RESPONSE OF SELECTED SOYBEAN (*Glycine max* [L.] MERR.) LINES TO CUCUMBER MOSAIC VIRUS DISEASE IN MINNA, NIGER STATE

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ABSTRACT

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Response of twenty four soybean (Glycine max) lines to Cucumber mosaic virus was evaluated in Minna, Southern Guinea Savanna agro-ecology of Nigeria cropping season. The experiment which comprised as inoculated and uninoculated plants was laid out in a randomized complete block design (RCBD) with three replications. Seedlings were inoculated with CMV inoculum by sap transmission at seven days after sowing. Disease incidence and severity, growth and yield components were studied. Data were subjected to analysis of variance (ANOVA) and means separated with the Duncan Multiple Range Test (DMRT) and the least significant difference (LSD) at 5 % probability level. Disease incidence varied from 0 to 100 % at one week after inoculation (WAI) and 13.3 to 100 % at 2WAI. All the infected plants elicited leaf curling and chlorosis typical of cucumber mosaic virus disease. There was no reduction in 100-seed weight of the CMV-infected TGX 2004-3F compared with the control plants, whereas relatively low reduction values were observed in four genotypes namely, TGX 1989-65FN (1 %), TGX 2007-2F (1.7 %), TGX 1989-1FN (5 %), and TGX 1995-5FN (7.5 %). The five genotypes could be utilized in breeding programme for development of soybean CMV resistant varieties for the area.

Keywords: Cucumber mosaic virus, disease incidence, disease severity, genotypic resistance, soybean lines

INTRODUCTION

The soybean (*Glycine max* [L.] Merill) is often described as a miracle crop. It is the leading source of oil and protein all over the world. It is basically a crop of temperate origin. Soybean contains 40-42 % protein, 18-22 % oil comprising of 85 % unsaturated fatty acids and 15 % saturated fatty acids, 28 % carbohydrate and good amount of other nutrients like phosphorus, calcium, vitamins and iron (Antalina, 2009). Soybean has many benefits, nutritionally for man and livestock, as well as other industrial and commercial uses. It is classified as an oilseed, containing significant amounts of all the essential amino acids, minerals and vitamins for human nutrition (Adu-Dapaah *et al*., 2004). It also helps to improve soil fertility through symbiotic nitrogen fixation (McNeil, 2010). In Nigeria the haulms and post-processed pulp (soybean meal) serve as important sources of animal feed. This soybean residue (haulm) also improves the soil condition, and on decay supplies nutrients to subsequent crops. It also contributes to improvement in cereal based cropping systems in the Guinea savanna of Nigeria (Yusuf *et al*., 2006).

Soybean is mostly cultivated by small-scale farmers in Africa where it is grown as a minor food crop among sorghum, maize, or cassava. About 6 million tonnes of soybeans were produced in Nigeria in 2013, in a land area of 6 million hectares and a yield of 10,000 kg ha^{-1} (FAO, 2013). Nigeria is the largest producer of soybean in sub-Saharan Africa (SSA), followed by South Africa. Low yield of soybean (<1 t ha^{-1} in tropical Africa) and shortage of fertilizer limits the ability of some countries to increase production. 30 % annual growth in the poultry industry from 2003 to 2008 resulted in a demand for soybean meal that an increase in imports was required. Despite its tremendous domestic and industrial uses, soybean is still faced with some diseases in Africa such as, red leaf blotch, rust, frog-eye leaf spot, bacterial pustule, bacterial blight, *Cucumber mosaic virus* (CMV) and *Soybean mosaic virus* (SMV) (Arogundade *et al*., 2009). Insect pests include pod (stink bugs) and foliage feeders, bean flies and nematodes (Ajubor, 1997). *Cucumber mosaic virus* is one of the most economically important viruses lowering legumes productivity in sub-Saharan Africa (Mih *et al*., 1991). The virus has been reported as a major threat to annual crops in several countries including Argentina, France, USA and some African countries (Moury, 2004; Nault *et al*., 2006). Infection affects both the quality and quantity of soybean produced in the State, and there is direct relationship between yield loss and genetic architecture of the host plant.

