



EVALUATION OF VEGETATIVE GROWTH STAGE SUSCEPTIBILITY OF QUALITY PROTEIN MAIZE TO FALL ARMYWORM (*Spodoptera frugiperda* SMITH) INFESTATION

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Abstract

Screen-house experiments were conducted during the 2020 and 2021 wet seasons at the Department of Crop Protection, Ahmadu Bello University, Zaria, Nigeria, to determine the susceptibility of different vegetative growth stages of Quality Protein Maize (QPM) variety SAMMAZ 36 to damage by the fall armyworm (*Spodoptera frugiperda*). The experiments were laid out in a Completely Randomized Design (CRD) with three replications. Maize plants were grown in plastic pots placed inside wooden cages and artificially infested with six second-instar larvae at early-whorl (V4), mid-whorl (V8), and late-whorl (V12) growth stages corresponding to 2, 4, and 6 weeks after emergence, respectively. Leaf damage was assessed at one and two weeks after infestation using a 1–5 rating scale, while cob damage and grain yield were evaluated at maturity. Results from both seasons showed that plants infested at the early-whorl stage have significantly higher leaf damage ratings (3.25) compared to mid- and late-whorl stages. In contrast, the late-whorl stage had the highest cob damage rating (3.00) and the lowest grain yield. The findings indicate that the early-whorl stage is the most susceptible to foliar damage, while infestation at the late-whorl stage results in greater cob damage and yield reduction. The study concludes that effective fall armyworm management should commence at early vegetative stages and be sustained through later stages to minimize economic losses in QPM production.

Keywords: Fall Armyworm; Quality Protein Maize, Early, Mid, Late-whorl Vegetative Growth Stage

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INTRODUCTION

Maize is one of the most important cereal crops grown in the Northern Guinea and Sudan Savanna ecological zones of Nigeria, where it is cultivated under both rain-

fed and irrigated conditions (Ado, 1999). Approximately half of global maize production occurs in developing countries, where maize serves as a staple food for millions of people. The maize kernel is composed of 70–75% starch, 9–12% protein, 4.5% oil, and small quantities of minerals and vitamins (Bello *et al.*, 2024). The nutritional

quality of maize depends largely on the composition and balance of essential amino acids. Although maize contains all essential amino acids, it is generally deficient in lysine and tryptophan (Oladejo and Akinwale, 2024). This deficiency has contributed to widespread protein malnutrition in many developing countries (Maqbool *et al.*, 2024). Quality Protein Maize (QPM) varieties contain higher levels of lysine and tryptophan and therefore offer improved nutritional value compared to conventional maize (Sani *et al.*, 2024).

Despite its importance, maize production is constrained by several biotic and abiotic factors, among which insect pests remain a major challenge. The fall armyworm (*Spodoptera frugiperda*) has recently emerged as one of the most destructive pests of maize in Africa. Yield losses of up to 73% have been reported in severely infested fields (Usamn, 2023; Gadekar *et al.*, 2025; Kandeh *et al.*, 2025). The pest attacks maize at all growth stages, causing severe defoliation and damage to developing ears. Although FAW damage has been widely reported, there is limited information on the specific vegetative growth stages of QPM that are most susceptible to attack. Understanding stage-specific susceptibility is essential for developing effective and targeted management strategies. Therefore, this study was conducted to determine the vegetative growth stages of SAMMAZ 36 QPM that are most susceptible to fall armyworm damage.

MATERIALS AND METHODS

Experimental sites

The experiments were conducted during the 2020 and 2021 wet seasons at the screen-house of the Department of Crop Protection, Ahmadu Bello University, Samaru, Zaria

(11°10'N, 07°37'E) located in the Northern Guinea Savanna zone of Nigeria.

Collection and rearing of fall armyworm larvae

Fall armyworm larvae used for the experiment were obtained from the insect rearing laboratory of the Department of Crop Protection, Ahmadu Bello University, Zaria. The larvae were reared on artificial diet following the protocol of the International Maize and Wheat Improvement Center (CIMMYT) as adapted from Tefera *et al.* (2011).

