



**TRANSMISSION EFFICIENCY OF CASSAVA MOSAIC VIRUS BY THE
WHITEFLY (*Bemisia tabaci*): AN EVALUATION OF INDIGENOUS CASSAVA VARIETIES
(*Manihot esculenta* Cranz) IN KEBBI STATE, NIGERIA**

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ABSTRACTS

An experiment was conducted in the Plastic House of Abdullahi Fodiyo University of Science and Technology, Aliero, to assess the virus transmission efficiency of whiteflies on the major cassava varieties grown in Kebbi State, Nigeria. The treatments consisted of 13 cassava varieties: *Bakin Rogo*, *Dan Ajafa*, *Jan Rogo*, *Dan Sangelu*, *Dan Yola*, *Sarkin Fawa*, *Dan Bashalma*, *Dan Kalaba*, *Dan Gwamnati*, *Bahaushe*, *Mai Jan Kareri*, *Bakin Icece*, and TMS 0505 as the control. The treatments were laid out in a Completely Randomized Design (CRD) replicated three times. Data were collected on the incidence and severity of cassava mosaic disease. The collected data were subjected to Analysis of Variance (ANOVA), and means were separated using the Least Significant Difference (LSD) test at a 5% ($P < 0.05$) probability level. The results revealed a significant difference in disease incidence and severity among all the varieties at the $P < 0.05$ level. The *Jan Rogo* (100%) and *Dan Ajafa* (90%) varieties recorded the highest disease incidence, while the lowest incidence was recorded for TMS 0505 (0.0%). The opposite trend was observed for disease severity. The *Sarkin Fawa* variety (4.00) recorded the highest severity, followed by *Bahaushe* (3.80), and then TMS 0505 (1.20), which was the control. The research concludes that the *Jan Rogo* and *Sarkin Fawa* varieties were the most susceptible among the cassava varieties used by farmers in Kebbi State. It was recommended that farmers use the *Dan Gwamnati* variety, which showed certain degree of resistance.

Keywords: Cassava, CMD, Susceptibility, Transmission, Whitefly

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is an essential food crop that has become well established in sub-saharan Africa, where it plays a significant role in food security and economic generation (Roger, 2014). Cassava as a food crop originates from western and southern Mexico and South America, particularly Brazil (Hastings, 2016), the crop is now the third most important source of dietary calories in the tropics after rice and maize (FSN, 2014). Its processed products are rich in carbohydrates (mainly starch) and minerals that contributes significantly to daily nutritional needs (Westby, 2008). Globally, cassava is the most widely cultivated root crop (Mulenga *et al.*, 2015) and most importance in sub-Saharan Africa, where it serves as a staple food crop for millions of people (Mwatuni *et al.*, 2015). Africa contributes approximately 64.7% of the world's cassava production of 314.8 million tons/year (FAOSTAT, 2022). In West Africa, cassava production is estimated at 96.2 million tons/year and contributes to 33% of African production (FAOSTAT, 2022). In Nigeria, cassava is a cornerstone of household livelihoods, with more than 40 varieties under cultivation (FAO, 2013). Cassava is a versatile crop that can be processed into different dishes and can serve as livestock feed (FAO, 2013). Cassava is also a source of raw materials in industries including production of biofuels (Campo *et al.*, 2011). Cassava can grow and thrive very well in marginal and drought prone regions (Nweke *et al.*, 2004), as it can survive harsh environmental conditions such as poor soils and drought (Pormer *et al.*, 2017). Despite the significance of cassava for food security and economics of a various developing countries,

biotic factors (Alabi *et al.*, 2011) such includes; Cassava Mosaic Virus (CMV) and Cassava Brown Streak Disease (CBSV) (Aloyce *et al.*, 2013) affect the crop.

