

Assessment of Pepper Leaf Curl Virus Disease Incidence, Severity (PepYLCV) and Vector (*Bemisia Tabaci*) Population Dynamics in Kebbi State, Nigeria

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ABSTRACT

Pepper (*Capsicum* spp.) is widely produced and consumed in Sub-Saharan Africa (SSA). Nigeria is the largest producer of pepper in Africa. A field study was conducted in two Local Government Areas of Kebbi State, Nigeria. A field assessment was carried out in Jega (Birnin Malan and Gindi) and Aliero (Kashin Zama and Marmaro) to assess the incidence and symptom severity of Pepper Leaf Curl Virus (PLCV) and the population density of its whitefly vector on pepper plants. Thirty symptomatic and asymptomatic pepper plants were randomly selected per location and evaluated for visual disease symptoms and severity. Whiteflies were counted on the terminal leaflets of each assessed plant. Results revealed notable PLCV incidence, symptom severity, and high whitefly populations across both locations. Among the surveyed areas, Kashin Zama recorded the highest disease incidence (60.0%), followed by Aliero and Birnin Malan (53.33%), Marmaro and Gindi (50.0%), and Jega (40.0%). The highest symptom severity was observed in Aliero (2.2%), followed by Kashin Zama (2.0%), Marmaro (1.9%), Birnin Malan and Gindi (1.8%), with Jega recording the lowest severity (1.5%). Whitefly populations were highest in Kashin Zama (23.0 per plant), followed by Aliero (21.0), Birnin Malan (20.0), Marmaro (19.0), Jega (18.0), and Gindi (17.0). These findings confirm the presence and variability of PLCV and its vector in Kebbi State, highlighting the need for region-specific management strategies as this will mitigate vector population and disease pressure in the study area

INTRODUCTION

Peppers (*Capsicum* spp.) are an important Solanaceae crop cultivated for culinary use as a vegetable and spice, and as a source of food colorants and secondary metabolites (Islam et al., 2020). As a high-value crop, pepper is a significant source of income for farmers, particularly smallholder farmers in Asia and Africa (Waweru et al., 2020). Pepper is one of the oldest crops domesticated by humans (Perry et al., 2007). In Sub-Saharan Africa (SSA), it plays a key role in maintaining the annual vegetable supply. In Nigeria, peppers are the most widely produced vegetable fruit and the most widely consumed spice also (Gniffke et al., 2013). Africa contributes 1,008,574 tons (approximately 21% of global production) from a harvested area of 375,989 hectares to global dry pepper production, and 3,472,485 tons (approximately 10% of global production) from 331,064 hectares to global green pepper production (FAOSTAT, 2022). The genus *Capsicum* comprises 43 species, five of which are domesticated and cultivated (Barboza et al., 2022). The widely cultivated domesticated species are *C. annuum* (L.), *C. frutescens* (L.), *C. chinense* (Jacq.), *C. baccatum* (L.), and *C. pubescens* (Ruiz and Pav.) (da Costa et al., 2006; Ibiza et al., 2012). Globally, *C. annuum* is the most widely produced and consumed species; however, in Africa, significant production of *C. chinense* and, to a lesser extent, *C. frutescens* also occurs (Zohoungbogbo et al., 2024).

In Africa, chili production is generally limited to small plots ranging from 0.5 to 1.2 hectares (Dagnoko et al., 2013; Zohoungbogbo et al., 2024). The crop can be an important source of income for smallholder and family farmers in rural areas. However, pepper production is frequently threatened by many biotic factors, such as pests and diseases. Among these, viral diseases are reported to be the most significant constraint to pepper production in Africa (Zohoungbogbo et al., 2022). Increasing outbreaks of viruses infecting pepper have become a major problem for producers across the continent (Arogundade et al., 2020; Waweru et al., 2021; Zohoungbogbo et al., 2022). Most viruses infecting pepper are transmitted by arthropod vectors, namely aphids, whiteflies, mealybugs and thrips. Consequently, farmers rely heavily on insecticides for their management (Schreinemachers et al., 2015; Zohoungbogbo et al., 2024). Numerous viruses cause symptoms in pepper in Africa, including Chili veinal mottle virus (ChiVMV; Potyvirus), Pepper veinal mottle virus (PVMV; Potyvirus), and Pepper leaf curl virus (PLCV). PLCV is one of the most serious viral diseases infecting pepper in Nigeria, particularly in the northern region. It causes considerable yield loss; in severe cases at the flowering stage, many flowers may abort due to the infection. Pepper leaf curl virus is transmitted by the whitefly through sap feeding, however, the symptoms include flower abortion, leaf curling, plant stunting, the presence of honeydew on infected leaves, leaf yellowing and drop, wilting and plant death in severe cases.

