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Evaluation of insect pests associated with growth of soybean [*Glycine max* (L.) Merr] in Nigerian Guinea Savanna

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ABSTRACT

Cultivation of soybean in Nigeria has expanded as a result of its diverse nutritive value and economic importance. It is also a prime source of vegetable oil in the international market and has an average protein content of 40%. The major constraint to the production of this crop is attack by insect pests and diseases. Therefore, this study was carried out to assess the diversity of insect pests associated with soybean production in University Research Farm, Abuja, Guinea Savanna Zone of Nigeria in June to August, 2013. Four soybean varieties (TGX144-7t, TGX1835-10f, TGX1485-1d and a local variety) were planted in a randomized complete block design in triplicate. Insect pest traps were set at random on the ground between rows of plants. Each tray was filled up to one-quarter capacity with solution containing 70% Ethanol, 15% Teepol detergent and made up to 100% with water. Trapped insects were collected weekly and identified at the Insects Museum Laboratory of the Institute for Agricultural Research, Ahmadu Bello University, Zaria. The temperature, rainfall and relative humidity were also recorded. Observed physical damage to leaf surfaces and infection were recorded. The results revealed that 37 species of insects in the order Hymenoptera, 27 in the order Orthoptera, 14 in the order Coleoptera and 1 in the order Hemiptera were trapped. Mean environmental temperature was 30°C, relative humidity 83%, 6 hours of sunshine and 774.3 mm rainfall (average 129.1 mm/month) for the period June to November. Viral symptoms of Soybean mosaic virus (SMV), Bean pod mottle virus (BPMV) and Cowpea mild mottle virus (CPMMV) infection were observed.

INTRODUCTION

Soybean [*Glycine max* (L.) Merr] is one of the important bean crops grown in many parts of the world that provides a high source of plant protein 40% and oil 20% for human consumption (Dudje et al., 2009). The crop is grown in many States in Nigeria using low agricultural inputs such as fertilizer (Dudje et al., 2009). Nigeria is Africa's leading producer of soybean which is consumed locally or used by processing industries (Auwal and Auta, 2011). Unfortunately, insect pests constitute constraints to the production of the crop (Jackai and Singh, 1987; Jackai et al., 1990). Most of the insects associated with soybean are harmful to the crop and can cause yield loss. Hartman et al. (2001) reported that about 15-20% of total soybean production is lost directly and indirectly due to attacks by insect pests. The prevalence of insect pests and the damage that they cause vary from one year to another and also from one location to the other (Hill et al., 2004). The class of insects that cause the greatest potential damage to soybean crop are the defoliators (Giesler et al., 2002). These insects belong to 29 orders

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from class insecta and nine of them feed on living green plants and are possible vectors of plant viruses (Alegbejo, 1986, 1996).

About 70% of insect vectors belong to order Homoptera and aphids are the most important of these, followed by Aleyrodidae (Whiteflies), Coleoptera (Beetles), Pseudococcidae (Mealy bugs), Cicadellidae (Leafhoppers) and Thysanoptera (Thrips). Other vectors of less importance are Orthoptera (Grasshoppers), Delphacidae (Plant hoppers) and Membracidae (Tree hoppers) (Alegbejo, 1996). The plant viruses are capable of penetrating unwounded plant cells when feeding, during which the virus that they have acquired in persistent and non-persistent manner, is inoculated into the healthy plant. Green peach aphid, *Myzus persicae* Sulzer (Homoptera: Aphididae) is an important insect pest of many crops such as *Capsicum* spp., *Cucumis* spp., *Lycopericon* spp., *Gossypium* spp., *Solanum* spp. and *Leguminous* spp. in the temperate, tropical and sub-tropical countries (Alegbejo, 1986; Donaldson and Gratton, 2007). The viruses of soybean, Soybean mosaic virus (SMV), Alfalfa mosaic virus (AMV), Bean yellow mosaic virus (BYMV), Peanut stunt virus (PSV), Peanut mottle virus (PMV) and Bean pod mottle virus (BPMV), are transmitted by several species of aphid and bean leaf beetle (Donaldson and Gratton, 2007). Other insect pests of soybean are the bean leaf beetles which exist as root or leaf feeders and pod-feeding adults. The feeding activity has great impact on growth, development and subsequent yield loss depending on the level of damage (Lam and Pedigo, 2000). Several beetles including the bean leaf beetle have been found to transmit the BPMV and Cowpea mosaic virus (CPMV) in southern Nigeria (Gibbs et al., 2008). Adult grasshopper destroys the soybean by eating the pods as well as the developing seeds while the nymphs feed on the seedling (Rice, 2001). The types of insect pests that are commonly found on soybean fields have not been systematically evaluated in the Guinea Savanna Zone of Nigeria.

