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Maruca vitrata (Fab.) [Lepidoptera: Pyralidae] Damage on Cowpea (*Vigna unguiculata* L. Walp.) in Katsina, Sudan Savanna, Nigeria: The Role of IPM

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Abstract: A combination of intra-row spacings, sowing dates, and pesticides on cowpea damage and control caused by *M. vitrata* was carried out towards developing an integrated pest management of *M. vitrata* on cowpea. The experiment was laid out in split-split plot design. Intra-row spacing and sowing dates were respectively allocated to the main and sub-plot while pesticides were allocated to the sub-sub-plot. The treatments were randomized and replicated three times. Data collected were subjected to the analysis of variance and means were separated using LSD at 5%. The result showed that varying intra-row spacings did not have any significant effect (P>0.05) on cowpea flower damage by *M. vitrata* at 10 WAS in all the years and the combine except in 2016. Close spacing was observed to record the least flower damage. Early sowing was observed to significantly (P<0.05) recorded the highest percentage flower damage in all the years and the combine (22.95, 22.78 and 22.85). Pesticide treated plots (13.06, 13.06 and 11.67) significantly (P<0.05) recorded the least percentage flower damage compared with the control plots (26.30). The effect of pesticides was statistically similar, however plots treated with Cyper diforce during recorded the least percentage flower damage. There was no significant difference on the effect of varying intra-row spacing on percentage cowpea pod damaged by *M. vitrata* 10 WAS. However, delay in sowing to SD3 significantly recorded least percentage pod damage (4.89, 14.03 and 2.94) than early sowing SD1 (24.47, 30.14 and 12.74) which recorded the highest. The effect of pesticides showed that plots treated with MaviMNPV significantly (P<0.05) recorded the least percentage damage (6.69) compared with the control (13.08). However, treatments effects were statistically similar. The effect of varying sowing dates showed that sowing cowpea at SD3 significantly (P<0.05) reduce dried cowpea pod damage at harvest (5.55% and 6.81%) than early sowing SD1 (12.85% and 10.61%) during 2016 and the combine respectively. It is therefore recommended that varying sowing date and use of Cyper diforce reduce cowpea damage in the study area and is hereby recommended.

Keywords: *Maruca vitrata*, Damage, Cowpea, Bio-pesticide and Integrated Pest Management

1. Introduction

Cowpea (*Vigna unguiculata* L. Walp.), is a dicotyledonous plant belonging to the family *Fabacea*. It is one of the ancient crops known to man. It is one of the most important crops in Africa cultivated by peasant farmers as a subsistence crop. The crop originated from Africa and spread through Egypt and domesticated in parts of Southern, Eastern and Western Africa where a large number of primitive cultivars and semi wild forms were found [1--3] stated that cowpea is grown mainly in the savanna regions of the tropics and sub-tropics in Africa, Asia and South America. According to [4], cowpea is considered as the most important grain legumes in the dry savannas of tropical Africa, where it is grown on more than 12.8 million hectares of land. Highly rich in quality protein and has energy content almost equivalent to that of cereal grain. The dried seeds of cowpea provide an inexpensive source of protein in many diets of urban and rural people in the tropics and sub-tropics [2, 5]. The crop is a good source of quality fodder for livestock and provides cash income. [6] reported that nearly 200 million people of Africa consume the crop. The productivity of this crop is under threats by many biotic and abiotic factors, most importantly the legume pod-borer, *M. vitrata*. It is one of the most important pests of grain legume throughout the tropics and sub-tropics of Central and South America, Asia and Africa [7-9] identified the borer among the most important grain legume pests in the northern Nigeria. The production of cowpea has continued to decline due to activities of wide spectra of insect pests, notably damage caused by *M. vitrata*. Severe infestation by the borer can cause up to 80% yield losses [4, 7, 6]. Cowpea losses due to pests attack or diseases can be as high as 90% [10, 3].

