



Check for updates

**Research Article****Assessment of rodent damages to stored maize and wheat in rural Swabi, Pakistan****Zobia Amin¹, Surrya Khanam¹, Alex Mayamba²**¹ Department of Zoology, Women University Swabi, Khyber Pakhtunkhwa, Pakistan.² Biotechnology and Biodiversity Program, National Agricultural Research Laboratories (NARL) Kawanda, Uganda.**ABSTRACT**

Rodents are one of the major reasons for the postharvest grain losses in storages especially in developing countries. To control grain losses, it is necessary to estimate the actual post-harvest damages to the stored grains. Therefore, the objective of the present study was to assess rodent caused post-harvest losses in maize and wheat grains stores of District Swabi, Khyber Pakhtunkhwa, Pakistan. For this study, three maize stores and three wheat stores were selected in different locations of district Swabi. For damage assessment, two plastic containers with known quantity of grains (3 kg) were placed in each of the maize and wheat stores. One of the containers was left open and the other was covered properly (served as control). The results showed that there were 10.91 ± 1.04 fecal droppings, 7.58 ± 0.67 rodent hairs, and 28.58 ± 2.02 damaged grains per 100 gram of maize. The mean weight loss of 509 ± 68.7 was recorded from the maize stores. Likewise, there were 16.25 ± 0.77 droppings, 12.41 ± 0.76 hairs and 21.41 ± 1.26 damaged grains per 100 gram of wheat. The mean weight loss of 483 ± 46.2 was reported from the wheat stores. These findings indicate that rodents were negatively impacting storage structures in the area, and proper pest management strategies are required to minimize post-harvest crop losses.

Keywords: Pests; grain losses; stored products; contamination; storage structures.**INTRODUCTION**

Agriculture plays a significant role in the economy of Pakistan, contributing 24% to the gross domestic production (GDP) and 37.4% to the employment (Economic Survey of Pakistan, 2024). About 10% of the agricultural production in Pakistan is lost due to inadequate post-harvest practices. The majority of these post-harvest losses occur during crop harvest, threshing, transportation, and inappropriate storage (Economic Survey of Pakistan, 2017). Also, an important problem in agriculture is yield losses due to different pests. Farmers worldwide face losses as a result of vertebrate pests that cause damage both during and after harvest (Bayani et al., 2016). Post-harvest losses are defined by De Lucia and Assennato (1994) as quantifiable losses of food, which can be either qualitative or quantitative. In developing countries, stored crops and food are heavily attacked by several species of rodents, but limited information is available on crop losses in these countries (Kumar and Kalita, 2017).

Rats and mice are currently the most successful and numerous animals on Earth, second only to humans (Admas and Yihune, 2016). Without unintentional human assistance, they would not have achieved this status. Rats and mice are considered as commensals as they live at the expense of man, infiltrating their home, devouring his food, and damage his possessions (Bonney et al., 2008). The order Rodentia (including rats and mice) contains more than 40% of the species of mammals (Kay and Hoekstra, 2008). They are abundant on every continent except Antarctica and can flourish in any kind of habitat (from parched deserts to arctic tundra, except from oceans).

**Correspondence**Surrya Khanam
surryiamalik@gmail.com**Article History**

Received: November 18, 2024

Accepted: December 14, 2024

Published: December 31, 2024

**Copyright:** © 2024 by the authors.
Licensee: Roots Press, Rawalpindi, Pakistan.

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license:
<https://creativecommons.org/licenses/by/4.0>

According to the estimates, rats make up 28% of the entire mammalian population in East Africa (Habtamu and Bekele, 2008). Despite the large numbers of rodents in the world, less than 100 species of rats are major pests that cause serious damage to crops, stored goods and structures and also transmit diseases to humans and animals (Fall, 2011). In Pakistan, wheat, maize, sorghum and groundnuts are considered as the major crops damaged by rodents (Khanam and Mushtaq, 2021). Maize is one of the significant crops known for its adaptability to a variety of climatic situations (Khan et al., 2012). With a total yield of 4.920 million tonnes, maize (*Gossypium hirsutum* L.) is the third most widely cultivated crop in Pakistan after wheat and rice. Due to the country's expansion of poultry and animal industries, in recent years maize demand has increased (Bashier et al., 2022). Another important cereal crop of Pakistan is wheat, which serves as a staple food. Wheat farming covers 17% of the world's cultivable area and provides food for about 35% of the global population (Dixon et al., 2009). Wheat is not only considered as a main food for human survival but also as a major contributor in any country's economy (Yu et al., 2017). In Pakistan, wheat is a main staple food that fulfills the dietary requirements of individuals who cannot afford high protein food items such as meat and pulses. It is one of the most commonly cultivated crops in the country (Khan and Kulachi, 2002) and its production has reached 31.44 million tons in the financial year 2024 (Economic Survey of Pakistan, 2024). Pakistan being the world's 6th most populous nation, by 2050, its population will reach 350 million (Planning Commission, 2014, United Nations, 2015). To fulfill the rising demands of the expanding population and ensure Pakistan's food security, further food must be produced (Kirby et al., 2017).

