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Documentation of storage practices of major cereals followed by farmers

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Abstract

Adoption of appropriate cereal storage practices plays a vital role in ensuring food availability for household consumption, future marketing, and seed requirements for succeeding cropping seasons. In the Union Territory of Jammu and Kashmir, empirical evidence on the extent and nature of cereal storage practices adopted by farmers remains limited. To address this gap, the present investigation, entitled "Documentation of Storage Practices of Major Cereals Followed by Farmers" was undertaken using an exploratory research design and a multistage random sampling technique. The study was conducted in irrigated blocks (Arnia and Bishnah) and unirrigated blocks (Bhalwal and Nagrota) of Jammu district, with a total sample of 160 farmers, equally drawn from irrigated and unirrigated areas. The findings revealed that hermetic metal silos emerged as the most widely adopted storage structure, indicating a gradual shift towards improved and scientific storage methods. Rice, wheat, and maize were the major cereals stored, primarily for household consumption, seed purposes, and delayed sale. Farmers reported noticeable storage losses, with insect infestation, particularly weevils, being the most common problem across cereals. Chemical protectants were predominantly used, with boric acid widely adopted for rice storage, while aluminium phosphide was commonly applied for maize and wheat. Traditional practices such as the use of neem leaves, cloves, and other plant-based materials exhibited very low adoption levels. Overall, farmers demonstrated a favourable perception towards cereal storage technologies, reflecting positive acceptance and continued use of improved storage practices in the study area.

Keywords: Adoption, cereal storage practices, hermetic metal silos, storage losses, weevils

1. Introduction

Ensuring food security for a rapidly expanding population under the dual pressures of accelerating urbanization and climate change remains one of India's most pressing challenges. With an annual population growth rate of 1.26 per cent, India's population is projected to reach 166.8 crore by 2050 ^[1]. Since the advent of the Green Revolution in the mid-1960s, the country has achieved remarkable progress in food grain production, emerging as the second largest producer globally after China, with a total output of 317.58 million tonnes ^[2]. However, agricultural self-sufficiency has not translated proportionately into food and nutritional security. Nearly 224.3 million people, representing about 16 per cent of the population, continue to remain undernourished ^[3], underscoring the critical role of post-harvest management, storage, and distribution inefficiencies rather than production constraints alone.

Post-harvest grain losses comprise both quantitative losses, including physical damage and storage losses, and qualitative losses such as nutritional degradation, contamination, handling damage, and decline in market

value ^[4]. FAO estimates indicate that post-harvest losses of food grains in India range between 10 and 25 per cent, with storage losses alone accounting for more than five per cent of the total losses. These losses occur throughout the post-harvest continuum- from harvesting and preprocessing to transportation, storage, and marketing and result in weight loss, reduced seed viability, deterioration in grain quality, and substantial economic losses to farmers ^[5]. The World Bank has estimated that the magnitude of post-harvest grain losses in India could potentially feed nearly one-third of the country's poor population, highlighting the urgency of addressing storage-related inefficiencies ^[6].

Grain storage plays a pivotal role in agricultural sustainability by ensuring year-round food availability, safeguarding seed for subsequent cropping seasons, stabilizing farm income, and enhancing livelihood security ^[7]. Efficient storage enables farmers to retain produce for household consumption, seed purposes, livestock feeding, or delayed marketing to take advantage of favourable prices. Despite its importance, a considerable proportion of food grains in India continues to be stored under suboptimal

conditions due to inadequate infrastructure, limited technical knowledge, and heavy reliance on traditional storage systems, resulting in significant grain deterioration and economic loss [8].

Stored grains are particularly vulnerable to damage by insect pests belonging mainly to the orders Coleoptera and Lepidoptera, which often initiate infestation during crop development in the field and continue their activity throughout the storage period. These pests cause direct quantitative losses through feeding and indirectly promote secondary fungal and microbial infections, thereby accelerating quality deterioration and loss of market value [9]. In addition, rodent species such as *Bandicota bengalensis*, *Rattus norvegicus*, *Rattus rattus*, and *Mus musculus* pose serious threats to stored grains by causing direct consumption, spillage, and contamination through droppings and urine, adversely affecting both grain quality and human health [10].