Management of insect pests of cowpea can be achieved through varying sowing date or intra-row spacing. Manipulation of sowing date in order to escape period of high insect populations in insect pest management in cowpea was extensively studied [11,12,2]. Plant density can also be a strategy in cowpea insect pest control. Close spacing increases plant population per unit space. According to [13], high plant population increase denser canopies which improve the crop micro climate. The improvement in the micro climate will as well increase the population of biocontrol agents which predates/parasitize *M. vitrata*. The use of chemical as means of pest control measures proved effective on cowpea pests. However, its high cost coupled with its potential hazards to the environment, humans, animals and livestock have necessitated the search for viable non chemical methods to reduce the consequences generally caused by pests. Pesticides not only cause environmental pollution especially by non-biodegradable, highly persistent residues, but they also off-set the dynamic equilibrium in aquatic ecosystem [14]. It also affect non target soil micro and macro fauna and flora, predatory beetles, spiders, birds, insect pollinators and other wild life. Besides, they ramify every nooks and corners of aquatic and terrestrial food chains and the more complex food webs [8, 15, 9] observed that farmers who adopted control through chemical sprays are exposed to serious health hazards. Search for a viable and environmentally friendly control measure within the reach of economic resource-poor farmers is necessary in order to reduce losses suffered by cowpea farmers. No single strategy can achieve control of major cowpea pest complexes and notably *M. vitrata*. [16] opined that the use of microbial biopesticides especially fungus has been tried with successes mostly in the stored products. Recent, the use of microbial biopesticides in *M. vitrata* control using the *Maruca vitrata* multi-nucleopolyhedrovirus (MaviMNPV) has been demonstrated [17]. Control of *M. vitrata*is crucial for sustainable cowpea production. The research was carried out in order to determine the effect of varying intra-row spacings and sowing dates and use of pesticides on the damage caused by *M. vitrata* on cowpea in Sudan savanna.

2. Materials and Methods

2.1. Study Area

A field trial was conducted during the cropping season of 2015 and 2016 in the Teaching and Research Farm, College of Agriculture, Hassan Usman Katsina Polytechnic, Latitudes 11°07′49″to 13°22′57″N and Longitudes 06°52′03″and 09°02′40″E and 619 m above sea level in the Sudan savanna ecological zone [18]. The soil of the area is sandy loam. The rainy season starts from May and ends in October with mean annual rainfall of 742 mm. The State has a total land mass of 24,192 km^2 with an estimated population of 6,483,429 [19]. The inhabitants are Hausa-Fulani and predominantly farmers. The major crops grown include maize, sorghum, millet, rice, cotton, groundnut, sesame, soya bean and cowpea [20].

2.2. Sources and Preparation of Plant Materials

2.2.1. Neem Kernels Seed Extract

Matured and ripe neem seeds were collected immediately after rainfall in neem tree forest reserve outskirts of Katsina town. The fruits were de-pulped, washed in a bucket containing clean water and subsequently dried under the shade. The seeds were cracked and the kernels removed and were ground using an electric blender (Model: DJ-BL242 manufactured by DAICHI Home essentials). About 5 kg ha^{-1} of kernels powdertogether with 2 kg ha^{-1} bar soap as emulsifier were wrapped in a clean white cloth and soaked overnight in a bucket containing 100 litre ha^{-1} of water [21]. The mixture was stirred thoroughly and was squeezed the next day until milky suspension was produced [22- 23]. Gum arabic was added to the filtrate at the rate of 2.7 kg in 6.75 litres of water ha^{-1} as sticker [1]. This forms the crude extract.

2.2.2. Maruca Vitrata Multi-nucleopolyhedrosis Virus (MaviMNPV) Suspension

Maruca vitrata Multi-nucleopolyhedrosis virus (MaviMNPV) suspension was obtained from IITA, Cotonou, Benin Republic.

2.2.3. Cyperdiforce®

A systemic, contact and stomach poison insecticide belonging to toxicity class II. It is composed of 30 g L^{-1} Cypermethrin and 250 g L^{-1} Dimethoate EC (Systemic pyrethroid for cypermethrin, organophosphate for Dimethoate) manufactured by Jubaili Agrotech. The insecticide was applied at the rate of 1.5 L ha^{-1}in 925 L of water using Knapsack CP-3 sprayer having hollow cone nozzle type [12].

