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EVALUATING THE EFFECT OF HOST PLANT RESISTANCE AND PLANTING DATES ON THE INCIDENCE OF LEGUME POD BORER (*Maruca vitrata*, GEYER) ON AFRICAN YAM BEAN IN NIGERIA

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ABSTRACT

Legume pod borer (*Maruca vitrata* (Geyer)) is one of the major biotic constraints to increasing the productivity of most grain legumes in the tropics. In this study, field experiments were conducted to assess the effect of host plant resistance and planting dates on the incidence of African yam bean pod borer *Maruca vitrata* (Geyer) in Nigeria. Planting of African yam bean (*Sphenostylis stenocarpa*) varieties in May led to less infested by *M. vitrata* and differed significantly ($P \leq 0.05$) from those planted in June and July. Of all the varieties assessed, TSs9 was the most resistance and differed significantly ($P \leq 0.05$) from the rest of the varieties; while TSs84 was the most susceptible with poorest grain yields. All the varieties when planted in May had less post-flowering insect infestations and produced higher grain yields than those planted later. Flowering and podding formation stages of African yam bean (AYB) planted in July coincided with the peak population densities of *M. vitrata,* resulting in a significant reduction in yields. The highest grain yields were recorded under a combination of early planting with resistant varieties.

Key Words: *Maruca vitrata, Sphenostylis stenocarpa,* susceptibility

RÉSUMÉ

L'insecte foreur de gousses, *Maruca vitrata* (Geyer) est une des contraintes abiotiques majeurs à la productivité des légumineuses dans les tropiques. Dans cette étude, des essais en champs étaient conduits pour évaluer l'effet de la résistance de la plante hôte et les dates de plantation sur l'incidence de l'insecte Africain foreur de gousses d'ignames Maruca *vitrata* (Geyer) au Nigeria. La plantation des variétés de haricot d'ignames africaines en Mai a conduit à moins d'infestations par *M. vitrata* et étaient significativement ($P \leq 0.05$) différentes de celles plantées en Juin Juillet. De toutes les variétés évaluées, TSs9 était la plus résistante et différait significativement ($P < 0.05$) du reste des variétés; pendant que TSs84 était la plus susceptible avec des rendements en grains plus pauvres. Toutes les variétés plantées en Mai étaient moins infectées par les insectes post-floraison et ont produit des rendements plus élevées par rapport à celles plantées avec retard.Les stades de floraison et de formation de gousses duharicot d'ignames africaines plantés en Juillet a coïncidé avec l'augmentation des densités de populations de M. *vitrata,* résultant en une réduction des rendements. Les rendements les plus élevés étaient obtenus lorsque les variétés résistantes étaient tôt plantées.

Mots Clés: *Maruca vitrata, Sphenostylis stenocarpa,* susceptibilité

INTRODUCTION

One major causes of food insecurity in many African countries and Nigeria in particular is the underutilisation of some potential food security crops in Africa. Among the underutilised crops with high food potential in Nigeria is the African yam bean (*Sphenostylis stenocarpa*, Hochst. Ex. A. Rich). African yam bean (AYB) is one of the most important grain and tuberous legumes of tropical Africa. It is cultivated as a secondary crop with yam and other crops in many parts of Africa, mainly by subsistence farmers (Potter 1992; Amoatey *et al*., 2000; Klu *et al*., 2001). The seed grain and tuber are the two major organs of immense economic importance as food for Africa with regional preferences (Ene-Odong, 1992; Potter 1992; Klu *et al*., 2001; Adewale 2010; Adewale and Dumet 2011). While the seeds are preferred in the West African countries, the tubers are preferred both in the east and central Africa. African yam bean has a huge potential for food security in Africa. According to Uguru and Madukaife (2001), AYB is well balanced in essential amino acids and has higher amino acid content than pigeon pea, cowpea and bambara nut. The grain is a good source of proteins, fibre and carbohydrate. It is rich in minerals such as phosphorus, iron and potassium. However, the under-exploitation of the crop has subjected it to be classified as minor grain legumes (Saka *et al*., 2004).