Among these, CMV and CBSV are the most significant viral diseases threatening cassava production in sub-Saharan Africa (Legg *et al.*, 2006). CMV is the most widespread, posing a substantial barrier to cassava production in the Africa (Legg *et al.*, 2006). CMV is caused by cassava mosaic Geminiviruses (CMGs) including *African Cassava Mosaic Virus* (ACSV) and *East African Cassava Mosaic Virus* (EACMV) that are transmitted by whitefly vector known as *Bemisia tabaci* (Lee *et al.*, 2013). The symptoms of these viruses range from mosaic patterns, twisted leaflets, mottling, stunting, distortion and reduction in the size of the cassava leaves. CMV infested plants often produce few, reduced or no tubers, depending on the severity of the infection and the plant's growth stage at the period of infection (Otim *et al.*, 2006; Sheat *et al.*, 2019). CMV causes yield losses between 50% and 70% (Chickoti *et al.*, 2019), whereas CBSV is caused by Ipomoviruses and results in total crop loss of up to 100% in susceptible cultivars (Mbamzibwe *et al.*, 2011; Munguti *et al.*, 2023).

The impact of CMV on cassava farming can be profound, as it reduces farm yields, compromises the quality and quantity of harvests, and diminishes the productivity and profits of cassava farmers. Therefore, it is essential to assess the efficiency of whitefly *Cassava mosaic virus* transmission to major cassava varieties grown in Kebbi State, Nigeria. However, the research may be of great benefits in identifying the tolerant cassava varieties that will be utilized by the cassava farmers for the optimum cassava production in Kebbi State.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Plastic house of Abdullahi Fodiyo University of Science and Technology, Aliero. The area is located in Kebbi State Sudan Savanna agro-ecological zone of Nigeria. The climate of the area is characterized by annual rainfall range from 550-700mm and temperature average between 30°C during dry season and 27°C and 41°C during the raining season and the relative humidity range from 21 to 47 percent in the dry season and 51 to 79 percent during rainy season. The area characterized by long dry season with a cool air during hammatan (November to February), followed by short rainy season may/June to September/October.

Source of Cassava Cuttings

The diseased-free cassava cuttings were sourced from major cassava growing areas of Kebbi State. The Cassava cuttings were properly labeled and preserved in a jute bag during collection, the cuttings were kept in under the shade prior to the experiment Fig 1.



Figure 1: (a) Diseased-free Cassava Farm (b) Diseased-free Cassava Stem Cuttings

Treatment and Experimental Design

The treatments consisted of 13 varieties namely: *Bakin Rogo, Dan Ajafa, Jan Rogo, Dan Sangelu, Dan Yola, Sarkin Fawa, Dan Bashalma, Dan Kalaba, Dan Gwamnati, Bahausha, Mai Jan Kareri, Bakin Icce* and TMS 0505 as control, the treatments were laid out in a Completely Randomized Design (CRD) with three replication (figure 2).



Figure 2. Cassava Varieties planted in a port at the Plastic House

Agronomic Practices

Soil Preparation and Cutting Preparations

A good mixture of well drained sandy loam soil, cow dung and saw dust were thoroughly made, in to a plastic port and watered for a week, a healthy stem cutting of about 7cm were washed with detergent and rinsed with cleaned water before planting.

Planting

Slanting method of cassava planting were employed and watered immediately, all the plastic ports were placed under the shade for about three (3) days before sprouting and taken to plastic cage, located behind Molecular biology laboratory of Abdullahi Fodjo University of Science and Technology, Aliero for study.

Irrigation

Watering was done two days after transplanting and subsequently three-day interval were maintained when the cassava plants were fully established.

Weeding

Hands pulling of weeds were carried out in each plastic port used for the experiment.

Whitely Collection

Live, adult whiteflies were collected from severed cassava plant using pocket porter aspirator while whiteflies were clipped up to five virus diseased-free plants of each variety in a compartment and monitor for begomoviruses transmission. The insects were removed after 24 hours before the data collection.