Environmental factors such as grain moisture content, relative humidity, temperature, and ventilation critically influence the extent of storage losses. Relative humidity levels exceeding 70 per cent favour insect multiplication and mold growth, whereas long-term safe storage of cereals requires grain moisture content below 13 per cent. Poorly designed and inadequately managed storage structures exacerbate pest infestation and moisture accumulation, particularly among smallholder farmers who largely depend on traditional storage methods such as gunny bags, earthen bins, and household-level storage structures. At the farm level, storage loss assessment is commonly based on visual observation of damage symptoms and estimation of weight loss, which may underestimate the actual magnitude of losses [11].

In this context, indigenous traditional knowledge related to grain storage assumes considerable significance. Indigenous storage practices, developed through generations of experiential learning and local adaptation, offer cost-effective, environmentally sustainable, and culturally acceptable solutions to post-harvest challenges. Systematic documentation of such knowledge is essential to prevent its erosion and to ensure its continued relevance for present and future generations. Moreover, proper documentation facilitates scientific validation, refinement, and integration of indigenous practices with modern storage technologies, thereby enhancing their effectiveness and wider dissemination through agricultural extension systems [12].

Although several studies have examined post-harvest losses and storage constraints in different parts of India, systematic investigations focusing on cereal storage practices, pest incidence, associated losses, and the role of indigenous knowledge systems in the Union Territory of Jammu and Kashmir remain limited. A comprehensive understanding of farmers' storage behaviour, purposes and duration of storage, extent of losses, pest management practices, indigenous innovations, and factors influencing storage-related decision-making is essential for designing location-specific extension strategies. Such evidence-based interventions can significantly contribute to reducing post-harvest losses, improving household food availability, and strengthening overall food and nutritional security in the region.

2. Materials and Methods

The present study was conducted during the agricultural year 2023–24 in selected villages of Jammu district, Union Territory of Jammu and Kashmir, to examine the storage practices adopted for major cereal crops. Jammu district was selected purposively owing to its substantial area under rice, wheat, and maize cultivation.

A multistage sampling technique was employed. In the first stage, Jammu district was selected purposively. In the second stage, two irrigated blocks (Arnia and Bishnah) and two rainfed blocks (Bhalwal and Nagrota) were selected randomly. In the third stage, four villages from each selected block were chosen using simple random sampling, resulting in a total of sixteen villages. From these villages, 160 farmers (80 each from irrigated and unirrigated areas) were selected randomly to constitute the sample size.

Primary data were collected through personal interviews using a structured and pre-tested interview schedule covering cereal storage practices, purpose and duration of storage, perceived storage losses, and factors influencing storage decisions. Informal discussions and field observations were also undertaken to validate responses and ensure reliability and consistency of the data.

Hypothesis of the study

H₀₁: There is no significant difference in the storage practices of major cereals followed by the farmers.

H₁₁: There is a significant difference in the storage practices of major cereals followed by the farmers.

Testing of Hypothesis H₀₁ / H₁₁

The results revealed variations in storage practices across major cereals in terms of storage duration, structures used, pest management methods, and perceived losses. Hence, H₀₁ was rejected and H₁₁ was accepted, indicating a significant difference in storage practices of major cereals followed by the farmers.

H₂: Farmers do not significantly use modern storage structures and pest management methods for storing major cereals.

H₂: Farmers significantly use modern storage structures and pest management methods for storing major cereals.

Testing of Hypothesis H₀₂ / H₁₂

The widespread use of modern storage containers and chemical as well as botanical pest management practices across cereals demonstrates significant adoption of modern storage methods. Hence, H₀₃ was rejected and H₁₃ was accepted, indicating that farmers significantly use modern storage structures and pest management methods for storing major cereals.

