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# A Survey of Major Constraints Associated with Sugarcane Production in Northern Guinea Savannah Region of Nigeria

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## Abstract

*Sugarcane, Saccharum officinarum family Poaceae, is a perennial grass grown for its stem (cane) which is primarily used to produce sucrose. Three landraces: purple, white and green cane are mainly cultivated by commercial farmers in Northern Guinea Savannah region (NGS) of Nigeria. Survey was conducted to determine the cropping system, viruses as well as other abnormalities associated with sugarcane fields in Kaduna, Kano and Katsina states across the northern guinea savannah region of Nigeria. Eighty three percent (83%) of growers interviewed practice monocropping while the remaining intercropped sugarcane with maize, sorghum, pepper and tomato for economic reasons. Sugarcane is grown via seed cane rather than ratoon by 80 % of growers because ratoon harbors more diseases and requires more fertilizer. Sugarcane mosaic virus (SCMV); Potyvirus, Sugarcane chlorotic streak virus (SCSV), Maize streak virus (MSV); mastrevirus and Maize yellow mosaic virus (MaYMV); polerovirus are the viruses diagnosed infecting and causing yield losses in sugarcane in the surveyed regions. Potyvirus (SCMV) recorded the highest disease prevalence of 64% followed by mastrevirus (MSV and SCSV). Maize chlorotic mottle virus (MCMV) was not detected in the areas surveyed. Another important disease naturally infecting sugarcane in the surveyed region is smut disease caused by a fungal pathogen, Sporisorium scitamineum. Insect pests associated with sugarcane fields include aphids, leafhoppers, grasshoppers and termites. Rats and millipede infestation were also recorded, inadequate irrigation facilities, poor extension services to farmers and theft were reported as additional problems to sugarcane cultivation in the regions.*

**Keywords:** Survey, Sugarcane, Diseases, Viruses, fungi, pest.

## INTRODUCTION

Sugarcane (*Saccharum officinarum* L.), is a perennial crop of the family Poaceae, primarily cultivated for its juice from which sugar is processed and it is also grown for biofuel production. The crop has long stems, which are fibrous, stout jointed, and is rich in the sucrose (used to provide about 70-80% of the world's sugar). Sugarcane has immense industrial uses aimed at nutritional and economic sustenance (Girei and Giroh, 2012; Ebenezer, 2021). Its by-

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products have found use in industrial settings of medicine, pharmaceuticals, confectionery and beverages, electricity and motor fuels (Wada *et al*., 2017). Sugarcane is an important food and cash crop in Nigeria and two types are produced, the industrial cane and the chewing cane. The industrial cane is the major raw material used in the sugar processing mills. By contrast, the chewing cane which accounts for 60 % of total production is mainly chewed in its natural form for its sweet juice but it can also be processed into various forms. Sugarcane is mostly grown in Northern Nigeria where the weather and soil conditions are most conducive. (NBS, 2009: USDA, 2022).

Sugarcane cultivation in this region of the country plays a very important role in the livelihood of rural farmers and serves as their main source of income. In spite of sugarcane's wide adaptability, uses and role in the economy and livelihood of the rural poor farmers in NGS region, many constraints hamper its production in the region and across the country (Ebenezer, 2021). Such constraints include internal security, poor soil conditions and nutrition, lack of capital, insects, and diseases, with virus diseases among the most important. The impacts of virus diseases are exacerbated by the fact that sugarcane's vegetative mode of propagation supports their transmission from one generation to the next. The perennial nature of the crop especially where ratooning is practiced makes it serve as a virus reservoir for cereal crops. The recycling of infected planting materials yearly from and between farmers' fields leads to a build-up of diseases. Viruses directly affect the photosynthesis and growth of sugarcane, leading to a significant decrease in cane yield and sucrose content, and thus serious economic losses (Lu *et al*., 2021). Therefore, this research's major focus was to document the virus and other associated problems with sugarcane production in the region.