Cucumber mosaic virus is a member of the genus *Cucumovirus* in the family *Bromoviridae.* It has been reported that CMV infects over 1000 plant species in different genera and families (Palukaitis and Garcia-Arenal, 2003). The virus is seed-borne (O'keefe *et al*., 2007) and also transmitted by over 75 species of aphids in a non-persistent manner. The symptoms of cucumber mosaic virus disease vary from slight to severe mosaic, mottling, distortion of the leaves and stunting. The virus has a wide host range and attacks a greater variety of vegetables, ornamentals, weeds and other plants than other viruses (Crescenzy, 1993). Knowledge of the severity of CMV infection on available soybean germplasm would be valuable for genetic improvement of soybean. Such information could be utilized in breeding soybean cultivars with high yield and appreciable level of resistance to the virus. Cultivation of CMV- resistant/tolerant varieties would in turn enhance food security in Nigeria.

Therefore, this study was conducted to evaluate the pathogenicity of CMV on selected soybean lines under field conditions in Minna, Niger State.

MATERIALS AND METHODS

Source of soybean seeds

Seeds of soybean lines; TGX 1485-1D, TGX 1835-10E, TGX 1951-3F, TGX1987-10F, TGX 1987-62F, TGX 1988-5F, TGX 1989-19F, TGX 1989-62F, TGX 1989-63F, TGX 1989-69F, TGX 1989-1FN, TGX 1989-48FN, TGX 1989-49FN, TGX 1989-65FN, TGX 1989-68FN, TGX 1989-75FN, TGX 1990-3F, TGX 1990-21F, TGX 1990-67F, TGX 1991-10R, TGX 1993-5FN, TGX 1995-5F, TGX 2004-3F and TGX 2007-2F used in the experiment were obtained from the National Cereals Research Institute (NCRI), Baddegi, Niger State, Nigeria. They were selected from the soybean germplasm bank designated for improvement against biotic stresses at the Institute.

Source of virus inoculums and maintenance

The CMV isolate used for this study was obtained from the virus stock in the Department of Crop Production, Federal University of Technology, Minna, Niger State. It is the descent of a severe Nigerian strain of CMV prevalent in different part of Nigeria (Shoyinka *et al*., 1997), its physical and biological properties have been well documented (Taiwo, 2001). The virus was multiplied and sprayed on cowpea plants by mechanical inoculation. This was achieved by grinding the CMV-infected leaves in inoculation buffer, at pH 7.2 (0.1 M sodium phosphate dibasic, 0.1 M potassium phosphate monobasic, 0.01_M ethylene diamine tetra acetic acid and 0.001 M L-cystine per litre of distilled water) at 1:1 weight/volume (1g of leaf in1 mL of buffer) using a pre-cooled sterilized mortar and pestle. Five microlitres of β- mercapto-ethanol was added to the extract just before used. The extract was applied on the upper leaf surface of the topmost fully expanded leaves of the cowpea cultivar Ife brown (10-day old) previously dusted with carborundum powder (600-mesh). This was accomplished by rubbing the leaves gently with a cotton wool dipped in the sap. Inoculated leaves were rinsed with distilled water in order to remove excess inoculum. Symptomatic leaves were harvested three weeks later and preserved in airtight tubes with anhydrous Calcium chloride ($CaCl_2$) covered with a thin layer of cotton wool. The tubes were kept at room temperature and leaf tissues were used for inoculation in the field.

Description of the study area

The experiment was conducted at the Teaching and Research Farm of the Department of Crop Production, Federal University of Technology, Minna, during the 2014 cropping season (Latitude 6.44675 ^{0}E, Longitude 9.51715 ^{0}N and about 220 m above sea level). Minna is located in the Southern Guinea Savanna agro-ecological zone of Nigeria with a mean annual rainfall of 1200 mm. The rainfall normally begins in April and ends in the first week of October. The peak rainfall occurs in September. Temperatures vary between 35.0 and 37.5 °C with relative humidity between 60% and 80 % in the month of July and 40 and 60 % in January. The soils of Minna originated from basement complex rocks and are generally classified as Alfisols (Adeboye *et al*., 2011).

