Vol. 14(7), pp. 280-288, July 2020
DOI: 10.5897/AJPS2020.2003
Article Number: 8B8EBFD64303
ISSN 1996-0824

http://www.academicjournals.org/AJPS

ACADEMIC JOURNALS
expand your knowledge

African Journal of Plant Science

*Full Length Research Paper*

# Evaluating the incidence and severity of rice yellow mottle virus and maize streak virus on rice (*Oryza sativa* L.) and associated insects in the Federal Capital Territory, Abuja, Nigeria

**Oladapo Oluwatobi Folarin[1,2*], Shatu Wudiri Asala[2], Akeem Abolade Oyerinde[2] and Tolani Islamiat Okelola[2]**

[1]National Agricultural Seeds Council, Abuja, Nigeria.
[2]Department of Crop Protection, Faculty of Agriculture, University of Abuja, Abuja, Nigeria.

Received 25 April, 2020; Accepted 26 June, 2020

**Rice is an important staple food in Nigeria, affected by several diseases especially viruses. This study was carried out to evaluate the incidence and severity of two important viruses on rice plants and to identify associated insects in the Federal Capital Territory (F.C.T), Abuja in 2019. Field experiment was carried out from June to October, 2019 at the Teaching and Research Farm of the Faculty of Agriculture, University of Abuja, Nigeria, where ten rice varieties were assessed for incidence and severity. The seed and leaf samples were collected for serological indexing. Data collected was subjected to statistical analysis using SPSS and mean separation was done with Duncan Multiple Range Test. Of the 210 leaf samples collected, FARO 61 and 44 had the lowest incidence (19%), while FARO 65 recorded the highest (25.3%). FARO 52 recorded the highest severity (46%) while FARO 61 and FARO 60 had the lowest severity (30.1%) for rice yellow mottle sobemo-virus (RYMV) and maize streak geminivirus (MSV). Insects such as Spittle bug (*Locris rubens* and *Poophilus costalis*), Ladybird beetle (*Cheilomenes sulphurea*) and Groundhopper (*Paratettix* sp) were trapped on the field. All rice seed and leaf samples collected did not test positive to RYMV and MSV using Enzyme-Linked immunosorbent assay (ELISA). This study provides the first research work on rice viruses in the FCT and further studies are recommended.**

**Key words:** Nigeria, rice, rice yellow mottle sobemo-virus (RYMV), maize streak geminivirus (MSV), incidence, severity, virus symptoms, enzyme linked immuno sorbent assay (ELISA).

## INTRODUCTION

In several West African countries namely Guinea Bissau, the Gambia, Guinea, Sierra Leone, Cote d'Ivoire, Liberia and Nigeria, rice has become a major component of diet. In 2000, rice represented a third of the total

*Corresponding author. E-mail: oladapo.folarin@gmail.com. Tel: +2348035619213.

**Table 1.** Ten varieties of rice planted on the experimental field at the Teaching and Research Farms, Faculty of Agriculture, University of Abuja, FCT

| S/N | Variety | Type | Source | Type |
|---|---|---|---|---|
| 1 | Faro 61 | Lowland | NCRI | Certified seeds |
| 2 | Faro 45 | Upland | NCRI | Certified seeds |
| 3 | Faro 47 | Upland | NCRI | Certified seeds |
| 4 | Faro 60 | Lowland | NCRI | Certified seeds |
| 5 | Pac 832 | Lowland | Premier seeds | Certified seeds |
| 6 | Faro 65 | Upland | NCRI | Certified seeds |
| 7 | Faro 44 | Lowland | NCRI | Certified seeds |
| 8 | Faro 52 | Lowland | NCRI | Certified seeds |
| 9 | Faro 64 | Upland | NCRI | Certified seeds |
| 10 | Faro 22 | Lowland | NCRI | Certified seeds |

cereal-derived calorie intake of the West African population (FAO, 2017). The increase in Nigeria's population has necessitated an increase in the level of food production, among which is rice. Rice (*Oryza sativa*) is one of the most widely grown crops in all parts of Nigeria with consumption per capita of 32 kg. In the past decade, consumption has increased by 4.7%, almost four times the global consumption growth, and 6.4 million tons in 2017, accounting for 20% of Africa's consumption (PwC, 2018). It is grown for market and home consumption. With the increased availability of rice, it has become part of the everyday diet of many in Nigeria.

In spite of the efforts made in increasing rice cultivation, yield has remained very low, thus, the production has not met the consumption level of the growing population (Ajala and Gana, 2015). Rice production in Nigeria is affected by pests, diseases and some other constraints. Some of the insect pests that usually affect rice are Planthoppers (*Laodelphax striatellus; Sogatella furcifera; Nilaparvata lugens*), Leafhoppers (*Nephotettix* spp), Beetles (*Cheilomenes* spp), Aphids (*Rhopalosiphum rufiabdominale*), Rice mealy bug (*Brevennia rehi*) and Stem borers (*Scirpophaga incertulas*) (Li et al., 2019; Hegde et al., 2016). Small holder farmers in Nigeria usually do not have access to low-interest credit facilities and this limits the rate of production of rice. Also, inadequate funding for research and extension in Africa especially Nigeria, is limiting the production of rice, as research and extension can be used to provide support for farmers to increase their production output (Osanyinlusi and Adenegan, 2016). Diseases such as: Fungus [Rice blast (*Magnaporthe grisea*) (Dean et al., 2005)], Nematodes [Stem nematode (*Ditylenchus dipsaci*), Root knot nematode (*Meloidogyne graminicola*)], Virus [Sobemovirus - Rice Yellow Mottle Virus (RYMV), Mastrevirus – Maize Streak Virus (MSV)], are also major constraints in the production of rice in Nigeria, causing low yield, low quality and sometimes yield loss. The viruses that have been reported to infect rice in West Africa and of economic importance are Grassy stunt disease (transmitted by *Nilaparvata lugens* Stal.), Orange leaf disease (transmitted by *Inazuma dorsalis* Motschulsky), Rice stripe necrosis virus (RSNV), Rice crinkle disease, Maize streak geminivirus (MSV), African cereal streak virus and RYMV (Abo and Sy, 1997). In Nigeria, RYMV has being the most prevalent causing a major challenge in rice production since 1976 when it was first reported (Rossel et al., 1982). Earlier studies done in the Southern part of Nigeria show the incidence of RYMV is up to 70% (Onasanya et al., 2011; Odedara et al., 2016). The adverse effect of viruses on rice production in Nigeria as well as limited information and literature on rice viruses in Abuja, necessitated this research with the objective to evaluate the incidence and severity of RYMV and MSV infecting rice and identify insects associated with rice production in Abuja.

