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REGULAR ARTICLE

Maruca vitrata (Fabricius) [Lepidoptera: Pyralidae] larval population dynamics as affected by intra-row spacing, sowing dates and biopesticides on cowpea

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Abstract

The objective of the research was to test the effect of sowing dates, intra-row spacing and biopesticides on the larval population dynamics of *M. vitrata* in Samaru, Nigeria. The experiment was laid out with biopesticides (B0; control, B1; Neem seeds kernel extract (NKE), B2; *Maruca vitrata* Multi-nucleopolyhedrosis virus (MaviMNPV) suspension and B3; Cyper diforce (30 g cypermethrin + 250 g dimethoate). The result at 10 WAS showed that varying sowing dates to SD3 significantly (*P*=.01) reduced mean population of *M. vitrata* larva in sampled flowers in all the years and the combine. MaviMNPV was effective in reducing pod borer populations (7.22, 6.11 and 6.67) better than NKE (10.19, 5.74 and 7.96) and Cyper diforce (7.41, 8.89 and 8.15). The control significantly recorded the highest mean (11.67, 12.59 and 12.13) population in all the years and the combined. Similarly, varying sowing dates to SD3 significantly reduced mean population (5.56, 5.00 and 5.28) of *M. vitrata* in cowpea pods sampled 10 WAS better than SD1 and SD2. Statistically similar effect of biopesticides was observed on mean population of *M. vitrata*, however, the control recorded the highest mean (22.59 and 13.89) in 2015 cropping season and the combined. High cowpea grain yield was obtained in SD2 (337.85, 689.10 and 800.66 kg ha^{-1}) even though statistically similar with SD3 (244.89, 618.10 and 639.68 kg ha^{-1}). Cyper diforce treated plots gave the highest yield of 394.56, 887.69 and 976.51 kg ha^{-1} during 2015 and 2016 cropping seasons and combine but was statistically at far (*P*=.01) with NKE and MaviMNPV. The interaction of SD2 and Cyper diforce gave the highest grain yield. The effect of sowing at SD2 and insecticide spray will give a better control of *M. vitrata* for an increased yield of cowpea in the study area.

Key words: Sowing dates; intra-row spacing; biopesticides; damage; *Maruca vitrata*

Introduction

Cowpea (*Vigna unguiculata* L. Walp.), is one among the leguminous plants in the family Fabacea. It is one of the ancient crops known to man. Cowpea is one of the most important crops in Africa cultivated by small scale farmers as a subsistence crop (Abdullahi and Ibrahim, 2014). The crop originated from Africa and spread through Egypt and domesticated in parts of Southern, Eastern and Western Africa where a large number of

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primitive cultivars and semi wild forms were found (Kwaifa et al., 2012). According to AATF (2011) it is considered as a significant legume for cultivation in arid regions in tropical Africa. When compared to cereas grains, it contains good amount of protein and energy and can be used as a forage also (Aliyu et al., 2007). Cowpea is rich source of protein and carbohydrates together with other mineral constituents (AATF, 2011). The crop suffers much attack from insect pests at various stages of growth. The legume pod-borer, *Maruca vitrata* is one of the most important pests of grain legume throughout the tropics and sub-tropics of Central and South America, Asia and Africa (Agunbiade et al., 2012). Singh and Jackai, (1988) identified the borer among the three important grain legume pests as most important. The production of cowpea has continued to decline due to activities of wide spectra of insect pests, notably damage caused by *M. vitrata*. According to AATF (2011) and Agunbiade et al. (2012) *M. vitrata* is causing significant loss to cowpea on field.

The use of synthetic chemicals in the management of post-flowering insect pests including *M. vitrata* at 10 days interval give effective control of pod-borer (Sharma, 1998). However, excessive use of these chemicals has some associated problems often leading to general environmental contamination, elimination of economically beneficial insects as well as development of resistance by the pest (Immaraju et al., 1992) and expensive for small scale farmers as well as highly toxic to humans and animals (Sharma, 1998; Asante et al., 2001). Farmers who have adopted control through chemical sprays are exposed to serious health hazards (Damalas & Eleftherohorinos, 2011). Control of this pest is therefore crucial for sustainable production of cowpea. As such, search for viable and environmental friendly control measure within the reach of economic resource-poor farmers is necessary in order to reduce losses suffered by cowpea farmers. This study is therefore designed to integrate varying intra-row spacings, sowing dates, and biopesticides to manage the population dynamics of *M. vitrata* in Samaru, Nigeria, thereby reducing economic damage.

Materials and method

Study area

A field trial was carried out in Samaru during the rainy seasons of 2015 and 2016 at Teaching and Research Farm, Institute for Agricultural Research, Ahmadu Bello University (IAR/ABU), Zaria. The area lies between Latitudes 11° 10' N and Longitudes 07° 38' E, 686 meters above sea level (Eneh and Ati, 2010). The area falls within northern Guinea savanna ecological zone.

Cultural practices

The area was ploughed, harrowed and ridged using tractor. Cowpea variety SAMPEA 7 a susceptible to *M. vitrata* infestation variety was used. Allstar® 40 SD a seed dressing chemical at the rate of one sachet per 4 kg of seeds was used to dress the seeds prior to planting (Oparaeke et al., 2005). Three cowpea seeds were sown per hole and later thinned to two seedlings per stand (Komolafe *et al.*, 1985). Single Super Phosphate fertilizer was applied at the rate of 25 kg P_2O_5 a.i. ha^{-1}. Weeding was carried out at 3 and 6 weeks after sowing (WAS).

