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SEED VIABILITY OF SOME COWPEA CULTIVARS AFFECTED BY SINGLE AND MIXED VIRUS INFECTIONS IN NIGER STATE, NIGERIA

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ABSTRACT

A field trial was carried out in 2017 cropping season to assess the response of twenty five cultivars of cowpea to single and mixed infections with *Blackeye cowpea mosaic virus* (BICMV) and *Cowpea mottle virus* (CMeV) on seed quality. The field trial was conducted at the Teaching and Research Farm, Ahmadu Bello University, Zaria, Mokwa Station (090211 N and 50135 E, 201 m above sea level). The trial was a randomized complete block design replicated three times. Three cowpea seeds of each cultivar were sown after dressing with Apron – star at the rate of 3.0 kg seed per 10 g of the chemical. Seeds were sown at an intra and inter–row spacing of 0.30 × 0.75 m along the ridges and later thinned to two per stand at 2 weeks after sowing. Four independent trials were conducted simultaneously, for single and mixed infections. For the single virus infection, seedlings of the twenty five cultivars were inoculated at 10 days after sowing while for the mixed virus infections, seedlings were inoculated at 10 and 17 DAS. Seed viability was determined at the Crop Production Laboratory, Department of Crop Production, Federal University of Technology, Minna, Nigeria. The results of the experiment revealed that all cultivars were susceptible to single and mixed infections of the two viruses but to different extents. The viability of seeds from single infection with CMeV was slight in some instances, also, test of accelerated ageing for four weeks indicated that seed vigour was seriously impaired as compared to the other three virus treatments even when seeds viability was not much affected.

Keywords: *Blackeye cowpea mosaic virus*, *Cowpea mottle virus*, cowpea seeds, Germination; Longevity

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.) is an important food legume in the Sub-Saharan Africa countries (FAO, 2012). The relatively high protein content (22%) of cowpea makes it an important supplement to the diet of many African people (Batiano, 2011; IITA, 2013) who consume cereals, root, and tuber high in carbohydrate and low in protein. However, despite the importance of cowpea in the West and Central Africa (WCA) savanna ecology and its wide high potential (Dugje *et al*., 2009), its growth and yield are constrained by several biotic and abiotic factors. These include insect pests, parasitic weeds and pathogen such as virus (Omoigui *et al*., 2007), bacteria, fungi and nematodes (IITA, 2013).

Infection of plants by two or more viruses is frequent in nature (Agrios, 2005) and has variable consequences, ranging synergistic exacerbation to from symptom amelioration (Susana and Elena, 2009). In mixed infections, each viral population changes the environment and becomes part of the fitness landscape of the co-infecting population (Mathew, 1991). Therefore, the fitness of each virus depends not only on its adaptation to the host, but also on the influence of its counterparts in a frequency-dependent manner.

Cowpea mottle virus (CMeV) was first described from Nigeria (Alegejo, 2015), where it was isolated from cowpea, *V. unguiculata* L. and Bambarra groundnut (*Vigna subterranea*). In Nigeria, the virus is commonly found in the southern rainforest and guinea savanna zones where most of the Bambara groundnut is grown (Abdullahi *et al.,* 2016). *Cowpea mottle virus* is much tolerant to cowpea varieties, the symptom of this virus consists basically of mottling; whereas in severe infections, CMeV may induce leaf distortion, reduction in leaf size and witches broom syndrome. It is transmitted principally by a beetle vector, *Ootheca mutabilis* and by sap inoculation (Nsa and Kareem, 2015). It is also seed-borne in cowpea, but transmission is dependent upon virus strain and cowpea cultivar (Owolabi *et al.,* 1988).

Blackeye cowpea mosaic virus (BlCMV) is one of the major limitations to legume productivity (Golnaraghi *et al*., 2004). The virus was first observed in Florida (Alegbejo, 2015) but has expanded its geographical coverage to other parts of the world including Nigeria. Symptoms elicited in infected plants vary with genetic architecture of the host cultivar. The virus induces both local and systemic symptoms in susceptible genotypes. Systemic symptoms include large reddish lesions usually found along the veins. Systemic symptoms are characterized by severe mottling, distortion, yellowing, mosaic and vein necrosis (Thottappilly and Rossel, 1992). BlCMV is transmitted in nature by insect vectors belonging to the family Aphididae. These include *Aphis craccivora* Koch and *Myzus persicae* Sulzer, in a non-persistent manner. It has been reported that BlCMV is readily sap transmissible and seed transmission has been reported **(**Owolabi *et al.,* 1988).