2.3. Treatments and Experimental Design

The treatments consisted of three Intra-row spacings, three sowing dates and three pesticides (of which included two biopesticides and a synthetic check) and a control. The experiment was laid out using Split-split-plot design with Intra-row spacing (Factor A) SP1; 75 x 20 cm, SP2; 75 x 30 cm and SP3; 75 x 40 cm allocated to the main plot, sowing date (Factor B) (SD1; 02 July, SD2; 23 July, SD3; 13 August) allocated to the sub plot and pesticides (Factor C); neem kernel seeds extract (NKE) (P1), MaviMNPV suspension (P2) and Cyper diforce (P3) and the control (P0) were allocated to the sub-sub-plot. The treatments were randomized and replicated three times. Each plot consisted of six ridges of 6 m long and 4.5 m wide. The ridges were 0.75 m apart. The two middle rows constituted the net plot, the second and fifth rows for sampling while first and sixth rows constituted boarders [1]. The blocks were separated by unplanted space of 2 m while 1 m was left between plots. A distance of 1 m was also left between main plots. The trial was repeated during the same date in 2016.

2.4. Cultural Practices

The area was harrowed and ridged using tractor. Cowpea variety SAMPEA 7 which is susceptible to *M. vitrata* infestation and widely grown in the ecological zone was planted. Allstar® 40 SD, a seed dressing chemical consisting of 20% Metalaxyl and 20% limidacloprid was used at the rate of one sachet per 4 kg of seeds was used to dress the seeds prior to planting against soil-borne diseases and insect pests [22]. Sowing was varied at three weeks interval. A day prior to sowing, the sub plot was weeded. Three cowpea seeds were sown per hole and later thinned to two seedlings per stand [24]. Single super phosphate fertilizer was applied at the rate of 6.75 g to each plot immediately after sowing. Mancozeb 80% as Z-force (family of ethylene Bisdithiocarbamate) was applied at the rate of 0.891g in 2.5 L water per each plot against fungal diseases when symptoms of diseases were observed. Weeding was carried out at 3 and 6 weeks after sowing (WAS) [25]. Gap filling was done at three weeks after germination to replace dead seedlings [8].

2.5. Treatments Application

Field applications of neem kernels seeds extract and the insecticide was achieved using 2 different 20 litre CP3 Knapsack sprayer. The viral suspension was applied using hand operated manual sprayer. Treatments application commenced at 7 WAS (49 days) which coincided with the period of onset of flowering in the variety (vegetative phase) [23-24]. Foliar spraying was done between 06:00 to 07.00 a.m. each day. All the treatments were sprayed once every week for four weeks according to [24].

2.6. Data Collection

2.6.1. Assessment of M. vitrata Damage in Flowers 24 Hrs Before and After Treatment

Twenty flower buds or flowers depending on the stage of growth were randomly sampled from four plants (five each) between 3rd and 10th stand per plot for assessment of *M. vitrata* population 24 hrs before and after treatment [26]. The flowers were placed in vials containing 30% alcohol to allow dislodgement of larvae and were dissected the following day [27]. The sampled flowers were examined based on damage such as presence of entry/exit holes, presence of dirty frass/excretes or life/dead larvae [28, 29-30]. The flowers were dissected and observed and numbers of larvae found in each flower were counted and recorded.

2.6.2. M. vitrata Pod Damage Assessment 24 Hrs Before and After Treatment

Pod damage assessment was determined through destructive sampling. Twenty pods were randomly examined 10 WAS from five plants from four stands for *M. vitrata* damage per net plot. The pods were placed in large brown (35 x 25 mm) envelops for laboratory assessment of the parameter. Pod damaged were examined based on presence of entry/exit holes, frass deposition as well as presence of life or dead larva. Borer damaged pods were separated from the undamaged ones. The percentage pod damage was expressed as total number of damaged pods divided by the total number of pods harvested multiplied by 100 [28].

Dried pod damage at harvest was assessed by separating the damaged pods due to *Maruca* from that of complex of pod sucking bugs. The bug damage pods were shriveled, twisted, stunted and constricted [8].

