Resistance to African Cassava Mosaic and Productivity of Improved Cassava Cultivars

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Abstract

Improved cassava cultivars TMS 30211 and TMS 30395 (with varying levels of resistance to African cassava mosaic) were evaluated for their productivity under varying levels of CMD incidence and stress and compared with a local susceptible cultivar.

Yield reductions due to clonal CMD-infection (plants established from CMD-infected cuttings) differed significantly among the three test cultivars, with the highest reductions in the susceptible unimproved cultivar. Yield reductions due to vector CMD-infection were consistently lower than those in plants established from CMD-infected cuttings. The lowest rate of increase of CMD incidence and severity on plants established from CMD-free cuttings was recorded for resistant cultivars TMS 30395.

The data indicate that one component of resistance to CMD is resistance to vector inoculation of the agent into the cassava plant. The implication of this finding and its importance in maximizing cassava productivity under African cassava mosaic disease stress is discussed.

Introduction

Breeding for resistance to cassava mosaic disease (CMD) began in 1935 when H.H. Storey made a world-wide search for cultivars of *Manihot esculenta* resistant to CMD. Although Storey identified cultivars with some degree of CMD resistance, he made interspecific and repeated backcrosses between *M. esculenta* and other (tree) *Manihot* species, viz. *M. glaziovii* Muell-Arg (ceara rubber) *M. dichotoma* Ule (Jaqui Manicoba Rubber), *M. catingea* Ule, *M. melanobasis* Muell-Arg and *M. saxicola* Lang, to produce higher levels of resistance than had been observed in *M. esculenta* (Jennings, 1976).

Storey observed that all the tree species were graft susceptible to CMD, but that they conferred to their progenies a form of field resistance in which plants tended to remain CMD-free or produce only mild and frequently transient symptoms (Jennings, 1976). Nichols (1947) concluded after repeated graft transmission tests that immunity to CMD did not exist in interspecific hybrids. This was confirmed by Jennings (1960) who suggested that varieties are described as resistant if they do not readily show disease

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symptoms when exposed to infection.

Jennings (1957, 1959) evaluated the Amani (Tanzania) cassava germplasm and made the following conclusions with respect to their value for resistance to CMD: (1) that some of the derivates of *M. glaziovii* provided the best combinations of yield, root quality and CMD resistance, (2) that although CMD resistance was satisfactory for inland areas in East Africa, it was frequently inadequate for coastal regions, (3) that the good resistance of some of the "tree" cassava selections was not successfully combined with good yield potential, (4) that *M. melanobasis* hybrids had a characteristic growth cycle which seemed to reduce the effectiveness of the mechanism of resistance to CMD although it enhanced their yield potential.

The major objective of the International Institute of Tropical Agriculture (IITA) cassava breeding program is to develop improved varieties with higher yield potentials and stable resistance to disease. The main source of CMD resistance utilized in this program is the cassava cultivar TMS 58308 which is a hybrid from an interspecific cross between *M. esculenta* and *M. glaziovii* introduced as true seed from the Amani germplasm into Nigeria in 1958 (Jennings, 1976) by M.J. Ekandem.

According to Hahn (1975), desirable agronomic characteristics have been obtained by using breeding material from Latin America. These contribute genetic factors which directly affect yield. The breeding method at IITA allows for intercrossing among large populations of improved plants, and so recessive CMD resistant forms like TMS 58308 segregate in each generation.

This article reviews data on the productivity and field behavior of improved (CMD-resistant) and unimproved (CMD-susceptible) cassava cultivars under different levels of CMD stress in the field.

In the absence of immunity to the African cassava mosaic, an attempt is also made to identify some desirable cultivar characteristics for minimizing cassava yield depression under CMD stress.

Materials and Methods

The test cultivars used for performance evaluation were:

1. Improved cultivar TMS 30395, which is a clone selected in 1973 from a cross between TMS 58308 and a local unimproved CMD-susceptible variety Isunikakiyan.
2. Improved cultivar TMS 30211 which is a clone selected in 1973 from 58308 open pollinated material.
3. Unimproved CMD susceptible local variety Isunikakiyan.

The experimental procedure was a comparison of sample means of selected yield components from randomly selected pairs of plants where each pair consisted of a plant established from a clonal CMD-infected cutting (CI) and either (a) a plant established from a CMD-free cutting (DF) of the same cultivar, or (b) a plant established from a CMD-free cutting but eventually became diseased through vector infection (VI).