Seed-borne viruses are important for source of diseases at the beginning of production even at low rates of seed transmission (Bashir *et al*., 2000; Kareem and Taiwo, 2007). Also, the viruses can aggravate other transmission methods and cause disease to spread rapidly (Hamim *et al*., 2014). Accordingly, seed-borne and seed transmitted viruses (Golnaraghi *et al*., 2004) are also damaging to cowpea productivity owing to inherent primary inoculum and potential for their widespread. Information on the possibility of seed transmission in virus infected cowpeas will be valuable to numerous cowpea farmers. Information on quality, germination and longevity of infected seeds and survival of resulting plants, magnitude of yield loss and amount of infection in harvested seeds in replicated field

experiments is required to establish acceptable threshold levels of seed-borne infections. This study is necessary to develop preventive and management measures for cowpea virus diseases. Therefore, this research aimed at investigating and examining the effects of virus infections on seed quality of some selected cultivars of cowpea.

MATERIALS AND METHODS

Description of Experimental Site

Field trial was conducted during the 2017 wet session at the Teaching and Research farm of the Ahmadu Bello University (ABU) Farm, Mokwa Station ($09^0211^{`}$N and $5^0135^{`}$E, 201 m above sea level) in the Southern Guinea Savannah of Nigeria.

Treatments and Experimental Design

Four independent trials were conducted simultaneously, for single and mixed infections of CMeV and BICMV. In each trial, 25 cowpea cultivars namely Ife Brown, IT90K – 277 – 2, IT96D – 610, IT97K – 499 – 35, IT97K – 568 – 18,IT97K – 573 – 2 –1, IT98K – 205 –M8, IT98KD – 288, IT99K – 316 – 2, IT99K – 377 – 1, IT00K – 901 – 5, IT03K – 337 – 6, IT04K – 267 – 8, IT04K – 291 – 2, IT04K – 321 – 2, IT04K – 332 – 1, IT06K – 124, IT06K – 137 – 1, IT07K – 211 – 1 – 8, IT07K – 222 – 2, IT07K – 243 – 1 – 10, IT07K – 251 – 3 – 3, IT07K – 292 – 1 – 10, IT07K – 299 – 6, IT07K – 318 – 33) constituted the treatments. The cultivars were photosensitive and high yielding under virus free conditions. The trial was arranged as randomized complete block design (RCBD) replicated three times giving a total land area of 900 m^2. Each cultivar was evaluated in 0.375 m ridge wide, 3 m long and 0.75 m apart giving a total plot size of 18.75 m per replicate.

Source of Inoculum and Multiplication

CMeV and BICMV isolates used were obtained from the Department of Crop Production, Federal University of Technology, Minna Niger State. The virus isolates were extracted by grinding 1g/1ml of each isolate in extraction buffer containing 0.1M sodium phosphate dibasic, 0.1M potassium phosphate monobasic, 0.0lM ethylene diamine tetra acetic acid and 0.00lM-cystine per litre of distilled water using a pre-cooled sterilized mortar and pestle as described by Kumar (2009). Two microlitres of β- mercapto-ethanol was added to the extract just before used. Thereafter, cowpea seedlings were infected with inoculum at 10 days after sowing (DAS) by rubbing the virus extracts on the upper surface of the leaves that was dusted with carborundum powder (600-mesh). The leaves of inoculated plant were rinsed with sterile distilled water. Symptomatic cowpea leaves were collected from the infected plants at 3 weeks after inoculation (WAI) and used for inoculation during the main experiment. The leaves were preserved at room temperature in airtight via bottle on silica gels covered with a thin layer of non-absorbent cotton wool.

Cultural Practices

The field was manually cleared of the previous plant remains, ploughed, harrowed and ridged with tractor at 0.75 m apart then marked out into plots and replications in the second week of August, 2017. Three cowpea seeds of each cultivar were sown after dressing with Apron – star (methylthiuram + metalaxyl + carboxin) at the of rate 3.0 kg seed per 10 g sachet of the chemical to protect seed against soil borne pathogens. The sowing was carried out at an intra and inter–rowspacing of 0.30 × 0.75 m along the ridges and later thinned to two per stand at 2 weeks after sowing (WAS). The CMeV and BICMV infected cowpea leaves previously preserved on silica gels were used for inoculation. For the single virus infection, seedlings of the twenty five cultivars were mechanically inoculated singly with CMeV BICMV at 10 days after sowing while for the mixed virus infections, seedlings were inoculated at 10 and 17 DAS. Weeds were manually controlled through hand weeding at 4 and 6 weeks after sowing. Insect pests were controlled by spraying D-D force (Cypermethrin plus Dimethoate) and pods were harvested at physiological maturity. The pods were processed and packaged for seed quality assessment in the laboratory.

