INCIDENCE AND SEVERITY OF FUNGAL AND COMMON VIRAL DISEASES OF SOME SOYBEAN LINES IN A DERIVED GUINEA SAHANNA AGRO-ECOLOGY

Shina SALIHU1,2*, Clement Gboyega AFOLABI2, Mariam Olugbemileke OTUSANYA2, David Kolawole OJO3, Nahemiah DANBABA1, Shakiru Adewale KAZEEM4

1 National Cereals Research Institute Badeggi, Ibadan Research Station – Nigeria.
2 Department of Crop Protection, College of Plant Science and Crop Production, Federal University of Agriculture Abeokuta – Nigeria.
3 International Institute of Tropical Agriculture, Ibadan – Nigeria.
4 General and Biotechnology Unit, Nigeria Agricultural Quarantine Service, Moor Plantation, Ibadan – Nigeria.

* Corresponding author. E-mail: shinashining2012@gmail.com, ORCID: 0000-0002-3236-6969

Abstract: Nigeria is the largest producer and consumer of soybean in Sub-Saharan Africa with a low yield of less than 1 ton per hectare. Plant diseases play a major role in yield reduction for the crop. The study was to investigate the incidence and severity of fungal and common viral diseases of some soybean lines and determine their effects on soybean yield. Nineteen newly developed soybean lines with two local checks were evaluated. Fungal isolates were identified using cultural and morphological characteristics while Antigen Coated Plate-Enzyme-Linked Immunosorbent Assay was used for detecting viruses. Data were subjected to Analysis of Variance and means were separated at $P \leq 0.05$ using Duncan’s Multiple Range Test. Eight fungi isolated from diseased soybean plants were Fusarium oxysporum, Choanephora infundibulifera, Colletotrichum gloeosporioides, Culvularia spp., Fusarium verticilloides, Aspergillus flavus, Lasiodiplodia theobromae and Pestalotia spp., while the common viral symptom on the field was mosaic and mottling. F. oxysporum recorded the highest frequency of occurrence of 40.91% and 22.30%, in both years. F. oxysporum and C. infundibulifera showed characteristics symptoms of blight when used for pathogenicity on both checks. The soybean lines differed significantly [$P \leq 0.05$] in disease incidence and severity for both fungi and viral diseases. All lines were positive for Cowpea mild mottle virus [CPMMV] in 2016. All the lines evaluated were moderately resistant to leaf blight disease. The study concluded that these lines were tolerant to all observable diseases occasioned by their abilities to produce higher grain yield compared with the local checks, despite the high disease incidence and severity.

Keywords: Cowpea mild mottle virus, Fusarium blight, Fusarium oxysporum, incidence and severity, leaf blight, resistant.

Introduction

Soybean (Glycine max L.) is one of the most important oilseeds crop all over the world [ANONYMOUS, 2018] widely cultivated in tropical, subtropical, and temperate climates of the world [IITA, 2009]. The spread of the crop from its native land of origin has been mainly due to its adaptability and predominant use as a food crop for human nutrition, source of protein for animals, medicinal plant and lately as an industrial crop [YUSUF & IDOWU, 2001]. This legume provides cheap and high-quality protein, containing all amino acids essential for human nutrition when compare to meat and eggs. The crop can be successfully grown in many states of the country, using low agricultural input. Its cultivation

Received: 11 June 2022 / Revised: 1 December 2022 / Accepted: 6 December 2022
in Nigeria has expanded as a result of its nutritive and economic importance and diverse domestic usage. Soybean has an average protein content of 40% and is more protein-rich than any of the common vegetable or animal food sources found in Nigeria. When oil is extracted from soybean the residue left is used as protein supplement in livestock feeds. Soybean seeds also contain about 20% oil on a dry matter basis, and this is 85% unsaturated and cholesterol-free [DUGJE & al. 2009].

Nigeria is the largest producer and consumer of soybean in Sub-Saharan Africa with a low yield of less than 1 ton per hectare [IITA, 2009]. Several factors are attributed to this low yield, such as climatic conditions, differences in rainfall patterns, outbreak of diseases and pests etc. Among these factors, plant diseases play a major role in yield reduction for the crop. The increase in the number of soybean diseases and their expansion emanate from intensive production and increased acreage in new regions of the world [HARTMAN & al. 2005]. More than 300 diseases have been reported to affect soybean worldwide [HARTMAN & al. 1999; HARTMAN & al. 2005]. All parts of soybean plant are susceptible to a number of pathogens which reduce quality and/or quantity of seed yield, due to the facts that propagules of various pathogens have increased to densities that cause economic yield losses [HARTMAN & al. 2005].

