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Effects of Variety and Planting Density on the Incidence of Common Viral Diseases of Cowpea (*Vigna unguiculata*) in a Southern Guinea Savannah Agro-ecology

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ABSTRACT
Virus diseases are a limiting factor in cowpea production in all agro-ecological zones of Nigeria and yield reductions of between 80-100% have been reported. Some cowpea varieties show resistance to viruses, cultural practices such as varying plant population have been found useful in the control of these viral pathogens. Field experiments were conducted in the 2009 and 2010 cropping seasons to evaluate the effect of crop variety and varying planting density on the incidence of common viral diseases of cowpea. *Vigna unguiculata* (L.) Walp in the Southern guinea savannah agro-ecology of Nigeria. This is to identify tolerant varieties and an optimum planting density that could lead to lower viral incidence and high crop yields. A split-plot fitted into a randomised complete block experimental design with three replications was established with three cowpea cultivars (IT89KD-288, IAR-48 and Ife brown), in the main plots and three planting densities (25×75, 50×75 and 75×75 cm) in the sub-plots. The results of the study indicated that variety and planting density had significant effect on viral disease incidence. The lowest incidence was in variety IT89KD-288 (10.3%) while the highest was in variety IAR-48 (28.6%). The lowest mean incidence was also in plots under planting density of 25×75 cm. However, planting at a mid-level density of 50×75 cm with variety IT89KD-288 outperformed the other combinations for yields and is therefore, recommended.

Key words: Tolerance, cultural control strategy, plant population, crop resistance, farming system, insect vectors

INTRODUCTION
Cowpea *Vigna unguiculata* (L.) Walp is an important staple in many parts of the world; United States, South and Central America, the Caribbean, India and Australia (Quinn and Myers, 2002). It is also the most economically important indigenous African legume crop (Langyintuo *et al*., 2003). It is estimated that over 200 million people in Africa are dependent on cowpea as a cheap source of protein (Gowda *et al*., 2000). Nigeria accounts for over 70% of the total world production (Singh *et al*., 2000), with the production of 2,907,091 tonnes in 2001 (FAOSTAT, 2003).

Viruses constitute the major group of pathogens infecting cowpea (Kang *et al*., 2005) and over 140 viruses infect cowpeas world-wide but only nine of these viruses have been reported in Nigeria (Taiwo, 2003). The economically important viruses in Africa include cowpea aphid-borne mosaic virus potyvirus, cowpea mild mottle virus Carlavirus, cowpea mosaic virus comovirus, cowpea chlorotic mottle virus carmovirus, cowpea golden mosaic geminivirus, southern bean mosaic sobemovirus, cucumber mosaic cucumovirus and tobacco mosaic tobamovirus (Alegbejo and Kashina, 2001).

Most plant viruses are transmitted by vectors from one host to another. Equally, they are efficiently disseminated by human activities such as vegetative plant propagation, grafting, global exchange of infected material, changes in cropping systems and the introduction of novel crops in existing or new agricultural areas (Andret-Link and Fuchs, 2005).

Irwin *et al.* (2000) had suggested that the breeding and adoption of desirable mixtures of crop varieties with resistance to pests and pathogens for increased production be encouraged. It is believed that if susceptible plants are scattered among resistant plants within a field, vectors are less likely to encounter susceptible ones than if they were in pure stands (Hooks and Fereres, 2006).

The outcome of the interaction between host density and parasitism depends on the host genotype, which determines the plasticity of life-history traits and consequently, the host capacity to develop different tolerance mechanism to the direct or indirect costs of parasitism (Pagan *et al.*, 2009). The yield and nutritional quality of soybean seed has been found to be influenced by plant density (Rahman *et al.*, 2011). Also in an experiment to evaluate the effect of cultivar and plant population on spotted wilt in Virginia Market-Type Peanut, Hurt *et al.* (2004), reported variation in cultivar susceptibility to Spotted Wilt Virus (SWV) and also that the incidence of SWV increased as plant population decreased.