Sources and preparation of plant materials

Neem kernels extract (B1)

Matured neem seeds were collected after rainfall in neem tree forest reserve outskirts. The fruits were de-pulped, washed in a bucket containing clean water and dried under the shade. The seeds were cracked and the kernels removed and ground into powder using an electric kitchen blender. About 5 kg ha^{-1} of kernels powder together with 2 kg ha^{-1} washing soap (emulsifier) were wrapped in a clean white cloth and soaked overnight in a bucket containing 100 litre ha^{-1} of water (Neem Foundation, 2005). The mixture was stirred thoroughly and was squeezed until milky suspension was produced (Oparaeke et al., 2005 and Oparaeke, 2006). Gum arabic was added at the rate of 2.7 kg in 6.75 litres of water ha^{-1} as sticker (Kwaifa *et al.*, 2012). This forms the crude extract.

Maruca vitrata multi-nucleopolyhedrosis virus (MaviMNPV) suspension (B2)

Maruca vitrata Multi-nucleopolyhedrosis virus (MaviMNPV) suspension was obtained from the International Institute for Tropical Agriculture (IITA), Cotonou, Benin Republic. The viral suspension was applied at the rate of 106 mls + 115 litre water per hectare.

Laboratory preparation of MaviMNPV was done according to Sokame *et al.* (2015).

Cyper diforce (B3)

A systemic, contact and stomach poison insecticide composed of 30 g L-1 cypermethrin and 250 g L-1 Dimethoate EC The insecticide was applied at the rate of 1.5 L ha-1 (Asante *et al.*, 2001).

Experimental design

The experiment was carried out during the rainy seasons of 2015 and 2016. Split split plot design with factorial combination of intra-row spacing SP1; 75 x 20, SP2; 75 x 30 and SP3; 75 x 40 cms allocated to the main plot, sowing dates SD1; 21/07/2015, SD2; 11/08/2015, SD3; 01/09/2015 allocated to the sub plot and biopesticides consisting of neem kernels seeds extract (NKE) (B1), MaviMNPV suspension (B2) and Cyper diforce (B3) and control (B0) were allocated to the sub-sub-plot. The treatments were randomized and replicated three times. The trial was repeated in 2016. Each plot consisted of six (6) ridges of 6 m long and 4.5 m wide. The ridges were separated by 0.75 m apart. The two middle rows constituted the net plot (Kwaifa *et al.*, 2012). The blocks were separated by a space of 2 m while 1 m was left between plots. A distance of 1 m was also left between main plots.

Treatments application

Field applications of neem kernel seeds extract and the insecticide was achieved using 2 different CP3 Knapsack sprayers. The viral suspension was applied using hand operated manual sprayer. Treatments application commenced at 7 weeks after sowing (WAS) at 06:00-07.00 hrs once every week for four weeks.

Data collection

Assessment of *M. vitrta* larval populations in flowers

Twenty flowers or flower buds depending on the stage of growth were randomly sampled from four stands per plot for assessment of *M. vitrta* population 24 hrs after treatment. The flowers were placed in vials containing 30% alcohol to allow dislodgement of larvae and were dissected the following day (Amatobi, 1994). The sampled flowers were assessed based on damage characteristics such as presence of entry/exit holes, dirty frass/excretes and presence of life/dead larvae (Abdullahi, 2013, Asiwe *et al.*, 2005; Oghiakhe *et al.*, 1991). Number of larvae found in each flower were counted and recorded after dissection.

***M. vitrta* pod damage assessment**

Pod damage was achieved through destructive sampling. Twenty pods were examined for *M. vitrata* damage by randomly sampling five pods per plant per net plot. The pods were placed in large envelops for laboratory assessment. Pod damaged were assessed based on presence of entry/exit holes, frass deposition and well as presence of life or dead larva. Borer damaged pods were separated from the undamaged. Percentage damage was expressed as total number of damaged pods divided by the total number of pods sampled multiplied by 100 (Oghiakhe *et al.*, 1991). Dried pod damage at harvest was assessed by separating the pods based due to *Maruca* from total pods harvested per plot (Ogah, 2013).

Assessment of yield

Harvesting of dried cowpea pods was carried out when about 75 % of the pods in the net plot dried. Subsequently, harvesting was carried out until all the pods were fully harvested. Plot yields were placed in large envelops/polythene bags and adequately labelled labelled. Pod borer damaged pods were separated, counted. Post harvest operations on the yield were carried out separately for each plot and grains measured using an Electronic Compact Scale, ATOM (A-110 model). Yield per plot was extrapolated to kg ha^{-1} (Ahmed *et al.*, 2007, 2009).

RESULTS

Effect of intra-row spacing, sowing dates and biopesticides on mean population of *M. vitrata* in flowers sampled during 2015 and 2016 cropping seasons

The result in Table 1 showed that varying sowing dates in Samaru was observed to significantly affect *M. vitrata* populations in flowers. The result showed that delay in sowing to (SD3) significantly ($P \leq 0.01$) recorded the least pod borer populations in all the sampling periods. There was no significant difference on mean population of *M. vitrata* between SD1 and SD2, however higher *M. vitrata* populations were recorded in SD2 in all the sampling periods except at 10 WAS in 2016. The result of the combined showed that varying sowing date to SD3 consistently recorded less pod borer populations compared to SD1 and SD2 which were statistically similar except at 8 WAS. SD2 (25.21) significantly recorded higher *M. vitrata* populations better than SD1 (14.03). Varying intra row spacing does not have any effect on *M. vitrata* population in all the sampling period in 2015, 2016 and the combined (Table 1) except at 9 WAS during 2015 cropping season. Close spacing significantly ($P \leq 0.01$) recorded the lowest mean pod borer population (11.11) better than SD1 (15.83) and SD3 (16.94) which were statistically similar during 2015 cropping season. The effect of biopesticides in Samaru showed highly significant ($P \leq 0.01$) difference in all the sampling periods in 2015, 2016 and the combined (Table 1). In 2015, there was no significant difference among the treatments but MaviMNPV was effective in reducing pod borer populations better than NKE and Cyper diforce except at 9 WAS in 2015. Similarly, the same result was obtained in 2016 and the combine. The effectiveness of the treatments was comparable to one another but, MaviMNPV was most effective. The control recorded significantly highest mean population of *M. vitrata*.