Among the devastated diseases of soybean are, *Fusarium* blight or wilt disease of soybean, caused by the common soil-borne fungus *Fusarium oxysporum*; it is one of the most destructive diseases of soybean [HASHEM & al. 2009; FAYZALLA & al. 2009]. The pathogen can affect soybeans at any stage of development [FERRANT & CARROLL, 1981]. *F. oxysporum* can also cause root rot and wilt disease of soybean [RAHMAN & al. 2020] *Fusarium* blight symptoms are more noticeable under reduced moisture and hot conditions. The pathogen is difficult to control owing to its persistence nature in the soil and wide host range [ABDEL-MONAIM & al. 2011]. *Phytophthora sojae* causes seedling blight, root and stem rot, this disease is rapidly becoming a very destructive disease in Nigeria [DUGJE & al. 2009]. Asian soybean rust, caused by *Phakopsora pachyrhizi*, is another important soybean foliar disease in Nigeria. The infected leaves have small tan to dark brown or reddish-brown lesions on which small raised pustules occur on the lower surface of the leaves, severe infection leads to premature defoliation and yield losses up to 80% had been recorded [DUGJE & al. 2009]. The crop is also, susceptible to several viruses transmitted by aphids, beetles and whiteflies prevailing in Nigeria, Cowpea mild mottle virus (CPMMV; genus *Carlavirus* transmitted by whitefly (*Bemisia tabaci*) is the most prevalent virus associated with soybean mosaic disease in Nigeria [DUGJE & al. 2009]. Infection with Soybean mosaic virus (SMV) causes mosaic symptoms (light and dark green areas, chlorosis, and leaf curl), necrosis (necrotic areas, stem browning, and stem tip necrosis), and seed mottling, resulting in serious yield losses [ZHENG & al. 2005], yield losses due to SMV infection range from 8% to 50% under natural field conditions [HILL, 1999], to total crop loss during severe outbreaks [LIAO & al. 2002].

Hence, the objectives of this study were, to investigate the incidence and severity of fungal and common viral diseases of some soybean lines, confirm the pathogenicity of the isolates and to determine their effects on soybean yield.
Materials and methods

Experimental site

This study was carried out during the 2015 late cropping season and 2016 early cropping season at Research Farm of National Cereal Research Institutes, Ibadan Research Station, Latitude 7º22' N and Longitude 3º58' E with mean annual rainfall of 1150-1250 mm.

Soybean Lines used

The lines are Early lines: TGx 1990-40F, TGx 1989-48FN, TGx 1989-68FN, TGx 1990-55F, TGx 1989-40F, TGx 1990-52F, TGx 1989-49FN, TGx 1990-57F, TGx 1990-55F, TGx 1485-1D (Check). Medium lines: TGx 1989-45F, TGx 1989-11F, TGx 1989-75FN, TGx 1990-114FN, TGx 1990-78F, TGx 1993-4FN, TGx 1989-53FN, TGx 1990-95F, TGx 1989-42F, TGx 1990-110FN, TGx 1448-2E (Check), and were collected from International Institute for Tropical Agriculture (IITA), Ibadan.

Experimental design and disease assessment

The lines were laid out in a Randomized Complete Block Design with three replications. Plot sizes were 4m row length with inter-row spacing of 50cm and 5cm intra-row, and were observed for natural development of foliar diseases symptoms. Soybean leaf blight severities were determined according to [ABDOU & al. 2001] using rating scale of 1-5: 1 = no yellow/spots on leaf, 2 = (1-25%) yellow colouration on one leaf, 3 = (26-50%) yellow colouration on more than one leaf, 4 = (51-75%) yellow colouration plus one wilted leaf, 5 = (76-100%) yellow colouration with more than one wilted leaf. While virus disease severities on the different plots were assessed using a modified scale of 1-5, by ASADI (2005): 1 = no visible symptoms, 2 = mild leaf mottling, 3 = chlorosis and mottling, 4 = stunted with severe mottling and chlorosis, 5 = stunted, severe mottling, leaf bunching, chlorosis with leaf defoliation. Disease incidence was determined by counting diseased plants and expressing it as a percentage of total plants in each plot.

Resistance level

The plants were rated as tolerant, resistant or susceptible on the basis of the following scales: resistance or otherwise to fungal diseases were assessed according to [EL-BRAMAWY & ABD AL-WAHID, 2009], using a scale of 1-5 based on the % disease incidence of: 0.1-20% resistant (R), 20.1-40% moderately resistant (MR), 40.1-50% moderately susceptible (MS), 50.1-75% susceptible (S), 75.1-100% highly susceptible (HS). And soybean viral resistances were assessed based on the mean severity, using modified scale of 1-5 by AKBAR & al. (2015): 1 = (1.0-1.9) highly resistant (H), 2 = (2.0-2.99) moderately resistant (MR), 3 = (3.0-3.99) moderately susceptible (MS), 4 = (4.0-4.99) susceptible (S), 5 = (5 and above) highly susceptible (HS).

Isolation and identification of pathogen associated with soybean foliar diseases

Potato dextrose agar was used for fungal cultures, by dissolving thirty-nine grams of the agar in 1000mls of distilled water and autoclaved at 121°C for 15 minutes, allowed to cool sufficiently before pouring on Petri dishes, 2 mm of the diseased sample, surface sterilized in 3% sodium hypochlorite solution for 1 minute, rinsed in sterile distilled water and then dried in three folds of Whatman’s filter paper was then inoculated on the agar aseptically and was incubate at room temperature for 72 hours. The various fungal isolates from each of the samples were sub-cultured to obtain pure cultures for identification. The structural features of colony, colour, extent of growth, presence or absence of mycelia, spores and the nature of colony surface were observed. Microscopic examination involved slide mounts of each isolates and stained with Lacto phenol cotton blue. Fungal identification was confirmed with
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the aid of books by BARNETT & HUNTER (1999), ALEXOPOULOS & al. (2002) and
AGRIOS (2005).