This study was therefore designed to assess the insect pests of soybean grown in Guinea Savanna of Nigeria.

MATERIALS AND METHODS

The study was conducted at the University Research Farm, Abuja in the Guinea Savanna Zone of Nigeria in the months of June to August, 2013. The farm is located within latitude 08°59'N and longitude 007°10'E. The mean annual rainfall ranges between 1100 and 1800 mm (Barnabas and Nwaka, 2014). Mean temperature ranges from 28 to 32°C. The soils are sandy loamy, sandy clay and clay loamy. Fertility of soil is moderate with acidity rating of 5.60 to 5.80 (Ishaya and Grace, 2007; Barnabas and Nwaka, 2014). The land was manually cleared, ploughed and harrowed mechanically. The area measured 17 × 21 m, with seed beds size of 3 × 4 m and spacing between plots of 1 m. Three improved soybean seed varieties (TGX144-7t, TGX1835-10f and TGX1485-1d) were obtained from Kubuwa-Abuja station of International Institute of Tropical Agriculture, while one local variety was bought from the open market in Abuja. The trial was laid in a randomized complete block design in triplicate, and sowing was done mid-June on a flat beds with a spacing of 70 × 30 cm. Weeding and thinning started three weeks after germination. During thinning, the most developed plants were left and weak ones removed, leaving one plant per stand. Weeding was carried out manually thrice with hoe while hand pulling of weed was done as necessary. The following parameters were assessed and determined: germination percentage, incidence and severity of observable signs of virus disease, plant height, plant diameter, insect trapping and yield of crop at the end of harvest. Symptoms expressed on randomly selected plants were observed for ten weeks. Assessed plants were scored for virus incidence and severity using the Equations 1 and 2:

Disease incidence:

$$DI = \frac{\text{Number of symptomatic plants}}{\text{Total number of plants sampled}} \times 100(\%) \quad (1)$$

Disease severity:

$$DS = \frac{\text{Sum of all disease ratings}}{\text{Number of plants assessed}} \times \text{maximum score (100)} \quad (2)$$

Rating scale (0-5) was used to assess disease symptoms; where 0 = no symptom, 1 = 1-10% leaf area affected, 2 = 11-30% leaf area affected, 3 = 31-40% leaf area affected, 4 = 41-90% leaf area affected, while 5 = > 90% leaf area affected (Hartman et al., 1999).

The degree of germination of planted seeds was assessed at two weeks after planting using Equation 3:

$$\text{Germination \%} = \frac{\text{Number of seeds germinated}}{\text{Total number of plants planted}} \times 100 \quad (3)$$

Plant height was measured from the base of plant to the apical shoot with the help of meter rule (Tailor's tape) and recorded in centimetre weekly for ten weeks. Plant diameter was measured weekly with the use of a thread carefully placed around the stem. The circumference measurement was placed on a meter rule and read. Insect traps (plastic containers) were set at random at ground level. Each tray was filled up to one-quarter capacity with solution containing 70% Ethanol, 15% Tee pol detergent and made up to 100% with water (Alegbejo, 1996 modified). Trapped insects were collected,

Figure 1. Symptoms of virus disease on soybean leaves.

Table 1. Mean percentage germination, incidence and severity of virus symptom expression on soybean grown.

Treatment	Germination (%)	Virus incidence (%)	Severity (%)
TGX 1440-7t	96.0^{a}	33.7^{c}	19.5^{b}
TGX 1835-10f	45.3^{b}	66.8^{a}	22.5^{a}
TGX 1485-1d	87.8^{a}	49.3^{b}	20.4^{ab}
Abuja local variety	97.5^{a}	40.6^{c}	19.6^{b}

Values in the same column with different superscripts differ significantly (P<0.05) at 5% level of probability.

counted and recorded on weekly basis for ten weeks. The liquid in trap containers were changed after every collection in order to refresh the solution. The insects trapped were collected and identified in the Insect Museum Laboratory, Department of Crop Protection, Institute of Agricultural Research, Zaria. After the soybean pods were matured and turned brown in colour, they were harvested, threshed and weighed. The weather data (temperature, hours of sunshine, relative humidity and rainfall) for the year of trial were collected from the Meteorological Department of the Nnamdi Azikwe International Airport, Abuja. The values were related to the type, number and distribution of insects, and the incidence of disease. Physical damage to leaf surfaces by insects was also observed.