Data Collection

Disease Incidence

Disease incidence were calculated according to the method developed by (Sseruwagi *et al.*, 2004)

$$\text{Disease incidence (\%)} = \frac{\text{number of diseased plants}}{\text{total number of plants examined}} \times 100$$

Disease Severity Status

The severity status was assessed based on the severity scale of 1-5 developed by (Sseruwagi *et al.*, 2004). The following scale were used to classify the disease severity as; 1: symptomless 2: Mild 3: Severe 4: Very severe 5: Extremely severe

Data Analysis

Data obtained on incidence and symptoms severity were subjected to Analysis of Variance (ANOVA) and means were separated using Least Significance Difference (LSD) at ($P < 0.05$) probability level.

RESULTS

The efficiency of *Bemisia tabaci* in transmitting Cassava Mosaic Virus (CMV) varied significantly ($P < 0.05$) among the thirteen cassava varieties evaluated, as reflected in both disease incidence (DI%) over time and final disease severity (Table 1). A clear progression of CMV incidence was observed across the 12-week assessment period. The variety *Jan Rogo* exhibited complete

susceptibility, reaching 100% incidence by 6 weeks after treatment (WAT) and maintaining it through 12 WAT. *Dan Ajafa* also showed high susceptibility, with incidence reaching 90% by 12 WAT. In contrast, the improved variety TMS 0505 (control) and the local variety *Dan Gwamnati* demonstrated high resistance, recording 0% and 20% incidence at 12 WAT, respectively. Other varieties, such as *Sarkin Fawa* and *Bahausha*, showed consistently high intermediate to high incidence rates throughout the trial.

Final disease severity at 12 WAT of CMV symptoms varied independently of the final incidence percentage. The variety *Sarkin Fawa* recorded the highest mean severity score (4.40), significantly surpassing all others, followed by *Bahausha* (3.80) and *Dan Kalaba* (3.40). Notably, *Jan Rogo*, despite its 100% incidence, presented a relatively moderate mean severity score (1.60). The most resistant varieties, TMS 0505 and *Dan Gwamnati*, along with *Bakin Rogo* and *Dan Sangelu*, registered the lowest severity scores (ranging from 1.20 to 1.80). Analysis of Variance confirmed significant differences ($P < 0.05$) among varieties for all measured parameters incidence at 3, 6, 9, 12 WAT and severity at 12 WAT, mean separation using the Least Significant Difference (LSD) test at the 5% probability level validated the observed groupings, as indicated by the superscript letters in Table 1. The results delineate distinct varietal responses to whitefly-mediated CMV transmission. *Jan Rogo* was the most susceptible in terms of infection rate, while *Sarkin Fawa* was the most severely affected by the disease. Conversely, TMS 0505 (control) and *Dan Gwamnati* exhibited the most resistant profiles, showing both low incidence and mild symptom expression

Table 1: Incidence and Severity Status of CMV as Affected by Whitefly Inoculation
Within a treatment group mean followed by the same letters (S) are not significantly different at

Treatments	DI% @ AT 3WAT	DI% @ AT 6WAT	DI% @ AT 9WAT	DI% @ AT 12WAT	Severity at 12 WAT
BAKIN ROGO	25.00 ^d	45.00 ^c	50.00 ^e	73.00 ^{de}	1.60 ^{de}
DAN AJAFA	25.00 ^d	50.00 ^c	50.00 ^e	90.00 ^b	3.00 ^{bc}
JAN ROGO	34.00 ^b	100.00 ^a	100.00 ^a	100.00 ^a	1.60 ^{ab}
DAN SANGELU	20.00 ^e	25.00 ^{ef}	60.00 ^d	70.00 ^{ef}	1.80 ^{de}
DAN YOLA	10.00 ^g	15.00 ^{gh}	75.00 ^b	75.00 ^d	1.80 ^{de}
SARKIN FAWA	40.00 ^a	65.00 ^b	65.00 ^c	85.00 ^c	4.40 ^a
DAN BASHALMA	15.00 ^f	20.00 ^{fg}	25.00 ^h	25.00 ⁱ	1.80 ^{de}
DAN KALABA	30.00 ^c	35.00 ^d	35.00 ^g	67.00 ^f	3.40 ^b
BAHAUSHE	25.00 ^d	30.00 ^{ed}	45.00 ^f	60.00 ^g	3.80 ^{ab}
DAN GWAMNATI	5.00 ^h	10.00 ^h	17.00 ⁱ	20.00 ^j	1.20 ^e
MAI JAN KARERI	10.00 ^g	10.00 ^h	20.00 ^{hi}	25.00 ⁱ	3.00 ^{bc}
BAKIN ICCE	12.00 ^{fg}	17.00 ^g	23.00 ^{ji}	30.00 ^h	2.40 ^{dc}
TMS 0505	0.00 ⁱ	0.00 ⁱ	0.00 ^k	0.00 ^k	1.20 ^e
Sig.	*	*	*	*	*
LSD (P<0.05)	3.421	5.567	3.922	3.695	0.918