3 Results and Discussion

3.1 Training Status and Cereal Storage Behaviour of Respondents

The findings revealed an extremely low level of formal training on cereal storage among the respondents, with almost the entire sample lacking exposure to institutional training programmes. This clearly indicates a major gap in post-harvest extension services in the study area. The absence of training may limit farmers' awareness regarding

improved storage technologies and scientific grain management practices, which could otherwise help in reducing post-harvest losses. Similar observations highlighting inadequate extension support in post-harvest management have been reported in literature [13,14].

Despite the lack of training, almost all respondents reported storing cereals during the previous year. Storage was mainly undertaken for household consumption, followed by seed

and animal feed requirements, while storage for speculative market sale was minimal. This pattern suggests that cereal storage in the study area is largely subsistence-oriented rather than commercially driven. Such subsistence-focused storage behaviour has also been reported, emphasizing the role of cereal storage in ensuring household food security rather than profit maximization [15].

Table 1: Distribution of respondents based on cereal storage behaviour and training status (%)

Parameter	Irrigated area (n=80)	Unirrigated area (n=80)	Overall (n=160)
Storage of cereals			
Stored the cereal last year	99	94	96
Not stored the cereal last year	01	06	04
Purpose of cereal storage*			
For own consumption	99	94	96
As feed for animals	52	56	54
For seed	55	33	44
For sale at the right prices	14	01	08
For performing rituals	0	01	01
Training for safe storage of cereals			
Training received	0	01	01
Training not received	100	99	99

3.2 Grain Utilization and Storage Pattern

The results indicated that a substantial portion of harvested grains was sold immediately after harvest, while the remaining quantity was retained for domestic use. Immediate sale of produce may be attributed to farmers' urgent cash needs for meeting household expenses and financing the next cropping season, as also reported in literature [14].

The longer duration of storage observed for rice compared to wheat and maize highlights its importance in ensuring year-round food availability. Rice, being a staple food, is commonly stored for extended periods to maintain household food security. Similar storage trends have been reported, noting that cereals intended primarily for consumption are stored for longer durations compared to those meant for sale [16].

Table 2: Grain utilization and storage pattern of major cereals

Cereals	Sold immediately			Storage for domestic purpose*				
	Average quantity harvested (q)	Average quantity sold immediately after harvest (q)	Average duration of storage before selling (days)	Average quantity retained for consumption (q)	Human (%)	Cattle (%)	Seed purpose (%)	Average duration for their own consumption (days)
Rice (n=80)	23.07	14.71	09	8.91	99	54	52	369
Wheat(n=158)	16.38	9.98	13	6.58	95	53	43	353
Maize (n=62)	5.43	2.00	28	3.61	90	62	25	346

3.3 Type and Location of Cereal Storage Structures

The predominance of storage structures located within residential premises reflects farmers' preference for convenient monitoring and protection of stored grains. Storing cereals within the household allows better supervision and reduces the risk of theft and pest infestation. Comparable findings were reported, observing that residential storage remains common among smallholder

farmers [17].

The higher adoption of scientific storage structures, particularly in irrigated areas, may be attributed to better access to resources, higher production levels, and increased awareness of improved storage technologies. However, the limited adoption in unirrigated areas suggests disparities in technology access and extension outreach.

Table 3: Type and location of cereal storage structures adopted by respondents (%)

Parameter	Irrigated area n=80	Unirrigated area n=80	Overall n=160
Location of cereal storage structure			
Stored within the residence	95	92	94
Stored outside the residence	4	0	02
No storage	01	08	04
Type of storage structures/ containers			
Scientific	98	95	96
Traditional	01	05	03
Both	01	00	01

3.4 Adoption of Storage Containers

Hermetic metal silos emerged as the most preferred storage containers, either used independently or in combination with other containers. Farmers' preference for hermetic structures may be due to their effectiveness in minimizing insect infestation, moisture ingress, and rodent damage. The

airtight nature of these containers creates unfavourable conditions for pest survival, thereby reducing storage losses. Similar preferences for hermetic storage technologies were reported, highlighting their role in improving grain preservation and reducing post-harvest losses^[18].

