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Determination of Growth and Seed Weights in Cowpea (*Vigna unguiculata* L. Walp) Genotypes Due to Cowpea Aphid-Borne Mosaic Virus Infection

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Abstract

Cowpea is an important food source for man and livestock feed in sub-Saharan Africa. It is also integrated in the traditional cropping system with the aim of improving soil fertility. Unfortunately, growth and seed production are hampered by several viruses, one of which is Cowpea aphid-borne mosaic virus (CABMV). To date, use of resistant varieties is the best management approach. The objective of this study was to identify cowpea genotypes with desirable growth and seed weight. Twenty four cowpea genotypes were evaluated against CABMV using completely randomised design with three replications. Cowpea seedlings were mechanically inoculated with virus extract at 10 days after sowing. Plant height, number of leaves per plant, leaf diameter and seed weight per plant were recorded. Data were subjected to analysis of variance and significant mean separation was accomplished with Duncan Multiple Range Test at p≤0.05. The virus impacted severely on the cowpea plants. However, the cowpea genotypes 98K-1092-1 and 11D-24-40 were the best for seed weight per plant (1.4 - 1.6 g). Therefore, both genotypes are recommended to farmers in areas that are prone to CABMV infection in order to enhance food sufficiency and nutrition security.

Keywords: *Seed weight, resistant varieties, cowpea, CABMV, nutrition security*

Introduction

The origin and domestication of cowpea has been traced to Africa near Ethiopia but is predominantly cultivated in sub-Saharan Africa, particularly in savanna agro-ecology (Gómez, 2012). Cowpea is an important source of protein for millions of people in developing countries and forms a basic component of livestock feed. It is a source of soil nutrient when intercropped with cereal crops such as maize, sorghum and millet and due to the advantages of residual nitrogen, originating from the decay of roots and root nodules (Dugje *et al*., 2009). Thus it has the capacity to increase soil organic matter content and improve soil structure (Valenzuela and Smith, 2010). Cowpea can be cultivated with little or no nitrogen requirement because its roots have nodules in which soil bacteria called *Rhizobia* help to fix nitrogen from the air (Asiwe *et al*., 2009). The world cowpea production in 2015 was estimated at 5.8 million tonnes, harvested from about 11.9 million hectares (FAO, 2015). In 2016, the world land area cultivated with cowpea increased to 12.3 million hectares and approximately 7 million tonnes of output was realized, indicating about 17 % yield increment from 14.3 % increase in land area cultivated with the crop. Nigeria is the leading cowpea producer globally (FAO, 2016). In 2016, cowpea production in the country was estimated at 3 million tonnes, obtained from 3.6 million hectares. This translated to about 0.9 tonnes per hectare.

Low cowpea yield has been attributed to weed and insect pest infestations as well as infections caused by pathogens. Weeds are capable of inducing over 70 % yield losses in vulnerable varieties (Gupta *et al*., 2016). The major insect pests of field-grown cowpea are whiteflies (*Bemisia tabaci*), leafhoppers (*Empoasca* sp.), mites (*Tetranychus* spp.) (Oyewale and Bamaiyi, 2013). Considerable yield losses are also caused by various pathogens and these include bacterial blight induced by the bacterium *Xanthomonas axonopodis* pv *phaseoli* (Ganiyu *et al*., 2017), anthracnose and scab caused by *Colletotrichum lindemuthianum* (Enyiukwu *et al*., 2014) and *Sphaceloma* sp. (Mbong *et al*., 2012), respectively. Cowpea is susceptible to several viruses including *Cowpea aphid-borne mosaic virus* (CABMV), genus *Potyvirus*, *Cowpea yellow mosaic virus* (CYMV), genus *Comovirus*, *Southern bean mosaic virus* (SBMV), genus *Sobemovirus, Cowpea mottle virus* (CMeV), genus *Carmovirus*, *Cowpea*

golden mosaic virus (CPGMV), genus *Bigeminivirus*, *Cucumber mosaic virus* (CMV), genus *Cucumovirus, Cowpea mild mottle virus* (CPMMV), genus *Carlavirus*, *Sunn-hemp mosaic virus* (SHMV), genus *Tobamovirus* and *Blackeye mosaic virus* (BICMV), genus *Potyvirus* (Kareem and Taiwo, 2011). Estimated yield losses due to virus infections have been variously put at between 10 and 100 %, depending on the virus-host- vector relationships as well as the prevailing epidemiological factors. Virus diseases can be managed through application of insecticide to reduce insect vectors, elimination of weeds that serve as alternative hosts of the viruses, use of clean planting materials but adoption of resistant varieties is the most effective and sustainable approach (Alegbejo, 2015). Therefore, there is need to intensify research efforts aiming at identifying sources of resistance to infections. The objective of this study was to determine the growth and seed weights of some cowpea genotypes infected with CABMV.