## Materials and Methods

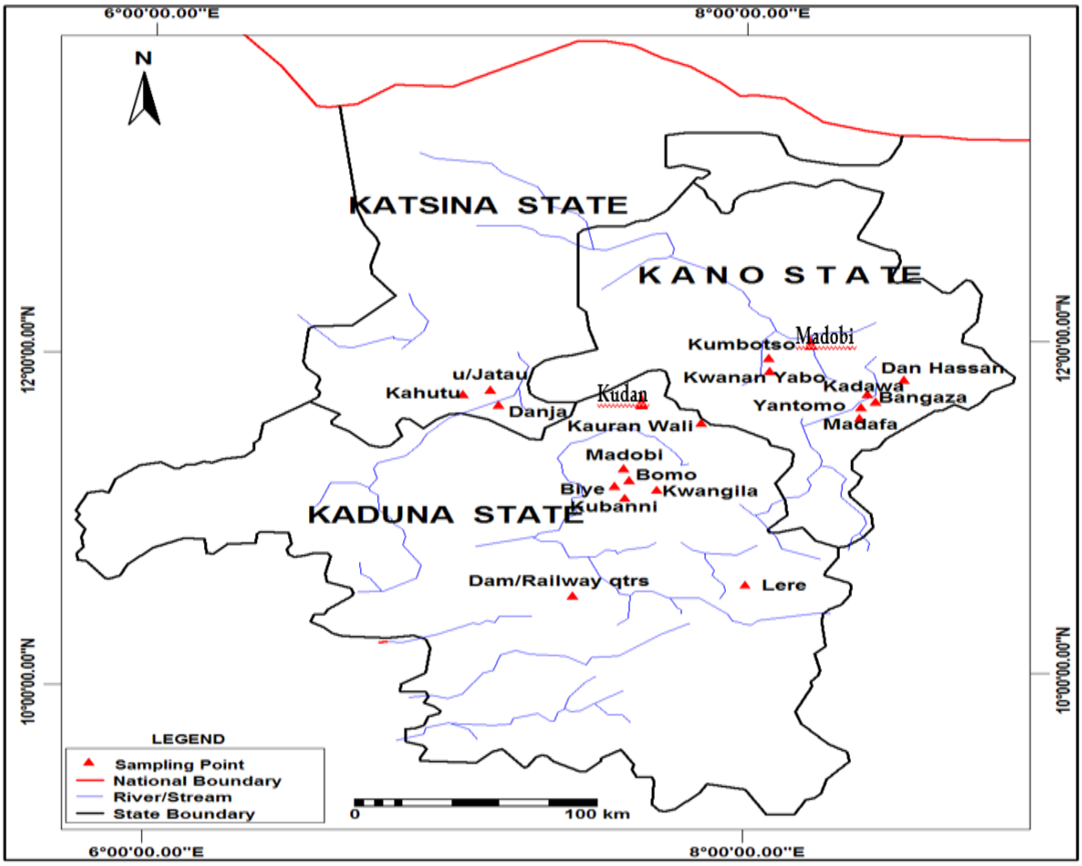



Figure 1. Map of Kaduna, Kano and Katsina States showing areas surveyed for virus disease symptoms

**Survey and interview of farmers**

A survey of viruses infecting sugarcane was carried out in seven (7), four (4) and one (1), Local Government Areas (LGAs) of Kaduna, Kano and Katsina States of Northern Guinea Savannah (NGS) region of Nigeria respectively. Farmers were interviewed during the field surveys to gauge their awareness of virus diseases, the causative viral agents, their farming and cropping systems and approaches to disease management. Individual virus incidence was determined as a percentage of the total number of infected leaf samples divided by the total leaf samples assessed.

Occurrences of other diseases and abnormalities observed on the fields as well as insect pests, rodent infestation, and cropping and planting systems practised were recorded. Growers were orally interviewed in order to determine their perception of problems associated with sugarcane cultivation.

