Faculty of Natural and Applied Sciences Journal of Applied Biological Sciences
Print ISSN: 3027-0685, e-ISSN: 3043-6494
www.fnasjournals.com
Volume 2; Issue 3; May 2025; Page No. 132-138.
DOI: https://doi.org/10.63561/jabs.v2i3.942

Susceptibility of Beans and Maize Grains to Insect Infestation among Vendors in Boluwaduro Local Government, Osun State, Nigeria

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Abstract
Grain infestation by insects is a widespread issue globally and traditional methods of storage usually enhance this challenge among local vendors. This study aimed to determine the susceptibility of beans grain to insect infestation among vendors in Boluwaduro Local Government, Osun State, Nigeria. A multi-stage sampling procedure was used to select three beans and maize grains vendors in the three different markets; Igbajo, Otan Ayegbaju and Iresi (one in each district) in the study area. An interview approach was used to obtain the beans and maize grains history from the three randomly selected vendors in the selected and a measure of each of grains were purchased separately and transported to Science Laboratory Technology (SLT), Igbajo Polytechnic, Igbajo, Osun State for entomological analysis (insect infestation, insect emergence, percentage weight loss and percentage economic loss) were determined. Sack and chemicals are used by majority of the vendors for storage and preservation respectively. The result showed that only *Callosobruchus maculatus* affected the beans in the study and Iresi has the lowest insect infestation (a total of 3 insects) while 3 species (*Sitophilus zeamais*, *Prostephanus truncatus*, and *Tribolium castaneum*) were found in the maize, with Iresi also the location with lowest infestation (only 1 insect). Two vendors from Iresi have the lowest emergence (<3 insects emerged) and percentage seed damage (<25% grains damaged) for beans while Igbajo and Iresi have lowest emergence (<7 insects emerged) and percentage seed damage (<18% grains damaged). A vendor in Iresi has the lowest percentage weight loss (<10%) for both beans and maize grains, and the economic losses recorded for beans (>60%) are greatly higher when compared to maize (<50%). To address these challenges, it is crucial for vendors to adopt Integrated Pest Management (IPM) during the storage.

Keywords: Insect, Maize, Beans, Boluwaduro, Storage

Introduction

Grain infestation by insects is a widespread issue globally, particularly in regions with warm and humid climates, where favorable conditions for insect proliferation exist (Bharathi et al., 2017). Insects pose significant challenges to the storage and preservation of grains, affecting their quality, nutritional value, and marketability (Stathas et al., 2023; Huang et al., 2022). The storage of grains, such as beans, among vendors in Boluwaduro Local Government, is often characterized by traditional methods that may not effectively mitigate insect infestation.

Previous studies have highlighted the role of various factors in influencing the susceptibility of grains to insect infestation, including storage conditions, grain moisture content, and insect species (Tushar et al., 2023; Kumar & Kalita, 2017). Economic constraints may limit vendors' ability to invest in effective storage facilities and pest management practices, perpetuating the cycle of infestation and losses (Faghih et al., 2011). Smallholder farmers, in particular, are vulnerable to post-harvest losses due to limited resources and access to effective storage facilities (Femi, 2022).

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Despite the prevalence of grain infestation, efforts to mitigate this problem have been hampered by various challenges, including limited awareness of proper storage practices, inadequate access to resources and technologies, and socio-economic constraints (Feizollah et al., 2025). Vendors with limited financial resources may resort to using traditional storage methods that are less effective in preventing infestation, thereby increasing their vulnerability to grain losses (Mobolade et al., 2019).

The objectives of this study are: to determine the level of insect infestation in stored beans among the vendors in the study area; to determine the adult emergence (progeny) and seed damage in stored beans in the study area; and to determine the percentage weight loss and economic loss due to the susceptibility of beans to insect infestation among vendors in the study area.

