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GROWTH AND YIELD COMPONENTS OF SOME GROUNDNUT (*Arachis hypogaea* L.) CULTIVARS INFECTED WITH *BLACKEYE COWPEA MOSAIC VIRUS*

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ABSTRACT

Blackeye cowpea mosaic virus (BlCMV) is a major virus, infecting legumes with attendant huge losses. Cultivation of resistant varieties is the most effective and sustainable control strategy. Therefore, some groundnut (Arachis hypogaea) cultivars were evaluated against BlCMV in Minna, Southern Guinea savanna zone of Nigeria. The experiment was conducted at the Teaching and Research Farm, Federal University of Technology, Minna. It was arranged as infected and uninfected using Randomised Complete Block Design (RCBD) with three replications. Groundnut seeds were sowed in the second week of August, 2015. Seedlings were inoculated by sap transmission at 10 days after sowing. Disease incidence, severity, growth and yield attributes were recorded. Data were subjected to analysis of variance (ANOVA) and means separated at p≤0.05 probability level. Disease incidence varied significantly p<0.05 from 28.3 to 60.3 % at one week after inoculation (WAI) and 44.7 to 100 % at 2 WAI. ICGV 91317 which expressed mild infection (symptom score = 2) at 9 WAI also exhibited the lowest leaf diameter reduction (3.6 %) at that growth stage. FDRF7-82 which had the lowest reduction in number of leaves per plant at 3 and 6WAI (10.7 and 9.6 %, respectively) also exhibited the lowest reduction in fresh haulm weight per plant (42.2 %). None of the cultivars exhibited consistent reactions, FDRF7-82 and ICGV 91317 had an appreciable combination of growth and yield attributes under BlCMV infection. However, these cultivars could be improved upon either through conventional or molecular breeding by coding with desirable genes. The cultivars which were adversely affected by BlCMV disease could so be improved genetically through appropriate gene introgression from the resistant cultivars.

Keywords: Blackeye cowpea mosaic virus; disease incidence and severity; growth and yield; groundnut

INTRODUCTION

Groundnut or peanut (*Arachis hypogaea* L.) native to South America is an annual oilseed and food legume crop grown in diverse environments throughout the world between 40°N and 40°S (FAO, 2013). In the year 2013 it was cultivated on 25.4 million hectares of land with productivity of 45.2 million metric tonnes (FAO, 2013). Groundnut seed contains about 50 % edible oil and 25 % protein and is consumed as whole seed or processed as snack foods. Groundnut oil is used for cooking and the residual cake is used as animal feed. Nearly 75 to 80 % of world's groundnut is grown by resource poor smallholder farmers in developing countries who routinely obtain yields of 500 – 800 kg ha^{-1} as opposed to the potential yields of >2.5 t ha^{-1} (Idem and Showemimo, 2005).

Low yields are mainly due to numerous diseases caused by fungi, viruses, bacteria and nematodes (Arogundade *et al.*, 2010; Aliyu *et al.*, 2011; Osei *et al.*, 2013). Diseases in groundnut caused by *Blackeye cowpea mosaic virus* (BlCMV), *Cucumber mosaic virus* (CMV), *Groundnut bud necrosis virus* (GBNV), *Groundnut rosette virus* (GRV), *Indian peanut clump virus* (IPCV), *Peanut clump virus* (PCV), *Peanut mottle virus* (PeMoV), *Peanut stripe virus* (PStV), *Tobacco streak virus* (TSV) and *Tomato spotted wilt virus* (TSWV) are the most economically important and are responsible for serious yield losses globally or regionally (Taiwo, 2001). They are also known to naturally infect several other crops and inflict significant losses in them.

Blackeye cowpea mosaic virus is a major virus disease of legume (Arogundade *et al.*, 2010). It is flexuous, rod-shaped particles 750 mm long which induces characteristic pinwheel inclusions in infected cells. The dilution endpoint is 10^{-4} – 10^{-5}, thermal inactivation point is 50 - 60 °C and longevity *in vitro* 2-3 days. The virus is transmitted, mostly by aphids in a non-persistent manner. From experimental results, some aphid species such as *Aphis craccivora* have been found to be vectors of the virus (Alegbejo, 2015). According to Balogun (2010), the virus could also be seed borne and seed transmitted. Seed borne infection of the virus has been detected with incidences as high as 50 % in cowpea seed (Alegbejo 2015). Yield reduction from expected 2500 kg/ha to 50 kg/ha has been reported in fields infected with BlCMV in India (Puttaraju *et al.*, 2000).

Plants can be attacked by the virus at seedling and vegetative growth stages. Groundnut varieties infected with BlCMV at the primary leaf stage showed 92-100 % infection at first trifoliate leaf. Disease symptoms include leaf discolouration, mosaic, mottling, vein banding, vein clearing, leaf deformation and yellow spot, while on seeds, shrivelling can be observed (Arogundade *et al.*, 2010). There are severe green and yellow mosaic, vein banding, mottle, blistering, leaf roll and growth reduction on the whole plant. The spread of BlCMV on the field is enhanced by aphids after initial seed transmission from infected seeds planted.

