



Reactions of some Cowpea (*Vigna unguiculata* L. Walp) Cultivars Genotypes to Blackeye Cowpea Mosaic Virus Disease

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Abstract

Keywords:

Cowpea, Genotype, Incidence, Infections and Severity.

Cowpea is a dependable source of protein for human growth and development. The crop is widely cultivated in Sub-Saharan Africa including Nigeria. In spite of its numerous uses, infection by Blackeye cowpea mosaic virus (BICMV) constitutes a serious problem to cowpea productivity and once plants are infected, there is no remedy as in the case of other pathogens such as bacteria, fungi and nematodes. Cultivation of resistant genotypes is cost effective, ecologically sound and sustainable strategy against the pathogen. Twenty-five cowpea genotypes with differential yield and resistance background were evaluated against BICMV infection on the field. Cowpea seedlings were inoculated at ten days after sowing. The plants were observed for BICMV disease incidence, disease severity, growth and yield parameters. The data collected were subjected to analysis of variance. Cowpea genotype IT97K – 568 – 18 was observed to have the lowest disease incidence of 22.2%. However, the genotypes IT07K – 292 – 1 – 10 and IT07K – 299 – 6 exhibited the lowest disease severity score of 2.3. Seed weight of 1.5 g per plant was highest in IT97K – 568 – 18. Therefore, the genotype IT97K – 568 – 18 is recommended for cultivation in areas that are prone to BICMV disease. This genotype probably contains tolerant genes to BICMV that could be explored for breeding purposes.

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INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp.) is a short day leguminous crop in the tropics and subtropics. It is a drought tolerant and warm-weather crop. The crop has the ability of fixing atmospheric nitrogen into the soil with the help of bacteria living in its root nodules (Asiweet *et al.*, 2009). This crop can grow well in soil containing above 85% sand and 0.2% organic matters and low level of phosphorus (Asiwe *et al.*, 2009). The crop can be grown under rainfall condition, irrigation or residual moisture along river or lake flood plains during dry season provided temperature range is between 28°C and 30°C [night and day temperatures]

(Timkoet *et al.*, 2007). Cowpea thrives well in agro-ecological zone where the annual rainfall is between 500 mm-1200 mm.

International Institute of Tropical Agriculture [IITA] (2015) reported that more than 5.4 million metric tonnes of dried cowpea are produced worldwide, and Africa produces nearly 5.2 million metric tonnes per year. It was further reported that Nigeria produced 61% of Africa production share and 58 % worldwide production. Nigeria, Niger, Senegal, Ghana, Mali and Burkina Faso are known to be the key producers of cowpea in West Africa (FAO, 2008). However, Nigeria is the largest producer and consumer of cowpea in the World, and the country

production share comes from the Northern region of Nigeria (FAOSTAT, 2011).

Blackeye cowpea mosaic virus (BICMV) has a wide host range and it attacks vegetables, ornamentals, weeds and other crops such as cowpea (Crescenzy, 2003). This virus has a major threat to annual crops including cowpea (Nault et al., 2006). It affects yield, quality and quantity of infected crops and severity of infection can be determined by the level of susceptibility of the cultivar. The pathogen constitutes a serious problem to cowpea productivity and once cowpea is infected, there is no remedy as in the case of other pathogens such as bacteria, fungi and nematodes (Puttarajuet al., 2000).

In order to achieve a successful breeding programme to improve the yield potentials of the crop, the quality of the grains in term of its nutritional values should also be a paramount concern. This enables the breeder to operate selection efficiently and subsequently developed appropriate breeding strategies to solve the problems of poor yield as well as improve the nutritive quality of the crop. Therefore, this study was conducted to screen and identify cowpea genotypes that are resistance Blackeye mosaic virus disease in the southern guinea agro-ecological zone of Nigeria.

MATERIALS AND METHODS

The experiment was conducted in the Teaching and Research Farm of the Ahmadu Bello University, Mokwa Station, Niger State, Nigeria (9.52¹ N, 6.45¹ E and 220 m above sea level), during 2016/2017 cropping seasons. Mokwa is located in the Southern Guinea Savannah agro-ecological zone of Nigeria with a mean annual rainfall of 1200 mm (Anon, 2011). The rainfall usually begins in April and terminates in the first week of October. The temperature ranges of Mokwa are between 35⁰C and 37.5⁰C and relative humidity between 40% and 80%. The soils of Mokwa are said to originate from basement complex rocks and are generally classified as Alfisol (Anon, 2011).