## MATERIALS AND METHODS

### Research location

The field study was conducted between June to October, 2019 at the Teaching and Research Farm of the Faculty of Agriculture, University of Abuja, F.C.T, Nigeria. This location has Longitude and Latitude (8.9817° N, 7.1811° E) and an elevation of 273 m. The average annual rainfall in the FCT is 1350 mm (Balogun, 2001).

### Samples

Six lowland rain-fed and four upland rice varieties obtained from National Cereal Research Institute (NCRI) Badeggi and Premier Seeds Nigeria Ltd were used for this study. The rice varieties were identified by their new name FARO (Federal Agriculture Research Oryza) (Table 1).

### Experimental design

A Randomized Block Design (RBD) with three replications was used. The field was divided into three blocks with 10 plants of each variety. Plots size was 3 m × 3 m with plant spacing of 0.3 m × 0.3

m. Distance between replications was 1 m and distance between each plot was 0.5 m, with a total field size of 34.5 m × 11 m. Sowing was done by direct seeding with 3 seeds per hole.

**Cultural practices**

Layout and pegging of the field was done followed by land clearing; this was done with hand labor, and this involved removing of stumps, brush, stones and other obstacles from the field. This was followed by ploughing in order to break up the soil; harrowing and leveling was then done afterwards to produce fine tilth. The land preparation activities were done before the onset of the rain, in order to create a favorable environment for the rice plants to germinate. The rice plants were thinned from 3 plant stand per hole to 1 plant stand per hole and empty spaces were gap filled 3 weeks after planting (WAP), in order to allow the plants receive proper growth requirements and avoid competition. Selective herbicide (2,4-D) was used to control weeds on the field at 3, 6 and 9 WAP. Compound fertilizer (NPK 15-15-15) was added using basal application at 6 and 10 WAP respectively. A scarecrow was erected and catapult was used in order to control birds. Also, fence was erected with bamboo and chicken wire mesh round the field to control cattle, goats, rats and grass-cutters. Rogueing was also done by removing off-types and weeds between headings to harvesting. Harvesting was done at maturity (19-20 WAP) by cutting the rice stands close to the ground level with the use of a sickle, after the rice panicle changed color from green to yellow/brown and became hard.

**Data collection**

Data was collected on germination percentage, virus disease incidence and severity of 270 rice plants belonging to 10 varieties and 3 replicates as well as weather data for 2019.

**Germination percentage**

Germination percentage was estimated 3 weeks after planting, by counting the number of seeds that germinated and expressed as a percentage of the total number of seeds planted.

$$\text{Germination (\%)} = \frac{No\ of\ seeds\ that\ germinated}{Total\ no\ of\ seeds\ planted} \times 100$$

**Assessment of incidence**

Disease incidence was estimated by counting the number of plants that expressed virus-like symptoms by close observation and recording of each symptom type and expressed as a percentage of the total number of plants assessed.

$$\text{Disease incidence (\%)} = \frac{No\ of\ symptomatic\ \ plants}{Total\ no\ of\ plants\ \ sampled} \times 100$$

**Assessment of severity**

Symptom severity was done by scoring plants showing virus-like symptoms (7 per plot). This was done by visual assessment and using a modification of the Standard Evaluation System (SES) of International Rice Research Institute (1996) on a scale of 1-9. Where 1 = No symptom observed, 3 = Leaves green but with sparse streaks and less than 5% symptoms on leaves, 5 = Leaves green or pale green with mottling and 6-25% symptoms on leaves, 7 = Leaves pale, yellow and 26-75% symptoms on leaves, 9 = Leaves turn yellow or orange with more than 75% symptoms on leaves and some plants dead.

$$\text{Disease severity (\%)} = \frac{Sum\ of\ all\ disease\ \ ratings}{No\ of\ plants\ \ assessed} \times \text{maximum score (100)}$$

**Weather data**

The weather data (Temperature, Hours of sunshine, Relative humidity and Rainfall) for the year of experiment (2019) was gotten from the Nigeria Meteorological Agency (NiMet).

**Insect trapping**

Insects were trapped and collected on the field by using plastic bucket traps filled with one-quarter solution of water, 70% ethanol (as a preservative) and 1.5% teepol detergent. The trap was monitored periodically and the liquid in the trap containers were changed after every collection. Insects collected at the end of the experiment were sent to the Insect Museum, Department of Crop Protection, Ahmadu Bello University (ABU), Zaria, for identification.

**Collection of samples**

***Seed samples***

Rice seed samples of each variety planted were collected before planting. The samples were taken to the Virology and Molecular Diagnostic laboratory of the International Institute of Tropical Agriculture (IITA), Ibadan, for virus indexing using Enzyme Linked Immuno Sorbent Assay (ELISA).