Although, incidence and severity of this virus can be mitigated by insecticidal control of the insect vectors, the various negative consequences associated with this strategy outweigh its benefits. These include development of resistance by the insects, environment and soil contamination, health hazards to the applicators and pesticide residues to consumers. More so, high cost and poor knowledge of application are limiting factors. It has also been reported that management of viruses includes the practice of close spacing which will create unfavourable environment to the aphids and early planting (Damiri *et al.*, 2013). In addition, intercropping cowpea with tall cereals such as maize or sorghum and keeping the field free of weeds has been recommended (Taiwo and Akinjogunla, 2006). Alegbejo (2015) also suggested the planting of resistant varieties. Quarantine measure and adoption of virus free seeds have also been recommended (IITA, 2011). However, host- plant resistance remains the most effective method for the control of legume viruses (Damiri *et al.*, 2013). Therefore, the objective of this research was to ascertain the level of resistance of the selected groundnut cultivars to BICMV.

MATERIALS AND METHODS

Study Location

The experiment was conducted on the Teaching and Research Farm of the Department of Crop Production, Federal University of Technology (FUT), Minna, Nigeria. The site is located in southern Guinea savanna agro-ecological zone on 09^0 44.613 N, 006^0 30.641 E and 224 m above sea level. The temperature of the site ranges between 35 and 40 °C with a relative humidity between 40 and 80 %. The experimental field has been used for the cultivation of maize and millet for the past five years.

Treatments and Experimental Design

Twenty popular groundnut cultivars (FDRF7-57, FDRF7-61, FDRF7-67, FDRF7-82, ICG6654, ICG02189, ICGV01276, ICGV91317, ICGV-IS-07883, ICGV-IS-13003, ICGV-IS-13986, ICGV-IS-76855, SAMNUT10, SAMNUT14, SAMNUT21, SAMNUT22, SAMNUT23, SAMNUT24, SAMNUT25 and SAMNUT26) constituted the treatments. Each cultivar was laid out separately as infected and uninfected plots using Randomised Complete Block Design (RCBD) with three replicates. Gross plots size was 11 m × 17.25 m (189.75 m^2) and the net plot size was 8 m × 14.25 m (114 m^2), containing 20 rows of 2 m long ridges each. An alley of 1 m was left between replicates and 20 m between infected and uninfected plots.

Source of Seeds and Propagation of Groundnut

The groundnut cultivars evaluated were obtained from the Institute for Agricultural Research (IAR), Samaru, Zaria, Nigeria. They were selected among the commonly grown cultivars in the study area.

Source of Inoculum, Maintenance and Inoculation

The BICMV inoculum used was obtained from the stock in the Department of Crop Production, FUT, Minna. Virus inoculum was multiplied in the seedlings of a susceptible cowpea variety (Ife Brown) through mechanical transmission (Salaudeen and Aguguom, 2014). It was accomplished by macerating the BICMV-infected leaves in inoculation buffer (0.1M sodium phosphate dibasic, 0.1M potassium phosphate monobasic, 0.01M ethylene diamine tetra acetic acid and 0.001M L-cystine per litre of distilled water, adjusted to pH 7.2) at the rate of 1 g/ mL, using a pre-cooled sterilized mortar and pestle (Adama *et al.*, 2015). Five micro litre of β-mercapto- ethanol was added to the extract just before use (Adamu *et al.*, 2015).

The topmost leaves of 10-day-old Ife Brown seedlings were dusted with carborundum powder (Aliyu *et al.*, 2011) (600-mesh), a piece of cotton wool was dipped in the BICMV extract and the inoculum was gently rubbed on the upper leaf surface. Distilled water was then sprinkled on the inoculated leaves. Symptomatic leaves were collected from the infected plants at four weeks after inoculation (WAI), preserved in an air-tight tube with silica gels covered with a thin layer of nonabsorbent cotton. The infected leaves were used for subsequent inoculation of the evaluated cultivars.

Field Establishment, Management and Inoculations

Groundnut seeds (FDRF7-57, FDRF7-61, FDRF7-67, FDRF7-82, ICG6654, ICG02189, ICGV01276, ICGV91317, ICGV-IS-07883, ICGV-IS-13003, ICGV-IS-13986, ICGV-IS-76855, SAMNUT 10, SAMNUT 14, SAMNUT 21, SAMNUT 22, SAMNUT 23, SAMNUT 24, SAMNUT 25 and SAMNUT 26) were sown on 13th August, 2015. Sowing was done on 2 m long ridges at the rate of 2 seeds per hole, using an inter-and intra-row spacing of 75 ×10 cm. Seedlings were thinned to one plant per stand at one week after sowing (WAS). Seedlings of the 20 groundnut lines were infected with the BICMV at 10 days after sowing using the same procedure for inoculation as described above. Weeds were manually controlled using hoe at 3 and 6 WAS. Pods were harvested when most of the leaves had turned yellow or had been shed (IAR, 2009). Harvesting was done by uprooting the whole plant from the ground level, stacked loosely in paper bags and allowed to dry in the open for 2 weeks before shelling (IAR, 2009).