Source of Cowpea Seeds

Twenty four (24) cowpea genotypes were collected from the International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State, Nigeria for the study. These genotypes are: (IfeBrown, TVU 408, 11D-15-40, 04K-267-8, 07K-230-2-9, 07K-291-69, 08K-125-24, 08K-125-107, 08K-193-15, 09K-480, 10K-819-4, 10K-836-3, 12K-261, 12K-515, 12K-809, IT08K-125-100, IT08K-187-5, IT10K-292-10, IT10K-822-7, IT10K-828-3, IT10K-830-9, IT10K-837-1, IT10K-837-1 and IT12K-113). These genotypes were chosen due to desirable attributes such as early maturing and high yielding.

Treatments and Experimental Design

The twenty-four (24) genotypes (treatments) were arranged in a Randomized Complete Block Design (RCBD) with three replications.

Source of Inoculi and Inoculation

The BICMV isolate was obtained from the Department of Crop Production, Federal University of Technology, Minna Niger State. *Blackeye cowpea mosaic virus* isolate was extracted by grinding 1g/1ml of isolate in extraction buffer containing 0.1m sodium phosphate dibasic, 0.1m potassium phosphate monobasic, 0.01m ethylene diamine tetra acetic acid and 0.001m-cystine per litre of distilled water using a pre-cooled sterilized mortar and pestle as described by Kumar (2009). Two microliters of β - Mercapto-ethanol was added to the extract just before used following the Kumar (2009) method. Thereafter, cowpea seedlings were infected with the inoculum at 10 days after sowing (DAS) by rubbing the virus extract on the upper surface of the leaves that were dusted with carborundum powder (600- mesh).

The leaves of inoculated plant were rinsed with sterile distilled water according to Abdullahi et al. (2019). This is to prevent leaves from shedding and enlargement of lesions on the leaf surface by the carborundum powder. Cowpea leaves with symptoms of BICMV infection were collected from the infected plant at 3 weeks after inoculation (WAI) to be used for inoculation during the main experiment. The leaves were preserved at room temperature, in an air tight condition vial bottle on silica gels that was covered with a thin layer of non-absorbent cotton wool.

Data Collection

Data were collected on BICMV disease incidence and disease severity. Disease severity was based on a visual scale (1 – 5) of Samuel et al. (2016). On the scale, 1 = no symptoms, 2 = slight mosaic; 3 = moderate mosaic, 4 = severe mosaic, leaf distortion and stunting, 5 = severe mosaic, stunting and plant death. Number of leaves per plant, number of pod and number of seeds per plant were also recorded.

Statistical Analysis

All data were subjected to analysis of variance (ANOVA) using the general linear model (PROC GLM) procedure of SAS (2008). Where ANOVA result was significant ($P \leq 0.05$) treatment means were separated using Duncan Multiple Range Test (DMRT). And cluster analysis was carried out on all the growth and yield data to determine the relationship among the selected genotypes.

RESULTS

Incidence and Severity of BICMV infection

Disease symptoms were first sighted at 10 days after inoculation (DAI). All inoculated plants in trial 1 and 2 showed typical foliar symptoms of BICMV

infection at different level. The symptoms were mild leaf chlorosis and mosaic on the secondary leaves of the infected plants (Table 1).

At 1 WAI in 2016, the disease incidence varied between 0.00 and 88.9% in trial 1. A significantly highest ($p \leq 0.05$) disease incidence of 88.9 % was found in cowpea genotype 12K-809 followed by genotype 12K-261 with 77.8% incidence. Similarly, Ife Brown, TVU 408 and IT12K-13 exhibited 66.6% level of infection, whereas 08K-193-15 and 09K-480 exhibited no disease incidence (Table 1).

In 2016, at 2 WAI, disease incidence was significantly ($p \leq 0.05$) highest (100%) in Ife Brown, TVU, 07K-230-2-5, 07K-291-69, 12K-261, 12K-515, 12K-809, IT08K-125-100, IT08K-187-5, IT10K-292-10, IT10K-822-7, IT10K-830-9, IT10K-837-1 and IT12K-13. This was followed by genotypes 08K-125-107 which had 88.9% disease incidence. In 11D-15-40, 10K-819-4 and 10K-836-3, disease incidence of 77.8 % was found whereas 09K-480 and IT10K-828-3 had the lowest disease incidence of 55.6% each while genotype 08K-193-15 showed no symptom (Table 1).

