Incidence and severity of African cassava mosaic disease (ACMD) and cassava bacterial blight (CBB) on some local and exotic cassava varieties in different ecological zones of Ghana

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SUMMARY

Seven exotic varieties of cassava, namely TMS 30001, TMS 91934, TMS 4(2)1425, TMS 30555, TMS 50395, TMS 63397, and TMS 30572 developed in IITA, Ibadan, Nigeria, and three local varieties, namely 'Ankra', 'Bosomensia' and 'Katawia' were evaluated for African cassava mosaic disease (ACMD) and cassava bacterial blight (CBB) resistance in five ecological zones of Ghana. The trials were conducted in experimental fields of Crops Research Institute at Fumesua (Forest zone) in 1988, 1989, 1990; Aiyinase (High Rain Forest zone), Pokuase and Ohawu (Coastal Savanna zone), and Ejura (Forest-Savanna Transition zone) in 1989 and 1990; Techiman (Forest-Savanna Transition zone); and Nyankpala and Damongo (Guinea Savanna zone) in 1990. ACMD and CBB damage at 3 and 6 months after planting were scored on a 1-5 scale based on the severity of the diseases. The exotic varieties were significantly more tolerant to ACMD across the 3 years at Fumesua as well as in 1989 and 1990 across all locations. For CBB in 1990, the exotic varieties were significantly more tolerant than the local varieties in the Coastal Savanna zone where CBB incidence and severity was relatively high.

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RÉSUMÉ

LAMPTEY, J. N. L., OKOLI, O. O. & FRIMPONG-MANSO, P. P.: *L' incidence et la sévérité de la maladie mosaïque du manioc africain (MMMA) et de la rouille bactérienne du manioc (RBM) sur quelques variétés de manioc exotique dans les zones écologiques différentes du Ghana.* Sept variétés exotique de manioc à savoir TMS 30001, TMS 91934, TMS 4(2) 1425, TMS 30555, TMS 50395, TMS 63397 et TMS 30572 développées en IITA, Ibadan, Nigéria et trois variétés locales à savoir 'Ankra', 'Bosomensia' et 'Katawia' étaient évaluées pour la résistance à la maladie mosaïque du manioc africain (MMMA) et la rouille bactérienne du manioc (RBM) dans cinq zones écologiques du Ghana. Les essais étaient menés dans les champs expérimentaux de L' Institut de Recherche en Cultures (Zone forestiére) en 1988, 1989, 1990; Aiyinase (Zone de haute forêt humide), Pokuase et Ohawu (Zone de savane littorale), Ejura (Zone de transition forêt-savane) en 1989 et 1990; Techiman (Zone de transition forêt-savane); et Nyankpala et Damongo (Zone de savane guinéenne) en 1990. Les dégâts de MMMA et RBM à 3 et 6 mois après la plantation étaient marqués sur une échelle de 1-5 basée sur la sévérité des maladies. Les variétés exotiques étaient considérablement plus tolérantes à MMMA à travers les 3 années à Fumesua ainsi qu' en 1989 et 1990 à travers tous les emplacements. Pour RBM en 1990 les variétés exotiques étaient considérablement plus tolérantes que les variétés locals dans la Zone de savane littorale où l' incidence et la sévérité de RBM étaient relativement élevées.

Introduction

Cassava provides more than 50 per cent of the calorific requirements for 200 million Africans and yet yields are low in Africa; about 6.1 tons/ha in 12 months compared with potential yields of more than 30-51 tons/ha (Hahn, Isoba & Ikotun, 1989). Cassava contributed 19 per cent of the agricultural Gross Domestic Product, excluding forestry, evaluated at 1987 constant prices in Ghana (MTADP, 1991).

The major biological constraints to cassava production in Ghana are diseases and pests. Two important diseases which limit the yield of cassava in the country are the African cassava mosaic disease (ACMD) caused by the African cassava mosaic virus (ACMV), a geminivirus, and cassava bacterial blight (CBB) caused by a bacterium *Xanthomonas campestris* pv *manihotis*. ACMV is transmitted by the whitefly *Bemisia tabaci*, Gennadius (Storey & Nichols, 1938) under natural field conditions principally by means of infected planting materials (Caveness *et al.*, 1985). ACMD was first observed near Accra in 1926 (Doku, 1966) and its spread was more significant in the coastal areas of the country around 1930 (Leather, 1959; Clerk, 1974). At present, the disease is widespread and is found in all the ecological zones in Ghana. CBB was first observed in the country in 1975 in Amasaman/Pokuase areas of the Greater Accra Region, and was later observed in certain parts of Greater Accra, Volta, Eastern, and Central Regions of Ghana (Korang-Amoako, 1977).