In Asian countries, rodents are generally considered the main pests in the agricultural system, causing economic losses at both pre- and post-harvest stages (Singleton et al., 2010). There exists direct grain loss as well as spoiling due to the presence of fecal droppings and hairs. It is generally considered that losses at the post-harvest stage are greater than at the pre-harvest stage (Parshad, 1999). However, there is not much data rigorously gathered on this subject. Limited information is available on storage losses reported about 10% loss in Laos (Brown et al., 2013), 14 % loss in Myanmar (Htwe et al., 2017), and losses ranging from 2.5% to 16% in Bangladesh (Belmain et al., 2015; Krijger et al., 2020).

The biology of rodents has usually been used to assess potential food damage caused by specific rat populations. Food consumption rates are commonly used for estimation of losses (Ahmad et al., 1995). It is difficult for a household to monitor grain removal by rodents in order to assess the actual quantity of stored grains losses, even though farmers will frequently notice fecal droppings in grain storages, within their home or see several holes in grain bags due to rodent gnawing that leads to grain spillage. Knowledge of the extent of grain loss due to rodent damage can encourage farmers to make greater investments in creating rodent-proof grain storage facilities (Belmain et al., 2015).

Some studies from Pakistan have estimated grain losses based on the population of rodents present in indoor conditions; perusal of literature demonstrated that there is no available information on the estimation of actual grain damage caused by these pest species particularly in this area. Having an understanding of the extent of grain loss due to rodent damage can help motivate farmers to take pest control measures. Therefore, the objective of the present study was to estimate the quantitative and qualitative losses due to rodents in two types of stored grains, maize and wheat.

MATERIALS AND METHODS

Study Site

The study was conducted in district Swabi, the fourth most populated district of Khyber Pakhtunkhwa, Pakistan. It is situated between the Indus River and the Kabul River. Due to the fertile agricultural land in the district, the majority of the population is involved in agriculture. The district has a substantial comparative advantage in the cultivation of cash crops including tobacco, wheat, and maize, which account for roughly 56%, 5.4%, and 7% of the province's yearly production, respectively.

Sampling Protocol

The study protocol was adopted from previously conducted studies on damage assessment in storages (Brown et al., 2013; Belmain et al., 2015). After obtaining consent from the store owners, six grain stores (three for maize and three for wheat) were selected for this experiment. For sampling, plastic containers of the diameter of 25 cm and width 9 cm were placed in each store. The container was pre weighted and later filled with 3 kg grains from the farmer's store. Two containers were kept in each grain store. One was left open, and the other was kept covered with wire gauze to measure the change in moisture content. The covered container served as a control measure of moisture loss or gain from the ambient air by wheat and maize in the container. The containers were placed between the grain bags.

Experimental trials were conducted from June to September 2021. After every two weeks, each store in the study area was visited. The changes in containers' weight, contamination from rat hairs and droppings, and grain damage were tracked over time. Farmers were asked not to add or take away maize and wheat from the containers within the store to obtain precise weight and contamination measurements. Four trials were conducted, each lasting fifteen days. The containers were taken out of the store during each visit; weighed and checked for droppings, hairs and damaged grains. From the containers, 100 g of wheat and maize samples were taken to record hairs, droppings and damaged grains. For sample collection, the top one cm layer of maize and wheat was gathered into the center of the container. These samples were then spread out on a plastic sheet and the number of rodent droppings, hairs and number of damaged grains was counted from each sample.

Data Analysis

Descriptive statistics, including mean with standard errors was used for data presentation. ANOVA was used to compare the difference in number of hairs, rodent droppings, damaged grains and weight loss between stores. All deviations with $P > 0.05$ were considered non-significant.