Of all the factors militating against increased African yam bean production in Nigeria, its low grain yield compared with other legumes (cowpea) and tuber crops (sweet potatoes) under monocrop conditions has always been cited (Saka *et al*., 2007). Several biotic factors have been reported to be responsible for the low grain yields. Of all the biotic factors that challenges AYB production, the most important is insect infestation. Insect infestation, hitherto, has not been given the desired attention as a major factor that hinder the production of AYB. Though it has been reported that African yam bean contain genes that resist the infestation of so many insect pests, its grain yield has been reported to be reduced significantly by insects. According to them (Ameh and Okezie, 2005) so many insects pests have been recorded attacking the crop at different stages of growth. Among the insect pests of AYB, reproductive insects are the most serious pests. One major insect pest of AYB at the reproductive stage is the pod borer *(Maruca vitrata* G. *M. vitrata)* belonging to the family Pyralidae of order Lepidoptera. The caterpillars damage flower buds, flowers and developing pods. They also web inflorescence resulting in the malformation of webbed pods. According to Jackai (1981) and Sharma (1998), infestation starts in the terminal shoots (21 days after planting), but later spreads to the reproductive parts. Infestation is highest in flowers > flower buds > terminal shoots > pods (Sharma, 1998). *Maruca vitrata* alone causes grain yield losses in field legumes varying from 20–60% in different parts of Africa (Singh and Allen, 1980). Flower buds may be shed and pod production drastically reduced.

Due to the economic importance of this pest, various control measures have been assessed including the use of chemical control. While chemical control is popu-lar and effective (Jackai and Daoust, 1986), the improper application of insecticides has resulted in environmental hazards, human health problems and insect resistance (Ogah *et al*., 2011). The high cost of importing pesticides, aggravated further by local currency devaluation, not only creates a serious drain on the economy of countries with low Gross Domestic Products such as Nigeria, but also makes such pesticides unaffordable to limited resource farmers. Consequently, the adoption of locally available technologies were invoked. Strategies as host plant resistance and planting dates have been cited as having potentials to control many field insect pests of crops such as legumes. More so, they are environmentally friendly and affordable by local resource poor farmers. Though information is available on genotypic resistance to M. *vitrata* in cowpea, such information on pigeon pea and other legumes AYB inclusive is limited.

Considering the nutritional values of AYB, there is need to adopt measures that will control this important pest of this crop that has relegated it to minor status because of significant yield losses caused by this pest in the field. Evaluating available varieties to exploit the benefit of resistance inherent in it would serve as a source of materials for hybridisation for improved crop yield. In addition, following the fact that *M. vitrata* is one of the economic and stubborn pests of African yam bean, knowledge of the mechanisms that are involved in African yam bean resistance to the pest becomes quite eminent. In this study, we assessed the impact of host plant resistance and planting dates in the management of *M. vitrata* incidences, and to identify among these practices, those that could be integrated for management of AYB pests in Nigeria and elsewhere.

MATERIALS AND METHODS

Field experiments were conducted at the experimental farm of the Faculty of Agriculture and Natural Resources Management, Ebonyi Sate University, Abakaliki during 2009 and 2010 farming seasons under rain fed conditions. Abakaliki lies within 7^o 30'E, 5^o 45'N with a mean annual rainfall of 2000 mm.

The fields were laid out in split-plots in a randomised complete block design. Three different planting dates (May 4th, June 2nd and July 1st) for 2009/10 were used as the main-plot treatments. Seven promising varieties of African yam bean (TSs 9, TSs 48, TSs84, TSs86, TSs93, TSs94 and TSs166) collected from IITA genetic bank at Ibandan in Nigeria, were randomly assigned to sub-plots. Each treatment was replicated three times. The AYB varieties seeds were planted in rows in each plot with a variety occupying a row. Sowing was at 2 seeds per hole at a spacing of 1 m x 0.7 m.