Treatments and experimental design, sowing and inoculation

The experiments were laid out in a randomized complete block design (RCBD) with three replications. Each replicate contained 24 ridges, representing each soybean line, with each line sown in 3.6 m long manually constructed ridge. Seeds were sown on August 24, 2014 at an intra and inter- row spacing of 50 and 75 cm, respectively. Five seeds were sown per hole and thinned to three plants per stand after seedlings emergence. The CMV-infected leaves collected from the infected plants (Ife brown) were ground in inoculation buffer and used for inoculation. Inoculation was carried out as described above and the inoculated plants were monitored for symptoms development.

Data collection and statistical analysis

Data were collected on percentage of infected plants, disease severity, and number of leaves per plant, plant height, number of branches per plant and 100-seed weight. Disease severity was evaluated using a visual scale of 1-5 (Arif and Hassan, 2002). Where, 1 = no symptoms (apparently healthy plants); 2 = slightly mosaic leaves (10-30 %); 3 = mosaic (31-50 %); 4 = severe mosaic (51-70 %), leaf distortion and stunting; 5 = severe mosaic (>70 %), stunting and death of plants. All data collected were subjected to analysis of variance (Gomez and Gomez, 1984). Means of the disease incidence and severity were separated using the Duncan Multiple Range Test (DMRT) at 5% probability level. Significant differences between inoculated and uninoculated plants (growth and yield data) were separated using the Least Significant Difference (LSD) at 5% probability level.

RESULTS

Symptoms first appeared on the infected plants at ten days after inoculation (DAI) except in TGX 1935-10F, where the symptoms manifested at fourteen DAI. These include leaf chlorosis, blistering and curling, and were found on the secondary leaves of the infected plants. Disease incidence was variable among the genotypes (Table 1). At 1 WAI, disease incidence varied between 0 and 100 %. with the highest observed in 1951-3F. This was followed by TGX 1989-69F, TGX 1990-67F, and TGX 1991-10R with high (>90 %) level of disease incidence, although, differences among them were not significant (P>0.05). Similarly, the differences in disease incidence among the genotypes TGX 1987-10F, TGX 1988-5F, TGX 1989-19F, TGX 1989-65F, TGX 1989-48FN, TGX 1990-3F, and TGX 1995-5FN were not statistically significant (P > 0.05), although, percentage of infection generally exceeded 70 %. Disease incidence in TGX 1989-49FN was comparable to that observed in TGX 2004-3F. Also, disease incidence in TGX 1485 was similar to that of TGX 1989-63F. However, in soybean lines TGX 1989-1F and TGX 1989-68FN the percentage of infection was lower than 50 %, though the difference observed between them was not significant. Cucumber mosaic disease incidence in TGX 1989-75FN was the same as in TGX 2007-2F. The last group comprised TGX 1987-62F, TGX 1989-62F, and TGX 1990-21F in which the disease incidence ranged between 20.0 and 26.7 %, although the differences among them were not significant (P > 0.05) (Table 1).

Table 1: Disease incidence and severity in soybean plants inoculated with *Cucumber mosaic virus* in Minna, 2014