Assessment of Virus Infection on Percent Seed Quality

Seed lots from the various virus treatments were subjected to seed quality test as follows;

Viability and longevity of seeds of all the virus treatment combinations were determined by germination test after seed processing and at four weeks of storage at the Crop Production Laboratory, Department of Crop Production, Federal University of Technology, Minna. There were 25 seeds placed in distilled-water moistened filter paper lined in Petri-dish in three replicates. The filter paper in the petri-dishes was kept moist as found necessary. The petri-dishes were arranged inside the seed germination chamber. Germination counts were taken at 1, 2, 3, 4 and 5 days after sowing. Seeds were considered germinated when the tip of the radicle had grown free from the seed coat (El Balla *et al*., 2011). Germination percentage (GPCT) was calculated as follows:

$$\text{GPCT} = \frac{\text{Total number of seedlings that emerged on the final day}}{\text{Total number of seeds planted}} \times 100$$

Similarly, cowpea seeds were also subjected to accelerated ageing tests at two and four weeks as described by El Balla *et al*. (2011) for vigour determination. The seeds of all the treatments were stored in open plastic plates and arranged inside an incubator at 35 ^{0}C and 86 % relative humidity. This was aimed at accelerating the ageing of the seeds so that the relative longevity of the seed samples could be determined. Twenty five seeds from each treatment that were artificially aged in three replications were counted and placed on layer of distilled water moistened-filter paper placed in Petri-dishes over a wire mesh screen inside a growth chamber at 30 ^{0}C. Germination count was taken as described above.

Data Analysis

Data were subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS, 2008) to verify if there were significant differences among the cultivars and virus treatments tested. Significance was determined at 5 % level of probability. Where the *F*-test ratio was significant, means were separated using Student-Newman-Keuls (SNK) test.

RESULTS

Symptom Severity Induced by Single and Mixed Virus Infections

The twenty five cowpea cultivars were susceptible to the four virus treatments used in this investigation. Cowpea leaves were observed for symptom development at different stages of growth after infection. Symptoms became visible on the

leaves of cowpea plants irrespective of the virus treatments at 1 Week after inoculation (WAI). Disease severity differed significantly (p<0.05) amongst the 25 cowpea cultivars investigated irrespective of the four virus treatments. The progress of infection in the cowpea plants inoculated with each virus and the virus combinations is shown in Table 1. Disease severity increased progressively after inoculation, at 2 WAI, the symptoms observed on plants inoculated with BICMV + CMeV were not much different from those of BICMV alone, and the symptoms observed on CMeV + BICMV were also like those of CMeV alone. Disease severity values remained constant between 3 and 4 WAI irrespective of the virus treatment, but not the same in all cowpea cultivars.

Disease severity at 2 WAI was significantly (p<0.05) higher in Ife brown with 3.6 score, IT97K-568-18, IT06K-124 and IT07K-292-1-10had a symptom score of 2 in BICMV infected cowpea plants, IT03K-337-6 exhibited a mean severity score of 1.0 and moderate level of severity symptom score of 3 was observed in the other cultivars. In CMeV infected cowpea plants, disease severity ranged between 1.0 and 3.6. The lowest symptom score of 1.0was observed inIT90K-277-2, IT96D-610, IT99K-316-2, IT04K-267-8, IT04K-332-1 and IT07K-243-1-10, disease severity was mild in IT07K-222-2 and IT07K-292-1-10 with 2.0, while IT97K-499-35, IT97K-568-18, IT98K-205-M8, IT98KD-288, IT99-377-1, IT00K-901-5, IT03K-337-6, IT04K-291-2, IT04K-321-2, IT06K-124, IT06K-137-1, IT07K-211-1-8, IT07K-251-3-3 and IT07K-299-6 exhibited a mean severity score of 3.0. The other cultivars Ife brown, IT97K-573-2-1 and IT07K-318-33 had a mean symptom score of 3.6 (Table 4.5). Disease severity was significantly (p<0.05) mildest with a symptom score of 1.6 in IT96D-610, IT97K-499-35, ITIT97K-573-2-1, IT04K-332-1 and IT07K-292-1-10 cowpea plants co-infected with BICMV + CMeV, whereas moderate level of severity symptom score of 3was recorded in IT97K-568-18,IT98K-205-M8, IT98KD-288, IT99K-316-2,IT99-377-1, IT00K-901-5, IT03K-337-6, IT04K-267-8, IT04K-291-2, IT04K-321-2, IT06K-124, IT06K-137-1, IT07K-211-1-8, IT07K-222-2, IT07K-243-1-10, IT07K-251-3-3, IT07K-299-6 and IT07K-318-33 cultivars (Table 1).