**Survey and sampling of farmers' fields**

SCMD incidence was assessed in each field on 18 plants that were systematically chosen on each of the two longest opposite sides of the field and a diagonal (Z-pattern) after every 20 to 30 steps (depending on the size of the field) (Barnett, 1986).

**Characterization of recovered samples**

Disease incidence per field was confirmed from PCR results that were conducted using: (1) degenerate mastrevirus primer pairs MSV215- 234 and MSV1770 – 1792, capable of amplifying ~1400 bp DNA fragment spanning the coat protein (CP) and near full-length RepB sequences of several mastreviruses (Palmer and Rybicki, 2001). (2) Generic primer pairs capable of amplifying ~700 bp DNA fragments spanning the partial cylindrical inclusion (CI) of potyviruses (Ha *et al*., 2008). A species-specific primer pair targeting *Maize chlorotic mottle virus* (Wangai *et al*., 2012) were utilized in RT-PCR capable of amplifying ~550 bp partial virus genome segments.

Pol-G-F/Pol-G-R primer pairs (Knierim *et al*., 2010) was capable of amplifying ~1100 bp DNA band specific to the P1-P2 fusion protein and coat protein encoding regions of luteovirids was used to screen all samples for Amplified products were analyzed in 1.5% agarose gel stained with ethidium bromide and visualized under UV light (Bio-rad). Amplicons of expected sizes were cloned individually into PCR 2.1 TOPO-TA vector, putative recombinant plasmids were isolated, purified and sequenced (data not showed).

## RESULTS

**Farmers perception**

Sixty percent of farmers (n = 105/183) were ignorant of virus disease and most of them associated virus-like disease symptoms with varietal characteristics and an extent urea fertilizer application. In addition, farmers from all locations complained of sugarcane plants exhibiting the mosaic symptom as a bad variety, is harder and has low sucrose content. Observations on cropping systems showed that 79% of farmers practised mono-cropping of sugarcane and maize in adjacent fields while 21% intercropped both crops in mixtures with each other or with other crops such as tomato, pepper and watermelon for economic reasons. A large number of farmers (77%) cultivate sugarcane through seed cane while 23% of farmers grow sugarcane via the ratoon system. Farmers reported having abandoned the ratoon planting system because it harbors more diseases and requires more fertilizer while the few that still practice ratoon reported that it saves them the cost of land preparation and acquiring seed cane.

The majority of farmers (172/183; 94 %) cultivate landrace for chewing while the remaining 6 % grow exotic varieties specifically for refining purposes. Three landraces are produced, the purple "Bakar kwama" (81%; 149/183), the white "Farar kwama" (12.6 %; 23/183) and the green "yar Hausa" (6.6 %; 12/183) (Table 1). The green and the purple landraces are mostly for chewing and the white for local sugar production referred to locally as "mazankwaila" (Plate III). Growers across the three States lament over the lack of extension workers visiting their fields to advise them on how to go about managing and controlling diseases. They also complain about their poor purchasing power and inability to purchase inputs and farm implements for the adoption of improved technologies. Theft is a serious problem faced by many farmers, as there is a village in Kaduna state that stopped sugarcane cultivation due to the high rate of theft. Insecurity, lack of sufficient irrigation facilities to sustain the crops during the dry season, disease incidence and low market due to restricted movement caused by insurgency in some parts of the country led to lots of farmers abandoning sugarcane cultivation for other crops.

Table 1. Farmers' perception of sugarcane cultivation in NGS of Nigeria

| States | | Kaduna (%) | Kano (%) | Katsina (%) |
|---|---|---|---|---|
| Knowledge of virus disease | | 44 | 31 | 52 |
| Farming system | Commercial | 72 | 89 | 84 |
| | Subsistence | 28 | 11 | 16 |
| Cropping system | Mono-cropping | 72 | 88 | 75 |
| | Mixed cropping | 28 | 12 | 25 |
| Planting system | Seed cane | 74 | 85 | 72 |
| | Ratoon | 26 | 15 | 28 |
| Type cultivated | Land races | 89 | 80 | 92 |
| | Exotic | 11 | 20 | 8 |
| Type of landrace | Purple | 80 | 92 | 88 |
| | White | 12 | 4 | 8 |
| | Green | 8 | 4 | 4 |