Extensive cultural management strategies and insecticide applications have been employed to manage virus infections in cultivated peppers, especially for viruses transmitted by whiteflies in a non-persistent manner, with varying degrees of success. However, the vector has often developed resistance due to the frequent use of synthetic chemicals (Sasikala, 2013; Pahla et al., 2014).

Therefore, assessing the incidence, symptom severity, and vector dynamics of Pepper leaf curl virus in the study areas is of great importance to develop strategies for reducing the spread of the disease and its vector. This study may be highly relevant to farmers, entomologists, plant pathologists, and plant breeders.

The use of synthetic insecticides has often been ineffective against numerous hemipteran insect pests, as they generally feed on the underside of foliage or within the plant canopy. Their small size, short life cycle, high fecundity, and resistance to synthetic chemicals contribute to high reproductive rates. In this context, plants with insecticidal properties could serve as beneficial antifeedants against such pests. These, coupled with farming practices such as farm sanitation, removal of infested plants, and regular weeding, would greatly benefit efforts to minimize the spread of Pepper leaf curl virus and its vector. Consequently, this research aims to provide a sound and better alternative control strategy for farmers in the study area

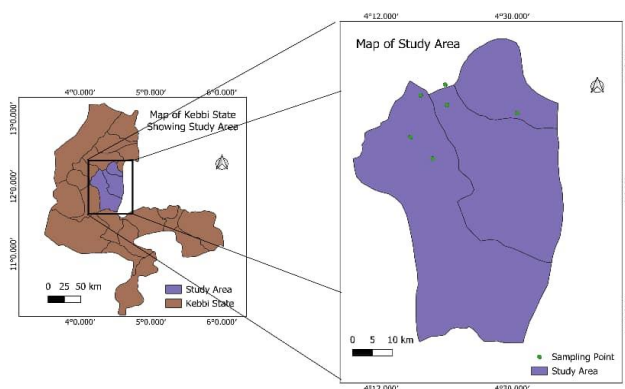
LITERATURE REVIEW

Materials used for this study were mainly survey materials such as field survey data sheet for collecting relevant information for the research, Global Positioning System (GPS) receptor for taking coordinates of the locations (longitude and latitude); pencil and eraser were also used as writing materials.

METHODOLOGY

Fields Survey

A Fields survey was conducted in December, 2021 dry season across pepper producing villages of two selected LGAs of Kebbi State: Aliero, Marmaro, Kashin zama, in Aliero while Jega, Gindi and Birnin malan in Jega local government area. In each field 30 pepper plants were randomly sampled along two diagonals in form of an 'X' and examined for symptoms of Pepper Leaf curl virus (PLCV) on disease incidence, symptom severity, and whiteflies preference (Ndunguru et al., 2009) Five symptomatic and asymptomatic leaf samples were sampled from each field and recorded in a data sheet. The coordinates of each location were taken and map was produced figure1.



Picture 1. Map Showing the Study Area

Disease Incidence

Disease incidence of each field was calculated as the percentage (%) of visually diseased plants over the total plants assessed in the two diagonal methods using the following formula as suggested by (Sseruwagi *et al.*, 2004) and the percentage of disease incidence of each field were used to calculate percentage disease incidences.