***Leaf samples***

Young leaf samples were collected at 8 weeks after planting (WAP) from plants that showed typical virus-like symptoms and also from weed on and around the rice field. Collected leaf samples were placed in 25 ml plastic bottles containing Calcium Chloride ($CaCl_2$). Each sample was prevented from direct contact with the $CaCl_2$, with the placement of piece of non-absorbent cotton wool in between, before being grounded and later placed into vials which were analysed using ELISA.

**Serological tests**

***Detection of virus in seed samples using antigen-coated plate enzyme linked immunosorbent assay (ACP-ELISA)***

Ten rice seed samples (made up of husk, endosperm and embryo) were collected from the 10 different rice varieties before planting and indexed for viruses using ACP-ELISA as described by Afolabi et al. (2009). The rice seed samples collected were indexed for RYMV and MSV. The method and protocol used in detecting these viruses from samples using ELISA is as follows.

10 seed samples were drawn from each of the 10 rice varieties, weighed and subjected to the Antigen Coated Plate (ACP) form of Enzyme Linked Immunosorbent Assay (ELISA). The seed samples were ground with mortar and pestle in 2 ml of extraction buffer [8 g sodium chloride, 0.2 g monobasic potassium phosphate, 1.15 g diabasic sodium phosphate, 0.2 g potassium chloride, 0.2 g sodium azide dissolved in 900 ml $H_20$ adjusted to pH 7.4 with HCl to make

**Table 2.** Effect of varietal difference on germination percentage, plant height and number of leaves of rice during growing season 2019 in Abuja, Nigeria.

| Variety | Germination % | Plant height (cm) | | | No. of leaves | | |
|---|---|---|---|---|---|---|---|
| | | Week3 | Week6 | Week9 | Week3 | Week6 | Week9 |
| FARO 61 | 90.33$^{b}$ | 15.61$^{f}$ | 31.41$^{a}$ | 56.12$^{e}$ | 5.23$^{c}$ | 7.52$^{d}$ | 10.04$^{d}$ |
| FARO 45 | 91.66$^{b}$ | 17.14$^{c}$ | 37.50$^{a}$ | 80.55$^{a}$ | 5.80$^{a}$ | 8.42$^{a}$ | 11.57$^{a}$ |
| FARO 47 | 91.33$^{b}$ | 16.69$^{d}$ | 39.44$^{a}$ | 65.19$^{c}$ | 4.95$^{c}$ | 7.66$^{cd}$ | 10.80$^{bc}$ |
| FARO 60 | 69.66$^{d}$ | 18.18$^{a}$ | 23.79$^{a}$ | 51.47$^{e}$ | 5.19$^{c}$ | 8.00$^{bc}$ | 10.52$^{bcd}$ |
| PAC 832 | 84.66$^{c}$ | 14.60$^{h}$ | 25.24$^{a}$ | 58.82$^{e}$ | 5.42$^{b}$ | 8.09$^{ab}$ | 11.14$^{abc}$ |
| FARO 65 | 82.00$^{c}$ | 15.60$^{f}$ | 29.80$^{a}$ | 62.34$^{d}$ | 4.95$^{c}$ | 7.71$^{bcd}$ | 10.42$^{cd}$ |
| FARO 44 | 80.33$^{c}$ | 15.84$^{e}$ | 32.62$^{a}$ | 61.08$^{d}$ | 5.42$^{b}$ | 8.09$^{ab}$ | 10.66$^{bcd}$ |
| FARO 52 | 96.66$^{a}$ | 17.84$^{b}$ | 33.30$^{a}$ | 67.85$^{b}$ | 5.80$^{a}$ | 8.00$^{bc}$ | 10.90$^{abc}$ |
| FARO 64 | 80.33$^{c}$ | 14.75$^{g}$ | 34.89$^{a}$ | 69.20$^{b}$ | 5.66$^{a}$ | 8.42$^{a}$ | 11.28$^{ab}$ |
| FARO 22 | 72.00$^{d}$ | 14.72$^{g}$ | 29.73$^{a}$ | 55.62$^{e}$ | 5.19$^{c}$ | 7.76$^{bcd}$ | 10.95$^{abc}$ |

Means in the same column with different alphabets are significantly different at P ≤ 0.05.

up (1 l) + 0.5 ml Tween 20/L and 2% polyvinyl pyrollidone (PVP)]. The 96 polystyrene microtitre plates were labeled and coated with 100 µl of antigen 1/10 in coating buffer with 1% Dieca, covered and incubated for 1 hour at 37°C. The plates were removed, washed with PBS-Tween thrice at 3 min interval and tap dried. Blocking was done with 200 µl per well of 3% dried skimmed milk in PBS-Tween to trap the virus and incubated at 37°C for 30 min to enable binding. The plates were removed and washed as stated above. 100 µl of sap of healthy cowpea leaf samples mixed with pool of antibodies (21 different vegetable and cowpea antibodies were mixed together) was added into wells and incubated for 2 h at 37°C. Plates were removed and washed. Then, 100 µl enzyme goat anti-rabbit antibody diluted at 1:2000 was added to wells and incubated then washed as above. Substrate pNPP in substrate buffer at 3 mg in 30 ml was added into wells and kept for change in color. The optical density (OD) of the content of each well was subsequently read after 4 h and overnight respectively using ELISA reader (Diagnostic and Medical Solutions Micro Plate Read - ELISA Plate Analyzer) at a wavelength of 405 nm.

