Assessment of the susceptibility of different cereal grains to *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae) in Katsina state, Nigeria

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Abstract

Investigations were carried out to assess the susceptibility of local varieties of some selected local varieties of cereal crops namely maize, rice and sorghum to the maize weevil, *Sitophilus zeamais* Motsch. Five pairs of unsexed adults of the weevils were introduced into rearing bottles containing 100 g of each type of clean and disinfested grains in Postgraduate Laboratory of the Department of Biology of Umaru Musa Yar'adua University, Katsina (UMYUK) at 27±2ºC and 65±5% (RH). The experiment was arranged in a Completely Randomized Design (CRD) and replicated five times. Adult emergence, mean developmental periods, grain weight loss, index of susceptibility of the weevils and concentration of body protein of *S. zeamais* were investigated. Highest number (194.60 ± 1.21) of emerged adults of the weevils was recorded in sorghum, while the least (88.80 ± 1.75) was in rice. The longest developmental period (27.51 ± 1.21 days) of the weevil was in sorghum, while the shortest (25.63 ± 1.36 days) in maize. Grain weight loss due to infestation of *S. zeamais* ranged from 5.42 ± 2.32% in rice to 7.48 ± 3.12% in sorghum. The index of susceptibility showed that both maize and sorghum were susceptible, while rice was moderately resistant to *S zeamais.* Farmers are advised not to store sorghum and maize for a relatively long period of time over rice variety in a mix storage system.

Keywords: Adult emergence, Cereal grains, *Sitophilus zeamais*, Resistance, Susceptibility

1. Introduction

Cereal grains such as maize, sorghum, rice, barley, millet, oats and wheat are described as an essential dietary components providing substantial amount of nutrients including vitamins, minerals, dietary fibre, protein and complex carbohydrates for human and animal consumption particularly in developing and underdeveloped countries of the world. However, the health benefits of these grains' nutritional compositions are very paramount for human consumption (Hallman, 2001) [1].

Maize is one of the most vital cereal crops used in the human diet in large parts of the world and an important feed component for livestock. It also serves as raw material for manufacture of many industrial products such as corn starch, corn oil, corn syrup and products of fermentation and distillation industries (Yadesa and Diro, 2023) [2].

Sorghum is also one of the cereals that constitute a major source of proteins, calories and minerals for millions of people in Africa and Asia. The crop is rich in minerals but with bioavailability vary from less than 1% for some forms of iron to greater than 90% for sodium and potassium (Dahlberg *et al.*, 2011) [3].

Rice is a staple food for over half of the world's population and the most important among cereal crops (Fakagawa and Ziska, 2019) [4]. Rice is very important grain in Nigeria because of the various ways it can be used (Mohammed *et al.*, 2019) [5].

Insect pests are a key constraint to effective production and utilization of cereal crops in sub-Saharan Africa (SSA), and post-harvest losses resulting from insect remain a huge challenge (Benjamin *et al.*, 2024) [6]. The attack may cause loss and damages to the commodity both qualitatively and quantitatively (Ojo and Omoloye, 2016) [7]. Insect infestation causes loss in dry mass of the kernels, nutritional composition and, if the seeds are heavily damaged reduction in germination potential (Hallman, 2001) [1].

The maize weevil, *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae), is one of the most destructive stored product pests of grains, cereals, and other processed and unprocessed stored products in sub-Saharan Africa (Ojo and Omoloye, 2016) [7]. This storage pest causes qualitative and quantitative damage to stored products, with grain weight loss ranging between 20 to 90% for untreated stored maize and the severity of damage depends on factors which include storage structures and physical and chemical properties of the produce (Muzemu *et al.*, 2013) [8]. Heavy infestation of adults and larvae of maize weevil which cause postharvest losses have become increasingly important constraints to storage entomology and food security in the tropics (Ojo and Omoloye, 2016) [7].

2. Materials and methods

2.1 Collection of selected grains

Three (3) different grains were obtained from Katsina central market, Nigeria. All the three selected grains were local varieties namely "Fana", "Yar Dashe" and "Jar Kaura" for maize, rice and sorghum grains, respectively. The grains were disinfested in a refrigerator for five days.