Cowpea is growing in importance in Nigeria and efforts are on by breeders to breed new cultivars that yield more but yet diseases especially those caused by viruses continue to militate against optimization of yield. It is equally important to focus research on alternative control strategies which will protect the environment against chemical pollution (Abdelhamid *et al.*, 2011), the use of agricultural wastes has been successful in this regard (Osman *et al.*, 2011) but the use of some other cultural control strategies looks more promising.

The objective of this study therefore, was to evaluate the use of varietal difference and plant population in the control of virus diseases of cowpea.

MATERIALS AND METHODS

The study was conducted at the University of Ilorin, Teaching and Research Farm during the 2008 and 2009 cropping seasons. The Research farm is approximately 307 m above sea level and is located within the Southern Guinea savannah ecological zone (9°29' N, 4° 35' E) of Nigeria. The annual rainfall is between 1250-1500 mm which peaks between June and September with a characteristic dry spell in mid July/early August. The mean temperature range for the area is between 20-35°C. The soil type is well drained sandy-loam.

Experimental design and field layout: A split-plot treatment fitted into randomised complete block experiment with three replications was established with three cowpea cultivars (IT89KD-288, IAR-48 and Ife brown), in the main plots and three planting densities (25×75, 50×75 and 75×75 cm) in the sub-plots. Each experimental plot consisted of nine (9) ridges, each 25 m long. Land preparation followed the conventional method of ploughing, harrowing and ridging. The cowpea cultivars were obtained from the National Seed Service Centre Ilorin, Kwara State Nigeria. The seeds were planted at the rate of three seeds per hole and thinning to two plants per stand was done some fourteen days later. Cypermethrin dimethrate at the rate of 50 g a.i ha^{-1} was sprayed at 4 weeks after seedling emergence and twice after flowering to control insects. Weeding was done manually as and when due.

Data collection: Data collected were on number of plants per plot, number of infected plants per plot, plant height, number of pods using 10 plants from each sub-plot, pod weight and grain weight.

Percentage disease incidence was calculated from collected primary data as follows:

$$\frac{\text{No. of infected plants}}{\text{Total No. of plants per plot}} \times 100$$

Harvesting: The cowpea pods harvested at maturity from each plot at 75-80 days after planting were manually threshed and weight of pods and grains appropriately measured using electronic weighing balance (Model Kerro No. Ka-3002 c).

Statistical analysis: All collected data were subjected to analysis of variance using the statistical package for the social sciences SPSS version 15.0. Treatment means, where significant, were separated using the New Duncan's multiple range test at 5% level of probability.

RESULTS

Percentage disease incidence: Table 1a and b are the results of the analysis of variance on percentage disease incidence for the 2008 and 2009 seasons. The results indicated that variety, density and a combination of these two factors had significant effect on incidence of viral disease. An assessment of the results for 2008 season on varietal basis (Table 1a) showed that by the 8th week after planting, variety IT89KD-288 had the lowest viral incidence (10.3%) while variety IAR-48 had the highest viral incidence of 28.6%. Analysis of results on the effect of planting density showed that planting density at 25×75 cm consistently produced the lowest viral disease

Table 1a: Main and interactive effects of variety and planting density on percentage viral disease incidence in cowpea during the 2008 cropping season

	Percentage viral disease				
Effects	4th week	5th week	6th week	7th week	8th week
IT89k288	0	0.7^{c}	2.3^{c}	8.4^{c}	10.3^{c}
IAR48	0	2.3^{a}	11.4^{a}	22.6^{a}	28.6^{a}
Ife brown	0	1.9^{b}	5.0^{b}	13.6^{b}	16.2^{b}
Density					
25×75 cm	0	0.4^{c}	2.1^{c}	6.9^{c}	11.3^{c}
50×75 cm	0	1.6^{b}	5.4^{b}	10.3^{b}	16.4^{b}
75×75 cm	0	2.4^{a}	9.3^{a}	16.3^{a}	28.4^{a}
Variety× Density					
IT89K288@ 25×75 cm	0	10.3^{f}	16.8^{g}	20.1^{g}	24.3^{g}
IT89K288@ 50×75 cm	0	6.8^{g}	11.3^{c}	15.3^{h}	19.8^{h}
IT89K288@75×75 cm	0	14.1^{cd}	21.1^{de}	25.3^{ef}	30.1^{e}
IAR48@ 25×75 cm	0	16.9^{b}	24.6^{bc}	29.6^{cd}	31.2^{de}
IAR48@ 50×75 cm	0	6.7^{g}	14.9^{h}	30.1^{bc}	36.2^{bc}
IAR48@ 75×75 cm	0	22.5^{a}	31.4^{a}	36.4^{a}	43.7^{a}
Ife brown@ 25×75 cm	0	11.8^{ef}	17.9^{fg}	23.8^{f}	27.6^{f}
Ife brown@ 50×75 cm	0	13.0^{de}	20.4^{e}	27.1^{de}	31.4^{de}
Ife brown@ 75×75 cm	0	16.6^{b}	23.6^{cd}	30.7^{bc}	35.2^{c}