Statistical analyses

All data obtained were subjected to one-way analysis of variance (ANOVA) using SPSS software (version 16.0) and means that were significant were further separated using Duncan multiple range test (DMRT).

RESULTS

Germination percentage, symptoms and Incidence and severity of virus infection

The results showed that for germination percentage, the soybean varieties TGX 1440-7t (96.0%), TGX 1485-1d (87.8%) and Abuja local variety (97.5%) were not significantly different from one another (P>0.05), while the variety TGX 1835-10f recorded a significantly lower percentage germination in comparison with others (Table 1). The expressed symptoms of SMV, BPMV and CPMMV were observed on the field (Figure 1). The incidence and severity of symptoms of virus disease were highest in the variety TGX1835-10f, which recorded the lowest germination percentage (Table 1).

Plant height, diameter and yield

Variety TGX 1440-7t recorded the highest growth (37.7 cm), while the differences in height between other varieties were not significant (P>0.05). The differences

Table 2. Mean plant height, stem diameter and plant yield of soybean grown.

Treatment	Plant height (cm)	Stem diameter (cm)	Yield (kg/ha)
TGX 1440-7t	37.7[a]	2.1[a]	15,400[a]
TGX 1835-10f	27.3[b]	2.2[a]	2,900[b]
TGX 1485-1d	29.4[b]	2.0[a]	13,500[a]
Abuja local variety	29.9[b]	2.0[a]	14,100[a]

Values in the same column with different superscripts differ significantly (P<0.05) at 5% level of probability.

Table 3. Mean weather data and virus incidence during soybean growing season.

Month	Temperature (^oC)	Sunshine (h)	Rainfall (mm)	Relative humidity (%)	Virus incidence (%)
June	30.1	5.1	162.7	83	45.3
July	28.6	4.2	193.3	86	49.3
Aug.	27.5	2.2	140.2	89	100
Sept.	29.5	5.3	134.8	86	100
October	31.3	7.4	143.3	83	100
November	34.0	9.3	0.0	71	100

in stem diameters between the varieties recorded higher yields which were not significantly different (P>0.05). The variety TGX-10f had the lowest yield while the other three varieties recorded higher yield which was not significant from each other (Table 2).

Prevailing weather

Peak temperature was obtained in the early part of the growing season (May and June) and reduced through the following months as rainfall became established and increased. The temperature increased again towards the end of the growing season (October-November). The duration of sunshine was longest at the beginning and at the end of the growing season. Rainfall and relative humidity were highest in the middle of the growing season (July-September). Disease incidence started from the beginning of growing season with a low figure of 45.3% and kept increasing until all the plants (100%) in trials showed symptoms of viral disease (Table 3).

Associated insects

As shown in Table 4 different insects were trapped and identified. Insects from the order Hymenoptera recorded the highest number of trapped insects (37) including *Compoostus vestitus, Camponotus sericeus.* Fab., *Crematogaster* spp., followed by the order Orthopthera (27) including *Gryllus bimaculatus.* Deg., *Scarsipedus marginatus, Catantops melanostictus* (Table 4). Insects of economic importance trapped included *Aphis glycines* from the order Hemiptera (1), foliage eating beetles (Coleoptera, 14) which included Bean Leaf beetle, Curculionid beetle and Firefly beetle (Table 4).

DISCUSSION

Germination percentage did not differ among most varieties in the trial except for one variety (TGX1835-10f) which also recorded highest incidence and severity of disease and lowest crop yield at the end of harvest. Virus disease symptoms were those of SMV, BPMMV and CPMMV respectively. The presence of important vectors found in this study could have also initiated the viral infection. This is supported by the work of Gibbs et al. (2008) which showed that several of these beetles, including the bean leaf beetle, have been found to transmit the BPMV and CPMV in southern Nigeria.

Many types of insects are found in soybean fields from the orders Hymenoptera and Orthoptera consisting of ants, cricket and grasshoppers but, the biting and chewing insect were more abundant. The ants (Hymenoptera: *Formicidae*) constituted the highest numbers of insects collected in this study. These ants are agriculturally important omnivores, having excellent food recruitment system (Dussutour et al., 2009). They attack wide varieties of crops including legumes (soybean), root crops, cereal and vegetables (Vander Meer, 1986; Morrison et al., 1997). The ants feed on the soybean seed, especially after the seeds have imbibed water, after which they progressively eat the growing stem, cotyledon and roots. Carbohydrate is an important diet of ants.