In CMeV + BICMV infected cowpea plants, the mildest disease severity score of 1.0 was recorded in IT07K-292-1-10, next to this was IT97K-568-18, IT04K-332-1 and IT07K-222-2 with symptom score of 1. Moreover, IT97K-499-35, IT97K-573-2-1, IT98K-205-M8, IT98KD-288, IT99K-316-2,IT99-377-1, IT00K-901-5, IT03K-337-6, IT04K-267-8, IT04K-291-2, IT04K-321-2, IT06K-124, IT06K-137-1, IT07K-211-1-8, IT07K-243-1-10, IT07K- 251-3-3, IT07K-299-6 and IT07K-318-33 expressed disease severity score of 3.0, whereas the highest symptom score of 4.0was recorded in Ife brown, IT90K-277-2 and IT96D-610 cultivars (Table 1). At 5 WAI, a total of 15 cowpea cultivars accounting for 60 % of the entire BICMV infection resulted in a significantly (p<0.05) highest disease severity of 4.3, whereas the lowest severity rate of 1.6 was recorded with 2 or 8 % of the cultivars. Similarly, 12 cowpea cultivars or 48 % exhibited significantly (p<0.05) highest disease severity score of 4.3 to CMeV infection, whereas 6 of the entire cultivars or 24 % showed the mildest severity score of 1.6 (Table 1).

On the other hand, in BICMV + CMeV infected cowpea plants, 5 or 20 % of the entire cultivars exhibited significantly (p<0.05) lowest disease severity symptom score of 1.6 and 20 cultivars accounting to 80 % elicited disease severity score of 4. Also, 18 or 72 % CMeV + BICMV infected cowpea plants elicited the highest disease severity symptom score of 4 and the lowest disease severity symptom score of 2 was obtained in 2 or 8 % of the cultivars. Severity of the infection varied from mild to moderate level among the cultivars during the entire period of the evaluation (Table 1).

Effects of Single and Mixed Virus Infections on Seed Quality

The study revealed significant impairments in germination before and after four weeks of storage of the 25 cultivars of cowpea both in single and mixed infections of the viruses used. The variation in seed viability of cowpea cultivars with respect to virus infections is presented in Table 2. Prior to storage of seeds, the difference between the lowest and highest mean value for seed viability was wide and significant (p<0.05) on seed germination test (SGT). Seed germination percentage varied from 77.4 to 99.7 % for the BICMV infected cultivars, 77.4 to 98.7 % for CMeV infected cultivars, 74.8 to 98.5 % for BICMV + CMeV infected cultivars and 78.6 to 98.5 % for CMeV + BICMV inoculated cultivars (Table 1).Seeds obtained from IT97K-568-18, IT04K-332-1 and IT07K-292-1-10 cowpea cultivars infected with BICMV had significantly (p<0.05) higher germination percentage of 99.7 which was statistically similar to 97.6 and 97.3 % germination obtained from seeds of cultivar IT07K-243-1-10 and IT03K-337-6respectively. Seeds from cultivars IT90K-277-2, IT07K-211-1-8 and IT06K-124 had germination values of 94.7, 94.3 and 93.7 % respectively which were not significantly different among each other. Seeds of cultivars IT07K-251-3-3 and IT07K-222-2 had 92.3 and 92.5 % germination values respectively which were statistically similar while seeds from the remaining cowpea cultivars had germination percentages ranging between 77.4 and 91.3.