The comparisons were made at 2, 5 and 7 month intervals after planting, and the differences in sample means of the selected yield components were tested for significance by the student's test.

Productivity was evaluated by measuring the following parameters: root fresh weight, root number, root size, top fresh weight and dry matter content.

Field behavior with respect to CMD stress was evaluated by measuring the rates of increase of CMD incidence and CMD severity on plants established from CMD-free cuttings.

Results

TMS 30211 produced a fresh root yield of 34.4 tons/ha at 7 months from VI and 14.5 tons/ha from CI plants (Table 1). The differences in yield components between DF and CI plants were highly significant at the 2 months harvest, except for the difference in root size which was significant. The differences between VI and CI plants at the 5 and 7 months harvest were also highly significant except for root size at 5 months (significant) and dry matter content at 7 months (non-significant) (Tables 2, 3, 4, 5 and 6). There was no definite trend in percentage reduction of yield components between the 2nd and 7th month of growth (Figures 1, 2, 3, 4 and 5).

The rate of increase in CMD incidence on TMS 30211 established from DF cuttings was high, reaching a peak of 100%, 5 months after planting. The incidence dropped to 3.7% at 9 months (Figure. 6). The rate of increase of CMD severity reached a peak of 4.0 (1–5 increasing severity scale) 2 months after planting and dropped to 2.0 at 9 months.

Isunikakiyan produced a fresh root yield of 14.3 tons/ha at 7 months from VI and 4.4 tons/ha from CI plants (Table 1). The differences in yield components between DF and CI plants were highly significant at the 2 months harvest, except for the differences in fresh root yield and top fresh weight which were significant. The differences between VI and CI plants at the 5 and 7 months harvest were also highly significant, except for fresh root yield, root size, and top fresh weight at 5 months, and dry matter content at 7 months, which were all significant (Tables 2, 3, 4, 5 and 6). There was a slight tendency towards a smaller yield loss between the 2nd and 7th month of growth (Figures 1, 2, 3, 4 and 5).

The rate of increase in CMD incidence on Isunikakiyan established from CMD-free cuttings was high, reaching a peak of 98.4% at 2 months and 99% at 5 months after planting. This incidence dropped to 16% at 9 months (Fig. 6). The rate of increase of CMD severity reached a peak of 4.0 at 3 months and dropped to 2.0 at 9 months.

TMS 30395 produced a fresh root yield of 29.6 tons/ha at 7 months from DF and 20.7 tons/ha from CI plants (Table 1). The differences in the yield components were all highly significant at the 2 months harvest and decreased progressively during the growth cycle (Tables 2, 3, 4, 5 and 6). The yield loss due to clonal CMD-infection also decreased significantly between the 2nd and 7th month of growth (Figures 1, 2, 3, 4 and 5).

The rate of increase in CMD incidence on TMS 30395 established from DF cuttings was extremely low, reaching a peak of 17.4% at 5 months after planting. The incidence dropped to zero at 7 months (Fig. 6). The rate of increase of CMD severity reached a peak of 3.7 at 2 months and dropped rapidly to 1.0 (symptomless) at 7 months.

Conclusions

Cultivar 30211 is clearly superior to the other 2 test cultivars in yield potential for fresh and dry root yields, total root number and top fresh weight when harvest is taken from either DF or VI plants. However, yield depressions due to CI were consistently higher than those for TMS 30395, especially at the 5th and 7th months of harvest.

Yield depressions due to CI or VI in Isunikakiyan were consistently higher than those for TMS 30395 and invariably higher than those for TMS 30211 during their growth periods.

The productivity of VI TMS 30211 and Isunikakiyan was significantly higher than those of CI plants of the same cultivars except for dry matter content of TMS 30211 at 7 months. This indicates that yield production in plants of these cultivars established from CMD-free cuttings but eventually become infected by vector inoculation is much lower compared to that resulting in plants established from clonal CMD-infected cuttings. It is, however, important to note that material that is VI in the first year represent CI planting material in successive years.

The differences between the productivity of CI and DF TMS 30395 decreased more rapidly between the 2nd and 7th month of plant growth than those of TMS 30211 and Isunikakiyan, indicating an inherent capacity in TMS 30395 for rapid compensation under CMD stress (Terry, unpublished).