2.2 Insect culture

A parent stock of *S. zeamais* was obtained from Institute of Agricultural Research (IAR), Ahmadu Bello University (ABU) Zaria, Nigeria. Twenty five (25) pairs of *S. zeamais* were introduced into rearing bottles containing 200 g of disinfested maize grains. These bottles were covered with a net to allowed ventilation and also prevent the weevil from escape. The set up was kept in the incubator for oviposition under 27 ± 2°C and 65 ± 5% RH. The introduced weevils were sieved out after 14 days (Suleiman *et al.*, 2013) [9]. The set up was arranged in a completely randomized design (CRD) and replicated five times. The bottles were left in the laboratory for newly emerged adults (F_1 progeny). The subsequent offspring freshly emerging of one to seven days old were used for the experiment.

2.3 Examination of adult emergence of *S. zeamais* in maize, rice and sorghum grains

Adults emerging from each replicate of the grains were removed, counted and recorded daily from the respective bottles for five (5) weeks. Collected data were pooled to arrive at the total number of adults emerged from each replicate (Suleiman *et al.*, 2013) [9].

2.4 Determination of mean development period of *S. zeamais* in maize, rice and sorghum grains

The mean development period of the test insect was calculated using the following formula (Howe, 1971) [10]:

$$D = \frac{\Sigma\,(A \times B)}{C}$$

Where,
A = Number of adults emergence per day.
B = 'n' days required for their emergence
C = Total number of adults emerged during the experimental period.
D = Mean development period (Days)
Σ = Sum total of A and B

2.5 Assessment of weight loss in grain types infested by *S. zeamais*

After complete emergence of the weevils, the grains were weighed again separately. The weight lost due to infestation was calculated by subtracting the final weight from the initial weight of the grains and multiplied by one hundred.

2.6 Determination of index of susceptibility of maize, rice and sorghum grains to *S. zeamais*

Index of susceptibility of the test grains was calculated based on the data obtained from adult emergence and mean developmental periods of the weevils using the following formula (Dobie, 1977) [11].

$$I = \frac{\log_e F}{D} \times 100$$

Where,
F = Total number of adult emerged
D = Mean development period (days)
I = Index of susceptibility
Log e = Natural logarithm

2.7 Data analyses

Data collected from the number of emerged adults of *S. zeamais*, mean developmental periods of the insect, percentage of weight loss of grains and susceptibility index were subjected to one way analysis of variance (ANOVA) using statistical package for social science (SPSS). All analyses were performed at 5% probability ($p < 0.05$).

3. Results

3.1 Adult emergence of *S. zeamais* in different types of cereal grain

Result showed that the mean highest number (194.60 ± 1.21) of emerged adults of *S. zeamais* was recorded in sorghum followed by maize (128.00 ± 1.36) and the least (88.80 ± 1.75) was in rice (Figure 1). Although the number of emerged adults varied, the results clearly indicated that the adult emergence of *S zeamais* was not significantly different ($p = 0.064$) among the grain types.