Interaction effect was observed between intra row spacing and biopesticides at 10 WAS during 2015 cropping season. Early sowing was observed to significantly differ ($P \leq 0.01$) among the treatments in the three sowing dates. The least effect on mean population of *M. vitrata* was obtained by interaction of MaviMNPV and SP2 (5.56) but was statistically similar to SD2 except in the control plots. Statistically similar interaction was observed among Cyper diforce, MaviMNPV and NKE. However, lower mean populations were obtained in MaviMNPV treated plots. All the treatments were significantly better than the control in reducing mean pod borer population (Figure 1). Highest interaction effect was by MaviMNPV at SD2 (5.56) and the lowest effect was observed by control at SD2 (11.67) but statistically similar with SD1 (11.67). There was high significant interaction between sowing dates and biopesticides at 10 WAS during 2016 cropping season. Late sowing (SD3) and application of biopesticides even though statistically similar with the control but resulted in significantly lower mean population of *M. vitrata* in flowers than SD2 and SD1. Similarly, there was high interaction among the biopesticides compared with the control, even though statistically similar interaction occurred among the treatments in all the three sowing dates except at SD3 in which Cyper diforce differed significantly. The highest interaction occurred between MaviMNPV and SD3 (5.00) while the least effect was between SD2 and control (16.67). The result is presented in Figure 2. The result of the combined interaction of sowing dates and biopesticides at 10 WAS on post spray *M. vitrata* population in flowers is presented in Figure 3. Combine interaction occurred among the biopesticides in late sowing SD3 which significantly ($P \leq .01$) recorded the lowest pod borer population. However, their effects were statistically similar with the control. Similarly, high significant interaction occurred among the treatments in the sowing dates with the exception of SD3. Higher *M. vitrata* populations were observed in the control in all the sowing dates. The lowest effect was by control at SD2 (16.11) and the highest effect was by MaviMNPV at SD3 (5.00). The combine interaction effect between intra row spacing and biopesticides at 10 WAS during 2015 and 2016 cropping seasons is presented in Figure 4. There was significant ($P \leq 0.05$) interaction effect on the application of biopesticides on post spray mean population of *M. vitrata* compared with the control in all the sowing dates except at SD1. Even though, the effectiveness of the treatments was statistically similar. The highest interaction effect was between MaviMNPV at SD2 which recorded the least population (5.83) while the lowest interaction effect was observed by the control at the same sowing date (SD2) (12.78).

Table 1. Effect of intra row spacing, sowing dates and biopesticides on post spray population of *Maruca vitrata* in 20 Flowers Sampled 8, 9 and 10 WAS in Samaru during 2015 and 2016 cropping seasons.

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	
S1: 75 x 20	14.03	11.11ᵇ	8.89	15.14	11.53	7.22	14.58	11.32	8.06
S2: 75 x 30	14.17	15.83ᵃ	9.31	14.44	11.25	9.31	14.31	13.54	9.31
S3: 75 x 40	18.61	16.94ᵃ	9.17	16.39	10.28	8.47	17.50	13.61	8.82
Mean	15.60	14.63	9.12	15.32	11.02	8.33	15.46	12.82	8.73
SE (±)	0.148	1.390	0.854	2.432	1.348	0.701	2.145	1.437	0.585
LSD	5.212	4.283	2.632	7.492	4.153	2.161	4.323	2.826	1.613
Sowing dates (SD)									
SD1	16.67ᵃ	17.78ᵃ	9.44ᵃ	11.39ᵇ	11.53ᵃᵇ	10.42ᵃ	14.03ᵇ	14.65ᵃ	9.93ᵃ
SD2	21.39ᵃ	18.61ᵃ	12.50ᵃ	29.03ᵃ	15.83ᵃ	9.58ᵃ	25.21ᵃ	17.22ᵃ	11.04ᵃ
SD3	8.75ᵇ	7.50ᵇ	5.42ᵇ	5.56ᶜ	5.69ᵇ	5.00ᵇ	7.15ᶜ	6.60ᵇ	5.21ᵇ
Mean	15.60	14.63	9.12	15.32	11.02	8.33	15.46	12.82	8.73
SE (±)	3.572	2.078	1.181	1.48	2.180	0.493	1.481	0.968	0.553
LSD	14.024	8.159	4.638	5.818	8.559	1.725	6.758	4.527	1.843
Biopesticides (B)									
B1: Neem kernel extract	14.74ᵇ	15.19ᵇ	10.19ᵃ	10.37ᵇ	9.07ᵇ	5.74ᶜ	12.56ᵇ	12.13ᵇ	7.96ᵇ
B2: MaviMNPV suspension	11.04ᵇ	11.85ᵇᶜ	7.22ᵇ	11.85ᵇ	8.52ᵇ	6.11ᶜ	11.44ᵇ	10.19ᵇ	6.67ᵇ
B3: Cyper diforce	13.15ᵇ	10.74ᶜ	7.41ᵇ	12.22ᵇ	8.33ᵇ	8.89ᵇ	12.69ᵇ	9.96ᵇ	8.15ᵇ
B0: Control	23.48ᵃ	20.74ᵃ	11.67ᵃ	26.85ᵃ	18.15ᵃ	12.59ᵃ	25.17ᵃ	19.44ᵃ	12.13ᵃ
Mean	15.60	14.63	9.12	15.32	11.02	8.33	15.46	12.82	8.73
SE (±)	1.607	1.405	0.816	1.622	1.542	0.644	1.142	1.043	0.520
LSD	4.555	3.984	2.314	4.600	4.372	1.825	3.200	2.924	1.457
Interactions									
SD x SP	NS	**	NS	NS	NS	NS	NS	NS	NS
SD x B	*	NS	NS	**	NS	**	**	NS	**
SP x B	NS	NS	*	NS	NS	NS	NS	NS	NS
SD x SP x B	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 $P \leq 0.05$, ** Significant at $P \leq 0.01$, WAS = weeks after sowing, SD = Sowing dates, SP = Intra row spacing, B = Biopesticides, SD1: 21/07/2015 and 21/07/2016, SD2: 11/08/2015 and 11/08/2016, SD3 01/09/2015 and 01/09/2016.