Materials and Methods

Area of study: Boluwaduro is one of the Local Government Areas in Osun State and it lies between latitude 7º57'00''N longitude 4º48'00''E. Its land area is about 144km^2 and population of 70,775.

Vendor of the study: The vendor for the study involved marketers of stored beans and maize grain

Sample collection: The study was carried out in Boluwaduro Local Government Area, located in Osun State, Nigeria. A multi-stage sampling technique was used to select the needed vendors for the study. Firstly, the 3 districts, which constituted Boluwaduro Local Government Area, were completely selected (Otan Ayegbaju, Iresi and Igbajo). Secondly, 3 major markets in each of the districts were completely selected (Igbajo market, Iresi market and Otan Ayegbaju market). Thirdly, three major beans and maize grains marketers were randomly selected. An interview approach was used to obtain the beans and maize grains history and a measure of each of the grains were purchased from three randomly selected vendors in each of the selected markets in Boluwaduro LGA, Osun State. The price from each of the vendors were recorded. The grains samples collected were kept inside well labelled Ziploc bag and transported to Science Laboratory Technology (SLT) laboratory, Igbajo Polytechnic, Igbajo, Osun state for analysis. The grains were weighed and then sieved to remove all insects (dead and alive). The number of (dead and live) insects were counted and identified. The grain sample from each vendor were divided into three lots then placed inside different 360ml kilner jar. The cap lids were perforated and closed with the muslin cloth to allow aeration and prevent insects from escaping. The jars were arranged on the table in laboratory using Complete Randomized Design (CRD).

After 25 and 40 days, the contents in the jars (Beans and maize respectively) were sieved to remove all insects (new emergence). The newly emerged adult insects were counted and the grains were weighed, and the percentage loss in weight, percentage seed damage and percentage economic loss were determined and recorded.

Level of insect infestation: The number of insect present after sieving were identified using physical observation and the species observed were recorded to know the level of the insect infestation in the Beans and maize grains among the vendors in the various markets of this study.

Emergence: The number of adult insects emerged after 25 and 40 days of (beans and maize respectively) storage were counted, identified and recorded.

Percentage weight loss, Percentage Seed Damage and Economic loss: The Percentage weight loss were calculated using the formula used by Olagunju et al. (2021);

$$\%Weight\ loss = \frac{W1 - W2}{W1}\ x\ \frac{100}{1}$$

Where; W1= initial weight of each grain sample W2= final weight of the grain after emergence

After re-weighing, the number of damaged grains were evaluated by counting wholesome and seed with weevil emergent holes. Percentage seed damage was also calculated.

The Percentage Seed Damages were calculated by;

$$\%Seed\ Damage = \frac{Number\ of\ damaged\ kernels}{Total\ number\ of\ the\ kernels}\ x\ \frac{100}{1}$$

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Also, the Percentage Economic grain losses were calculated using the formula used by Chris et al. (2014) as;

$$\%Economic\ Loss = \frac{(W1 - W2)g}{Cost\ price\ of\ the\ grain}\ x\ \frac{100}{1}$$

Where; W1= initial weight of each grain sample W2= final weight of the grain after emergence

Data Analyses: Statistical analyses were performed using a computer program (SPSS 11.01, SPSS Inc.) by Analysis of Variance (ANOVA) and mean were calculated and separated using the Duncan's test when significant ($P < 0.05$).

Results and Discussion

Table 1: Storage facilities and preservation method used by the vendors for beans and maize grains collected from the study area

