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Original Research Article

Whitefly distribution and cassava mosaic disease occurrence in cassava fields of The Gambia

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ABSTRACT

The whitefly *Bemisia tabaci* is a major insect vector associated with the transmission of cassava mosaic begomoviruses causing cassava mosaic disease (CMD) in Africa. However, information on whitefly populations associated with cassava fields in The Gambia remains limited. This study aimed to investigate the whitefly abundance and its association with CMD incidence in major cassava growing regions of The Gambia. Field surveys were conducted in 44 cassava fields across the West Coast Region (WCR), Lower River Region (LRR), and North Bank Region (NBR) following the harmonized West and Central African Virus Epidemiology protocol. Whiteflies were counted on the top five leaves of sampled cassava plants, while CMD incidence was determined based on the proportion of plants showing characteristic symptoms. Whitefly populations were generally low across surveyed regions, with an overall mean abundance of 21.1 whiteflies per plant. The highest mean whitefly abundance was recorded in LRR (36,6), followed by the NBR (19) and WCR (14). Despite widespread CMD occurrence, no consistent association was observed between regional whitefly abundance and CMD incidence. Assessment of probable infection pathways based on symptom distribution showed 94.5% of CMD affected plants exhibited symptom patterns consistent with cutting borne infection, while 5.5% showed patterns consistent with whitefly-transmitted infection. The findings suggest that infected cassava planting materials may currently contribute more substantially to CMD dissemination than whitefly-mediated spread in the surveyed areas. This study provides baseline information on whitefly abundance and CMD occurrence in cassava fields of The Gambia and supports future vector surveillance and disease management strategies.

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INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is one of the most important staple food crops in tropical and subtropical regions. It contributes significantly to food security and rural livelihoods in Africa including Western Africa (FAO, 2013). The crop is valued for its adaptability to harsh environmental conditions, tolerance to drought, and ability to produce reasonable yields under marginal farming conditions (Jarvis *et al*., 2012). Despite its importance, cassava production in Africa is constrained by several insect pests and diseases, among which cassava mosaic disease (CMD) remains one of the most economically damaging viral diseases (Thresh & Cooter, 2005). CMD is caused by cassava mosaic begomoviruses belonging to the family *Geminiviridae* and is transmitted primarily through infected stem cuttings and the whitefly vector *Bemisia tabaci* Gennadius (Legg & Fauquet, 2004). Whiteflies are highly destructive insect pests with extensive host ranges and strong dispersal abilities (Asiimwe *et al*., 2007). Apart from direct feeding damage, whiteflies play an important role in transmitting cassava viral diseases including CMD (Legg *et al*., 2003). Studies have demonstrated that even short feeding periods are sufficient for whiteflies to acquire and transmit cassava mosaic viruses (Njoroge *et al*., 2017).

Several epidemiological studies conducted across Africa have reported varying relationships between whitefly abundance and CMD incidence. In some regions, high whitefly populations have been associated with increased disease spread and severe CMD outbreaks (Sseruwagi *et al.*, 2004; Kouakou *et al.*, 2024). However, other studies have shown that infected stem cuttings remain the dominant pathway for CMD dissemination, particularly in areas where farmers recycle planting materials from previous harvests (Chikoti *et al.*, 2013). The population dynamics of *Bemisia tabaci* are influenced by environmental conditions, cassava cultivar preferences, cropping systems, and agro-ecological characteristics (Gold, 1994; Kouakou *et al.*, 2024). Understanding regional whitefly abundance patterns is therefore important for designing effective CMD management strategies. In The Gambia, information regarding whitefly populations associated with cassava cultivation is extremely limited. A recent study involving the present author indicated that there is a big gap regarding farmer knowledge and awareness on CMD in The Gambia (Barrow *et al.*, 2026). However, no previous studies have examined the relationship between whitefly abundance and CMD occurrence in the country. Therefore, this study aimed to assess whitefly abundance and investigate its association with CMD incidence in major cassava-growing regions of The Gambia.

MATERIALS AND METHODS

Study area

The study was conducted in three major cassava-producing regions of The Gambia: West Coast Region (WCR), Lower River Region (LRR), and North Bank Region (NBR) (Figure 1). These regions represent important cassava production zones covering different agro-ecological conditions. The Gambia experiences a tropical Sahelian climate characterized by a distinct rainy season from June to October and a dry season from November to May (World Bank Group, 2021).