The lower rates of increase in CMD incidence and severity recorded for CMD-free TMS 30395 compared with those for TMS 30211 and Isunikakiyan under apparently equal levels of activity of the CMD vector *Bemisia tabaci* indicate a higher level of resistance in TMS 30395 to vector inoculation of the CMD agent under field conditions.

One component of resistance to CMD appears, therefore, to be resistance by certain cultivars to vector transmission of the CMD agent. The value of this type of resistance as exemplified by TMS 30395 is the resulting low field CMD incidence and the possibility of maintaining a CMD-free crop by rogueing out the small number of plants with disease.

The foregoing data indicate that some cassava cultivars like TMS 30395 provide the best combination of high productivity, stable performance and high levels of resistance to vector CMD-infection under CMD stress. Furthermore, cultivars like TMS 30211 appear to have the capacity for higher productivity only when grown CMD-free.

The recommendation that yield depressions can be minimized under CMD stress by growing CMD-free cassava should, therefore, be modified in light of the evidence that large differences exist in the level of resistance to vector CMD-infection among cassava cultivars.

The drastic drop in CMD incidence and severity in all three test cultivars after 7 months' growth indicates the existence of a recovery phase during the period of drought-induced cessation of growth. This recovery phase appears to extend into the onset of the second growth cycle and is even more marked during periods of high ambient temperatures. The phenomenon may be associated with heat masking or suppression of CMD which has been observed in cassava exposed to high temperatures (Terry, unpublished) and deserves further investigation. The data indicate that TMS 30395 has a stronger capacity for recovery than TMS 30211 and Isunikakiyan since after 7 months' growth, CMD incidence for TMS 30395 dropped to zero, compared with 3.7% for TMS 30211 and 16.0% for Isunikakiyan.

The following cultivar characteristics appear, therefore, to be desirable for minimizing yield depressions and optimizing productivity in cassava under CMD stress: (1) the capacity to minimize yield depressions due to clonal and vector CMD infection, (2) the capacity to compensate rapidly for depression of yield sustained at early growth stages due to clonal CMD-infection, and (3) the capacity to minimize the level of field CMD incidence due to vector transmission of the CMD agent.

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Table 1. Fresh and dry root yields (tons/ha) of cassava harvest under varying levels of CMD stress at 7 months harvest.

	Fresh Yield		Dry Yield	
Cultivar	DF	CI	DF	CI
30395	29.6	20.2	11.7	7.4
30211 [(1)]	34.4	14.5	11.0	4.8
ISUNI [(1)]	14.3	4.4	5.3	1.3

[(1)] Yield from vector CMD-infected plants.

Table 2. Effect of CMD on fresh root yield (kg.) IITA, Ibadan, 1978

Cultivar	2 Months			5 Months			7 Months		
	Diff	SE	% Reduction	Diff	SE	% Reduction	Diff	SE	% Reduction
30395	0.058**	±0.001	77.1	0.57**	±0.022	42.0	0.94**	±0.073	31.7
30211	0.067**	±0.002	66.1	1.21**(1)	±0.038	67.0	1.99**(1)	±0.051	57.8
ISUNI	0.040*	±0.003	93.2	0.21* (1)	±0.019	58.0	0.99**(1)	±0.029	69.2

** significant at P = 0.01
* significant at P = 0.05
(1) difference between vector CMD–infected and clonal CMD–infected plants

Table 3. Effect of CMD on root number. IITA, Ibadan, 1978

Cultivar	2 Months			5 Months			7 Months		
	Diff	SE	% Reduction	Diff	SE	% Reduction	Diff	SE	% Reduction
30395	2.2**	±0.097	55.0	3.1**	±0.183	33.0	1.9*	±0.156	13.0
30211	2.1**	±0.090	48.8	6.2**(1)	±0.190	54.0	3.5**(1)	±0.123	35.0
ISUNI	3.0**	±0.222	90.0	2.5**(1)	±0.178	53.0	2.5**(1)	±0.116	47.1

** significant at P = 0.01
* significant at P = 0.05
(1) difference between vector CMD–infected and clonal CMD-infected plants

Table 4. Effect of CMD on root size (kg.) IITA, Ibadan, 1978

	2 Months			5 Months			7 Months		
Cultivar	Diff	SE	% Reduction	Diff	SE	% Reduction	Diff	SE	% Reduction
30395	0.01**	±0.0007	66.6	–0.001	±0.002	–	0.03	±0.009	7.5
30211	0.01*	±0.0008	41.0	0.052*(1)	±0.005	31.4	0.11**(1)	±0.005	33.3
ISUNI	0.008**	±0.0003	88.6	0.03*	±0.003	46.1	0.14**(1)	±0.004	55.1