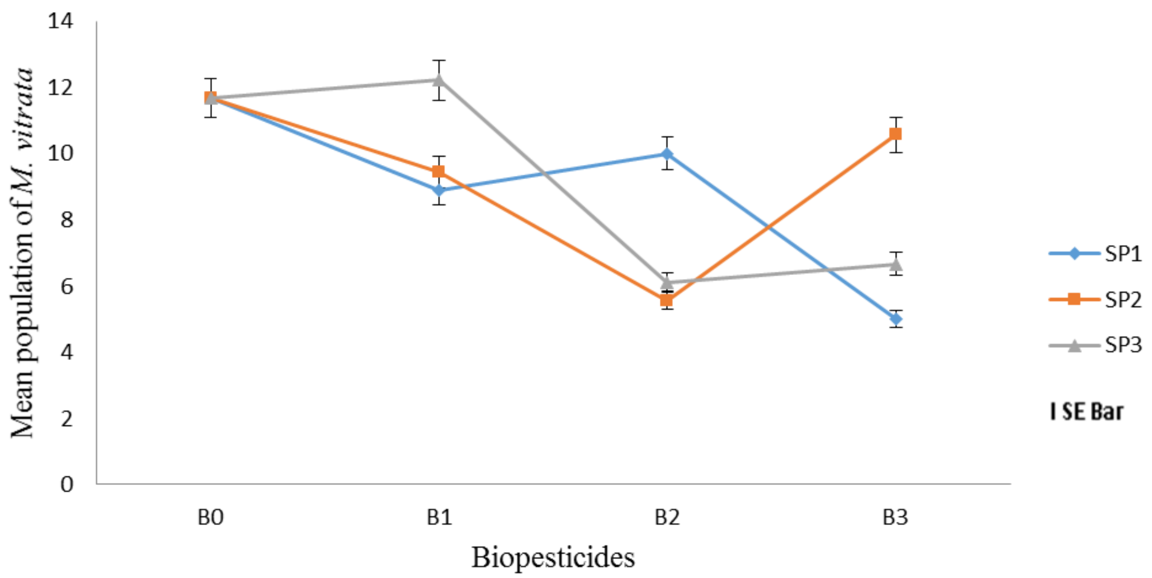

Fig. 1. Interaction effect of sowing dates and biopesticides on post spray population of *M. vitrata* 10 WAS in Samaru during 2015 cropping season
Key: SD = Sowing dates, SD1; 23/07/2015, SD2; 11/08/2015, SD3; 01/09/2015, B = Biopesticides, B0; control, B1; Neem seeds kernel extract (NKE), B2; MaviMNPV suspension, B3; Cyper diforce

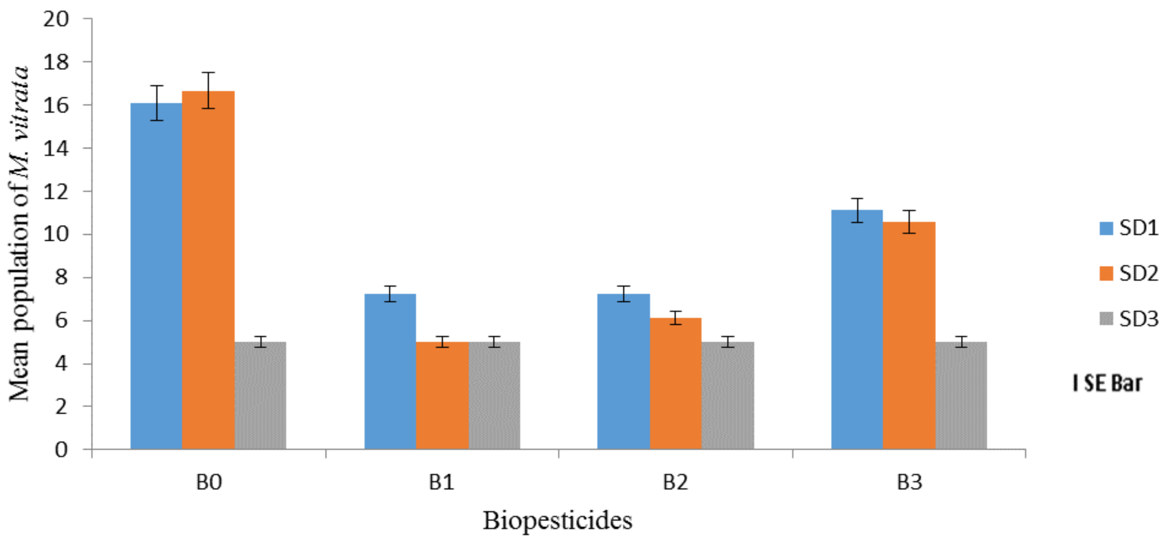

Fig. 2. Interaction effect of sowing dates and biopesticides on post spray population of *M. vitrata* 10 WAS in Samaru during 2016 cropping season
Key: SD = Sowing dates, SD1; 23/07/2016, SD2; 11/08/2016, SD3; 01/09/2016, B = Biopesticides, B0; control, B1; Neem seeds kernel extract (NKE), B2; MaviMNPV suspension, B3; Cyper diforce