Furthermore, seed germinability of 98.7 % was highest in IT90K-277-2 with CMeV infected cowpea seeds which was not significantly ($p > 0.05$) different from seeds obtained from cultivars IT04K-332-1 (98.5 %), IT07K-243-1-10 (98.4 %), IT04K-267-8 (98.2 %) and IT96D-610 (97.7 %), while significantly lowest seed germination percentage of 77.4 was recorded in seeds of cowpea cultivar IT07K-292-1-10 (Table 1). On the other hand, co-infections of cowpea seeds significantly (p<0.05) affected seed germinability across the cowpea cultivars investigated. BICMV + CMeV infected IT04K-332-1 exhibited the highest germination percentage of 98.5 % than all other cultivars, whereas IT96D-610 and IT97K-499-35 gave 97.6 % each. Seeds of cultivars IT07K-292-1-10 and IT97K-573-2-1 had 96.0 and 94.8 % germination respectively, while seeds of cultivar IT07K-222-2 gave in the lowest germination percentage of 74.8. Seeds obtained from cultivar IT97K-568-18 infected with CMeV + BICMV exhibited the highest germination percentage of 98.5 before storage which was not significantly ($p > 0.05$) different from 97.3 % obtained from seeds of IT99K-316-2. Next to these with high germination percentage of 96 were seeds obtained from IT90K-277-2, IT96D-610, IT98K-205-M8, IT98KD-288, IT04K-332-1 and IT07K-222-2 whereas the significantly lowest germination percentage of 78.6 was recorded in seeds of cowpea cultivars IT04K-321-2 and IT07K-211-1-8. (Table 2).

Similarly, the difference between the lowest and highest percentage mean values for seed vigour traits was also wide and significant (p<0.05) when seeds were stored for four weeks (accelerated ageing). Significantly highest germination percentage of 77.9 was recorded in seeds of BICMV infected Ife Brown followed by IT90K-277-2, IT00K-901-5 and IT96D-610 with 76.6, 70.6 and 70.3 germination percentage,

respectively. Seeds of cultivar IT97K-568-18, IT07K-292-1-10 and IT07K-299-6 exhibited germination values of 69.5, 64.4 and 62.1 %, respectively whereas the least germination values of 46.6 % was obtained from seeds of IT06K-124. Mean value for accelerated ageing germination (AAG) on CMeV infected cowpea cultivars showed that seeds of IT98K-205-M8 had 70.6 % germination. This was closely followed by seeds of Ife Brown with 69 % while 68, 66.8 and 66.5 % were obtained from cultivars IT90K-277-2, IT03K-337-6 and IT96D-610, respectively. The germination capacity of 64 % was recorded from seeds of cultivars IT99K-316-2 while IT07K-299-6 and the remaining cultivars had AAG percentages ranging from 53.4 to 62.7 % (Table 2).

For the mixed infection treatments, germination value of 58.6 % was obtained from IT90K-277-2, IT06k-124 and IT07K-292-1-10 BICMV + CMeV infected cowpea cultivars. This value (58.6 %) was significantly (p<0.05) higher than the values obtained from seeds of other cultivars. Seeds from cultivars IT98K-205-M8, IT97K-499-35, IT06K-137-1 and IT07K-211-1-8 gave germination values of 56.5, 55, 54.5 and 53.4 % respectively. Seeds of cultivars IT96D-610 and IT00K-901-5 exhibited similar germination percentage of 52 while the remaining cowpea cultivars had germination percentages of between 44.0 and 50.6. Also, seed germinability of 57.3 % was highest in IT07K-292-1-10 with CMeV + BICMV infected cowpea seeds which was statistically (p>0.05) similar to the performance of seeds of IT97K-499-35 with 56 %. Seeds of cultivar IT04K-267-8 and IT07K-222-2 exhibited 54.6 and 53.7 % respectively, while IT96D-610 and IT04K-291-2 had germination values of 52 % which did not differ from one another. The lowest AAG percentage of 31.6 was recorded in seeds of cowpea cultivar IT99K-377-1 (Table 2).

DISCUSSION

Viability and vigour are two major indices used for determining the performance capability of seed lot. Seed quality is influenced by the environment where it is produced. Pathogens namely virus, nematode, fungi, bacteria among others are integral components of the environment of any seed crop; failure to effectively manage their competition could mean zero harvest (Adesina *et al*., 2012) as found in this study. However the imperative of understanding the impact of virus management strategies and management for quality seed production arises from the paucity of information on the agronomy of seed production (Gómez, 2012; Adesina *et al*., 2012), more so that seed production efforts are judged on the basis of quality of the produce rather than quantity.

The result of this study has established a clear negative influence of virus infection on cowpea seed quality and that the differential ranking of the virus infection treatments in different seed quality test is an indication of the response of the developing seeds on the mother plant to competing virus infection situations. Differences in time of flower initiation, pod setting, seed formation and maturity to virus infections are critical factor to tropical farming. The results obtained from this study revealed that there was a variation in germination percentage before and after four weeks of storage which is a measure of seed viability and longevity. When seed that has this trait is sown on the field for production, it exhibits a wide variation in performance after sowing due to the differences in quality (Anjorin and Mohammed, 2014). Since seeds did not ripen at the same time amongst virus treatments across the test cowpea cultivars, variations in seed viability due to age at harvest is inevitable (Singh, 2014).