** significant at $P = 0.01$
* significant at $P = 0.05$
(1) difference between vector CMD-infected and clonal CMD-infected plants

Table 5. Effect of CMD on top fresh weight yield (kg.) IITA, Ibadan, 1978

	2 Months			5 Months			7 Months		
Cultivar	Diff	SE	% Reduction	Diff	SE	% Reduction	Diff	SE	% Reduction
30395	0.10**	±0.004	33.4	0.30	±0.38	17.0	0.78*	±0.068	29.3
30211	0.09**	±0.005	36.0	0.90**(1)	±0.046	50.0	1.85**(1)	±0.064	57.9
ISUNI	0.09*	±0.011	52.0	0.20* (1)	±0.022	28.0	0.94**(1)	±0.040	52.5

** significant at $P = 0.01$
* significant at $P = 0.05$
(1) difference between vector CMD-infected and clonal CMD-infected plants

Table 6. Effect of CMD on dry matter percentage. IITA, Ibadan, 1978

	2 Months			5 Months			7 Months		
Cultivar	Diff	SE	% Reduction	Diff	SE	% Reduction	Diff	SE	% Reduction
30395	11.0**	±0.404	55.0	2.6*	±0.230	7.0	2.9**	±0.181	7.3
30211	5.0**	±0.241	31.0	4.9**(1)	±0.290	15.0	–1.4(1)	±0.196	–4.1
ISUNI	7.9**	±0.122	74.0	10.7**(1)	±0.615	36.0	8.0*(1)	±0.803	21.0

** significant at P = 0.01
* significant at P = 0.05
(1) difference between vector CMD-infected and clonal CMD-infected plants

