Original article

Assessment of maize and beans storage insect pest in major grain markets, Morogoro-Tanzania

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Abstract

Post-harvest losses for maize and beans are common storage challenges affecting Tanzania’s smallholder and large-scale farmers’ storage facilities. Consequently, this leads to a reduction of over 50% of harvested grain qualitatively and quantitatively per year. Therefore, this experimental study was conducted at the entomological laboratory of the Sokoine University of Agriculture Tanzania, where the research was aimed to assess different common storage insect pests of beans and maize at Morogoro major markets (i.e., Kihonda, Mazimbu and Morogoro Central Market) with similar storage conditions in Morogoro municipality. The complete block design (CBD) with three experimental replications was used. Where locations (Kihonda, Mazimbu and Central market) markets were considered as experimental treatments. The results obtained show that there were no significant differences in number of insect pests (such as maize weevils and bean bruchids) identified between the Kihonda and Central markets (\( P > 0.05 \)). However, there is a significant difference (\( P < 0.05 \)) between Mazimbu and other markets regarding the number of insect pest multiplication resulting from the storage condition of those grains in a particular market. Nevertheless, continuous winnowing of stored grains was observed to significantly intensify the infestation of the storage pest in maize and common beans. Therefore, alternatively, to reduce insect pest infestation to maize and common beans in storage facilities, it is important to avoid constant winnowing of stored grains.

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1. Introduction

Storage insect pests are arthropods that cause damage to the stored produce. The damage can be either quantitative or qualitative, leading to a loss of value of the marketed produce (Mugo, 2007). Depending on the stage or the form at which the produce is attacked, the pest is grouped as either primary or secondary pests; the former applies to insects that attack undamaged produce, while the latter is used for insects that attack damaged produce. A primary insect pest is a group of insects that attack whole, undamaged grains. Where the immature stages of these insects occur inside the grain, where detection is difficult. Examples of primary insects include bean bruchid (Acanthoscelides obtectus), maize (Sitophilus zeamais) and lesser grain borers (Rhyzopertha dominica) (Nandagopal, 2004). A secondary insect pest is a group of complexes of insects that feed on fragments of grains and cereals. They are also referred to as bran bugs (Robert, 2012). The direct-feeding damage by insects reduces grain weight, nutritional value, and germination capacity of stored grains. As a result, commercial grain buyers may refuse to accept delivery of insect-contaminated grain or may pay a reduced price (Linda et al., 2007). Several produces are stocked and marketed as grains at Morogoro central market. Although maize and Beans are important and the most supporting crops produced for life of people in developing countries, their storage in market are still poor, leading to decreased quality and quantity loss due to insect storage pest, especially in the local market. The leading causes of this are poor storage practices like sanitation and improper preparation of those crops before being sent to the market, like poor drying, winnowing even poor storage containers used. This leads to crop losses which may be direct by reducing the quality and quantity due to feeding of feeding of insect pests. The loss of crops like maize in Southern highlands of Tanzania which are main maize producers have been estimated to be in a range of 17.5 to 25 %, meaning that for every 100 kg of maize produced, about 25 % are lost due to insect pest infestation.
at storage facilities. Most traders in Tanzania market use unimproved storage facilities like bags and drums, which are easily attacked by insect pests and, hence destroy the stored grains. Therefore, the current study was intended to assess the diversity of insect pests in marketed products and hence recommend the appropriate measures to minimize losses suffered by grain traders and buyers at Morogoro central market.

The overall objective of the study was to examine the common grain storage pests found in marketed produce at Morogoro major markets; where three specific objectives were considered in accomplishing this study such as: (i) to identify common storage insect pests of major marketed grains (Maize and Beans) at Morogoro major markets, (ii) to determine multiplication rate of different storage pest over period, and (iii) to assess quantitative and qualitative losses of stored produce (maize and beans) caused by the storage pests.

2. Materials and methods

2.1. Study area description

The experiment was conducted at Morogoro major markets and the entomological laboratory of the Department of Crop Science and Production at Sokoine University of Agriculture (SUA). SUA is about 3–4 km from the Morogoro main market with at latitude 5° 40’S and longitude 37 ° 39’E and an altitude of 525 m above sea level.

2.2. Maize and beans sample collection

About six kilograms each of maize and beans samples were collected from each of the three marketplaces within Morogoro municipal viz are Kihonda, Mazimbu and central market. About 6 kg of grains of different in forms of maize (Zea mays) and common beans (P. vulgaris) infestations were collected from different parts of Morogoro major markets portions. The different marketplace were considered as treatments. In the laboratory, 500 g of each sample were incubated in an insect rearing jar which was covered with a mesh at the top to avoid the escape of insect pests from a jar and was replicated three times. That is, each of the three (2 kg) sampled from each crop species was regarded as a replicate, and each replicate will comprise four sub-samples.