2.7. Data Analysis

Data obtained were subjected to analysis of variance (ANOVA). Means with significant differences were separated using LSD at P≤0.05 using [31] statistical package. Prior to analysis, data with zero values were subjected to transformation using √n+0.5.

3. Results

Varying intra-row spacing on post spray percentage flower damage by *M. vitrata* in all the years and the combined except at 10 weeks after sowing (WAS) in 2016. Highly significant (P≤0.01) difference was observed to record lower flower damage in closely spaced cowpea (14-15) (SP1). Although, the effect was statistically similar with cowpea sown at 75 x 30 cm SP2 (15.28). Significantly higher flower damage was obtained in wider spaced cowpea 75 x 40 cm SP3 (20.14) (Table 1). Varying sowing dates on percentage flower damage showed that there was high significant (P≤0.01) difference on mean flower damage among the three sowing dates. Cowpea sown on 2nd July significantly (P≤0.05) recorded the highest damage in all the periods of sampling while cowpea sown on 13th August recorded the least damage in 2015, 2016 and the combined. The highest percentage flower damage was recorded in cowpea sown in 2nd July (25.28) at 8 WAS and 13th August recorded the lowest percentage (5.69) at the same sampling. The effect of NKE, MaviMNPV and Cyper diforce on post spray percentage flower damage was significantly different (P≤0.05) at 8 WAS in 2015. Although, the effectiveness of the treatments were statistically similar and comparable, Cyper diforce was most toxic/potent. The control plots significantly (P≤0.05) recorded the highest flower damage in all the sampling periods. The highest percentage damage in the control plots was obtained at 10 WAS in 2016 (34.26) while the least flower damage (7.96) was recorded in the plot treated with Cyper diforce in the same year (Table 1).

Table 1. *Effect of IPM on post spray cowpea flower damaged by M. vitrata on flowers sampled 8, 9 and 10 WAS.*

Treatments	8 WAS	9 WAS	10 WAS	8 WAS	9 WAS	10 WAS	8 WAS	9 WAS	10 WAS
Intra-row spacing (cm) (SP)	2015			2016			Combined		
SP1: 75 x 20	19.86	15.42	15.83	13.33	20.28	15.14^{b}	16.60	17.85	15.49
SP2: 75 x 30	17.22	16.39	16.11	13.47	18.06	15.28^{b}	15.35	17.22	15.69
SP3: 75 x 40	16.67	14.44	14.58	13.89	16.11	20.14^{a}	15.28	15.28	17.36
Mean	17.92	15.42	15.51	13.56	18.15	16.85	15.74	16.78	16.18
LSD	3.315	2.179	3.610	3.125	5.805	3.598	2.604	3.884	2.414
Sowing dates (SD)									
2nd July	25.28^{a}	25.28^{a}	22.92^{a}	20.00^{a}	19.72^{a}	22.78^{a}	22.64^{a}	22.50^{a}	22.85^{a}
23rd July	22.78^{a}	13.75^{b}	14.31^{b}	13.61^{b}	23.61^{a}	14.17^{b}	18.19^{b}	18.68^{b}	14.24^{b}
13th Aug.	5.69^{b}	7.22^{c}	9.31^{b}	7.08^{c}	11.11^{b}	13.61^{b}	6.39^{c}	9.17^{c}	11.46^{b}
Mean	17.92	15.42	15.51	13.56	18.15	16.85	15.74	16.78	16.18
LSD	3.658	4.189	4.109	4.408	7.484	8.241	2.452	3.536	3.676
Pesticides (P)									
P1: Neem seed kernel extract	16.85	12.78^{a}	15.37^{ab}	10.56^{b}	15.74^{b}	12.04^{b}	13.70^{b}	14.26^{b}	13.06^{b}
P2: MaviMNPV suspension	16.11	15.00^{b}	12.96^{b}	11.30^{b}	16.85^{b}	13.15^{b}	13.70^{b}	15.93^{b}	13.06^{b}
P3: Cyper diforce	19.07	14.63^{b}	15.37^{ab}	8.52^{b}	8.15^{c}	7.96^{c}	13.80^{b}	13.70^{b}	11.67^{b}
P0: Control	19.63	19.26^{a}	18.33^{a}	23.89^{a}	31.85^{a}	34.26^{a}	21.76^{a}	23.24^{a}	26.30^{a}
Mean	17.92	15.42	15.51	13.56	18.15	16.85	15.74	16.79	16.18
LSD	4.206	3.496	3.685	3.747	5.513	3.269	2.784	3.27	2.435
Interactions									
SD x SP	NS	NS	NS	NS	NS	NS	NS	NS	NS
SD x P	**	*	NS	**	NS	**	**	NS	**
SP x P	NS	NS	NS	NS	NS	NS	NS	NS	NS
SD x SP x P	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means with the same letter (s) in the same column are not significantly different using LSD at 5 % level, NS = not significant, * significant at $P \leq 0.05$, ** = highly significant at $P \leq 0.01$, WAS = weeks after sowing, SD = Sowing dates, SP = Intra-row spacing, P = Pesticides.