**Symptoms of virus diseases in sugarcane fields**

Mosaic symptoms observed on sugarcane leaves were mostly pale and dark green stripes (Plates Ia and Ib), and yellow chlorotic stripes (Plate Ic) compared to healthy-looking leaves (1e). White stripes on the stem and shortening of internodes (Plate Id) were observed on sugarcane associated with the pale green or chlorotic mosaic leaf pattern of the diseased plants.

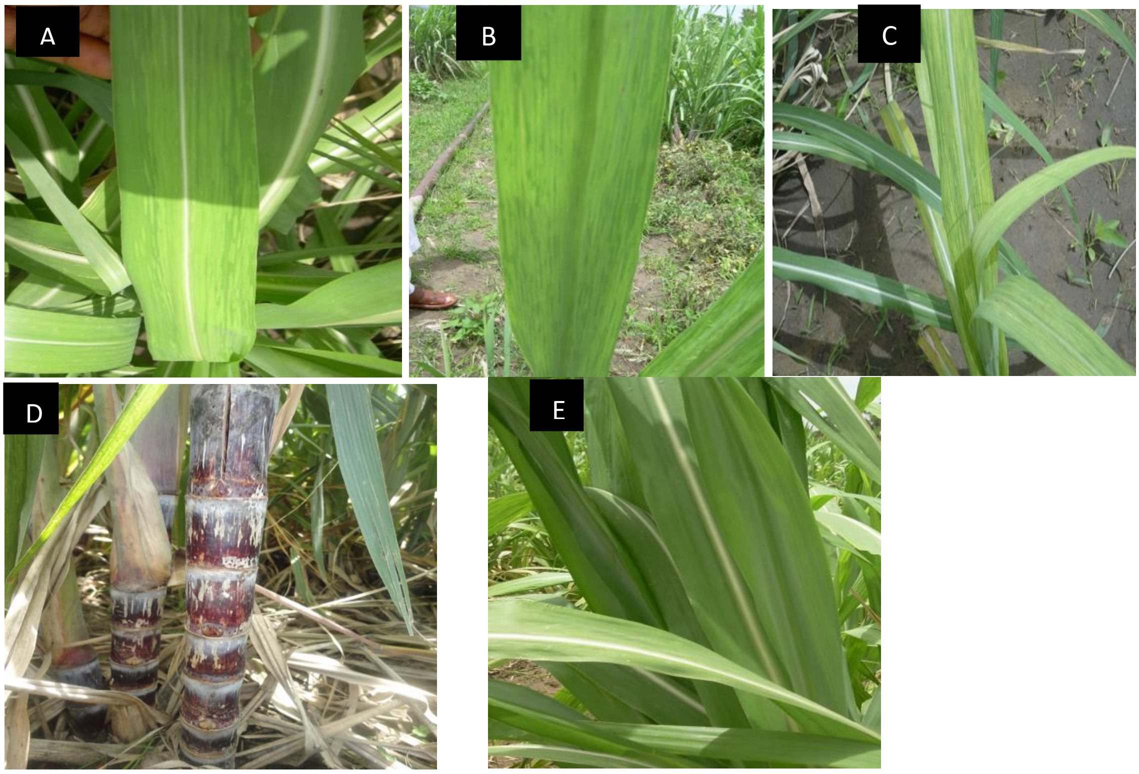



Plate 1. Mosaic symptoms observed on field: A & B. Pale green mosaic stripes, C. Yellow chlorotic mosaic pattern, D. Whitish streaks observed on sugarcane stems E. Healthy sugarcane leaves.