2.3. Laboratory experimental study

In the laboratory, each sample of maize grain and beans were sieved over a 2 mm mesh sieve (Abraham, 1995). Where insect pests identified were removed, counted, and grouped according to order and family. Identification was made using a combination of insect identification keys and pictures. Insect damage was assessed by weighing the remained weight after ten weeks of incubation.

2.4. Statistical data analysis

The collected experimental data were analyzed by GenStat discovery software (version 13), and all analyses were conducted at a 5 % level of significance ($P < 0.05$). Furthermore, the mean separation among studied markets (Kihonda, Mazimbu and Central Market) were further analyzed by Duncan’s Multiple Range Test and the value obtained are summarized in Appendix 1 to 4.

3. Results

3.1. Common storage pests of maize and beans

3.1.1. Beans sample

The number of insects detected on the sample of beans were only one which was bean bruchid, whereby the number of insect pest in sample were not significantly different ($P > 0.05$) from samples collected from all three market places for the first two weeks but henceforth, the number of insect pest in samples from these three market were statistically different ($P < 0.05$), whereby sample collected from Mazimbu observed to have a larger number of bruchid followed by Central and Kihonda (Table 1).

3.1.2. Maize sample

The number of insects detected on the sample of maize were only two, which were maize weevils (Sitophilus zeamais) a lesser grain bore (Rhyzopertha dominica), whereby the number of insect pest in the sample were significantly different ($P < 0.05$) from samples collected from all three markets. Maize Weevils (Sitophilus zeamais); The number of S. zeamais detected on the sample of maize were significantly different from samples collected from all three market places for the first four weeks, whereby Kihonda and Central market showed to have larger number of weevils followed by Mazimbu market but henceforth the number of weevils in the samples from these three market were not statistically significant ($P > 0.05$) among those market places for remained six weeks (Table 2).

*Rhyzopertha dominica* were found in large number in the sample collected from Kihonda and Central market but samples from Mazimbu market showed to have less number of *R. dominica* for the entire experiment (ten weeks) (Table 3).

3.2. Sample weight loss after ten weeks of incubation

The weight of both maize and beans samples were weighed at the end of experiment (ten weeks), and their weight was found to be reduced from 500 g to the new weight as indicated in the table below also, the variation in weight was different across the market places also across the grain samples example in case of maize sample weight reduction were not significantly different between samples from kihonda and Mazimbu market, but a sample from Mazimbu market showed little reduction in weight (Table 4) while for the case of beans grain sample the reduction in weight was significantly different between both market whereby sample from kihonda shows higher weight reduction followed by a sample from Mazimbu and those from Central market (Table 4).

Weight of sample after 10 weeks of incubation also represented on the histogram below to show the comparison of weight reduction across the market (Fig. 1).

4. Discussion

4.1. Bean bruchid in bean grains

The number of bean bruchid in bean samples was observed to be not significantly different ($P > 0.05$) for the first two weeks in all market places, but after 4th weeks there was a significant difference ($P < 0.05$) between Mazimbu and other places, this shows that the sample collected from Mazimbu market were resistant to attacks of bean bruchid because few bruchids were recorded from it suggesting that those grains were stored to the conditions which maintain the quality of the grain because for insect pest to attach the grain easily the grain must be poorly stored or prepared which
result to high moisture which softens the seed coat hence easily attacked by an insect (Abebe et al., 2009). For this reason, it seems that the grains sold at mazimbu are less prone to insect infestation, meaning that the grains are well stored and protected from the infestation of insect pests (Abraham, 1997); this due to the fact that the volume of grains sold in that market (mazimbu) is lower compared to other market places under the study so it is easy to take care of the grain compared to those handling large volumes example at central market one seller he was handling 40 tonnes of maize and beans but they were poorly stored hence the incidences of insect pest attacks become large/were larger.

4.2. Maize weevils (Sitophilus zeamais) in maize sample

For maize sample two insect species were observed, viz maize weevils (Sitophilus zeamais) and lesser grain borer (Rhyzopertha dominica). The multiplication of maize weevil (Sitophilus zeamais) were observed to have significantly different ($P < 0.05$) between market places for the first four weeks but after 4th week there were no significant difference between market places (Table 2) because maize weevils prefer intact grains so by the time in seed samples there was a lot of flour as resulted due to damage made by those weevils so the growth were not significant between market places for the rest of the incubation period, once the grains sieved the multiplication are expected to raise (Taylor et al., 1992). So, to control these weevils, you can leave the grains with that flour, and the damage of the weevil will be low compared to those sieved because the chance of finding the intact grain will be low; hence less damage will be inflicted to the stored grains (Akira, 1986).

