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PRE-HARVEST RODENT-INFLICTED DAMAGE TO MAIZE AND SUGARCANE CROPS IN SWABI, PAKISTAN

Surrya Khanam*[a], Shaheen Akhtar[a], Saha Bukhari[a], Abra Sheema[a], Muhammad Mushtaq[b] Asima Azam[c], Gulnaz Parveen[d]

[a]Wildlife and Ecology Laboratory, Department of Zoology, Women University Swabi, Pakistan;
[b]Wildlife and Ecology Laboratory, Department of Zoology, PMAS Arid Agriculture University Rawalpindi, Pakistan;
[c]Department of Zoology, Shaheed Benazir Bhutto Women University, Peshawar, Pakistan;
[d]Department of Botany, Women University Swabi, Pakistan
*Corresponding author. Email: surryiamalik@gmail.com
Surrya Khanam: https://orcid.org/0000-0002-6502-2054

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Abstract. Rodents are considered to be one of the most important pests in the agricultural system of Pakistan. The present study was conducted to assess the pre-harvest damage to maize and sugarcane crops. Also, a survey of farmers was conducted to assess their knowledge and understanding about rodent pest species. For estimation of crop damages, we selected 40 maize fields in two villages and 30 sugarcane fields in three villages of district Swabi. In maize fields, the average damage was found to be higher in village Guloo Deri as compared to village Baikot. In the case of sugarcane fields, the average damage was higher in the village Menai as compared to villages Ghoati and Jandaboka. However, these differences were statistically non-significant ($p > 0.05$) in both crops. In maize crops, two rodent species, including *Rattus rattus* (7) and *Mus musculus* (4) and one insectivorous species house shrew (*Suncus murinus*) (6) was captured. In sugarcane crops, there were three rodent species including *R. rattus* (2) and *M. musculus*, (2) *Bandicota bengalensis* (2) and a single insectivorous species house shrew (*S. murinus*) (5) caught. The results of the farmers' survey shows that farmers consider insects to be the major pest in both crop fields and storage structures. Among the crops affected by rodents, wheat was reported to be the major crop followed by maize. Most of the farmers believed that rodent control is required and that crop losses can be minimized through pest control. In conclusion, for the effective management of rodent pests in the area, further investigation into rodent ecology and their damage to different growth stages of crops is necessary.

INTRODUCTION

Rodents are an important pest causing pre and post-harvest losses in agricultural systems throughout the world. According to an estimate, prevention of rodent-inflicted losses could feed 200 million people for the whole year (Aplin et al. 2003). Rodents affect environment, directly and indirectly through their feeding habit and through being a stable food item for many predators in the food chain (Abazaid 1997). Rodents cause different types of damage, including damage to trees, agricultural crops, disease transmission and various indoor damage, all of which lead to financial losses (Aplin et al. 2003).

Maize and sugarcane crops are considered to be the most significant cash crops throughout the world. In developing countries, maize accounts for about 30% of the required calorie intake for more than 4.5 billion people (Shiferaw et al. 2011). Pre- and post-harvest losses of maize crops are caused by different kinds of damage inflicted by pest species across the world (Justice and Bass 1979; Bekele et al. 2003; Makundi et al. 2006; Mohammed 2013; Kamanula et al. 2011). Sugarcane crops also suffer different types of damage due to rodent gnawing, mostly leading to bacterial and fungal infections to sugarcane (Meyer 1994).

In the present study area, maize and sugarcane are the two major winter crops. Both are important cash crops and their production has an important impact on farmers' living standards. Throughout the country, these crops suffer different types of damage caused by various rodent species. However, rodent-inflicted damage to crops has not been well documented, and the situation is the area under study is not different. In order to develop effective management plans for damage control, it is necessary to understand the major pest species, their damage and impacts on living standards of farmers. Therefore, the present study was undertaken with the view to determine the pest-inflicted damage

to both maize and sugarcane crops in Swabi, Khyber Pakhtunkhwa. Also, a survey of farmers was conducted in order to determine their knowledge and understanding about rodent pests.

MATERIALS AND METHODS

The present study was conducted in the district Swabi, the 8th largest city of Khyber Pakhtunkhwa, Pakistan. It is located near the bank of the Indus River. The total area of Swabi is 1543 km². It lies between the longitude of 72°28'12.5544" E and the latitude of 34°7'12.5580" N. The weather in Swabi is hot and humid in summer and cold in winter. The average temperature in the district is 22.2°C and the average annual precipitation is 639 mm.

The composition of rodent species and their pre-harvest damage to maize crops were determined in the villages Guloo Deri and Baikot. The pre-harvest damage to the sugarcane crops and the composition of rodent species responsible for this damage was ascertained in villages Menai, Ghoati, and Janda boka. Maize and sugarcane, which represent the major crops of the season in all the villages are often cultivated adjacent to one another. The harvesting of crops starts in October and continues until the beginning of December.