Materials and Methods

Study location and source of seeds

The experiment was carried out in a screenhouse at the Teaching and Research Farm, Federal University of Technology Minna (9º 51′ N, 6º 44′ E and 212 m above sea level), Niger State, Nigeria. Minna is located in the Southern Guinea Savanna agro-ecology with annual mean rainfall of 1200 mm. The rainfall is normally distributed between April and early October with peak around September and the relative humidity varies between 40 and 80 %. Twenty four cowpea genotypes (Ife-Brown, TVU408, 06K-180-11, 07K-210-1-1, 09K-456, 10K-816-1, 10K-816-3, 12K-487, 12K—489, 12K-612, 98K-1092-1, 99K-573-2-1, 11D-24-25, 11D-24-29, 11D 24 40, IT11D-21-143, IT08K-150-11, IT09K-269-1, IT10K-817-1, IT10K-817-7, IT10K-821-6, IT12K-420, IT12K-425 and IT12K-488) were obtained from the International Institute of Tropical Agriculture (IITA), Kano, Nigeria.

Experimental layout and inoculation

The cowpea genotypes listed above constituted the treatments. Two trials were conducted using completely randomised design with three replications. Cowpea seeds were sowed in plastic pots (bottom diameter of 15 cm and 30 cm deep) at the rate of four seeds per pot. Water was sprinkled on the pots to field capacity immediately after sowing and seedlings were thinned to three plants per pot at one week after emergence (WAE). Cowpea seedlings were inoculated with CABMV extract at 10 days after sowing. Extract was prepared by grinding (1g mL^{-1}) CABMV-infected leaves with inoculation buffer (0.1M sodium phosphate dibasic, 0.1M potassium phosphate monobasic, 0.1M ethylene diamine tetra acetic acid and 0.001M L-cysteine per litre of distilled water, adjusted to pH 7.2) using cold sterile mortar and pestle. Leaf surface was dusted with carborundum powder (600-mesh) in order to facilitate virus entry into the plants. Inoculation was accomplished by dipping a piece of cheesecloth in virus extract and gently rubbing on the leaf surface. The inoculated were maintained in the screenhouse and monitored for symptom expression.

Data collection and analysis

Plant height, number of leaves per plant, leaf diameter, and seed weight per plant were recorded. Data were subjected to Analysis of variance (ANOVA) and significance of the treatment differences determined at $p \leq 0.05$. Data analysis was performed using Statistical Analysis System (SAS, 2008). Treatments mean separation was based on Duncan Multiple Range Test (DMRT).

Results

Plant height

Generally, in trial 1 CABMV disease caused significant ($p<0.05$) differences in the heights of

infected plants. The plants exhibited poor growth and low vigour. Some of them were characterized by small stems. At 3 WAI of trial 1, plant height varied from 28.7 to 49 cm (Table1). The infected plants of IT11D-21-143 (28.7 cm) were the shortest while plants from IT10K-821-6 (49 cm) were the tallest. The height difference between 06K-180-11 (40.1 cm) and IT12K-488 (39.1 cm) was not significant (p>0.05). Similarly, the height differences among TVU 408 (41.6 cm), 07K-210-1-1 (42.2 cm), 09K-456 (,43.6 cm), 10K-817-3 (41.1 cm), 98K-1092-1 (41.2 cm), JT08K-150-11 (41.0 cm), IT10K-817-1 (41.7 cm), IT10K-817-7 (42.2 cm) and IT12K-425 (41.6 cm) were not significant (p>0.05). Additionally, the height difference between 06K-180 (40.1 cm) and IT12K-488 (39.1 cm) was statistically at par. Similarly, the differences in the height of Ife-Brown (35.1cm),12K-487 (34.4 cm), 12K-489 (36.4 cm), 12K-632 (37 cm), 99K-573-2-1(37 cm), 11D-24-25 (36.4 cm), 11D-24-29 (36.1 cm), 11D-24-40 (35.6 cm) and IT12K-420 (34.8 cm) were not significant (p>0.05).