In 2017, disease incidence differed significantly ($p \leq 0.05$) amongst the twenty-four genotypes investigated at 1 WAI. The highest was observed in IT12K-13 with 77.8 % followed by genotypes 10K-819-4 and IT10K-125-100 with 33.3%, next were 09K-480 and IT08K-187-5 with 22.2% each. Ife Brown, TVU 408, 11D-15-40, 07K-291-69, 08K-125-107, 10K-836-3, and 12K-809 had 11.1% disease incidence each while 04K-267-8, 07K-230-2-5, 08K-193-15, 12K-261, 12K-515, IT10K-292-10, IT10K-822-7, IT10K-828-3, IT10K-830-9 and IT10K-837-1 showed no symptom (Table 1).

At 2 WAI in 2017, the differences observed in disease incidence differed significantly ($p \leq 0.05$). Cowpea genotypes 11D-15-40, 12K-515, IT08K-125-100, IT08K-187-5 and IT10K-822-7 exhibited significantly ($p \leq 0.05$) highest disease incidence of 100% each. Ife Brown, TVU 408, 07K-230-2-5 and IT12K-13 were next with each having 88.9%, this was followed by

genotypes 07K-291-69, 08K-125-24 and 10K-836-3 with 77.8% each whereas the lowest disease incidence of 66.7 % was found in genotypes 04K-267-8, 10K-819-4, 12K-261, IT10K-292-10 and IT10K-837-1 (Table 1).

At 3 WAI in 2016, there were plants with severity score of 3 and this was peculiar to 04K-267-8 and IT10K-822-7. Genotypes 10K-836-3 and IT10K-837-1 exhibited 2.7 disease severity score whereas Ife Brown, TVU 408, 07K-230-2-5, 07K-291-69, 08K-125-107, 09K-480, 10K-819-4, 12K-809, IT10K-828-3 and IT10K-830-9 had severity score of 2.3 each (Table 1).

At 5 WAI in 2016, genotypes 09K-480, 10K-819-4 and 10K-836-3 exhibited significantly ($p \leq 0.05$) highest severity score of 4.0, 11D-15-40, 04K-267-8, IT10K-822-7 and IT10K-837-1 elicited disease severity score 3.7, whereas the lowest severity score of 1.0 was observed in 08K-193-15 (Table 1).

At 3 WAI in 2017, the differences observed in disease severity differed significantly ($p \leq 0.05$). The highest of 2.3 was observed in 07K-230-2-5. Ife Brown, TVU 408, 04K-267-8, 07K-291-69, 08K-125-24, 08K-125-107, 08K-193-15, 09K-480, 10K-819-4, 10K-836-3, 12K-261, 12K-515, 12K-809, IT08K-125-100, IT08K-187-5, IT10K-292-10, IT10K-822-7, IT10K-837-1 and IT12K-13 exhibited a severity score of 2.0 each, in addition, genotypes 11D-15-40 and IT10K-828-3 had 1.7 severity score while IT10K-830-9 had the lowest severity score of 1.3 (Table 1).

At 5 WAI in 2017, genotypes IT10K-292-10 and IT10K-822-7 exhibited significantly ($p > 0.05$) highest disease severity score of 3.3, 04K-267-8, 07K-291-69, 08K-125-107, 10K-819-4, 12K-515, IT08K-125-100, IT08K-187-5 and IT12K-13 had a severity score of 3.0 while Ife brown, 11D-15-40, 12K-261 and 12K-809 exhibited the lowest severity score of 2.3. Generally, severity of the infection varied from mild to moderate level among the genotypes during the entire period of the evaluation (Table 1).