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

Symptom Severity

Symptom severity of each field was scored by the arbitrary score: 1-5 indicating the degree of symptom development of each sampled plant in the field. Mean symptom severity of each field was calculated according to the method of (Sseruwagi *et al.*, 2004)

Where:

1. Healthy/Symptomless (no symptom development),
2. Mild (symptoms but no pronounced development),
3. Moderate (pronounced symptom on about one thirds of the leaves),
4. Severe (symptoms on about two thirds of the leaves),
5. Very severe (symptoms on almost all the leaves)



Picture 2. (a) Healthy Pepper plant from the surveyed area (b) Diseased pepper plant in the surveyed area

Estimation of Whiteflies preference

Adult whiteflies were directly counted on the five (5) youngest apical leaves of pepper from each 30 plants sampled according to the method developed by (Ndunguru *et al.*, 2009)

Data Analysis

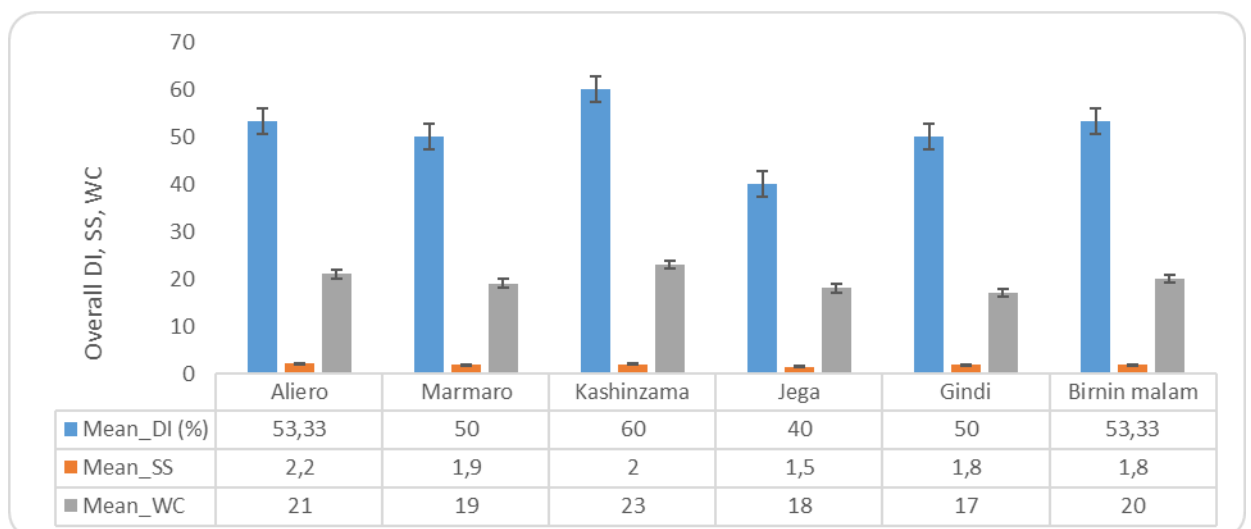
Data collected on incidence, symptom severity of (PLCV) and whiteflies count in Aliero LGA of and Jega of Kebbi State Nigeria were analyzed using GenStat software (17th Edition)

RESULTS

The results showed that, there is higher Disease incidence of pepper leaf curl disease and Symptom severity than whitefly count Figure 2.

The epidemiological survey of Pepper leaf curl virus (PLCV) across six locations in Kebbi State revealed a clear and consistent pattern regarding disease pressure and its vector, *Bemisia tabaci*. As summarized in Figure 1 and the accompanying data, the mean values for both disease incidence (DI) and symptom severity (SS) were significantly higher than the corresponding whitefly count (WC) in all surveyed Local Government Areas. This indicates a non-linear relationship between vector population density at the time of sampling and the resulting disease expression in the field.