Table 4. Different orders of insect pests identified on soybean grown.

Order/Scientific name	Common name	Family	Total number of insects trapped
Order: Hymenoptera			
Compoostus vestitus	South Africa ant	*Formicidae*	3
Camponotus sericeus. Fab	Golden backed ant	*Formicidae*	14
Crematogaster spp.	Acrobat ant	*Formicidae*	20
		Total	37
Order: Orthoptera			
Gryllus bimaculatus. Deg	Field cricket	*Gyllidae*	17
Scarsipedus marginatus	Walking cricket	*Gryllidae*	7
Catantops melanostictus	Grasshopper	*Acrididae*	3
		Total	27
Order: Coleoptera			
Nematocerus acerbus	Curculioid beetle	*Curculioidae*	3
Luciola spp.	Firefly beetle	*Lampyridae*	3
Rhizopertha dominica. F.	Lesser grain borer	*Bostrychidae*	3
Onthophagus spp.	Dung beetle	*Scarabachidae*	3
Cerotoma trifurcate	Bean leaf beetle	*Chrysomelidae*	2
		Total	14
Order: Diptera			
Chrysomyia albiceps wied	Blow fly	*Calliphoridae*	6
Ptecticus spp.	Soldier fly	*Strationmyiidae*	4
Glaurocara flava Thorms	Tachnid fly	*Tacchinidae*	2
		Total	12
Order: Heteroptera			
Piezodorus rubrofasciatus. F.	Small stinkbug	*Pentatomidae*	2
Coptosoma spp.	Stinkbug	*Plastaspidae*	1
Nezara viridula.v.	Green stinkbug	*Pentatomidae*	1
Aethus indicus westiv	Black stinkbug	*Cydnidae*	1
		Total	5
Order: Hemiptera			
Aphis glycines	Aphid	*Aphididae*	1
		Grande Total	96

According to research work by Robert et al. (2000), ants associated with seed/seedling germination in the soil, resulted in reduced seedling vigour, 28% less root dry matter, 11% less total dry matter and 81% reduction in the root nodules. The Orthoptera (grasshoppers and crickets) were the next to the Hymenoptera with respect to the number of insects collected. They chew leaves, bore holes in tubers and suck sap from plants as also reported by Wood and Ambridge (1996). If these insects are not controlled, some of them can cause yield loss.

Among the insect pests that cause serious damage are the foliage eaters such as the different beetle species in the order Coleoptera and were the third highest insects encountered. They eat the plant leaves and also transmit viral diseases. Study by Lam and Pedigo (2000) showed that beetles eat and make small round holes in leaves. The seriousness of the damage done is due to subsequent expansion of the holes with the growth of the plant. The leaf beetles attack soybean throughout the season but more intensely in late July and early September in late maturing beans. This study shows that the highest number of insects was recorded during the month of July accompanied by high temperature and rainfall. Aphids, which had already done their damage early in the growing season, were difficult to trap under the high rainfall. Insect pest population can be vastly different from year to year, from area to area and from one variety to another (Hill et al., 2004).

The earlier the soybean is infected with virus, the greater the effect on yield and seed quality which is in agreement with studies by Giesler et al. (2002) which recorded soybean yield reductions of 10 to 40%. Except for variety TGX 1835-10f with very low yield, other varieties have similar level of high yields.

The Homoptera and Hemiptera were found at the lowest level of incidence, yet they are very important vectors in the transmission of viral diseases of soybean. Soybean aphids cause damage by sucking plant sap and trans-mitting viruses through the creation of sooty mold that will reduce photosynthesis. Donaldson and Gratton (2007) reported that symptoms of direct feeding by these insects include plant stunting, pod and flower abortion, reduced seed size and seed count, puckering and yellowing of leaves. The yield loss that is caused by aphids can be influenced by several factors including high aphid population, intense virus transmission, weather variation, reduced number of predators and variety selection of soybean. As a result of this, soybeans must be scouted at intervals throughout the growing season.

Conclusion

Six orders of insects were identified in association with soybean plants in this study. Among the insect pests that caused serious damage are the foliage eaters such as the different beetle species, bugs and aphids. They suck saps of plant and cause leaves to curl or wrinkle. Their ability to transmit plant virus diseases is more harmful than any direct feeding damage. The highest number of insects was recorded during the month of July. Insect pest population can be influenced by factors such as the prevailing weather, population of natural enemies of pests and the variety of soybean planted. As a result of this, soybeans must be scouted for insect pest at intervals throughout the growing season.

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