Data Collection

Disease incidence was determined as percentage of inoculated plants eliciting BICMV disease symptoms at 1 and 2 weeks after infection (WAI). Disease severity was scored at 3, 6 and 9 WAI based on percentage of the topmost leaves showing BICMV disease symptoms. A scale of 1 – 5 (Adamu *et al.*, 2015) was used as follows:

1 = no symptoms (apparently healthy plant)
2 = mild mosaic (10 - 30 % infection)
3 = moderate mosaic (31 – 50 % infection)
4 = severe mosaic, chlorosis and stunting (51 – 70 % infection)
5 = very severe mosaic, chlorosis, stunting and plant dead (>70 % infection)

At 3, 6 and 9 WAI, leaf diameter and number of leaves per plant were recorded. In addition, fresh haulm weight per plant and 100-seed weight were evaluated after harvesting.

RESULTS

Incidence and Severity of *Blackeye cowpea mosaic virus* Disease

The first cultivar to exhibit symptoms (vein clearing) was FDRF7-61 at 1 WAI. Disease incidence varied significantly ($p<0.05$) between 28.3 and 60.3 % but was relatively lower than 50 % in most cultivars (ICG 6654, ICGV 01276, ICGV 91317, ICGV-IS-07883, ICGV-IS-76855, SAMNUT 10, SAMNUT 14, SAMNUT 21, SAMNUT 22, SAMNUT 24, SAMNUT 25 and SAMNUT 26) (Table 1). At 2 WAI, symptoms ranging from leaf discolouration, mosaic, vein clearing and disease incidence increased in all the infected cultivars except in SAMNUT 26 which exhibited a constant value of 44.7 %. One hundred percent infection was observed in the FDRF7-57, FDRF7-61, FDRF7-67, FDRF7-82, ICG 02189, ICGV 01276, ICGV 91317, ICGV-IS-13003, ICGV-IS-13986 and ICGV-IS-76855 cultivars.

Disease severity (3 WAI) was significantly ($p<0.05$) mildest in SAMNUT 26 (symptom score = 2), whereas moderate level of severity (symptom score = 2) was observed in the other cultivars. Disease severity at 6 WAI, ranged between 2.7 and 4.0. The lowest symptom score was observed in SAMNUT 23 while FDRF7-61, ICGV 01276, ICGV 91317, ICGV-IS-07883, ICGV-IS-13986, ICGV-IS-76855, SAMNUT 10, SAMNUT 14, SAMNUT 21, SAMNUT 22, SAMNUT 24, SAMNUT 25 and SAMNUT 26 exhibited a mean severity score of 3.0. The other cultivars (FDRF7-57, FDRF7-67, FDRF7-82, ICG 6654, ICG 02189 and ICGV-IS-13003) had a mean symptom score of 4.0. However, at 9 WAI, disease severity decreased to 2.0 in FDRF7-61, ICG 6654, ICGV 01276, ICGV-IS-13986, ICGV 91317, SAMNUT 14 and SAMNUT 23. Moreover, ICG 02189, ICGV-IS-07883, ICGV-IS-76855, SAMNUT 22, SAMNUT24, SAMNUT 25 and SAMNUT 26 expressed disease severity score of 3.0, whereas the highest symptom score (4.0) was found in FDRF7-57, FDRF7-67, FDRF7-82, ICGV-IS-13003, SAMNUT 10 and SAMNUT 21.

Effect of *Blackeye cowpea mosaic virus* disease on leaf diameter per plant

The leaf surface which has a very important function in photosynthetic activities of plants was severely affected in diseased plants. At 3 WAI, there was significant ($p<0.05$) difference between the leaf diameter of uninfected and infected plants (Table 2). Leaf diameter of uninfected plants ranged between 1.8 (FDRF7-82, SAMNUT 21 and SAMNUT 23) to 2.9 cm (SAMNUT 26) while infected plants exhibited leaf diameter between 1.5 (FDRF7-67) and 2.1 cm (ICGV 91317, ICGV-IS-13003, ICGV-IS-07883 and SAMNUT 10). Percentage leaf diameter reduction was highest in SAMNUT 26 (31 %) and lowest in ICGV 91317 (4.5 %).

Table 1. Disease incidence and severity in groundnut plants infected with *Blackeye cowpea mosaic virus* disease