RESULTS AND DISCUSSION

In open maize containers, the mean number of rodent droppings/100g were 10.91 ± 1.04 (mean \pm SE). No significant difference was found between the three maize stores in the number of droppings found in samples from the containers ($F = 0.238$, $df = 11$, $P = 0.793$). In store 3, 12 ± 1.3 droppings/100 g were found followed by store 2 and store 1 where 10.5 ± 1.75 and 10.25 ± 2.52 droppings/100 g were found, respectively. The mean number of hairs/100g was 7.58 ± 0.67 (mean \pm SE). No significant difference was found between the three maize stores in the number of hairs found in samples from the containers ($F = 0.60$, $df = 11$, $P = 0.569$). In store 3, 8.25 ± 1.10 hairs/100 g were found followed by store 1 and store 2, where 8 ± 1.68 and 6.5 ± 0.64 hairs/100 g were found, respectively (Figure 1).

In open wheat containers, the mean number of droppings/100g was 16.25 ± 0.77 (mean \pm SE). There was no significant difference in the number of fecal droppings between the three wheat stores ($F = 0.115$, $df = 9$, $P = 0.893$). In store 2, 16.75 ± 1.03 droppings/100 g were found followed by store 3 and store 1 where 16.25 ± 1.79 and 15.75 ± 1.49 droppings/100 g were found, respectively. Likewise, at the end of an experiment the mean number of hairs/100g was 12.41 ± 0.76 (mean \pm SE). Results showed that no significant difference was present in the number of hairs recorded from the open containers at the three wheat stores ($F = 0.725$, $df = 9$, $P = 0.511$). In store 3, 13.75 ± 1.31 hairs/100 g were found followed by store 1 and store 2 where 11.75 ± 1.6 and 11.75 ± 1.10 hairs/100 g were found, respectively (Figure 2).

At the end of experiment, the mean number of grain damage/100g was 28.58 ± 2.02 (mean \pm SE) in maize stores. There was no significant difference found between the three maize stores in number of droppings found in samples from containers ($F = 0.38$, $df = 9$, $P = 0.69$). In store 2, 31.25 ± 3.47 damaged grains/100 g were found followed by store 3 and store 1 where 27.25 ± 4.25 and 27.25 ± 3.35 damaged grains/100 g were found, respectively (Figure 3). Likewise, in wheat stores, the mean number of grain damage/100g was 21.41 ± 1.26 (Mean \pm SE). There was no significant difference between the three wheat stores in the number of grain damage found in samples from containers ($F = 0.300$, $P = 0.748$). In store 1, 22.5 ± 2.32 damaged grains/100 g were found followed by store 3 and store 2 where 21.75 ± 3.19 and 20 ± 0.91 damaged grains/100 g were found, respectively (Figure 3).

There was no significant difference between the three maize stores in weight loss found from the open containers ($F = 1.83$, $df = 11$, $P = 0.21$). Collectively, at the three maize stores there was 509 ± 68.7 (Mean \pm SE) weight loss in grams. In store 3, 668 ± 90.7 weight loss was found followed by store 2 and store 1 where 488 ± 62.35 and 370 ± 1.57 weight loss were found, respectively (Figure 4). Similarly, there was no significant difference between the three wheat stores in weight loss from the open containers ($F = 3.03$, $df = 11$, $P = 0.98$). Collectively, at the three wheat stores there was 483 ± 46.2 (mean \pm SE) weight loss in grams. In store 1, 619 ± 50.16 weight loss was found followed by store 2 and store 3, where 429 ± 77.97 and 400 ± 73.7 weight losses were found, respectively (Figure 4).

The present study showed that rodents were causing different levels of damage in the study area; this poses an important problem for the safe storage of grains at the smallholder level. This conclusion is supported by the few comparable on-farm studies conducted in Asia (Brown et al., 2013). Since, Pakistan's storage facilities are usually not rat-proof, there is a considerable amount of loss, damage. This leads to food instability, poor nutrition, through rodents' urine, faeces, and saliva. Vulnerable food sources will increase the number of rats foraging and surviving (Ahmad et