Highly significant (P≤0.05) difference on percentage cowpea pod damaged by *M. vitrata* was observed among the three sowing dates. Higher damage was recorded in cowpea sown in 2nd July which significantly differs with that sown in 13th August. Cowpea sown on the 2nd July recorded higher pod damage (12.74%) compared with that sown on the 23rd July SD2 (3.64%) and that of 13th August (2.94%) which were statistically similar. The result of the effect of pesticides on percentage cowpea pod damage at 10 WAS varied (Table 2). Statistically similar effects were observed among the pesticides. However, their effectiveness were significantly (P≤0.05) superior than the control which recorded the highest pod damage (39.44%).

The result of the effect of varying sowing dates on percentage cowpea pod damage at harvest (Table 3). Highly significant (*P*≤0.01) difference was observed in varying sowing dates on percentage pod damaged by *M. vitrata* recorded at harvest. Significantly lower pod damage was recorded in cowpea sown on the 13th August during 2016 cropping season and the combine (6.81%). However, high pod damage was obtained in cowpea sown on the 2nd July (10.61%).

High percentage pod damage at harvest was recorded in the control plots in all the years and the combined (13.08). The effectiveness of the pesticides was however statistically similar except during 2015 cropping season. Plots treated with Cyperdiforce recorded lower percentage pod damage (5.07) compared with NKE (10.42) and MaviMNPV (7.57) plots. The performance of MaviMNPV was comparable to Cyperdiforce in all the years and the combined.

Table 2. *Effect of intra-row spacings, sowing dates and pesticides on percentage cowpea pod damage by M. vitratasampled 10 WAS during 2015 and 2016 cropping seasons.*

Treatments	2015	2016	Combined
Intra-row spacings (cm) (SP)			
SP1: 75 x 20	10.58	25.83	5.79
SP2: 75 x 30	12.67	24.17	6.83
SP3: 75 x 40	12.39	25.00	6.69
Mean	11.88	25.00	6.44
LSD	3.159	4.759	1.496
Sowing dates (SD)			
2nd July	24.47^{a}	30.14^{a}	12.74^{a}
23rd July	6.28^{b}	30.83^{a}	3.64^{b}
13th Aug.	4.89^{b}	14.03^{b}	2.94^{b}
Mean	11.88	25.00	6.44
LSD	3.752	8.819	2.031

Treatments	2015	2016	Combined
Pesticides (P)			
P1; Neem seeds kernels extract	11.97[ab]	20.74[b]	6.46
P2: MaviMNPV suspension	10.26[b]	20.37[b]	5.63
P3: Cyper diforce	11.37[ab]	19.44[b]	6.19
P0: Control	13.37[a]	39.44[a]	7.48
Mean	11.88	25.00	6.44
LSD	3.331	5.503	1.647
Interactions			
SD x SP	NS	NS	NS
SD x P	NS	NS	NS
SP x P	NS	NS	NS
SD x SP x P	NS	NS	NS

Means with the same letter (s) in the same column are not significantly different using LSD at 5% level, NS-not significant, SD - Sowing dates, SP -Intra-row spacings, P-Pesticides.