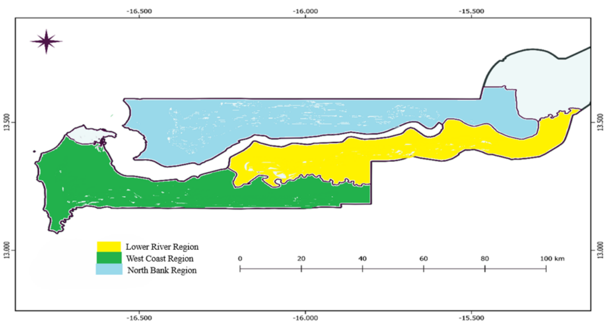

Figure 1. *Map of surveyed cassava-growing regions in The Gambia.*

Field survey and sampling procedure

Field surveys were conducted during the 2024 cropping season following the harmonized cassava virus epidemiology survey protocol developed by the West and Central African Virus Epidemiology (WAVE) program (Sseruwagi *et al.*, 2004).

A total of 44 cassava fields were surveyed including:

- 17 fields in WCR
- 9 fields in LRR
- 18 fields in NBR

Fields were purposively selected and within each field, 30 cassava plants were systematically assessed along two diagonal transects arranged in an X-shaped sampling pattern.

Assessment of whitefly abundance

Adult whitefly populations were estimated by carefully turning over the top five leaves of each sampled cassava plant and counting the number of adult whiteflies present (Sseruwagi *et al.*, 2004). Whitefly abundance was calculated as the mean number of adult whiteflies per sampled cassava plant for each field and subsequently summarized by region.

Assessment of CMD incidence

CMD incidence was calculated as the percentage of plants showing characteristic CMD symptoms among the total number of plants assessed per field using the formula:

Determination of infection mode

The probable mode of CMD infection was assessed visually based on symptom distribution on cassava plants.

- Plants showing CMD symptoms predominantly on older/lower leaves were classified as having symptom patterns consistent with cutting-borne infection.
- Plants showing CMD symptoms restricted mainly to young/upper leaves were classified as having symptom patterns consistent with whitefly-transmitted infection.

Data analysis

Data collected from surveyed fields were entered into Microsoft Excel and analyzed using R statistical software. Descriptive statistics were used to summarize regional whitefly abundance, CMD incidence, and probable infection modes. Scatter plots and boxplots were generated to visualize whitefly distribution patterns and the association between whitefly abundance and CMD incidence. Graphs and boxplots were generated to visualize whitefly distribution patterns and CMD incidence relationships.

RESULTS AND DISCUSSION

Whitefly abundance and CMD incidence across surveyed regions

Whitefly populations varied among the surveyed cassava growing regions of The Gambia, with an overall mean abundance of approximately 21.1 whiteflies per plant. The Lower River Region (LRR) recorded the highest mean abundance (38.6 whiteflies plant^{-1}), followed by the North Bank Region (NBR) (19.0 whiteflies plant^{-1}) and the West Coast Region (WCR) (14.0 whiteflies plant^{-1}) (Figure 2). The higher abundance recorded in LRR may reflect differences in local ecological conditions, cassava production practices, cultivar characteristics, or crop management practices that favour whitefly population development. Previous studies have similarly demonstrated that *Bemisia tabaci* abundance can vary according to host genotype and environmental conditions (Gold, 1994; Kouakou *et al.*, 2024). The mean whitefly abundance observed in the present study was relatively low compared with populations reported from some East and Central African cassava growing systems, where high *Bemisia tabaci* populations have been associated with severe CMD epidemics (Legg *et al.*, 2003; Sseruwagi *et al.*, 2004). However, relatively low whitefly populations have also been documented in West African cassava production systems (Soro *et al.*, 2021). These differences suggest that the epidemiology of CMD may vary considerably among production systems and that disease occurrence cannot necessarily be explained by current vector abundance alone. CMD incidence ranged from 37.2% to 46.6% across the three surveyed regions (Table 1). The highest incidence was recorded in LRR (46.6%), followed by WCR (43.7%), while NBR recorded the lowest incidence (37.2%). Although LRR recorded both the highest whitefly abundance and the highest CMD incidence, WCR had relatively high CMD incidence despite recording the lowest whitefly abundance. The scatter plot therefore showed a general positive trend between whitefly abundance and CMD incidence (Figure 3), but this relationship should be interpreted cautiously because the comparison was based on only three regional observations. The occurrence of relatively high CMD incidence in areas with comparatively low whitefly abundance suggests that other mechanisms may be contributing substantially to disease persistence and spread.