At 5 WAI, significant differences (p<0.05) in plant height were also observed among the infected plants. Plant heights ranged from 32.7 to 61.7 cm. The plants of 10K-816-1 (32.7 cm) were the shortest while the tallest plants were observed in IT10K-817-7 (61.7 cm). The height difference between TVU 408 (58 cm) and IT10K-821-6 (58.1cm) was not significant (p>0.05). Similarly, the genotypes 09K-456 (55.2) and 98K- 1092-1 (55.2 cm) had uniform heights. Moreover, 06K-180-11(51.7 cm) and 10K-817-3 (52.2 cm) exhibited statistically similar heights. Also, 12K-487 (42.3 cm), 12K-489 (43.1 cm) and 99K-573-2-1 (41.3 cm) had uniform heights. The height differences among 07K-210-1-1 (47.5 cm), 11D-24-25 (49 cm), 11D-24-29 (47.3 cm), IT10K-817-1 (48.2 cm) and IT12K-425 (47.9 cm) were also not significant (p>0.05). In addition, height differences among the cowpea genotypes Ife-Brown (45.8 cm), 12K-632 (45.1 cm), JT08K-150-11 (47 cm) IT09K-269-1(47.1 cm) and IT12K-488 (44.9 cm) were also not significant (p>0.05). Significant differences (p<0.05) existed amongst the genotypes 11D-24-40 (44.4 cm), IT12K-420 (40.5 cm) and IT11D-21-143 (41.3 cm).

At 3 WAI of the trial 2, significant (p<0.05) height differences were also observed among the infected plants (Table 1). Plant heights varied from 30.4 cm (IT11D-21-143) to 55.7 cm (11D-24-40). There were no significant (p>0.05) height difference between 07K-210-1-1 (46.7 cm) and 98K-1092-1 (46.6 cm). Similarly, the genotypes 10K-817-3 (45.8 cm) and IT12K-488 (45.3 cm) exhibited statistically uniform heights. Also, 10K-816-1 (44.4 cm) and IT12K-420 (44.4 cm) had similar heights. The height difference between IT10K-817-7 (42 cm) and IT2K-425 (39.8 cm) was not significant (p>0.05). The genotypes IT08K-150-11 (37.9 cm), Ife Brown (37 cm) and IT10K-817-1 (36.6 cm) exhibited non-significant (p>0.05) height differences. The height differences among 09K-456 (39.7 cm), 12K-632 (39.1 cm) and IT12K-425 (39.8 cm) were also not significant (p>0.05). The cowpeas 12K-489 (37.8 cm), IT09-269-1 (38.4 cm), 11D-24-25 (37.4 cm),11D-24-29 (38.6 cm) and IT09K-269-1 (38.4 cm) exhibited statistically uniform plant heights which were significantly higher than those observed in 12K-487 (36.5 cm) and 99K-573-2-1 (34.5 cm).

At 5 WAI, there were significant (p<0.05) height differences among the tested genotypes. Plant heights ranged from 31.8 to 67.7cm. The infected plants of IT11D-21-143 (31.8 cm) were the shortest while those of TVU 408 (67.7 cm) were the tallest. The genotypes 12K-489 (53.7 cm) and 10K-817-3 (53.1 cm) exhibited statistically similar plant heights, which were significantly (p<0.05) higher than those observed in 12K-632 (51.1 cm), IT12K-420 (50.4 cm) and 99K-573-2-1 (49 cm). Similarly, the differences in the heights of:09K-456 (47.7 cm), 12K-487 (46.1 cm), 12K-487 (46.1 cm), 11D-24-25 (47.8 cm), IT08K-150-11 (47.9 cm), IT09K-269 (45.9 cm), IT10K-821-6 (48.2 cm) and IT121K-425 (46.6 cm) were comparable to the height of Ife-Brown (47.7 cm). Furthermore, the cowpeas 11D-24-29 (44.8 cm), IT10K-817-7 (44.5 cm)

and IT10K-817-1 (42.9 cm) had statistically uniform heights.

Number of leaves per plant

The differences in the number of leaves per plant among the genotypes were significant ($p<0.05$) (Table 1). In trial 1, at 3 WAI the number of leaves ranged from 6 to 17 per plant. The lowest number of leaves per plant was observed in 10K-816-1 while the highest was found in IT10K-817-7 and IT12K-425. Number of leaves of the remaining genotypes varied between 12 and 16 leaves per plant but the differences were not significant ($p>0.05$). At 5 WAI, the differences in the number of leaves per plant among the genotypes were significant ($p<0.05$) and varied from 5 (10K-816-1) to 23 (98K-1092-1 and IT10K-817-7). However, the highest number of leaves per plant in observed 98K-1092-1 and IT10K-817-7 was not significantly ($p>0.05$) different from those observed in the remaining genotypes (15-22 leaves).

