Loss assessment and loss prevention in wheat and storage — technology development and transfer in Pakistan

U.K. Baloch, M. Irshad and M. Ahmed*

Abstract

Pakistan produces about 20 Mt of foodgrains annually that includes wheat, rice, maize, barley and pulses etc. Wheat accounts for about two third of the total foodgrain produced in the country. Substantial losses were known to occur during the postharvest handling operation in Pakistan. However, no estimate based on actual assessment was available before 1984. An attempt was made to investigate the postharvest losses with emphasis on storage losses at farm and public sectors in Pakistan. It was recorded that 5.2% losses takes place during storage at farm level. The losses were more in irrigated areas comparing the rainfed or unirrigated area. At public sector storage losses of 3.5% were observed. This includes the pre-storage, losses due to insects and moulds. Altogether a net quantity of 70.1416 Mt was lost during storage at public sector in Pakistan.

Introduction

Foodgrain production is highly important in the agriculture sector of Pakistan. The main foodgrains of the country are wheat, rice, maize, sorghum, millet and barley. Wheat is by far the most important food of the people of Pakistan accounting for over 87% of the cereal intake. The marketable surplus of foodgrains varies with the farm size and rainfall during wheat season. However it is estimated that over 70% of the total wheat produced in Pakistan is stored at farm level for domestic consumption, meeting the seed requirements and payment of wages etc.

The small farmers normally store the produce in specially constructed mud bins, and the jute bags that are kept in living rooms. Whereas the big farmers store wheat in mud or concrete rooms. Metal bins or boxes are also used for the storage of wheat.

Wheat in the public sector is commonly handled by Provincial Food Departments and Pakistan Agricultural Storage and Supplies Corporation. The procured wheat is mostly stored in house type godowns. Other storage structures includes binnishells, hexagonal bins, silos and open platforms. The storage period may vary from few weeks to about two years. Losses are generally caused by biological agents that includes insects, moulds, birds and rodents. The physical factors viz grain moisture content, relative humidity and temperature favours the development and activity of pest organisms. Of all these insects have been reported to be of foremost importance. However, the management practices plays an important role.

*Pakistan Agricultural Research Council, P.O. Box 1031, Islamabad, Pakistan.

Prior to 1984 very little work was done on assessment of storage losses to wheat in Pakistan. MICAS (1976) guesstimated a 5–7% loss to stored wheat whereas, Khan and Cheema (1978) reported it to be 2–3% of the total production. Chaudhry (1980) conducted a study that was based on questionnaires. It was apparent that the previous information on the extent of losses were not based on sound scientific surveys and correct methodologies. The present study was therefore planned with the aim to determine the extent of storage losses to wheat in public sector and farm level. The loss assessment studies were followed by loss prevention programs on pilot projects basis. In the past the absence of scientific data prevented the loss reduction programs.

Material and Methods

The design used for selection of farmers at farm level was stratified random sampling. The province of Punjab was divided into irrigated and unirrigated or rainfed area. For unirrigated area, three land tenure strata were used i.e. 12.5 acres and less, 12.5–25.0 acres and above 25.0 acres. For irrigated areas four (ha) land tenure strata were used 6.25 acres and less, 6.25–12.5 acres, 12.5–25 acres and above 25 acres. A total of 32 villages were selected for detailed investigations. In each village 16 farmers were chosen for loss assessment studies. Samples were collected from each farmers store at monthly interval. Loss assessment methods used were simple thousand grain Mass (TGM), multiple thousand grain mass, simple count and weigh, multiple count and weigh and bulk density. Representative samples of one kilogram were drawn, labelled and packed (in polyethylene bags) and brought to the laboratory. Samples were immediately analysed. They were first sieved by 2 mm mesh sieve. The sieved material was weighed on electronic balance and insects were counted. Other foreign matter was removed by hand picking. Bulk density was determined by chondrometer and moisture was measured by an air or on calibrated digital moisture meter. Each sample was subdivided by riffle type divider to get a representative subsample of about 25 grams. Shrivelled, broken, insect damaged, mouldy grain fractions were separated and weighed. Consumption record of wheat by each farmer was maintained periodically and this factor was given due consideration in calculating the final losses.