Table 1. Regional CMD incidence and whitefly abundance across surveyed cassava fields in The Gambia.

Survey Regions	CMD Incidence (%)	Mean White fly Abundance
West Coast Region (WCR)	43.7	14
Lower River Region (LRR)	46.6	38.6
North Bank Region (NBR)	37.2	19

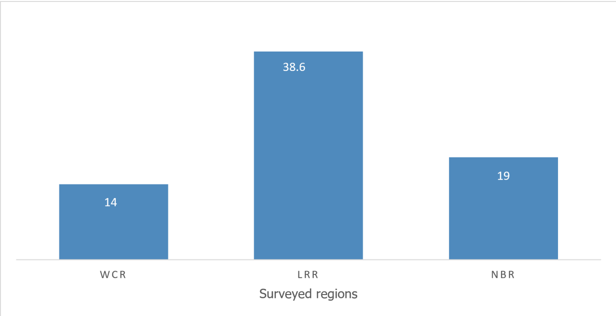

Figure 2. *Regional mean whitefly abundance across surveyed cassava fields.*

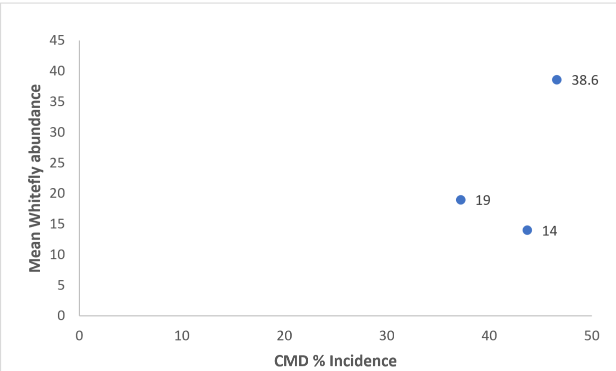

Figure 3. *Association between CMD incidence (%) and mean whitefly abundance (whiteflies plant^{-1}) across surveyed regions.*

Probable modes of CMD infection based on symptom distribution

Assessment of symptom distribution provided further evidence that planting material mediated infection may be an important pathway of CMD dissemination in the surveyed cassava fields. Of the 550 CMD affected plants assessed, 520 plants (94.5%) exhibited symptom patterns consistent with cutting-borne infection, characterized by symptoms occurring on lower leaves, whereas only 30 plants (5.5%) showed symptom patterns consistent with recent whitefly transmitted infection, characterized by symptoms occurring on upper leaves (Figure 4). Thus, the predominance of symptom patterns associated with cutting borne infection suggests that the movement and repeated use of infected cassava planting materials may contribute substantially to CMD persistence and spread in The Gambia. This finding is further supported by recent evidence from The Gambia. Barrow *et al.* (2026), in a farmer-based assessment conducted in the same three regions surveyed in the present study, reported that 65.9% of farmers obtained cassava cuttings from previous harvests, while only 4.5% obtained planting materials from research institutions. The study also found that 95.5% of farmers had no knowledge of the cause of CMD and that 86% had never received training or technical support on cassava disease management. These findings provide an important management context for the high proportion of probable cutting borne infections observed in the present study. The widespread reliance on recycled planting materials, combined with limited farmer knowledge of CMD transmission and limited access to technical support, creates conditions that may facilitate the continued movement and establishment of infected cassava cuttings across farms. The findings of Barrow *et al.* (2026) are particularly relevant because their study was conducted among farmers in WCR, LRR, and NBR, the same regions included in the present epidemiological survey. Their observation that most farmers rely on cuttings from previous harvests provides a plausible explanation for why CMD incidence remained relatively high despite the generally low whitefly populations recorded in the present study. Together, the two studies suggest that planting-material mediated transmission may represent an important pathway sustaining CMD in cassava production systems in The Gambia.