Streaking symptoms of those typically caused by mastrevirus were observed on sugarcane plants. Internodes of mastrevirus-infected cane were very short (Plate II A & B) compared to the healthy ones (Plate II C). Stems of mastrevirus-infected sugarcane plants were without whitish steaks as against those observed on the stem (Plate I D) of sugarcane infected with sugarcane mosaic disease. Two patterns: fine broken pencil-like streaks (Plates II D and E) and wider continuous types (Plates II F) were observed on sugarcane leaves.

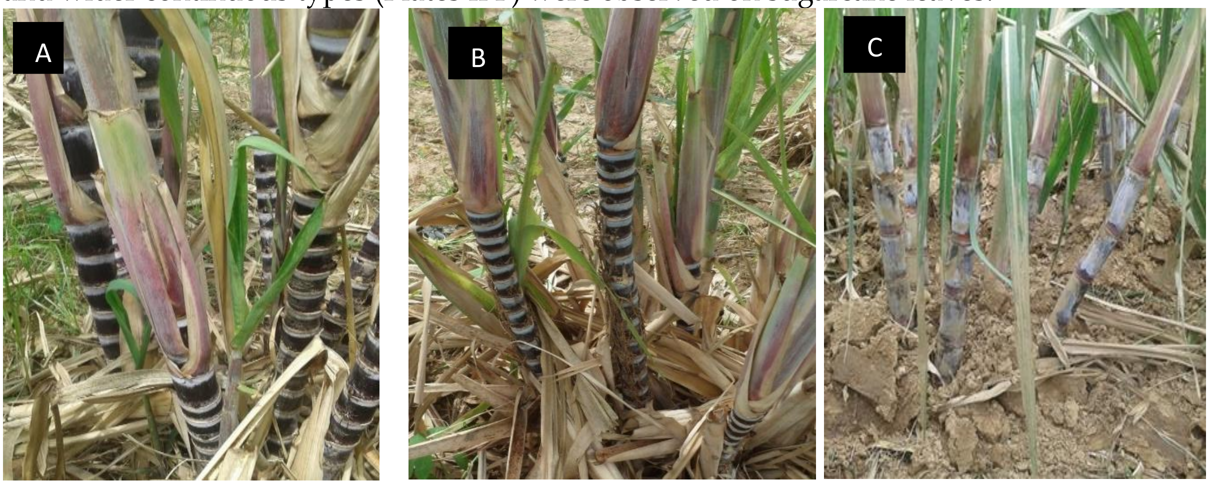



Plate II. Shortening of internodes and streaking associated with Mastrevirus: A & B. Shortened internodes associated with *Sugarcane chlorotic streak virus* (SCSV), C. Healthy sugarcane stem, D & E. Fine broken streaks, F. wider streaks all associated with SCSV. G. Chlorotic streaks caused by *Maize streak virus* (MSV) infection

Plate III. Locally processed brown sugar ('Mazankwaila")

**Virus disease incidence**

Based on a visual assessment of symptoms, potyvirus and mastrevirus are the predominant viruses observed. Reverse transcriptase polymerase chain reaction (RT PCR) of symptomatic and asymptomatic samples collected were used to determine the incidence of potyvirus (Plate IV).

Potyvirus disease incidence ranges from 36.2% in Kano to 63.3 % in Kaduna state with an overall mean incidence of 55.5 % for the three states. Fields with the highest potyvirus incidence were recorded in Makarfi and dam quarters (Kaduna south) of Kaduna state while the lowest incidence was recorded in Kura and Lere LGAs of Kano and Kaduna States respectively. The potyvirus causing mosaic on sugarcane and other poaceous crops in the study area was determined to be *Sugarcane mosaic virus* (SCMV) (sequenced data not shown). Mastrevirus disease incidence ranged from 36.0% in Kaduna State to 12.5% in Kano State (Table 2). Fields with the highest mastrevirus incidence include Kubanni in Zaria LGA – Kaduna state, Dam quarters in Kakure (Kaduna south) and Bangaza, Kura LGA of Kano state. Two viruses were responsible for streaking on sugarcane plants and they are *Sugarcane chlorotic streak virus* (SCSV) and *Maize streak virus* (MSV). These viruses cannot be distinguished based on mere observation on the field as both viruses caused similar symptoms on sugarcane. The two viruses were distinguished from sequence analysis, as the two viruses were both amplified by polymerase chain reaction (PCR) using the degenerate mastrevirus primer pairs (Plate V).