The initial general high germination percentage recorded in seeds of all treatment combinations in this study is an indication that the seeds did not exhibit dormancy contrary to what is known with most vegetable seeds when freshly harvested. This rapid germination also showed that the activities of the pathogens (viruses) on the seeds were not severe enough to impaired germination (Ahmad *et al.,* 2006; Abdullahi *et al*., 2019). Mandhare and Gawade (2010) reported that though seeds obtained from mosaic infected bean at harvest exhibited high seed germination, a significant sharp decline in germination percentage of the seeds was recorded following four weeks of storage at 32 ^{0}C and 50 % relative humidity.

Following storage of seeds for four weeks in this study, a sharp decline in the germination capability of seeds of all the treatment combinations was recorded. This sharp decline in the quality of seeds is abnormal according to the normal/natural seed ageing process (Anjorin and Mohammed, 2014). The reason may be that the pathogen activities must have been activated which resulted in the sudden and heavy decline in the germination percentages (Adesina *et al*., 2012). Furthermore, the variation in germination percentages amongst the cultivars and treatments as shown in this study suggest genetic superiority (Hamim *et al*., 2014) and tolerant level of the cultivars over one another.

CONCLUSION

The results of the experiment revealed that all cultivars were susceptible to single and mixed infections of the two viruses but to seemingly different extent. The viability of seeds as seen from this study was generally high before storage; the high initial germination percentage was not sustained (short lived); an indication that conservation of infected seeds of all cultivars was impaired. More so, all the cowpea cultivars did not exhibit dormancy which is a problem with most freshly harvested vegetable seeds.

RECOMMENDATIONS

The benefits of increased cowpea production include improved nutrition for humans and livestock, improved soil properties and substantial opportunities for greater income. The monitoring and management of these viruses therefore is crucial to sustainable cowpea production most especially in sub-Saharan Africa. There is the need, therefore, for constant monitoring of legume fields through regular field sanitation, disease surveys to identify new and emerging viruses because these facts present a good starting point for legume virus diseases diagnosis in the study area. There is also need to ensure availability of acceptable, desirable cowpea cultivars with a high level of resistance to cowpea viruses for the nation to sustain its high level of productivity

Table 1: Severity of single and mixed infections of *Blackeye cowpea mosaic virus*(BICMV) and *Cowpea mottle virus* (CMeV) on cowpea plants at Mokwa in 2017