In trial 2 at 3 WAI, significant ($p<0.05$) differences were found for number of leaves per plant (Table 1). The number of leaves was significantly ($p<0.05$) lowest in 12K-489 and IT11D-21-143 (9 leaves) while the highest was observed in IT12K-420 (19 leaves). The genotypes 99K-573-2-1, 11D-24-25, 11D-24-40, IT09K-269-1 exhibited uniform number of leaves per plant (15 leaves) which was not significantly ($p>0.05$) different from the number of leaves observed in IT10K-821-6 (16 leaves) and IT12K-425 (16 leaves). The cowpeas 07K-210-11, 10K-816-1, 10K-817-3, 11D-24-29, IT10K-817-7 and IT12K-488 exhibited similar number of leaves per plant (14 leaves). The remaining genotypes produced between 11 and 13 leaves per plant but the differences were not significant ($p>0.05$). At 5 WAI, the number of leaves ranged significantly ($p<0.05$) from 9 (IT11D-21-143) to 21 (12K-487, 11D-24-40, IT09K269-1 and IT10K 817-1) per plant. The number of leaves per plant among Ife-Brown (17 leaves), TVU 408 (18 leaves), 07K210-1-1 (19 leaves), 10K-816-1 (16 leaves), 10K-817-3 (17 leaves), 12K-489 (18 leaves), 12K-632 (16 leaves), 98K-1092-1 (18 leaves), 99K-573-2-1 (19 leaves), 11D-24-25 (17 leaves), 11D-24-29 (16 leaves), IT08K-150-11 16 leaves), IT10K-817-7 (18 leaves), IT10K-821-6 (18 leaves), IT12K-420 (17 leaves) and IT12K-488 (19 leaves) were all statistically similar. Higher number of leaves per plant was observed in 09K-456 (11 leaves) than that of IT11D-21-43 (9 leaves) but the difference was not significant ($p>0.05$).

Leaf diameter

The differences in leaf diameter among the genotypes were significant ($p<0.05$) (Table 2). In trial 1 at 3 WAI, leaf diameters ranged from 2.4 to 5.6 cm. The lowest leaf diameter per plant was observed in IT11D-21-143 (2.4 cm) while the widest was found in IT12K-425 (5.6 cm). Leaf diameter of 5.3 cm was observed in IT10K-817-1. This was followed by IT10K-817--3 (4.8 cm). The plants of Ife-Brown (4.4cm), TVU 408 (4.5 cm), 09K-456 (4.4 cm) and IT12K-420 (4.5 cm) had statistically uniform leaf diameters. The genotypes 06K-180-11 (4.2 cm), 07K-210-1-1 (4.2 cm), 99K-573-2-1 (4.2 cm), IT10K-821-6 (4.2 cm) and IT09K-269-1 (4.1 cm) also produced statistically similar leaf diameters. Non-significant ($p>0.05$) leaf diameter difference was found between IT08K-150-11 (3.8 cm) and IT12K-488 (3.7 cm). Also, 10K-817-3 (3.4 cm), 12K-487 (3 cm), 12K-489 (3.2 cm), 12K-632 (3.4 cm), 98K-1092-1 (3.1 cm), 11D24-25 (3.3 cm) and 11D-24-29 (3.1 cm) produced statistically similar leaf diameters (Table 2). Leaf diameter of the cowpea genotype 10K-816 (2.8 cm) was the same as that of 11D-24-40 (2.8 cm). At 5 WAI, there were significant ($p<0.05$) leaf diameter differences among the evaluated genotypes. Leaf diameter ranged from 1.8 to 6.4 cm. (Table 2). The leaves of 10K-816-1 (1.8 cm) had the lowest diameter while the widest was observed in TVU 408 (6.4 cm). Leaf diameter of 12K-487 was 3.6 cm. The remaining genotypes exhibited leaf diameters that ranged between 3.8 and 6.2 cm but the differences were not significant ($p>0.05$).

