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ON-FARM ASSESSMENT OF S*podoptera frugiperda* (LEPIDOPTERA: NOCTUIDAE) INFESTATION AND DAMAGE TO EARLY-WHORL AND LATE-WHORL MAIZE IN A SOUTHERN GUINEA SAVANNA AGRO-ECOLOGY

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Abstract[1]
Maize, Zea mays L. is an important cereal crop in Nigeria whose production has, in recent times, been constrained by the fall armyworm, Spodoptera frugiperda – a highly destructive trans-boundary and euryphagous lepidopterous insect pest. Information on the susceptibility of maize to infestation and damage at different stages of development will aid development of appropriate integrated pest management strategies for S. frugiperda but this is scanty in major maize-growing agro-ecological zones of Nigeria. To bridge the knowledge gap, this study assessed S. frugiperda infestation and damage severity on early and late-whorl maize. In Kwara State, Ilorin-south and Moro Local Government Areas (LGA) located in the southern guinea savanna agro-ecological zone were purposively selected. In each LGA, two farms with early-whorl (1 – 3 weeks old) and two with late-whorl (5 – 7 weeks old) maize plants were randomly chosen. On each farm, 20 plants were randomly sampled and assessed for presence or absence of larval infestation and frass, and for foliar-damage-severity using standard-rating-scale of zero to five. Irrespective of developmental stage, plants were generally observed to have moderate infestation (45.0%). More plants with larval frass were found at the early-whorl stage (82.5%) than at the late-whorl stage (71.3%). The percentage of plants with foliar damage at the late-whorl stage (82.5%) was slightly higher than at the early-whorl stage (81.5%). Damage severity scores on early-whorl plants (1.26) was not significantly different ($p>0.05$) from late-whorl plants (1.21). Information provided would inform pest management intervention for S. frugiperda.

Keywords: *maize, fall armyworm, foliar damage severity, southern guinea savanna larval frass*

Introduction

Maize, *Zea mays* L. is the second most important cereal crop in the world after wheat and a major component in the diet of more than 300 million people in sub-Saharan Africa (FAOSTAT, 2018). Globally, about 116 million tons of maize is consumed per year with sub-Saharan Africa (SSA) accounting for 21% of global consumption. Maize is also a source of raw material for industries including those involved in the production of animal feed, ethanol, biodiesel etc. (Iken and Amusa, 2004; Abdulraham and Kolawole, 2006). Maize is therefore a major staple food crop that contributes to food security and poverty alleviation in the world.

Despite being a valuable crop with great potentials to ameliorate hunger and assure food security, maize production is constrained by a number of factors. Low maize yield has been attributed to a combination of various production constraints especially the lack of improved production technologies, moisture stress, low soil fertility, poor cultural practices and pest infestations (Tufa and Ketema, 2016). Insect pests belonging to more than 40 species have been implicated in the low yields output experienced in maize production. In 2016, the fall armyworm, *Spodoptera frugiperda* J. E. Smith – an invasive lepidoperous insect pest (Goergen et al., 2016) was reported in Africa for the first time. The insect has a highly euryphagous larva (Montezano et al., 2018) that primarily attacks maize in Africa (Prasanna et al., 2018) where it has reportedly caused significant yield losses of about 20 million tons (ICIPE, 2020).

Unlike other parts of Africa where substantial studies on the genetic characteristics, socio-economic impacts, and management options for fall armyworm having been conducted (Cock et al., 2017; Day et al., 2017; Bateman et al., 2018; Midega et al., 2018), only few studies have provided empirical-based information about the pest in Nigeria. Odeyemi et al. (2020) investigated the infestation and damage severity of fall armyworm on maize in the humid forest and derived agro-ecological zones of Nigeria, and reported extensive infestation and foliar damage severity. Ojumoola et al. (2022) working in a derived guinea savanna agro-ecology also reported that commonly cultivated maize varieties in Nigeria showed partial resistance to seasonal fall armyworm infestation and damage especially at the early-whorl growth stage. Nevertheless, the status of infestation and damage to field maize at different growth stages in other agro-ecological zones of Nigeria remain unknown. Different agro-ecological zones are known to have distinctive agro-climatic conditions that influence seasonal pest occurrence

and abundance (Day et al., 2017; Patel et al., 2017), which in turn informs the development of effective integrated pest management programs (Phillips et al., 2017). To bridge the knowledge gap, a survey of fall armyworm infestation and damage severity to early and late-whorl maize was conducted on farmers' fields in a southern guinea savanna agro-ecological zone of Nigeria. Considering anecdotal and empirical reports that very young maize seems to be more heavily infested (Prasanna et al., 2018; FAO, 2018a; Ojumoola et al., 2022), it was hypothesized that early-whorl maize would be more susceptible to fall armyworm infestation than the late-whorl in the focus agro-ecological zone. Information on the susceptibility of maize to infestation and damage at different stages of development will aid development of appropriate integrated pest management strategies for *S. frugiperda* in the southern guinea savanna agro-ecology.