Cultivar	Disease incidence (%)		Disease severity (1-5)		
	1 WAI	2 WAI	3 WAI	6 WAI	9 WAI
FDRF7-57	55.0^{a-d}	100.0^{a}	3.0b	4.0^{a}	4.0^{a}
FDRF7-61	54.7^{a-d}	100.0^{a}	3.0b	3.0^{b}	2.0^{c}
FDRF7-67	58.0^{a-c}	100.0^{a}	3.0b	4.0^{a}	4.0^{a}
FDRF7-82	59.3^{ab}	100.0^{a}	3.0b	4.0^{a}	4.0^{a}
ICG 6654	43.3^{c-g}	96.7^{ab}	3.0b	4.0^{a}	2.0^{c}
ICG 02189	51.0^{a-e}	100.0^{a}	3.0b	4.0^{a}	3.0^{b}
ICGV 01276	49.3^{a-e}	100.0^{a}	3.0b	3.0^{b}	2.0^{c}
ICGV 91317	45.0^{a-f}	100.0^{a}	3.0b	3.0^{b}	2.0^{a}
ICGV-IS-07883	31.0^{fg}	83.3^{d}	3.0b	3.0^{b}	3.0^{b}
ICGV-IS-13003	50.7^{a-e}	100.0^{a}	3.0b	4.0^{a}	4.0^{a}
ICGV-IS-13986	60.0^{ab}	100.0^{a}	3.0b	3.0^{b}	2.0^{c}
ICGV-IS-76855	48.3^{a-e}	100.0^{a}	3.0b	3.0^{d}	3.0^{b}
SAMNUT 10	36.7^{e-g}	88.3^{c}	3.0b	3.0^{b}	4.0^{a}
SAMNUT 14	44.3^{b-f}	96.7^{ab}	3.0b	3.0^{a}	2.0^{c}
SAMNUT 21	41.7^{d-g}	96.7^{ab}	3.0b	3.0^{b}	4.0^{a}
SAMNUT 22	42.0^{d-g}	98.3^{ab}	3.0b	3.0^{c}	3.0^{b}
SAMNUT 23	60.3^{a}	100.0^{a}	3.0b	2.7^{b}	2.0^{c}
SAMNUT 24	28.3^{g}	78.3^{e}	3.0b	3.0^{b}	3.0^{b}
SAMNUT 25	39.3^{d-g}	95.0^{b}	3.0b	3.0^{b}	3.0^{b}
SAMNUT 26	44.7^{a-f}	44.7^{a-f}	2.0c	3.0^{b}	3.0^{b}
±SEM	4.2	1.7	0.21	0	0.1

Means with the same letters along the same column are not significantly different at $p=0.05$ by Duncan Multiple

Range Test (DMRT)

At 6 WAI, the leaf diameter of uninfected and infected plants differed significantly ($p<0.05$). Uninfected plants had a range of 2.1 (ICG 02189) to 3.7 cm (FDRF7-61) while infected plants exhibited a range of 1.9 (ICG 02189) to 3.2 cm (FDRF7-57 and ICGV-IS-07883). Percentage reduction in leaf diameter was highest in ICGV-IS-13003 (30 %) and lowest in ICG 02189 (1.9 %). At 9 WAI, the leaf diameter of uninfected plants was highest in IFDRF7-61 (4.2 cm) while the lowest was observed in SAMNUT 14 and SAMNUT 22 (2.8 cm). Conversely, the infected plants had 3.4 cm as the highest leaf diameter (FDRF7-61) and 1.5 cm as the lowest (ICGV-IS-13986). Percentage leaf diameter reduction was highest in ICGV-IS-13986 (58.3 %) whereas the lowest was observed in SAMNUT 14 and SAMNUT 22 (3.6 %).

Effect of *Blackeye cowpea mosaic virus* disease on number of leaves per plant

Effect of *Blackeye cowpea mosaic virus disease* on number of leaves per plant varied significantly ($p<0.05$) among the infected groundnut cultivars (Table 3). At 3 WAI, number of leaves in uninfected plants varied between 51 (FDRF7-57) and 118 (SAMNUT 22) while in infected plants, it ranged from 40 (FDRF7-57) to 94 (ICGV-IS-76855). Percentage leaf reduction was highest in ICGV 91317 (38.9 %) and the lowest was observed in FDRF7-82 (10.7 %). At 6 WAI, there were no significant ($p>0.05$) differences in number of leaves per plant between uninfected and infected plants of FDRF7-57, FDEF7-61, FDRF7-82, ICGV-IS-13003, ICGV-IS-13986, ICG-IS-76855, SAMNUT 10, 1SAMNUT 14, SAMNUT 24 and SAMNUT 26. The difference was significant ($p<0.05$) in the other cultivars. Number of leaves varied between 127 (FDRF7-57) and 243 (ICG 6654) from uninfected plants but ranged between 101 (FDRF7-57) and 170 (SAMNUT 14) in diseased plants. The highest percentage reduction was observed in ICGV 01276 (49.1 %) and the lowest was observed in FDRF7-82 and SAMNUT 10 (9.6 %).

At 9 WAI, the difference between number of leaves per plant from uninfected and infected plants was significant ($p<0.05$) in all the cultivars except in FDRF7-57. The number of leaves from uninfected plants varied between 149 (FDRF7-57) and 364 (ICG 02189) while in infected plants it ranged between 130 (FDRF7-57) and 286 (ICG 02189 and SAMNUT 24). The highest percentage in the reduction of number of leaves was observed in FDRF7-67 (51.1 %) and the lowest in ICGV-IS-13003 (1.9 %).

