CONTROL OF MOSAIC DISEASE OF CASSAVA BY MANIPULATION OF PLANTING DATE AND PROPAGATING MATERIALS OF RESISTANT GENOTYPES

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ABSTRACT
Secondary stem cuttings of NR 8083 (resistant) and TMS 30572 (moderately resistant) cassava genotypes expected to contain a low concentration of *African cassava mosaic virus* (ACMV) or *East African cassava mosaic virus* (EACMV), and delayed planting of cassava until the whitefly vector populations are expected to be low, were investigated for the control of cassava mosaic disease (CMD). The control treatments were mixture of an equal number of primary and secondary stem cuttings (to simulate the indiscriminate use of stem cuttings by farmers) and planting in April when the whitefly vector population is expected to be high. The experimental design was a split-split-plot with four replicates. Planting date was the main plot, genotype the sub-plot and stem type the sub-sub-plot. Significantly (P=0.05) more whiteflies infested TMS 30572 than NR 8083 and the insect population on the crop was significantly higher in April than in June. Three months after planting, the CMD incidence and severity were significantly higher (P=0.05) on plants established in April than on plants established in June. The use of secondary stem cuttings conferred no advantage over the indiscriminate use of primary and secondary stem cuttings in reducing whitefly population, CMD incidence or disease severity. Irrespective of the type of stem cuttings, cassava plots established in June had a significantly lower whitefly population and reduced CMD incidence and severity. Planting resistant or moderately resistant cassava genotypes when whitefly vector populations are low has greater potential to control CMD than the selection of specific cuttings of the resistant genotypes.

Key words: Cassava, cassava mosaic disease, planting date, propagating material

INTRODUCTION
Cassava mosaic disease (CMD) is controlled by cultural methods and by cultivating resistant cassava genotypes (Thresh *et al.*, 1998). CMD is wide spread in sub-Saharan Africa (Fauquet and Fargette, 1990; Otim-Nape *et al.*, 1994) and causes yield reductions of between 20 and 75 % (Terry and Hahn, 1980; Seif, 1982). The disease is caused by three species of cassava mosaic begomoviruses in sub-Saharan Africa. They are *African cassava mosaic virus* (ACMV) (Bock and Woods, 1983), *East African Cassava mosaic virus* (EACMV) (Hong *et al.*, 1993) and *South African cassava mosaic virus* (SACMV) (Berrie *et al.*, 1998). The viruses belong to the family *Geminiviridae*, genus *Begomovirus* (Mayo and Pringle, 1998). SACMV has only been reported in South Africa Republic (Berrie *et al.*, 1998) and Madagascar (Ranomenjanahary *et al.*, 2002) while ACMV and EACMV are wide spread in sub-Saharan Africa (Ogbe *et al.*, 1997a, b; Fondong *et al.*, 1998; Offei *et al.*, 1999; Pita *et al.*, 2001) and both are known to occur in Nigeria (Ogbe *et al.*, 1999).

The viruses that cause CMD are transmitted by whiteflies, *Bemisia tabacci* Genadius (Storey and Nichols, 1938; Seif, 1981). ACMV and EACMV are not fully systemic in resistant cassava genotypes, which can allow healthy plants to develop from cuttings taken from infected source plants (Pacumbaba, 1985); a phenomenon that is called reversion (Fauquet *et al.*, 1987). The resistant cassava genotypes have low virus concentration (Atiri and Akano, 1995). The use of such stems for planting is, therefore, expected to reduce the incidence of CMD in young cassava fields. Usually farmers indiscriminately use stem cuttings from both the primary and secondary stems.

In the humid forest and coastal savanna of Nigeria, two whitefly population peaks occur. A major peak occurs between March and May, followed by a fall in the population from June to August and a minor population peak between September and November (Leuschner, 1977). High populations of the vector are associated with rapid spread of CMD (Fauquet *et al.*, 1988). Establishing cassava farms during periods of low vector populations could mitigate the spread of CMD.