Bulk rearing of fall armyworm larvae

Prepared artificial diet consisting of maize flour 25.2g, soybean flour 88.4g, brewer's yeast 22.7g, sugar 35.5g, agar 12.6g, vitamin mixtures (2.0g), sorbic acid 1.3g, methyparabenzic 2.0g, ascorbic acid 2.5g and water 100ml. The ingredients were mixed with distilled water and cooked to form a homogenous diet, which was allowed to cool before being provided to the larvae. The diet was renewed regularly to maintain freshness and prevent contamination. (200 g) was placed in plastic rearing jars, and 100 neonate larvae were introduced into each jar using a camel hair brush. The jars were maintained at room temperature (28 ± 2 °C) and relative humidity of $70 \pm 5\%$. Larvae were monitored daily and second-instar larvae were selected for infestation of maize plants.

Screen-house experiment

Maize seeds (SAMMAZ 36) were planted in plastic pots filled with sterilized loamy soil. Two seeds were sown per pot and later thinned to one plant per pot two weeks after emergence. Pots were placed in wooden cages measuring 2.0 m × 1.0 m × 0.5 m to prevent external infestation. Plants were infested with six second-instar larvae at three vegetative growth stages:

Early-whorl stage (V4) – 2 weeks after emergence

Mid-whorl stage (V8) – 4 weeks after emergence

Late-whorl stage (V12) – 6 weeks after emergence

The experiment was arranged in a Completely Randomized Design (CRD) with three replications.

Data Collection

Leaf Damage Rating

Leaf damage was assessed one and two weeks after infestation using the 1–5 scale (Table 2) described by Fernández and Expósito (2000).

Table 1: Assessment scale for foliar damage due to fall armyworm in maize

Score/Rating	Damage symptoms/description
1	No evident damage, or less than 1-3 pinhole type injuries
2	More than 3 pinhole injuries, and/or 1-3 injuries less than 10 mm each
3	More than 3 injuries less than 10 mm, and/or 1-3 injuries larger than 10 mm each (shothole type injuries)
4	3 to 6 shothole injuries, and/or at lowest 50% of the whorl destroyed
5	More than 6 shothole type injuries, and/or whorl totally destroyed

Source: Fernández and Expósito (2000)

Cob Damage Rating

Cob damage at harvest was rated using a modified 1–5 scale (Table 2) adapted from Davis and Williams (1992).

Table 2: Modified scale for assessment of cob damage due to fall armyworm in maize

Score/Rating	Damage symptoms/description	Response
1	No damage to the ear	Highly resistant
2	Damage to a few kernels (1-15) or less than 10 % damage to an ear	Resistant
3	Damage to 16-50 kernels or less than 25 % damage to an ear	Partially resistant
4	Damage to 51-100 kernels or more than 50 % but less than 60% damage to an ear	Susceptible
5	Damage to >100 kernels or 60 – 100 % damage to an ear	Highly susceptible

Source: Modified Davis and Williams (1992)

Grain Yield

Grain yield per pot was recorded at harvest and extrapolated to kilograms per hectare.

Statistical Analysis

Data collected were subjected to Analysis of Variance (ANOVA) using SAS software (version 9.4). Means were separated using Student Newman Keuls (SNK) test at 5% probability level.

RESULTS

Susceptibility of vegetative growth stages of SAMMAZ 36 Quality Protein Maize to FAW damage

In 2020, the early-whorl growth stage of SAMMAZ 36 differed significantly from mid-whorl and late-whorl growth stages in leaf damage rating at one and two weeks after infestation (Table 3). On the other hand, the late-whorl growth stage had higher cob damage rating (3.00), followed by the mid-whorl growth stage (2.67) while the early-whorl growth stage (2.25) had the

lowest significant cob damage rating. The cob damage rating of the mid-whorl and late-whorl growth stages are statistically similar. Grain yield was significantly highest at the early-whorl growth stage than the mid-whorl while the late-whorl growth stage had the lowest grain yield.

In 2021, the effect of FAW damage at the different growth stages of SAMMAZ 36 showed that plants infested at the early-whorl (V4) growth stages had significantly higher leaf damage ratings at one and two weeks after infestation than those infested at mid-whorl and late-whorl growth stages (Table 4). The late-whorl (V12) growth stage had lower leaf damage ratings at one and two weeks (1.50 and 2.42) after infestation respectively. In contrast, higher cob damage rating was observed at late-whorl growth stage (3.00), even-though it did not significantly differ from the mid-whorl growth stage (2.75), while the early-whorl growth stage had the lowest (2.25). Grain yield of plants infested at the early-whorl growth stage was higher (3511.02 kg/ha) and significantly differed from that of mid-whorl growth stage (2888.83 kg/ha), while the late-whorl growth stage had the lowest (2444.77 kg/ha) grain yield.