	Disease incidence (%)		Disease severity (scale 1 - 5)	
Soybean line	2 WAI	3 WAI	2 WAI	3 WAI
TGX 1485-1D	60.0^{a-e}	60.0^{a-e}	1.3^{de}	2.9^{b-f}
TGX 1935-10F	0.0^{f}	13.3^{f}	1.0^{e}	1.7^{f}
TGX 1951-3F	100.0^{a}	100.0^{a}	2.1^{bc}	4.1^{ab}
TGX 1987-10F	73.3^{bc}	73.3^{bc}	1.7^{b-e}	3.4^{a-d}
TGX 1987-62F	26.7^{ef}	26.7^{ef}	1.0^{e}	3.0^{b-e}
TGX 1988-5F	86.7^{bc}	86.7^{ab}	1.5^{b-e}	2.7^{c-f}
TGX 1989-19F	73.33^{bc}	80.0^{ab}	1.6^{b-e}	3.3^{a-d}
TGX 1989-62F	20.0^{ef}	20.0^{ef}	1.2^{de}	2.7^{c-f}
TGX 1989-63F	60.0^{a-e}	60.0^{a-e}	2.1^{bc}	3.4^{a-d}
TGX 1989-69F	93.3^{ab}	93.3^{a}	1.7^{cd}	3.3^{a-d}
TGX 1989-1FN	46.7^{de}	46.7^{b-f}	1.5^{b-e}	3.8^{bc}
TGX 1989-48FN	80.0^{bc}	80.0^{ab}	1.4^{de}	3.2^{a-e}
TGX 1989-49FN	66.7^{a-d}	66.7^{a-d}	2.1^{bc}	3.4^{a-d}
TGX 1989-65FN	80.0^{bc}	80.0^{ab}	1.5^{b-e}	3.5^{a-d}
TGX 1989-68FN	46.7^{de}	60.0^{a-e}	1.2^{de}	3.1^{a-e}
TGX 1989-75FN	53.3^{b-e}	60.0^{a-e}	1.3^{de}	3.1^{a-e}
TGX 1990-3F	86.7^{bc}	86.7^{ab}	2.2^{b}	3.8^{bc}
TGX 1990-21F	20.0^{ef}	20.0^{ef}	1.0^{e}	2.0^{ef}
TGX 1990-67F	93.3^{ab}	93.3^{a}	1.4^{de}	3.7^{bc}
TGX 1991-10R	93.3^{ab}	100.0^{a}	1.6^{b-e}	3.7^{bc}
TGX 1993-5FN	26.7^{ef}	33.3^{c-f}	1.8^{cd}	3.4^{a-d}
TGX 1995-5FN	86.7^{bc}	93.3^{a}	3.5^{a}	4.3^{a}
TGX 2004-3F	66.7^{a-d}	73.3^{bc}	1.3^{de}	2.3^{ef}
TGX 2007-2F	53.3^{b-e}	60.0^{a-e}	1.6^{b-e}	2.7^{c-f}
±SE	12.5	12.2	0.2	0.4

Means with dissimilar letters within the column differ significantly (P≤0.05) by the Duncan Multiple Range Test (DMRT)

At 2 WAI, percentage of infection ranged between 13.3 and 100 %. The lowest value was observed in TGX 1935-10F, whereas the highest value was found in TGX 1951-3F and TGX 1991-10R. Disease incidence observed at 2 WAI was the same as in the preceding week for TGX 1485-1D, TGX 1987-10F, TGX 1988-5F, TGX 1989-62F, TGX 1989-63F, TGX 1989-69F, TGX 1989-1FN, TGX 1989-48FN, TGX 1989-49FN, TGX 1989-65FN, TGX 1990-3F, TGX 1990-21F, and TGX 1990-67F. In contrast, uninoculated plants were apparently symptomless. The severity of CMV disease varied significantly (P < 0.05) among the evaluated genotypes (Table 1). Symptom scores ranged between 1 and 3.5 at 2 WAI, but varied from 1.7 to 4.3 at 3 WAI. Disease severity was consistently lowest in TGX 1935-10F while the greatest value was observed in TGX 1995-5FN. At 2 WAI, 79.2 % of the genotypes exhibited low symptom score of less than 2. At 3 WAI, disease severity increased in all the soybean lines except for TGX 1951-3F and TGX 1995-5FN which average symptom score was greater than 4.