*(P<0.05) level of probability, NS = not significant, *= There is Significance Difference. DI = disease incidence, WAT = weeks after planting*

DISCUSSION

The differential response of cassava varieties to *Bemisia tabaci*-mediated Cassava Mosaic Virus (CMV) transmission, as observed in this study, underscores the complex interaction between host genetics, vector efficiency, and viral pathogenicity. The complete susceptibility of the *Jan Rogo* variety, evidenced by its rapid and total infection, aligns with findings by Ogbe *et al.* (2022), who documented that certain traditional landrace varieties lack effective genes for obstructing viral replication or movement within the phloem, leading to swift systemic infection following whitefly feeding. Conversely, the high level of resistance demonstrated by the improved cultivar TMS 0505 corroborates a substantial body of literature on the success of breeding programs that have introgressed the CMD2 resistance gene from wild *Manihot* species into elite backgrounds, conferring robust and durable field



resistance (Akinbade *et al.*, 2021; Nwafor *et al.*, 2023). The significant resistance shown by the local variety *Dan Gwamnati* is a particularly promising finding, suggesting the presence of novel resistance alleles within Nigeria's indigenous germplasm that could be leveraged for future breeding (Echendu *et al.*, 2024).

The notable divergence between disease incidence and ultimate symptom severity, most pronounced in the comparison between *Jan Rogo* and *Sarkin Fawa*, highlights a critical epidemiological distinction. A high infection incidence reflects efficient virus transmission and establishment, while severe symptom expression is governed by the plant's physiological response to infection. The extreme severity in *Sarkin Fawa* despite a slightly lower final incidence than *Jan Rogo* may indicate a hypersensitive or more damaging interaction with the specific virus strain(s) transmitted, a phenomenon noted by Munga *et al.* (2022) in East African cassava varieties. This decoupling suggests that resistance mechanisms can operate at different levels: preventing initial infection (as in TMS 0505), suppressing viral accumulation (potentially in *Dan Gwamnati*), or tolerating infection with minimal yield penalty (Legg *et al.*, 2021).

The progressive increase in disease incidence across assessment intervals for most varieties is characteristic of persistent-circulative transmission by *B. tabaci* and the systemic nature of begomoviruses (Ngueji *et al.*, 2023). The significant differences in infection rates at each time point underscore variable rates of virus acquisition, latency, or within-plant movement among varieties. Varieties like *Dan Bashalma* and *Bakin Icee*, which maintained lower incidence levels, may possess traits that deter whitefly settling or probing, thereby reducing effective inoculation events, as hypothesized by Macfadyen *et al.* (2023) in their study on antixenosis components of CMD resistance.

CONCLUSION AND RECOMMENDATION

In conclusion, the findings confirm that farmers' reliance on highly susceptible local varieties like *Jan Rogo* and *Sarkin Fawa* constitutes a key risk factor for CMD epidemic persistence in Kebbi State. The identification of *Dan Gwamnati* as a resistant local variety provides an immediately adoptable option for farmers, favoring cultivar substitution as a management strategy. For sustainable control, integrating the cultivation of such resistant varieties, whether improved (TMS 0505) or locally adapted (*Dan Gwamnati*), into integrated pest management frameworks is essential to reduce inoculum pressure and mitigate the significant yield losses attributable to whitefly-transmitted mosaic diseases.

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