In trial 2, at 3 and 5 WAI significant (p<0.05) differences existed for leaf diameter among the infected plants (Table 2). At 3 WAI, leaf diameters varied from 2.5 to 5.4 cm with the lowest value observed in 12K-487 (2.5 cm) while IT12K-420 (5.4 cm) and 11D-24-25 (5.4 cm) exhibited the highest. Leaf diameters among TVU 408 (5 cm), 98K-1092-1 (4.9 cm), 99K-573-2-1 (4.9 cm), IT12K-425 (5 cm) and IT12K-488 (5 cm) were statistically at par. Similarly, 06K-180-11 (4.7 cm) and 07K-214-1-1 (4.6 cm) had statistically uniform leaf diameters. The leaf diameters of Ife-Brown (4.4 cm), 10K-816-1 (4.1 cm), 11D-24-29 (4 cm), 11D-24-40 (4 cm), IT08K-150-11 (4.2 cm) and IT10K-821-6 (4.1 cm) were statistically uniform. Leaf diameters of 12K-632 (3.4 cm), IT09K-269-1 (3.4 cm) and IT10K-817 (3.4 cm) were significantly (p<0.05) higher than those of IT11D-21-143 (3.1 cm), IT10K-817-1 (3.0 cm), 12K-489 (2.9 cm) and 10K -817-3 (2.7 cm).

At 5 WAI, there were significant (p<0.05) leaf diameter differences among the cowpea genotypes which varied from 3.4 cm to 6.7 cm. (Table 2). The narrowest was observed in IT10K-817-1 (3.4 cm) whereas the widest was found in TVU 408 (6.7 cm). The leaf diameter of 99K-573-2-1 (6.6 cm) was significantly (p<0.05) higher than those of 06K-180-11 (6.4 cm), 11D-24-25 (6.4 cm) and Ife-Brown (6.1 cm). This was followed by leaf diameter of IT12K-420 (5.8 cm) which was statistically comparable to that of IT12K-425 (5.7 cm). Similarly, statistically uniform leaf diameters were observed among 10K-816-1 (5.5 cm), IT12K-488 (5.5 cm), 07K-210-1-1 (5.4 cm) and 98K-1092-1 (5.4 cm). The leaf diameters of 11D-24-29 (4.8 cm) and11D-24-40 (4.8 cm) were significantly (p<0.05) higher those of IT08K-150-11 (4.7 cm), 12K-632 (4.6 cm), IT08K-150-11 (4.7 cm) and IT10K-821-6 (4.6 cm). Moreover, there was no significant (p>0.05) leaf diameter difference between IT09K-269-1 (4.4 cm) and IT10K-817-7 (4.5 cm). The difference between the leaf diameter of 12K-487 (3.5 cm) and IT10K-817-7 (3.4 cm) was not significant (p>0.05).

Seed weight per plant

In trial 1, the differences in seed weights among the genotypes were not significant (p>0.05) (Table 2). Most of the infected plants produced small and deformed seeds. Seed weights varied between 0.4 and 1.4 g per plant. The seed weights of 06K-180-11 (1.1 g), 07K210-1-1 (1.2 g), 09K-456 (1.1 g), 10K-817-3 (1.3 g), 12K-487 (1.2 g), 12K-489 (1.1 g), 12K-632 (1.2 g), 98K-1092-1 (1.4 g), 99K-573-2-1 (1.4 g), 11D-24-40 (1.4 g), IT10K-817-7 (1.4 g), IT10K-821-6 (1.3 g) and IT12K-420 (1.1 g) were higher than that of Ife-Brown (1 g), which was used as susceptible check. Contrary to the results observed in trial 1, seed weight ranged significantly (p<0.05) from 0.2 g (IT08K-150-1) to 1.6 g (98K-1092-1, 11D-24-40 and IT12K-488) per plant in trial 2. The differences in seed weight per plant (0.4 -1.4 g) among the remaining genotypes were not significant (p>0.05) (Table 2).

Discussion

Cowpea aphid-borne mosaic virus has been identified as one of the major viruses threatening cowpea productivity in developing countries. From time immemorial cultivation of resistant or tolerant varieties is an effective and sustainable control strategy to mitigate the stress posed by virus disease. Generally, the growth and yield of the cowpea genotypes infected with CABMV differed significantly probably due to heterogeneous nature of the plant materials. The levels of significance suggested that CABMV impacted severe infection on the cowpea genotypes. Similar observation has been recorded in some cowpea genotypes infected with CABMV (Taiwo and Akinjogunla, 2011). Growth impairment was observed among the evaluated genotypes, revealing the deleterious impacts of the virus on infected plants. This is similar to the findings of Salaudeen (2016) who stated that virus infection interfered with normal plant

growth and physiology. In this study, some severely were sterile. This agrees with the findings of Taiwo *et al*. (2007) who reported that inoculation at 10 days after sowing resulted in complete yield loss. Despite the negative effects of the CABMV severity, most genotypes produced leaves, pods and appreciable height, indicating some levels of tolerance to infection. Another findings from this study showed that all the cowpea genotypes infected with CABMV gave low seed weight per plant. This agrees with the findings of Nsa and Kareem (2015) who reported that there were cases where single virus infection had more devastating effects on the crop than double infections with more than one virus.