Materials and Methods

Study Area

The study was conducted in the southern guinea savanna agro-ecological zone of Kwara state, Nigeria. The state is located in the North Central part of Nigeria which mainly comprises the northern guinea savanna and southern guinea savanna agro-ecological zones. The southern guinea savanna zone receives between 1000 and 1500 mm of annual rainfall (Oriola *et al,* 2010).

Sampling Procedure

Out of the 16 Local Government Areas (LGA) in the state, two LGAs namely Ilorin-south and Moro were purposively sampled based on their location in a southern guinea savanna agro-ecological zone. In each LGA, two communities were randomly chosen, after which two farms were selected from each community. In each community, one farm with plants between one and three weeks old (i.e. early-whorl maize plants), and which had not been sprayed with insecticides was purposively selected. The second farm selected from each community had maize plants between five and seven weeks old (i.e. late-whorl maize). In all, a total of eight farms (Table 1) were sampled for the study in the southern guinea savanna zone of the state in late maize planting season (October and November, 2021).

Table 1. Agro-ecological zones and location of on-farm assessment of infestation and damage to maize by the fall armyworm, *Spodoptera frugiperda* in southwest Nigeria

Local Government Area (LGA)	Community	Geolocation Information
Moro	Shao	8°36'21.04"N 4°32'43.93"E
	Okete	8°41'39.51"N 4°29'59.21"E
		8°42'14.77"N 4°28'56.85"E
Ilorin-South	Unilorin	8°28'05.88"N 4°39'48.96"E
		8°28'23.80"N 4°37'34.52"E
	Ilorin-Ajase-Ipo	8°23'49.06"N 4°39'45.65"E
		8°24'36.64"N 4°38'09.12"E

On each farm, 20 maize plants were randomly selected for assessment using the 'W' or 'Ladder' sampling method described by McGrath *et al.* (2018) for early or late whorl maize, respectively.

Assessment of Fall Armyworm Infestation and Damage to On-farm Maize

Each plant sampled was visually assessed for presence (1) or absence (0) of *S. frugiperda* larval infestation, and larval frass. In addition, plants were assessed for severity of foliar damage due to larval feeding. Foliar damage severity was scored on a 0 – 5 visual scoring scale (Dal Pogetto *et al.,* 2012). Based on the scale, plants without damage were scored 0; plants with erasure leaves were scored 1; plants with pin holes or shot holes due to larval feeding were scored 2; plants with significant number of holes and some whorl damage were scored 3; plants with the whorl completely eaten off or destroyed were scored 4; and a score of 5 was awarded to dead plants.

Data Analysis

Binomial data on the presence of larval infestation and larval frass were expressed as percentage values (0% or 100%), and summarized using means. Similarly, data on damage severity was summarized with means. Mean comparison of early and late whorl groups was done using independent sample t-test at 5% level of significance. All descriptive and inferential statistics was done in Microsoft Excel (Microsoft Office Excel, 2019).

Results

Regardless of development stage, maize plants in the present study generally had below average larval infestations (45.0%), which were the same on early-whorl and late-whorl plants (Fig. 1). Furthermore, more plants in the early-whorl growth stage (82.5%) had *S. frugiperda* larval frass compared to those in the late-whorl (71.3%) stage (Fig. 2). Irrespective of growth stage, more than 80 percent of maize plants had one form of foliar damage or the other (Fig. 3). However, in comparison to late whorl maize plants (82.5%), higher percentage of early whorl maize plants (87.5%) sustained foliar damage due to feeding by *S. frugiperda* larvae. Generally, foliar damage severity was low with most plants having erasure leaves or window pane effects and feeding holes (Fig. 4). Though mean foliar damage severity was higher on early-whorl (1.26) than on late-whorl (1.21) maize plants, no significant difference ($p>0.05$) was found in foliar damage severity caused by *S. frugiperda* larvae at the two vegetative growth stages (Fig. 4).

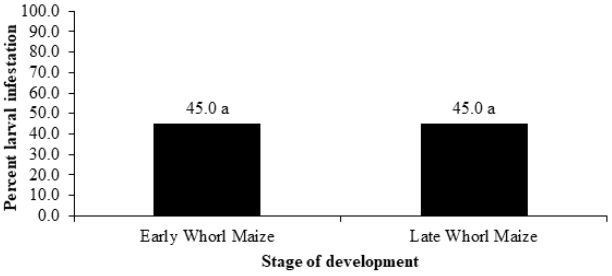

Figure 1: Percentage infestation of fall armyworm, *Spodoptera frugiperda* larvae on early and late whorl maize

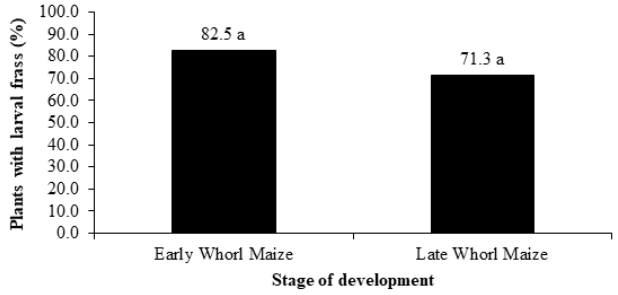

Figure 2: Percentage number of early and late whorl maize plants with fall armyworm, *Spodoptera frugiperda* larval frass