Table 4: Adoption of different cereal storage containers by respondents (%)

Parameter	Irrigated area n=80	Unirrigated area n=80	Overall n=160
Having storage container	99	90	95
No storage container	01	10	05
Type of storage container			
Hermetic Metal Silos only	77	78	78
Hermetic Metal Silos & Rectangular bins	21	09	15
Hermetic Metal Silos & Plastic drum	01	08	04
Only plastic drum	0	03	01
Hermetic Metal Silos & Traditional structure (koll)	0	01	01
Hermetic Metal Silos, Rectangular bin & Plastic drum	01	01	01

3.5 Storage Practices Followed by Farmers

The widespread adoption of cleaning, sun drying, and winnowing practices before storage reflects farmers' reliance on simple and cost-effective methods for maintaining grain quality. Immediate sealing of storage containers after filling and the separation of fresh and old grains further indicate farmers' awareness of basic storage hygiene practices. These practices help in preventing moisture absorption and pest infestation, thereby extending the shelf life of stored grains. Similar storage practices have been documented in the literature^[19, 20].

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Plate 1: Hermetic Metal Silos and Drums used for cereal storage by respondents in unirrigated sampled village



Plate 2: Traditional non-functional storage structure (koll) and rectangular bins in an unirrigated sampled village

Table 5: Storage practices followed by farmers for safe cereal storage (%)

Parameter	Irrigated area n=80	Unirrigated area n=80	Overall n=160
Cleaning of storage containers	96	93	95
Sundry only	98	98	98
Sundry & fire	01	01	01
Sundry & water wash	01	01	01
Sorted the impurities from grains			
Rice	91	0	46
Winnowing only	100	0	100
Wheat	84	90	87
Winnowing only	99	100	99
Winnowing & water wash	01	0	01
Maize	0	69	34
Winnowing only	-	100	100
Store fresh & older grain separately	97	91	94
Reasons for separation or not separation of grains			
Safe during storage	60	82	71
Good for digestion	39	0	19
Religious purpose	01	0	01
Less production, finished till next season	0	18	09
Fully fill the storage container	37	29	33
Reasons for not filling storage container completely	62	65	63

Ventilation	62	40	51
Less production	26	58	42
Imbibition	10	02	06
Less requirement	02	0	01
Immediate sealing of storage containers	97	91	95
Use gunny bag for storage	51	48	50
Respondents not using gunny bag for storage	47	43	46
Reasons for not using gunny bag			
Rodent attack	16	12	14
Gunny bags are not safe for storage	42	40	41
High cost	24	0	12
No need	18	48	33



Plate 3: Storage of cereals in heaps of gunny bags in sampled irrigated village

3.6 Pre-storage and Storage Management Practices

Sun drying was the most commonly adopted pre-storage practice, emphasizing its importance in reducing grain moisture and preventing spoilage. However, the limited practice of repeated sun drying may expose grains to moisture-related damage during prolonged storage.

Winnowing was widely used for cleaning, whereas sieving was rarely adopted, possibly due to the lack of appropriate equipment or awareness.

During storage, farmers relied on a combination of conventional and chemical pest management practices. Neem leaves were the most commonly used traditional material, owing to their repellent properties, as also reported in literature ^[21]. Chemical control measures were more prominently used in rice, wheat, and maize storage, reflecting farmers' perception of their effectiveness and rapid action against pests. Similar trends in the use of chemical insecticides were reported in the literature ^[22].

Perceived storage losses were highest in maize, followed by wheat and rice. This may be due to the higher moisture content of maize and its greater susceptibility to insect and fungal infestation during storage, as reported in the literature ^[13].