Market		Beans						Maize					
		Storage facilities			Preservation method			Storage facilities			Preservation method		
		Sack	Drum	Other	Chemical	Botanical	Other	Sack	Drum	Other	chemical	Botanical	Others
Igbajo	Vendor 1	**Yes**	**No**	**No**	**Yes**	**No**	**No**	**Yes**	**No**	**No**	**Yes**	**No**	**No**
	Vendor 2	**Yes**	**No**	**No**	**No**	**No**	**No**	**Yes**	**Yes**	**No**	**No**	**No**	**No**
	Vendor 3	**Yes**	**No**	**No**	**No**	**Yes**	**No**	**Yes**	**No**	**No**	**No**	**No**	**No**
Otan Ayegbaju	Vendor 1	**Yes**	**No**	**No**	**Yes**	**No**	**No**	**Yes**	**No**	**No**	**No**	**No**	**No**
	Vendor 2	**Yes**	**No**	**No**	**Yes**	**No**	**No**	**Yes**	**No**	**No**	**No**	**No**	**No**
	Vendor 3	**Yes**	**No**	**No**	**Yes**	**No**	**No**	**Yes**	**No**	**No**	**No**	**No**	**No**
Iresi	Vendor 1	**Yes**	**Yes**	**No**	**Yes**	**No**	**No**	**Yes**	**Yes**	**No**	**No**	**No**	**No**
	Vendor 2	**Yes**	**Yes**	**No**	**Yes**	**No**	**No**	**Yes**	**Yes**	**No**	**No**	**No**	**No**
	Vendor 3	**Yes**	**No**	**No**	**Yes**	**No**	**No**	**Yes**	**No**	**No**	**No**	**No**	**No**

Table 1 shows storage facilities and preservation methods used by each vendor in the selected areas. For beans, majority (100%) of vendors stored their produce inside sacks while few (only 2 out of 9 vendors) stored theirs in drum. As for maize, all the vendors also stored their produce inside sacks and only 3 of them stored theirs inside drums. Majority of the vendors selling beans in the study area (7 out 9) used chemicals to preserve their produce while only 1 vendor used chemical for maize preservation. Only 1 vendor used botanical to prevent beans while none of the maize vendors used botanicals for preservation. The storage of grains in sacks by majority of the vendors in the study area for this research is similar to what was reported by Babarinde et al. (2018), and this storage method is considered as poor storage because it makes the grains vulnerable to pests, diseases and unfavorable environmental conditions, which in return considered major causes of postharvest losses (Kuyu et al., 2022; Taddese et al., 2020; Affognon et al., 2015; Mvumi et al., 2013).

Figure 1 shows population and species of insects present in beans and maize obtained from three different vendors in the selected markets. The results show that beans obtained from Iresi market has the lowest level of infestation (only 3 insects) while Igbajo market has the highest number of insects (a total of 105) among the selected markets. *Callosobruchus maculatus* is the only species of insects that infested beans in the study area. In Igbajo and Iresi markets, the number of insects alive is more than the number of dead insects while Otan Ayegbaju has a greater number of dead insect that those that are alive. The species of insects obtained for maize in this study namely; *Sitophilus zeamais, Prostephanus truncatus,* and *Tribolium castaneum*. The results show that maize obtained from Iresi market has the lowest infestation (1 insect) while highest number of insects (22 insects) infestation was obtained among the selected marketers in Otan Ayegbaju. The total number of insects alive and dead obtained from Igbajo markets are 1 and 4; 0 and 1; and 0 and 0 for *S. zeamais, P. truncatus,* and *T. castaneum*. In Otan Ayegbaju, the total number of insects alive and dead obtained from the three marketers are 15 and 0; 3 and 0; and 4 and 0 for *S. zeamais, P. truncatus,* and *T. castaneum*. In Iresi, only 1 alive (*S. zeamais*) was obtained. The result also shows that the number of dead insects obtained from Igbajo is more than the number of those that are alive while in Otan Ayegbaju and Iresi, the number of insects alive were more than the number of dead insects. *C. maculatus* and *S. zeamais* obtained in this study as the major insect pest for beans and maize is similar to what have been reported in previous research findings (Babarinde et al., 2018). Previous studies (Makinya et al., 2021; Hodges et al., 2011)