Antigen coated plate-enzyme-linked immunosorbent assay [ACP-ELISA] for
viruses’ assay
Leaf samples collected were stored at 4 °C and were tested using ACP-ELISA for the
presence of Cowpea Aphid-borne mosaic virus (CabM), Black eye cowpea mosaic virus
(BICMV), Cucumber mosaic virus (CM), Soybean mosaic virus (SBMV), Cowpea mottle
virus (CpMov), Cowpea yellow mosaic virus (CYMV) and Cowpea mild mottle virus
(CPMMV) using homologous rabbit polyclonal antiserum available in the virology unit at
IITA Ibadan, following the procedure for ACP-ELISA.

Pathogenicity of the isolated organisms on healthy soybean
All the pathogens isolated from infected soybean leaf were inoculated into healthy
soybean plant to determine whether they could induce similar symptoms on re-inoculation.
Fungal suspension (ranges from 10^4 – 10^6 spore /ml) was prepared from the 8 days old culture
plates of the isolated fungi. The Mycelia mass of the fungus growth culture in the Petri dishes
were scooped out into a sterile conical flask, which contains 10 ml of sterile distilled water,
and a drop of Tween 20 detergent (for spore dispersal) was added [TODD, 2022; KEHINDE,
2008]. Inoculated soybean seedlings were covered with a transparent polythene bag for 24
hours to maintain high humidity required for disease initiation and disease symptoms were
observed for up to 15 days. Distilled water served as negative control.

Data collection and analyses
Agronomic data taken includes, days to 50% flowering, days to maturity, height at
harvest (cm), lodging at harvest, shattering, number of pods/plant, number of seeds/plant,
grain yield (kg/ha) and 100 seed weight (g). All the data collected were subjected to analysis
of variance (ANOVA), using SAS system 9.1 edition and means values separated and
compared using Duncan’s Multiple Range Test (DMRT) at 5% significant level of probability.

Results

Pathogens isolated from disease soybean leaf
Eight fungi were isolated from disease soybean plant in this study, Fusarium
oxysporum, Culvularia spp., Fusarium verticilloides, Choanephora infundibulifera and
Aspergillus flavus in 2015, while the same fungi were also isolated in 2016, including,
Colletotrichum gloeosporioides, Lastodiplodia theobromae and Pestalotia spp.

The Percentage occurrence of pathogens isolated
The percentage occurrence of fungi isolates from disease soybean leaf were presented
in Figure 1. F. oxysporum had the highest percentage of occurrence in both years (40.91% and
22.3%), followed by Culvularia spp. (26.67% and 12.63%), F. verticilloides (22.22% and
10.20%), C. infundibulifera (5.00% and 17.50%) and A. flavus (5.20% and 8.32%). While C.
gloeosporioides (11.5%), L. theobromae (7.30%) and Pestalotia spp. (10.25%) were only
isolated in 2016.
Figure 1. Percentage Occurrence of Fungi isolates from disease soybean leaf

Pathogenicity test

*F. oxysporum*, showed characteristics symptom of blight when used for pathogenicity on both checks, disease symptoms were first noticed on the lower (older) leaves 7 day after inoculation. The leaves turned yellow and upper leaves of infected plants appear scorched. *C. infundibulifera*, also showed blighted symptoms 7 day after inoculation with grayish patches developed on the leaves and later became necrotic.

Incidence and severity of *Fusarium* blight

Table 1 shows the average disease incidence and severity of *Fusarium* blight in early maturing lines, in 2015 and 2016 planting season, over the period of 10 weeks, after planting. TGx 1485-1D (Check) had significantly (P ≤ 0.05) higher disease incidence of (47.90%) and (32.33%) in both years respectively, while lines TGx 1990-40F, 1989-48FN, 1989-68FN, 1990-55F and 1989-40F had significantly lower disease incidence than all other lines in 2016. The check also recorded significantly higher disease mean severities of (4.67) and (4.50) than lines TGx1989-49FN and TGx 1990-55F in 2015 and 2016 respectively.

Table 2 shows the average disease incidence and severity of *Fusarium* blight in medium maturing lines, in 2015 and 2016 planting season, over the period of 12 weeks, after planting. TGx1448-2E (Check) had significantly (P ≤ 0.05) higher disease incidence of (47.50%) than all the lines evaluated in 2015, while the check (36.67%) and TGx 1989-42F (34.17%) had significantly lower disease incidence than other lines in 2016. TGx 1989-45F and TGx 1989-11F recorded significantly (P ≤ 0.05) lower disease mean severity of (2.50) and (1.50) than the check (3.78) in 2015, while there was no significant difference for disease severity among all the lines evaluated in 2016.
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Incidence and severity of Choanephora leaf blight

For early maturing lines; in 2015, TGx 1990-40F (16.17%) recorded significantly (P≤ 0.05) lower disease incidence than all the lines evaluated and the check, the same trend was also recorded in 2016 for the same line. The Check (TGx 1485-1D) had significantly (P≤ 0.05) higher mean disease severity of (4.50) and (3.33) than all the lines in both years respectively (Table 1). In the medium maturing lines, TGx1448-2E (Check) and TGx 1989-42F recorded significantly (P ≤ 0.05) higher disease incidence of (36.67%) and (34.17%) respectively than all the lines evaluated in 2015, while the check recorded higher mean severity of (2.64) and (4.36) in both years respectively (Table 2).