Table 2. Leaf diameter per plant in groundnut cultivars infected with *Blackeye cowpea mosaic virus disease*

	Leaf diameter (cm)											
	3 WAI				6 WAI				9 WAI			
Cultivar	Uninfected	Infected	SEM	% Reduction	Uninfected	Infected	SEM	% Reduction	Uninfected	Infected	SEM	% Reduction
FDRF7-57	2.1^{a}	1.8^{b}	0.0	14.3	3.5^{a}	3.2^{b}	0.0	8.6	3.8^{a}	3.0^{b}	0.0	21.1
FDRF7-61	1.9^{a}	1.7^{b}	0.0	10.5	3.7^{a}	2.8^{b}	0.2	24.3	4.2^{a}	3.4^{b}	0.0	19.0
FDRF7-67	1.9^{a}	1.5^{b}	0.0	21.1	3.3^{a}	2.5^{b}	0.2	24.2	3.9^{a}	3.0^{b}	0.0	23.1
FDRF7-82	1.8^{a}	1.7^{b}	0.1	5.6	2.4^{a}	2.1^{b}	0.1	12.5	3.4^{a}	2.3^{b}	0.1	32.4
ICG 6654	2.1^{a}	1.8^{b}	0.1	14.3	2.4^{a}	2.2^{b}	0.1	8.3	3.1^{a}	2.4^{b}	0.1	22.6
ICG 02189	2.1^{a}	1.9^{b}	0.0	9.5	2.1^{a}	1.9^{b}	0.1	9.5	2.9^{a}	1.8^{b}	0.3	37.9
ICGV 01276	2.2^{a}	1.9^{b}	0.0	13.6	2.8^{a}	2.5^{b}	0.0	10.7	3.9^{a}	2.3^{b}	0.0	41.0
ICGV 91317	2.2^{a}	2.1^{b}	0.0	4.5	2.5^{a}	2.3^{b}	0.0	8.0	3.4^{a}	2.3^{b}	0.0	32.4
ICGV-IS-07883	1.9^{a}	1.7^{b}	0.0	10.5	3.5^{a}	3.2^{a}	0.1	8.6	3.8^{a}	3.2^{b}	0.0	15.8
ICGV-IS-13003	2.4^{a}	2.1^{b}	0.0	12.5	3.0^{a}	2.1^{b}	0.0	30	3.2^{a}	2.9^{b}	0.0	9.4
ICGV-IS-13986	2.2^{a}	2.0^{b}	0.0	9.1	2.8^{a}	2.5^{a}	0.1	10.7	3.6^{a}	1.5^{b}	0.0	58.3
ICGV-IS-76855	2.4^{a}	2.1^{b}	0.0	12.5	3.1^{a}	2.7^{b}	0.0	12.9	3.5^{a}	2.7^{b}	0.1	22.9
SAMNUT 10	2.4^{a}	2.1^{b}	0.0	12.5	3.1^{a}	2.7^{b}	0.0	12.9	3.4^{a}	2.7^{b}	0.1	20.6
SAMNUT 14	2.1^{a}	1.7^{b}	0.0	19.0	2.8^{a}	2.6^{b}	0.0	7.1	2.8^{a}	2.7^{b}	0.0	3.6
SAMNUT 21	1.8^{a}	1.6^{b}	0.0	11.1	2.9^{a}	2.3^{b}	0.0	20.7	3.6^{a}	2.6^{b}	0.0	27.8
SAMNUT 22	2.2^{a}	1.9^{b}	0.0	13.6	2.6^{a}	2.2^{a}	0.1	15.4	2.8^{a}	2.7^{a}	0.0	3.6
SAMNUT 23	1.8^{a}	1.7^{b}	0.0	5.6	2.6^{a}	2.2^{b}	0.0	15.4	2.9^{a}	1.9^{b}	0.0	44.8
SAMNUT 24	1.9^{a}	1.7^{b}	0.0	10.5	3.0^{a}	2.7^{b}	0.1	10.0	3.2^{a}	2.8^{b}	0.0	12.5
SAMNUT 25	1.9^{a}	1.7^{b}	0.0	10.5	2.4^{a}	2.3^{a}	0.0	4.2	3.0^{a}	2.1^{b}	0.0	30.0
SAMNUT 26	2.9^{a}	2.0^{b}	0.0	31.0	2.4^{a}	2.3^{a}	0.0	4.2	3.3^{a}	2.1^{b}	0.0	36.4

Means with the same letter within the row are not significantly different at $p=0.05$ by Least Significant Difference (LSD)

Effect of *Blackeye cowpea mosaic virus* disease on fresh haulm weight per plant and 100-seed weight

There was a significant ($p<0.05$) difference in fresh haulm weight per plant between uninfected and infected plants in all the groundnut cultivars (Table 4). The fresh haulm weight per plant from uninfected plants ranged between 177.4 (SAMNUT 14) and 621.4 g (FDRF7-61) while in the infected plants it varied between 76.8 (ICGV 91317) and 217.5 g (SAMNUT 24). Percentage reduction in fresh haulm weight was highest in FDRF7-61 (81.9 %) and the lowest occurred in FDRF7-82 (42.2 %). *Blackeye cowpea mosaic virus disease* reduced seed weight at varying levels among the infected plants (Table 4). Most of the seeds produced by infected plants were small and deformed, contrary to the large and normal seeds produced in uninfected plants. All the cultivars exhibited significant ($p<0.05$) difference in 100-seed weight between uninfected and infected plants. One hundred-seed weight in uninfected plants varied between 119 (ICGV-IS-13986) and 163.0 g (FDRF7-61) while infected plants had a range of 78 (FDRF7-82) to 118.0 g (FDRF7-57). Percentage reduction in 100-seed weight was highest in FDRF7-57 (33.6 %) and the lowest was encountered in ICGV 91317 (12.5 %).