This paper evaluates the potential of using secondary stem cuttings (expected to contain low concentration of ACMV or EACMV) of resistant cassava genotypes and manipulation of planting date (when whitefly vector population is low) to control CMD.

MATERIALS AND METHODS

Two cassava genotypes (NR 8083, resistant and TMS 30572, moderately resistant) and two planting dates (April and June) were evaluated at the experimental fields of National Root Crops Research Institute (NRCRI), Umudike, Nigeria in the 1997 and 1998 cropping seasons. The stem cuttings used were secondary stems (SS) and a mixture of equal number of primary stems (PS) and SS (PS+SS) to simulate farmers' practices. The infected stems of both genotypes exhibit reversion and can sprout into both infected and healthy plants. The stem cuttings were obtained indiscriminately from ACMV-infected fields. They were planted on ridges at 1 m 1 m in a 5 m 6 m plot to give 30 plants per plot. The experimental design was a split-split-plot with four replicates. The main plot was devoted to the date of planting, the sub-plot contained the genotype and the sub-sub-plot was assigned the stem type. The experimental plots were weeded 1, 3 and 6 months after planting (MAP) while slashing was done 11 MAP, a month before harvest. No fertilizer was used.

The whitefly population was recorded 4, 6, 8, 10, 12 weeks after planting, which is within the period of the vector population peak on cassava (Palaniswami *et al.*, 1996). CMD incidence was taken 1 MAP to determine the proportion of healthy plants since the genotypes are capable of reversion and most symptoms at this age are due to cutting-borne infection. The following data were collected 3 MAP, the age at which these parameters are at their peaks (Ogbe *et al.*, 1996): incidence (% plants exhibiting CMD symptoms), index of symptom severity (Njock *et al.*, 1996) (average severity scores based on healthy and infected plants, which determines the impact of CMD in reducing root yield) and symptom severity of infected plants (a measure of the degree of reactions of the genotypes to CMD). The severity scores were based on a scale of 15, where 1 being no symptoms expressed and 5 being severe mosaic and distortion of entire leaf (Terry, 1975). Root tuber weights were recorded 12 MAP.

ANALYSIS OF DATA

Cumulative whitefly numbers recorded over the 12 weeks, disease incidence and severity, and yield data were analysed using general linear model of the Statistical Analysis System (SAS Institute Inc., 1989).

RESULTS

Type of genotype

Genotype TMS 30572 (moderately resistant) had a significantly higher number of whiteflies (*P*0.05) than NR 8083 (resistant) in 1997 and 1998 cropping seasons (Table 1). The two genotypes had similar number of infected plants 1 and 3 MAP. The severity index was also similar for the two genotypes in 1997 but TMS 30572 had a significantly higher symptom severity index (*P*0.05) than NR 8083 in 1998. Symptom severities of infected plants were similar for the two genotypes in 1997 and 1998. TMS 30572 significantly (*P*0.05) out yielded NR 8083 in both cropping seasons.

Type of planting material

Plants from secondary stem cuttings and those from the mixture of cuttings of primary and secondary stems were not significantly different in supporting whitefly vector populations and CMD incidence was also not significantly different in the two seasons. The severity index (average disease severity of healthy and infected plants) and disease severities of infected plants alone were also similar for the two types of planting material, as were the root tuber yields.

Planting date

A significantly (*P*0.05) greater number of whiteflies was recorded in April than in June in the two cropping seasons (Table 2). Disease incidence 1 MAP, which was mainly due to the use of infected cuttings, was significantly (*P*0.05) lower in April than in June plantings in 1997 but it was the reverse in 1998 plantings. The disease incidence on plants of April planting was significantly higher (*P*0.05) than on plants of June planting 3 MAP in the two cropping seasons. The severity index followed the same pattern as the disease incidence 3 MAP. However, disease severity of infected plants in April and June were not significantly different in 1997 and 1998 cropping seasons. The root tuber yield was significantly higher (*P*0.05) in April planting than in June planting for 1997 but such difference was not observed in 1998.

