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Incidence and Severity of Virus Diseases of Cowpea (*Vigna unguiculata* L. Walp) Under Varying Planting Density and Insecticidal Spray Regimes

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ABSTRACT

Viral diseases are a major problem for cowpea production in Nigeria, causing yield reductions of up to 100%. To combat this, farmers use insecticide sprays and manipulate plant population densities. A field experiment was conducted in the Southern Guinea Savannah agro-ecological zone of Nigeria in 2016 cropping season to assess the impact of planting density and insecticidal spray regimes on virus diseases in cowpea. The study found that the lowest disease incidence (32.2%) was observed at a density of 25×75 cm, and the highest (41.9%) at a density of 75×75 cm. The combination of a density of 25×7 5cm with three insecticidal spray regimes had the lowest incidence (18.6%), while 75×75 cm with no insecticidal spray had the highest (66.5%) disease incidence. Thus, it is recommended to use a planting density of 25×75 cm with three insecticidal spray regimes. This study emphasizes the importance of planting density and insecticidal spray regimes in managing viral diseases in cowpea production. Farmers can utilize this information to reduce disease incidence and severity and increase yield.

Keywords: Cowpea, Insecticidal spray, Plant virus, Planting density.

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INTRODUCTION

Cowpea *Vigna unguiculata* (L.) is a vital leguminous crop that is widely grown in tropical and subtropical areas of Asia, Africa, and Latin America, as well as parts of southern Europe and the USA (Singh *et al*., 1997; Boukar *et al*., 2004). In the year 2000, the worldwide production of cowpea dry grains was estimated to be 3.3 million tonnes, with Nigeria being the largest producer with 2.1 million tonnes, followed by Niger (650,000 tonnes) and Mali (110,000 tonnes) (IITA, 2004; Adegbite and Amusa, 2008). FAO reports indicate that globally, about 7.56 million tonnes of cowpea are produced annually on approximately 12.76 million hectares, with Sub-Saharan Africa accounting for about 70% of total world production (IITA, 2009). Cowpea is a popular food crop in Nigeria, particularly in the middle belt and drier northern regions, due to its high protein and lysine contents, which make it a natural supplement to staple diets of cereals, roots, and tubers commonly grown in many poor countries (Bressani, 1985; Adekola and Oluleye, 2007). Cowpea's importance as a food crop makes it a vital crop to millions of people, especially the poor.

Cowpea, a vital crop to millions of poor people in tropical and subtropical areas, is vulnerable to a variety of diseases including fungal, bacterial, nematode, and viruses. Among these, viruses are the most detrimental to cowpea (Kang *et al.,* 2005). Although over 140 viruses have been reported to infect cowpea worldwide, only nine of these have been identified in Nigeria (Taiwo, 2003). The economically significant viruses affecting cowpea in Africa include potyvirus, Carlavirus, Comovirus, Carmovirus, Geminivirus, Sobemovirus, Cucumovirus, and Tobamovirus (Alegbejo and Kashina, 2001).

Plant viruses are easily transmitted from one host to another by vectors (leafhoppers, thrips and aphids) and can also be spread through human activities such as plant propagation, grafting, global exchange of infected material, changes in cropping systems, and the introduction of novel crops in new agricultural areas (Andret-Link and Fuchs, 2005). Viral diseases are notorious for causing significant yield losses in cowpea crops, ranging from 10% to 100% (Taiwo, 2003). Cowpea plants are often infected by more than one virus disease, which can exacerbate the economic losses (Kang *et al.,* 2005). The symptoms of viral infections in cowpea include systemic chlorosis, leaf distortion, leaf mottling, and stunting of plants (Ng and Perry, 2004).

Reports by Saidi and Safaeizadeh (2011) suggest that natural infections of cucumber mosaic virus on Pelargonium occur in Iran, while in Southern India, sunflower leaf curl disease caused by a begomovirus and transmitted by Bemisia tabaci was observed to an extent of 40% on some sunflower hybrids grown in experimental plots in China (Govindappa *et al.,* 2011). This highlights that viruses are a potential threat to optimal agricultural production, and effective control measures are urgently needed.

Cowpea is a significant crop in Nigeria, but viruses pose a threat to its yield optimization. Researchers are exploring alternative control strategies that protect the environment from chemical pollution. One successful approach is the use of agricultural waste and manipulating planting density and using insecticidal spray have also shown promise. However, their use is not common in some developing countries, including Nigeria. Therefore, this study aims to evaluate the effectiveness of manipulating planting density and using insecticidal spray in controlling virus diseases in cowpea. The findings of this research will contribute to the development of more sustainable and effective disease control strategies for cowpea production in Nigeria.