	2 Week after inoculation				5 Weeks after inoculation			
Cultivar	BICMV	CMeV	BI + CM	CM + BI	BICMV	CMeV	BI + CM	CM + BI
Ife Brown	3.7^{a}	3.6^{a}	3.6^{a}	3.6^{a}	4.3^{a}	5.0^{a}	4.3^{a}	4.5^{a}
IT90K – 277 – 2	3.7^{a}	2.0^{b}	3.6^{a}	2.0^{b}	4.3^{a}	3.0^{bcd}	4.3^{a}	4.3^{ab}
IT96D – 610	3.7^{a}	2.0^{b}	3.6^{a}	2.0^{b}	4.0^{a}	2.3^{cd}	4.3^{a}	2.3^{cd}
IT97K – 499 – 35	3.0^{ab}	3.0^{ab}	3.0^{ab}	3.0^{ab}	4.3^{a}	4.3^{ab}	4.3^{a}	4.3^{ab}
IT97K – 568 – 18	3.0^{ab}	3.6^{a}	3.0^{ab}	3.6^{a}	3.6^{ab}	4.3^{ab}	3.6^{ab}	4.3^{ab}
IT97K – 573 – 2 – 1	3.0^{ab}	2.7^{ab}	3.0^{ab}	2.7^{ab}	4.3^{a}	4.3^{ab}	4.5^{a}	4.3^{ab}
IT98K – 205 –M8	3.0^{ab}	2.0^{ab}	3.0^{ab}	2.0^{ab}	4.3^{a}	4.3^{ab}	4.3^{a}	4.3^{ab}
IT98KD – 288	2.7^{ab}	3.0^{ab}	2.7^{ab}	3.0^{ab}	4.0^{a}	3.6^{a-d}	4.0^{a}	3.6^{a-d}
IT99K – 316 – 2	3.0^{ab}	2.0^{b}	3.0^{ab}	2.0^{b}	4.3^{a}	2.6^{bcd}	4.3^{a}	2.6^{bcd}
IT99K – 377 – 1	2.7^{ab}	2.7^{ab}	2.6^{ab}	2.7^{ab}	4.0^{a}	4.3^{ab}	4.0^{a}	4.3^{ab}
IT00K – 901 – 5	2.7^{ab}	2.7^{ab}	2.6^{ab}	2.7^{ab}	4.3^{a}	4.0^{abc}	4.3^{a}	4.0^{abc}
IT03K – 337 – 6	2.7^{ab}	2.7^{ab}	2.6^{ab}	2.7^{ab}	4.3^{a}	4.3^{ab}	4.3^{a}	4.3^{ab}
IT04K – 267 – 8	3.0^{ab}	2.0^{b}	3.0^{ab}	2.0^{b}	3.6^{ab}	2.0^{d}	3.6^{ab}	2.0^{d}
IT04K – 291 – 2	2.7^{ab}	3.0^{ab}	2.6^{ab}	3.0^{ab}	4.0^{a}	3.6^{a-d}	4.3^{a}	3.6^{a-d}
IT04K – 321 – 2	3.0^{ab}	2.7^{ab}	3.0^{ab}	2.7^{ab}	2.7^{ab}	4.3^{ab}	2.6^{ab}	4.3^{ab}
IT04K – 332 – 1	3.0^{ab}	2.0^{b}	3.0^{ab}	2.0^{b}	4.3^{a}	2.3^{cd}	4.3^{a}	2.3^{cd}
IT06K – 124	3.0^{ab}	3.0^{ab}	3.0^{ab}	3.0^{ab}	4.2^{a}	3.6^{a-d}	4.3^{a}	3.6^{a-d}
IT06K – 137 – 1	2.7^{ab}	3.0^{ab}	2.6^{ab}	3.0^{ab}	4.3^{a}	4.0^{abc}	4.3^{a}	4.0^{abc}
IT07K – 211 – 1 – 8	2.0^{b}	2.7^{ab}	2.0^{b}	2.7^{ab}	2.3^{b}	4.3^{ab}	2.3^{b}	4.3^{ab}
IT07K – 222 – 2	2.7^{ab}	2.0^{b}	2.6^{ab}	2.0^{b}	4.3^{a}	2.3^{cd}	4.3^{a}	2.3^{cd}
IT07K – 243 – 1 – 10	2.7^{ab}	2.0^{b}	2.6^{ab}	2.0^{b}	4.3^{a}	2.0^{d}	4.3^{a}	2.0^{d}
IT07K – 251 – 3 – 3	2.0^{b}	2.7^{ab}	2.0^{b}	2.7^{ab}	2.3^{b}	4.3^{ab}	2.3^{b}	4.3^{ab}
IT07K – 292 – 1 – 10	3.0^{ab}	2.0^{b}	3.0^{ab}	2.0^{b}	4.0^{a}	2.6^{bcd}	4.0^{a}	2.6^{bcd}
IT07K – 299 – 6	2.7^{ab}	3.0^{ab}	2.6^{ab}	3.0^{ab}	4.3^{a}	4.0^{abc}	4.3^{a}	4.0^{abc}
IT07K – 318 – 33	3.3^{a}	2.7^{ab}	3.3^{a}	2.7^{ab}	4.0^{a}	4.3^{ab}	4.0^{a}	4.3^{ab}
± SEM	0.21	0.19	0.21	0.19	0.35	0.35	0.35	0.35

Means with the same letter (s) within the same column are not significantly (p<0.05) different by Student-Newman -Keuls (SNK) test.

Table 2: Cowpea seed quality as affected by single and mixed infections of *Blackeye cowpea mosaic virus* (BICMV) and *Cowpea mottle virus* (CMeV) at Mokwa in 2017

	Viability Test (%)				Accelerated Ageing Germination (%) 4 Weeks of Storage			
Cultivar	BICMV	CMeV	BI + CM	CM + BI	BICMV	CMeV	BI + CM	CM + BI
Ife Brown	93.5^{bcd}	90.5^{c-f}	86.7^{f}	86.5^{gh}	77.9^{a}	69.0^{b}	56.6^{b}	46.2^{l}
IT90K – 277 – 2	94.7^{bc}	98.7^{a}	78.5^{c}	96.0^{bc}	76.6^{a}	68.0^{bc}	58.4^{a}	51.6^{e}
IT96D – 610	87.3^{g}	97.7^{a}	97.6^{b}	96.0^{bc}	70.3^{b}	66.5^{d}	52.0^{e}	52.0^{de}
IT97K – 499 – 35	88.0^{fg}	86.9^{i}	97.6^{b}	92.0^{e}	61.5^{de}	60.0^{g}	55.0^{c}	56.0^{ab}
IT97K – 568 – 18	99.7^{a}	91.2^{c}	81.3^{j}	98.5^{a}	69.5^{b}	57.2^{h}	48.0^{h}	41.2^{l}
IT97K – 573 – 2 – 1	87.8^{g}	93.4^{b}	94.8^{d}	94.5^{d}	50.6^{l}	57.1^{hi}	45.5^{i}	35.6^{m}
IT98K – 205 –M8	87.6^{g}	89.2^{efg}	77.5^{m}	96.0^{bc}	57.5^{gh}	70.6^{a}	56.3^{b}	41.5^{l}
IT98KD – 288	91.3^{c-g}	90.7^{cde}	82.6^{i}	96.0^{bc}	48.0^{m}	62.7^{f}	48.3^{gh}	51.3^{ef}

