EFFECTS OF *SOUTHERN BEAN MOSAIC VIRUS* ON GROWTH AND YIELD OF SOYBEAN

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Abstract

Six soybean lines were evaluated for resistance to Southern bean mosaic virus (SBMV) under screenhouse conditions. The trial was laid out using completely randomised design with four replications. Seedlings were mechanically inoculated with the virus at 10 days after sowing. Disease incidence, disease severity (scale 1 – 5; 1 = apparently healthy plants, 5 = severe mosaic), morphological and yield parameters were recorded. Data were subjected to Analysis of Variance (ANOVA) at 5 % level of probability. One hundred percent infection was observed in all the lines but disease severity was significantly lowest in TGX 2007 – 1F (2.4). The same soybean line exhibited the lowest reductions in number of leaves per plant ((5.1 %)), leaf diameter (5.9 %), number of branches per plant (14.3 %), number of pods per plant (12.5 %), and seed weight per plant (6.3 %). The present results indicated the potential of TGX 2007 – 1F as a source of resistance gene (s) for breeding soybean cultivars against SBMV disease.

Keywords: Disease severity; pathogenicity; seed weight; *Southern bean mosaic virus*; soybean

Introduction

Soybean (*Glycine max* [L.] Merr.) is one of the major legume crops grown in sub-Saharan Africa. The plant originated in Asia, where it has two wild relatives (Carpenter and Gianessi, 2000). It later spread to Europe, America and other parts of the world in the 18th century (Ngeze, 1993). In the year 2013, about 276 million tonnes of soybean was produced worldwide (FAO, 2013). The United States of America was the highest producer with approximately 32 % of the world output, followed by Brazil (30 %), Argentina (17 %), China (5 %), India (4 %), Paraguay (3 %), and Canada (2 %), while output from all other countries was about 7 % of the overall (FAO, 2013). The crop is beneficial in cereal cropping system because it contributes substantially to soil fertility (Yusuf *et al*., 2006). Soybean is used to supplement cereal foodstuff in many instances because cereals have low protein content and are imbalanced in essential amino acid composition. Studies have shown that cereal grains do not supply adequate protein for satisfactory growth of infants and children or for the bodily maintenance of adults (Singh *et al*., 2008). Consequently, soybean protein has been the subject of intense investigation and has played an increasing role in human nutrition over the last few decades (Riaz, 2001).

Dry soybean seed contains 36 % protein, 19 % oil, 35 % carbohydrate, 5 % minerals and several other components such as vitamins, isoflavones and saponins (Liu, 1997; Kanchana *et al.,* 2016). Nigeria is the largest producer of soybean in sub-Saharan Africa (SSA) but productivity is usually low. According to FAO (2013), about six million tonnes of soybean were produced in Nigeria in 2013, from 6 million hectares of land. Low productivity of the crop has been partly attributed to several virus diseases including *Southern bean mosaic virus* (SBMV, genus *Sobemovirus*) (Thottappilly & Rossel, 1992). It is transmissible by sap and beetles. Infected plants elicit symptoms such as vein clearing, mosaic, and leaf distortion (Shoyinka *et al*., 1997; Taiwo, 2001). Adoption of resistant soybean cultivars remains the best management strategy against SBMV disease. Therefore, this study was conducted to identify sources of SBMV resistance genes for genetic improvement of soybean germplasm.

Materials and Methods

Virus inoculum and maintenance: The SBMV inoculum used was obtained from the stock at the Department of Crop Production, Federal University of Technology (FUT), Minna. Its physical properties have been described by Taiwo (2001). Soybean leaf tissues infected with SBMV were preserved on nonabsorbent cotton wool over silica gels in airtight vial bottles. The virus was activated by propagating in 10-day old TVU 76 seedlings. This was accomplished by rubbing the upper leaf surface with virus extract after grinding SBMV-infected leaves (1:10; w/v) with inoculation buffer, pH 7.2 (0.1M sodium phosphate dibasic, 0.1M potassium phosphate monobasic, 0.01M ethylene diamine tetra acetic acid and 0.001M L-cysteine per litre of distilled water). Distilled water was applied to the inoculated plants in order to remove excess inoculum.