Effect of cucumber mosaic virus infection on number of leaves per plant

Effect of CMV on leaf number per plant varied with soybean genotypes (Table 2). In uninoculated plants, the number of leaves per plant varied between 17 and 32, whereas the infected plants produced leaves ranging from 6 to 18. Among the control plants, TGX 1989-19F produced the highest number of leaves per plant while the lowest was found in TGX 1988-5F. Considering the infected plants alone, TGX 1987-62F produced the highest number of leaves, whereas the lowest number of leaves was produced by TGX 1990-3F. Significant differences were observed for number of leaves in both inoculated and uninoculated plants of TGX 1935-10E, TGX 1951-3F, TGX 1988-5F, TGX 1989-19F, TGX 1989-62F, TGX 1989-63F, TGX 1989-69F, TGX 1989-1FN, TGX 1989-

48FN, TGX 1989-49FN, TGX 1989-68FN, TGX 1989-75FN, TGX 1990-3F, TGX 1990-21F, TGX 1990-67F, TGX 1991-10R and TGX 2007-2F (Table 2). Percentage leaf reduction was highest in TGX 1989-49FN (74.1 %). Reduction in number of leaves per plant was also >70 % in TGX 2007-2F and TGX 1990-3F. The lowest (38.1 %) reduction in leaf number was observed in TGX 1485-1D.

Table 2: Number of leaves per plant and plant height in soybean plants inoculated and uninoculated with *Cucumber mosaic virus* in Minna, 2014

	Leaf per plant (no.)		Plant height (cm)	
Soybean line	Inoculated	Control	Inoculated	Control
TGX 1485-1D	13[a]	21[a]	48.0[a]	55.7[a]
TGX 1935-10F	14[b]	28[a]	52.0[a]	66.0[a]
TGX 1951-3F	8[b]	23[a]	52.3[b]	75.3[a]
TGX 1987-10F	8[a]	19[a]	45.0[a]	59.7[a]
TGX 1987-62F	18[a]	31[a]	59.7[a]	67.3[a]
TGX 1988-5F	7[b]	17[a]	38.3[b]	71.3[a]
TGX 1989-19F	11[b]	32[a]	45.0[b]	69.0[a]
TGX 1989-62F	11[b]	28[a]	53.0[b]	69.0[a]
TGX 1989-63F	11[b]	23[a]	42.0[b]	67.0[a]
TGX 1989-69F	12[b]	29[a]	42.0[b]	66.0[a]
TGX 1989-1FN	13[b]	30[a]	42.0[b]	63.0[a]
TGX 1989-48FN	14[b]	28[a]	39.0[b]	71.0[a]
TGX 1989-49FN	7[b]	27[a]	29.7[b]	65.3[a]
TGX 1989-65FN	10[a]	21[a]	47.7[b]	75.0[a]
TGX 1989-68FN	9[b]	24[a]	39.0[b]	68.3[a]
TGX 1989-75FN	8[b]	22[a]	46.0[a]	64.7[a]
TGX 1990-3F	6[b]	22[a]	51.7[a]	69.0[a]
TGX 1990-21F	12[b]	26[a]	49.3[a]	76.7[a]
TGX 1990-67F	12[b]	21[a]	55.0[b]	69.7[a]
TGX 1991-10R	12[b]	30[a]	54.7[b]	66.7[a]
TGX 1993-5FN	11[a]	29[a]	41.7[b]	59.7[a]
TGX 1995-5FN	16[a]	27[a]	45.7a	55.0[a]
TGX 2004-3F	14[a]	31[a]	71.3a	73.3[a]
TGX 2007-2F	8[b]	30[a]	55.7[b]	75.3[a]

Means with dissimilar letter within the row differ significantly (P≤0.05) by the Least Significant Difference (LSD)