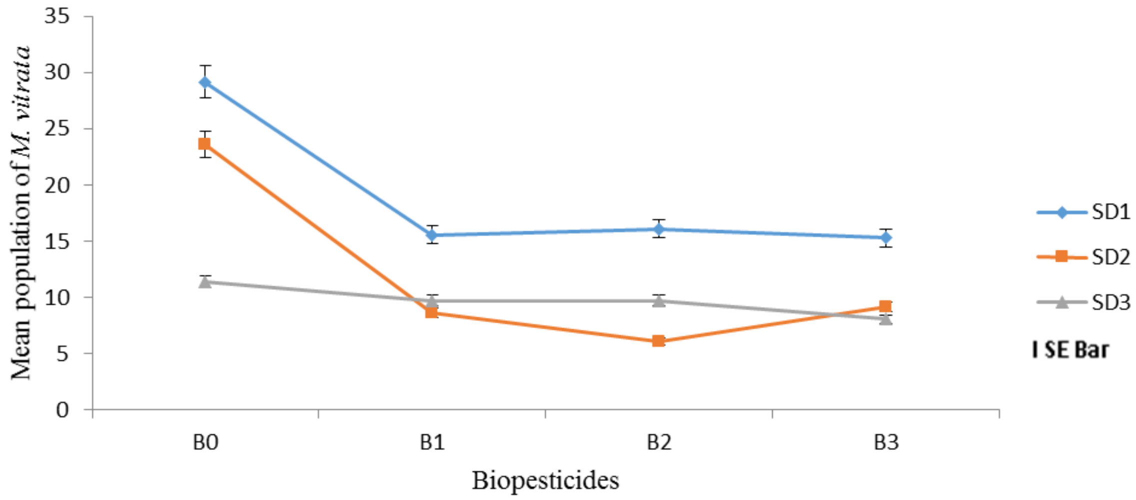

Fig. 3. Combine interaction between sowing dates and biopesticides on post spray population of *M. vitrata* 10 WAS in Samaru during 2015 and 2016 cropping seasons
Key: SD = Sowing dates, B = Biopesticides, B0; control, B1; Neem seeds kernel extract (NKE), B2; MaviMNPV suspension, B3; Cyper diforce, SD1: 21/07/2015 and 21/07/2016, SD2: 11/08/2015 and 11/08/2016, SD3 01/09/2015 and 01/09/2016

Effect of intra-row spacing, sowing dates and biopesticides on mean population of *M. vitrata* in Cowpea pods 10 WAS

Varying sowing date to SD3 was observed to significantly ($P\leq$ 0.01) reduce lower mean population of *M. vitrata* in all the years and the combined (5.28). Significantly higher means were obtained in SD1 during 2015 (24.72) and the combined (14.93). The result is presented in Table 2. The effect of varying intra row spacing differed significantly ($P\leq$ 0.05) during 2015 and the combined. Although, a statistically similar result was obtained between SP1 and SP2, higher mean populations were obtained in SP1 (15.00). Wider spacing (SP3) were observed to record lower means significantly in 2015 (11.81) and the combined (8.40). The result is shown in Table 2. Cyper diforce was more effective in reducing post spray mean *M. vitrata* population (7.50) in cowpea sampled 10 WAS during 2015 cropping season and the combined. However, its effectiveness was statistically similar with MaviMNPV and NKE. The control significantly recorded the highest mean *M. vitrata* population in both 2015 (22.59) and the combined (13.89). The result is presented in Table 2.

The result of the interaction of sowing dates and intra row spacing in sampled cowpea pods at 10 WAS during 2015 cropping season is presented in Figure 5. Varying sowing dates significantly ($P \leq 0.01$) reduced *M. vitrata* populations in all the intra row spacings. However, there was no significant difference between SD2 and SD3 on the same parameter. Similarly, varying intra row spacing resulted in statistically similar interaction effects in all the sowing dates except at SD1. Highest interaction effect was obtained in SP1 at SD3 (5.00) and the lowest effect was between the same intra row spacing at SD1 (28.33). The result of the combined interaction of sowing dates and biopesticides on *M. vitrata* population in cowpea sampled 10 WAS is presented in Figure 6. Varying sowing dates from SD1 to SD3 significantly ($P \leq 0.01$) reduced *M. vitrata* populations in sampled cowpea in all the biopesticides treated plots. The least population was observed in SD3. Similarly, statistically similar effects were observed among the biopesticides in all the sowing dates including the control except at SD1. The lowest interaction effect was observed by the control at SD1 (26.67) while the highest effect was obtained by MaviMNPV at SD3 (5.00) although statistically similar with NKE (5.00) and Cyper diforce (5.00). The interaction of intra row spacing and biopesticides showed that the biopesticides treated plots significantly reduced *M. vitrata* populations compared with the controls. However, the effectiveness of MaviMNPV was comparable to Cyper diforce in SP1. The highest interaction effect was observed by the interaction of Cyper diforce at SP3 (6.67) and the lowest effect was between the control at SP2 (14.72). The result is presented in Figure 7.

Table 2. Effect of Intra row Spacing, Sowing Dates and Biopesticides on Mean Population of *M. vitrata* in Cowpea Pods Sampled 10 WAS during 2015 and 2016 Cropping Seasons in Samaru.