Bands were produced by a few samples from RT PCR screening of poleroviruses (Plate VI). The sequenced amplicons reveal the polerovirus to be Maize yellow mosaic disease (MaYMV).

**Table 2.** Incidences of potyviruses and mastreviruses in sugarcane and weed plants obtained across 36 farmer's fields in three major sugarcane-producing (Kaduna, Kano and Kastina) states of Nigeria.

| Host plant | Total no. plants | Potyviruses (P) | | Mastreviruses (M) | | Co-infection of P and Polerovirus | | Co-infection of P and M | |
|---|---|---|---|---|---|---|---|---|---|
| | | **No.** | **(%)** | **No.** | **(%)** | **No.** | **(%)** | **No.** | **(%)** |
| Kaduna | 120 | 76 | 63.3 | 43 | 36 | 2 | 1.6 | 5 | 4.2 |
| Kano | 80 | 29 | 36.2 | 10 | 12.5 | 0 | 0 | 1 | 1.3 |
| Katsina | 40 | 18 | 45 | 8 | 20 | 1 | 0.8 | 2 | 5 |
| Total | 240 | 123 | 55.5 | 108 | 44 | | | 8 | 3.3 |

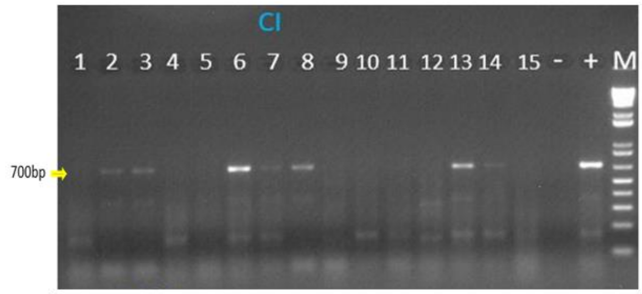



Plate IV. Agarose gel electrophoresis showing bands of amplicon spanning the cylindriccal inclusion protein (CI) of Sugarcane mosaic virus. M – Molecular marker (100 -12,000 bp), 1-15 representative samples with 2,3,6,7,8,13 and 14 being positive with expected band size.

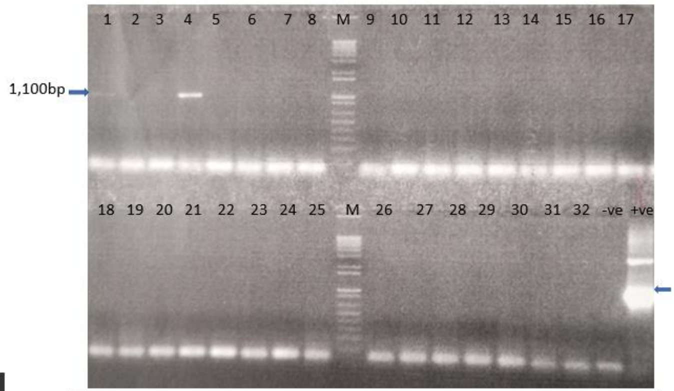
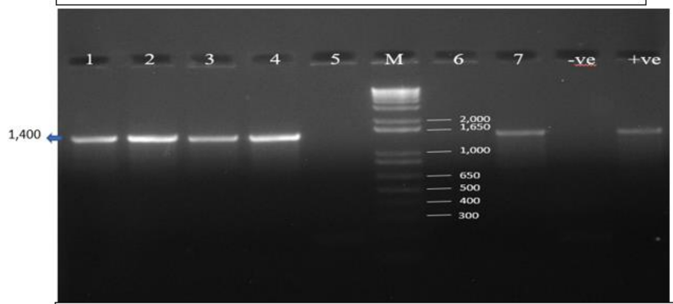