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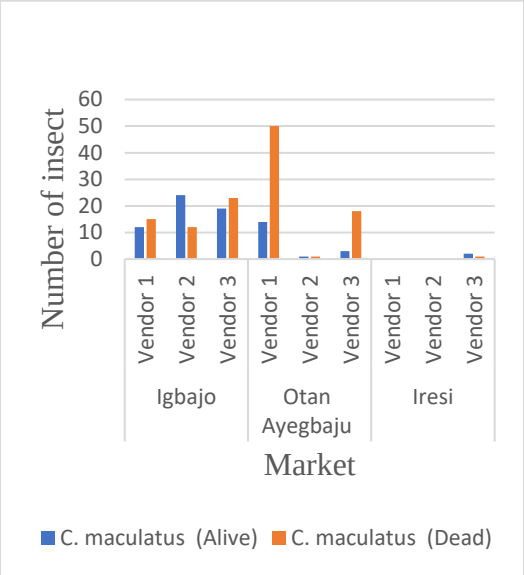
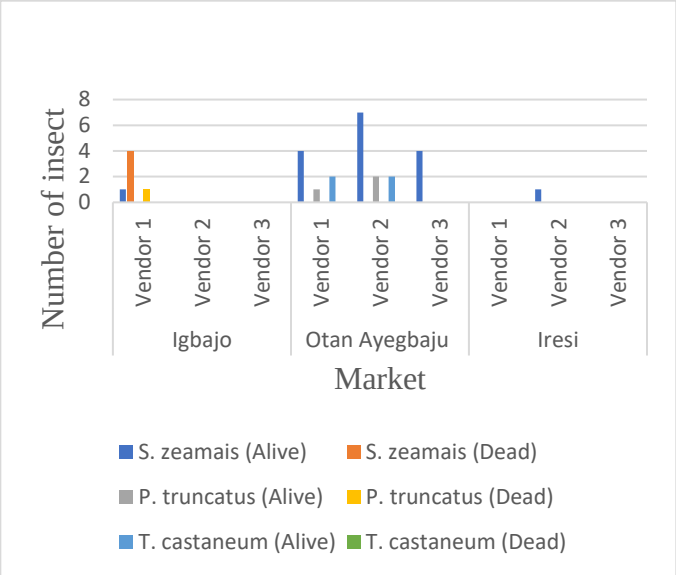
have highlighted that market conditions, storage practices, and hygiene levels significantly impact the degree of infestation. According to Hatzenbuehler et al. (2018), inadequate storage facilities, especially in rural markets, create conducive environments for insect breeding and grain damage.



(a) Beans grain infestation



(b) Maize grain infestation

Figure 1: Level of infestation for beans and maize grains collected from the study area

Table 2: Number of adult emergence and Percentage Seed Damage for beans and maize grains collected from the study area

Market	Vendor	Adult Emergence (Progeny)		% Seed Damage	
		Beans	Maize	Beans	Maize
Igbajo	Vendor 1	234.33±17.227^{e}	6.67±0.882^{a}	100.00±0.000^{e}	13.62±2.422^{abc}
	Vendor 2	146.67±9.025^{d}	0.00±0.000^{a}	99.55±0.042^{e}	5.27±3.546^{a}
	Vendor 3	451.33±11.319^{f}	1.33±0.333^{a}	100.00±0.000^{e}	15.60±1.400^{abc}
Otan Ayegbaju	Vendor 1	110.67±7.126^{c}	37.33±2.028^{b}	76.82±0.605^{d}	20.21±1.939^{c}
	Vendor 2	2.67±0.667^{a}	56.00±10.786^{c}	25.68±0.468^{b}	18.90±2.178^{bc}
	Vendor 3	22.00±9.504^{a}	45.67±7.424^{bc}	34.85±1.408^{c}	20.69±4.300^{c}
Iresi	Vendor 1	0.00±0.000^{a}	0.00±0.000^{a}	10.57±0.538^{a}	14.16±3.994^{abc}
	Vendor 2	1.67±0.667^{a}	1.33±0.667^{a}	21.30±3.722^{b}	16.40±5.623^{bc}
	Vendor 3	54.67±3.480^{b}	0.00±0.000^{a}	37.66±3.720^{c}	7.97±2.374^{ab}

Means±Standard Error of the Mean (SEM). Values are means of triplicate samples followed by the standard error of means. Means for each market in the same column with the different superscripts are significantly different ($p<0.05$) according to Duncan Post Hoc test.