Table 1: Disease incidence and severity of Blackeye cowpea mosaic virus on selected cowpea genotypes

Cultivar	Disease incidence (%)				Disease severity			
	2016		2017		2016		2017	
	1 WAI	2 WAI	1 WAI	2 WAI	3 WAI	5 WAI	3 WAI	5 WAI
Ife Brown	66.7 ^{ab}	100.0 ^a	11.1 ^b	88.9 ^a	2.3 ^{ab}	3.0 ^a	2.0 ^{ab}	2.3 ^a
TVU 408	66.7 ^{ab}	100.0 ^a	11.1 ^b	88.9 ^a	2.3 ^{ab}	3.0 ^a	2.0 ^{ab}	2.7 ^a
11D-15-40	33.3 ^{ab}	77.8 ^a	11.1 ^b	100.0 ^a	2.0 ^{ab}	3.7 ^a	1.7 ^{ab}	2.3 ^a

04K-267-8	11.1 ^{ab}	66.7 ^a	0.0 ^b	66.7 ^a	3.0 ^a	3.7 ^a	2.0 ^{ab}	3.0 ^a
07K-230-2-5	22.2 ^{ab}	100.0 ^a	0.0 ^b	88.9 ^a	2.3 ^{ab}	3.3 ^a	2.3 ^a	2.7 ^a
07K-291-69	22.2 ^{ab}	100.0 ^a	11.1 ^b	77.8 ^a	2.3 ^{ab}	2.3 ^a	2.0 ^{ab}	3.0 ^a
08K-125-24	44.4 ^{ab}	66.7 ^a	11.1 ^b	77.8 ^a	2.0 ^{ab}	2.3 ^a	2.0 ^{ab}	2.7 ^a
08K-125-107	22.2 ^{ab}	88.9 ^a	11.1 ^b	55.6 ^a	2.3 ^{ab}	3.0 ^a	2.0 ^{ab}	3.0 ^a
08K-193-15	0.0 ^b	0.0 ^b	0.0 ^b	44.4 ^a	1.0 ^b	1.0 ^b	2.0 ^{ab}	2.7 ^a
09K-480	0.0 ^b	55.6 ^a	22.2 ^b	22.2 ^a	2.3 ^{ab}	4.0 ^a	2.0 ^{ab}	2.7 ^a
10K-819-4	22.2 ^{ab}	77.8 ^a	33.3 ^b	66.7 ^a	2.3 ^{ab}	4.0 ^a	2.0 ^{ab}	3.0 ^a
10K-836-3	44.4 ^{ab}	77.8 ^a	11.1 ^b	77.8 ^a	2.7 ^{ab}	4.0 ^a	2.0 ^{ab}	3.0 ^a
12K-261	77.8 ^{ab}	100.0 ^a	0.0 ^b	66.7 ^a	2.0 ^{ab}	2.7 ^a	2.0 ^{ab}	2.3 ^a
12K-515	55.6 ^{ab}	100.0 ^a	0.0 ^b	100.0 ^a	2.0 ^{ab}	3.0 ^a	2.0 ^{ab}	3.0 ^a
12K-809	88.9 ^a	100.0 ^a	11.1 ^b	55.6 ^a	2.3 ^{ab}	3.0 ^a	2.0 ^{ab}	2.3 ^a
IT08K-125-100	11.1 ^{ab}	100.0 ^a	33.3 ^b	100.0 ^a	2.0 ^{ab}	2.7 ^a	2.0 ^{ab}	3.0 ^a
IT08K-187-5	22.2 ^{ab}	100.0 ^a	22.2 ^b	100.0 ^a	2.0 ^{ab}	2.7 ^a	2.0 ^{ab}	3.0 ^a
IT10K-292-10	11.1 ^{ab}	100.0 ^a	0.0 ^b	66.7 ^a	2.0 ^{ab}	2.7 ^a	2.0 ^{ab}	3.3 ^a
IT10K-822-7	33.3 ^{ab}	100.0 ^a	0.0 ^b	100.0 ^a	3.0 ^a	3.7 ^a	2.0 ^{ab}	3.3 ^a
sIT10K-828-3	22.2 ^{ab}	55.6 ^a	0.0 ^b	66.6 ^a	2.3 ^{ab}	3.3 ^a	1.7 ^{ab}	2.7 ^a
IT10K-830-9	22.2 ^{ab}	100.0 ^a	0.0 ^b	55.6 ^a	2.3 ^{ab}	3.3 ^a	1.3 ^b	2.7 ^a
IT10K-837-1	33.3 ^{ab}	100.0 ^a	0.0 ^b	66.7 ^a	2.7 ^{ab}	3.7 ^a	2.0 ^{ab}	2.7 ^a
IT12K-13	66.7 ^{ab}	100.0 ^a	77.8 ^a	88.9 ^a	2.0 ^{ab}	3.0 ^a	2.0 ^{ab}	3.0 ^a
± SEM	15.5	10.6	9.6	19.7	0.3	0.3	0.1	0.3

Means followed by different letter (s) in superscript on the same column are significantly different at 5 % probability level of significance using Duncan Multiple Range Test (DMRT).