Means with the same letter. (s) within each segment of a column are not significantly different at p = 0.05 level using Duncan's multiple range test

Table 1b: Main and interactive effects of variety and planting density on percentage viral disease incidence in cowpea during the 2009 cropping season

	Percentage viral disease				
Effects	4th week	5th week	6th week	7th week	8th week
IT89k288	0	2.9^{c}	5.7^{c}	31.3^{c}	34.5^{c}
IAR48	0	5.1^{a}	34.1^{a}	49.1^{a}	52.3^{a}
Ife brown	0	3.7^{b}	14.9^{b}	38.3^{bc}	44.6^{b}
Density					
25×75 cm^2	0	1.1^{c}	3.9^{c}	8.1^{c}	12.1^{c}
50×75 cm^2	0	2.9^{b}	8.2^{b}	16.9^{b}	19.6^{b}
75×75 cm^2	0	3.6^{a}	12.4^{a}	20.3^{a}	39.3^{a}
Variety×Density					
IT89K288@ 25×75 cm	0	3.3^{ef}	11.6^{g}	16.7^{g}	19.9^{g}
IT89K288@50×75 cm	0	2.9^{f}	10.1^{h}	14.5^{h}	17.3^{h}
IT89K288@75×75 cm	0	3.7^{ef}	13.2^{ef}	18.9^{ef}	22.1^{f}
IAR48@ 25×75 cm	0	6.8^{cd}	15.4^{d}	20.3^{d}	27.6^{cd}
IAR48@ 50×75 cm	0	7.4^{bc}	16.3^{c}	21.6^{cd}	28.9^{bc}
IAR48@ 75×75 cm	0	9.8^{a}	19.3□	25.8^{a}	32.7^{a}
Ife brown@ 25×75 cm	0	3.1^{ef}	12.6^{fg}	17.9^{fg}	20.6^{g}
Ife brown@ 50×75 cm	0	6.9^{cd}	16.7^{c}	21.4^{cd}	23.1^{ef}
Ife brown@ 75×75 cm	0	5.4^{d}	17.6^{bc}	23.6^{b}	26.4^{d}

Means with the same letter. (s) within each segment of a column are not significantly different at $p = 0.05$ level using Duncan's multiple range test

incidence. The percentage disease incidence at the 8th week was 11.3%. The lowest plant population density (i.e., spacing at 75×75 cm) led to the highest viral disease incidence (28.4%). Analysis of the effect of variety and density on viral incidence at flowering showed that variety IT89KD-288 at planting density 50×75 cm had the lowest incidence of viral disease (19.8%). The highest incidence (43.7%) was attained when variety IAR-48 was planted at a density of 75×75 cm.

Infection levels were generally higher for the 2009 season (Table 1b). However, the results obtained followed the same trend that was observed in the 2008 season. An analysis of varietal effect per sec showed that variety IAR-48 cumulatively manifested the highest infection levels from the 4th to the 8th week. It attained an incidence rate of 52.3% which was significantly higher compared with the variety IT89KD-288 which had the lowest value of 34.5%. Consideration of planting density as a main effect showed that at 25×75 cm, significantly lower viral infection was recorded compared to other density regimes. However, the combination of variety IT89KD-288 at the planting density of 50×75 cm produced the significantly lowest viral disease incidence (17.3%).