Figure 1. Fresh Root Yield Reduction Due To CMD

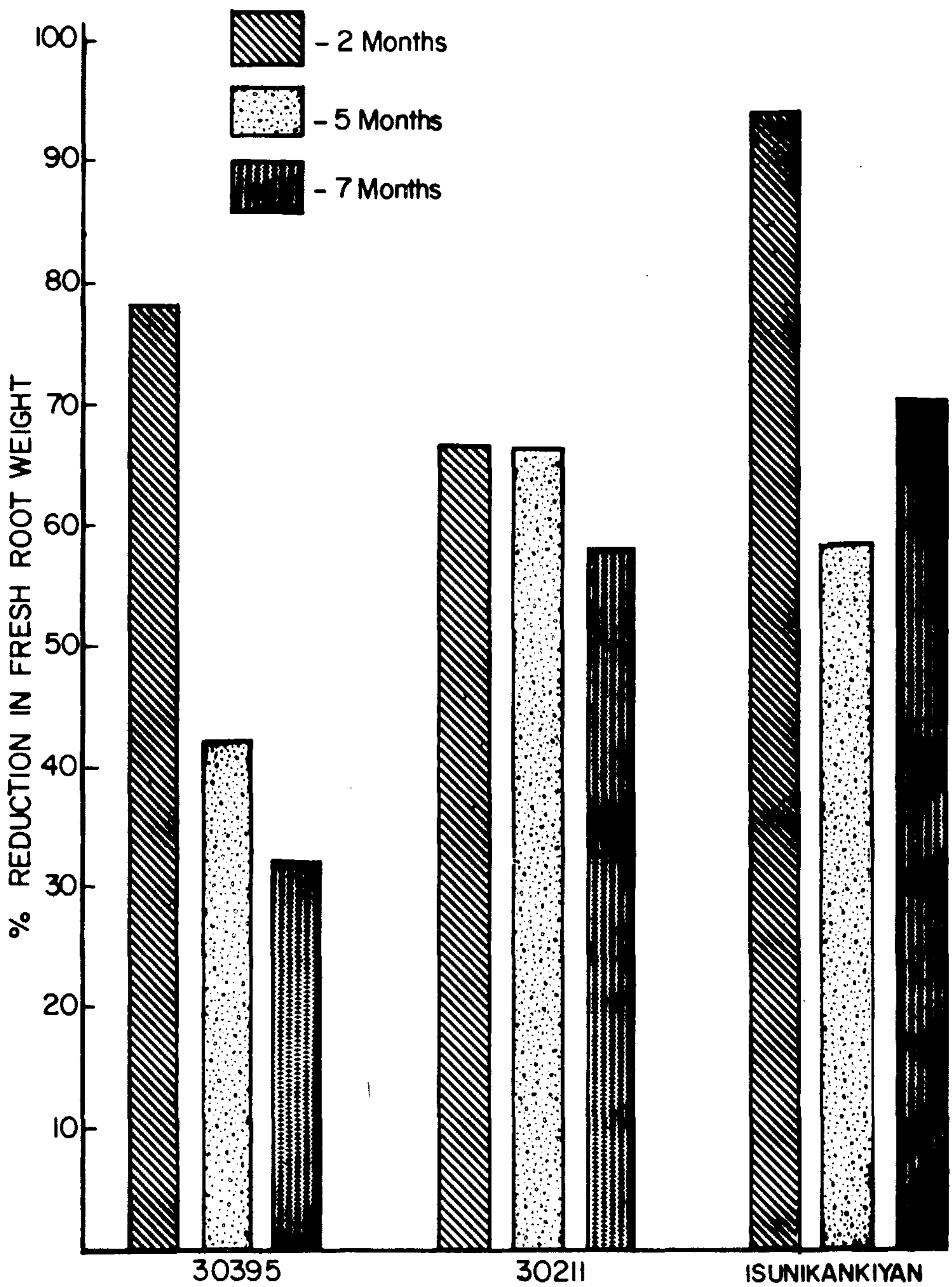

Figure 2. Root Number Reduction Due to CMD