Effect of BICMV on Plants' Growth and Yield Attributes

Prior to inoculation, all the cowpea plants produced equal number of leaves. The number of fully expanded leaves per plant remained uniform at one week post inoculation. The variation in leaf count of cowpea cultivars with respect to the virus treatment at 3 and 5 WAI is presented in Table 2. At 3 WAI in 2016, number of leaves varied between 18 and 10. Significant ($p < 0.05$) highest number of leaves per plant (18) was found in each of genotypes 12K-261 and IT10K-292-10. Genotype 08K-125-24 had 16 leaves, 08K-193-15 and IT10K-828-3 produced 15 leaves each and Ife Brown, 07K-291-69, 08K-125-107, 10K-836-3, 12K-809, IT1-0K-837-1 had 14 leaves whereas the lowest of 10 leaves was found in IT10K-822-7 (Table 2).

At 5 WAI in 2016, the highest number of leaves of 28.0 was observed in genotype 04K-267-8 followed

by 09K-480 with 23 leaves per plant. Genotypes 08K-125-24 and 08K-125-107 had 21 leaves each, Ife Brown, 12K-261 and 12K-809 produced 19.0 leaves each while others produced between 14 and 17 leaves per plant (Table 2).

At 3 WAI in 2017, Ife Brown, 07K-230-2-5, 08K-125-107 and 08K-125-107 produced significantly ($p < 0.05$) highest number of leaves per plant (17), 07K-291-69 and 08K-125-24 gave 16 leaves each per plant while the remaining genotypes produced fewer number of leaves that did not differ significantly (Table 2).

At 5 WAI in 2017, significantly ($p < 0.05$) highest number of leaves per plant of 26 was recorded in genotypes 04K-267-8 and 04K-267-8 respectively whereas genotypes IT08K-187-5, IT10K-822-7, IT10K-830-9 and IT12K-13 elicited the least of 14 leaves each. The remaining genotypes had fewer numbers of leaves that did not differ statistically.

Table 2: Effect of Blackeye cowpea mosaic virus disease on number of leaves

Cultivar	Number of Leaves			
	2016		2017	
	3 WAI	5WAI	3 WAI	5 WAI
Ife Brown	14 ^{a-f}	19 ^{b-e}	17.0 ^{ab}	20.0 ^{ab}
TVU 408	11 ^{ef}	16 ^{b-e}	15.0 ^{a-d}	19.0 ^{ab}
11D-15-40	11 ^{def}	10 ^e	14.0 ^{a-d}	17.0 ^b
04K-267-8	17 ^{abc}	28 ^a	19.0 ^a	26.0 ^a
07K-230-2-5	13 ^{c-f}	17 ^{b-e}	17.0 ^{ab}	20.0 ^{ab}
07K-291-69	14 ^{a-f}	20 ^{bcd}	16.0 ^{abc}	19.0 ^{ab}
08K-125-24	16 ^{a-d}	21 ^{bc}	16.0 ^{abc}	18.0 ^b
08K-125-107	14 ^{a-f}	21 ^{bc}	17.0 ^{abc}	19.0 ^{ab}
08K-193-15	15 ^{a-f}	17 ^{b-e}	15.0 ^{a-d}	17.0 ^b
09K-480	13 ^{b-f}	23 ^b	13.0 ^{bcd}	20.0 ^{ab}
10K-819-4	12 ^{c-f}	16 ^{b-e}	13.0 ^{bcd}	15.0 ^b
10K-836-3	14 ^{a-f}	20 ^{bcd}	16.0 ^{abc}	19.0 ^{ab}
12K-261	18 ^{ab}	19 ^{b-e}	16.0 ^{abc}	20.0 ^{ab}
12K-515	13 ^{c-f}	15 ^{b-e}	15.0 ^{a-d}	16.0 ^b
12K-809	14 ^{a-f}	19 ^{b-e}	14.0 ^{a-d}	19.0 ^{ab}
IT08K-125-100	13 ^{c-f}	14 ^{b-e}	14.0 ^{a-d}	17.0 ^b
IT08K-187-5	13 ^{c-f}	17 ^{b-e}	11.0 ^d	14.0 ^b
IT10K-292-10	18 ^{ab}	15 ^{b-e}	14.0 ^{bcd}	19.0 ^{ab}
IT10K-822-7	10 ^f	10 ^{de}	12.0 ^{cd}	14.0 ^b
IT10K-828-3	15 ^{a-f}	16 ^{b-e}	14.0 ^{a-d}	18.0 ^b
IT10K-830-9	13 ^{c-f}	15 ^{b-e}	13.0 ^{bcd}	14.0 ^b
IT10K-837-1	14 ^{a-f}	17 ^{b-e}	12.0 ^{bcd}	16.0 ^b
IT12K-13	12 ^{c-f}	13 ^{cde}	12.0 ^{bcd}	14.0 ^b
± SEM	1.0	1.9	1.0	1.6