Plate VI. Agarose gel electrophoresis showing expected bands sizes of ~1100 bp DNA band specific to the P1-P2 fusion protein and coat protein encoding regions of Maize yellow mosaic virus MaYMV (luteovirids). M – Molecular marker (100 -12,000 bp). Two positives (1 and 4) in a set of 32 samples




PlateV: Agarose gel showing ~1400 bp Amplicon (spanning the partial rep and movement proteins of *Mastrevirus*) of seven isolates (representatives). 1 ,2,3, 4,7 are positive with expected band sizes while 5 and 6 are negative with no bands, -ve = negative control, + = positive control. M – Molecular marker (100-12,000 bp)

## Other problems associated with sugarcane cultivation

### Smut Disease

A fungal disease of importance observed during the survey of sugarcane fields in the regions was smut disease caused by the fungus *Sporisorium scitamineum*. It is observed especially on young plants and causes stunted growth (3A-B) which later develops a "smut whip" (sori with teliospores) which may be long, short, curved or twisted and emerges from the top of the infected sugarcane plant (Plate VII). Smut diseases were observed in all three states in almost every field and incidents, especially in the ratoon field were as high as 31 %.



Plate VII. (a) Arrow pointing at smut whip, (b). Smut infected cane tillers profusely and appeared grass-like and Stunted

**Vectors and Pests associated with sugarcane fields**

White aphids colony *Aphis gossypi* (Plate VIIIa) were observed on the lower surface of the older leaves of some sugarcane stands. The green aphids (*Myzus persicae*) colony (Plate VIIIb) on the adaxial surface of the youngest (rolled) leaf. These aphids are responsible for the transmission of several diseases like the Sugarcane mosaic virus and the Maize yellow mosaic virus both observed on some of the sugarcane fields surveyed.

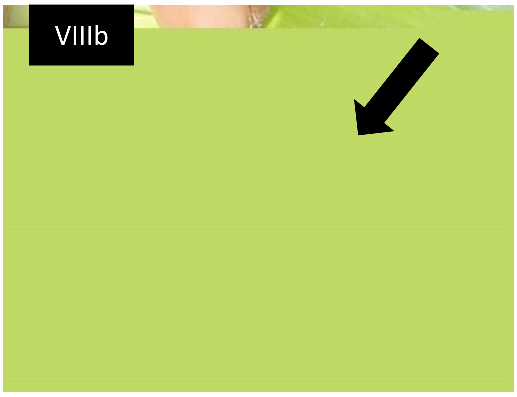




Plate VIII. A. white aphids, B. Green aphids

**Early shoot borer**

Sugarcane borer, sometimes is a serious pest of sugarcane. Larvae bore into the sugarcane stalks (Plate IXb). In mature plants, the shoot tends to weaken, dry and die off (Plate IX a & c), sometimes breaking off. In young plants the inner whorl of leaves is killed, resulting in a condition known as "dead heart." Sugarcane borer were observed in Kaduna state in 3% of plants.

Termite, **Odontotermes obesus**, attacks cane at a very young stage after planting and causes poor germination of setts (sprouting) which hollow inside and may be filled with soil (Plate X) and at a later stage during growth causing the entire shoot to dry up and be pulled out easily. Grasshoppers (Plate XB) infestation was seen across the three states feeding intensively on the leaves, eating all the leaf blades down to the midrib in irregular patterns, and removing valuable photosynthetic tissues from the plants.