MATERIALS AND METHODS

Description of the Experimental Site

The study was conducted at the University of Ilorin Teaching and Research Farm, located within the Southern Guinea Savannah ecological zone of Nigeria. The experimental period spanned from August to November 2016. The farm is situated at an altitude of approximately 307 m above sea level, with an annual rainfall ranging between 1250-1500 mm and mean temperature between 20 and 35 ^{0}C. The soil type at the experimental site is well-drained sandy-loam, as reported by previous studies (Aliyu and Balogun, 2012).

Experimental Design and Field Layout

The study adopted a randomized complete block design with twelve (12) treatment combinations replicated three (3) times. Four insecticidal spray treatments were applied in the experiment, including an untreated control, two sprays at two and six weeks after emergence, three sprays at two, four, and six weeks after emergence, and four sprays at seedling, flowering, and podding stages. A standard insecticide formulation of Cypermethrin+dimethoate at the dose of 30 + 250 g a.i/ l was used for all insecticidal spray treatments. The three planting densities used in the experiment were 25x75 cm, 50x75 cm, and 75x75 cm, respectively, for one cowpea cultivar. The experimental site measuring 12 m x 100 m (1200 m^{2}) was divided into three blocks, each measuring 4 m x 100 m (400 m^2) and further divided into 12 plots. Each experimental plot consisted of four ridges, each 7 m long, with an alleyway of 1.5 m between each plot. The three blocks were based on three different planting densities (25x75 cm, 50x75 cm, and 75x75 cm), and the treatments were randomly allocated to each replicate within each block, resulting in a total of 36 replicates used for the study. The use of insecticidal sprays and manipulation of planting density are proven cultural control strategies that can be effectively used to control virus diseases in cowpea. This study aims to evaluate the effectiveness of these strategies in controlling virus diseases in cowpea.

Collection of Planting Materials

The study utilized a single cowpea cultivar, namely Vita 5, which was obtained from the National Seed Service Centre in Ilorin, Kwara State, Nigeria.

Land Preparation and Planting

Land preparation for the cowpea cultivation followed the conventional method of ploughing, harrowing, and ridging. The planting was done on August 16th, 2016, using the Vita 5 cowpea cultivar obtained from the National Seed Service Centre in Ilorin, Kwara State Nigeria. The seeds were planted at a rate of three (3) seeds per hole with spacing of 25x75 cm, 50x75 cm, and 75x75 cm. At two (2) weeks after germination (2 WAG), the seedlings were thinned to two (2) per stand. Insecticidal treatments using Cypermethrin and dimethoate were sprayed at the second week after seed emergence at the rate of 50 g a.i/ ha.

Agronomic Practices

Rainfed conditions were employed for the growth of the cowpea plants, and weed control was achieved through a combination of chemical and manual weeding methods. Prior to seedling emergence, a selective pre-emergence herbicide known as Butachlor (N'-(butoxymethyl)-2-chloro-2',6'-diethylacetani-lide) was applied at a rate of 1 liter per active ingredient per hectare. The application of subsequent hand weeding was carried out manually at appropriate intervals.

Data Collection

Data was collected on various growth and yield parameters, including virus disease incidence. The percentage incidence of the virus was estimated by observing 20 randomly selected plants per plot and calculating the percentage incidence using the formula described by Chan and Jeger (1994), which is given as:

$$\% \; incidence = [Number\ of\ diseased\ plants\ /\ Total\ number\ of\ plants\ sampled\ (20)] \times 100$$

The equation for calculating the percentage severity based on the number of diseased leaves relative to the total number of leaves of a plant is as follows:

$$\% \; severity = (Number\ of\ diseased\ leaves\ /\ Total\ number\ of\ leaves) \times 100$$

Upon reaching maturity at 85-90 days after planting, cowpea pods were harvested from each plot and manually threshed. The weight of the pods and grains were then measured using an electronic weighing balance.

Statistical Analysis

The collected data was analyzed using the statistical package for the social sciences (SPSS) version 16.0 and subjected to analysis of variance (ANOVA). In cases where significant differences were observed, the New Duncan's multiple range test was used to separate treatment means at a 5% level of probability. This approach was employed to ensure the accuracy and reliability of the statistical analysis in this research study.

RESULTS AND DISCUSSION

Effect of Treatment on Percentage Disease Incidence

The results of the analysis of variance on the percentage disease incidence of cowpea are presented in Table 1 and 2. The main effect was significantly varied at ($P < 0.05$). The findings revealed that both planting density and insecticidal spray regimes had a significant impact on the incidence of viral disease. The assessment based on planting density (Table 1) indicated that a density of 25×75 cm resulted in the lowest viral disease incidence (32.2%) by the 8th week after planting, while a density of 75× 75 cm had the highest incidence (41.9%). Furthermore, the main effect of insecticidal spray regimes demonstrated that three regimes consistently led to the lowest viral disease incidence, with a percentage incidence of 24.4% by the 8th week.