Effect of cucumber mosaic virus disease on plant height

Cucumber mosaic virus disease affected plant height significantly (Table 2). Uninoculated plants showed normal growth while the infected plants exhibited poor growth and low vigour. Some of the inoculated plants produced small stems and short internodes. Plant height in control plants ranged from 55 to 76.7 cm, and from 29.7 to 71.3 cm in the inoculated plants. Although uninoculated plants of TGX 1993-5FN were the tallest, TGX 2004-3F produced the tallest plants among the CMV-infected plants. The difference between the height of CMV-inoculated and uninoculated plants was significant making 62.5 % of the entire genotypes (TGX 1951-3F, TGX 1988-5F, TGX 1989-19F, TGX 1989-62F, TGX 1989-63F, TGX 1989-69F, TGX 1989-1FN, TGX 1989-48FN, TGX 1989-49FN, TGX 1989-65FN, TGX 1989-68FN, TGX 1990-67F, TGX 1991-10R, TGX 1993-5FN and TGX 2007-2F). The lowest and highest percentage reductions in plant height were observed in TGX 2004-3F (2.7 %) and TGX 1995-5FN (54.5 %), respectively.

Effect of cucumber mosaic virus infection on number of branches per plant

The effect of CMV infection on the number of branches per plant varied according to different lines (Table 3). Infected plants produced between 2 and 5 branches per plant, as opposed to 6 to 10 in the control plants. In TGX 1485-1D, TGX 1935-10F, TGX 1951-3F, TGX 1988-5F, TGX 1989-19F, TGX 1989-62F, TGX 1989-63F, TGX 1989-48FN, TGX 1989-49FN, TGX 1989-65FN, TGX 1989-68FN, TGX 1989-75FN, TGX 1990-3F, TGX 1990-67F and TGX 2007-2F there was a significant difference between uninoculated and inoculated plants with respect to number of branches per plant. Percentage reduction in number of branches was greatest in TGX 1988-5F (83.3 %) while the lowest was found in TGX 1995-5FN (16.7 %). Other genotypes which suffered high reductions in number of branches were TGX 1989-65FN (70 %), TGX 1989-68FN (75 %), and TGX 2007-2F (80 %).

Effect of cucumber mosaic virus infection on 100-seed weight

Cucumber mosaic virus infection reduced seed weight at varying levels among the genotypes (Table 3). Majority of the inoculated plants produced small and deformed seeds contrary to large seeds with normal shape produced by control plants. The 100-seed weight of control plants varied between 8.8 and 13.4 g with the two values produced by TGX 1989-62F and TGX 1995-5FN, respectively. However, these two genotypes produced the lowest (7.5 g) and highest (12.4 g) 100-seed weights under CMV infection. In TGX 2004-3F, there was no reduction (0 %) in 100-seed weight and reductions were relatively low in TGX 1989-65FN (1 %), TGX 2007-2F (1.7 %), TGX 1989-1FN (5 %) and TGX 1995-5FN (7.5 %), In TGX 1485-1D, TGX 1935-10F, TGX 1988-5F, TGX 1989-49FN, TGX 1989-75FN, TGX 1990-67F, and TGX 1993-5FN the reductions in 100-seed weights were only marginally higher than 10 %. The difference in 100-seed weight between uninoculated and inoculated plants was significant ($P < 0.05$) in only 12.5 % of the entire genotypes, namely: TGX 1987-62F, TGX 1989-69F and TGX 1990-21F. The highest (26.3 %) reduction in 100-seed weight was found in TGX 1990-3F, followed by TGX 1989-48FN (25.2 %).

Table 3: Number of branches and 100-seed weight per plant in soybean plants inoculated and uninoculated with *Cucumber mosaic virus* in Minna, 2014