Table 6: Pre-storage and storage management practices adopted by respondents (%)

Cereals	Pre storage*								
	Sun drying		Cleaning			No practices adopted	Perceived loss%		
	Frequently	Duration (days)	Sieving	Winnowing					
Rice(n=79)	03	06	01	91		09	4.13		
Wheat(n=154)	01	03	0	88		06	3.18		
Maize(n=62)	0	09	0	90		08	2.11		
	During storage*								
	Conventional practices					Chemical practices		No practices adopted	Perceived loss%
	Neem leaves	Match box	Clove	Curry leaves	Eucalyptus leaves	Boric acid	Aluminium phosphide56% (Fumigant bag/insecticide)		
Rice(n=79)	05	01	01	0	01	93	0	09	9.86
Wheat(n=154)	27	02	01	02	01	0	79	06	9.95
Maize(n=62)	27	03	0	02	0	0	60	08	10.61

Stored Grain Pests Observed by Respondents

Weevils were identified as the most destructive pests across all cereals. Their high reproductive potential and ability to infest grains internally make them particularly damaging during storage. Similar observations were reported in the literature [16,23]. Khapra beetle infestation was also observed across cereals, with a higher incidence in rice, while moth infestation was more common in maize, as illustrated in Figures 1, 2, and 3. Figure 1 depicts the major storage pests infesting rice, Figure 2 shows the pest complex associated with wheat, and Figure 3 highlights the predominant pests observed in maize. The presence of these pests indicates inadequate storage sanitation and prolonged storage duration, which create favourable conditions for pest multiplication.