IT99K – 316 – 2	92.1^{c-f}	93.4^{b}	85.0^{gh}	97.3^{ab}	53.3^{jk}	64.0e^{f}	57.3^{ab}	46.0^{j}
IT99K – 377 – 1	88.9^{efg}	90.8^{cd}	85.4^{gh}	92.0^{e}	60.0ef	60.0^{g}	50.6^{f}	31.6^{n}
IT00K – 901 – 5	88.8^{efg}	86.1^{i}	81.3^{j}	89.3^{f}	70.6^{b}	65.0^{e}	52.0^{e}	47.0^{ij}
IT03K – 337 – 6	97.3^{ab}	89.4^{d-g}	84.6^{h}	89.3^{f}	50.5^{l}	66.8^{cd}	46.4^{i}	41.4^{l}
IT04K – 267 – 8	92.2^{c-f}	98.2^{a}	81.3^{j}	86.5^{gh}	56.0^{hi}	62.6^{f}	49.5^{fg}	54.6^{bc}
IT04K – 291 – 2	87.8^{g}	86.9^{i}	89.3^{e}	87.7^{g}	54.6^{ij}	58.7^{g}	57.4^{ab}	52.0^{de}
IT04K – 321 – 2	90.5^{c-g}	93.8^{b}	85.3^{gh}	78.6^{k}	58.6^{fg}	56.3^{hi}	48.0^{h}	50.6^{efg}
IT04K – 332 – 1	99.7^{a}	98.5^{a}	98.5^{a}	96.0^{bc}	60.0^{ef}	53.4^{k}	49.3^{fgh}	48.1^{hi}
IT06K – 124	93.7^{bc}	90.1^{c-g}	80.0^{k}	81.2^{j}	46.6^{m}	56.8^{hi}	58.6^{a}	49.6^{fgh}
IT06K – 137 – 1	77.4^{h}	87.2^{hi}	78.8^{l}	80.0^{jk}	52.0^{kl}	56.0^{hij}	54.5^{cde}	44.0^{k}
IT07K – 211 – 1 – 8	94.5^{bc}	88.5^{gh}	89.3^{e}	78.6^{k}	53.3^{jk}	56.0^{hij}	53.4^{d}	49.3^{gh}
IT07K – 222 – 2	92.5^{cde}	93.0^{b}	74.8^{n}	96.0^{bc}	54.2^{j}	56.4^{jk}	45.3^{ij}	53.7^{bc}
IT07K – 243 – 1 – 10	97.6^{ab}	98.4^{a}	89.3^{e}	94.8^{cd}	57.5^{gh}	54.7^{jk}	50.5^{f}	50.8^{efg}
IT07K – 251 – 3 – 3	92.3^{cde}	88.5^{gh}	82.8^{i}	85.3^{h}	57.3^{gh}	56.6^{ij}	44.0^{k}	47.0^{ij}
IT07K – 292 – 1 – 10	99.7^{a}	77.4^{j}	96.0^{c}	81.3^{j}	62.1^{d}	57.3^{h}	58.3^{a}	57.3^{a}
IT07K – 299 – 6	80.3^{h}	89.0^{gh}	86.8^{f}	82.6^{i}	64.4^{c}	64.0^{ef}	49.7^{f}	44.0^{k}
IT07K – 318 – 33	89.3^{d-g}	77.6^{j}	85.6^{g}	80.0^{jk}	59.8^{f}	58.7^{g}	44.9^{jk}	46.5^{ij}
SE ±	1.27	0.5	0.26	0.43	0.54	0.46	0.42	0.61

Means with the letter (s) within the same column are not significantly ($p \leq 0.05$) different by Student-Newman-Keuls (SNK) test

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