Conclusion and Recommendations

This experiment established that the twenty four cowpea genotypes were susceptible to CABMV. Consequently, plant height, leaf diameter; number of leaves per plant, number of seeds per pod and seed weight per plant were adversely affected. However, the cowpea genotypes 98K-1092-1 and 11D-24-40 were the best for seed weight per plant (1.4 - 1.6 g). Therefore, both genotypes are recommended to farmers in areas that are prone to CABMV infection in order to enhance food sufficiency and nutrition security.

Table 1. Plant heights and number of leaves per plant from cowpea genotypes infected with *Cowpea aphid-borne mosaic virus* at various weeks after inoculation (WAI) in a screenhouse

Genotype	Plant height (cm) Trial 1		Trial 2		Number of leaves per plant Trial 1		Trial 2	
	3 WAI	5 WAI	3 WAI	5 WAI	3 WAI	5 WAI	3 WAI	5 WAI
Ife-Brown	35.1^{bcd}	45.8^{cde}	37.0^{f-i}	47.7^{fg}	14^{ab}	20^{a}	12^{bcd}	17^{abc}
TVU 408	41.6^{ab}	58.0^{ab}	48.3^{b}	67.7^{a}	13^{ab}	19^{a}	12^{bcd}	18^{abc}
06K-180-11	40.1^{b}	51.7^{a-d}	47.3^{bc}	57.2^{a-f}	14^{ab}	18^{a}	11^{bcd}	12^{bcd}
07K-210-1-1	42.2^{ab}	47.5^{b-e}	46.7^{bcd}	62.2^{abc}	14^{ab}	17^{a}	14^{abc}	19^{abc}
09K-456	43.6^{ab}	55.2^{abc}	39.7^{c-h}	47.7^{fg}	13^{ab}	17^{a}	11^{bcd}	11^{cd}
10K-816-1	30.1^{cd}	32.7^{g}	44.4^{b-f}	61.1^{a-d}	6^{c}	5^{b}	14^{abc}	16^{abc}
10K-817-3	41.1^{ab}	52.2$^{a—d}$	45.8^{b-e}	53.1^{b-g}	14^{ab}	20^{a}	14^{abc}	17^{abc}
12K-487	34.4^{bcd}	42.3^{d-g}	36.5^{ghi}	46.1^{fg}	14^{ab}	22^{a}	13^{bcd}	21^{a}
12K-489	36.4^{bcd}	43.1^{d-g}	37.8^{e-i}	53.7^{b-g}	12^{ab}	16^{a}	9^{cd}	18^{abc}
12K-632	37.0^{bcd}	45.1^{cde}	39.1^{c-h}	51.1^{c-g}	12^{ab}	16^{a}	13^{bcd}	16^{abc}
98K-1092-1	41.2^{ab}	55.2^{abc}	46.6^{bcd}	59.7^{a-e}	14^{ab}	23^{a}	12^{bcd}	18^{abc}
99K-573-2-1	37.0^{bcd}	41.3^{d-g}	34.5^{ghi}	49.0^{efg}	14^{ab}	17^{a}	15^{ab}	19^{abc}
11D-24-25	36.4^{bcd}	49.0^{b-e}	37.4^{e-i}	47.8^{fg}	13^{ab}	16^{a}	15^{ab}	17^{abc}
11D-24-29	36.1^{bcd}	47.3^{b-e}	38.6^{e-i}	44.8^{g}	12^{ab}	19^{a}	14^{abc}	16^{abc}
11D-24-40	35.6^{bcd}	44.4^{c-f}	55.7^{a}	63.7^{ab}	13^{ab}	18^{a}	15^{ab}	21^{a}
IT11D-21-143	28.7^{d}	34.0^{fg}	30.4^{i}	31.8^{h}	11^{b}	15^{a}	9^{cd}	9^{d}
IT08K-150-11	41.0^{ab}	47.0^{cde}	37.9^{f-i}	47.9^{fg}	16^{ab}	20^{a}	13^{bcd}	16^{abc}
IT09K-269-1	38.0^{bc}	47.1^{cde}	38.4^{e-i}	45.9^{fg}	15^{ab}	20^{a}	15^{ab}	21^{a}
IT10K-817-1	41.7^{ab}	48.2^{b-e}	36.8^{f-i}	42.9^{g}	16^{ab}	22^{a}	12^{bcd}	21^{a}
IT10K-817-7	42.2^{ab}	61.7^{a}	42.0^{b-h}	44.5^{g}	17^{a}	23^{a}	14^{abc}	18^{abc}
IT10K-821-6	49.0^{a}	58.1^{ab}	38.9^{c-i}	48.2^{fg}	13^{ab}	16^{a}	16^{ab}	18^{abc}
IT12K-420	34.8^{bcd}	40.5^{efg}	44.4^{b-f}	50.4^{d-g}	16^{ab}	20^{a}	19^{a}	17^{abc}
IT12K-425	41.6^{ab}	47.9^{b-e}	39.8^{c-h}	46.6^{fg}	17^{a}	19^{a}	16^{ab}	20^{ab}
IT12K-488	39.1^{b}	44.9^{cde}	45.3^{b-e}	52.4^{e-f}	14^{ab}	18^{a}	14^{abc}	19^{abc}
±SEM	2.6	3.3	2.6	3.4	1.2	1.8	1.1	1.6