Table 3. Number of leaves per plant in groundnut cultivars infected with *Blackeye cowpea mosaic virus* disease

	Number of leaves per plant											
	3 WAI				6 WAI				9 WAI			
Cultivar	Uninfected	Infected	SEM	% Reduction	Uninfected	Infected	SEM	% Reduction	Uninfected	Infected	SEM	% Reduction
FDRF7-57	51^{a}	40^{b}	1.1	20.5	127^{a}	101^{a}	7.7	20.5	149^{a}	130^{a}	14	12.8
FDRF7-61	87^{a}	63^{b}	3.1	27.0	231^{a}	139^{a}	39.3	39.8	311^{a}	171^{b}	13.3	45.0
FDRF7-67	67^{a}	52^{b}	2.2	22.4	157^{a}	119^{b}	8.4	24.2	309^{a}	151^{b}	10.5	51.1
FDRF7-82	93^{a}	83^{a}	3.8	10.7	178^{a}	161^{a}	8.4	9.6	330^{a}	237^{b}	12.2	28.1
ICG 6654	99^{a}	76^{a}	7.2	23.2	243^{a}	151^{b}	12.9	37.9	344^{a}	263^{b}	15.1	23.5
ICG 02189	75^{a}	56^{b}	4.1	25.2	235^{a}	124^{b}	10.4	47.2	364^{a}	286^{b}	6.9	21.4
ICGV 01276	110^{a}	70^{b}	6.6	36.8	216^{a}	110^{b}	10.5	49.1	334^{a}	251^{b}	16.4	24.9
ICGV 91317	92^{a}	56^{b}	4.3	38.9	168^{a}	111^{b}	5.8	16.1	268^{a}	161^{b}	11.1	40.0
ICGV-IS-07883	109^{a}	91^{a}	5.3	16.8	180^{a}	115^{b}	3.9	36.1	281^{a}	179^{b}	7.3	36.3
ICGV-IS-13003	106^{a}	87^{b}	3.1	17.9	158^{a}	121^{a}	9.9	23.4	257^{a}	252^{b}	28.5	1.9
ICGV-IS-13986	58^{a}	43^{a}	5.8	25.9	148^{a}	125^{a}	17.8	15.5	267^{a}	140^{b}	17.2	47.6
ICGV-IS-76855	115^{a}	94^{a}	5.8	18.3	187^{a}	156^{a}	8.4	16.6	327^{a}	180^{b}	8.4	45.0
SAMNUT 10	105^{a}	86^{b}	4.7	18.4	177^{a}	160^{a}	8.7	9.6	292^{a}	247^{b}	4.2	15.4
SAMNUT 14	111^{a}	75^{b}	5.9	32.7	195^{a}	170^{a}	8.7	12.7	291^{a}	237^{b}	10.0	18.6
SAMNUT 21	87^{a}	68^{b}	4.8	21.9	174^{a}	121^{b}	7.8	30.5	277^{a}	172^{b}	7.9	37.9
SAMNUT 22	118^{a}	88^{b}	3.8	25.7	235^{a}	122^{b}	17.8	48.1	317^{a}	227^{b}	12.8	28.4
SAMNUT 23	107^{a}	73^{b}	3.9	32.1	210^{a}	147^{b}	8.2	30.0	305^{a}	263^{b}	7.0	13.8
SAMNUT 24	94^{a}	68^{a}	6.8	27.8	196^{a}	142^{a}	16.3	27.6	337^{a}	286^{b}	7.9	15.1
SAMNUT 25	95^{a}	65^{b}	7.8	32.1	165^{a}	125^{b}	8.9	24.1	286^{a}	210^{b}	5.7	26.6
SAMNUT 26	104^{a}	73^{a}	10.5	29.7	180^{a}	146^{a}	17.7	18.9	348^{a}	239^{b}	14.9	31.3

Means with the same letter within the same row are not significantly different at p=0.05 by Least Significant Difference (LSD)

Table 4. Fresh haulm weight per plant and 100-seed weight in groundnut plants infected with *Blackeye cowpea mosaic virus*