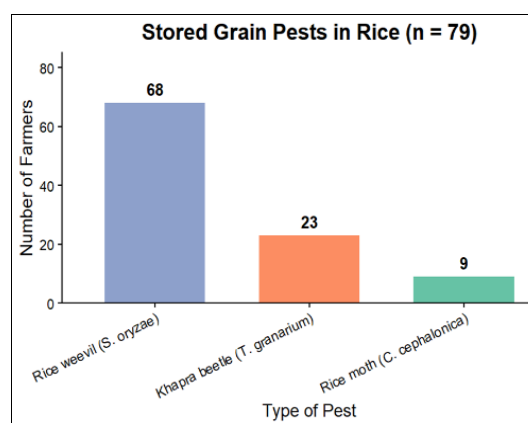


Fig 1: Stored grain pests of Rice

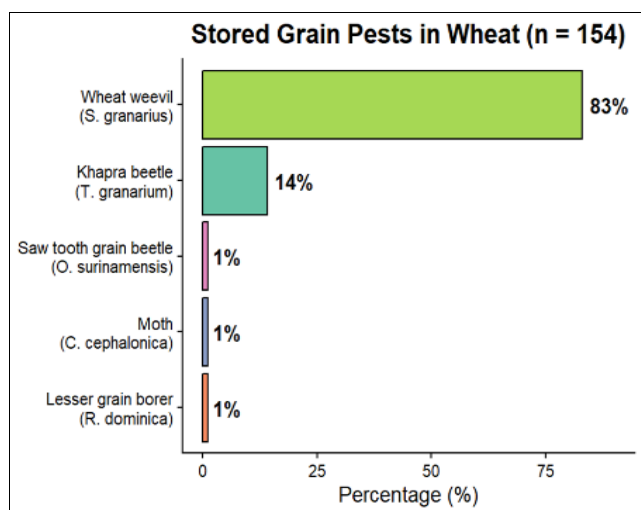


Fig 2: Stored grain pests of Wheat

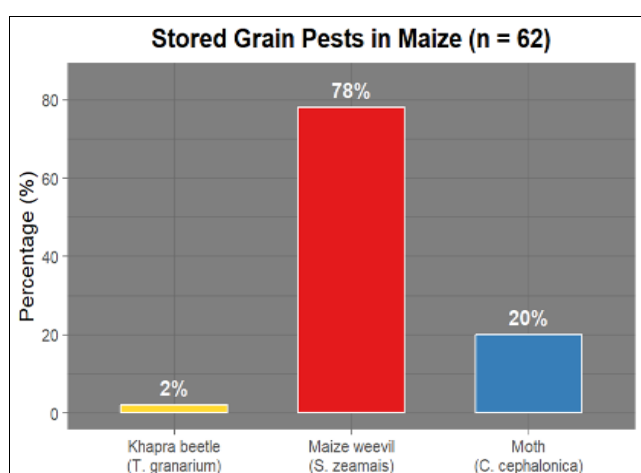


Fig 3: Stored grain pests of Maize

Table 7: List of stored grain pests observed by respondents

Rice (n=79)	
Type of pests	Percentage
Khapra beetle (<i>Trogoderma granarium</i>)	23
Rice weevil (<i>Sitophilus oryzae</i>)	68
Rice moth (<i>Corcyra cephalonica</i>)	09
Wheat (n=154)	
Khapra beetle (<i>Trogoderma granarium</i>)	14
Wheat weevil (<i>Sitophilus granarius</i>)	83
Moth (<i>Corcyra cephalonica</i>)	01
Saw tooth grain beetle (<i>Oryzaephilus surinamensis</i>)	01
Lesser grain borer (<i>Rhyzopertha dominica</i>)	01
Maize (n=62)	
Khapra beetle (<i>Trogoderma granarium</i>)	02
Maize weevil (<i>Sitophilus zeamais</i>)	78
Moth (<i>Corcyra cephalonica</i>)	20

3.8 Perceived Factors Causing Damage to Stored Grains

Improper drying was perceived as the most significant factor contributing to insect damage, followed by climatic variations and poor ventilation. Excess rainfall was identified as the primary cause of moisture-related damage, leading to mould development and discoloration of grains. Rodent damage was mainly attributed to external entry through burrows and mud floors, resulting in broken grains and contamination.

These findings underline the combined influence of biological, environmental and infrastructural factors on storage losses and are consistent with the observations in the literature [24]. These findings underline the combined influence of biological, environmental, and infrastructural factors on storage losses and are consistent with the observations in the literature [24] that insects, moisture, and rodents as major contributors to post-harvest losses.

Table 8: Perceived factors causing damage to stored food grains (n = 160)

Factor	Causes	No.	%	Type of loss	No.	%
Insects	Improper drying	105	66	Aggregate	20	12
	Climatic variation	28	17	Powder	125	78
	Improper ventilation	18	11	Development of holes in grain	9	5
	Long term storage	3	2			
Moisture	Excess rain	140	87	Change in colour	42	26
	Moisture from wet floor	9	6	Black mould development	112	70
Rodents	External entry through burrows	50	31	Broken grains	80	50
	Burrows in mud floor	38	24	Mix the grains with soil	9	6

4. Conclusion

Overall, the study highlights distinct variations in post-harvest losses, utilization patterns, and storage behaviour across major cereals. Rice emerged as the most vulnerable crop during harvesting, threshing, and transportation stages due to its fragile grain structure and high sensitivity to moisture conditions, which increase the risk of mechanical damage and quantitative losses. In contrast, maize exhibited greater susceptibility to storage losses, primarily owing to its relatively higher moisture content at harvest and increased vulnerability to insect and fungal infestations during prolonged storage.

The predominance of consumption-oriented storage clearly reflects farmers' prioritization of household food security over market-oriented storage, with cereals largely retained

for consumption, seed preservation, and livestock feeding. At the same time, the growing preference for improved storage structures, particularly hermetic metal silos, indicates a gradual transition towards scientific and more efficient storage solutions, even in the absence of adequate formal training or institutional support. This shift suggests farmers' experiential recognition of the benefits of improved storage in minimizing losses.

However, the continued dependence on chemical pest control measures and the persistence of inadequate pre-storage practices, such as improper drying and insufficient ventilation, remain key constraints contributing to post-harvest losses. These shortcomings underline the need for greater emphasis on integrated storage management approaches that combine improved handling practices

across the post-harvest chain with enhanced pre-storage preparation and the balanced adoption of scientific and eco-friendly storage methods. Addressing these issues can play a crucial role in reducing losses, improving grain quality, and enhancing the overall efficiency and sustainability of cereal storage systems in the study area.

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