Interaction between planting date and type of planting material

There was significant interaction (*P*0.05) between planting date and type of planting material with regard to whitefly count, CMD incidence, severity index and root tuber yield (Table 3). Irrespective of the type of planting material, significantly higher (*P*0.05) number of whiteflies was recorded on plants in April than in June during the two cropping seasons. Similar results were observed with CMD incidence, 3 MAP except plantings in 1998. Such interaction was also observed for severity index in 1997 and 1998 cropping seasons on all the plants. The interaction significantly (*P*0.05) increased root tuber yield in 1997 with higher yield from April planting than June planting. However, the interaction gave no significant yield differences between the two planting dates in 1998 cropping season.

Interaction between genotype and type of cuttings

There was no significant difference in yield of cassava arising from the interaction between the genotypes and the respective stem cuttings in 1997 cropping season. This interaction was, however, significant (P0.05) in 1998 between the genotypes in which the yield arising from the mixture of

primary stem and secondary stem (PS+SS), and secondary stem (SS) for TMS 30572 was more than that for NR 8083 (Table 4).

DISCUSSION

Differences in whitefly population on the two genotypes (Table 1) were consistent with the findings that cassava genotypes display a wide range of response to whitefly infestation (Fauquet *et al*., 1987; Legg, 1994; Fargette *et al*., 1996). The higher whitefly population on TMS 30572 ought to have given rise to a higher CMD incidence than on NR 8083, which however, was not the case suggesting that the responses of the two genotypes to infection by ACMV or EACMV were, therefore similar. The higher severity index recorded by TMS 30572 in 1998 was expected of a moderately resistant genotype. However, the two genotypes had similar severity indices in 1997 and the infected plants of the genotypes had similar disease severity indicating that the resistant NR 8083 is not more resistant to CMD than the moderately resistant TMS 30572. The higher yield recorded by TMS 30572 than NR 8083 agrees with previous reports (Nnodu and Ogbe, 1994; Eke-Okoro *et al*., 2001). TMS 30572 may be inherently higher yielding and also more tolerant to CMD than NR 8083. The low CMD incidence recorded 1 MAP was as a result of the use of infected cuttings rather than whitefly inoculation and could, therefore, be a measure of the health status of the cuttings with respect to CMD. Plants that sprouted from secondary stem cuttings are expected to have lower CMD incidence

1 MAP than plants that sprouted from primary stem (Atiri and Akano, 1995). The mixture of equal numbers of primary and secondary stems as a treatment in this study might have cancelled out the expected difference in CMD incidence between plants that sprouted from secondary stems and those from the primary stems. The farmer's practice of indiscriminate use of primary and secondary stem cuttings as planting material is, therefore, appropriate.

The greater number of whiteflies recorded in April than in June agrees with the earlier report of Leuschner (1977). The higher CMD incidence 3 MAP in April than in June (Table 2) could be attributed to the higher whitefly population in April. High whitefly populations are associated with high CMD incidence (Storey and Nichols, 1938; Fauquet *et al*., 1988). Time of planting and not type of stem cuttings of a genotype (resistant or moderately resistant genotype), was the major factor that affected CMD incidence and severity index suggesting that for a relatively healthy farm with low vector transmission, cassava farms should be established when whitefly population is low.

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Table 1. Whitefly count, incidence and severity of cassava mosaic disease and root tuber yield of resistant (R) and moderately resistant (MR) cassava genotypes

Year	Genotype	Whitefly t[a] count per plan	Incidence (%) 1 MAP[b]	3 MAP	Severity index (3 MAP)[c]	Disease severity of infected plant (3 MAP)	Root Tuber yield (t/ha)
1997	TMS 30572 (MR)	33.99	9.63	35.33	1.45	2.23	8.68
	NR 8083 (R)	21.56	9.45	34.36	1.44	2.33	7.11
	LSD (0.05)	11.536	NS	NS	NS	NS	1.463
1998	TMS 30572 (MR)	20.86	14.89	52.28	1.74	2.46	7.70
	NR 8083 (R)	13.16	12.02	45.58	1.53	2.36	5.57
	LSD (0.05)	3.599	NS	NS	0.077	NS	1.793

[a] Cumulative average whitefly count over 12 weeks.