	Branches per plant (no.)		100-seed weight (g)	
Soybean line	Inoculated	Control	Inoculated	Control
TGX 1485-1D	4^b	8^a	9.8^a	10.9^a
TGX 1935-10F	4^b	9^a	9.4^a	10.7^a
TGX 1951-3F	3^b	8^a	9.8^a	12.4^a
TGX 1987-10F	3^a	7^a	9.5^a	11.8^a
TGX 1987-62F	5^a	10^a	7.6^b	9.5^a
TGX 1988-5F	1^b	6^a	10.2^a	11.6^a
TGX 1989-19F	4^b	7^a	9.8^a	11.7^a
TGX 1989-62F	3^b	7^a	7.5^a	8.8^a
TGX 1989-63F	3^b	7^a	8.8^a	11.2^a
TGX 1989-69F	4^a	7^a	8.7^b	10.4^a
TGX 1989-1FN	4^a	9^a	11.4^a	12.0^a
TGX 1989-48FN	3^b	9^a	9.2^a	12.3^a
TGX 1989-49FN	3^b	9^a	10.3^a	11.7^a
TGX 1989-65FN	3^b	10^a	9.7^a	9.8^a
TGX 1989-68FN	2^b	8^a	9.3^a	11.4^a
TGX 1989-75FN	3^b	7^a	9.7^a	10.8^a
TGX 1990-3F	2^b	6^a	9.8^a	13.3^a
TGX 1990-21F	4^a	7^a	10.8^b	12.6^a
TGX 1990-67F	3^b	6^a	9.8^a	11.2^a
TGX 1991-10R	3^a	8^a	9.8^a	11.4^a
TGX 1993-5FN	2^a	5^a	10.3^a	11.7^a
TGX 1995-5FN	5^a	6^a	12.4^a	13.4^a
TGX 2004-3F	5^a	8^a	11.4^a	11.4^a
TGX 2007-2F	2^b	10^a	11.4^a	11.6^a

Means with dissimilar letter within the row differ significantly ($P \leq 0.05$) by Least Significant Difference (LSD)

DISCUSSION

Cucumber mosaic virus is one of the economically important viruses infecting soybean. Incidence and severity, however, depends on the genetic composition of the attacked plant. The data obtained from the present study reveal the genetic variability of the evaluated soybean germplasm. Complete infection occurred in TGX 1951-3F shortly after inoculation owing to absence of CMV resistance genes. The high (>70 %) level of CMV disease incidence observed in other genotypes is also an indication of their susceptibility to the pathogen. Because TGX 1935-10F was apparently symptomless for 13 days after inoculation, suggested that the candidate possesses the highest level of tolerance to CMV disease. These observations are in agreement with Gergerich and Dolja (2006) who stated that susceptibility or resistance to virus infection is determined by plant genotype. The symptoms observed on CMV-inoculated plants are consistent with previous findings (Arogundade *et al*., 2009). Disease severity was variable among the genotypes because of the differences in their genetic make-up. The genotype TGX 1935-10F which suffered the lowest level of CMV disease incidence also elicited the mildest symptoms of infection because of the presence of CMV tolerance genes. However, because foliar symptoms were generally moderate it could be argued that majority of the evaluated genotypes possess some level of tolerance to the pathogen.

The differences in morphological and yield data of the control and inoculated plants are indications of pathogenicity of CMV on the tested soybean lines. However, the fact that none of the genotypes exhibited consistent reaction means that there was no direct relationship between disease severity and plant traits. The soybean genotype TGX 2004-3F in which plant height was the lowest and 100-seed weight not affected could be described as the best among the genotypes. Seed weight is one of the most valuable characters in soybean production (Dilnesaw *et al*., 2014) and genotypes with high yield are easily adopted by farmers. Reduction in seed weight observed in this study is similar to the findings of Jones *et al*. (2008) in chickpeas infected with CMV. Although none of the soybean lines was resistant to the virus cultivation of virus tolerant variety is a desirable option. Agnew *et al*. (2000) noted that tolerance is one of the mechanisms by which plants adapt to the stresses imposed by pathogens which may contribute to high yield in diseased plants.

CONCLUSION

This study established that leaf number, plant height, number of branches and 100-seed weights were affected by cucumber mosaic virus. Although none of the genotypes was consistent in response to CMV severity, the five soybean lines (TGX 1989-1FN, TGX 1989-65FN, TGX 1995-5FN, TGX 2004-3F, and TGX 2007-2F) in which CMV effect on 100-seed weight was either nil or marginally low could be utilized in breeding soybean for CMV resistance. Cultivation of soybean genotypes with level of tolerance to CMV infection could contribute to food security in the study area.

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