Thinning was done after three weeks of planting, to one seedling per stand. Forty kilogrammes per hectare of compound fertiliser, 15: 15: 15 NPK, was added to all the plots at three weeks after germination, to boost growth. Staking was done three weeks after germination, using strong stakes, each measuring about 3 m high. Each seedling was staked independent of the other to avoid mixing the varietal yields. The experimental plots were weeded at three weeks intervals No insecticide was applied in order to have the study under perfectly natural infestation conditions.

Determination of the level of resistance of the varieties on the incidences of *M. vitrata* were based on flower, pod and seed damages, larval population in flowers and ratio of grain yield at harvest. These were recorded at weekly intervals, starting from 50% flowering to pod maturity from each variety. Five plants per plot were randomly selected and tagged from each variety. From the tagged plants, the population densities of *M. vitrata* were estimated by randomly picking 20 flowers depending on the stage of growth. The picked buds or flowers were placed in glass vials containing 50% ethanol solution. Subsequently, *M. vitrata* larvae were counted under binocular microscope. Pod damage (shriveling, twisting, stunting, constriction) was assessed by examining 20 pods randomly selected from the tagged plants per plot. At harvest, data were collected on total grain yield per variety from the tagged plants. Estimate of grain yield per unit area was done when the grains were dry, using the tagged plants. The pods were threshed and winnowed using indigenous technology. The results were extrapolated to kilogramme per hectare for each variety at the different planting dates.

Damage percentages were subjected to Arcsine transformations before analysis of variance was carried on them through computer software (SAS, 2003). Mean separation was carried out by Student Newman's Keuls ($P \leq 0.05$) test. Pearson correlation coefficient (r) was used to determine the relationship between percent infestation and planting dates.

RESULTS

The effect of host plant resistance of the African yam bean varieties and planting dates significantly influenced the incidence of *M. vitrata* and grain yield throughout the experimental periods (Table 1). The incidence of *M. vitrata* differed significantly ($P<0.05$) across the varieties throughout the experimental periods. Among the varieties assessed, TSs9 was the most resistance and differed significantly ($P\leq 0.05$) from the rest of the varieties; followed by TSs48 and TSs86 that also differed from other varieties. TSs84 was the most susceptible variety with the poorest grain yield. On the other hand, the incidence of *M. vitrata* was significantly lower on African yam bean planted earlier in May 4th of each season (Table 1). It differed significantly (P<0.05) from those planted in July of each season. In other words, the *M. vitrata* incidence significantly (P<0.05) increased with the planting dates with the minimum incidence recorded on AYB planted on May 4th and highest on those planted in July.

In the two planting seasons, the incidence of *M. vitrata* was higher during 2009 than in 2010 across the varieties and planting dates. In both seasons, varieties TSs84 and TSs93 had higher proportions of number of infested flowers and damaged pods than other varieties. All the varieties were less attacked during the earlier period characterised with less rain and drier period than at the later period that was characterised with more rains (Tables 1 and 2).

Grain yield per plant varied across the varieties and planting dates throughout the experimental periods. Overall, variety TSs86 gave the highest grain yields across the experimental periods and differed significantly from others (Table 3); while TSs84 gave the poorest grain yield. African yam bean planted earlier gave higher grain yield across all the varieties and differed significantly from those planted later.

There were significance positive correlations between larvae density and percentage pod damage (r = 0.73 and 0.69, P<0.05), varieties and pod damage (r = 65 and 61, P<0.05) and planting date and pod damage (r = 0.81 and 77, P< 0.01) for 2009 and 2010, respectively.

DISCUSSION

The results demonstrated the potentials of host plant resistance and planting dates in the management of *M. vitrata*. The significant reduction in *M. vitrata* infestation at the early planting (Table 1) could be attributed to the lower populations of the *M. vitrata* early in the season, which subsequently build-up as the season

TABLE 1. Effect of host plant resistance and planting dates on mean number of *M. vitrata* larvae per 20 flower buds/flowers/ pods