Treatments	2015	2016	Combined
Intra row spacing (cm) (SP)			
SP1: 75 x 20	15.00^{a}	5.00	10.00^{a}
SP2: 75 x 30	14.31^{a}	5.28	9.79^{a}
SP3: 75 x 40	11.81^{b}	5.00	8.40^{b}
Mean	13.70	5.09	9.40
LSD	1.824	0.349	2.189
Sowing dates (SD)			
SD1	24.72^{a}	5.14	14.93^{a}
SD2	10.83^{b}	5.14	7.99^{b}
SD3	5.56^{c}	5.00	5.28^{c}
Mean	13.70	5.09	9.40
LSD	4.306	0.315	1.666
Biopesticides (B)			
B1: Neem kernel extract	12.04^{b}	5.00	8.52^{b}
B2: MaviMNPV suspension	10.37^{b}	5.00	7.69^{b}
B3: Cyper diforce	9.82^{b}	5.19	7.50^{b}
B0: Control	22.59^{a}	5.19	13.89^{a}
Mean	13.70	5.09	9.40
LSD	2.608	0.371	1.743
Interactions			
SD x SP	NS	NS	NS
SDx B	*	NS	*
SP x B	NS	NS	NS
SD x SP x B	NS	NS	NS

Means with the same letter(s) within the same column are not significantly different using LSD at 5 % level, NS = Not significant, * = Significant at $P \leq 0.05$, ** = Significant at $P \leq 0.01$, SD = Sowing dates, SP = Intra row spacing, B = Biopesticides, SD1: 21/07/2015 and 21/07/2016, SD2: 11/08/2015 and 11/08/2016, SD3 01/09/2015 and 01/09/2016

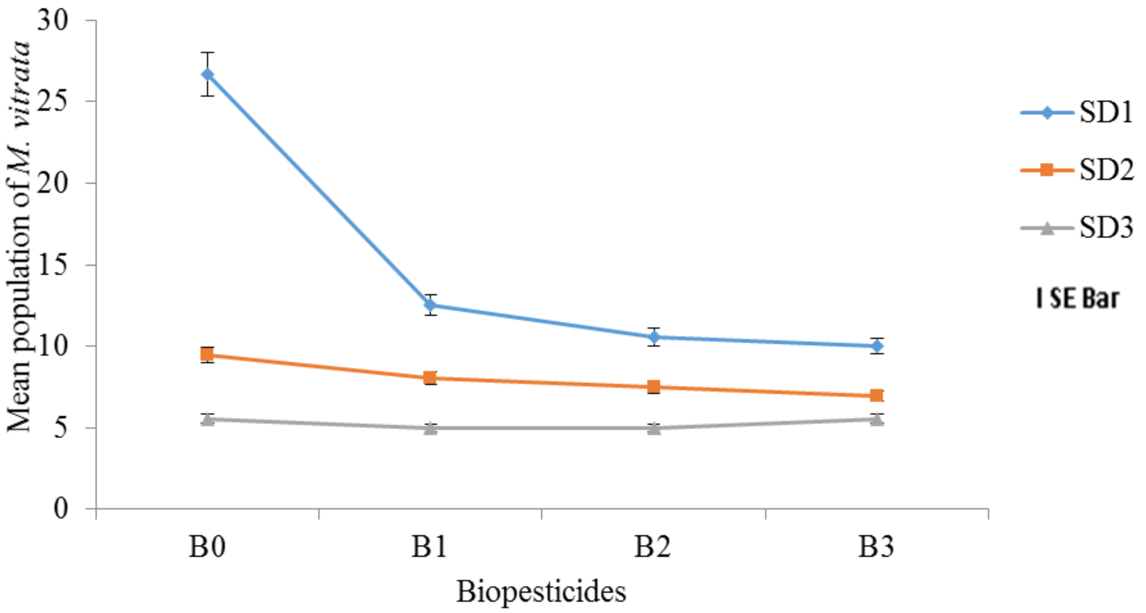

Fig. 4. Combine interaction between sowing dates and biopesticides on post spray population of *M. vitrata* in cowpea sampled 10 WAS in Samaru during 2015 and 2016 cropping seasons
Key: SD ≤ Sowing dates, B ≤ Biopesticides, B0; control, B1; Neem seeds kernel extract (NKE), B2; MaviMNPV suspension, B3; Cyper diforce, SD1: 21/07/2015, SD2: 11/08/2015, SD3 01/09/2015

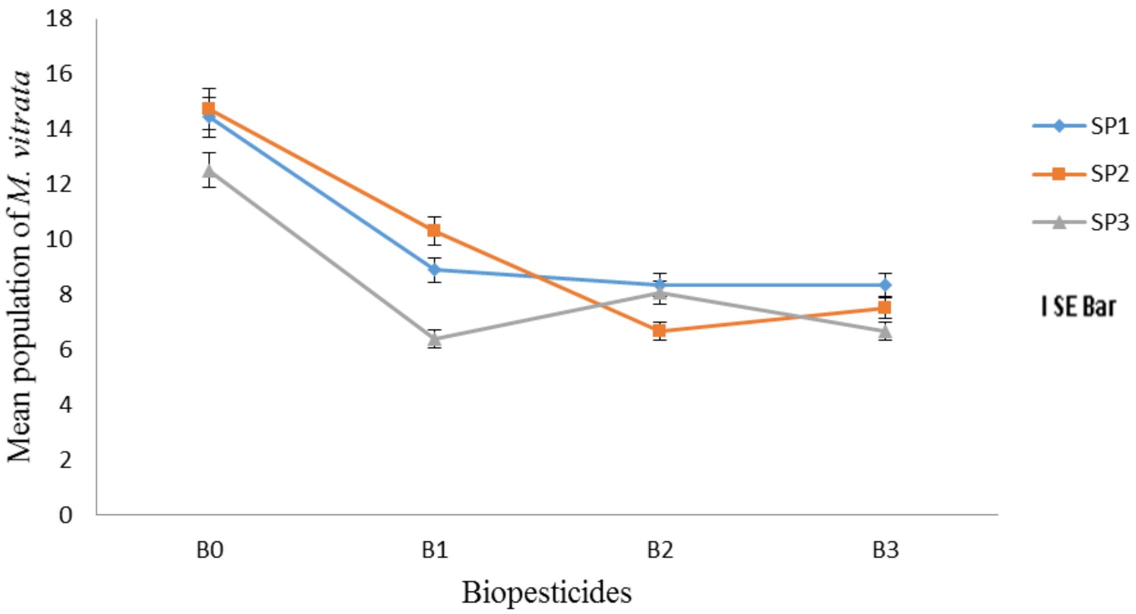

Fig. 5. Combine interaction between intra row spacing and biopesticides on post spray population of *M. vitrata* in cowpea sampled 10 WAS in Samaru during 2015 and 2016 cropping seasons, SD1: 21/07/2015 and 21/07/2016, SD2: 11/08/2015 and 11/08/2016, SD3 01/09/2015 and 01/09/2016
Key: SP = Intra row spacing, B = Biopesticides, B0; control, B1; Neem seeds kernel extract (NKE), B2; MaviMNPV suspension, B3; Cyper diforce