Means followed by different letter (s) in superscript on the same column are significantly different at 5 % probability level of significance using Duncan Multiple Range Test (DMRT).

Effect of Blackeye cowpea mosaic virus disease on number of pod per plant and number of seeds per pod

Generally, number of pods per plant differed significantly ($p < 0.05$) among the genotypes. Ife Brown, 07K-230-2-5, 07K-291-69 and 12K-261 produced the highest number of pods per plant (3 pods each), followed by 08K-125-24, 08K-125-107, 08K-193-15, 10K-819-4, 10K-836-3, 12K-515, 12K-809, IT08K-125-100, IT08K-187-5, IT10K-292-10, IT10K-828-3 and IT12K-13 which produced 2 pods per plant each. However, only 1 pod was produced by each of the remaining genotypes (Table 3).

In 2017, Ife Brown produced the highest number of pods per plant (4 pods), followed by 07K-230-2-5, 07K-291-69, 08K-193-15 and 12K-515 which produced 3 pods per plant each. Genotypes 11D-15-40, 08K-125-24, 08K-125-107, 09K-480, 10K-836-3, 12K-261, 2K-809, IT08K-125-100, IT10K-292-10, IT10K-822-7, IT10K-828-3 and IT12K-13 produced 2 pods per plant each. Meanwhile, the remaining cowpea genotypes produced the lowest number of only 1 pod per plant (Table 3).

The seeds obtained from the plants were malformed, shriveled and small irrespective of the cowpea genotypes (data not shown). The number of seeds per pod did not differ significantly ($p > 0.05$) from 4 to 10 (Table 2). In 2016, 07K-291-69 and 08K-125-107 produced the highest number of seeds per pod of 10. However, the same number of seeds per pod of 7 was obtained from 04K-267-8, 07K-291-69, 08K-125-24, IT08K-125-100, IT08K-187-5 and IT10K-292-10 each while the remaining genotypes produced the lowest number of seeds per pod ranging from 4 to 6 which did not differ (Table 3).

Similar trend was recorded in 2017 with 08K-125-107 exhibiting the highest number of seeds per pod of 9, followed by Ife Brown, TVU 408, 07K-291-69, 08K-125-24, 10K-836-3, IT08K-125-100 and IT10K-830-9 with 8 seeds per pod each, next to this were 07K-230-2-5, 08K-193-15, 12K-261, 12K-515 and IT10K-828-3 that produced 7 seeds per pod each. However, the lowest number of seeds per pod of 5 and 6 were obtained from the remaining genotypes (Table 3).

Table 3: Effect of Blackeye cowpea mosaic virus disease on number of pods per plant and number of seed per pod of selected cowpea genotypes