***Detection of viruses in leaf samples using antigen-coated enzyme linked immunosorbent assay (ACP-ELISA)***

A total of 210 rice leaf samples (7 per plot) were collected from the field and indexed for Rice Yellow Mottle Virus (RYMV) and Maize Streak Virus (MSV). 0.1g of leaf sample was weighed and grinded with mortar and pestle in 1 ml of extraction buffer [8 g sodium chloride, 0.2 g monobasic potassium phosphate, 1.15 g diabasic sodium phosphate, 0.2 g potassium chloride, 0.2 g sodium azide dissolved in 900 ml $H_2O$ adjusted to pH 7.4 with HCl to make up (1 l) + 0.5 ml Tween 20/L and 2% polyvinyl pyrollidone (PVP)]. The 96 polystyrene microtitre plates were labeled and coated with 100 µL of antigen 1/10 in coating buffer with 1% Dieca, covered and incubated for 1 h at 37°C. The plates were removed, washed with PBS-Tween thrice at 3 min interval and tap dried. Blocking was done with 200 µl per well of 3% dried skimmed milk in PBS-Tween to trap the virus and incubated at 37°C for 30 min to enable binding. The plates were removed and washed as stated above. 100 µl of sap of healthy cowpea leaf samples mixed with pool of antibodies (21 different vegetable and cowpea antibodies were mixed together) was added into wells and incubated for 2 h at 37°C. Plates were removed and washed. Then, 100 µl enzyme goat anti-rabbit antibody diluted at 1:2000 was added to wells and incubated then washed as above. Substrate pNPP in substrate buffer at 3 mg in 30 ml was added into wells and kept for change in color. The optical density (OD) of the content of each well was subsequently read after 4 h and overnight respectively using ELISA reader (Diagnostic and Medical Solutions Micro Plate Read - ELISA Plate Analyzer) at a wavelength of 405 nm.

***Detection of viruses in weed samples using antigen-coated enzyme linked immunosorbent assay (ACP-ELISA)***

Ten weed samples were collected from within, inside and outside the field and indexed for RYMV and MSV. The ELISA protocol used for detection of RYMV and MSV as described for rice leaf samples above was used.

**Data analysis**

Rice virus disease incidence and severity was calculated based on the number of plants sampled on the field. Germination percentage, percentage disease incidence and mean severity were calculated. The data were subjected to statistical analysis using Statistical Package for the Social Sciences (SPSS) version 16.0. Mean separation was done with Duncan Multiple Range Test.

## RESULTS

### Growth of rice from the field study

Table 2 shows the effect of varietal difference on the growth of rice from the field study in Abuja in 2019. The variety FARO 52 recorded the highest germination percentage of seed (96.66%) while FARO 60 recorded the lowest germination percentage of seed (69.66%). At 3 weeks after planting (WAP), FARO 60 had the highest plant height (18.18 cm); while FARO 22 had the shortest plants (14.72 cm). At 6 WAP FARO 47 recorded the tallest plant height (39.44 cm) while FARO 60 recorded

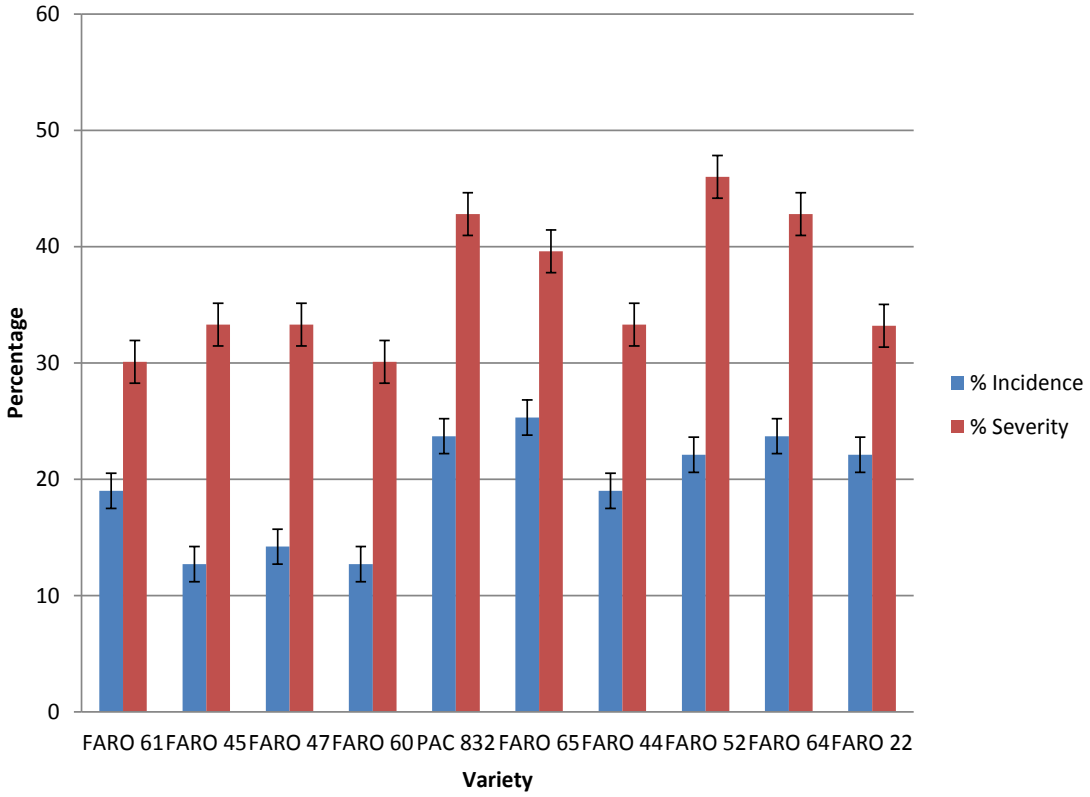


**Figure 1.** The mean incidence and severity of important viruses infecting rice (*Oryza sativa* L.) in Abuja, FCT in 2019.

the shortest plant height (23.79 cm). The variety FARO 45 recorded the highest plant height (80.55 cm) at 9WAP while the lowest plant height was recorded on FARO 60 (51.47 cm). After analysis, the number of leaves per plot at 3 WAP for FARO 45 and FARO 52 were the highest (5.80) while the lowest was recorded on FARO 47 and FARO 65 (4.95). At 6 WAP, FARO 45 and FARO 64 recorded the highest number of leaves (8.42) while FARO 61 recorded the lowest number of leaves (7.52). FARO 45 recorded the highest number of leaves (11.57) at 9WAP while FARO 61 had the lowest number of leaves (10.04).

