (58308) from that programme became the source of resistance to ACMV. Several genotypes and seed populations, combining high stable yield, consumer quality, and resistance to ACMV, have been generated and distributed to national programmes throughout Africa for testing under specific local conditions. Some of these programmes have released or recommended such materials for multiplication and distribution to farmers. By using improved cultivars, African farmers, particularly those of Nigeria (now the world's largest cassava producer), can obtain yields that are as much as five times those of many local susceptible cultivars under severe disease pressure. Although resistance breeding is beginning to have an effect, it is yet to prevent the devastations caused by ACMV in many cassava-producing countries. More genetic resources from the cultivated species and other wild relatives of cassava are being used to diversify resistance and so make further progress in breeding ACMV resistance.

Introduction

Cassava accounts for about one-third of all staples produced in sub-Saharan Africa, and is grown almost exclusively as food in 39 African countries. The crop forms a wide belt across the continent, from Madagascar in the south east to Senegal in the north west. Cassava supplies more than 50% of the energy intake of more than 200 million people in Africa. The leaves are also consumed as a vegetable, providing protein, vitamins, and minerals.

African Cassava Mosaic Virus

The ACMV has, for many years, caused one of Africa's most serious, yield-limiting, diseases of cassava. The disease causes losses between 20% and 60% of the edible starchy roots. The etiology of ACMD is relatively well known, with strong evidence pointing to a geminivirus as being the causal agent. The virus is carried in cuttings of infected plants and is also readily transmitted by a whitefly (*Bemisia tabaci* Genn), the adults of which can fly long distances from their host plants. The transmission of ACMV to cassava plants depends on both the availability of inoculum and the density and activity of the whitefly.

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Breeding ACMV-resistant cassava

To breed for ACMV resistance, advantage was taken of resistant material developed through interspecific hybridization in East Africa. A resistant backcross derivative (58308) from that programme became the source of resistance to ACMV and cassava bacterial blight (CBB), and of low cyanide potential. Crosses between 58308 and local cultivars from Nigeria have resulted in several useful ACMV-resistant cultivars. Several genotypes and seed populations, combining high stable yield, consumer quality, and resistance to ACMV and other economic pests have been generated (Table 1). Widely adopted clones such as TMS 30572 and TMS 4(2)1425 were derived from such efforts.

Germ plasm transfer to national programme collaborators. The presence of viruses, particularly of that causing ACMD, restricted the distribution of improved germ plasm to seed populations until appropriate tissue culture and virus indexing techniques for cassava were developed at the International Institute of Tropical Agriculture. Improved ACMV-resistant populations in seed form and as virus-tested, *in vitro* clones have been distributed to collaborators in more than 40 African agricultural research programmes (NARS) for evaluation and selection under their specific agroecologies and farming systems. Several NARS have since developed and released improved varieties in their own countries (Table 2), leading to a substantial boost in production in countries such as Cameroon, Ghana, Liberia, Nigeria, Rwanda, Sierra Leone, Uganda, and Zaire.

By using improved cultivars, African farmers, particularly in Nigeria (now the world's largest cassava producer), can obtain yields that are as much as five times those of many local susceptible cultivars under severe disease pressure.

New sources of resistance to ACMV. An expanded genetic base from the cultivated species and its wild relatives is being used to diversify resistance breeding. Numerous derivatives of interspecific hybrids are undergoing evaluation for their reactions to ACMV. These include progenies from different accessions of *Manihot tristis, M. glaziovii, M. anomala, M. epruinosa, M. pohlii*, and *M. tripartita*. Early indications from the evaluations are very encouraging.

Several new sources of resistance to ACMV have been identified among landraces in Nigeria. They have been incorporated into breeding populations to diversify resistance to ACMV. Several genotypes with higher levels of ACMV resistance from these populations are now at advanced stages of evaluation (Table 3).

ACMV resistance in cassava in the African farming system. Varietal resistance of cassava to ACMV serves only as a component of an integrated strategy to control ACMV; no genotype immune to ACMV has yet been found. ACMV resistance has several advantages: it is economical for the farmers, it is specific to the targeted species, leaves no harmful residue

in foods or the environment, and is compatible with other control methods. Thus, varietal resistance offers an environmentally sound and sustainable basis for integrated ACMV control programmes. Moreover, ACMV-resistant clones and families grown under different environmental conditions have continuously shown resistance to the virus for nearly 20 years.