Experimental Layout and Crop Establishment: The independent trials were laid out in completely randomized design with four replications. Each genotype was evaluated under SBMV inoculated and healthy (control) conditions. Six soybean lines 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. Seeds were sown in plastic pots (30-cm diameter) under screenhouse conditions (28 – 40 ^oC).

Inoculation, Data Collection and Analysis: Seedlings were mechanically inoculated with the virus at 10 days after sowing. Grinding and inoculation procedure were accomplished as indicated above. Both inoculated and uninoculated plants were observed for disease incidence, disease severity, growth and yield performance. Disease incidence was assessed as percentage of inoculated plants showing virus disease symptoms for the first two weeks after inoculation (WAI). Disease severity was recorded from 2 to 5 WAI, based on 1 – 5 visual scale (Arif and Hassan 2002). On the scale: 1 = no symptoms (apparently healthy plant); 2 = slightly mosaic leaves (10 – 30 %); 3 = mosaic (31 – 50 %) and leaf distortion; 4 = severe mosaic (51 – 70 %), leaf distortion and stunting; 5 = severe mosaic (>70 %), stunting and death of plants. Both virus inoculated and healthy plants were assessed for growth and yield characteristics. Data collected were subjected to analysis of variance (ANOVA) using the general linear model (PROC GLM) tool of SAS (Statistical Analysis System, 2008).

Results

Incidence and severity of *Southern mosaic virus*

Symptom expression started one week after inoculation (WAI) and at 2 WAI 100 % infection was observed irrespective of the soybean genotype. The inoculated plants showed typical symptoms of SBMV infection but at varying levels. At 2 to 4 WAI, the differences in severity scores among the infected plants were not significant (p>0.05). However, TGX 2007 -1F exhibited consistently lowest level of infection (score = 1.7) (Fig. 1). At 5 WAI, the differences in reactions of soybean lines to SBMV pathogenicity and severity were statistically significant (p<0.05). The lowest severity score was obtained in TGX 2007 -1F, followed by TGX 1951 -3F. Intermediate level of infection was observed in the remaining genotypes but the highest symptom score was found in TGX 2005 -1F (score = 3.3), which was not significantly different from the value observed in TGX 1990 – 46F. The uninoculated plants of all the genotypes were apparently healthy and showed normal green leaf colouration.

Effect of *Southern bean mosaic Virus* on Growth Parameters

Virus infection affected growth and development of the inoculated plants as shown in Table 1. With the exception of TGX 2007 -1F, uninoculated plants (33 to 41) produced significantly higher number of leaves than their infected counterparts (15 to 37) (Table 1). Reduction in leaf number was most conspicuous in the infected plants of TGX 1990 – 46F (63.4 %) while TGX 2007 – 1F was least affected (5.1 %). In TGX 1951 – 3F, TGX 1990 – 57F, and TGX 2007 – 3F leaf reduction was 44.4, 47.2, and 45.5 %, respectively. In inoculated plants of TGX 2005. – 1F, reduction in leaf number was quite high, and the value was approximately 59 %. Uninoculated plants produced broader leaves than infected plants. However, in TGX 1990 – 57F and TGX 2007 – 1F, there was no significant (p>0.05) difference between the leaf diameter of infected and healthy plants. TGX 1990 – 46 suffered the highest reduction in leaf diameter (34.2 %) while TGX 2007 – 1F was least affected (5.9 %). Reduction in leaf diameter was also relatively low in TGX 1990 – 57F (9.7 %).

The plants from infected soybean lines were generally shorter (57 and 69 cm) than healthy plants (97.5 to 102.5 cm). Height reductions of the infected plants in TGX 1990 – 46F and TGX 2007 – 3F were 30.8 and 32 %, respectively. In the remaining genotypes, height reductions were greater than 40 %. Branching was more profuse in healthy than infected plants. Inoculated soybean lines produced lower number of branches (5 to 12) than healthy ones (12 to 16) but there was no significant difference between the number of branches of infected and healthy plants in TGX 2007 – 1F. Reduction in number of branches was highest in TGX 2005 – 1F (68.8 %), followed by TGX 1990 – 46F (58.8 %). Furthermore, number of branches was reduced by 50 % in TGX 1990 – 57F and TGX 2007 – 3F, which was relatively lower than 53.8 % reduction observed in TGX 1951 – 3F.