Means with dissimilar letter (s) within the same column differ significantly (p<0.05)

Table 2. Leaf diameters and seed weights of cowpea genotypes infected with *Cowpea aphid borne mosaic virus* in a screenhouse

	leaf diameter (cm)				Seed weight per plant (g)	
	Trial 1		Trial 2			
Genotype	3 WAI	5 WAI	3 WAI	5 WAI	Trial 1	Trial 2
Ife Brown	4.4^{a-d}	5.0^{ab}	4.4^{a-d}	6.1^{ab}	1.0^{a}	0.9^{ab}
TVU408	4.5^{a-d}	6.4^{a}	5.0^{ab}	6.7^{a}	0.4^{a}	0.4^{ab}
0K-180-11	4.2^{a-e}	5.7^{abc}	4.7^{abc}	6.4^{abc}	1.1^{a}	1.3^{ab}
07K-210-1-1	4.2^{a-e}	4.7^{ab}	4.6^{abc}	5.4^{a-f}	1.2^{a}	1.3^{ab}
09K-456	4.4^{a-d}	5.4^{ab}	4.0^{a-d}	5.2^{a-h}	1.1^{a}	0.7^{ab}
10K-816-1	2.8^{de}	1.8^{c}	4.1^{a-d}	5.5^{a-f}	0.4^{a}	1.0^{ab}
10K-817-3	3.4^{cde}	4.0^{ab}	2.7^{f}	3.6^{gh}	1.3^{a}	0.8^{ab}
12K-487	3.0^{cde}	3.6^{b}	2.5^{f}	3.5^{h}	1.2^{a}	0.9^{ab}
12K-489	3.2^{cde}	4.2^{ab}	2.9^{f}	3.7^{fgh}	1.1^{a}	1.1^{ab}
12K-632	3.4^{cde}	4.3^{ab}	3.4^{a-e}	4.6^{c-h}	1.2^{a}	1.4^{ab}
98K-1092-1	3.1^{cde}	5.0^{ab}	4.9^{ab}	5.4^{a-f}	1.4^{a}	1.6^{a}
99K-573-2-1	4.2^{a-e}	5.0^{ab}	4.9^{ab}	6.6^{ab}	1.4^{a}	0.9^{ab}
11D-24-25	3.3^{cde}	4.8^{ab}	5.4^{a}	6.4^{abc}	0.8^{a}	1.2^{ab}
11D-24-29	3.1^{cde}	4.3^{ab}	4.0^{a-d}	4.8^{b-h}	0.9^{a}	0.9^{ab}
11D-24-40	2.8^{de}	4.1^{ab}	4.0^{a-d}	4.8^{b-h}	1.4^{a}	1.6^{a}
IT11D-21-143	2.4^{e}	3.8^{ab}	3.1^{f}	4.1^{e-h}	0.9^{a}	0.3^{ab}
IT08K-150-11	3.8^{b-ei}	4.6^{ab}	4.2^{a-d}	4.7^{c-h}	0.9^{a}	0.2^{b}
IT09K-269-1	4.1^{a-e}	4.7^{ab}	3.4^{a-e}	4.4^{d-h}	0.9^{a}	0.5^{ab}
IT10K-817-1	5.3^{ab}	6.2^{ab}	3.0^{f}	3.4^{h}	1.0^{a}	0.7^{ab}
IT10K-817-7	4.8^{bc}	5.8^{ab}	3.4^{a-e}	4.5^{d-hi}	1.4^{a}	0.9^{ab}
IT10K-821-6	4.2^{a-e}	4.7^{ab}	4.1^{a-d}	4.6^{c-h}	1.3^{a}	1.3^{ab}
IT12K-420	4.5^{a-d}	5.5^{ab}	5.4^{a}	5.8^{a-e}	1.1^{a}	0.9^{ab}
IT12K-425	5.6^{a}	6.1^{ab}	5.0^{ab}	5.7^{a-e}	1.0^{a}	1.0^{ab}
IT12K-488	3.7^{b-ei}	4.6^{ab}	5.0^{ab}	5.5^{a-f}	1.0^{a}	1.6^{a}
±SEM	0.4	0.5	0.4	0.4	0.2	0.3

