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Influence of planting date and cultivar on pod-sucking bug infestation and yield of soybean in northern Ghana

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ABSTRACT

Soybean cultivation in Ghana is on a rapid increase because of its importance as food and cash crop. However, its production is constrained by pod-sucking insects that attack the pods and seeds. Field studies were conducted to deterimine the effect of planting date and cultivar on pod-sucking bug (PSB) infestation and yield of soybean. Four soybean varieties, four planting dates and two insecticide spraying regimes were evaluated. The results showed that soybean planted early (i.e. mid-June) suffered less PSB attack resulting in low seed damage and high yields. This suggests that mid-June is the best period to plant soybean to avoid PSBs for maximum yields in northern Ghana. Planting should be completed by mid July to avoid poor yields. The genotypes TGX 1799-8F and TGX 1834-5E consistently suffered less insect attack and can therefore be incorporated in an IPM package because of their relative resistance to insect pests.

1. Introduction

Soybean [*Glycine max* (L.) Merrill] is the world's most important legume in terms of production and trade due to its high content of protein and oil. It has a high nutritive value and important uses such as for human food, animal feed, oil and industrial derivatives (Onwueme and Sinha, 1991; Abdallah, 2012; American Soybean Association, 2017). These characteristics reduce its vulnerability to market fluctuations, storage and transportation costs, and have contributed to a rapid expansion in the area of its cultivation (Kaimowitz and Smith, 2001; Grau et al., 2005). In sub-Saharan Africa, the potential of soybean as a cheap source of protein is the main driving force behind its increased production (Rao and Reddy, 2010).

In the early years of its introduction to Africa, soybean cultivation was relatively free of the insect pests associated with other grain legumes. However, with its increased cultivation over the years insect pests damage has now been widely reported (Jackai and Singh, 1987; Anyim, 2002, 2003; Abudulai et al., 2012). The defoliators *Spodoptera* spp., *Zonocerus variegatus* L. *Sylepta derogata* F., and the Hemipteran pod-sucking bug (PSB) complex including *Nezara viridula* L, and *Riptortus dentipes* F. have been reported as the major insect pests of soybean in Africa (Jackai et al., 1990; Anyim, 2003; Abudulai et al., 2012). Yield losses due to these insects are up to 30% in unprotected soybean fields in Ghana (Abudulai et al., 2012) and 60% in Nigeria (Jackai and Singh, 1987; Anyim, 2003).

Soybean plants have a great capacity to compensate for leaf defoliation by insects at the vegetative stage without yield loss (Hunt et al., 2010). This compensation, however, is limited when insect damage occurs at the reproductive stage such as during podding. PSBs are present in vegetative and reproductive period, but they are most important in reproductive period during which populations are highest due to improved nourishment from pods and damage pods and seeds (Jackai and Singh, 1987; Abudulai et al., 2012; Omoloye et al., 2015). These insects feed on developing pods and seeds resulting in pod and seed abscission, shriveling and decay (Gore et al., 2006; Musser et al., 2011; Abudulai et al., 2012).

Despite the importance of these pests, farmers in Ghana seldom manage insect pests on soybean fields due largely to their inability to purchase recommended insecticides (Abudulai et al. 2012). It is therefore necessary to develop pest management options for soybean that are economically feasible to farmers and yet also effective against insect pests (Luther et al., 1995). Several studies (Sastawa et al., 2004; McPherson et al., 2001, 2008) have shown that sustainable management of insect pests can be achieved when farmers practice early planting and use cultivars that are resistant to insects. Studies in the southern United States showed that early planted soybean escaped from pressure of insect pests and produced higher yields than those planted late (McPherson et al., 2001; Gore et al., 2006). In Nigeria, Omoloye et al. (2015) evaluated the effect of planting date on Hemipteran sucking bugs in soybean and reported that infestations and seed damage were lower in early planted than in late planted crop. Khanzada et al. (2013) studied the relative resistance of ten soybean genotypes to pod-

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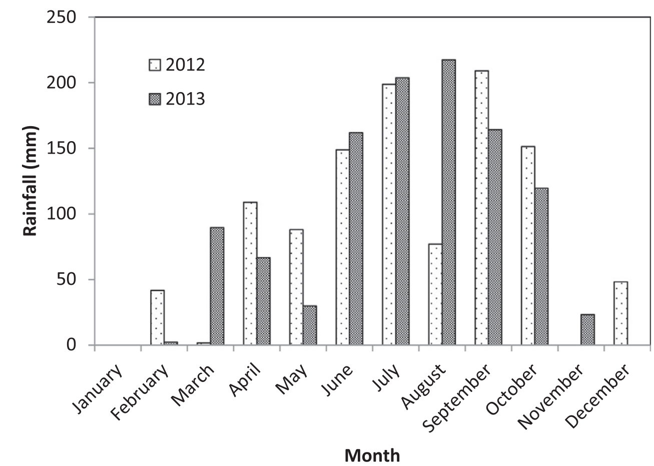

Fig. 1. Rainfall amounts and distribution during the crop growing seasons in 2012 and 2013.

sucking insect pests. They reported that two genotypes, PR-142 and AGS-9, were relatively resistant while the other genotypes ranged from susceptible to moderately resistant. Jackai et al. (1988) found TGx 713-09D, TGx 307-048D, TGx 306-036C and TGx 814-036D as manifesting high levels of field resistance to stink bugs in Nigeria.