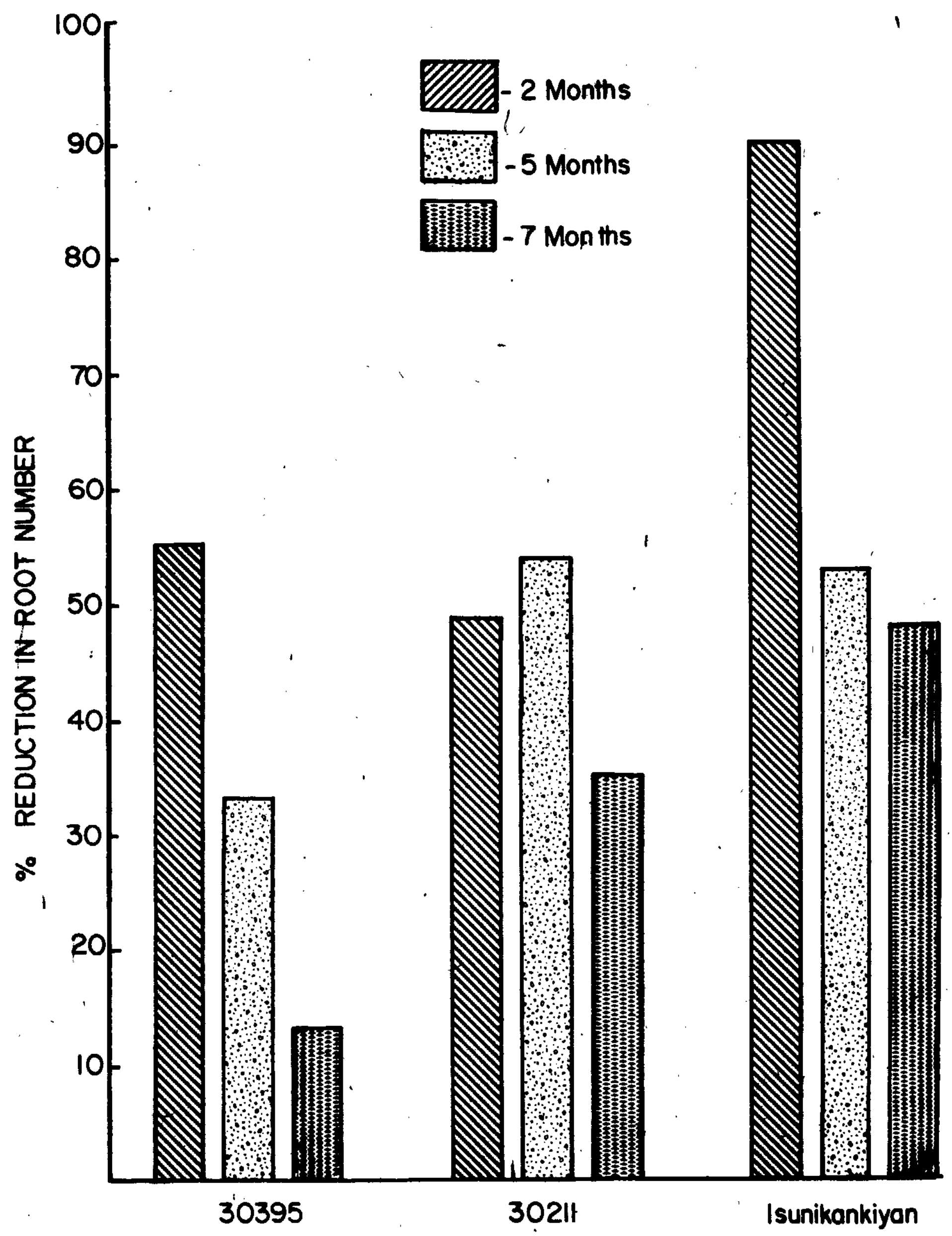

Figure 3. Root Size Reduction Due To CMD

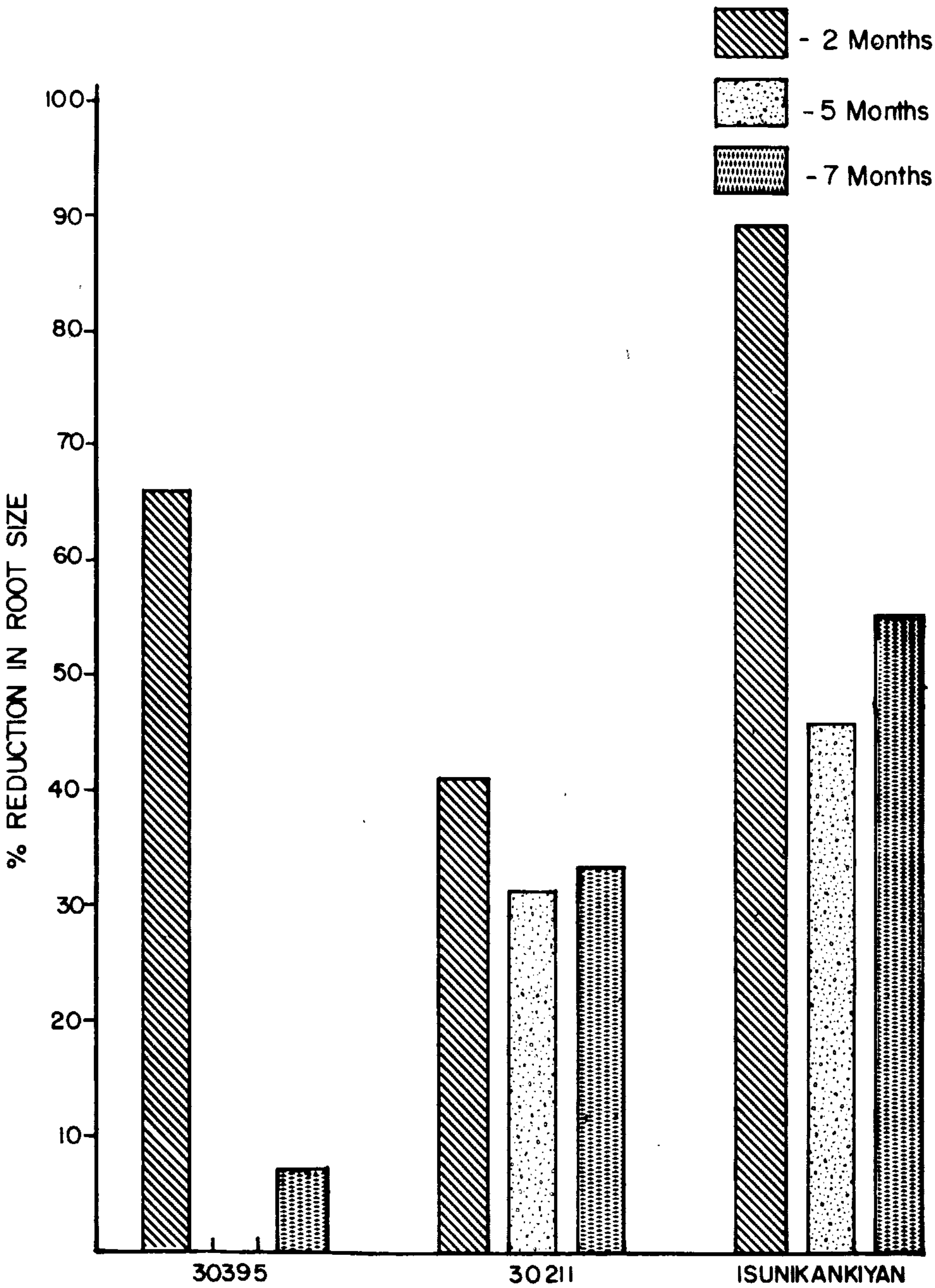