Growth attributes

Plant height: The results showed that variety and planting density interaction significantly influenced plant heights. At flowering (8th week) in the 2008 season as shown in Table 2a, variety Ife-brown at a density of 25×75 cm produced the significantly tallest plants (44.7 cm) while the combination of variety IAR-48 at density 75×75 cm had the shortest plants (29.9 cm). In the 2009 season (Table 2b) the effect of the combinations showed that there was a higher growth rate for the year compared to 2008. An analysis of the results, however, showed a pattern that was not different from the 2008 season. The results shown in the Table 2b, indicate that at the flowering

Table 2a: Combination effect of variety and planting density on plant height of Cowpea during the 2008 cropping Season

	Plant hight (cm)				
Treatment combination	4th week	5th week	6th week	7th week	8th week
IT89K288@25×75 cm	19.6[b]	23.7[b]	32.4[a]	37.3[bc]	40.1[bcd]
IT898@50×75 cm	20.3[a]	22.9[bc]	30.3[b]	39.6[ab]	42.6[bc]
IT89K288@75×75 cm	20.9[a]	25.6[a]	32.7[a]	34.2[d]	39.8[de]
IAR48@ 25×75 cm	17.3[c]	22.6[bc]	30.6[b]	35.4[cd]	43.6[ab]
IAR48@ 50×75 cm	16.4[de]	19.8[d]	23.6[e]	28.8[e]	31.4[g]
IAR48@ 75×75 cm	15.9[e]	16.4[f]	19.4[f]	24.6[ef]	29.9[h]
Ife brown@ 25×75 cm	21.3[a]	26.4[a]	33.6[a]	42.3[a]	44.7[a]
Ife brown@ 50×75 cm	16.3[e]	19.2[d]	26.2[cde]	39.4[ab]	42.6[bc]
Ife brown@ 75×75 cm	15.9[e]	18.3[de]	29.4[bc]	34.2[d]	38.7[ef]

Means with the same letter (s) within each column are not significantly different at p = 0.05 level using Duncan's multiple range test

Table 2b: Combination effect of variety and planting density on plant height during the 2009 cropping season

	Plant hight (cm)				
Treatment combination	4th week	5th week	6th week	7th week	8th week
IT89K288@25×75 cm	34.4[ab]	38.7[a]	45.3[abc]	51.9[cd]	53.2[cd]
IT89K288@50×75 cm	36.1[a]	38.6[a]	45.9[abc]	52.1[abc]	55.9[bc]
IT89K288@75×75 cm	31.3[bc]	36.4[bc]	43.6[cd]	45.4[fg]	50.6[f]
IAR48@ 25×75 cm	25.4[ef]	30.6[ef]	39.1[ef]	46.4[ef]	52.1[de]
IAR48@ 50×75 cm	26.9[de]	31.4[de]	40.6[cde]	44.1[g]	51.3[ef]
IAR48@ 75×75 cm	19.4[g]	26.6[g]	33.4[f]	38.1[hi]	46.3[h]
Ife brown@ 25×75 cm	23.6[f]	37.4[ab]	47.3[a]	53.6[a]	58.1[a]
Ife brown@ 50×75 cm	16.9[h]	33.5[cd]	43.2[cd]	49.6[de]	51.6[ef]
Ife brown@ 75×75 cm	12.9[i]	16.1[h]	29.8[g]	37.4[i]	48.7g[h]

Means with the same letter (s) within each column are not significantly different at p = 0.05 level using Duncan's Multiple Range Test