4.3. Lesser grain borer (Rhyzopertha dominica) in maize sample

Multiplication of Rhyzopertha dominica were observed to be not significant different between kihonda and Central Market ($P > 0.05$) but significantly different from Mazimbu market throughout the incubation period (Table 3) this indicates that maize samples from kihonda and central market were easily attacked by insect pest because the multiplication of R. dominica was very rapidly compared to those from Mazimbu market so it seems that those grains they were stored to the condition which were reducing their quality and resistance to insect pest attack because in those samples the number of Rhyzopertha dominica were observed higher compared to those from Mazimbu this shows that the grains were easily attacked so food supply to insect pest were high or adequate that’s why they reproduced more so storage conditions of grains should be taken into consideration when storing grains because

Table 1
Number of beans bruchid as evolved over ten weeks of incubation in three markets.

| Time/weeks | 0      | 2      | 4      | 6      | 8      | 10      |
|------------|--------|--------|--------|--------|--------|---------|
| Kihonda market | 14.33a | 23.67a | 41.00a | 164.00b| 240.00b| 243.00b |
| Central market | 14.67a | 24.00a | 57.67a | 80.30a | 91.00a | 93.00a  |
| Mazimbu market | 16.00a | 26.33a | 102.00b| 79.70a | 124.70a| 127.70a |
| CV         | 5.4    | 8.4    | 17     | 14.50  | 14.50  | 15.50   |
| Grand mean | 15.00  | 24.67  | 66.90  | 108.00 | 151.90 | 152.90  |
| LSD        | 1.851  | 4.719  | 25.82  | 35.58  | 49.93  | 49.99   |

Numbers followed by a different letter in a column are statistically significantly different at $P < 0.05$.

Table 2
Number of maize weevils (Sitophilus zeamais) as evolved over 10 weeks of incubation in three markets.

| Time/weeks | 0      | 2      | 4      | 6      | 8      | 10      |
|------------|--------|--------|--------|--------|--------|---------|
| Kihonda market | 13.67a | 24.33b | 57.33a | 60.33a | 78.33a | 78.36a  |
| Central market | 10.33a | 16.33ab| 22.33ab| 30.00a | 48.00a | 48.10a  |
| Mazimbu market | 4.00b  | 8.33a  | 18.67a | 31.00a | 52.00a | 52.05a  |
| CV         | 15.80  | 29.6   | 48.40  | 42.40  | 27.30  | 27.70   |
| Grand mean | 9.33   | 16.3   | 32.80  | 40.4   | 59.40  | 59.80   |
| LSD        | 3.34   | 10.95  | 35.98  | 38.88  | 36.84  | 36.94   |

Numbers followed by the same letter in a column are not statistically significantly different ($P < 0.05$).

Table 3
Number of R. dominica as evolved over 10 weeks of incubation in three markets.

| Time / weeks | 0      | 2      | 4      | 6      | 8      | 10      |
|--------------|--------|--------|--------|--------|--------|---------|
| Kihonda market | 10.00a | 14.33a | 16.00a | 17.67a | 28.33a | 28.35a  |
| Central market | 10.67a | 15.67a | 17.33a | 19.33a | 24.67a | 24.67a  |
| Mazimbu market | 3.00b  | 6.00b  | 6.67b  | 8.00b  | 11.33b | 11.34b  |
| CV           | 21.10  | 19.20  | 14.40  | 17.20  | 23.4   | 23.14   |
| Grand mean   | 7.89   | 12.00  | 13.33  | 15.00  | 21.40  | 21.48   |
| LSD          | 3.78   | 5.24   | 4.34   | 5.85   | 11.36  | 11.39   |

Numbers followed by the same letter in a column are not significantly different ($P < 0.05$).

Table 4
Mean separation for weight measured after 10 weeks of incubation in both maize and bean samples.

| Market Places | Maize | Beans |
|---------------|-------|-------|
| Kihonda       | 387.7a| 299.3a|
| Central       | 387.0a| 442.3b|
| Mazimbu       | 470.0b| 383.7c|
| CV            | 2.5   | 1.7   |
| Grand mean    | 414.9 | 375.1 |
| LSD           | 23.48 | 14.74 |

Numbers followed by the same letter in a column are not statistically significantly different ($P < 0.05$).
it affect the longevity of the stored grains and insect attack to grains is low if they are stored well but will be high if the grains are poorly stored (Wambugu et al., 2009) also lesser grain borer is secondary pest prefer grains destructed by primary market because the maize from mazimbu market were less damaged by primary pest (weevils) the effect of the grain borer were little compared to the grains from other market so this shows that effect of lesser grain borer is usually enhanced by primary pest which pave the way for secondary pest to cause their damage to the stored grain (Campbell et al., 2002).