For determining the storage losses in public sector similar methodology was applied. The sampling sites were randomly selected throughout the country representing different ecological zones. Almost all types of godowns were included in the study which were house type, binnishells, hexagonal bins and platform storage. The basic sampling programs were adopted as follows:

i. A study of specific batches of grain to determine the extent of loss over time. Representative samples of grain were collected from grain as it was taken into and sampled again when it was taken out.
ii. Regular sampling of selected stacks/bulks of grains. Samples were collected at monthly interval. These samples were only representative of accessible grains.

iii. Samples were taken from the truck loads of grains both when received and despatched.

It was very difficult to obtain representative samples from a bagged stack on periodical basis. Therefore different approaches were applied so that grain sample are near to representative. For intake, final and periodic sampling spears were used for drawing samples out of randomised bags. It was not possible to dismantle stack and get sample from inside the stack. Long probe was used to get sample from bulk storage. Of all the loss assessment methods used bulk density on dry basis was selected for calculation of stage losses as it was found to be more reliable. All the methods used were compared for their relative accuracy with the bulk density method.

At farm level loss reduction techniques were tested out in villages selected for loss assessment studies. Different types of storage structures like metal bins, jute sacks, bharolas, open room stores were fumigated with phosphine. A sample of one kg was drawn before treatment of grains which was used as baseline sample. Subsequent sampling was done at monthly intervals and analysed for loss comparison. All measurement were on dry weight basis. In barani area, 67 stacks (10 sacks per stack) and 68 metal bins were fumigated. Stacks were fumigated under polyethylene sheet of 0.2 mm thickness and 10 × 7 ft size @ 3 tablets per ton of wheat. Six open room stores were also treated with phosphine. In the irrigated area, 29 stacks and 64 metal bins were also treated along with 50 mud bins and 45 concrete structures. Exposure period was one week.

For testing the resistance in stored-grain insect pests against contact insecticides method recommended by Busvine (1980) was used. Malathion and fenitrothion were dissolved separately in 3:1:1 mixture of petroleum ether, acetone and risella oil. A 0.5 mL solution was spread on filter paper and allowed to stay overnight. Fluon was used around glass rings to avoid escape of insects. Resistance in beetle pests of stored grain against phosphine was measured by generating the gas from aluminium phosphide tablets. Insects were collected from different stores and were exposed to known concentration of gas. Resistance factor was calculated by dividing LD50 of resistant strain with the LD50 of susceptible strain.

Results and Discussion

Extent of losses

At farm level storage losses of 4.26 and 6.8% were recorded in unirrigated (rainfed) and irrigated areas respectively (Table 1). The overall average was found to be 5.2%. The losses were found to have increased during the monsoon period (June–September). In Islamabad comparatively lower loss was encountered because less quantity of wheat was available for storage. Wheat is of good quality at harvest but is brought into infested stores. Moisture content of wheat is suitable for stage. Development of insects takes place when the grain moisture increases during the rainy period. Majority of farmers in the unirrigated area do not treat their grain because they store them in sacks and no control measures are available. Data in Table 2 indicate a loss of 3.70% in different districts of Punjab during total storage period. The variation in the extent of loss is due to variable agro-ecological conditions and length of storage etc.

In public sector storage the major insect pest species recorded infesting the stored wheat were *Rhizopertha dominica, Sitophilus oryzae,* and *Tribolium castaneum.* Almost the same insect pest complex was recorded at the farm level. Mould damage was not a serious problem. The average moisture content during storage was always found to be less than 12%. Grain stored in the wet and the open places showed comparatively higher damage. Occasionally rain entered through open or broken windows or through open doors and resulted in mould damage. The losses in public sector stage are shown in Tables 3 and 4. Average figure of loss for storage type, area or quantities of grain stored are therefore less meaningful. But these figures help administrators in deciding policy issues. A scrutiny of Tables 3 and 4 reveals that 0.9% pre-storage weight losses had taken place before the grain was taken into the store. This is due to the reason that the wheat is generally kept in the procurement areas for a few weeks or months before it enters the public sector system. Losses were comparatively higher in grains stored at Karachi and in NWFP. The higher loss in Karachi are attributed to favourable temperature and relative humidity conditions for insect development. The higher losses in NWFP are a reflection of the poor condition of grain received from other stores. Much of the grain had been stored for several months in the Punjab and Sindh was mostly from new crop procured and stored for the first time. Therefore loss in these two provinces were comparatively low.