The analysis of the interaction effect of planting density and insecticidal spray regimes (Table 2) was significantly varied at ($P < 0.05$). It was revealed that planting density of 25 ×75 cm at three insecticidal spray regimes resulted in the lowest viral disease incidence (18.6%). On the other hand, the highest incidence (66.5%) was observed in the planting density of 75 ×75 cm with no insecticidal spray.

The results showed that the incidence of virus diseases was highest in plant population density of 75 ×75 cm and lowest in population density of 25 ×75 cm. This suggests that low virus incidence can be observed in areas with high plant populations. This phenomenon may be attributed to reduced aphid infestations, which would typically occur through weed infestation serving as vectors for virus pathogens. The presence of a greater number of plants within a given area could potentially disrupt the spread of viruses by minimizing the availability of weed hosts for aphids, thus reducing the transmission of viral pathogens (Matthews, 1991; INHS, 1995).

Table 1. Main effects of planting density and insecticidal spray regimes on percentage disease incidence of cowpea at different times after planting.

Treatments	**Disease incidence percentage**			
Density	5 Weeks	6 Weeks	7 Weeks	8 Weeks
25 x 75 cm	2.7^{a}	4.9^{a}	20.6^{a}	32.2^{a}
50 x 75 cm	4.6^{b}	8.4^{b}	26.1^{ab}	39.9^{b}
75 x 75 cm	6.2^{c}	10.9^{c}	30.5^{b}	41.9^{b}
Std. Error	0.413	0.402	1.892	2.325
Number of insecticidal spray				
0	5.9^{b}	11.9^{c}	46.7^{c}	62.0^{c}
2	4.2^{a}	6.5^{ab}	25.7^{b}	37.5^{b}
3	3.6^{a}	6.1^{a}	14.9^{a}	24.4^{a}
4	4.3^{a}	7.7^{b}	15.5^{a}	25.1^{a}
Std. Error	0.477	0.464	2.184	2.685

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

Table 2. The interaction effects of planting density and insecticidal spray regimes on percentage disease incidence of cowpea at different times after planting**.**

Treatment combination		**Disease incidence percentage**			
Density	**Number of insecticidal sprays**	**5 Weeks**	**6 Weeks**	**7 Weeks**	**8 Weeks**
25 x 75 cm	0	3.7	8.1	38.7	56.4
	2	2.1	4.1	22.6	32.5
	3	2.5	3.5	10.1	18.6
	4	2.5	3.8	11.0	21.2
50 x 75 cm	0	4.9	11.0	49.7	63.1
	2	4.7	7.1	25.2	39.2
	3	4.1	6.9	15.2	26.9
	4	4.7	8.6	14.1	30.5
75 x 75 cm	0	8.9	16.8	51.8	66.5
	2	5.7	8.2	29.2	40.8
	3	4.2	7.9	19.3	34.2
	4	5.7	10.7	21.5	26.4
Std. Error		0.827	0.804	3.783	4.651

Effect of Treatment on Disease Severity Percentage

Table 3 and 4 present the results of the analysis of variance on the percentage disease severity of cowpea. The findings indicated that planting density, insecticidal spray regime, and the interaction between these two factors had a significant effect on the severity of viral disease. These was significantly varied at ($P < 0.05$). An assessment based on planting density (Table 3) revealed that a density of 50 ×75 cm resulted in the lowest viral disease severity (22.8%) by the 8th week after planting, while a density of 75× 75 cm had the highest severity (27.2%). Additionally, the main effect of insecticidal spray regimes demonstrated that three regimes consistently resulted in the lowest viral disease severity, with a percentage severity of 18.5% by the 8^{th} week.

The analysis of the interaction effect of planting density and insecticidal spray regimes (Table 4) revealed that planting density of 50 ×75 cm at three insecticidal spray regimes resulted in the lowest viral disease severity (13.3%). Conversely, the highest disease severity (43.3%) was observed in the planting density of 75 ×75 cm with no insecticidal spray. The study also found that virus disease severity was highest in the no insecticidal spray regimes and lowest in three (3) insecticidal spray regimes, indicating that insecticide use can effectively control aphid vectors. Insecticides are widely used to control cowpea insect pests, such as aphids, Maruca, thrips, and pod-sucking bugs (Jackai *et al.*, 1985; Amatobi, 1995; Jackai and Adalla, 1997). However, due to environmental concerns and safety issues, integrated pest control using the least toxic insecticides is recommended for small-scale farmers in tropical Africa. Cowpea management practices that combine early planting, close spacing, and minimum insecticide application have been found to be effective in reducing pest infestation (Kurungi *et al.,* 1999). Additionally, strategic insecticide sprays, as recommended by several authors (Ajeigbe and Singh, 2006; Asante *et al.*, 2001; Kamara *et al.,* 2010), can reduce the incidence and severity of virus diseases in cowpea.