The objective of the present study was to develop a sustainable integrated pest management (IPM) strategy for soybean farmers in the Guinea Savanna zone of Ghana by exploiting host plant resistance in existing cultivars and different planting dates.

2. Materials and methods

2.1. Study area

Field experiments were conducted at the research farm of the CSIR-Savanna Agricultural Research Institute (9°42′ N, 0°92′ W; 184 m ASL) in northen Ghana during the 2012 and 2013 growing seasons. The area has a unimodal rainfall pattern that falls between May and October of each year. The rainfall amount and distribution in the two years of the study are presented in Fig. 1. The rainfall amounts were not very different between the years, but it was better distributed in 2013 than in 2012. The rainfall amount in August was 77.0 mm in 2012 compared with 217.4 mm for the same month in 2013. The soils at the experimental site were of sandy loam texture.

2.2. Experimental design and treatments

The experiment was laid in a randomized complete block design with split-split plot arrangement of treatments. The treatments tested comprised four planting dates as main plots, four soybean cultivars of different maturity periods as sub plots within main plots and two insecticide spraying regimes as sub-sub plots. The planting dates were mid June, late June, mid July and late July. Planting for mid June was made between 13 and 17 June, late June between 26 and 30 June, mid July between 13 and 17 July and late July between 26 and 31 July in each year. Late June is the normal planting time for soybean in northern Ghana. The soybean genotypes/cultivars used were TGX 1799-8F (early maturity), TGX 1834-5F (medium maturity), Jenguma (medium maturity) and Salintuya II (late maturity). Jenguma and Salintuya II were released soybean varieties while TGX 1799-8F and TGX 1834-5F were elite genotypes being evaluated for release to farmers. The insecticide spraying regime treatments were sprayed and unsprayed. One row of sorghum (*Sorghum vulgaris* L) was planted between spray treatments to minimize drift from insecticide sprays. Sub-sub plots were each of 15 m^2 area and consisted of six rows, 5 m long. Inter and intra row distances of 0.60 m and 0.10 m, respectively, were maintained. Plots were separated by 1 m and blocks by 2 m alleys. Insecticide protection was made twice at R2 (full bloom) and R5 stage (beginning seed) (soybean development stages described by Fehr and Caveness, 1977). The protection was accomplished using one of the recommended insecticides, cypermethrin 10 E.C, applied at the rate of 0.02 kg ai/ha. Spray applications were made using a CO_2-pressurized backpack sprayer fitted with Teejet cone nozzles (Spraying systems Co., Wheaton, IL, USA). Except for treatment applications, all the recommended agronomic practices for soybean were similar for all plots. After planting in each year, a combination of the total weed killer herbicide glyphosate and pendimethalin pre-emergence were applied at the rate of 0.91 kg ai ha^{-1} followed by hand weeding three weeks later to control weeds. No fertilizer of any kind was applied to treatment plots.

2.3. Data collection

Pod-sucking bugs were sampled weekly from flowering (R1) until pod maturity (R8) (Gore et al., 2006). The samples were taken from the inner two rows of each plot using a 1 m^2 beat cloth (Kogan and Herzog, 1980). Two sites were sampled in each plot by placing the cloth between rows, bending the plants from one row over and beating them downward to dislodge insects onto the cloth. The PSBs recorded included *Nezara viridula* L. *Thyanta* sp. *Riptortus dentipes* F. *Anoplocnemis curvipes* F. and *Aspavia armigera* F., with *N. viridula* being the most dominant and constituting about 70% of all the insects. Since they inflict a common damage, the PSBs were recorded as one pest guild (Afun et al., 1991). At maturity, pods were harvested from the middle four rows of plots. The pods were shelled to determine percentage PSB seed damage and yield. Shriveled and decayed seeds were considered damaged by PSBs.

2.4. Statistical analysis

Data were analyzed using analysis of variance (ANOVA) for split-split plot using the SAS Statistical Software (SAS Institute, 2003). Planting date, variety and insecticide spray treatments were considered as fixed effects while replications and years were treated as random variables in determining expected means squares and appropriate F-statistics. The pdiff option of SAS was used in the LSMEANS statement to calculate differences between treatment means using the standard error of differences at $P < 0.05$. Insect counts and percentage damage data were subjected to square root transformation to normalize variances before analysis (Gomez and Gomez, 1983).

3. Results

There were significant effects of year and year × planting date interaction on populations of PSBs (Table 1). The interaction of year × planting date × variety was also significant. The populations were generally higher in 2012 than in 2013 (Table 2). When averaged across varieties, the populations were lower when planted early or from mid June to mid July than when planted late or late July in 2012; they were more in early planted soybean in 2013. In 2012, the populations were lowest on TGX 1799-8F when planted in mid June and on TGX 1834-5E when planted in late June. For 2013, the populations on all varieties generally were the lowest when planted in late July.

A significant effect of year, planting date, variety and insecticide spraying regime separately, was measured for percentage seed damage (Table 1). The percentage seed damage also was significantly affected by the interactions of year × planting date, planting date × variety, year × insecticide spraying regime, planting date × insecticide spraying regime and variety × insecticide spraying regime. In addition, the 3-way interactions of year × planting date × variety and year × planting date × insecticide spraying regime were significant. Averaged across varieties, seed damage was lower when planted from mid June to