Table 2 reveals emergence of adult insect and percentage seed damage of the beans and maize obtained from the three different vendors in the selected markets. For beans, Vendor 1 and 2 in Iree market and Vendor 2 in Otan Ayegbaju market have the least number of adult emergence when compare with others. Vendor 3 in Igbajo market have the highest (451) adult emergence. There were significant differences in the number of adult emergences among the selected vendors in the markets sampled (F= 305.498, P=0.000). Also, the results reveal that the seed emergence in the three vendors with least adult emergence (Vendor 1 and 2 in Iresi market and Vendor 2 in Otan Ayegbaju market), have the lowest percentage seed germination. And vendors 1 and 3 in Igbajo market have the highest percentage seed damage (100%). The adult emergences statistically had a significant (F= 411.422, P<0.05)

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effect on the percentage seed damages. For maize, vendors in Igbajo and Iresi have lower numbers of adult emergence when compare with vendors in Otan Ayegbaju. Vendor 2 in Otan Ayegbaju market have the highest (56) adult emergence. There were significant differences in the number of adult emergences among the selected vendors in the markets sampled ($F= 26.829$, $P<0.05$). Also, the results reveal that the seed damage and three vendors in with high adult emergence (Vendor 1, 2 and in in Otan Ayegbaju market) have the highest percentage seed damage. The reason for high seed damage in them could be attributed to high number of adult emergences, since the adults usually bore hole for the emergence. The actions of the insects on the grains obtained among the vendors in all the markets statistically had no significant ($F= 2.496$, $p=0.051$) effect on the percentage seed damages. Additionally, the higher percentage of seed damage in Otan Ayegbaju suggests that longer exposure to infestation before sale could lead to significant deterioration in grain quality. Previous research by Stejskal (2015) supports this, noting that prolonged storage periods without proper pest management exacerbate insect damage and reduce market value.

Table 3: Percentage Economic Loss for beans and maize grains collected from the study area

Market	Vendor	% Weight Loss		% Economic Loss	
		Beans	Maize	Beans	Maize
Igbajo	Vendor 1	48.88±1.132^{d}	11.15±1.920^{ab}	89.67±10.767^{bc}	16.70±2.786^{ab}
	Vendor 2	45.07±3.111^{d}	11.82±5.217^{ab}	77.42±12.679^{ab}	18.45±7.870^{ab}
	Vendor 3	50.19±2.279^{d}	17.38±2.400^{ab}	96.11±5.111^{c}	27.50±4.267^{ab}
Otan Ayegbaju	Vendor 1	36.95±2.033^{c}	23.36±4.045^{b}	77.40±4.697^{ab}	33.75±6.206^{b}
	Vendor 2	28.63±1.470^{b}	19.90±1.934^{b}	74.72±8,972^{ab}	29.00±4.521^{b}
	Vendor 3	26.20±2.594^{b}	19.15±2.144^{b}	67.25±8.075^{a}	28.30±2.483^{b}
Iresi	Vendor 1	9.02±1.780^{a}	5.66±2.910^{a}	74.72±8.972^{ab}	8.80±4.579^{a}
	Vendor 2	15.18±1.613^{a}	17.51±5.559^{ab}	64.52±10.566^{a}	25.75±8.478^{ab}
	Vendor 3	24.66±4.695^{b}	18.87±4.956^{b}	80.09±4.251^{ab}	28.00±7.584^{ab}

Means±Standard Error of the Mean (SEM). Values are means of triplicate samples followed by the standard error of means. Means for each market in the same column with the different superscripts are significantly different ($p<0.05$) according to Duncan Post Hoc test.