Figure 4. Top Fresh Weight Reduction Due To CMD

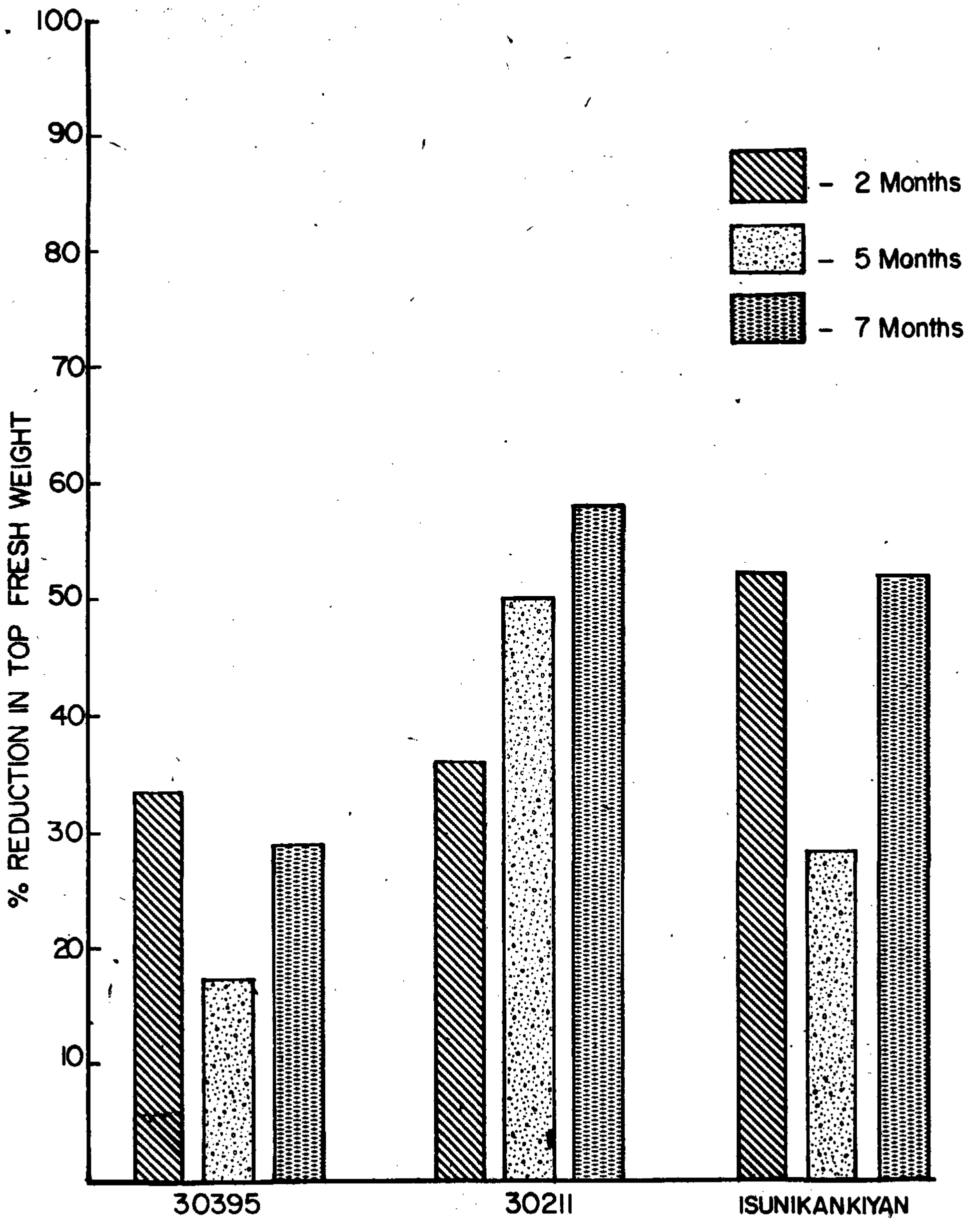