Means with dissimilar letter (s) within the same column differ significantly ($p<0.05$)

References

Alegbejo, M.D (2015). Virus and virus-like diseases of crops in Nigeria. Zaria, Nigeria. Ahmadu Bello University Press. 273pp

Asiwe, R, Miko, S. and Mohammed, I.B. (2009). Performance of improved cowpea genotypes in the Sudan Savannah: I. Growth and dry matter production. Biol. Environ. Sci. J. Tropics, 4: 12-18.

Dugje, I.Y., L. O. Omoigui, F. Ekeleme, A.Y. Kamara and Ajeigbe, H. (2009) *Farmers' Guide to Cowpea Production in West Africa*. Ibadan, Nigeria, IITA, Pp 5-12

Enyiukwu, D.N., Awurum, A.N., Ononuju, C.C. and Nwaneri, J.A. (2014). Significance of characterization of secondary metabolites from higher plants in phyto-disease management. A review. Intl. J. Adv. Agric., 2:8-28.

Food and Agriculture Organization (FAO). (2015). Cowpea production. Available from: http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor

Food and Agriculture Organization (FAO). (2016). Cowpea production. Available from: http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor

Ganiyu, S. A., Popoola, A. R., Owolade, O. F. and Fatona, K.A. (2017). Control of common bacterial blight disease of cowpea (*Vigna unguiculata* [L.] Walp) with certain plant extracts in Abeokuta, Nigeria. J. Crop Improv., 31: 280 – 288.

Gómez, C. (2012). *Cowpea: Post-harvest management*; Rome, Italy. Food and Agriculture Organization (FAO), 71p

Gupta, K.C., Gupta, A.K. and Rani, S. (2016). Weed management in cowpea [*Vigna unguiculata* (L.) Walp.] under rainfed conditions. Intl J. Agric. Sci., 12: 238-240.

Kareem, K. T and Taiwo, M. A. (2011). Interactions of viruses in cowpea: Effects on growth and yield parameters. Virol. J., 4: 234-240

Mbong, G.A., Fokunang, C.N., Emechebe, A.M. Alabi, O., Alegbejo, M.D. and Fontem, D.A. (2012). The effect of *Sphaceloma* sp. causal agent of scab infection on grain yield of cowpea (*Vigna unguiculata*) in Northern Nigeria. Intl. Res. J. Biochem. Bioinformatics, 2: 98 – 104.

Nsa, I.Y. and Kareem, K.T. (2015). Additive interactions of unrelated virus in mixed infections of cowpea (*Vigna unguiculata* L Walp) Front. Plant Sci., 6: 8-12.

Oyewale, R.O. and Bamaiyi,L.J. (2013). Management of Cowpea Insect Pests. Sch. Acad. J. Biosci., 1: 217-226.

Salaudeen, M.T. (2016) Growth and yield responses of some cowpea accessions to cucumber mosaic virus infection, Arch. Agron. Soil Sci., 62: 289-298.

SAS (Statistical Analysis System). (2008). Statistical analysis system SAS/STAT User's guide. Ver. 9.2. Cary: N.C SAS Institute Inc

Taiwo, M.A. and Akinjogunla, O.J. (2011). Cowpea viruses: Quantitative and qualitative effects of single and mixed viral infections. Afr. J. Biotech., 5: 1749 1756

Taiwo, M.A., Kareem, K.T., Nsa, I.Y. and Hughes, J. D.A. (2007). Cowpea viruses: effect of single and mixed infections on symptomatology and virus concentration. Virol. J., 4:95. doi: 10.1186/1743-422X-4-95

Valenzuela, H. and Smith, J. (2010). *Cowpea*. Honolulu, Hawaii. College of Tropical Agriculture and Human Resources. University of Hawaii at Monoa,. 274p