In Ghana, Nigeria, and other areas of West Africa, the disease spread through the introduction of new varieties developed since 1955 (Persley, 1977). Field surveys conducted in 1975 and 1976 showed that the disease was at epidemic levels (Korang-Amoako & Oduro, 1978). Currently, the disease is confined to the coastal savanna and high rain zones.

Although in Ghana, yield losses due to ACMD and CBB have not been quantifield, the importance of these diseases are indicated by the chlorosis and distortion of leaves and stunting of plants due to ACMD infection, and also by the blighting and wilting of leaves and stem die-back due to CBB infection. Studies of indvidual cassava varieties elsewhere have indicated losses due to ACMV ranging from 20 to 95 per cent (Beck & Chant, 1958; Fargette, Fouquet & Thouvenel, 1988; Hahn, Isoba & Ikotun, 1989; Otim-Nape, Shaw and Thresh, 1994; Terry & Hahn, 1980). For CBB, losses of over 50 to 70 per cent have been reported on cassava (Ezeilo, 1977; Ohunyon & Ogio-Okirika, 1978). Because of the limitations in the use of chemicals to control pests and diseases in Africa, the development of cultivars tolerant to diseases and pests becomes the most appropriate and realistic approach for effective control (Hahn *et al.*, 1980).

The objective of this study was, therefore, to compare the performances of some improved clones of cassava introduced from IITA with local varieties in the various ecological zones regarding their resistance or tolerance to ACMD and CBB. This is one of the principal objectives of the cassava improvement programme under the National Root and Tuber Crops Improvement Project. It is an important criterion used in selecting varieties for adoption in the different ecological zones where cassava is grown.

Materials and methods

Seven cassava varieties, TMS 30001, TMS 91934, TMS 4 (2)1425, TMS 30555, TMS 50395, TMS 63397, and TMS 30572 were brought in from IITA in Ibadan, Nigeria. They were evaluated together with some local varieties, namely 'Ankra', 'Bosomensia' and 'Katawia', for resistance to CBB and ACMD. These IITA varieties were selected, among other important traits, for their high-yielding potential and resistance to important diseases like ACMD and CBB.

The first experiment was set up in June 1988 on the experimental fields of Crops Research Institute at Fumesua near Kumasi. The design was a randomized complete block with four replications. Plot size was 40 m^2 with 40 plants spaced 1 m by

1 m in four rows each 10 m long. In 1989 and 1990, the trial using the 10 varieties tested at Fumesua in 1988 was conducted at five sites in four ecological zones: Aiyinase (High Rain Forest), Fumesua (Forest), Ejura (Forest/Savanna Transition), Pokuase and Ohawu (Coastal Savanna; and at three other locations, namely Techiman (Forest/Savanna Transition), Nyankpala, and Damongo (Guinea Savanna) in 1990.

ACMD and CBB damage for each plant at 3 and 6 months after planting were scored based on a 1-5 scale developed at IITA (IITA, 1990).

Table 1 shows the disease ranking and the corresponding symptom expression for ACMD. Table 2 shows the disease ranking and the corresponding symptom expression for CBB.

Two middle rows of 20 plants per each plot were evaluated for ACMD and CBB tolerance. Records were taken for both ACMD and CBB infection from the same plants. Generally, plants that scored between 1 and 3 were classified as being tolerant to either ACMD or CBB.

To compare the performances of the local varieties for ACMD tolerance at Fumesua and across locations, as well as CBB tolerance across locations, a non-parametric analysis was applied according to tests proposed by Friedman (1937) which involved ranking of treatments.

To establish the identity of CBB in locations where the disease was observed, samples of infected leaves and stem pieces of different cultivars were sent to the laboratory at the Biological Sciences Department, Kwame Nkrumah University of Science and Technology (KNUST) for the isolation of the causal agent in pure culture.