Table 1. Average disease Incidence and Severity for Fusarium and Choanephora leaf blight in early maturing soybean lines, in 2015 and 2016 planting season

| Early Lines | Fusarium leaf blight | Choanephora leaf blight |
|-------------|----------------------|-------------------------|
|             | Incidence            | Severity                | Incidence      | Severity   |
|             | Year’s               | Year’s                  | Year’s         | Year’s     |
|             | 2015  | 2016  | 2015  | 2016  | 2015  | 2016  | 2015  | 2016  |
| TGx 1990-40F | 38.50a | 18.90c | 4.00abc | 3.67bc | 16.17f | 13.00f | 3.00a | 2.00a |
| TGx 1989-48FN | 35.90a | 19.50e | 3.50bcd | 3.50c | 21.50e | 16.17f | 3.17c | 2.17d |
| TGx 1989-68FN | 37.33c | 20.20c | 3.33cde | 3.83bc | 20.33e | 16.83f | 3.00c | 2.17d |
| TGx 1990-55F | 37.50a | 19.00c | 4.00abc | 3.50c | 21.17e | 15.50g | 3.00c | 2.17d |
| TGx 1989-40F | 38.50a | 19.83e | 4.17abc | 3.83bc | 21.00e | 16.33f | 3.50c | 2.50d |
| TGx 1990-52F | 36.47f | 30.67a | 4.00abc | 4.00abc | 30.67bc | 27.16gd | 3.50c | 2.50d |
| TGx 1989-49FN | 34.67g | 31.00a | 2.83d | 3.67bc | 29.50c | 26.00de | 3.17c | 2.50d |
| TGx 1990-57F | 43.67c | 26.33b | 4.50ab | 3.87bc | 29.33c | 27.67bd | 3.70b | 2.50d |
| TGx 1990-46F | 45.50b | 32.33a | 4.17abc | 4.00abc | 26.67d | 23.83e | 3.17c | 2.50d |
| TGx 1485-1D (Check) | 47.90b | 32.33a | 4.67a | 4.50a | 35.50a | 32.00d | 4.50a | 3.33d |

*Means with the same alphabet are not significantly different from each other in the same column (P ≥ 0.05)

Table 2. Average disease incidence and severity for Fusarium and Choanephora leaf blight in medium maturing soybean lines, in 2015 and 2016 planting season

| Medium Lines | Fusarium leaf blight | Choanephora leaf blight |
|--------------|----------------------|-------------------------|
|              | Incidence            | Severity                | Incidence      | Severity   |
|              | Year’s               | Year’s                  | Year’s         | Year’s     |
|              | 2015  | 2016  | 2015  | 2016  | 2015  | 2016  | 2015  | 2016  |
| TGx 1989-45F | 42.00f | 22.33ed | 2.50bc | 3.60de | 22.33ed | 24.83e | 2.00e | 3.00ef |
| TGx 1989-11F | 42.33g | 25.17e | 1.50c | 3.50ec | 25.17e | 25.17g | 2.17bc | 3.33de |
| TGx 1989-75FN | 42.01f | 22.17ed | 3.56ab | 3.50ec | 22.17ed | 28.83ef | 2.00e | 2.83ef |
| TGx 1990-114FN | 42.50f | 20.83d | 3.06ab | 3.17c | 20.83d | 23.83f | 2.00e | 2.67f |
| TGx 1990-78FN | 42.00f | 23.00ed | 3.50ab | 3.33de | 23.00ed | 28.67ef | 2.22bc | 3.00ef |
| TGx 1993-4FN | 42.00f | 24.67c | 3.17ab | 3.33de | 24.67c | 31.00de | 2.46ab | 3.33de |
| TGx 1989-53FN | 46.01b | 20.33d | 3.56ab | 3.83bd | 20.33d | 25.17f | 2.15bc | 3.17ef |
| TGx 1990-95F | 44.00f | 22.33ed | 3.65ab | 3.83ed | 22.33ed | 27.33g | 2.17bc | 3.17ef |
| TGx 1989-42F | 42.50f | 34.17f | 3.17ab | 3.67de | 34.17a | 36.17bc | 2.33bc | 3.56bd |
| TGx 1990-110FN | 42.00f | 23.37ed | 3.45ab | 3.66de | 23.37ed | 25.67fg | 2.17bc | 3.17ef |
| TGx1448-2E (Check) | 47.50a | 36.67a | 3.78a | 4.70a | 36.67a | 43.33a | 2.64a | 4.36a |

*Means with the same alphabet are not significantly different from each other in the same column (P ≥ 0.05)
Incidence and severity of virus diseases

Table 3 shows the average incidence and severity of virus diseases in early maturing soybean lines, in 2015 and 2016 planting season, over the period of 10 weeks after planting. TGx 1990-40F and TGx 1989-48FN recorded significantly \((P \leq 0.05)\) lower disease incidence of (36.67%) and (36.83%) respectively, than TGx 1990-46F (43.37%); they also recorded significantly disease mean severity of (2.06) and (2.50) than TGx 1990-46F (3.96) in 2015. TGx 1990-40F had significantly average disease incidence of (17.34%) and also recorded lower mean disease severity than the check in 2016.

The average incidence and severity of virus diseases in medium maturing soybean lines, in 2015 and 2016 planting season, over the period of 12 weeks after planting, was presented in Table 4; TGx 1989-11F had significantly \((P \leq 0.05)\) lower disease incidence of (37.83%) and mean disease severity of (1.37), than all the lines and the check in 2015. The check also recorded significantly higher disease incidence of (48.33%) than all the lines evaluated in 2016.