[b] This determines the health status of planting material since most symptoms at this age is due to cutting-borne infection.

[c] Average severity score of healthy and infected plants (Njock *et al.*, 1996), which determines the impact of CMD in reducing root tuber yield.

MAPMonths after planting; NSNot significant

Table 2. Effect of planting date on whitefly count, incidence and severity ofcassava mosaic disease and cassava root tuber yield

Year	Date	Whitefly t[a] count per plan	Incidence (%) 1 MAP[b]	3 MAP	Severity index (3 MAP)[c]	Disease severity of infected plant (3 MAP)	Root Tuber yield (t/ha)
1997	April	51.14	4.46	1.61	2.31	2.23	9.37
	June	4.41	14.62	1.28	2.36	2.33	6.43
	LSD (0.05)	14.819	4.846	0.210	NS	NS	2.052
1998	April	30.90	16.46	1.81	2.39	2.46	6.38
	June	3.13	10.46	1.46	2.43	2.36	6.89
	LSD (0.05)	2.214	2.752	0.083	NS	NS	NS

[a] Cumulative average whitefly count over 12 weeks.

[b] This determines the health status of planting material since most symptoms at this age is due to cutting-borne infection.

[c] Average severity score of healthy and infected plants (Njock *et al.*, 1996), which determines the impact of CMD in reducing root tuber yield.

MAPMonths after planting; NSNot significant

Table 3. Interaction between planting date and stem type on whitefly count, incidence and severity of cassava mosaic disease and root tuber yield

Year	Date	Stem type	Whitefly count per plant[a]	Incidence (%) 1 MAP[b]	Incidence (%) 3 MAP	Severity index (3 MAP)[c]	Disease severity of infected plant (3 MAP)	Root tuber yield (t/ha)
1997	April	PS+SS	47.98	5.65	52.28	1.69	2.31	9.63
		SS	54.30	3.27	39.36	1.54	2.31	9.11
	June	PS+SS	4.11	14.90	23.09	1.24	2.28	6.48
		SS	4.71	14.34	24.66	1.31	2.44	6.39
		LSD (0.05)	17.090	6.845	11.740	0.194	NS	2.010
1998	April	PS+SS	30.55	16.88	60.29	1.85	2.38	6.83
		SS	31.23	16.04	51.54	1.78	2.41	5.94
	June	PS+SS	3.30	11.14	40.44	1.48	2.43	7.09
		SS	2.95	7.78	43.44	1.45	2.44	6.69
		LSD (0.05)	6.532	5.678	13.520	0.216	NS	NS

Cumulative average whitefly count over 12 weeks.

This determines the health status of planting material since most symptoms at this age is due to cutting-bo infection.

Average severity score of healthy and infected plants (Njock *et al*., 1996), which determines the root tuber yield.

MAPMonths after planting; NSNot significant.

PS+SS=A mixture of equal number of primary and secondary stems

SS=Secondary stem

Table 4. Interaction between cassava genotype and stem type on root tuber yield

Year	Genotype	Stem type	Root tuber yield (t/ha)
1997	TMS 30572 (MR)	PS+SS	8.84
		SS	8.53
	NR 8083 (R)	PS+SS	7.26
		SS	6.98
		LSD (0.05)	NS
1998	TMS 30572 (MR)	PS+SS	8.03
		SS	7.38
	NR 8083 (R)	PS+SS	5.89
		SS	5.25
		LSD (0.05)	2.013

MR=Moderately resistant, R=Resistant, NS=Not Significant, PS+SS=A mixture of equal number of primary and secondary stems, SS=Secondary stem

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