## Collection of leaf samples from field study

Five different virus-like phenotypic symptoms were expressed on leaf surfaces on the field in different proportions. The most common symptom observed was yellowing of leaves (Costa et al., 2018; Ndikumana et al., 2015) followed by necrosis, orange discolouration and dark patches.

## Incidence and severity

From the 210 leaf samples collected from the field study and according to visual assessment of virus-like symptoms, FARO 61 and 44 recorded the lowest mean percentage incidence (19%); while FARO 65 recorded the highest mean percentage incidence at 25.3% (Figure 1). Results also showed that FARO 52 recorded the highest mean percentage severity (46%), while FARO 61 and FARO 60 recorded the lowest mean percentage incidence (30.1%).

## Virus detection in rice seeds and leaves by ELISA

The seed samples of the ten rice varieties that were also indexed using ELISA did not test positive to RYMV and MSV. Also, all the leaf samples collected from the field study indexed for RYMV and MSV using ELISA did not test positive to RYMV and MSV (Figure 2). The absorbance values at spectrophotometric wavelength of 405 nm were not up to one and half times the values of the healthy controls after the one hour reading and overnight reading.

## Virus detection in weeds by ELISA

The weed samples which were collected from the field study 8 weeks after planting rice were indexed for RYMV

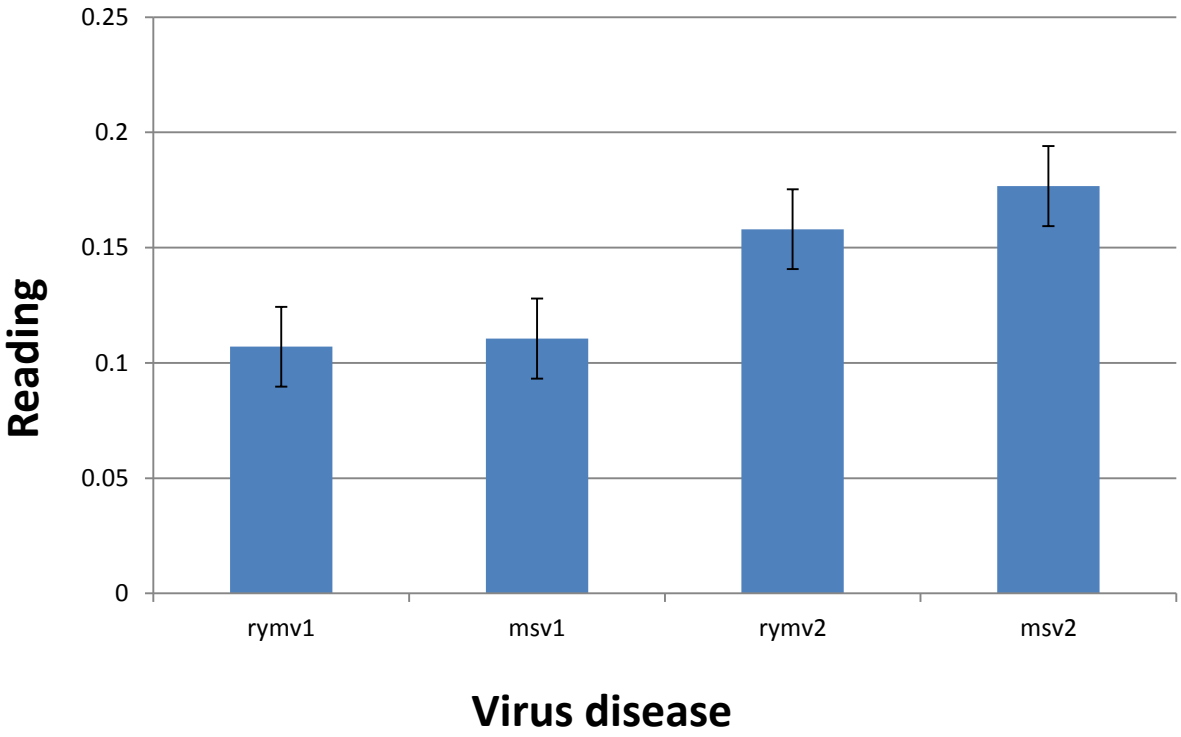


**Figure 2.** Result of Rice seed and leaf samples indexed for RYMV and MSV using ELISA. RYMV, Rice yellow mottle virus; MSV, maize streak virus; 1. One hour reading; 2, Overnight reading.

and MSV using ELISA did not test positive to RYMV and MSV (Figure 3). The absorbance values at spectrophotometric wavelength of 405 nm were not up to one and half times the values of the healthy controls after the 1 h reading and overnight reading.