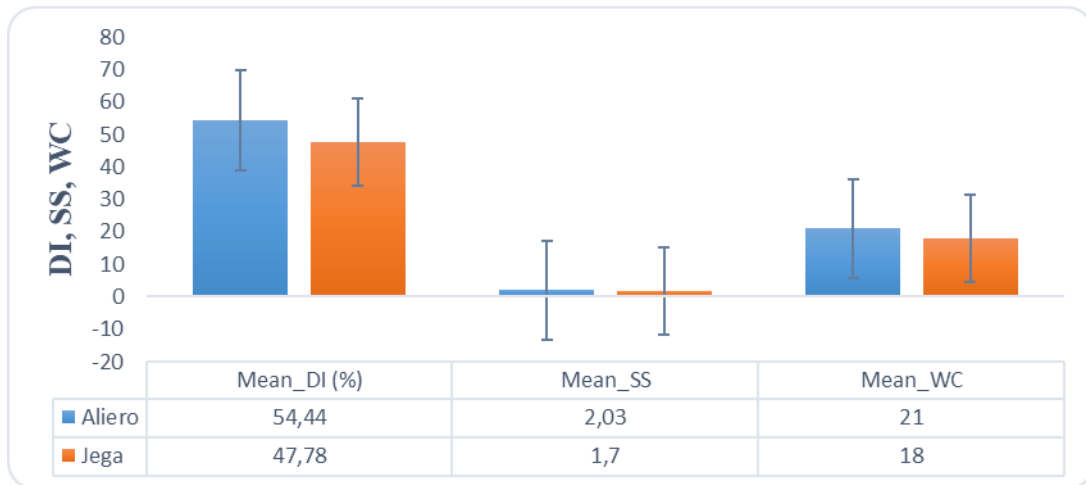
Kashin Zama recorded the highest disease incidence (60.0%) and the highest whitefly population (23.0%), suggesting a strong correlation between vector pressure and infection rate in that location. Similarly, Aliero, with the second-highest whitefly count (21.0%), exhibited the highest symptom severity (2.2%) and a high incidence (53.33%). This pattern aligns with the expected role of *B. tabaci* as the primary vector for PLCV. However, a more nuanced relationship is evident when comparing other sites. For instance, Birnin Mallam and Gindi reported identical disease incidence (53.33% and 50.0%, respectively) and similar symptom severity (1.8% for both), despite a noticeable difference in their whitefly counts (20.0% and 17.0%). Most notably, Jega presented the lowest metrics across all three parameters (DI: 40.0%, SS: 1.5%, WC: 18.0%), yet its disease levels were still proportionally high relative to its vector count figure 2.



Picture 3. DI: Disease Incidence, SS: Symptom Severity, WC: Whitefly Count Based on Locations Surveyed. Bars Indicate Standard Error of Means At 5 % Probability Level

The comparative analysis of Pepper leaf curl virus (PLCV) epidemiology between Aliero and Jega reveals a clear gradient in disease pressure, with Aliero exhibiting significantly higher agronomic and entomological metrics. Specifically, Aliero recorded a higher disease incidence (54.44%) and symptom severity (2.03) compared to Jega (47.78% and 1.7, respectively). This pattern was

mirrored in the whitefly (*Bemisia tabaci*) vector population, which was also greater in Aliero (21 counts) than in Jega (18 counts).



Picture 4. DI: Disease Incidence, SS: Symptom Severity, and WC: Whitefly Count in Jega and Government. Bars Indicate Standard Error of Means At 5 % Probability Level.

DISCUSSION

The survey carried out in the 2021 dry season in Aliero and Jega LGAs showed high PLCV incidence and relatively high whitefly populations but only low to moderate symptom severity. This pattern is consistent with studies on begomoviruses (including Pepper yellow leaf curl virus, PepYLCV/PepYLCIV) in Africa and Asia, where widespread infection and abundant vectors are often recorded, while symptom expression varies with host plant, environment and management practices (Mueangkhong et al., 2025).

However, Kashin Zama had the highest incidence, followed by Aliero and Birnin Mallam, with the lowest in Jega. Such spatial variation is typical of whitefly transmitted begomoviruses, where incidence can differ significantly between locations and crops within the same region (Yusuf et al., 2025). In northwest Nigeria, whitefly infestations and begomovirus incidence varied markedly among states and host crops, and pepper generally carried lower whitefly populations than some other hosts but could still show substantial virus incidence (Yusuf et al., 2025).