Table 1. Performance of 24 cassava genotypes (selected for multiple-pest resistance) in uniform yield (kg/ha) trials, Ibadan, Nigeria, 1993.

TMS clone	CMDS[a]	CMDI[b]	CBBS[c]	CBBI[d]	CADS[e]	CADI[f]	CGM[g]	CMB[h]	DM[i] (%)	FRY[j]	DRY[k]
30572	3.1	0.8	2.3	0.6	2.5	0.4	3.6	2.2	29.3	16.5	4.8
81/00110	3.3	0.9	2.3	0.5	3.2	0.7	3.6	2.2	25.7	15.7	4.0
81/01635	3.3	0.8	2.6	0.6	2.2	0.4	3.4	2.5	26.2	22.6	6.0
82/00058	2.8	0.8	2.3	0.7	2.7	0.4	3.3	2.7	29.6	25.6	7.7
82/00661	2.9	0.7	2.5	0.6	3.0	0.5	3.4	2.7	29.1	20.1	5.9
90/00099	2.9	0.8	2.7	0.6	2.2	0.3	2.8	2.5	26.8	13.4	3.5
90/00330	2.7	0.9	2.4	0.7	3.5	0.5	3.1	2.0	21.5	24.7	5.2
90/00350	3.0	0.9	2.1	0.5	2.0	0.3	3.2	2.2	27.0	10.4	2.8
90/01058	2.7	0.6	2.0	0.4	2.0	0.3	3.5	2.5	31.0	26.5	8.3
90/01204	2.4	0.5	2.5	0.6	2.2	0.3	3.2	2.2	27.4	14.2	3.9
90/01554	2.1	0.3	2.1	0.5	3.0	0.4	3.1	2.7	26.5	19.8	5.2
90/01718	2.8	0.7	2.7	0.7	3.0	0.6	2.5	2.0	30.0	19.4	5.8
90/02030	3.1	0.9	2.7	0.7	2.2	0.4	3.2	2.0	24.8	24.4	6.0
91/00453	3.1	0.8	2.9	0.7	2.2	0.5	3.1	2.2	27.8	15.8	4.3
91/00455	2.4	0.3	1.9	0.4	2.5	0.2	3.8	2.5	30.9	11.1	3.4
91/00457	3.3	0.9	2.1	0.6	3.2	0.7	3.7	2.7	33.8	13.1	4.4
91/00458	2.6	0.6	2.5	0.6	2.7	0.5	3.2	2.2	26.9	16.3	4.4
91/00459	3.3	0.9	2.6	0.7	2.0	0.5	3.5	2.2	25.7	14.7	3.8
91/01730	2.2	0.5	2.1	0.6	3.0	0.4	2.8	2.0	26.4	16.8	4.4
91/02319	2.6	0.7	2.3	0.7	2.5	0.3	3.5	2.2	26.5	13.8	3.6
91/02324	1.8	0.4	2.5	0.8	2.7	0.3	3.1	2.2	31.6	33.2	10.5
91/02325	2.8	0.2	2.3	0.5	3.0	0.5	3.6	2.2	24.2	13.3	3.1
91/02327	1.5	0.5	2.3	0.7	3.7	0.6	2.9	2.0	29.4	34.7	10.2
TME 1	2.5	0.7	2.1	0.5	3.0	0.5	2.2	1.7	29.5	16.2	4.7
SE	0.09	0.06	0.05	0.02	0.09	0.02	0.07	0.05	0.54	1.34	0.41

a. ACMD severity (scale: 1 = low to 5 = high).
b. ACMD incidence (proportion of total no. of plants).
c. CBB severity (scale: 1 = low to 5 = high).
d. CBB incidence (proportion of total no. of plants).
e. Cassava anthracnose severity (scale: 1 = low to 5 = high).
f. Cassava anthracnose incidence (proportion of total no. of plants).
g. Cassava green spider mite damage (scale: 1 = low to 5 = high).
h. Cassava mealybug damage (scale: 1 = low to 5 = high).
i. DM = dry matter.
j. FRY = fresh root yield.

k. DRY = dry root yield.