For the isolation of *Xanthomonas manihotis*, the bacterium which causes CBB, the method used was that described by Terry (1977). Nutrient Agar (Difco) was used as an isolation medium, First, a small portion of leaf was cut and transferred aseptically to a drop of sterile distilled water in a Petri dish and macerated. The macerate was allowed to stand for a few minutes and a few loopfuls streaked over the surface of dried agar plates and incubated at 30 °C. For the stem pieces showing bacterial exudate, a portion was surface-sterilized by dipping in ethyl alcohol and flaming. A small internal portion showing brown dicolouration was transferred aseptically to a drop of sterile distilled water where it was macerated and allowed to stand for a few minutes. A few loopfuls were then streaked onto dried agar plates and incubated at 30 °C.

After 2 days' growth, the presence of the pathogen was determined according to the gram-staining method (Bradbury, 1970). Pathogenicity test was then performed using the spray inoculation method where a bacterial suspension in sterile distilled water was sprayed on cassava leaves of young plants. The plants were kept at 100 per cent relative humidity for 48 h and then placed in the greenhouse at 25 °C.

TABLE 1

Sympton Expression for Ranking ACMD

Ranking	*Symptom*
1	No symptom observed
2	Mild chlorotic pattern on entire leaflets
3	Strong mosaic pattern on entire leaf narrowing and distortion of lower one-third of leaflets
4	Severe mosaic, distortion of two-thirds of leaflets, and general reduction of leaf size
5	Severe mosaic, distortion of four-fifths or more of leaflets, twisted and misshapen of leaves.

ACMD: African Cassava Mosaic Disease.

TABLE 2

Sympton Expression for Ranking CBB

Ranking	*Symptom*
1	No symptom observed
2	Only angular leaf spotting
3	Extensive leaf blight, leaf wilt and defoliation, and gum exudation on stems and petioles
4	Extensive leaf blight, wilt, defoliation, and stem die-back
5	Complete defoliation and stem die-back; stunting and die-back of lateral shoots.

CBB: Cassava Bacterial Blight

For the virus disease (ACMD), however, it was not found necessary to isolate the causal pathogen, because the ACMV is known to represent a geminivirus (Bock, Guthrie & Meridith, 1978; Harrison, 1985). Again, work done earlier and also recently confirmed by Swanson & Harrison (1994) indicate that cassava mosaic disease in Africa and the Indian sub-continent is caused by three distinct geminiviruses, ACMV, East African cassava mosaic virus (EACMV), and Indian cassava mosaic virus (ICMV) which have different geographical distributions, but all transmissible by the whitefly *Bemisia tabaci*. ACMV occurs in Africa and is limited to the western and southern parts of Africa.

Results

Fig. 1 shows the mean ACMD scores for the 10 varieties of cassava at Fumesua in 1988, 1989, and 1990 as well as the means for each variety over the 3 years. The value of the test criterion at 5 per cent level of significance using Friedman's procedure indicated that the exotic varieties were significantly better than the local varieties for ACMD severity, and thus for mosaic tolerance.

In 1989 (Fig. 2) at Aiyinase, Pokuase and Ohawu, the exotic varieties were more tolerant to the mosaic disease than the local varieties at $P=0.05$. However, at Ejura, except for TMS 30001 and TMS 91934, the exotic varieties were no better than the local varieties in mosaic tolerance. The across location means for all the varieties, however, showed that the exotic varieties generally had lower ACMD severity scores than the local varieties. In 1990, at all the eight locations, namely Aiyinase, Pokuase, Ohawu, Fumesua, Ejura, Techiman, Damongo and Nyankpala, each of the exotic varieties was significantly ($P=0.05$) more tolerant to the mosaic disease than the local varieties. The across location means for all cultivars again showed the superiority of the exotic varieties in ACMD tolerance (Fig. 3).