Table 3 depicts the percentage weight loss in the stored bean and maize grains obtained from the selected vendors in the sample markets. For beans samples, Vendors 1 and 2 in Iresi have lowest percentage weight loss when compare with the grains obtained from other vendors and it significantly different from the value obtain from other vendors at $p\leq0.05$. For maize sample, all the three vendors from Otan Ayegbaju market have highest percentage weight loss. The vendor 1 from Otan Ayegbaju has highest percentage weight loss while vendor 1 from Iresi has the lowest percentage weight loss when compare with other vendors in all the three markets. The values of percentage weight loss obtained among the nine vendors in the three markets were no significantly different ($F= 2.145$, $P=0.085$). Abdulbaki et al. (2022) have reported that a highest grain loss is observed in grain with the highest number of adult emergences.

The range of economic loss for beans among the vendors in Igbajo, Otan Ayegbaju and Iresi are 77 to 96%, 67 to 77% and 65 to 80% respectively. Vendor 2 from Iresi market and vendor 3 from Igbajo market have the lowest (64.52%) and highest (96.11%) economic loss respectively, when compared to other vendors in all the market. All the vendors have economic loss >60%. There were significant differences in the mean percentage economic loss among all the vendors ($F= 3.907$, $P=0.008$). And for maize samples, Vendor 1 from Irei market and vendor 1 from Otan Ayegbaju market has the lowest (8.80%) and highest (33.75%) economic loss respectively, when compared to other vendors in all the market. All the vendors have economic loss <50%. Statistically, there were no significant differences in the mean percentage economic loss among all the vendors in the sample markets ($F= 1.799$, $P=0.143$). The significant economic losses recorded in Otan Ayegbaju market, which were higher than in Igbajo and Iresi markets, further emphasize the financial implications of poor post-harvest management. A study by Constantine et al. (2020) indicated that maize vendors suffer substantial losses due to insect infestation, which ultimately affects their livelihoods and food security.

Conclusion

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This study has provided valuable insights into the susceptibility of maize to insect infestation in selected markets within Boluwaduro Local Government Area. It was evident that market conditions, storage practices, and pest management strategies play significant roles in determining the level of insect infestation, seed damage, and economic losses associated with stored maize. The findings highlighted those maize vendors in Otan Ayegbaju market experienced higher infestation levels, greater seed damage, and larger economic losses compared to vendors in Igbajo and Iresi markets. This suggests that better pest control and storage practices are being employed in the latter markets.

The presence of common insect pests such as *Sitophilus zeamais*, *Prostephanus truncatus*, and *Tribolium castaneum* further emphasizes the need for robust post-harvest handling techniques to prevent widespread damage to maize grains. Poor storage infrastructure and lack of knowledge on pest control were likely to be the major contributors to the high levels of infestation and subsequent losses in maize quality and quantity. To address these challenges, it is crucial for vendors to adopt improved storage methods, such as the use of hermetic storage bags or metal silos, which can help reduce insect infestation without relying heavily on chemical treatments. Additionally, regular monitoring of stored grains and the use of integrated pest management (IPM) strategies can also minimize the impact of insect pests. By implementing these measures, maize vendors can significantly reduce post-harvest losses, ensuring better grain quality, improved food security, and enhanced profitability in the local markets. The study underscores the importance of continuous education and support for grain marketers to adopt effective pest management and storage practices for the long-term sustainability of maize production and trade.

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Cite this article as:
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Cite this article as:
Abdulbaki, M.K, Lateef, S.A. , Fadairo, O.E., & Olaiya,J.O. (2025). Susceptibility of beans and maize grains to insect infestation among vendors in Boluwaduro Local Government, Osun State, Nigeria. *FNAS Journal of Applied Biological Sciences*, *2*(3), 132-138. https://doi.org/10.63561/jabs.v2i3.942