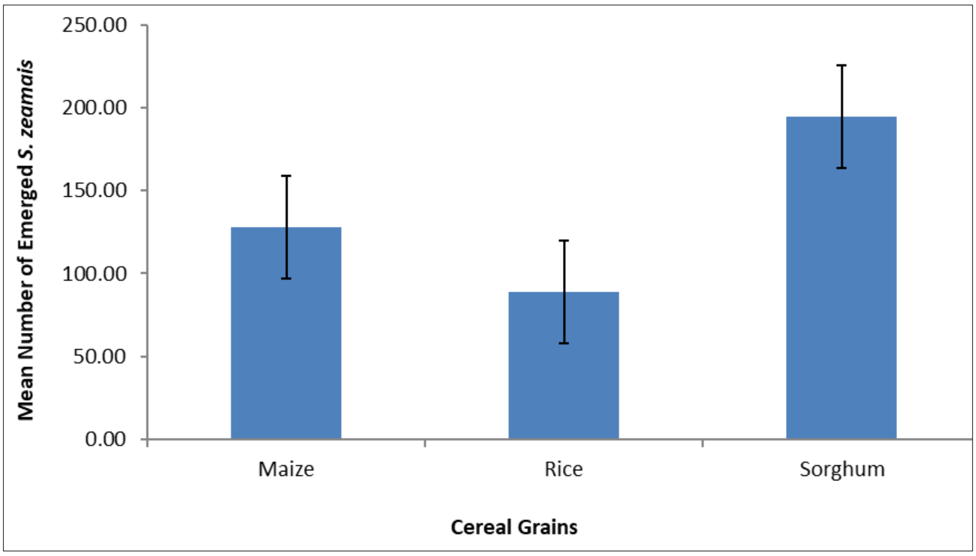

Fig 1: Mean number of emerged of adults of *S zeamais* in selected cereal grains

3.2 Mean developmental periods of *S zeamais* in different cereal grains

Results from this study showed that the mean developmental periods of *S zeamais* varied in the three types of grains examined. The mean developmental period was highest (27.51 days ± 1.21) in sorghum followed by rice (26.44 days ± 1.75) and the least (25.63 days ± 1.36) was in maize (Figure 2). The mean developmental period of *S zeamais* was however, not significantly different (*p* = 0.168) in the three types of the grains.

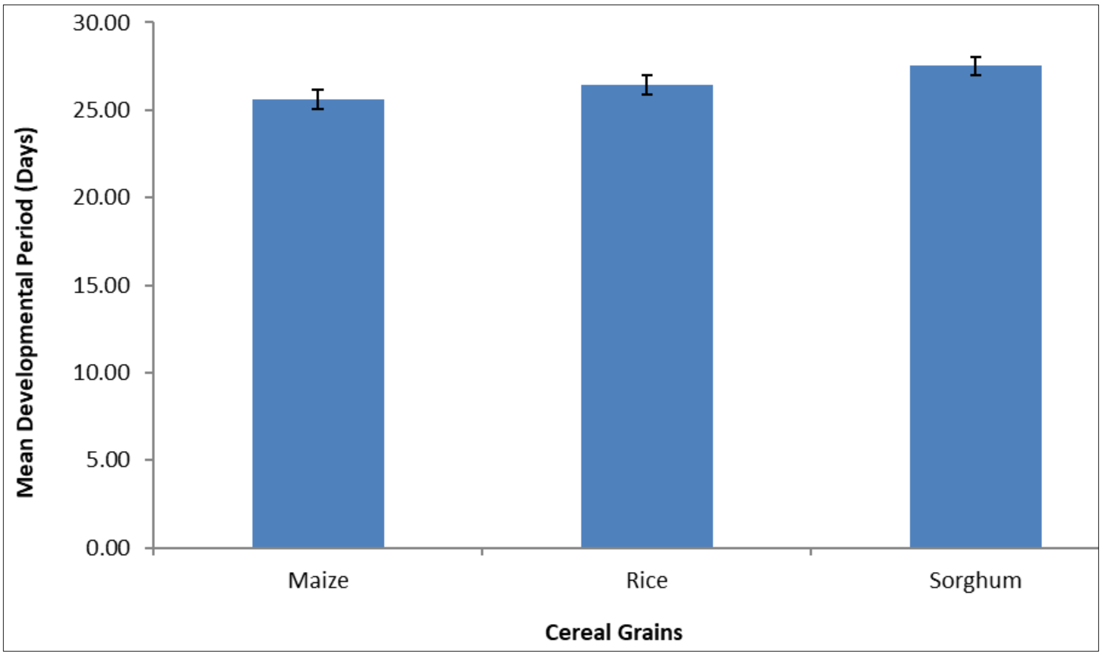

Fig 2: Mean developmental period of adults of *S zeamais* in selected cereal grains

3.3 Grain weight losses caused by *S zeamais*

Results showed that the highest (7.48 ± 3.124) weight loss was recorded in sorghum followed by maize (6.72 ± 2.699) and rice with the least (5.42 ± 2.320) (Table 1). But there was no significant difference in weight losses of the samples of maize, rice and sorghum grains infested by *S. zeamais*. (*p* = 0.971).