The incidence of CBB was lacking at Fumesua from 1988 to 1990. The incidence of the disease at

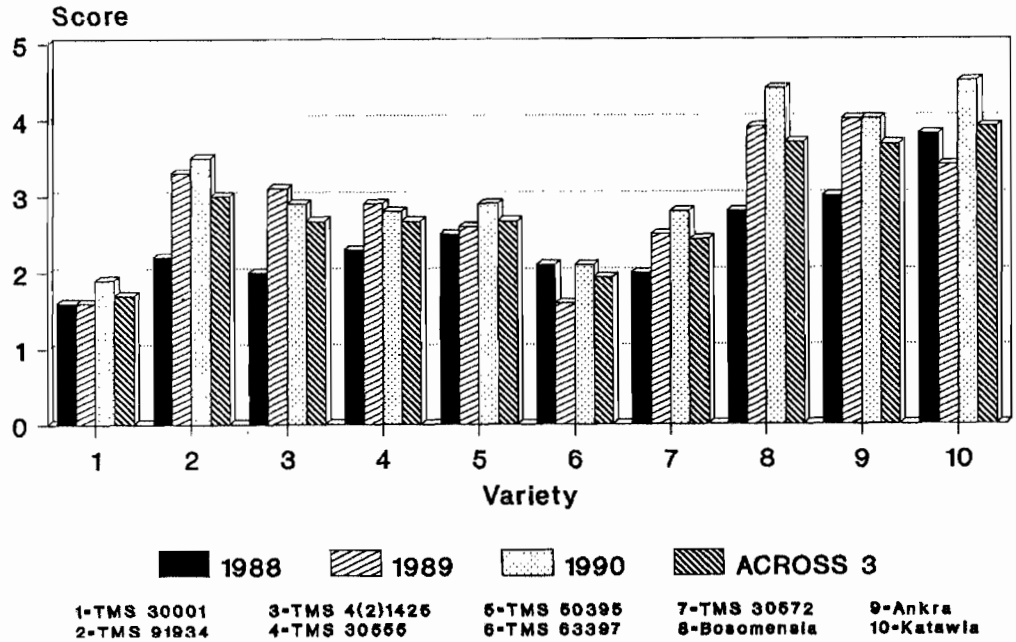

Fig. 1. Mean scores of cassava varieties for ACMD at Fumesua over a 3-year period.

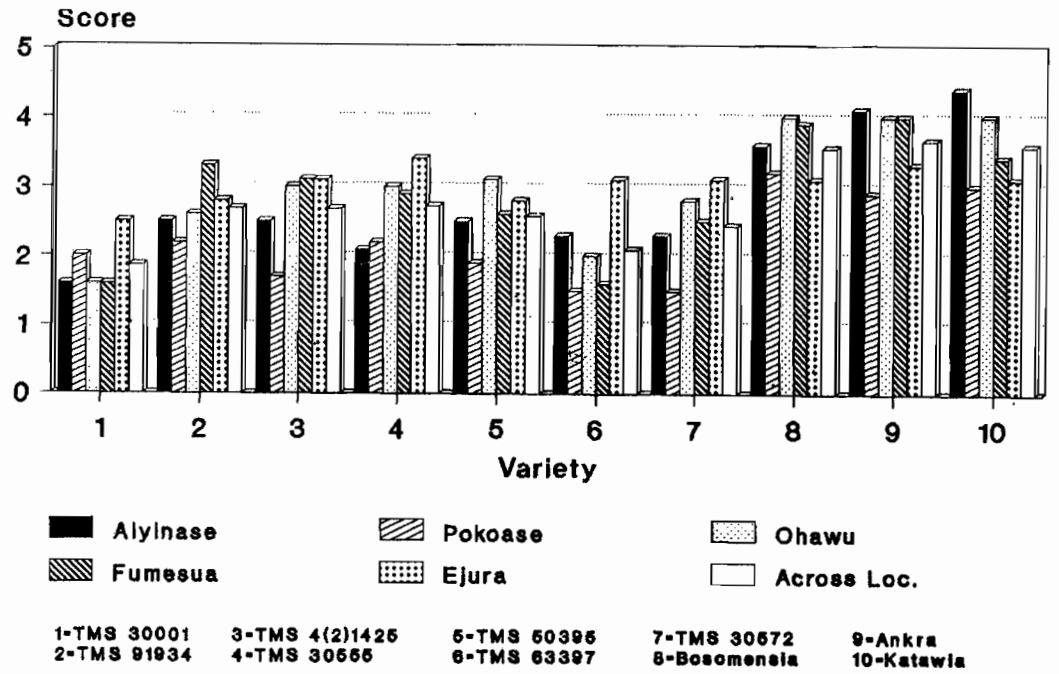

Fig. 2. Mean scores of cassava varieties for ACMD in 1989 at each of five locations and across the five locations.