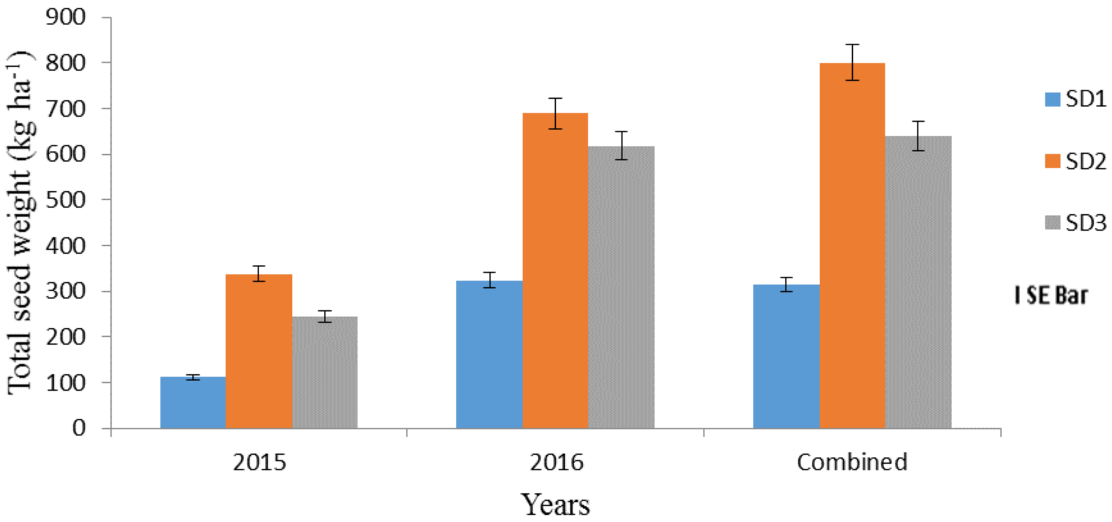

Fig. 6. Total cowpea grain seed weight (kgha^{-1}) in Samaru during 2015 and 2016 cropping seasons, SD1: 02/07/2015 and 02/07/2016, SD2: 23/07/2015 and 23/07/2016, SD3: 13/08/2015 and 13/08/2016

Table 3. Effect of sowing dates, intra row spacing and biopesticides on total cowpea grain seed weight during 2015 and 2016 cropping season in Samaru (kg ha^{-1})

Treatments	2015	2016	Combined
Intra row spacing (cm) (SP)			
SP1: 75 x 20	199.90	510.24	524.99^{b}
SP2: 75 x 30	272.88	565.74	651.26^{a}
SP3: 75 x 40	222.27	554.84	577.48^{ab}
Mean	231.68	543.61	584.58
LSD	69.165	143.740	117.950
Biopesticides (B)			
B1: Neem kernels extract	178.19^{b}	424.92^{b}	453.03^{b}
B2: MaviMNPV suspension	188.26^{b}	417.88^{b}	463.07^{b}
B3: Cyper diforce	394.56^{a}	887.69^{a}	976.51^{a}
B0: Control	165.70^{b}	243.94^{c}	445.69^{b}
Mean	231.68	543.61	584.58
LSD	79.976	117.410	121.670
Interactions			
SD x SP	NS	NS	NS
SD x B	**	**	**
SP x B	NS	NS	NS
SD x SP x B	NS	NS	NS

Means with the same letter(s) within the same column are not significantly different using LSD at 5% level, NS = Not significant, * = Significant at $P \leq 0.05$, ** = Significant at $P \leq 0.01$, SD = Sowing dates, SP = Intra row spacing, B = Biopesticides

Discussion

Effect of intra-row spacing, sowing dates and biopesticides on total grain yield (kg ha^{-1})

Cowpea sown in mid-August (SD2) yielded significantly ($P\leq.01$) better than early sown (SD1) but the later was statistically the same with cowpea sown in early September (SD3). The reason due to poor performance of early sown cowpea could be attributed due to heavy *M. vitrata* attacked that was observed. The low yield obtained in cowpea sown in mid-August (SD2) was 66.75 and 27.53 % better than late July (SD1) and early September sown cowpea (SD3). There were no significant differences among NKE, MaviMNPV and Cyper diforce on total cowpea grain yield. The result obtained in this study pointed to the fact that among the three treatments, significantly ($P\leq$ 0.01) higher cowpea grain yield was obtained from Cyper diforce treated plots (394.56 Kg ha^{-1}) compared with MaviMNPV (188.26, 417.86 and 463.07 Kg ha^{-1}) and NKE 178.19, 424.92 and 453.03 Kg ha^{-1}) which were statistically similar. MaviMNPV performance was poor compared with Cyper diforce. This showed that the toxicity of the virus suspension alone did not give effective control. However, its potency could be improved if applied in synergy with another control agent. This view is in consistent with that of Sokame *et al.* (2015). The toxicity conferred by Cyper diforce was superior to that of other treatments in protecting cowpea thereby increasing yield compared with the control. Our findings are in accordance with Karungi *et al.* (2000) and Ebenezer (2010) and Oyewale *et al.* (2014) who reported significant yield loss.