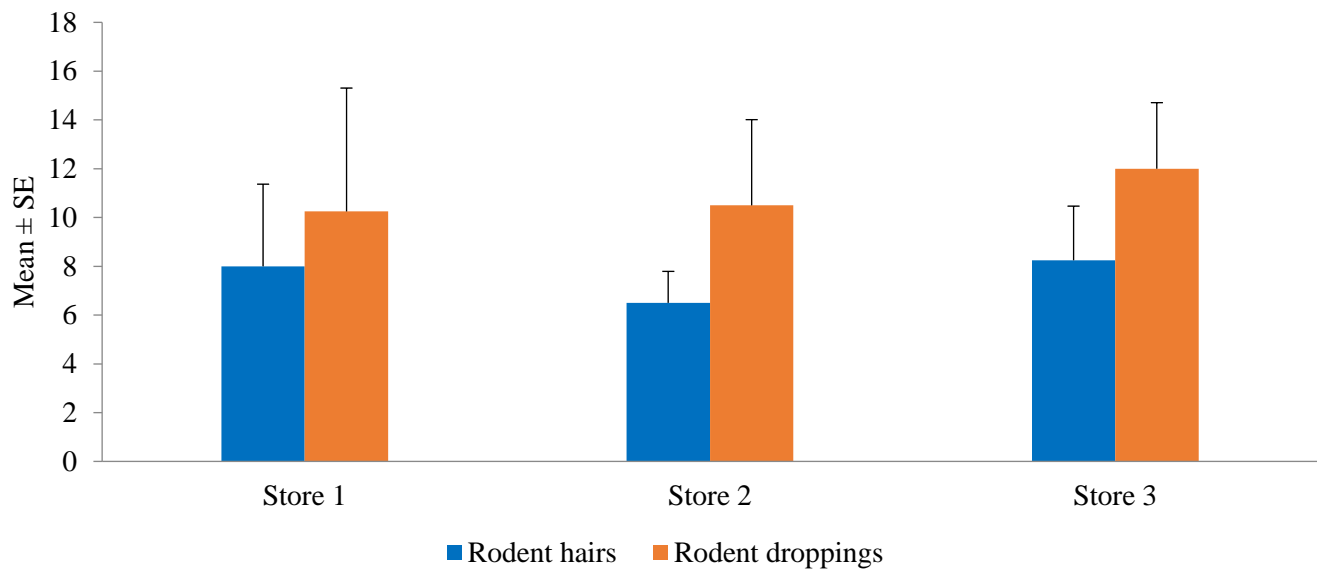


Figure 1. Rodent hairs and droppings recorded per 100-g sample (Mean \pm SE) at the three maize stores.

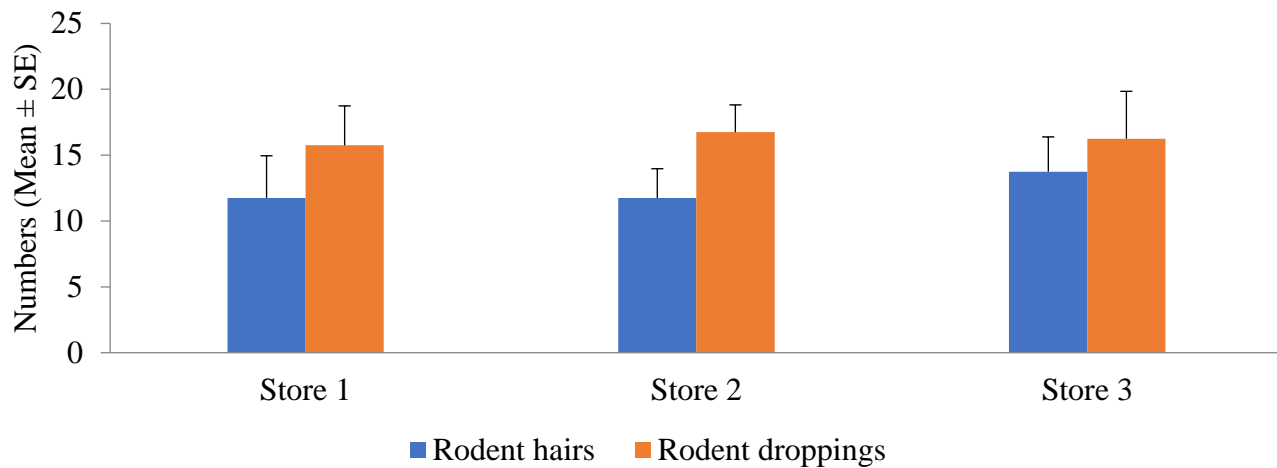


Figure 2. Rodent hairs and droppings recorded per 100-g sample (Mean \pm SE) in three wheat stores.