Table 3. Main effects of planting density and insecticidal spray regimes on percentage disease severity of cowpea at different times after planting.

Treatments	**Disease severity percentage**			
Density	5 Weeks	6 Weeks	7 Weeks	8 Weeks
25 x 75 cm	12.9^{a}	13.7	21.7^{b}	26.2^{b}
50 x 75 cm	18.4^{b}	14.4	17.9^{a}	22.8^{a}
75 x 75 cm	13.6^{a}	13.6	19.8^{ab}	27.2^{b}
Std. Error	1.163	0.965 NS	0.977	0.889
Number of insecticidal sprays				
0	18.6^{b}	19.0^{c}	31.3^{c}	42.0^{c}
2	19.7^{b}	15.7^{b}	18.5^{b}	24.6^{b}
3	9.8^{a}	11.7^{a}	14.3^{a}	18.5^{a}
4	11.8^{a}	9.5^{a}	15.0^{a}	16.6^{a}
Std. Error	1.343	1.115	1.128	1.027

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

Table 4. The interaction effects of planting density and insecticidal spray regimes on percentage disease severity of cowpea at different times after planting.

Treatments combination		Disease severity percentage			
Density	**Number of insecticidal sprays**	**5 Weeks**	**6 Weeks**	**7 Weeks**	**8 Weeks**
25 x 75 cm	0	16.7	22.4	39.4	43.2
	2	15.5	14.0	17.5	23.2
	3	11.8	10.4	15.3	22.6
	4	8.0	8.7	14.5	15.8
50 x 75 cm	0	21.9	18.8	27.6	39.5
	2	18.8	15.1	17.3	20.0
	3	12.8	9.2	10.6	13.3
	4	20.1	14.4	16.0	18.5
75 x 75 cm	0	17.4	15.7	27.0	43.3
	2	24.9	17.9	20.7	30.6
	3	4.9	15.3	16.9	19.6
	4	7.4	5.50	14.4	15.4
Std. Error		2.326	1.931	1.953	1.779

Effect of Treatments on Yield Attributes

The results of analysis of variance on cowpea yield parameters are presented in Table 5. The findings suggest that planting density, insecticidal spray regimes, and their interaction significantly influenced some of the yield parameters. Examining the results based on density (Table 5), the highest yield per plot was obtained with a planting density of 25 ×75 cm at maturity. This density resulted in the highest number of pods per plant (25.9), weight of dry pods per plot (1298 g), and weight of dry seeds per plot (1150 g), while the lowest yield parameters were recorded with a density of 75 ×75 cm. Analysis of variance of the main effect of insecticidal spray regimes showed that three (3) insecticidal spray regimes consistently produced the highest yield parameters, with the number of pods per plot (27.4), weight of dry pod per plot (1450 g), and weight of seed per plot (1315 g), while the lowest yield parameters were recorded with no insecticidal spray.

The results of this study suggest that plant population density and insecticidal spray regimes could be effective strategies in the control of virus diseases and improvement of cowpea yield. Planting cowpea at a higher plant population density of 25 ×75 cm was found to significantly reduce virus incidence and improve yield parameters. This finding supports the notion that optimizing plant population density could be an important step towards achieving effective control of viral diseases. Additionally, the use of three insecticidal spray regimes was found to be most effective in controlling insect pests and reducing the incidence and severity of virus diseases, which is consistent with previous studies (Ajeigbe and Singh, 2006; Asante *et al.*, 2001).

Table 5. Main effects of planting density and insecticidal spray regimes on yield attributes of cowpea.

Density	No. Pods/ Plant	Pod Wt./ Plot (g)	Seed Wt./ Plot (g)
25 x 75 cm	25.9^{a}	1298.0^{a}	1150.0^{a}
50 x 75 cm	25.0^{a}	1122.0^{a}	962.0^{a}
75 x 75 cm	20.8^{b}	664.8^{b}	564.4^{b}
Std. Error	1.028	66.903	68.529
Insecticidal Regime			
0	17.0^{b}	320.1^{c}	215.4^{c}
2	25.6^{a}	1069.0^{b}	928.9^{b}
3	27.4^{a}	1450.0^{a}	1315.0^{a}
4	25.6^{a}	1273.0^{ab}	1109.0^{ab}
Std. Error	1.187	77.253	79.131

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

CONCLUSION

This study has demonstrated that manipulating the planting density of cowpea plants can be an effective strategy in controlling viral diseases, particularly when combined with the proper timing of insecticidal spray. Specifically, a planting density of 25 ×75 cm and three insecticidal spray regimes produced the best results in this ecological zone. Therefore, it is recommended to use this combination to help mitigate yield losses caused by virus attacks in cowpea production.

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