Table 3. *Effect of intra-row spacings, sowing dates and pesticides on percentage cowpea pods damage by M. vitrata at harvest during 2015 and 2016 cropping season.*

Treatments	2015	2016	Combined
Intra-row spacing (cm) (SP)			
SP1: 75 x 20	9.04	8.80	8.92
SP2: 75 x 30	8.88	7.74	8.31
SP3: 75 x 40	9.29	9.25	9.27
Mean	9.07	8.59	8.83
LSD	1.970	2.698	1.582
Sowing dates (SD)			
2nd July	10.76	12.85[a]	10.61[a]
23rd July	8.38	7.38[ab]	9.07[ab]
14th Aug.	8.07	5.55[b]	6.81[b]
Mean	9.07	8.59	8.83
LSD	4.831	6.109	3.141
Pesticides (P)			
P1: Neem seeds kernels extract	10.42[b]	7.32[b]	8.87[b]
P2: MaviMNPV suspension	7.57[c]	5.80[b]	6.69[b]
P3: Cyper diforce	5.07[c]	8.31[b]	6.69[b]
P0: Control	13.23[a]	12.94[a]	13.08[a]
Mean	9.07	8.59	8.83
LSD	2.516	3.756	2.235
Interactions			
SD x SP	NS	NS	NS
SD x P	NS	NS	NS
SP x P	NS	NS	NS
SD x SP x P	NS	NS	NS

Means with the same letter (s) in the same column are not significantly different using LSD at 5% level, NS-not significant, SD - Sowing dates, SP -Intra-row spacing, P-Pesticides.

4. Discussions

Result from this study shows that varying intra-row spacing in the study area did not show any significant effect on percentage flower damage. However, lower percentage damage was obtained in cowpea spaced 75 x 30 cm. Similar reports on the non significant effect of plant spacing on the number the insect pests as well as pod damage abounds in literature [32]. The findings of this study is also similar to the results obtained by [33] in a trial conducted in Kano which showed that spacing had no significant effect (P>0.05) on population of insect pests on cowpea.

There were significant differences in the percentage flower damage among the three sowing dates. The last sowing recorded reduction in flower damage by *M. vitrata*could be due to the variation in the sowing dates. The flowering and podding stages of cowpea sown on 2nd July occurred in the 3rd week of August. The period is associated with high rainfall and humidity favoured by peak period of high densities of *M. vitrata*.

The result of this study on the effect of pesticides indicated that plots sprayed with NKE, MaviMNPV and Cyperdiforce recorded reduction in the percentage flower damage as compared to the control plots. Although, there was no significant difference between the treatments, NKE performed better although statistically similar with Cyperdiforce in reducing flower damage 24 after treatments. This implies that all the tested products are effective means of reducing *M. vitrata* population and damage on cowpea. Though NKE and the control plots did not differ significantly in all the periods of sampling, NKE reduced flower damage better than the control. This finding is similar to the observations of [43] who reported that crude extract of neem applied on bean plants resulted in significant reduction in flower damage when compared to the controls. Furthermore, the significant performance of neem relative to the control in suppressing pest populations confirms the earlier work conducted by [35] and [36] who reported insecticidal activities of plant extracts in suppressing populations of various insect pests of cowpea (*M. vitrata* inclusive) when compared with the control. The potency of NKE seen in this study could be attributed to the reported presence of active ingredients that are insecticidal to cowpea pests. [37] (in press) identified active ingredients in neem that are responsible for insect repellent, insect growth regulation, anti-feeding, oviposition deterrence, sterility, and some residual insecticidal properties on different species of insect pests to be Azadirachtin, nimbin, salanin and meliantriol. Same compounds are also assumed to be present which produces insecticidal effects on *M. vitrata*in this particular study.