Figure 5. Dry Matter Percentage Reduction Due To CMD

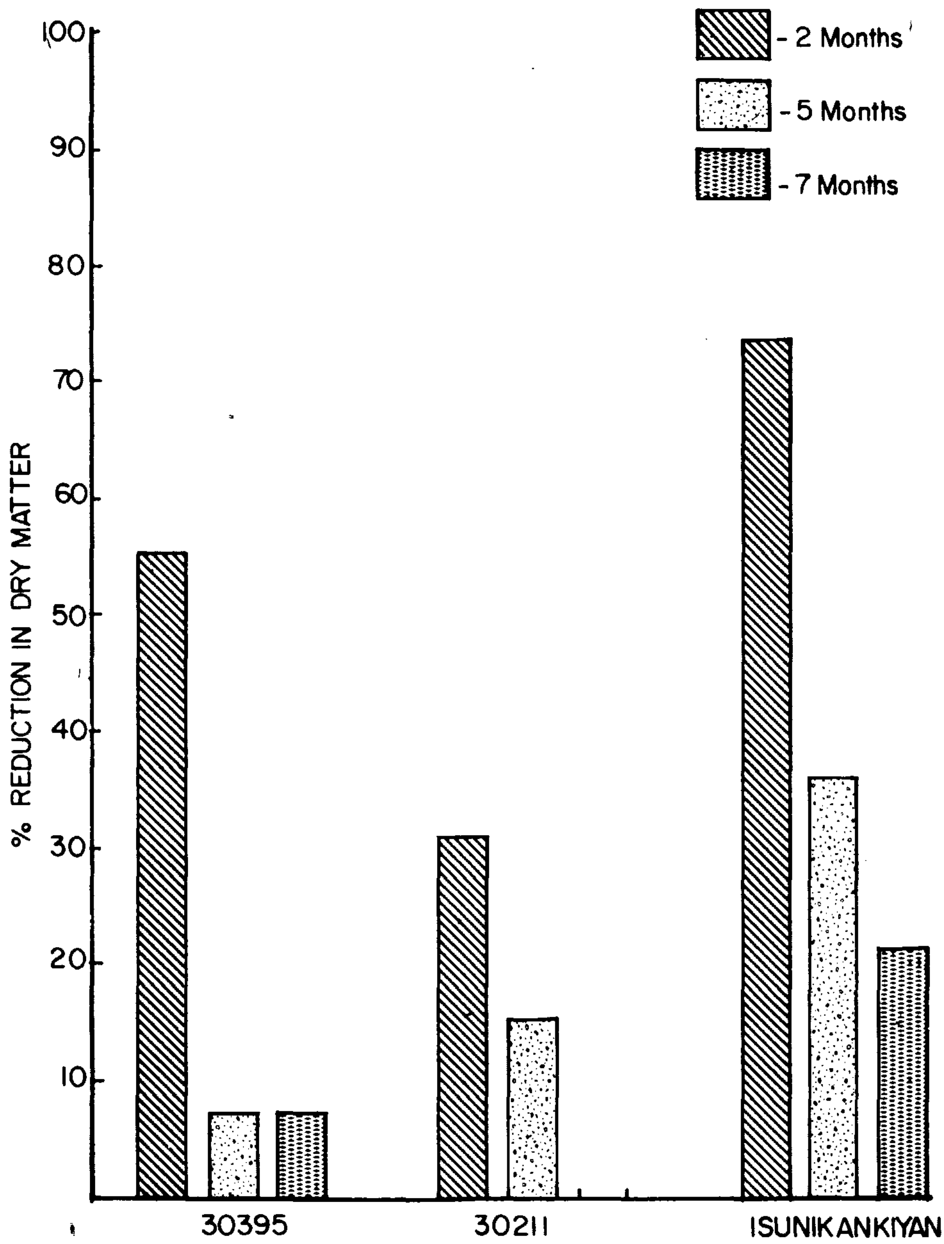

Figure 6. Rate of increase of CMD Incidence