Effect of *Southern bean mosaic Virus* on Yield and Yield Components

Flowering was earlier in healthy plants (39 to 45 days after sowing) than the infected ones (41 to 50 days after sowing) (Table 2). Days to flowering was delayed for two days in the infected plants of TGX 2005 – 1F and TGX 2007 – 1F. In TGX 1990 – 57F and TGX 2007 – 3F, number of days to flowering was increased by three days while the remaining genotypes flowered five days later than their healthy counterparts. Number of days to pod formation of the healthy plants varied between 48 to 52 days after sowing while in the infected ones, it ranged from 48 to 52 days. However, both the infected and healthy plants of TGX 2005 – 1F and TGX 2007 – 1F produced pods at the same time (52 days after sowing). Podding was most delayed in infected plants of TGX 1951 – 3F (6 days), followed by TGX 2007 – 3F (5 days). In TGX 1990 – 57F and TGX 1990 – 46F, podding was delayed for two and three days, respectively. *Southern bean mosaic virus* affected pod production (Table 2). Healthy plants produced 7 to 24 pods per plant while diseased plants produced pods ranging from 2 to 21 per plant. Apart from TGX 2007 – 1F, number of pods in healthy plants was significantly higher than the infected ones. Pod reduction was lowest in TGX 2007 – 1F (12.5 %) while values in other genotypes were generally high. In all, TGX 2007 – 3F suffered the greatest pod reduction (71.4 %), closely followed by TGX 2005 – 1F (69.2 %) and TGX 1951 – 3F (63.2 %). Furthermore, pod reduction was higher in TGX 1990 – 46F (60 %) than TGX 1990 – 57F (53.8 %).

Seeds of some infected plants were tiny and deformed. On the other hand, healthy plants produced large seeds with normal shape. In diseased plants, seed weights varied between 0.5 and 5.9 g which were different from 1.1 to 6.3 g observed in the healthy plants. With the exception of TGX 2007 – 1F, seed weights of infected were significantly different from healthy plants. Whereas TGX 2007 – 1F exhibited the lowest reduction in seed weight (6.3 %), substantial weight loss was observed in TGX 1951 – 3F (76.2 %), TGX 1990 – 57F (74.2 %), and TGX 2005 – 1F (63.6 %). Seed weight was reduced by 45.5 and 36.4 % in TGX 1990 – 46F and TGX 2007 – 3F, respectively.

Discussion

Appearance of disease symptoms on all the inoculated plants indicated that none of the evaluated soybean lines was immune to SBMV. The symptoms observed on SBMV-inoculated plants were consistent with previous findings (Thottappilly and Rossel, 1992). Also, the varying levels of symptoms were in agreement with the findings of Gergerich and Dolja (2006) that susceptibility or resistance to virus infection is determined by plant genotype. Therefore, disease severity was variable among the genotypes because of the differences in their genetic make-up.

The ability of SBMV isolate to reduce leaf number and diameter is an indication of its virulence on the evaluated genotypes. A similar phenomenon was encountered when some sweet pepper (*Capsicum annuum* L.) genotypes were infected with *Cucumber mosaic virus* (Zitikaitė and Urbanavičienė, 2010). Leaf diameter plays a significant role in photosynthesis which in turn has a direct relationship with plant growth and development. Infected plants were generally shorter because of the effect of the virus on their physiology. Earlier, Taiwo and Akinjogunla (2006) reported significant height reductions when some cowpea plants were inoculated with SBMV. Diseased plants produced fewer branches as a consequence of the stresses posed by the virus. The observation on the number of branches in infected and healthy plants of TGX 2007 – 1F was somewhat comparable which suggests some level of its tolerance to the pathogen. This partly reveals the vulnerability of other genotypes to SBMV.