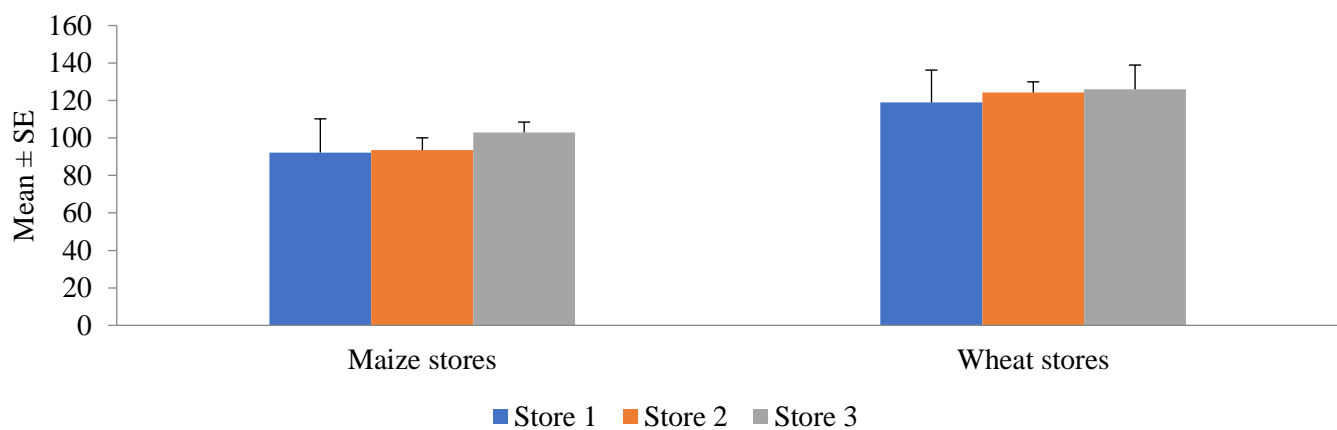


Figure 3. Number of damaged grains per 100 g sample (Mean \pm SE) at the three maize and wheat stores.

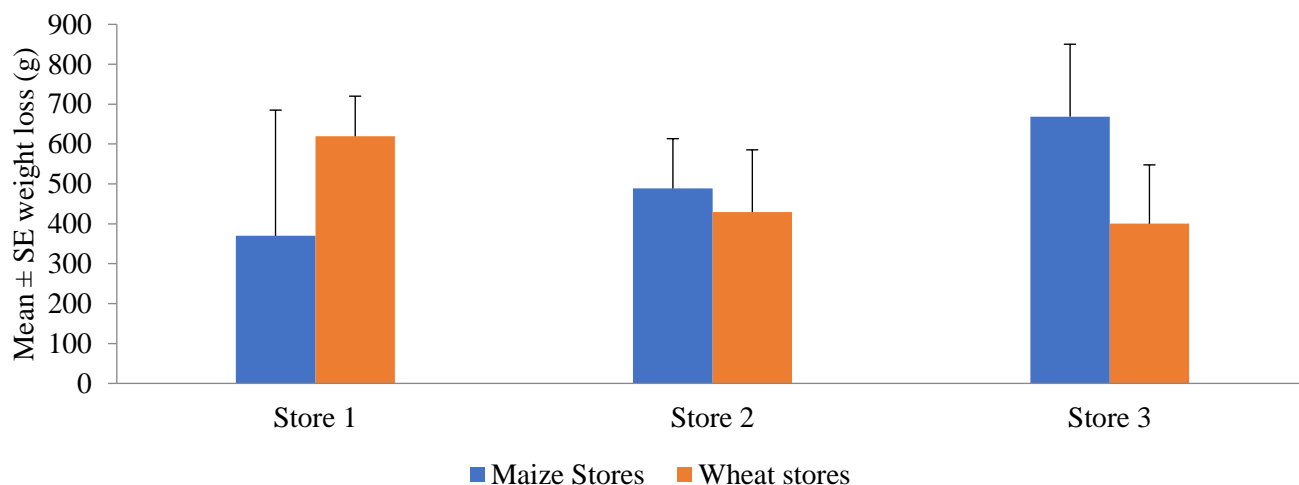


Figure 4. Cumulative weight loss (Mean \pm SE) of maize and wheat from open containers at the stores.