Furthermore, Cyperdiforce was found to be more effective. The potentials of using neem extract in pest control is still highly plausible, although it is not as effective as Cyperdiforce. Such potentials have been elaborated by several authors who reported the potentials of using neem extract as pesticides [38, 39 and 40]. Cyperdiforce still performed better than MaviMNPV but was statistically at par with NKE. This also revealed the potentials of using NKE as an alternative to Cyperdiforce (synthetic insecticide) in pest control. Similar control can be achieved with NKE considering the hazards posed by synthetic insecticide on the environment, the applicator, beneficial insects, non target organisms and high cost of purchase especially to the low income farmers [9].

Varying intra-row spacing did not have any effect on percentage cowpea pod damage sampled 10 WAS. This finding is in agreement with the report of [32] who reported non-significant difference of the effect of varying plant spacing on cowpea pod damage by insect pests in Abeokuta. This is also similar to the observations of [33] who reported that cowpea pod damage was not significant ($P \geq 0.05$) when the plant spacing (intra-row) was varied in Kano.

The result of this study showed that cowpea sown on the 2nd July recorded the highest pod damage by *M. vitrata*sampled 10 WAS ($P \leq 0.01$). Lower pod damage was recorded in cowpea sown on 13th August than that sown on 23rd July. The reasons for this could be that early sown cowpea flowering and pod formation stages coincided with the period of high population densities of *M. vitrata* as such were heavily attacked. This is similar to the observations of that reported flowering and pod formation of cowpea planted in July and August coincided with peak period of high population densities of post-flowering pests causing much loss in cowpea productivity.

Even though MaviMNPV and NKE reduced cowpea pod damage, Cyperdiforce was superior. However, there was no significant difference among the treatments, the control plots recorded the highest pod damage. This finding agreed with the observations of [41] who observed damage to cowpea pods significantly ($P \leq 0.05$) reduced in a synthetic insecticide (mixture of cypermethrin and dimethoate) sprayed plots in the Delmarva (Delaware, Maryland and Virginia) peninsula region of the United States. The performance of MaviMNPV compared with Cyperdiforce showed that the viral suspension is a potential biopesticide which could be use as an alternative to synthetic insecticide. However, using the viral suspension alone did not offer effective control in this study. However, its potency could be improved when used in combination with another control agent [42]. This is in line with the view of [43] who reported combination of azadirachtin and nucleopolyhedrovirus (0.25 ppm + $1x10^3$ OB and 0.5 ppm + $1x10^6$ OB) to have resulted in significantly causing higher larval mortality in *Spodoptera litura* than treatment with either the virus or botanical insecticide alone.

Varying intra-row spacing did not showed significant effect on dry pod damage. However, high plant density (close spacing) favoured high dried pod damage compared to less plant density. This is because cross infestation of *M. vitrata* is facilitated when canopies interlock with one another as reported by [13].

The effect of varying sowing dates in reducing dried cowpea pod damage by cowpea pod-borer showed that delay in cowpea sowing to 23rd July and 13th August although not significantly different but reduced dried pod damage. This showed that podding stages of cowpea sown on 2nd July coincided with the peak population densities of *M. vitrata*. This finding disagreed with the report of [12] that elite cowpea cultivar when planted in June or early July in Kano area, their flowering and podding stages escaped the peak population densities of the three major post-flowering pests which occur from mid-September through to November.

There was no significant difference among NKE, MaviMNPV and Cyperdiforce on dried cowpea pod damage at harvest. Cyperdiforce recorded the least damage while the control recorded the highest pod damage. This finding is consistent with the results obtained by [24] who reported least cowpea pod damage in Uppercott sprayed plots which was closely followed by mixtures of cashew nut shell + West African black pepper thereby reducing pod damage at 10 WAS. The control recorded the highest ($P<0.05$) pod damage.

5. Conclusion

The result of this study clearly showed that the performance of *Maruca vitrata* Multi-nucleopolyhedrosis virus (MaviMNPV) suspension as a promising control agent against cowpea pod borer. Its performance was comparable with the Cyber diforce (synthetic insecticide). Further research can be undertaken using the viral suspension alone or in combination with another control agent such as Jatropa or neem seed oil in synegy in the study area or somewhere else.

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