### Insects associated with rice production

From the field study, 5 insects were identified to be associated with rice production in the FCT (Table 3). The insects identified were Spittle bug (*Locris rubens* and *Poophilus costalis*), Ladybird beetle (*Cheilomenes sulphurea*), Groundhopper (*Paratettix sp*) and Grasshopper (*Catantops* sp). Ladybird beetle (*Cheilomenes sulphurea*) was found to occur more on the rice field. The two spittle bugs that were identified were of different family, genus and species but of same order (Homoptera). Furthermore, the grasshopper that was identified was at the nymphal stage.

### Weather data for 2019 rice growing season in F.C.T

The weather report in 2019 indicated that mean temperature was highest (26.4°C) during the early month of rice planting in June and the end of the season in November. The remaining months (July to October) recorded relatively lower temperatures with the lowest mean temperature (24.6°C) recorded in September towards the ending of the growing season. The longest sunshine (8.3 h) was recorded in November while the lowest (2.1 h) was recorded in August. The months of June and July recorded same duration of sunshine (3.9 h) and a short decline in sunshine hours (4.6- 4.9 h) was indicated from September to October. The highest rainfall (243 mm) during the growing season was recorded in September. There was a steady increase in monthly rainfall from the beginning of the growing season in June till September (114.6-243 mm) with a sharp decline recorded between October and November (199.9 and 50.7 mm). Relative humidity was highest (88%) in August while the lowest (68%) was recorded in November. There was a decline in relative humidity from June to July (82 - 84%) and another decline was recorded from September to November (83 - 68%) (Table 4).

## DISCUSSION

This study provides information on the incidence and severity of two important viruses infecting rice in Nigeria. The samples collected from the field experiment were indexed for RYMV and MSV. The serological diagnosis showed that rice seed samples from the 10 varieties planted on the field were not positive to RYMV and MSV.

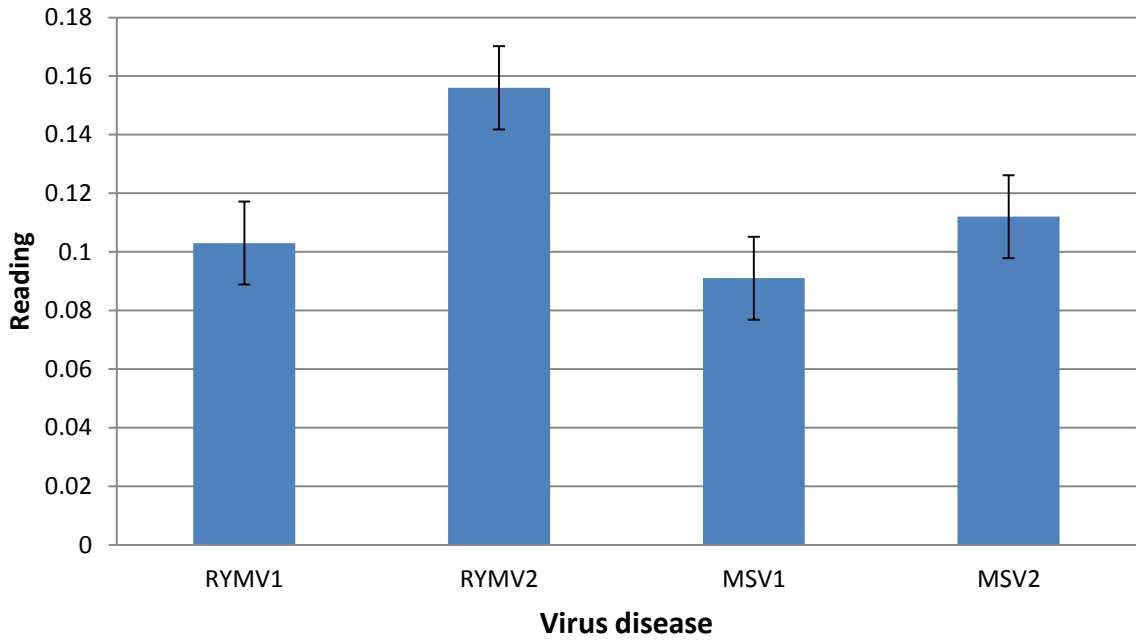


**Figure 3.** Result of weed samples indexed for RYMV and MSV using ELISA. RYMV, Rice Yellow Mottle Virus; MSV, Maize Streak Virus; 1, One hour reading; 2, Overnight reading.

**Table 3.** Identification of insect pest associated with Rice production from the field study in Abuja, F.C.T.

| S/N | Order | Family | Common Name | Genus | Species | Author | Status |
|---|---|---|---|---|---|---|---|
| 1 | Homoptera | Cercopidae | Spittle bug | Locris | Rubens | Erichson | Vector |
| 2 | Coleoptera | Coccinellidae | Ladybird beetle | Cheilomenes | Sulphurea | Olivier | Vector |
| 3 | Orthoptera | Acrididae | Grasshopper | Catantops | sp. (Nymph) | | Vector |
| 4 | Homoptera | Aphrophoridae | Spittle bug | Poophilus | Costalis | Walker | Vector |
| 5 | Orthoptera | Tetrigidae | Groundhopper | Paratettix | sp. | | Vector |
| 6 | Coleoptera | Coccinellidae | Ladybird beetle | Cheilomenes | Sulphurea | Olivier | Vector |

This could be due to the fact that the samples were certified seeds which met the required minimum standards of seed certification before they can be marketed as seeds (Seed Act, 2019). This can also be attributed to the non-transmission of these viruses through seeds as reported by Konate et al. (2001). The collected leaf samples showing virus-like symptoms of viral infection did not test positive to RYMV and MSV