Varieties	2009			2010		
	May	June	July	May	June	July
TSs 9	7.1±1.3e	12.9±3.3d	14.6±1.4d	4.3±1.1e	11.3±1.3e	15.8±5.1d
TSs 48	10.0±2.7d	17.2±2.3c	21.8±2.7c	12.0±2.2c	18.3±1.9cd	23.5±4.1b
TSs84	22.4±3.1b	24.4±1.7b	31.7±2.6ab	18.4±2.2b	24.0±1.6b	25.5±3.7b
TSs86	16.4±3.3c	20.2±3.4bc	22.0±2.5c	8.5±1.8d	15.5±1.6d	23.0±3.6b
TSs93	28.4±3.2a	30.6±2.0a	36.8±2.8a	23.3±2.4a	27.3±1.6a	31.0±2.8a
TSs94	22.0±3.5b	23.8±2.7b	26.4±2.2b	14.2±2.6 c	20.0±2.1c	24.1±4.1b
TSs166	14.7±2.5c	21.0±2.3b	26.7±2.0b	12.2±2.1c	18.8±1.7c	22.3±4.0c

Means followed by the same letter(s) do not significantly differ according to Student Newman Keuls (P < 0.05) test

TABLE 2. Effect of host plant resistance and planting dates on mean number of pod damage of AYB by *M. vitrata*

Varieties	2009	2010
TSs 9	9.7±3.2c	5.1±1.9d
TSs 48	15.7±3.0b	7.1±1.8c
TSs84	19.0±2.1a	18.2±1.5a
TSs86	14.2±2.8b	6.0±1.6c
TSs93	17.6±2.8a	11.1±1.8b
TSs94	17.1±2.2a	12.3±1.9b
TSs166	8.1±2.5c	6.2±1.8c

Means followed by the same letter(s) do not significantly differ according to Student Newman Keuls ($P \leq 0.05$) test

TABLE 3. Effect of host plant resistance and planting dates on grain yield (kg ha^{-1}) of AYB during 2009/2010

Varieties		2009			2010		
		May	June	July	May	June	July
		Grain yield	Grain yield	Grain yield	Grain yield	Grain yield	Grain yield
1	TSs 9	557.7b	456.9c	374.7c	511.1b	462.2b	343.0c
2	TSs 48	595.5a	517.8a	412.1b	591.0a	492.2a	384.0a
3	TSs84	425.0e	319.7e	277.1e	419.2e	403.5c	204.8e
4	TSs86	631.3a	520.0a	461a	521.6b	462.6b	353.9b
5	TSs93	512.0d	441.6cd	312.2de	491.0c	366.4d	344.8c
6	TSs94	544.7c	491.6b	343.4d	448.1d	311.8f	290.0d
7	TSs166	525.5d	393.9d	353.6cd	391.6e	344.0e	291.6d

Means followed by the same letter(s) do not significantly differ according to Student Newman Keuls (P < 0.05) test

progresses. Thus, pod borer infestation increases on the late sown crop (Alghali, 1993b; Sharama, 1998). Similar results have been reported on cowpea in Uganda by Karungi *et al*. (2000). Other studies have also indicated that early planting reduces pest infestation of some crops. For example, early season planted groundnut was shown to have low *A. craccivora* infestations, and consequently, little or no groundnut rosette (Naidu *et al*., 1998).

Pest control tactics that involve manipulating the insect environment are well known among traditional farmers. They have practiced these tactics for ages, usually for different reasons than those proposed by scientist (Rachie, 1985). Several of these agronomic practices are used in different parts of the tropics, especially in Africa (Okigbo and Greenland, 1976). One of the most valuable is the planting dates (Asante *et al*., 2001). This is evident in the present study that showed significant differences on the rate of infestations recorded across the three planting dates. Improved crop cultivars and alteration in planting dates of crops have been reported as an effective strategy in reducing pest damage by a number of researchers (Prasa and Singh, 1997; Karungi *et al*., 2000; Asante *et al*., 2001). It has also been reported that planting date alteration is probably the most promising approach for the control of pod-sucking bugs, because of difficulty in finding resistance to the cowpea Hemipteran complex (Jackai, unpublished). The less infestation recorded for the earlier planted crops (Table 1) may, therefore, be attributed to weather factors that were unfavourable to *M. vitrata* mass multiplication. At early season period, rainfall was not frequent; thus did not encourages vigorous growth of the plants required by the pest. *M. vitrata* needs denser canopy formation as hiding places for the larvae against predators (Oghiakhe *et al*., 1991). Furthermore, *M. vitrata* larvae do not survive under drought harsh environmental conditions (Oghiakhe *et al*., 1991). Similarly, earlier planted African yam bean probably may have passed the flowering stage before the peak infestation of *M. vitrata* that occur from mid-September through November.