Rodent damage assessment

For the assessment of crop damage by rodents at pre-harvest time, a randomized sampling technique was adopted. Fields for survey were selected on the basis of land owners' verbal consent. In total, 40 maize fields (20/ each village) were selected for the survey in two villages, Guloo Deri and Baikot. While in the case of sugarcane crop, 30 fields were selected (5 in Menai, 12 in Ghoati and 13 in Janda boka village). In this method, randomly four points were selected within the field for damage assessment. At each survey point, the surveyor walked until the tenth plant was reached and recorded the number of damaged plants during the walk along the ten plants.

The total damage was expressed in percentage terms. In both crops damage was assessed using the following formula (Brooks et al. 1990).

$$\text{Percent damage (\%)} = \frac{\text{Number of damaged plants}}{\text{Total number of plants observed}} \times 100$$

Rodent species diversity

To determine the diversity of rodent species in maize and sugarcane crops, rodent trapping was conducted at the pre-harvest stage. In total, 10–15 traps were randomly placed in maize and sugarcane fields for four consecutive nights to capture rodent species. The traps were set in the evening at 06:00 pm and checked the next morning (07:00 am to 08:00 am) for trapped animal. Each captured animal was given a field number, date of capture, capture location and was placed in bag before carrying it to the Laboratory of the Department of Zoology, Women University Swabi for further processing and analysis. In the laboratory, every specimen was identified and its gender, mass, and body measurements (viz. tail length, head- body length, hind foot and ear length) were recorded.

Farmer Survey

A survey of farmers was conducted to determine their knowledge, practices and attitude towards rodent pests. In total, 68 farmers were interviewed using a structured questionnaire. The survey questionnaire was divided into three sections. The first one included questions aimed to elicit the demographic information about the farmers. The second section contained detailed questions about farming practices and production constraints. The questions related to the rodent damages and management methods employed were presented in the third section of the questionnaire.

Data Analysis

Descriptive statistics were used for the analysis of the obtained data. For damage assessment, the mean and percentages were calculated. Non-parametric tests were applied for the analysis of results. Mann-Whitney test and Kruskal-Wallis test were used to compare variations in damage percentages between different villages. All the values with $p > 0.05$ were considered to be non-significant. As for the farmers' questionnaire, percentages were calculated for farmers' responses. All of the analyses were performed using IBM SPSS Statistical Package Version 23.0.

RESULTS

Rodent Damage and Species diversity

The percent damage determined in maize crops in the Guloo Deri and Bailkot villages was 21.1% and 17.1%, respectively (Table 1, Figure 1). No significant difference was found in maize damage between two villages (Mann-Whitney U = 137, $p = 0.8$). The average damage recorded in the village Guloo Deri was 8.45 ± 2.5 (Mean ± SD) and that in the village Baikot was 6.85 ± 3 (Mean ± SD) (Figure 2). The percent damage to sugarcane crops recorded in Menai, Ghoati and Janda boka was 21.5%, 15.6% and 14.3%, respectively (Table 1). In case of sugarcane fields, no significant difference was found in damage among three villages (Kruskal-Wallis

Table 1. Damage assessment in maize and sugarcane crop fields in different villages of Swabi, Pakistan.

	Maize		Sugarcane		
	Guloo Deri	Baikot	Menai	Ghoati	Janda boka
Total no. of fields assessed	20	20	5	12	13
Total no. of points studied (4/Field)	80	80	20	48	52
Total no. of plants checked (40/Field)	800	800	200	480	520
No. of damaged plants	169	137	43	75	74
Damage (%)	21.1	17.1	21.5	15.6	14.2

$H_{2.30} = 0.61$ $p = 0.7$). The highest average damage recorded in the village Menai was 8.6 ± 6.3 (Mean ± SD) followed by that in Ghoati (6.25 ± 4.5, Mean ± SD) and in Janda boka (5.7 ± 3.9, Mean ± SD) (Figure 3).

In total, 17 individuals were captured in the surveyed maize fields, 11 of which were murid rodents, while the remaining six individuals were representatives of the house shrew (*Suncus murinus*), an insectivorous species. The trapped rodents were *R. rattus* (n = 7) and *M. musculus* (4). In sugarcane fields, a total of 11 individuals were captured, six of which were murid rodents, while the remaining five individuals belonged to the insectivorous species, house shrew (*Suncus murinus*). The trapped rodents were *R. rattus* (2) and *M. musculus* (2) *Bandicota bengalensis* (2).