Virus assayed

Serological – Incidence of Soybean virus assayed in leaf sample of early and medium maturing soybean lines in 2015 and 2016 planting season were presented in Tables 3 and 4 respectively. In 2015, all early maturing lines tested negative for all the viruses assayed, except TGx 1989-68FN that tested positive for Cowpea mild mottle virus (CPMMV). All lines were positive for Cowpea mild mottle virus (CPMMV) in 2016, while the Check tested positive for Cowpea mottle virus (CpMov) in same year. In medium maturing lines, all lines were negative for all the virus assayed in 2015 and 2016, but positive for Cowpea mild mottle virus (CPMMV) in 2016.

Table 3. Average disease Incidence and Severity for Virus in early maturing soybean lines, in 2015 and 2016 planting season

| Early Lines | 2015 Incidence | 2015 Severity | 2016 Incidence | 2016 Severity | 2015 CPMoV | 2015 CYMV | 2015 CPMMV | 2016 CPMoV | 2016 CYMV | 2016 CPMMV |
|-------------|----------------|---------------|---------------|---------------|------------|-----------|-------------|------------|-----------|-------------|
| TGx 1990-40F | 36.67<sup>e</sup> | 2.06<sup>d</sup> | 17.34<sup>e</sup> | 2.97<sup>c</sup> | – | – | – | – | + |
| TGx 1989-48FN | 36.83<sup>a</sup> | 2.50<sup>d</sup> | 28.40<sup>a</sup> | 3.07<sup>bc</sup> | – | – | – | – | + |
| TGx 1989-68FN | 39.22<sup>d</sup> | 3.04<sup>c</sup> | 28.37<sup>a</sup> | 3.10<sup>bc</sup> | – | – | + | – | + |
| TGx 1990-55F | 39.78<sup>e</sup> | 3.13<sup>c</sup> | 22.94<sup>cd</sup> | 3.19<sup>abc</sup> | – | – | – | – | + |
| TGx 1989-40F | 38.81<sup>d</sup> | 3.52<sup>abc</sup> | 20.65<sup>d</sup> | 3.38<sup>abc</sup> | – | – | – | – | + |
| TGx 1990-52F | 38.96<sup>d</sup> | 3.37<sup>bc</sup> | 28.33<sup>a</sup> | 3.12<sup>bc</sup> | – | – | – | – | + |
| TGx 1989-49FN | 39.21<sup>d</sup> | 3.18<sup>bc</sup> | 27.00<sup>d</sup> | 3.36<sup>bc</sup> | – | – | – | – | + |
| TGx 1990-57F | 42.22<sup>b</sup> | 3.76<sup>ab</sup> | 25.72<sup>d</sup> | 3.66<sup>ab</sup> | – | – | – | – | + |
| TGx 1990-46F | 43.37<sup>a</sup> | 3.96<sup>a</sup> | 24.65<sup>bc</sup> | 3.31<sup>ab</sup> | – | – | – | – | + |
| TGx 1485-1D (Check) | 39.94<sup>c</sup> | 3.37<sup>bc</sup> | 28.34<sup>a</sup> | 3.79<sup>a</sup> | – | – | – | + | + |
### Table 4. Average disease Incidence and Severity for Virus in Medium Maturing Soybean lines, in 2015 and 2016 planting season

| Medium Lines | 2015 Incidence | 2016 Incidence | Serology – Incidence of soybean virus assayed in leaf Sample using ACP-ELISA |
|--------------|---------------|---------------|------------------------------------------------------------------------|
|              | Severity      | Severity      | CpMoV | CYMV | CPMMV | CpMoV | CYMV | CPMMV |
| TGx 1989-45F | 43.01<sup>b</sup> | 2.63<sup>b</sup> | 21.50<sup>f</sup> | 2.10<sup>b</sup> | – | – | – | + |
| TGx 1989-11F | 37.83<sup>k</sup> | 1.37<sup>c</sup> | 26.80<sup>bde</sup> | 2.40<sup>b</sup> | – | – | – | + |
| TGx1989-75FN | 42.22<sup>k</sup> | 2.50<sup>b</sup> | 24.37<sup>cdf</sup> | 2.15<sup>b</sup> | – | – | – | + |
| TGx1990-114FN | 44.33<sup>c</sup> | 2.48<sup>b</sup> | 30.23<sup>bc</sup> | 2.33<sup>ab</sup> | – | – | – | + |
| TGx1990-78FN | 41.51<sup>j</sup> | 2.63<sup>b</sup> | 25.67<sup>cdef</sup> | 2.11<sup>b</sup> | – | – | – | + |
| TGx 1993-4FN | 43.72<sup>f</sup> | 3.13<sup>abc</sup> | 28.73<sup>bde</sup> | 2.40<sup>b</sup> | – | – | – | + |
| TGx1989-53FN | 45.17<sup>bc</sup> | 3.15<sup>abc</sup> | 24.91<sup>cdef</sup> | 2.30<sup>b</sup> | – | – | – | + |
| TGx 1990-95F | 51.67<sup>bc</sup> | 3.70<sup>a</sup> | 31.05<sup>b</sup> | 2.49<sup>a</sup> | – | – | – | + |
| TGx 1989-42F | 44.84<sup>c</sup> | 3.41<sup>abc</sup> | 30.53<sup>b</sup> | 2.19<sup>b</sup> | – | – | – | + |
| TGx1990-110FN | 44.50<sup>c</sup> | 2.98<sup>abc</sup> | 25.50<sup>cdef</sup> | 2.03<sup>b</sup> | – | – | – | + |
| TGx1448-2E (Check) | 47.54<sup>b</sup> | 3.37<sup>abc</sup> | 48.33<sup>c</sup> | 2.29<sup>b</sup> | – | – | – | + |