Table 1: Weight losses caused by *S zeamais* on selected cereal grains

Grain Type	Variety (Local)	Mean Weight Loses (% ± SEM)
Maize	"Fana"	6.72 ± 2.699^a
Rice	"Yar Dashe"	5.42 ± 2.320^a
Sorghum	"Jar Kaura"	7.48 ± 3.124^a

3.4 Index of susceptibility of selected cereal grains to *S. zeamais*

Both maize and sorghum grains were susceptible to *S zeamais* with their mean index of susceptibility as 8.06 ± 0.21 and 8.20 ± 0.20, respectively. Moreover, rice was moderately resistant to *S zeamais* with 7.16 ± 0.56 as mean index of susceptibility (Table 2).

Table 2: Mean Index of Susceptibility of the selected cereal grains to *S. zeamais*

Grain Type	Variety (Local)	Index of Susceptibility	Susceptibility Status
Maize	"Fana"	8.06 ± 0.21^a	Susceptible
Rice	"Yar Dashe"	7.16 ± 0.56^a	Moderately Resistant
Sorghum	"Jar Kaura"	8.20 ± 0.20^a	Susceptible

4. Discussion

The findings of this research on the emergence of adults of *S zeamais* on local varieties of maize, rice and sorghum revealed that more emerged adults were recorded on sorghum and maize. This is supported by the findings of (Danho *et al*., 2002) [12] who reported large mean number of emerged adults of *S zeamais* in maize and sorghum grains, which might be due to the shortest developmental period. Similarly, Bhargude *et al*. (2021) [13] reported that significantly less adult emergence was observed in rice (9.00%) followed by pearl millet (15.00%), maize (16.67%), barley (17.00%) and sorghum (18.00%).

The varying mean developmental period of *S. zeamais* in maize, rice and sorghum recorded in this study was not in agreement with Ojo and Omoloye (2015) [14] who reported that the comparative biological cycle of *S. zeamais* from egg to adult was 34.7 days in maize, 34 days in rice, 34.1 days in sorghum and 33.5 days in millet. This variation could be as a result of the use of improved varieties in the previous research. Findings of this study have shown that there were weight losses established by *S. zeamais* in maize, rice and sorghum grains, though they varied. Sorghum ("Jar Kaura") lost more weight than maize ("Fana") and rice ("Yar Dashe"). This might be due to the highest number of emerged adults recorded in sorghum which in turns determined the infestation intensity. This is supported by the findings of Suleiman (2014) [15] where is was reported that a grain damage of 53.30% was obtained in sorghum after 28 days of storage under laboratory conditions of 32 ± 2°C and 65 ± 5% RH. It is further suggested by Shafique and Chaudry (2007) [16] that the low insect population and low weight loss of grain could be used as one of the attribute of grain resistance to insects. In addition to weight loss and number of F_1 progeny, Abebe *et al*. (2009) [17] considered median developmental time and percentage of seed damage as indicators of the susceptibility of maize varieties to the attack of *S. zeamais.*

The index of susceptibility recorded in this study revealed that both maize ("Fana") and sorghum ("Jar Kaura") grains were categorised as susceptible based on the criteria provided by Dobie (1974) [18], while rice ("Yar Dashe") grain was categorised as moderately resistant to *S. zeamais* infestation. This might be due to short developmental period of the selected grains that led to relatively high index of susceptibility. Furthermore, it was observed by Ojo and Omoloye (2015) [14] that beetles on grains having a high index of susceptibility displayed reduced periods for the completion of developments. Additionally, prolongation of development periods will also result in reduction of number of generations in a season. According to Garcia *et al*. (2023) [19], the index of susceptibility is based on the assumption that the more F_1 progeny and the shorter the duration of the development, the more susceptible the seeds would be. Tsegab and Getu [20] indicated that the extent of damage during storage depends upon the number of emerging adults during each generation and the duration of each life cycle and grains permitting more rapid and higher levels of adult emergence will be more seriously damaged.

5. Conclusion

In conclusion, the findings of this study showed that sorghum and maize grains were more susceptible to the maize weevils than the rice variety which was moderately resistant with the least number of emerged adults. Farmers and grain vendors should avoid storing sorghum of the local variety, "Jar Kaura", for a long period as it is found to be more susceptible to *S. zeamais*.

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