Cultivar	Fresh haulm weight per plant(g)				100-seed weight (g)			
	Uninfected	Infected	SEM	% Reduction	Uninfected	Infected	SEM	% Reduction
FDRF7-57	243.2ᵃ	104.3ᵇ	0	57.1	153.3ᵃ	118ᵇ	0	33.6
FDRF7-61	621.4ᵃ	112.7ᵇ	0	81.9	163.1ᵃ	99ᵇ	0	27.7
FDRF7-67	268.9ᵃ	153.2ᵇ	0	43.0	141.4ᵃ	101ᵇ	0	18.4
FDRF7-82	237.8ᵃ	137.4ᵇ	0	42.2	121.4ᵃ	78ᵇ	0	21.6
ICG 6654	359.5ᵃ	187.4ᵇ	0	47.9	123.0ᵃ	87ᵇ	0	17.2
ICG 02189	375.3ᵃ	196.8ᵇ	0	47.6	124.4ᵃ	93ᵇ	0	28.7
ICGV 01276	521.5ᵃ	204.4ᵇ	0	60.8	152.2ᵃ	93ᵇ	0	25.8
ICGV 91317	188.4ᵃ	76.8ᵇ	0	59.2	156.7ᵃ	82ᵇ	0	12.5
ICGV-IS-07883	258.3ᵃ	121.5ᵇ	0	53.0	127.3ᵃ	85ᵇ	0	27.3
ICGV-IS-13003	279.8ᵃ	113.6ᵇ	0	59.4	132.1ᵃ	69ᵇ	0	26.6
ICGV-IS-13986	198.5ᵃ	89.7ᵇ	0	54.8	119.1ᵃ	85ᵇ	0	26.6
ICGV-IS-76855	332.7ᵃ	133.2ᵇ	0	60.0	146.9ᵃ	79ᵇ	0	19.9
SAMNUT 10	185.9ᵃ	89.9ᵇ	0	51.6	153.0ᵃ	88ᵇ	0	25.8
SAMNUT 14	177.4ᵃ	84.3ᵇ	0	52.5	162.2ᵃ	97ᵇ	0	19.5
SAMNUT 21	184.6ᵃ	78.6ᵇ	0	57.4	142.0ᵃ	89ᵇ	0	24.8
SAMNUT 22	237.5ᵃ	132.5ᵇ	0	44.2	148.4ᵃ	102ᵇ	0	15.6
SAMNUT 23	285.8ᵃ	112.8ᵇ	0	60.5	135.8ᵃ	104ᵇ	0	16.1
SAMNUT 24	421.6ᵃ	217.5ᵇ	0	48.4	125.4ᵃ	107ᵇ	0	23.5
SAMNUT 25	266.4ᵃ	112.5ᵇ	0	57.8	148.1ᵃ	95ᵇ	0	18.
SAMNUT 26	284.8ᵃ	101.1ᵇ	0	64.5	127.6ᵃ	101ᵇ	0	20.

Means with the same letter within the same row are not significantly different at $p=0.05$ by Least Significant Differences (LSD)

DISCUSSION

BlCMV has been identified as one of the major viruses infecting cowpea. Apart from individual attack it is capable of causing synergistic disease complex in the presence of compatible plant virus (Aliyu *et al.*, 2012). Presently, cultivation of resistant varieties is the most effective, sustainable and ecologically sound control strategy. The results obtained from this investigation revealed the genetic variability among the groundnut cultivars. The cultivars which exhibited 100 % infection could be described as being the most susceptible to the virus. The observation that SAMNUT 26 maintained a constant and less than 50 % disease incidence at 1 and 2 WAI revealed its tolerance to BICMV. Symptom severity was generally between low and moderate level at 3 WAI among the infected cultivars probably because of the initial combat between virus particles and inherent plant defense mechanism. This corroborated the findings of Boualem *et al*. (2016).

Disease severity increased in some infected plants at 4 WAI, supporting the fact that some viruses have the capacity to escape plant's defense barriers (Boualem *et al*., 2016). In plant – virus pathotype, plants use mechanisms such as antiviral RNA silencing but viruses fight back using silencing-repressors. The cultivars in which symptom severity decreased at 9 WAI restricted systemic movement of the virus particles possibly owing to the presence of BICMV tolerant genes. Additionally, some plants have capacity to recover from systemic infection as an outcome of plant – virus interactions. The reduction in symptoms severity is associated with degradation or translation repression of viral RNAs and in the case of DNA viruses, it is effected by transcriptional arrest of viral minichromosomes (Ghoshal and Sanfaçon, 2015).

The differences in growth and yield parameters among the infected cultivars plants were direct consequences of BICMV infection. The pattern of reduction among the infected plants indicated that none of the cultivars exhibited complete superiority over the others. The infected plants of ICGV 91317 which exhibited the highest symptom score at 9 WAI had the lowest reduction in leaf diameter and 100-seed weight. Conversely, ICGV-IS-13986 which expressed low level of infection suffered the highest leaf diameter reduction at 9 WAI. The infected plants of FDRF7-82, SAMNUT 10 and ICGV-IS-13003 which suffered the highest disease severity exhibited the lowest reductions in fresh haulm weight and number of leaves per plant. All these indicated that there was no synergy between the genes controlling response to infection and agronomic performance. On the other hand, SAMNUT 14 which expressed mild infection at 9 WAI also exhibited the lowest leaf diameter reduction at that growth stage. This indicated a positive correlation between resistance gene (s) and growth parameters. Undoubtedly, plants possess genes whose products are important in its normal physiology, but these genes could also facilitate pathogen infection and colonization. Such genes are considered susceptibility genes (van Schie and Takken, 2014). Changes in such genes through conventional and molecular breeding could result in increased disease resistance (Berg *et al*., 2015).

FDRF7-82 which had the lowest reduction in number of leaves per plant at 3 and 6 WAI also exhibited the lowest reduction in fresh haulm weight per plant. This revealed that BICMV infection had little or no effect on the genes controlling these traits. Seed weight is an important agronomic trait and is normally given high priority during groundnut breeding. Reduction in 100-seed weight was markedly impaired in FDRF7-57 as a consequence of infection which culminated in small sized and deformed seeds. This is consistent with the findings of Aliyu *et al*. (2012) who reported significant reduction in seed weight of cowpea plants infected with BICMV.