al., 1995). In the present study, 10.91 ± 1.04 and 16.25 ± 1.77 droppings were reported from maize and wheat storages, respectively. Similarly, previous studies on different stored crops have also reported contamination due to rodent dropping. For instance, 2.5-3.0 dropping per 100g were reported from rice stores in Laos (Brown et al., 2013). In another study, 20.2 ± 6.21 dropping per 100g were reported from maize stores in Tanzania (Madangi et al., 2013). In another study Htwe et al. (2017) reported 1-2 dropping per 100g from Maubin and Daik U in Myanmar. Also, 7.58 ± 0.67 and 12.41 ± 0.76 hairs were reported from maize and wheat storages, respectively. Similarly, several studies on different stored crops have also reported contamination due to rodent hairs. For instance, 1.4-2.2 hairs per 100g were reported in Laos (Brown et al., 2013).

In this study, average grain damages of $28.58 + 2.02$ and $21.41 + 1.26$ grains per 100g were reported from maize and wheat storage, respectively. Similarly, in one study, 17.7 ± 3.47 damage were reported from maize stores in Tanzania (Madangi et al., 2013). Furthermore, $509 + 68.7$ and $483 + 46.2$ weight loss were reported from maize and wheat storages, respectively. Similarly, previous studies on different stored crops have also reported weight loss due to rodents. For instance, 10.3% weight loss was reported in Laos (Brown et al., 2013). In another study, 86.0 ± 23.39 weight loss were reported from maize stores in Tanzania (Madangi et al., 2013). Htwe et al. (2017) reported, 165.3 kg weight loss from Maubin and 334.9 kg weight loss from Daik U in Myanmar. Farmers in our study identified that rodents were the pest in their grains store that caused the loss. This, however, depends on different storage structures and durations of storage.

The key to minimizing losses is the use of good storage systems. Farmers use traditional systems after harvest for grain storage. Farmers used different storage systems to store their grains, depending on the environment. In Swabi, a survey of farmers was conducted to learn the fundamental facts from the farmers regarding their storage systems, the pests that cause damage, and the various management techniques used by the farmers.

According to Gwinner et al. (1990), high temperature and moisture content promote the growth of insects. According to the report, most farmers sell their grain stocks after four months, probably to prevent further losses due to bug infestation. The results of this survey indicated that farmers need assistance in improved storage techniques so that they could prolong storage without more grain loss. It's possible that farmers are unable to purchase the grain treatment chemicals needed to prevent/kill insects and that the storage facilities themselves were unable to adequately safeguard grain for prolonged lengths of time. The majority of responders reported that infestations in grain had been stored for a year. This study therefore concludes that farmers need a good storage system to store their grains for longer duration.

CONCLUSION

In conclusion, the study demonstrates that rodents are causing significant damage to maize and wheat crops in the area. The rodents were not only damaging grains, but also contaminating grains with their fecal matter and hairs. Therefore, management strategies for postharvest losses should include rodent control measures, especially among poor rural communities where living conditions encourage widespread rodent infestations that reduce the limited food

resources. Enhancing food security, reducing poverty, and increasing the profit of smallholder farmers can all be achieved by using better farming methods and suitable storage systems.