4.4. Sample weights after ten weeks of incubation

After ten weeks of incubation, the weight of samples was measured to determine the weight that remained (Table 4). In maize sample it was observed that there were no significant differences between the central and kihonda markets, but significant differences were observed between Mazimbu sample from the rest, whereby there was much decrease in weight in samples from Central and Kihonda markets due to high population of Rhyzopertha dominica and Sitophilus zeamais since more insect pest means more mouth to feed hence high damage to the stored grains (CABI, 2007). So during storage of grains, the number of insect pests should be maintained to lower levels as possible to reduce damage and loss in general for stored grains (McFarlane, 1990). For beans samples, there were significant differences between those marketplaces showing that the damage to the bean’s grains was different between market places that being due to storage conditions to which the grains were stored before the attack, the weight of the sample was very much reduced in samples from kihonda market followed by mazimbu finally central market all these due to higher population of bean bruchid in those samples as explained earlier (CABI, 2007).

5. Conclusion and recommendations

The study found three insect pests which seriously affected maize and beans in the major markets of Morogoro. Therefore, there should be crucial initiatives to reduce post-harvest losses due to insect pest infestation in storage facilities. To achieve that and to reduce the grain market loss, which resulted from storage insect pests for stored grains in all three-market place, the following are recommended to be adopted by all grain sellers in all three markets places; Sanitation, excluding air by using airtight containers. Where before stacking the grains, the godowns, store rooms or receptacles should be cleaned and made free from insects. Disinfection should be done by fumigation. The material to be stored should be cleaned and dried well in the sun to remove excess moisture in the grain and to bring it down below the optimum level (<10 %), and The bags should be stacked in such a way as to allow proper ventilation and sufficient.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Tables A1, Table A2, Table A3, Table A4.

Table A1
Summary of analysis variances for bean bruchid in common bean sample.

| Source of variation | DF  | 0 week | 2 weeks | 4 weeks | 6 weeks | 8 weeks | 10 weeks |
|---------------------|-----|--------|---------|---------|---------|---------|----------|
| Replication         | 2   | 10.33  | 93.00   | 149.8   | 508.00  | 2134.1  | 2134.1   |
| Treatment           | 2   | 2.33 ns| 6.33 ns | 2982.1 ns| 7056.3*| 18318.1**| 18318.1**|
| Residual/error      | 4   | 0.67   | 4.33    | 129.8   | 246.3   | 485.1   | 485.16   |
| LSD                 |     | 1.851  | 44.719  | 5.82    | 35.35.58| 49.93   | 49.98    |
| P-value             |     | 0.132  | 0.334   | 0.006   | 0.004   | 0.003   | 0.003    |

Note ns means no significance difference, * significant, ** highly significance.

Fig. 1. Histogram showing overall weight of maize and beans samples after 10 weeks of incubation.
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### Tables

#### Table A2
**Summary of Analysis Of Variance for Lesser Grain Borer in Maize Sample.**

| Source of variation | DF | 0   | 2   | 4   | 6   | 8   | 10  |
|---------------------|----|-----|-----|-----|-----|-----|-----|
| Replication         | 2  | 4.78| 7.00| 4.33| 9.33| 0.78| 0.78|
| Treatment           | 2  | 51.11*| 82.33*| 101.33*| 112.33**| 240.11*| 240.11*|
| Residual/error      | 4  | 2.78| 5.33| 3.67| 6.67| 25.11| 25.11|
| LSD                 | 3.78| 5.24| 4.34| 5.85| 11.36| 11.36|
| *P Value*           | 0.009| 0.013| 0.05| 0.01| 0.03| 0.03|

Note ns means no significance difference, * significant, ** highly significance.

#### Table A3
**Summary of analysis of variance for maize weevils in maize sample in different.**

| Source of variation | DF | 0   | 2   | 4   | 6   | 8   | 10  |
|---------------------|----|-----|-----|-----|-----|-----|-----|
| Replication         | 2  | 1.33| 8.33| 340.10| 386.1| 742.10| 742.12|
| Treatment           | 2  | 72.33*| 192.00*| 1366.80 ns| 890.80 ns| 814.80 ns| 814.70 ns|
| Residual/error      | 4  | 2.17| 23.33| 251.9| 294.10| 264.10| 264.40|
| LSD                 | 3.34| 10.95| 35.98| 38.88| 36.84| 36.88|
| *P Value*           | 0.003| 0.038| 0.073| 0.158| 0.155| 0.157|

Note ns means no significance difference, * significant, ** highly significance.

#### Table A4
**Summary of ANOVAs tables for weight obtained after 10 weeks of incubation.**

| Source of variation | DF | Maize | Beans |
|---------------------|----|-------|-------|
| Replication         | 2  | 28.8  | 12.44 |
| Treatment           | 2  | 6834.1*| 15501.44*|
| Residual/error      | 4  | 107.3 | 42.28 |
| LSD                 | 23.48| 14.748|
| *P Value*           | < 0.001| < 0.001|

Note ns means no significance difference, * significant, ** highly significance.