The high infestations observed in this study (Tables 1 and 2) differed significantly from earlier research results that suggested low levels of African yam bean infestation by pests. The low insect pest infestations recorded by many earlier researchers may be attributed to the mixed cropping system adopted for this crop, and mixed cropping is a control measure that deters a potential pest from attacking a target crop. The high level of African yam bean infestation by *M. vitrata* recorded in this work (Tables 1 and 2) may, therefore, be attributed to the fact that the crop was planted as a sole crop and created room for proper assessment of its pest load. This is in line with Ameh and Okezie (2005), who reported that insect pests are responsible for significant reduction in the yield of AYB. A similar result has also been reported in cowpea by Karungi *et al*. (2000). African yam bean is generally intercropped with other crops and several studies have shown that the population of *M. vitrata* is consistently lower under intercrop (Mateson, 1982). Intercropping also resulted in significant differences in temperature, relative humidity, and a reduction in photosynthetic activity of the plants. That is to say that intercropping causes the under estimation of insect infestation in African yam bean in almost all the cultivating areas. The differential resistance levels observed confirms the significant of this study for improved production of this crop, though the source of resistance was not yet clear.

The higher grain yield recorded in plots planted early than those planted later (Table 3) may be attributed to the fact that the flowering and podding formation stages of African yam bean planted in July, coincided with the peak population densities of *M. vitrata*, resulting in a considerable reduction in grain yields, or that early sown crops may have matured before peak infestation of the pests. This has been demonstrated for pod-sucking bugs in Nigeria (IITA, 1982). This is in agreement with (Akingbohungbe, 1982; Asante *et al*., 2001) who reported that cowpea planted in June or July in Southern Nigeria, usually escaped severe *M. vitrata* infestation; while those planted late in August coincide with the peak population densities of the major post-flower pests resulting in considerable reduction of grain yield. They maintained that cowpea yields depended on cowpea cultivars and planting dates. Similar results have also been reported by Karungi *et al*. (2000) in Uganda and for pod-sucking bugs in Nigeria (IITA 1982;Akesi *et al*., 1996).

Regardless of the pest attack, there was an increase in yield when varieties with resistance treats were planted earlier in the season than later (Table 3). Though the modes of resistance of these varieties are not yet clear, it could be genotype based. The seasonal variation in yield losses observed may also be attributed to the genetic make up of these varieties. The present study is in line with the results reported of this pest in cowpea in Nigeria (Ogunwolu, 1990). The fact that the highest resistant variety did not give the highest grain yield may be attributed to the genetic differences of these varieties. This is in line with the reports of Dreyer *et al.* (1994) who observed low seed damage despite heavy flower infestation in cowpea. Sharma (1985), Prabhakar *et al.* (1998) and Reddy *et al.* (2001) also found in-proportionate increase in the damage of different chickpea pods with increase in the larval population levels of *Helicoverpa armigera*. The higher yields recorded in some varieties compared to others may be due to differential pest pressure that differed due to the genetic differences of the varieties.

CONCLUSION

Host plant resistance and planting dates have great potentials as management strategies for the control of *M. vitrata* in African bean yam production and could provide suitable alternatives for pest control on field crops of small scale and low-input agriculture as commonly practiced in tropical countries without degrading the environment. In effect, the micro climatic conditions of a place determine the degree of African yam bean pod borer incidence. Proper planting time in association with resistance varieties could offer effective control measures of African yam bean pod borer with optimum grain yield. Finally, the highly resistance varieties can be utilised in breeding programmes for the management of *M. vitrata* as a component of IPM package for African yam bean pod borers control.

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