*Means with the same alphabet are not significantly different from each other in the same column (P ≥ 0.05). Virus assayed by antigen coated-plate enzyme-linked immunororbent assay (ACP-ELISA); CpMoV, Cowpea mottle virus; CYMV, Cowpea yellow mosaic virus; CPMMV, Cowpea mild mottle virus

Grain yield of soybean and resistance level to the diseases

Table 5 shows grain yield in kilogram per hectare and resistance level in early and medium maturing soybean lines, in 2015 and 2016 planting season. In early maturing lines, TGx 1989-40F (294.07 kg/ha) and TGx 1989-49FN (264.43 kg/ha) recorded significant (P ≥ 0.05) lower grain yield than the Check (567.40 kg/ha) and TGx 1990-46F (465.97 kg/ha). The same trend was also observed for these lines in 2016. There was no significant difference in grain yield for both years in medium maturing lines.

All the lines evaluated were moderately resistant to leaf blight disease for both the maturing groups. While lines: TGx 1990-40F, TGx 1989-48FN, TGx 1989-68FN, TGx 1990-55F, TGx 1990-52F and TGx 1989-49FN are highly resistant to the virus diseases in early maturing lines; TGx 1993-4FN, TGx1989-53FN, TGx 1990-95F, TGx 1989-42F and TGx1990-110FN were moderately resistant to the same disease in medium maturing lines. The checks were moderately susceptible to all the diseases evaluated in this study in both maturity groups (Table 5).
Discussion

Eight fungi were isolated from disease soybean plant in this study, from the pathogenicity test, only *F. oxysporum* and *C. infundibulifera* were the pathogenic ones. This result agrees with the findings of previous researchers who had associated these organisms with soybean foliar disease [FAYZALLA & al. 2009; HASHEM & al. 2009; SUBBA RAO & al. 1990]. While other fungal isolates shown no known symptom(s) when used for pathogenicity on any of the soybean checks either singly or mixed, except for *C. gloeosporioides* and *C. infundibulifera* that was re-isolated when mixed with *F. oxysporum*, they could be secondary invaders or opportunistic pathogens. *F. oxysporium* had the highest percentage of occurrence in both maturing lines. This pathogen can cause blight or wilt disease in soybean, and has been reported as one of the most destructive diseases of soybean [HASHEM & al. 2009; FAYZALLA & al. 2009], the pathogen can affect soybeans at any stage of development [FERRANT & CARROLL, 1981]. According to NELSON & al. (1997) and YANG (1997), *Fusarium* species are often favored by cool temperatures, particularly in the early growing season. The decreased in moisture condition of the soil during the 2015 growing period in this study could have triggered the susceptibility of the crop to *Fusarium* blight. This result corroborates the findings of ZHANG & al. (2010) who concluded that as soil moisture becomes more limiting, soybeans become stressed, thereby increasing susceptibility to infection by *Fusarium*. DAS & al. (2019) also reported that plant infection by * Fusarium* can occur from seeds germination to mature stage.

| Table 5. Grain yield and resistance level in early and medium maturing soybean lines 2015 and 2016 planting season |
|---|---|---|
| | Early Lines | Medium Lines |
| | Grain yield (kg/ha) | Grain yield (kg/ha) | Resistance Level |
| | | | |
| 2015 | 2016 | 2015 | 2016 |
| Fusarium blight/wilt | Viral disease | Fusarium blight/wilt | Viral disease |
| TGx 1990 | TGx 1989 | TGx 1989 | TGx 1989 |
| 40F | 45F | 48FN | 75FN |
| 345.93bc | 370.40a | 346.67bc | 288.90a |
| 547.80bc | 589.70a | 563.70bc | 509.60a |
| MR | MR | MR | MR |
| TGx 1989 | TGx 1989 | TGx 1989 | TGx 1989 |
| 40F | 55F | 68FN | 75FN |
| 436.30a | 402.97bc | 288.90a | 303.70a |
| 657.00a | 634.37bc | 509.60a | 532.00a |
| MR | MR | MR | MR |
| TGx 1989 | TGx 1989 | TGx 1989 | TGx 1990 |
| 114FN | 49FN | 42F | 110FN |
| 288.90a | 264.43c | 272.60a | 110.40c |
| 472.60a | 523.00a | 696.80a | 589.83c |
| MR | MR | MR | MR |

*Means with the same alphabet are not significantly different from each other in the same column (P ≥ 0.05)*

R= Resistant; HR= Highly Resistant; MR= Moderately Resistant; MS= Moderately Susceptible.
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*infundibulifera* Sacco. was also isolated in this study, as one of the foliar diseases of soybean, SUBBA RAO & al. (1990) have also documented the pathogen during their study of stem canker pathogen on soybean.