**Table 4.** Weather data for 2019 during the rice growing season in Abuja.

| Month | Mean temperature (°C) | Sunshine (h) | Rainfall (mm) | Humidity (%) |
|---|---|---|---|---|
| June | 26.4 | 3.9 | 114.6 | 82 |
| July | 25.8 | 3.9 | 140.6 | 84 |
| August | 24.7 | 2.1 | 226.7 | 88 |
| September | 24.6 | 4.6 | 243 | 83 |
| October | 25.0 | 4.9 | 199.9 | 80 |
| November | 26.4 | 8.3 | 50.7 | 68 |

using ELISA. Although the symptoms observed on the field were the usual symptoms of RYMV and MSV which had been described by Thottappilly and Rossel (1993) and Fauquet et al. (1988), the observed symptoms could have been caused by abiotic factors often related to physical factors, environmental factors or cultural practices. The high and consistent rainfall recorded in 2019 rice growing season could have been responsible for the low vector population and absence of infection, as the vectors would have been washed away. The two viruses that were selected for detection have been reported in other West African countries as well as some parts of Nigeria (Sere et al., 2008; Banwo et al., 2004; Alegbejo, 2013; Oludare et al., 2015; Odedara et al., 2016; Onasanya et al., 2011). Odedara (2016) reported from surveys carried out in Ogun State in 2012 the presence of RYMV in 7.7% of leaf samples collected and tested from Ewekoro Local Government Area (LGA) and 13.3% from leaf samples collected and tested from Obafemi Owode LGA. Further survey in 2013 recorded the presence of RYMV in 30.0% of leaf samples collected and tested in Ewekoro LGA, while Obafemi Owode recorded 90.0%. Though there have been reports of alternate hosts like weeds, harbouring these viruses (Awoderu, 1991; Konate et al., 1997; Okioma et al., 1983), the weed samples collected from the field for detection also did not test positive to the rice viruses.

The symptoms observed on these plants may have been caused by other viruses that were not identified or yet to be identified. The absence of RYMV and MSV in this study could also be due to low concentration of virus in the samples (Lacroix et al., 2016). In addition, the results recorded in this research may be attributed to the level of resistance or susceptibility of the rice varieties tested to the virus diseases (Arli-Sokmen et al., 2016; Mwaipopo et al., 2017). Previous reports by Abo et al., (2005) and Salaudeen (2012) show that some rice varieties (such as FARO 52) possess resistance to RYMV, although further classification has been recommended to aid breeding for resistance.

Bakker (1970) reported that RYMV was sometimes transmitted by biting insects such as grasshopper (*Conocephalus*); but all leaf samples indexed were not positive to RYMV and MSV, this may be because the insects were not able to transmit any virus. Most of the identified insects (*Locris rubens*, *Poophilus costalis, Cheilomenes sulphurea* and *Paratettix* spp) have been reported by Koudamiloro et al. (2014) to be found on rice fields in Burkina Faso, Cameroon, Mali, Nigeria and other parts of West Africa. The insects have also been confirmed as vectors of viral diseases infecting rice and have the capacity to cause extreme damage to the rice plant (Koudamiloro et al., 2019; Asala and Alegbejo, 2016). This study provides the first research on rice viruses in the Federal Capital Territory, Abuja and since epidemiologically, viral diseases are not static, further field trials and survey studies are recommended.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

## ACKNOWLEDGMENTS

The authors wish to sincerely thank the Management of the National Agricultural Seeds Council (NASC), Abuja, Nigeria and the International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria for their support during the research.

### REFERENCES

Abo ME, SY AA (1997). Rice Virus Diseases: Epidemiology and Management Strategies, Journal of Sustainable Agriculture 11:2-3, 113-134.

Abo ME, Gana AS, Maji AT, Ukwungwu MN, Imolehin ED (2005). The Resistance of Farmers' Rice Varieties to Rice Yellow Mottle Virus (RYMV) at Badeggi, Nigeria. Tropicultura 23(2):100-104.

Afolabi SK, Akator SK, Abo EM, Onasanya A, Séré Y (2009). Production of polyclonal antibodies to various strains of Rice yellow mottle virus (RYMV) obtained across different agro-ecological zones in West Africa. Science Research Essay 4:306-309.

Ajala AS, Gana A (2015). Analysis of Challenges Facing Rice Processing in Nigeria. Journal of Food Processing pp. 1-6.

Alegbejo MD (2013). Virus and virus-like diseases of crops in Nigeria. Kaduna, Nigeria: Ahmadu Bello University Press.

Arli-Sokmen M, Deligoz I, Kutluk-Yilmaz ND (2016). Characterization of Bean common mosaic virus and Bean common mosaic necrosis virus isolates in common bean growing areas in Turkey. European Journal of Plant Pathology 146:1-16.