Farmers' Survey

Socio demographic characteristics of the interviewed farmers

The respondents were divided by age into four groups (the group of respondents under the age of 30, 30–40 age group, 41–50 group and the group over the age of 50). Out of the 68 respondents interviewed, 18% were under the age of 30, 19% fell into the age group 30–40, 37% belonged to the age group 41–50, and 26% of the respondents were over the age of fifty. The majority of respondents were married (81%), the mean family size being seven members (range = 2–17). Most of the respondents had secondary education (33%) or the education above secondary level (26%). Farming was the major occupation for 17.6% of the respondents, a side business for rest of them, who were engaged in other activities, e.g., had their own small business (58.8%), worked in the private or public sectors (17.6%) or did day labour jobs (5.9%).

The monthly income of the majority of respondents (35.3%) ranged from 20000 to 30000PK Rupees (about 90–136 US$). The majority of farmers (72.1%) had their own land, their average farming experience was 16.2 years (range = 2–40 years) and the average land area was 2.84 ha (range = 0.05–120 ha).

Figure 1. Damage observed in the maize and sugarcane fields during the loss estimation survey.

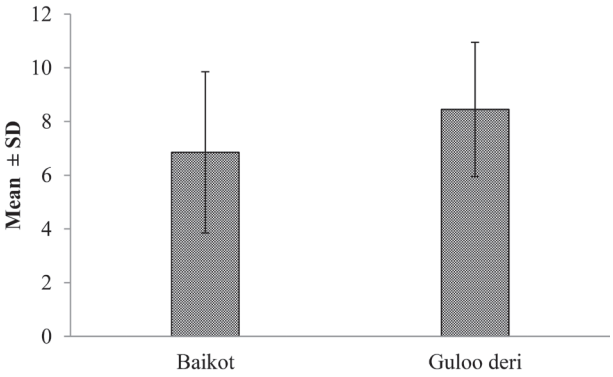

Figure 2. Mean ± SD of damaged plants in maize crop fields in the two villages of Swabi, Pakistan.

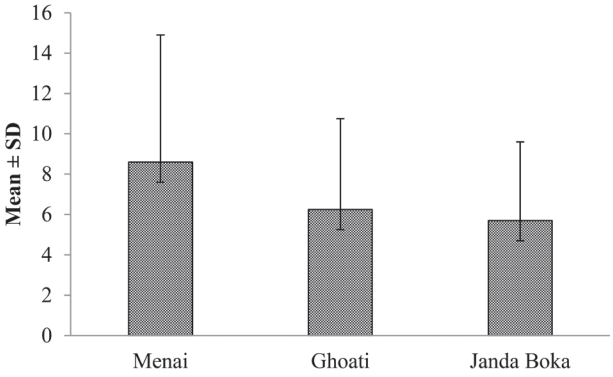

Figure 3. Mean ± SD of damaged plants in sugarcane fields in the three villages of Swabi, Pakistan.

Farmers' knowledge related to crops and pests

Most of the farmers planted crops in both summer and winter. High prices of fertilizers were pointed out by the majority of farmers as the major constraint in agriculture (91.2%) followed by water shortage (79.4%), labour cost (56%), and low seed quality (55.9%) (Table 2). According to farmers, wheat was the crop most affected (57.4%) by rodents, followed by maize (42.6%). The major pests in crop fields were insects (54.7%), followed by rodents (33.8%) and wild pigs (1.5%). Farmers perceived rodent damage to their crops by spotting their footprints (50%), by rodent burrows (44.1%), by directly spotting rats moving (2.9%) or by plant damage (1.5%). The most common measure employed by farmers for rodent management was the use of rodenticides (85.3%), followed by burrow flooding (7%) and trapping (1%). However, 4.4% of the respondents were using multiple methods for rodent control.

As regards crop storage, insects were identified as the major pests (60.3%), followed by rodents (35.3%). Farmers assessed their losses by directly noticing stored grains damage (55.9%), rodent droppings in grains (26.5%), by hearing noises or by directly spotting rats moving (16.2%).

Farmers' beliefs and perceptions

In order to elucidate farmers' beliefs about rodents, they were asked a set of questions. A three-point Likert scale was used to record their responses. The great majority of the interviewed farmers (97%) considered that rodent control is necessary, and almost all of them believed that crop production was affected by rodent pests (97%). In the opinion of approximately 86.8% of the farmers, rodents can cause diseases. Most of the farmers realized that they were working cooperatively with other farmers (60.3%), but the majority believed that farmers' cooperation in rodent management cannot control rodent pests (55.9%). The majority of farmers pointed out that they received no assistance or training in rodent control (71.6%) (Table 3).