There was no uniform number of days to flowering between diseased and healthy plants due to adverse effect of SBMV on physiology of the infected plants. A similar result was reported by Salaudeen (2014) when some rice cultivars were infected with *Rice yellow mottle virus* (RYMV). Non-uniform flowering could cause a serious setback to large scale soybean production because plants would not mature at the same time. This in turn would affect simultaneous harvesting of large fields. Again, the fact that number of days to flowering in the infected plants of TGX 2007 – 1F was similar to their healthy counterparts reveals that the genotype probably contains SBMV resistance gene (s). The disparity in number of days to pod formation among the infected soybean lines was probably a carryover effect of non-uniform number of days to flowering. Generally, pod production was better in the healthy than infected plants, confirming that SBMV is an economically important virus disease of soybean (Taiwo, 2001). Reduction in seed weight was relatively lowest in TGX 2007 – 1F probably because it was tolerant to SBMV. The present results indicated that SBMV could be a limiting factor for soybean production. The line TGX 2007 – 1F which exhibited the lowest reductions in leaf diameter, number of branches per plant, number of pods per plant, and seed weight per plant could be a possible source of resistance gene (s) for breeding soybean cultivars against SBMV disease in the study area.

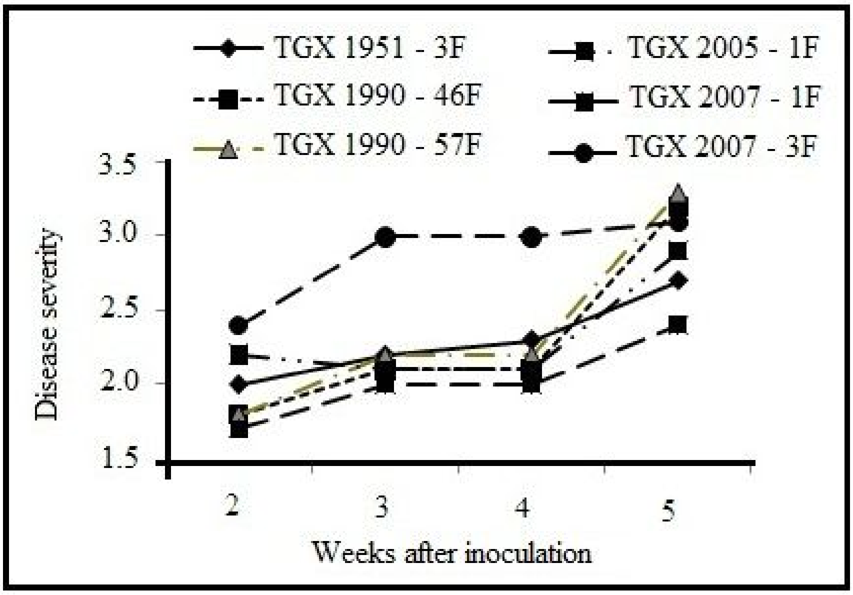

Fig. 1: Progress of disease severity in soybean plants inoculated with *Southern bean mosaic virus* in a screenhouse

Table 1: Growth attributes of healthy and *Southern bean mosaic virus*-infected soybean plants under screenhouse conditions

	Number of leaves per plant		Leaf diameter (cm)		Plant height (cm)		Number of branches per plant	
Soybean	Infected	Control	Infected	Control	Infected	Control	Infected	Control
TGX 1951 – 3F	20[b]	36[a]	2.6[b]	3.7[a]	58.0[b]	102.5[a]	6[b]	13[a]
TGX 1990 – 46F	15[b]	41[a]	2.5[b]	3.8[a]	68.5[b]	99.0[a]	5[b]	12[a]
TGX 1990 – 57F	19[b]	36[a]	2.8[a]	3.1[a]	57.5[b]	97.5[a]	6[b]	12[a]
TGX 2005 – 1F	16[b]	39[a]	2.7[b]	3.3[a]	60.5[b]	101.0[a]	5[b]	16[a]
TGX 2007 – 1F	37[a]	39[a]	3.2[a]	3.4[a]	57.0[b]	100.5[a]	12[a]	14[a]
TGX 2007 – 3F	18[b]	33[a]	2.3[b]	2.7[a]	69.0[b]	101.5[a]	6[b]	12[a]

Means followed by dissimilar letters within the row differ significantly ($p \leq 0.05$) by the Least Significant Difference (LSD)

Table 2. Yield attributes of healthy and *Southern bean mosaic virus*-infected soybean plants under screenhouse conditions