Asala SW, Alegbejo M (2016). Effects of serial planting of seed yam

tubers on virus incidence and yam tuber degeneration. African Crop Science Journal 24:341.
Awoderu VA (1991). Rice yellow mottle virus in West Africa. Tropical Pest Management 37:356-362.
Bakker W (1970). Rice yellow mottle, a mechanically transmissible virus disease of rice in Kenya. Neth. Journal of Plant Patholology 76:53-63.
Balogun O (2001). The Geography of Its Development, The Federal Capital Territory. Ibadan, Nigeria: University Press.
Banwo OO, Alegbejo MD, Abo ME (2004). Rice yellow mottle virus genus Sobemovirus: A continental problem in Africa. Plant Protection Science 39:26-36.
Costa T, Blawid R, Aranda M, Freitas D, Andrade G, Inoue-Nagata A, Nagata T (2018). Cucurbit aphid-borne yellows virus from melon plants in Brazil is an interspecific recombinant. Archives of Virology 164(1):249-254.
Dean RA, Talbot NJ, Ebbole DJ, Farman ML, Mitchell TK, Orbach MJ, Thon M, Kulkarni R, Xu JR, Pan H, Read ND, Lee YH, Carbone I, Brown D, Oh YY, Donofrio N, Jeong JS, Soanes DM, Djonovic S, Kolomiets E, Rehmeyer C, Li W, Harding M, Kim S, Lebrun MH, Bohnert H, Coughlan S, Butler J, Calvo S (2005). The genome sequence of the rice blast fungus *Magnaporthe grisea*. Nature 434(7036):980–86.
Fauquet C, Thouvenel D, Fargette D, Fishpool C (1988). Rice stripe necrosis virus: a soil-borne rod-shaped virus. Developmental Applied Biology 2:71.
Food and Agriculture Organization of the United Nations (2017). FAOSTAT Statistical Database “Crops/Regions/World list/Production Quantity (pick lists), Rice (paddy), 2017”. (Rome): FAO. Archived from the original on May 11, 2017. Retrieved (2019)
Hegde M, Girish VP, Balikai R (2016). Field efficacy of some new insecticides against rice yellow stem borer *Scirpophaga incertulas* and effect on yield. Journal of Experimental Zoology 19:583-586.
International Rice Research Institute (IRRI) (1996). The International Rice Testing Program – Standing Evaluation System (ITP-SES) for Rice, Los Baños, Laguna, The Philippines. 4th Edition.
Konate G, Traore O, Coulibaly NN (1997). Characterization of Rice yellow mottle virus isolates in Sudan-Sahelian areas. Archives of Virology 1425:1117-1129.
Konate G, Sarra S, Traoré O (2001). Rice yellow mottle virus is seed borne but not seed transmitted in rice seeds. European Journal of Plant Pathology 107:361-364.
Koudamiloro A, Nwilene FE, Silue D (2014). Identification of insect vectors of Rice Yellow Mottle Virus (RYMV) in Benin. Journal of Entomology 11(3):153-162.
Koudamiloro A, Togola A, Djihinto A, Douro-Kpindou O, Akogbeto M (2019). Survey of potential insect vectors of Rice Yellow Mottle Virus in the Southern and Central rice basin of Benin. Journal of Applied Biosciences 133:13504 -13515.
Lacroix C, Renner K, Cole E, Seabloom EW, Borer ET, Malmstrom CM (2016). Methodological Guidelines for Accurate Detection of Viruses in Wild Plant Species. Applied and Environmental Microbiology 82(6):1966-1975.
Li F, Hua H, Ali A, Hou M (2019). Characterization of a Bacterial Symbiont *Asaia* sp. in the White-Backed Planthopper, *Sogatella furcifera*, and Its Effects on Host Fitness. Frontiers in Microbiology 10:2179.
Mwaipopo B, Nchimbi-Msolla S, Njau P, Tairo F, William M, Binagwa P, Kweka E, Kilango M., Mbanzibwa D (2017). Viruses infecting common bean (*Phaseolus vulgaris* L.) in Tanzania: A review on molecular characterization, detection and disease management options. African Journal of Agricultural Research 12(18):1486-1500.
Ndikumana I, Galzi-Pinel A, Mzengeza T, Msolla SN, Njau P, Choi IR, Murori R, Bigirimana J, Fargette D, Hébrard E (2015). First report of Rice yellow mottle virus in rice in Malawi. Plant Disease 99(6):899.
Odedara OO, Ademolu KO, Ayo-John EI (2016). Prevalence of Rice Yellow Mottle Virus (RYMV) on Rice Plants Grown in Selected Farms in Ogun State: Preliminary Results. Nigeria Journal of Biotechnology, pp. 96-102.
Okioma SN, Muchoko RN, Gathuru EM (1983). Alternate hosts of Rice yellow mottle virus in the Lake Victoria basin in Kenya. Tropical Pest Management 29:25-29.
Oludare A, Sow M, Afolabi O, Pinel-Galzi A, Hébrard E, Silué D (2015). First Report of Rice stripe necrosis virus Infecting Rice in Benin. Plant Disease 99:735.
Onasanya RO, Olufolaji DB, Onasanya A, Sere Y, Nwilene FF, Woperels M, Kiepe P (2011). Occurrence, distribution and characterization of Rice yellow mottle virus isolates genus Sobemovirus in Southwestern Nigeria. Trends in Applied Science Research 6:1301-1323.
Osanyinlusi OI, Adenegan KO (2016). The Determinants of Rice Farmers' Productivity in Ekiti State, Nigeria. Greener Journal of Agricultural Sciences 6(2):049-058.
PricewaterhouseCoopers (PwC) (2018). Boosting rice production through increased mechanization. Lagos: PwC Publications. Available at: https://www.pwc.com/ng.
Rossel HW, Thottapilly G, Buddenhagen IW (1982). Occurrence of rice yellow mottle virus in two important rice-growing areas of Nigeria. FAO Plant Protection Bulletin 30(3/4):137-139.
Salaudeen MT (2012). Resistance in rice to *Rice yellow mottle virus* and evidence of non-seed transmission. Archives of Phytopathology and Plant Protection 45(20):2406-2413.
Sere Y, Onasanya A, Nwilene FE, Abo ME, Akator K (2008). Potential of insect vector screening method for development of durable resistant cultivars to rice yellow mottle virus disease. International Journal of Virology 4:41-47.
Seed Act (2019). National Agricultural Seeds Council. Available at: https://seedcouncil.gov.ng/uploads/2020/07/Official-Gazatte-No.-142B-NASC-Act-2019.pdf.
Thottappilly G, Rossel HW (1993). Evaluation of resistance to Rice yellow mottle virus in *Oryza* species. Indian Journal of Virology 9(1):65-73.