The variation in the disease incidence and severity observed in the lines evaluated, in both years could be attributed to differences in resistance status of each line and to the difference level of virulence in the pathogen. ODUBANWO & al. (2013) was also of the opinion that, soybean resistance depends on the lines level of expression and to their ability over time to tolerate the attack of the pathogens. Symptom of *fusarium* blight was more pronounced at about 6 weeks after planting, disease symptoms are first noticed on the lower (older) leaves. The leaves turn yellow and as the disease progresses, the upper leaves of infected plants wilt and appear scorched, in severe cases, the leaves dry up and drop prematurely leaving the petiole behind, which is in conformity with the report of ABIODUN & al. (2016) and NELSON & al. (1997). *C. infundibulifera* incidence was higher in 2016, there was heavy and frequent rainfall in this period, which agrees with SUBBA RAO & al. (1990) who concluded that heavy rainfall is one of the factors responsible for survival and spread of this pathogen.

Virus symptoms from this study majorly are mottling and mosaic symptoms, although other symptoms such as yellow vein banding, necrotic spots and chlorosis were also present in the field. Viruses assayed by antigen coated-plate enzyme-linked immunorbent assay (ACP-ELISA) in the laboratory were not in conformity with the field evaluation for both soybean lines in both years. This was possible because the observations in the field were based solely on visual virus-like symptoms, which were probably caused by other pathogens, physiological disorders and unidentified viruses; this finding gives credence to earlier reports of NJUKENG & al. (2013) that out of the 360 leaf samples of pepper showing virus-like symptoms collected from the field during survey followed by laboratory diagnosis using DAS-ELISA, 117 leaf samples were negative for viruses assayed. Cowpea mild mottle virus (CPMMV) is the commonest virus associated with all soybean lines used in this study, this result agrees with the conclusion of DUGJE & al. (2009) that CPMMV transmitted by whitefly (*Bemisia tabaci*) is the most prevalent virus associated with soybean mosaic disease in Nigeria.

Grain yield is considered an important indicator for any foliar disease. Grain yields among the evaluated lines varied during the two years of this study. TGx1990-46F (early maturing) and TGx1990-110FN (medium maturing) had high grain yield in both years respectively. This agrees with reports from earlier researchers who reported significant yield differences among soybean genotypes [ZHANG & ZHANG, 2000; ABLETT & al. 2000]. These lines were moderately resistant to all the diseases observed on the field, as they were able to produce high grain yield when compared with the local checks, despite the high disease incidence and severity.

**Conclusion and recommendation**

Leaf blight disease were the foliar diseases found to be associated with soybean lines used in this study and ecology, while Cowpea mild mottle virus (CPMMV) is the commonest virus associated with all soybean lines used. These diseases can reduce grain yield and yield traits, but it depends on the disease’s severity and the genetic make-up of each soybean genotypes, these soybean lines could be utilized as parent lines for breeding against soybean foliar diseases and useful for farmers in area endemic to any of the foliar disease encounter in
this study. It is therefore recommended that further studies should be carried out on these soybean lines in other agro-ecological zone to determine the effectiveness of their resistance to foliar diseases as claimed from this study.

References

ABDEL-MONAIM M. F., ISMAIL M. E. & MORSY K. M. 2011. Induction of systemic resistance of benzothiadazole and humic acid in soybean plants against Fusarium wilt disease. Mycology. 39(4): 290-298. https://doi.org/10.5941/MYCO.2011.39.4.290

ABDOU E. S., ABD-ALLA H. M. & GALAL A. A. 2001. Survey of sesame root rot/wilt disease in Minia and their possible control by ascorbic and salicylic acids. Journal of Agricultural Science. 32(3): 135-152.

ABIODUN J., PATRICK A. A., BENSON O. A. & AVWEROSUO E. 2016. Effect of tillage method on Fusarium blight severity and yield of soybean in Omu-Aran, Southern Guinea Savannah of Nigeria. African Journal of Agricultural Research. 11(4): 228-233. https://doi.org/10.5897/AJAR2015.10534

ABLETT G. R., STIRLING B. T. & FISCHER J. D. 2000. RC at legacy soybean. Canadian Journal of Plant Science. 80(3): 591-592.

AGRIOS G. N. 2005. Plant pathology. New York, NY, Academic Press, 922 pp.

AKBAR A., AHMAD Z., BEGUM F. & RAES N. 2015. Varietal Reaction of Cucumber against Cucumber mosaic virus. American Journal of Plant Sciences. 6(7): 833-838. https://doi.org/10.4236/ajps.2015.67090

ALEXOPOULOS C. J., MIMS C. W. & BLACKWELL M. 2002. Introductory mycology. 4th ed., Singapore: Wiley, 869 pp.

ANONYMOUS. 2018. Statistical Year Book of Bangladesh. Bangladesh Statistics Division, Ministry of Planning, Govt. of the People’s Republic of Bangladesh: 318-319.

ASADI. 2005. Genetika ketahanan dan pemuliaan kedelai terhadap virus kerdil (soybean stunt virus). PhD Thesis, UGM, Yogyakarta (in Indonesian).

BARNETT H. L. & HUNTER B. B. 1999. Illustrated genera of imperfect fungi. 4th ed. St. Paul, MN: American Phytopathological Society, 218 pp.

DAS I. R., BHUIYAN M. K. A., JANNAT R., KAYESH E., RUBAYET M. T. & AREFIN M. N. 2019. Effect of bio-fortified compost in controlling soil-borne diseases of lentil (Lens culinaris L.) and enhance the crop growth and yield. Advances in Biology & Earth Sciences. 4(2): 93-106.

DUGJE I. Y., OMOIGUI L. O., EKELEME F., BANDYOPADHYAY R., KUMAR P. L. & KAMARA A. Y. 2009. Farmers’ guide to soybean production in Northern Nigeria. International Institute of Tropical Agriculture, Ibadan, Nigeria. 21 pp.