REFERENCES

- Ahmad, E., Hussain, I. and Brooks, J. E. (1995). Losses of stored foods due to rats at grain markets in Pakistan. *International Biodeterioration and Biodegradation*, 36, 125-133.
- Admas, A., and Yihune, M. (2016). Species composition, relative abundance and habitat association of rodents in Yekoche Forest, East Gojjam, Ethiopia. *International Journal of Biodiversity and Conservation*, 8(9), 216-223.
- Economic Advisory Wing, Finance Division, Government of Pakistan. (2017). *Economic Survey of Pakistan (2016-17)*. Retrieved from https://www.finance.gov.pk/survey_1617.html
- Economic Advisory Wing, Finance Division, Government of Pakistan. (2024). *Economic Survey of Pakistan (2023-24)*. Retrieved from https://finance.gov.pk/survey/chapter_24/Economic_Survey_2023_24.pdf
- Bashier, O., Mustafa, G., Hussain, K., Shazad, M., & Waheed, A. (2022). Forecasting Area and Yield for Maize Crop of Punjab, Pakistan for 2021-2030. *Proceedings 19th International Conference on Statistical Sciences*, 36, 63-70.
- Bayani, A., Tiwade, D., Dongre, A., Dongre, A. P., Phatak, R. and Watve, M. (2016). Assessment of crop damage by protected wild mammalian herbivores on the western boundary of Tadoba-Andhari Tiger Reserve (TATR), Central India. *PLoS One*, 11, 0153854.
- Belmain, S., Htwe, N., Kamal, N. and Singleton, G. (2015). Estimating rodent losses to stored rice as a means to assess efficacy of rodent management. *Wildlife Research*, 42: 132-142.
- Bonnefoy, X., Kampen, H. and Sweeney, K. (2008). Public health significance of urban pests. World Health Organization, Copenhagen.
- Brown, P. R., McWilliam, A. and Khamphoukeo, K. (2013). Post-harvest damage to stored grain by rodents in village environments in Laos. *International Biodeterioration and Biodegradation*, 82: 104-109.
- De Lucia, M. and Assenato, D. (1994). Agricultural engineering in development: post-harvest operations and management of food grains. *FAO Agric. Ser. Bull.* (FAO): Rome, Italy.
- Dixon, J., Braun, H. J., Kosina, P. and Crouch, J. H., (Eds.). (2009). *Wheat facts and futures*, CIMMYT.
- Fall, M.W. (2011). Commensal rodent pests. David Pimentel, ed. *Encyclopedia of Pest Management*. NJ: Taylor and Francis.
- Gwinner, J., Harnisch, R. and Muck, O. (1990). Manual on the prevention of post-harvest seed losses, post-harvest project. *GTZ, D-2000, Hamburg, FRG*, 294.
- Habtamu, T. and Bekele, A. (2008). Habitat association of insectivores and rodents of Alatish National Park, northwestern Ethiopia. *Tropical Ecology*, 49: 1-11.
- Htwe, N. M., Singleton, G. R. and Maw, P. P. (2017). Post-harvest impacts of rodents in Myanmar; how much rice do they eat and damage? *Pest Management Science*, 73: 318-324.
- Kay, E. H. and Hoekstra, H. E. (2008). Rodents. *Current Biology*, 18, 406-410.
- Khan, M. B., Ahmad, M., Hussain, M., Jabran, K., Farooq, S. and Waqas-UI-Haq, M. (2012). Allelopathic plant water extracts tank mixed with reduced doses of atrazine efficiently control *Trianthema portulacastrum* L. *Zea mays*, *Journal of Animal and Plant. Science*, 22, 339-346.
- Khan, S. M. and Kulachi, I. R. (2002). Assessment of post-harvest wheat losses in DI Khan. *Asian. Journal of Plant Sciences*, 1, 103-106.
- Khanam, S. and Mushtaq, M. (2021). Farmers' knowledge, attitudes and practices towards rodent pests and their management in rural Pothwar, Pakistan. *Pure and Applied Biology*, 10, 1181-1193.
- Kirby, M., Mainuddin, M., Khaliq, T. and Cheema, M. J. M. (2017). Agricultural production, water use and food availability in Pakistan: Historical trends, and projections to 2050. *Agricultural Water Management*, 179, 34-46.
- Krijger, I. M., Gort, G., Belmain, S. R., Groot Koerkamp, P. W., Shafali, R. B. and Meerburg, B. G. (2020). Efficacy of management and monitoring methods to prevent post-harvest losses caused by rodents. *Animals*, 10, 1612.
- Kumar, D. and Kalita, P. (2017). Reducing postharvest losses during storage of grain crops to strengthen food security in developing countries. *Foods*, 6: 8.
- Madangi, M., Mulungu, L.S., Massawe, A.W., Eiseb, S.J., Tutjavi, V., Kirsten, F., Mahlaba, T., Malebane, P. Von Maltitz, E., Monadjem, A. and Dlamini, N. (2013). Assessment of rodent damage to stored maize (*Zea mays* L.) on smallholder farms in Tanzania. *International Journal of Pest Management*, 59: 55-62.
- Parshad, V. R. (1999). Rodent control in India. *Integrated Pest Management Reviews*, 4, 97-126.
- Singleton, G. R., Belmain, S. R. and Brow, P. R. (2010). Rodent outbreaks: an age-old issue with a modern appraisal. In, G. R. Singleton, S. R. Belmain, P. R. Brown and B. Hardy (Eds.). *Rodent Outbreaks: Ecology and Impacts*. p. 289. International Rice Research Institute. Los Baños
- Yu, W.Y., Xi, Y.B. and Yu, H. (2017). The empirical research of fertilizer source pollution caused by input subsidy. *Rural Economic*, 2: 89-94.