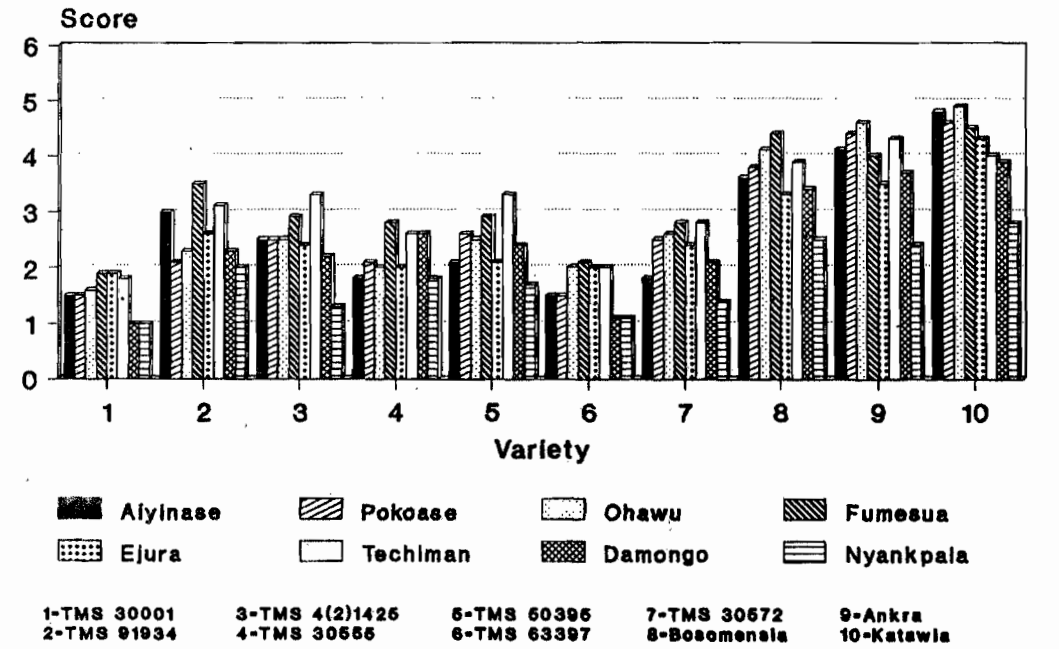

Fig. 3. Mean scores of cassava varieties for ACMD in 1990 at each of eight locations and across the eight locations.

five locations in 1989 was also very minimal. However, in 1990, an appreciable level of incidence was recorded at five locations (Fig. 4), the important locations being Ohawu in the Coastal Savanna zone and Damongo in the Guinea savanna zone. At Ohawu, each of the exotic varieties was significantly (P=0.05) more tolerant to CBB than the local varieties. Across location later and after 2 weeks, and leaf spots enlarged and coalesced resulting in a blight. Stem die-back was observed about 1 month after inoculation.

Discussion

The tolerance of exotic or improved varieties to ACMD across locations from 1989 to 1990 was quite stable, unlike the local varieties where