Table 3: Effect of fall armyworm damage on the different growth stages of SAMMAZ 36 Quality Protein Maize Evaluated in 2020

Growth stage	Leaf damage rating after infestation		Cob damage rating	Grain yield (Kg/ha)
	1 st week	2 nd week		
Early growth stage	2.58a	3.25a	2.25b	3195.49a
Mid growth stage	2.08b	2.67b	2.67a	2706.65b
Late growth stage	1.67c	2.25c	3.00a	2311.07c
L.S. D	0.21	0.54	0.36	369.63
SE±	0.074	0.189	0.126	129.695
P-value	<.0001	<.0001	<.0001	<.0001

Mean followed by different latter in the same column are significantly different at 5% level of probability by students Newman's Keuls (SNK)

Table 4: Effect of fall armyworm damage on the different growth stages of SAMMAZ 36 Quality Protein Maize Evaluated in 2021

Growth stage	Leaf damage rating after infestation		Cob damage rating	Grain yield (Kg/ha)
	1 st week	2 nd week		
Early growth stage	2.42a	3.25a	2.25b	3511.02a
Mid growth stage	1.92b	2.67b	2.75a	2888.83b
Late growth stage	1.50c	2.42b	3.00a	2444.77c
L.S. D	0.81	0.54	0.33	259.80
SE±	0.284	0.189	0.116	91.158
P-value	0.0001	0.0001	0.0023	<.0001

Mean followed by different latter in the same column are significantly different at 5% level of probability by students Newman's Keuls (SNK)



Plate Ia: Growth stage V4 infested with 6 larvae of fall armyworm



Plate Ib: Growth stage V8 infested with 6 larvae of fall armyworm



Plate Ic: Growth stage V12 infested with 6 larvae of fall armyworm

V4: 2 week after emergence

V8: 4 week after emergence

V12: 6 week after emergence

Plate I (a-c): Damage caused by six larval densities of fall armyworm at early, mid and late growth stages of SAMMAZ 36 QPM planted at the screen house in 2020/2021 wet seasons

DISCUSSION

This study demonstrated that the susceptibility of SAMMAZ 36 maize to fall armyworm (FAW) damage is strongly influenced by the growth stage at the time of infestation. Maize plants infested at the early-whorl stage experienced significantly higher levels of leaf damage compared to those infested at mid- and late-whorl stages. The greater damage observed at early growth stages can be attributed to the tender and succulent nature of young leaves, which are more palatable and suitable for larval feeding.

These findings are consistent with earlier reports by Pannuti *et al.* (2016) and Kuate *et al.* (2019), who similarly observed higher FAW injury on younger maize plants. However, the results differ from Britz (2020), who reported no significant variation in FAW susceptibility across growth stages. As maize plants matured, leaf damage declined while cob damage increased. Plants infested at the late-whorl stage recorded the highest cob damage severity and corresponding yield reductions. This shift in damage pattern reflects changes in FAW feeding behavior as

plant tissues age. Older maize leaves become tougher and less suitable for larval feeding due to increased structural hardness and higher calcium content, as reported by Lietti *et al.* (2005) and Tanaka *et al.* (2024). Consequently, larvae tend to migrate from foliage to developing ears during the reproductive stages, resulting in direct damage to cobs and greater economic losses.

The present findings agree with Caparros *et al.* (2013), who noted that increased leaf hardness associated with plant aging reduces foliar feeding by FAW. Similarly, Tao *et al.*, (2024) and Pannuti *et al.* (2016) reported that although young leaf tissues support larval growth, mature plants force larvae to concentrate feeding on ears and silks. Anega and Birhane (2025) also observed that late-stage infestations cause lower foliar injury but greater ear damage. This pattern is further supported by IITA (2016), which emphasized that FAW infestations during later maize growth stages result in more severe yield losses than infestations occurring earlier. Overall, the study highlights that the timing of FAW infestation plays a critical role in determining the nature and severity of damage on maize. Early infestations primarily cause defoliation, whereas late infestations lead to substantial cob damage and yield reduction. These findings underscore the importance of growth stage-specific management strategies for effective control of FAW in maize production.

CONCLUSION

The study revealed that the early-whorl (V4) and late-whorl (V12) vegetative stages of SAMMAZ 36 are the most susceptible to fall armyworm damage. Early infestation mainly results in severe leaf damage, while late infestation causes greater cob damage and yield loss. Effective FAW management strategies should therefore begin at the early vegetative stage and continue

through later stages to minimize economic losses in Quality Protein Maize production.

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