Rats were also seen to cause damage by feeding on the lower stem and root but the incident is insignificant at 0.2%. Millipede was observed to have bore a hole at the lowest stem close to the root causing gradual death of the plant (Plate XI)


Plate IX. A. Dead heart and browning of leaves a condition caused by sugarcane stem borer infestation B. Point of entry of larvae C. Larvae tunneled into stalk and resulted in dead heart


Plate X. A. Excavated cane setts by termites in soil leading to death of shoot B. Grasshopper infestation


Plate XI. A. Damage caused by rats B. Damage cause by millipede

## DISCUSSION

It is evident from the survey and farmer's perception that three different landraces are cultivated in the areas surveyed, however, their distribution varies. The majority of the sugarcane grown in NGS is for chewing. The purple cane is the most widely grown local landrace in the areas visited despite the fact that it is more susceptible to SCMV than the other two landraces. Similarly, the purple canes were reported to be most susceptible to other diseases in the Southern Guinea Savannah Zone of Nigeria (Wada *et al*., 1999). In the areas surveyed mix cropping with maize and sorghum was also observed. This failed to reduce disease incidence in the areas probably because sugarcane belongs to the same family and both sugarcane and the cereal serve as hosts to SCMV and MSV. Though mix cropping of some crops (non-host) has been shown to reduce disease incidence (Joshua, 2010).

These different symptoms encountered were similarly reported by Yahaya et al., (2021) when different maize varieties were inoculated with SCMV under field and screen house conditions. Wada *et al*., (1999) also reported the occurrence of SCMV based on symptoms observation of which the pale green and yellowish chlorotic stripes were observed on sugarcane leaves in the Southern Guinea Savannah zone of Nigeria. Ronald, (2007) reported contrasting shades of green, often islands of normal green on a background of paler green or yellowish chlorotic areas on the leaf blade as the most distinctive symptoms of mosaic in Florida, Gaur *et al*., (2002), reported interveinal chlorotic stripes on infected leaves in India while Alemu *et al*., (2004) reported the chlorotic stripe symptom on sugarcane and the severe mosaic symptom on Sorghum in Thailand.

Disease incidence and severity were less in the seedcane fields in all the areas visited. This might be due to the fact that farmers select disease-free seed sets for seed cane plantations. On the other hand, the disease was more severe on ratoon (personal discussions with the farmer) fields which might be due to the use of the same cutlass to harvest diseased and healthy stands as such the ratoon gets more contaminated or the disease spreads more. At the same time in ratoon fields, sugarcane is grown persistently for years. Similar observations were made with other diseases on sugarcane where ratoon crops were more susceptible than plant crops (Wada *et al.,* 1999).

Since most of these cereal-infecting viruses are not transmissible via true seeds, a plausible assumption is that they are perpetuating in fields on ratoon sugarcane stands or vegetative cuttings and perennial weed species such as itch grass to create 'green bridges' for re-infecting annual cereal crops such as maize, sorghum and millet. Support for this assumption could be seen in the monophyletic clustering pattern of SCMV, MSV and MaYMV isolates obtained regardless of their host origin: maize, sugarcane or weed (Yahaya et al., 2018; Yahaya et al., 2016; Yahaya et al., 2019). Co-infection of SCMV and MaYMV was also reported in maize from Kenya (Tanui et al., 2021) and aphids are responsible for the transmission of both viruses (Gonçalves et al., 2020).

The use of resistant sugarcane varieties is considered the most economical and effective approach to managing viral diseases, especially in vegetatively propagated crops such as sugarcane (Krishna, et al.,2023). Researchers and extension workers should avail and make themselves accessible to the farmers so they can channel any problem regarding production and be counselled on the best strategy or methods to tackle the problems.

## CONCLUSION

In addition to viruses, smut infection on sugarcane poses a threat to production in the regions. However, farmers are ignorant of most of the diseases and there is an urgent need to educate the farmers on these diseases by creating awareness programs. Disease incidence can be reduced by raising resistant varieties to grower's landraces since genomic sequence information is available for the viruses identified. Prior to that, the selection of disease-free seed cane remains the solution in addition to the screening of seed cane and regular quarantine services when new sugarcane varieties are introduced. For the smut disease, the removal of infected plant materials in bags far away from the field and burning will reduce disease spread.

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