	Days to flowering (no.)		Days to podding (no.)		Pods per plant (no.)		Seed weight per plant (g)	
Soybean	Infected	Control	Infected	Control	Infected	Control	Infected	Control
TGX 1951 – 3F	50[a]	45[b]	54[a]	48[b]	7[b]	19[a]	0.5[b]	2.1[a]
TGX 1990 – 46F	46[a]	41[b]	51[a]	48[a]	4[b]	10[a]	0.6[b]	1.1[a]
TGX 1990 – 57F	43[a]	40[a]	50[a]	48[a]	6[b]	13[a]	0.8[b]	3.1[a]
TGX 2005 – 1F	43[a]	41[a]	52[a]	52[a]	4[b]	13[a]	0.8[b]	2.2[a]
TGX 2007 – 1F	41[a]	39[a]	52[a]	52[a]	21[a]	24[a]	5.9[a]	6.3[a]
TGX 2007 – 3F	44[a]	41[a]	53[a]	48[b]	2[b]	7[a]	0.7[b]	1.1[a]

Means followed by dissimilar letters within the row differ significantly ($p \leq 0.05$) by the Least Significant Difference (LSD)

References

Arif, M. & Hassan, S. (2002). Evaluation of resistance in soybean germplasm to *Soybean mosaic Potyvirus* under field conditions. *Online Journal of Biol Sci.,* 2, 601–604.

Carpenter, J. E. & Gianessi, L. P. (2000). *Agricultural biotechnology: Benefits of transgenic soybeans.* Washington, D.C.: Natl. Center for Food and Agricultural Policy.

FAO (Food and Agriculture Organization) (2013). *Soybean production statistics.* Available at http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor. Retrieved on April 6, 2016.

Gergerich, R. C. & Dolja, V. V. (2006). Introduction to plant viruses, the invisible foe. *The Plant Health Instructor.* DOI: 10.1094/PHI-I-2006-0414-01

Kanchana, P., Santha, M. L. & Raja, K. D (2016). A review on *Glycine max* (l.) Merr. (soybean). *World J. Pharmacy Pharmaceutical Sci.* 5, 356 – 371.

Liu, K. (1997). Chemistry and nurtitional value of soybean components. *Soybean Chem Technol Util*., 25 – 113.

Ngeze, P. B. (1993). *Learn how to grow soybean.* Publ C, editor. Nairobi, Kenya, Pp 21.

Riaz, M. N. (2001). Uses and benefits of soy fiber. *Cereal Foods World*, 46(3), 98 – 100.

Salaudeen, M. T. (2014). Relative resistance to *Rice yellow mottle virus* in rice. *Plant Protect Sci.,* 50, 1 – 7.

SAS (Statistical Analysis System) (2008). *Statistical Analysis System SAS/STAT User's guide, ver. 9.2.* Cary, N.C SAS Institute Inc.

Shoyinka, S. A., Thottappilly, G., Adebayo, G. G. & Anno-Nyako, F. O. (1997). Survey on cowpea virus incidence and distribution in Nigeria. *Int J Pest Manage,* 43,127 – 132.

Singh, P., Kumar, R., Sabapathy, S. N. & Bawa, A. S. (2008). Functional and edible uses of soy protein products. *Comp Rev Food Sci Food Safety,* 7, 14 – 28.

Taiwo, M. A. (2001). *Viruses infecting legumes in Nigeria: case history. In: Plant virology in sub-Saharan Africa (Hughes JdA and Odu BO eds.).* Proceedings of a conference organized by the International Institute of Tropical Agriculture (IITA), Ibadan, 4 – 8 June, 2001. Pp 365 – 380.

Taiwo, M. A. & Akinjogunla, O. J. (2006). Cowpea viruses: Quantitative and qualitative effects of single and mixed viral infections. *Afr J. Biotech.,* 5, 1749 – 1756.

Thottappilly, G. & Rossel, H. W. (1992). Virus diseases of cowpea in tropical Africa*. Tropical Pest Manage,* 38, 337 – 348.

Yusuf, A. A., Iwuafor, E. N. O., Olufajo, O. O., Abaidoo, R. & Sanginga, N. (2006). Genotype effects of cowpea and soybean nodulation, N_2-fixation and balance in the northern Guinea Savanna of Nigeria. *Proceedings of the 31st Annual Conference of the soil science of Nigeria 13-17th November. Held at the Ahmadu Bello University, Zaria.* Pp, 147-154

Zitikaitė, I. & Urbanavičienė, L. (2010). Detection of natural infection by *Cucumber mosaic virus* in vegetable crops. *Biologija,* 56, 14 – 19.