Cultivar	Number of Pod (No)		Number of Seed (No)	
	2016	2017	2016	2017
Ife Brown	3.0 ^a	4.0 ^a	6.0 ^a	8.0 ^a
TVU 408	1.0 ^{bc}	1.0 ^{bc}	6.0 ^a	8.0 ^a
11D-15-40	1.0 ^c	2.0 ^{bc}	8.0 ^a	6.0 ^a
04K-267-8	1.0 ^{abc}	1.0 ^{bc}	7.0 ^a	5.0 ^a
07K-230-2-5	3.0 ^a	3.0 ^{abc}	7.0 ^a	7.0 ^a
07K-291-69	3.0 ^{ab}	3.0 ^{abc}	10.0 ^a	8.0 ^a
08K-125-24	2.0 ^{abc}	2.0 ^{abc}	7.0 ^a	8.0 ^a
08K-125-107	2.0 ^{abc}	2.0 ^{bc}	10.0 ^a	9.0 ^a
08K-193-15	2.0 ^{abc}	3.0 ^{abc}	6.0 ^a	7.0 ^a
09K-480	1.0 ^{bc}	2.0 ^{bc}	4.0 ^a	6.0 ^a
10K-819-4	2.0 ^{abc}	1.0 ^c	4.0 ^a	5.0 ^a
10K-836-3	2.0 ^{abc}	2.0 ^{bc}	6.0 ^a	8.0 ^a
12K-261	3.0 ^a	2.0 ^{abc}	8.0 ^a	7.0 ^a
12K-515	2.0 ^{abc}	3.0 ^{abc}	8.0 ^a	7.0 ^a
12K-809	2.0 ^{abc}	2.0 ^{abc}	8.0 ^a	6.0 ^a
IT08K-125-100	2.0 ^{abc}	2.0 ^{bc}	7.0 ^a	8.0 ^a
IT08K-187-5	2.0 ^{abc}	1.0 ^{bc}	7.0 ^a	5.0 ^a
IT10K-292-10	2.0 ^{abc}	2.0 ^{bc}	7.0 ^a	6.0 ^a

IT10K-822-7	1.0 ^c	2.0 ^{bc}	6.0 ^a	4.0 ^a
IT10K-828-3	2.0 ^{abc}	2.0 ^{bc}	8.0 ^a	7.0 ^a
IT10K-830-9	1.0 ^c	1.0 ^{bc}	4.0 ^a	8.0 ^a
IT10K-837-1	1.0 ^c	1.0 ^{bc}	9.0 ^a	6.0 ^a
IT12K-13	2.0 ^{abc}	2.0 ^{abc}	5.0 ^a	6.0 ^a
± SEM	0.4	0.4	1.3	1.1

Means followed by different letter (s) in superscript on the same column are significantly different at 5 % probability level of significance using Duncan Multiple Range Test (DMRT).

DISCUSSION

Blackeye mosaic virus disease causes significant yield losses in cowpea and several crops of economic importance. The symptoms observed on the infected plants are in agreement with those of by Aliyu *et al.* (2012) who reported symptoms of BICMV disease to vary from slight to severe mosaic, mottling, distortion of leaves and stunting. The mosaic symptoms observed on the infected plants reveals that none of the twenty-four genotypes was completely resistant to the virus. This is in consonance with the findings of Arogundade *et al.* (2010) who reported ten different viruses to infect a number of cowpea cultivars in Nigeria in which BICMV is of significance. Disease severity was variable among the cowpea cultivars owing to the differences in their genetic background. Similarly, the higher number of leaves in some of the cowpea genotypes investigated is in tandem with the findings of Pazarlar *et al.* (2013) who revealed virus diseases to caused yield loss in the range of 60-100% because of crop leaves inability to manufacture food due to virus infection. The variability in reductions of the growth and yield parameters is an indication of the differences in genotypes' genetic architecture. This corroborates the findings of Puttaraju *et al.* (2008), who recorded substantial negative consequences in the BICMV infected *Arabidopsis thaliana*. Seed weight is an important character in cowpea breeding and selection normally favours varieties with appreciable yield. None of the cowpea cultivars exhibited consistent performance for the morphological and yield attributes probably due to different gene actions required for each plant trait. Studies have shown that quantitative traits are controlled by two or more genes which may operate synergistically or antagonistically (Mamman *et al.*, 2017).

CONCLUSION AND RECOMMENDATION

This study has established the virulence and pathogen city of BICMV on the evaluated cowpea genotypes. The deleterious effect of BICMV disease could impact negatively on cowpea productivity and food security. Moreover, the results obtained revealed that

the best cowpea genotypes for seed (IT07K-243-1-2) production and fodder (IT10K-837-1) were the most tolerant to BICMV infection. Cultivation of these varieties is recommended in areas that are prone to BICMV disease in order to reduce malnutrition and food insecurity. More so, based on the inconsistencies of the evaluated genotypes to the pathogen (BICMV), it is recommended that further research of this type be carried out on other legume viruses of economic importance in the study area.

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