Table 2. Improved pest and disease resistant cassava cultivars released or recommended by NARS from IITA-derived germ plasm for adoption by farmers.

Country	Recommended genotypes or released cultivars
Benin	TMS 30572, TMS 4(2)1425, TMS 30572 A
Burundi	TMS 40160-1, TMS 40160-3
Cameroon	8034, 8017, 8061, 820516, 1005, 658, 244
Côte d'Ivoire	TMS 30572, TMS 4(2)1425
Gabon	CIAM 76-6, CIAM 76-7, CIAM 76-13, CIAM 76-33
Gambia	TMS 60142, TMS 4(2)1425
Ghana	Afisaifi (TMS 30572), Gblemo Duade (TMS 50395), Abasa Fitaa (TMS 4(2)1425)
Guinea	TMS 30572, TMS 4(2)1425
Guinea-Bissau	TMS 4(2)1425, TMS 60142
Liberia	CARICASS 1, CARICASS 2, CARICASS 3
Mozambique	TMS 30001, TMS 30395, TMS 42025
Nigeria	NC Idi-ose (TMS 30572), NC Savanna (TMS 4(2)1425), TMS 91934, TMS 90257, TMS 84537, TMS 81/00110, TMS 82/00058, TMS 82/00661
Rwanda	Gakiza, Karana, TMS 30572
Seychelles	SEY 14, SEY 28, SEY 32, SEY 41, SEY 52
Sierra Leone	ROCASS 1, ROCASS 2, ROCASS 3, NUCASS 1, NUCASS 2, NUCASS 3, 80/40, 86/1
Togo	TMS 4(2)1425, TMS 30572
Uganda	NASE 1 (TMS 60142), NASE 2 (TMS 30337), Migyera (TMS 30572)
Zambia	LUC 133
Zaire	Kinuani, Kivuru, F100

Table 3. Reaction of local cassava cultivars and one breeder's line to African cassava mosaic virus (ACMV), Ibadan, Nigeria, 1993.[a]

Clone	Severity of ACMV[b, c]						Incidence of ACMV[d, c]					
	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	Mean	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	Mean
2nd Agric	1.75	2.75	2.00	2.50	1.75	2.15	0.30	0.85	0.53	0.41	0.33	0.48
Alice Loc	1.33	1.50	1.83	2.25	-	1.70	0.04	0.10	0.17	0.18	-	0.12
Amala	1.50	2.83	2.33	2.50	2.33	2.30	0.14	0.84	0.55	0.75	0.56	0.57
ATU	1.50	1.50	1.50	1.50	1.25	1.45	0.20	0.30	0.20	0.30	0.10	0.22
Bagi Wawa	1.50	2.75	2.00	2.00	2.00	2.05	0.20	0.75	0.75	0.60	0.30	0.52
ISU	4.00	3.75	3.50	3.25	3.00	3.50	1.00	1.00	1.00	1.00	1.00	1.00
Lapa-1	1.66	2.33	2.16	2.50	1.66	2.06	0.20	0.83	0.70	0.70	0.26	0.54
MS 20	2.50	3.00	2.83	3.00	2.50	2.76	0.46	0.93	1.00	0.93	0.76	0.82
Oko-Iyawo	1.16	2.66	2.50	2.33	1.83	2.10	0.10	0.78	0.82	0.72	0.34	0.55
TME 1	1.33	2.66	2.66	2.83	2.50	2.40	0.10	0.66	0.83	0.93	0.76	0.66
Tokunbo	1.00	2.83	2.33	2.50	2.00	2.13	0.00	0.86	0.93	0.70	0.43	0.58
TMS 30572[e]	2.30	3.50	2.90	2.60	2.00	2.66	0.56	0.80	0.88	0.86	0.54	0.72
SE	0.11	0.08	0.07	0.07	0.07	0.07	0.04	0.03	0.03	0.04	0.03	0.03

a. Values are means of four replications at 10 plants per replication.
b. Scored on a scale of 1 to 5, where 1 = low and 5 = high.
c. MAP = months after planting.
d. Number of plants with ACMV symptoms as a proportion of total number of plants.
e. IITA breeder's line (the rest are landraces from Nigeria).