EL-BRAMAWY M. A. S. A. & ABD AL-WAHID O. A. 2009. Evaluation of resistance of selected sesame (Sesamum indicum) genotypes to Fusarium wilt disease caused by Fusarium oxysporum f. sp. sesami. Tunisian Journal of Plant Protection. 4: 29-39.

FAYZALLA E. A., EL-BAROUGY E. & EL-RAYES M. M. 2009. Control of soil-borne pathogenic fungi of soybean by biofumigation with mustard seed meal. Journal of Applied Science. 9: 664-666. https://doi.org/10.1016/S0975-8887(08)00064

HARTMAN G. L., MILES M. R. & FREDERICK R. D. 2005. Breeding for resistance to soybean rust. Plant Disease. 89: 664-666. https://doi.org/10.1094/PD-89-0664

HARTMAN G. L., SINCLAIR J. B. & RUPE J. C. 1999. Compendium of Soybean Diseases, Fourth edition. The American Phytopathological Society. APS Press: 65 pp.

HASHEM E. A., ABDALLA H. E., HUSSEIN Y. A. & ABD-ELNAB M. A. 2009. In vitro selection of soybean callus resistant to Fusarium oxysporum metabolites. Resource Journal of Agriculture and Biological Sciences. 5(4): 588-596.

HILL J. H. 1999. Soybean mosaic virus. In: HARTMAN G. L., SINCLAIR J. B. & RUPE J. C. (eds.) 1999. Compendium of Soybean Diseases. 4th edition. American Phytopathological Society: 70-71.

INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE (IITA). 2009. Soybean production Handbook. http://www.iita.org//957665glycinemax/html. Accessed 28/07/2014.

KEHINDE I. A. 2008. Identification and control of field and storage fungal pathogens of Egusi melon: Citrullus lanatus (Thumb) Mansf. in Southwestern Nigeria. PhD. Thesis. Department of Crop Protection and Environmental Biology, University of Ibadan, 211 pp.

LIAO L., CHEN P., BUSS G. R., YANG Q. & TOLIN S. A. 2002. Inheritance and allelism of resistance to soybean mosaic virus in Zao18 soybean from China. Journal of Heredity. 93(6): 447-452.

NELSON B. D., HANSEN J. M., WINDELS C. E. & HELMS T. C. 1997. Reaction of soybean cultivars to isolates of Fusarium solani from Red River valley. Plant Diseases. 81: 664-668.
INCIDENCE AND SEVERITY OF FUNGAL AND COMMON VIRAL DISEASES OF SOME SOYBEAN …

NIJUKENG P. A., NGWAKUM W. N. & MBONG G. A. 2013. Relative prevalence, incidence and severity of two viruses infecting cultivated pepper in the Western Highlands of Cameroon. Agricultural Science Research Journals. 3(8): 261-266.

ODUBANWO B. O., POPOOLA A. R., OJO D. K. & GANIYU S. A. 2013. Yield performance of soybean accessions on field naturally infected with bacterial pustules (Xanthomonas axonopodis pv. Glycines). African Crop Science Conference Proceedings. 11: 309-315.

RAHMAN M. T., RUBAYET M. T., KHAN A. A. & BHUIYAN M. K. A. 2020. Integrated management of fusarium root rot and wilt disease of soybean caused by Fusarium oxysporum. International Journal of Biosciences. 17(2): 83-96.

STATISTICAL ANALYSIS SYSTEM. 2012. PROC user’s manual, Version 9.1. SAS Institute, Cary, NC.

SUBBA RAO K. V., PADGETT D. K., BERNER G. T. & SNOW J. P. 1990. Choanephora leaf blight of soybeans in Louisiana. The American Phytopathological Society. https://doi.org/10.1094/PD-74-0614B

TODD W. 2022. Cucurbit breeding: Horticultural Science. NC State and USDA Cucumber Disease, Handbook. https://cucurbitbreeding.wordpress.ncsu.edu/cucumber-breeding/cucumber-disease-handbook/belly-rot-rhizoctonia-solani-kuhn-testing/

YANG X. B. 1997. Soybean Damping off. File Agronomy 2-5 and Pest management 2-Iowa State University Extension, Ames Iowa.

YUSUF I. A. & IDOWU A. A. 2001. Evaluation of four soybean varieties for performance under different lime regimes on the acid soil of Uyo. Tropical Oil Seeds Journal. 6: 65-70.

ZHANG J. X., XUE A. G., ZHANG H. J., NAGASAWA A. E. & TAM BONG J. T. 2010. Response of soybeans cultivars to root rot caused by Fusarium species. Canadian Journal Plant Science. 90: 767-776.

ZHANG R. J. & ZHANG R. J. 2000. A comparative experiment on soybean cultivars in Nyigchi in Tibet. Soybean Science. 19: 90-94.

ZHENG C., CHEN P. & GERGERICH R. 2005. Effect of temperature on the expression of necrosis in soybean infected with soybean mosaic virus. Crop Science. 45(3): 916-922.

How to cite this article:
SALIHU S., AFOLABI C. G., OTUSANYA M. O., OJO D. K., DANBABA N. & KAZEEM S. A. 2022. Incidence and severity of fungal and common viral diseases of some soybean lines in a derived Guinea Savannah agro-ecology. J. Plant Develop. 29: 159-170. https://doi.org/10.47743/jpd.2022.29.1.905