DISCUSSION

In the present study, significant damage was recorded in sugarcane crops at the time of harvesting. This is in agreement with the findings of previous studies performed in different parts of the world. For instance, Bekele et al. (2003) reported a 26.4% yield loss during maize harvesting due to rodents. Khan et al. (1997) reported 10.7% yield loss in maize crops from hilly areas of Azad Kashmir. As reported by Ali et al. (2003), the average 7% loss in the sugarcane crops in Sindh, Pakistan is caused by different rodent activities. The sugarcane crop damage in the range of 6.62% to 10.4% was reported from Sindh, Pakistan (Pervez et al. 2019). Similarly, 7–15% sugarcane losses due to rodents were reported from Tatta, Sindh (Pervez and Ali 2001).

In the present study, four species of small mammals were detected in maize and sugarcane crop fields. Of these, three species are generally considered to be commensal/ indoor species. Trapping of these species in

Table 2. Ranking of different crop production constraints by farmers.

Major constraints on crop production	n	Number of respondents (%)		
		True	Not true	Not sure/No opinion
High prices of fertilizers	68	62 (91.2)	5 (7.4)	1 (1.5)
Water shortage	68	34 (50.0)	34 (50.0)	–
Less fertile soil	68	36 (52.9)	28 (41.2)	4 (5.9)
Rain problems	68	37 (54.4)	26 (38.2)	5 (7.4)
Rodent problem	68	54 (79.4)	13 (19.1)	1 (1.5)
Low quality seeds	68	38 (55.9)	28 (41.2)	2 (2.9)
Labour cost	66	37 (56.0)	18 (27.3)	11 (16.6)

Table 3. Farmers' perceptions and beliefs about rodent pests and their management in Swabi, Pakistan.

Statements	Number of respondents (%)			
	n	True	Not true	Not sure/May be true
Rat control is needed	68	66 (97.1)	–	2 (2.9)
Crop production is affected by rodents	67	65 (97.0)	2 (2.9)	–
Rodents are sources of disease	68	59 (86.8)	5 (7.4)	4 (5.9)
Collective effort of farmers can decrease losses due to rodents	68	21 (30.9)	38 (55.9)	9 (13.2)
All farmers cooperate in rodent management	68	41 (60.3)	15 (22.1)	12 (17.6)
Help or training provided by government/private sector in rodent management	67	15 (22.4)	48 (71.6)	4 (5.9)

the crop fields could be due to the presence of houses in the near vicinity. In villages, houses and fields are often at a close enough distance from one another; hence rodent species tend to move from houses into the fields in search for food.

Farmers identified insects as the major pests in both crop fields and in storage facilities. Similarly, in Myanmar, rats were considered to be the second most popular pests after insects, which were the principal pests causing most damage (Brown et al. 2008). In one similar type of farmers' survey, rodents were reported as the major pest in Pothwar, an arid region of Pakistan (Khanam and Mushtaq 2021). In Indonesia and Vietnam, farmers considered rodents to be the major crop pests (Sudarmaji et al. 2003; Tuan et al. 2003). In maize warehouses, rodents cause common damage such as consumption of seed germs, contamination of grain with urine, faeces and hairs, which results in disease spreading and lower market values (Justice and Bass 1979). In Tanzania, the 35% damage has been recorded in stored maize seeds (Makundi et al. 2006).

In the uplands of Lao PDR, trapping was considered to be the most effective method for rodent control (Brown and Khamphoukeo 2007). According to farmers, rodenticides are the most effective rodent control measure.

Although farmers showed preference to rodenticides as the rodent control measure, they had no idea about their types and correct usage. In the Philippines, poisoning was also reported to be a common rodent control measure (Stuart et al. 2011).

In some of the developing countries, including Vietnam (Brown et al. 2006) and Indonesia (Singleton et al. 2005), ecologically based rodent management has been implemented successfully, as a result of which the use of rodenticides has decreased by 75% and 50%, respectively. Previous studies suggested that farmers should be encouraged to work together at a community level (Brown and Khamphoukeo 2007; Stuart et al. 2011) so as to successfully implement management plans.

Although most of the farmers agreed that they could manage rodents and decrease losses in their crop fields more effectively through joint efforts, most of them were controlling rodent pests individually. According to Babbar et al. (2014), crop damage and rodent infestation could be reduced if farmers were given proper education and training. Similarly, Khatam et al. (2014) proposed that the Farmer Field School (FFS) could be an operative strategy minimizing pre -and post- harvest losses due to various pests.

In conclusion, the present study has shown that rodents as well as insectivorous species were visiting maize and sugarcane fields during harvesting, causing significant damage to both crops in the area. Further extensive studies on damage assessment along with trapping campaigns throughout each crop phase are proposed in order to determine the composition and ecology of the pest species in these crops. This will help to track the species status along with the damage assessment throughout the crop stages.

DISCLOSURE STATEMENT

There is no conflict of interest among authors.

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