The higher incidence in Kashin Zama, Marmaro and Birnin Mallam is plausibly linked to the use of susceptible pepper varieties. Experimental work with PepYLCIV shows that susceptible cultivars consistently develop higher incidence and severity than resistant ones under similar whitefly pressure (Arfiani and Nasruddin, 2023). Genetic studies on PepYLCV resistance in pepper further demonstrate that specific resistance greatly reduce symptom expressions and disease scores when plants are challenged with viruliferous whitefly vectors (Barchenger et al., 2019). Thus, adoption of susceptible landraces by farmers in these villages likely facilitated rapid virus spread and higher incidence compared with areas where more tolerant varieties or better management practices were used.

At LGA level, the higher mean incidence in Aliero compared to Jega can be associated with poorer farm sanitation and vector favorable conditions since irrigation is constantly applied during the production. In northwest Nigeria, higher whitefly numbers have been linked to irrigated conditions, continuous host availability and poor field hygiene (Yusuf et al., 2025). Similar observations are reported in Benin, where limited sanitation, monoculture and lack of awareness about viral diseases contribute to high virus prevalence in pepper (Zohoungbogbo et al., 2024). Moreover, whitefly populations were relatively high among the LGAs, with Kashin Zama having the highest than Gindi and Jega with the lowest. Numerous studies on PepYLCV and related viruses show a positive correlation between whitefly density and disease incidence and severity, although the relationship is not always linear (Udiarto et al., 2023). In Indonesian chili fields, each additional whitefly per leaf increased begomovirus incidence by about 26% and severity by about 15%, illustrating the strong epidemiological role of the vector (Taufik et al., 2023).

However, surveys in northwest Nigeria documented cases where begomovirus incidence did not strictly follow whitefly population size, indicating that factors such as prior infection foci, alternative hosts and cropping history can decouple vector population from current incidence (Siddique et al., 2022). Likewise, Amaliah et al. (2023) reported low *B. tabaci* populations but relatively high PepYLCIV incidence, suggesting additional routes (e.g., seed borne virus) or early infection events.

The slightly higher whitefly population observed in Kashin Zama may also relate to insecticide use patterns and resistance. Repeated insecticide applications are widely used by African and Asian farmers against *B. tabaci* and can select for resistant biotypes and disrupt natural enemies, resulting over time in persistent or even increased whitefly pressure (Arfiani and Nasruddin, 2023; Zohoungbogbo et al., 2024). This aligns with the suggestion that excessive insecticide use in Kashin Zama could favor vector survival and persistence in the fields.

In contrast, the lower whitefly densities recorded in Jega and Gindi are consistent with improved management practices such as timely planting, regular weeding, and better field sanitation. In northwest Nigeria, good sanitation and removal of alternative hosts are recommended to suppress whitefly populations and reduce virus spread (Yusuf et al., 2025). Studies in chili also show that protected seedlings, barrier crops and field hygiene can significantly reduce whitefly abundance and PepYLCV incidence, improving yields (Udiarto et al., 2023).

CONCLUSIONS AND RECOMMENDATIONS

It has been concluded that, there is incidence, symptom severity of PLCV and whitefly population in Aliero and Jega LGA during the research work.

Therefore, the rapid spread of PLCV and whitefly population coupled with their polyphagous feeding behavior can lead to the emergence of damaging of crops. This occurrence of such disease and whitefly population may quickly

explain the rate at which the diseases can be spread may eventually lead to reasonable yield loss or even total crop failure.

FURTHER STUDY

The research work recommended that, the farmers should adopt appropriate planting methods, resistant cultivar and good farm sanitation to make the farm unsuitable for whiteflies which transmits disease to the pepper plants. However, the indiscriminate use of chemical insecticides to control insect should be avoided so as to prevent insect from been resistant to chemicals, The research work recommends that, the farmers should adopt appropriate agronomic practices such as field sanitation, regular weeding, crop rotation that may reduce the population of vector transmitting PLCV in the study areas.

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