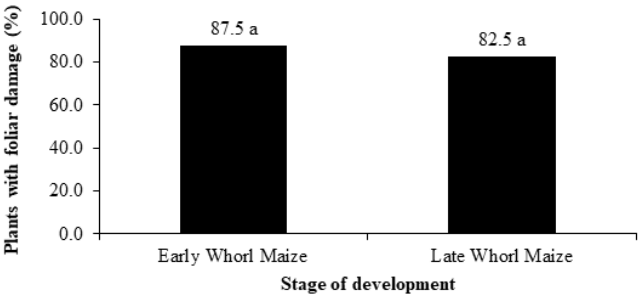

Figure 3: Percentage of early whorl maize plants with fall armyworm, *Spodoptera frugiperda* foliar damage

Figure 4: Severity of foliar damage by fall armyworm, *Spodoptera frugiperda* on early and late whorl maize

Discussion

On-farm infestation and damage of maize by *S. frugiperda* larvae starts with the deposition of egg-masses on the abaxial or adaxial sides of maize leaves. On hatching, neonate larvae initially feed together in groups but eventually disperse across the entire farm after a few days (Rojas et al., 2018). While no egg masses were found in the present study, sufficient evidence of infestation and foliar damage by *S. frugiperda* larvae were found on all maize farms surveyed in the present study. Maize plants were generally infested and damage by the fall armyworm larvae irrespective of vegetative growth stage. This shows that both early whorl and late whorl maize can be infested and damaged by the pest. Usually, eggs are laid when maize seedlings are at the two- or three-leaf stage (Prasanna *et al.*, 2018; FAO, 2018a) but damage may continue over the growing period owing to repeated egg-laying cycles that result in overlapping generations of larvae on the same plant (Prasanna *et al.*, 2018). Severity of observed foliar damage is, however, a function of larval size amongst other factors. According to CABI (2020), *S. frugiperda* damage may range from scraped or erasure leaf surfaces caused by very young larvae to complete destruction of whorls and stems by the mature larvae. Older larvae are also known to be capable of inflicting serious damage to developing tassels and kernels during the reproductive growth phase (Midega *et al.,* 2018; Prasanna *et al.,* 2018).

Agro-ecological zones in Africa are expected to support development and seasonal occurrence of the fall armyworm to varying extent owing to their different agro-climatic conditions (Day et al., 2017; Patel *et al.,* 2017; Huesing et al., 2018). Odeyemi et al. (2020), for instance recorded higher *S. frugiperda* damage severity in the humid forest zone of Nigeria than in the derived savanna agro-ecological zone. In the present study, the level of larval infestations and foliar damage severity on plants at the early whorl stage was not different from those of plants at the late-whorl stage in a southern guinea savanna agroecology. In contrast, Ojumoola et al. (2022) working in a derived guinea savanna agro-ecology reported significantly higher abundance of *S. frugiperda* larvae on maize plants at the third week (early whorl) than at the seventh (late whorl) week after planting. The same authors, however, reported comparable severity of damage on plants at the vegetative stage regardless of whorl-stage. It is important to note that most evidence of foliar damage observed on plants at the late whorl stages may be artifacts of damage sustained at the early-whorl growth stage and that observed damage at that stage may not always be due to ongoing larval infestations (Ojumoola et al., 2022).

The occurrence of larval infestations at the early- and late-whorl stages in the present study holds significant implications for pest management as it suggests that management strategies may need to span the entire vegetative growth phase. Nevertheless, since maize damage severity at both growth stages was generally mild in the present study, *S. frugiperda* management strategies in the southern guinea savanna agro-ecology may not depend on exclusive pesticide application, as would be needed in the case of an outbreak (Dinham, 2003). Instead, effective management of the fall armyworm in the agro-ecology could be achieved through the use of an integrated pest management approach that consists of carefully selected non-chemical pest management strategies including the cultivation of tolerant varieties (Ojumoola et al., 2022); periodic farm scouting and pest monitoring (FAO, 2018a), climate adapted push-pull system (Midega et al., 2018) and other sustainable methods including those that increase the populations of natural enemies in maize systems (Day et al., 2017; Bateman et al., 2018; FAO, 2018b).

Conclusion and Recommendations

Findings in this study show that the fall armyworm is a key insect pest of both early- and late-whorl maize in the southern guinea savanna agro-ecological zone of Kwara State. Nevertheless, damage severity seems to be mild at both the early- and late-whorl vegetative growth stages. It is thus recommended that exclusive use of insecticides for fall armyworm management be avoided and an integrated pest management approach adopted in the agro-ecology. Further

studies will be needed to provide more information on fall armyworm infestation and damage severity on maize at different growth stages in the early planting season of southern guinea savanna agroecology.

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