The predominance of probable cutting borne infection is also consistent with reports from other African cassava production systems, where the movement, exchange, and repeated use of infected stem cuttings have been identified as important mechanisms contributing to CMD dissemination (Chikoti *et al.*, 2013 and 2019; Mivedor *et al.*, 2020). In smallholder production systems where farmers commonly obtain planting materials from their own fields, neighbouring farmers, or previous harvests, infected cuttings can facilitate the establishment of CMD in new fields and maintain infection across successive cropping seasons. The relatively low proportion of plants showing symptom patterns associated with recent whitefly transmission, together with the limited regional relationship between whitefly abundance and CMD incidence, suggests that vector mediated transmission may not currently be the dominant mechanism driving CMD spread in the surveyed areas. This does not imply that whiteflies are epidemiologically unimportant. *Bemisia tabaci* remains an important vector of cassava viruses, and changes in vector abundance, population composition, environmental conditions, or cropping practices could alter CMD epidemiology over time. Continued surveillance is therefore necessary to detect changes in vector populations and their potential contribution to disease spread. The symptom-based classification of probable infection pathways should nevertheless be interpreted with caution because transmission mode was inferred from symptom distribution rather than confirmed through molecular or controlled transmission studies. Symptoms occurring on lower leaves are consistent with infection originating from infected planting material, whereas symptoms initially appearing on upper leaves may indicate more recent vector mediated infection. Overall, the findings indicate that CMD management in The Gambia should not focus exclusively on whitefly suppression. Greater emphasis should be placed on the production, distribution, and adoption of clean cassava planting materials, together with farmer education on CMD recognition and transmission. The evidence from Barrow *et al.* (2026) strengthens this recommendation by demonstrating substantial reliance on recycled planting materials and major gaps in farmer knowledge and access to disease-management support.

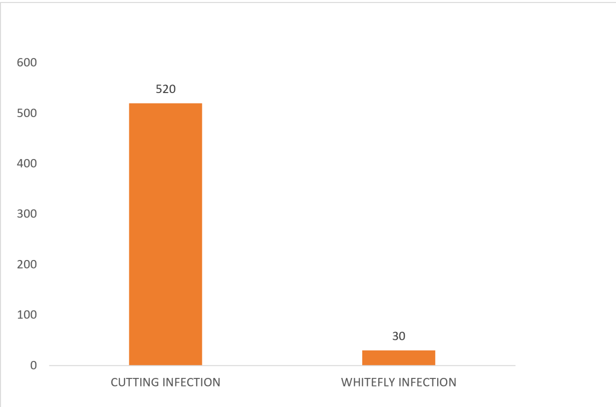

Figure 4. *Proportion of probable cutting-borne and whitefly transmitted CMD infections based on symptom distribution.*

Conclusion and recommendation

Whitefly populations associated with cassava fields in The Gambia were generally low across the surveyed regions, despite the widespread occurrence of cassava mosaic disease (CMD). However, regional variation in whitefly abundance was observed, with the highest populations recorded in the Lower River Region. The relationship between whitefly abundance and CMD incidence was weak at the regional level, while symptom-based assessment suggested that cutting-borne infection was likely the predominant mode of CMD dissemination among affected plants. These findings indicate that the movement and repeated use of infected cassava planting materials may play an important role in the spread of CMD in The Gambia. Therefore, greater emphasis should be placed on the production, multiplication, distribution, and use of clean, disease-free cassava planting materials to minimize cutting-borne transmission. Farmers should also be trained on the identification of CMD symptoms and the proper selection, handling, and use of healthy cassava cuttings, while discouraging the use and exchange of planting materials from visibly infected plants. Although whitefly populations were generally low, regular surveillance should be established to monitor their abundance, distribution, and seasonal dynamics in major cassava-growing areas. Further research is also needed to investigate whitefly species diversity and undertake molecular characterization of *Bemisia tabaci* populations in The Gambia to better understand their potential role in CMD transmission. In addition, longitudinal studies should be conducted to monitor seasonal fluctuations in whitefly populations and their relationship with CMD incidence and epidemiology over time. Such studies would provide a stronger basis for determining the relative importance of vector-mediated and planting-material-mediated transmission and for developing more effective, evidence-based CMD management strategies in The Gambia.

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DECLARATIONS

Author contribution statement: Conceptualization: L.B. and I. M.; Methodology: L.B.; Software and validation: L.B. and I. M.; Formal analysis and investigation: L.B.; Resources: L.B.; Data curation: I. M.; Writing—original draft preparation: I. M.; Writing—review and editing: L.B. and I. M.; Visualization: L.B. and I. M.; Supervision: I.M.; Project administration: L.B.; Funding acquisition: L. B. All authors have read and agreed to the published version of the manuscript.

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