CONCLUSION AND RECOMMENDATIONS

This study has shown the susceptibility of the evaluated groundnut cultivars to BICMV. None of the cultivars exhibited consistent reactions. FDRF7- 82 and ICGV 91317 had an appreciable combination of growth and yield attributes under BICMV infection. They are so recommended to groundnut farmers. However, these cultivars could be further improved either through conventional or molecular breeding by coding with desirable genes. The cultivars which were adversely affected by BICMV disease could also be improved genetically through appropriate gene introgression from the resistant cultivars.

REFERENCES

Adama, C.J., Salaudeen, M.T., Ishaq, M.N., Bello, L.Y. and Oyewale, R.O. (2015). Evaluation of *Blackeye cowpea mosaic virus* pathogenicity in soybean. **Nig. J. Agric. Food Environ.**, 11(4): 39 - 44.

Adamu, A.S., Salaudeen, M.T., Gana, A.S. and Ishaq, M.N. (2015). Response of selected soybean (*Glycine max* [l.] merr.) lines to *Cucumber mosaic virus* disease in Minna, Niger State. **Nig. J. Agric. Food Environ.**, 11(4): 45 - 51.

Alegbejo, M.D (2015). Virus and virus-like diseases of crops in Nigeria. Zaria, Nigeria, Ahmadu Bello University Press, 12, 89-91.

Aliyu, T.H, Balogun, O.S. and Adeoti, O.M. (2011). Pathogenic responses of cowpea (Vigna *unguiculata*) inoculated with *Cucumber mosaic virus* to soil amendment with neem leaf powder. ***Agrosearch***, 11(1): 99 – 110.

Aliyu, T.H., Balogun, O.S. and Gbadebo, F.M. (2012). Cowpea reaction to single and mixed viral infection with *Blackeye cowpea mosaic virus* and Cowpea yellow mosaic virus. **Agrosearch**, 12(2): 174-183.

Arogundade, O., Balogun, O.S., Shokalu, O. and Aliyu, T.H (2010). Influence of Cowpea mottle virus and *Cucumber mosaic virus* on the growth and yield of six lines of soybean (Glycine max L.Merrril). ***J. Agric. Sci.***, 2: 72–78.

Balogun, S.O. (2010). Seedling age at inoculation and infection sequence affect diseases and growth response in tomato mixed infected with *Potato virus X* and *Tomato mosaic virus*. ***Int. J. Agric. Biol.***, 10 (2): 145-150

Berg, J.A., Appiano, M., Martinez, M.S., Hermans, F.W., Vriezen, W.H., Visser, R.G., Bai, Y. and Schouten, H.J. (2015). A transposable element insertion in the susceptibility gene CsaMLO8 results in hypocotyl resistance to powdery mildew in cucumber. ***BMC Plant Biol.***, 15: 243 DOI 10.1186/s12870-015-0635-x

Boualem, A., Dogimont, C. and Bendahmane, A. (2016). The battle for survival between viruses and their host plants. ***Curr Opin Virol.***, 17: 32 – 38.

Damiri, B.V., Al-Shahwan, I.M., Al-Saleh, M.A., Abdalla, O.A. and Amer, M.A. (2013). Identification and characterization of *Cowpea aphid-borne mosaic virus* isolates in ***Saudi Arabia. J. Plant Pathol.***, 95 (1): 79 - 85.

FAO (Food and Agriculture Organization). (2013). Groundnut Statistics. Rome: FAO: Food and Agriculture Organization of the United Nations. http://www.faostat.fao.org/site/567/DesktopDefault.aspx?PageID ¼ 567# ancor

Ghoshal, B. and Sanfaçon, H. (2015). Symptom recovery in virus-infected plants: Revisiting the role of RNA silencing mechanisms. ***Virol.***, 479 – 480: 167 – 179.

Idem, N.U.A .and Showemimo, F.A. (2005). Major legumes and oil seeds of Nigeria: Principles of production and utilization, Ibadan Nigeria. xi, 211 p 22-110.

IITA (International Institute of Tropical Agriculture). (2011). Annual report. Ouagadougou. Burkina Faso. IITA SAFURAD 138-1932

AR (Institute for Agricultural Research). (2009). Cowpea production and utilization: A production Guide. Samaru, Nigeria Ahmadu Bello University (ABU).

)sei, K., Asibuo, J. Y., Agyeman, A., Osei-Bonsu, P., Danso, Y. and Adomako, J. (2013). Reactions of some confectionery groundnut accessions to plant parasitic nematodes infection. **Agrosearch**, 13(2): 1-11.

Puttaraju, H.R., Prakash, H.S. and Shetty, H.S. (2000). Field incidence, seed-transmission and susceptibility of cowpea varieties with reference to *Blackeye cowpea mosaic* Potyvirus. ***Seed Res.***, 28(2):196-202.

Salaudeen, M.T. and Aguguom, A. (2014). Identification of some cowpea accessions tolerant to *Cowpea mild mottle virus*. ***Int. J. Sci. Nature***, 5 (2): 261 - 267.

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

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

van Schie, C.C. and Takken, F.L. (2014). Susceptibility genes 101: How to be a good host. ***Annu. Rev. Phytopathol.***, 52: 551 – 581.