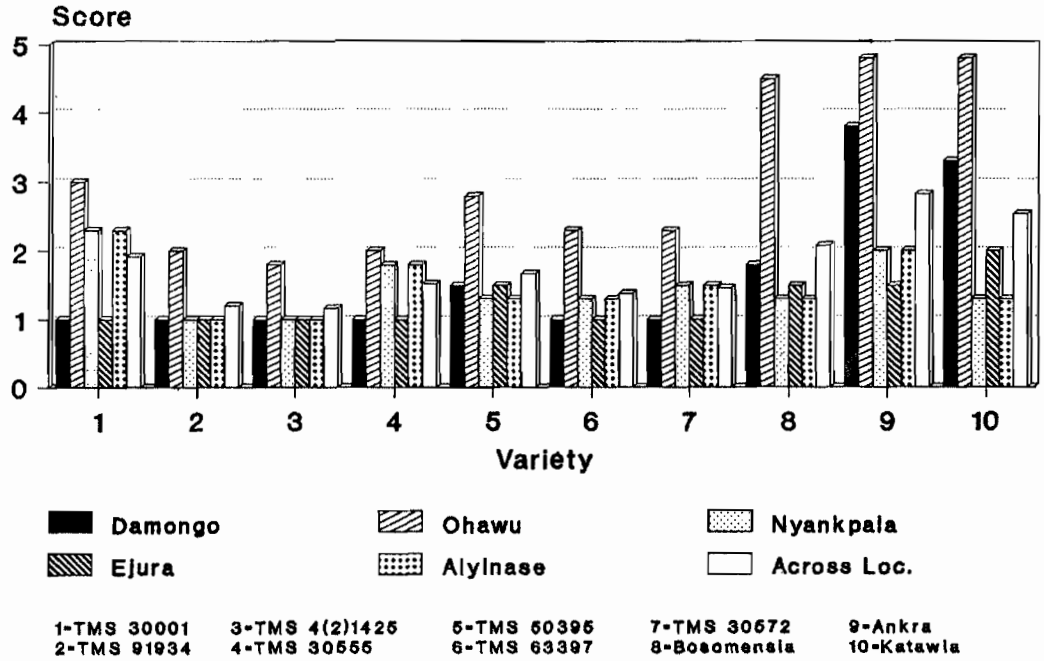

Fig. 4. Mean scores of cassava varieties for CBB in 1990 at each of five locations and across the five locations.

means for all the varieties also showed the superiority of the exotic over the local varieties.

For CBB isolation, using diseased leaves and stem pieces, the pathogen, *X. manihotis,* after 2 days' growth on the media, formed greyish-white circular colonies with a smooth, shiny surface. The characteristic features of *X. manihotis* such as its being gram-negative, straight rod, and motile with single polar flagellum were identified. In the pathogenicity test, leaves sprayed with bacterial suspension showed water-soaked angular spots 5 days after inoculation. Exudates appeared 3 days

disease severity increased with time. This observation compares favourably with that made by Hahn *et al.* (1980) that resistant breeding materials developed at IITA and tested during 1973-78 in West, Central, and East Africa were effectively resistant to ACMD and also proved durable over time and distance.

In 1990, where the tolerance of the exotic and local varieties to ACMD was evaluated at eight locations, virus severity was higher for both exotic and local varieties at Fumesua and Techiman located in the Forest zone where humidity is

normally high and cassava is widely cultivated. In the same year, ACMD was more severe on the local varieties at Ohawu located in the Coastal Savanna zone where cassava is also widely cultivated. ACMD severity was, however, very low at Nyankpala and Damongo located in the Guinea Savanna zone where humidity is normally low and cassava has low density. This confirms an observation made by Alaux & Claude (1987) that in each producer country, mosaic severity is related to the density of the cassava population and to the climatic characteristic, and that the most humid regions seem to be the most affected.

CBB severity was very high especially in the local varieties at Ohawu in the Coastal Savanna zone, one of the areas where the occurrence of CBB was first noted in Ghana. The exotic varieties were tolerant to CBB across locations . The tolerance of some IITA improved varieties to CBB has been confirmed by stem puncture, leaf clipping, and leaf spray inoculation tests (Perreaux, Terry & Persley, 1978), and is well correlated with the results of natural infection (IITA, 1977).

Generally, severity scores of ACMD for local and exotic varieties correlated positively with those of CBB, that is, those which had low or high ACMD scores respectively had low or high CBB scores and vice versa (Fig. 2 and 4). This compares favourably with an observation made by Hahn *et al.* (1980) where the resistance of cassava was correlated to ACMD and CBB.

Conclusion

Based on the results of the 1988-90 trials at Fumesua and 1989-90 trials at the other ecological zones, it could be inferred that the exotic varieties were more tolerant to African cassava mosaic disease and cassava bacterial blight than the local varieties. Since most of these exotic varieties have also proved to be high yielding in trials conducted across locations in the major ecological zones (Okoli *et al*, 1991), their adoption will greatly enhance cassava productivity in Ghana. This may improve the economy, especially where cassava is now an important export crop in the area of chip production.

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