Table 3: Combination effect of variety and planting density on yield attributes

	No. of pods/plant		wt. of dry pods/plant (g)		wt. of dry seeds/plant (g)	
Variety×density	2008	2009	2008	2009	2008	2009
IT89K288@ 25×75 cm	24.3[de]	26.7[cd]	43.7[bc]	48.1[b]	36.5[b]	40.7[b]
IT89K288@50×75 cm	32.8[a]	34.9[a]	59.0[a]	62.8[a]	51.6[a]	55.4[a]
IT89K288@75×75 cm	22.5[fg]	24.1[de]	40.5[d]	43.4[cd]	32.9[ef]	35.8[e]
IAR-48 @25×75 cm	20.5[gh]	22.2[ef]	29.7[fg]	32.2[fg]	24.8[gh]	27.4[gh]
IAR-48 @50×75 cm	19.3[h]	20.1[f]	27.9[h]	29.1[h]	23.1[h]	24.3[i]
IAR-48 @75×75 cm	19.9[h]	20.9[f]	28.8[gh]	30.3[gh]	23.8[h]	25.3[hi]
Ife brown @25×75 cm	26.3[bc]	27.4[bc]	41.6[cd]	43.3[cd]	35.9[bcd]	37.7[cd]
Ife brown @50×75 cm	25.4[cd]	26.7[cd]	40.1[d]	42.2[de]	34.5[de]	36.6[de]

Means with the same letter (s) within each column are not significantly different at p = 0.05 level using Duncan's multiple range test

stage (8th week after planting), the combination of variety Ife-brown at density 25×75 cm produced the tallest plants (58.1 cm) while the combination of variety IAR-48 planted at a density of 75×75 cm had the shortest plants (46.3 cm).

Yield attributes: Table 3 shows the results of analysis of the combination of variety and planting density on some yield attributes for the two years of the experiment. In both seasons of the study, cowpea variety IT89KD-288 at density 50×75 cm produced the significantly highest yields per plant. In the first year (2008) for example, the number of pods, weight of dry pods and weight of dry seeds averaged 32.8, 59.0 and 51.6 g per plant, respectively while variety IAR-48 at density 50×75 cm had the lowest yields. In the second year of the experiment (2009), though yields were slightly higher than in the preceding year, the observations were similar to that of the first year, with variety IT89KD-288 at density 50×75 cm also having the highest yield attribute values while variety IAR-48 at density 50×75 cm the lowest.

DISCUSSION

The identification of tolerant cowpea varieties is a crucial step towards achieving the objective of economic control of viral diseases. Tolerance in this case can be defined as the ability of a genotype to produce a good crop even when it is infected with a pathogen (Agrios, 2005). Nevertheless, different sources of resistance is recommended for enhanced durability of resistance (Ochola and Tusiime, 2011). The present study showed that the incidence of virus diseases was highest in variety IAR-48 and lowest in variety IT89KD-288. The ability of variety ITKD-288 to have less virus incidence could be attributed to the genetic inherencies in the variety. This assertion is in agreement with Goenaga *et al.* (2008) who reported that the different yield potential of cowpea genotypes grown under virus pressure was due to the genetic diversity. Alsemaan *et al.* (2011), likewise reported the existence of genetic diversity within *Rosa damascene* accessions used to broaden the production of rose oil.

Virus disease incidence was observed to be highest at a plant population density of 75×75 cm, and lowest at a population density of 25×75 cm, this implied that low virus incidence existed under high plant population. It has long been known (Matthews, 1991) that half of all known plant viruses are transmitted by aphids. Allarangaye *et al.* (2007) reported that the transmission of Rice Yellow Mosaic Virus (RYMV) was by coleopterous insects. One factor which governs the rate of virus epidemics, is the interaction of the aphid vector with the plant environment especially plant density (INHS, 1995). It can therefore be inferred that the low virus incidence recorded at high plant population is attributable to reduced aphid infestations which hitherto would have served as vectors of the virus pathogens.

This study also showed that cowpea variety IT89KD-288 planted at a density of 50×50 cm produced the highest yield parameters. This suggests that although planting density could be effective in viral disease control, it is better determined on varietal basis. Findings by Payne (2000) corroborates the point that competition for space can become very intense when plant population is high which could then predispose plants to mechanical inoculation of virus pathogens occasioned by leaf contact.

CONCLUSION

This study concludes that moderately high plant population could be an effective tool in the control of viral diseases of cowpea especially in combination with the right variety. To this end variety IT89KD-288 at a planting density of 50×75 cm which performed best in this study is recommended to help control yield losses due to virus attack in this ecological zone.

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