Effect of intra-row spacing, sowing dates and biopesticides on *M. vitrata* population and flower damage

Although, there was no significant difference in delaying sowing date from SD2 to SD3, but lower post spray populations of *M. vitrata* were obtained in the later date than in the former. Further delay in sowing to SD3 significantly ($P\leq.01$) reduced *M. vitrata* populations. The least population of pod-borer was recorded in SD3 in all the cropping seasons. This could be due to the amount and duration of rainfall has reduced which consequently increased larval death due to desiccation. This showed that early sowing (SD1) of cowpea coincide with the peak period when the post flowering pests especially cowpea pod-borer is at its peak population density. Cowpea sown at SD3 in the area grew during the period when pod-borer population densities were low and therefore suffer less damage. The result of this investigation agreed with the earlier report by Asante *et al.* (2001).

Varying intra row spacing did not showed any significant difference as well. Wider spacing (SP3: 75 x 40 cm) was observed to increased *M. vitrata* population over (SP2: 75 x 30 cm) although not significantly different. The result in Katsina agreed with the findings of Karungi *et al.* (1999).

The effect of biopesticides on pest management has been used worldwide by researchers and poor resourced farmers. The use of extracts of botanical origin such as neem, garlic, ginger, cashew nut shell, African pepper, African desert date were used in controlling insect pests of cowpea especially post flowering pests (Degri *et al.*, 2012; Ahmed *et al.*, 2009; Oparaeke *et al.*, 2006; Oparaeke, 2006). In this study, neem seed kernel extract (NKE), *Maruca vitrata* Multi-nucleopolyhedrosis virus (MaviMNPV) and Cyper diforce were tested. The result did not showed any significant difference among the treatments 24 hrs after treatment on the mean population of *M. vitrata*. Cyper diforce treated plots however recorded lower population densities of *M. vitrata* thereby providing effective control better than MaviMNPV and NKE. However, all the three treatments significantly ($P\leq$ 0.01) reduce *M. vitrata* population compared with the control. The result obtained from this study corroborated the earlier work by Saxena (1983) who reported that most plant products are less effective than synthetic insecticides. Therefore, synthetic insecticides still remain the most effective and immediate control strategy of *M. vitrata*. The results showed that MaviMNPV significantly ($P\leq$ 0.01) reduce mean population of *M. vitrata* in flowers and thereby achieving control. It was however not significantly better than Cyper diforce. The control plots recorded significantly ($P\leq$ 0.01) higher *M. vitrata* populations. The implication of this finding showed that in terms of potency, Cyper diforce was most toxic. It was followed by MaviMNPV and the least toxic was NKE. The non performance of virus suspension may be due to ineffectiveness if used alone than when combine with another control agent.

There were significant ($P\leq$ 0.01) differences in the per cent flowers damage among the three sowing dates. High percentage flower damage was however recorded in SD1 which was significantly higher than SD2. The least flower damage was obtained in SD3. High percentage flower damage was obtained in SD 2 but significantly lower per cent flower damage was obtained in cowpea sown in early September (SD3). The reason of high flowers damage in SD2 may be due to flowering and podding stages of the cowpea coincided with the high incidence of *M. vitrata* during the cowpea growth which was favoured by high rainfall and relative humidity. Conducive environment for cowpea growth could lead to luxuriant vegetative growth and development of dense canopies which give protection to *M. vitrata* larvae from desiccation (Oghiake *et al.*, 1992).

There was no significant difference in flowers damaged by *M. vitrata* between SP1 and SP2. Close spacing however recorded lower flower damage. The result of this study on the effect of biopesticides indicated that plots sprayed with NKE, MaviMNPV and Cyper diforce recorded reduction in the per cent flower damage compared to the control plots. Although, there was no significant difference between the treatments, NKE performed better although statistically similar with Cyper diforce in reducing flower damage 24 after treatments. There was no significance difference between NKE and the control in all the periods of sampling, neem extract reduced flower damage better than the control. This finding is similar to the observations made by Rauf and Sandar (2011). The same result was obtained in Samaru in which the treatments significantly and considerably recorded reduction in the per cent flowers damage compared to the controls. Cyper diforce and MaviMNPV performed better in reducing flower damage than NKE 24 after treatments although not significantly different ($P\geq$ 0.05). However, significantly higher flower damage was obtained in the control plots. This results agreed with the previous findings (Degri *et al.* 2012; Oparaeke, 2006; Oparaeke *et al.* 2005; Panhwar, 2002; Oparaeke *et al.*, 2000).

Effect of intra-row spacing, sowing dates and biopesticides on cowpea pod infestation by *M. vitrata* 10 WAS

The result of this study indicated that varying sowing dates of cowpea in Katsina could lead to reduction in per cent damage of cowpea pods. At 10 WAS, cowpea planted in SD1 (late July) was damaged by *M. vitrata* more, than damage recorded in SD2 and SD3. The reason could be podding stages of late sown cowpea coincided with the peak population densities of *M. vitrata* and thereby heavily damaged. The implication of this finding showed that delay in cowpea sowing from SD1 will flower and pod after the high population densities of *M. vitrata*. There by escaping pod-borer damage. Varying intra row spacing was found by this research not significantly different in reducing cowpea pod infestation caused by *M. vitrata* 10 WAS. Lower pod infestations were recorded in SP1 and SP3 for Katsina and Samaru respectively. Cyper diforce was found effective in reducing pod infestation 10 WAS but was not significantly better than MaviMNPV. NKE was least in reducing infestation but was significantly ($P\leq$ 0.01) better than the untreated control. The implication of this research finding showed that MaviMNPV is a promising biopesticide that can reduce pod infestation. Sokame *et al.* (2015) suggested application of MaviMNPV in combination with neem or Jatropha oil in order to give synergistic effect on larval mortality.

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