Table 1. Farm level storage losses to wheat in the unirrigated and irrigated areas of Punjab.

Unirrigated		Irrigated	
Districts	Loss (%)	Districts	Loss (%)
Islamabad	1.4	Sargodha	6.9
Rawalpindi	4.2	Jhang	5.1
Attock	4.8	Faisalabad	6.8
Jhelum	6.4	Toba Tek Singh	7.4
Rawalpindi	4.3	Gujrat	7.6
		Okara	8.3
		Lahore	5.9
Average	4.2		6.8
Overall average	5.2		

Loss reduction technology

By adopting the improved practices at farm level in unirrigated areas the losses were reduced to the magnitude of 2.23, 1.28, 1.32 % in sack storage, metal bins and open room respectively (Table 5). Thus magnitude of loss reduction was maximum in the jute sacks. Though, the total losses in sacks and open rooms were similar but fumigation under polyethylene sheet was most effective. For the same reason higher quantity of loss was reduced. In the irrigated areas the net reduction in stage losses of 4.15, 1.15, 1.07 % were recorded in sacks, metal bins and mud bins respectively. The maximum reduction of losses took place in sacks. The metal bins almost displayed the similar behaviour. In the mud bins fumigation was not very effective therefore small losses took place. Metal bins were considered to be the safest storage receptacles. It was estimated that fumigation under polythene sheet was more effective and economical. It was also easy to be handled by the farmers but sheet leakage was a danger. Considerable economic benefits were achieved.

Considering efficiency of the introduced interventions, testing of techniques for transfer of technology was also started. For this purpose, 32 villages and 480 farmers were selected. The interventions included distribution of metal bins, polythene sheet and fumigation material at subsidised cost. An improved version of locally manufactured metal bin was designed and in total 180 bins (0.5 ton capacity) were distrib-

Table 2. Losses in wheat at the farm level storage in Punjab.

S. No	District	Harvested production (t)	% stored farm from survey (data)	Estimated tonnage stored on farm	District storage loss by bulk density method (%)	Total damaged loss by bulk density method (tons)
1.	Attock	2288030	90.00	205227.00	2.32	4761.27
2.	Rawalpindi	160010	89.38	143016.94	2.87	4104.59
3.	Islamabad	21370	85.32	18232.90	5.45	993.69
4.	Jhelum	243140	90.71	220552.30	1.70	3749.39
5.	Sargodha	410900	68.33	280767.90	2.57	7215.74
6.	Khusab	110450	68.33	75470.49	2.57	1939.59
7.	Mianwali	143080	68.33	97766.56	2.57	2512.60
8.	Bhakkar	151300	68.33	103383.30	2.57	2656.95
9.	Faisalabad	589600	82.00	483472.00	6.50	31425.68
10.	Toba-Tek-Singh	339980	83.00	282183.40	6.87	19338.00
11.	Jhang	667410	56.00	373749.60	5.86	21901.73
12.	Gujrat	356780	82.35	283808.30	6.43	18891.80
13.	Sialkot	369980	82.35	304678.53	6.43	19590.83
14.	Gujranwala	534350	82.35	440037.20	6.43	28294.39
15	Sheikhupura	519660	82.35	42740.01	6.43	27516.54
16.	Lahore	138210	75.50	104348.50	4.40	4591.34
17.	Kasoor	380050	75.50	286937.70	4.40	12625.26
18.	Okara	497540	75.50	375642.70	4.40	16528.28
19.	Sahiwal	656780	72.01	472947.28	2.38	11256.15
20.	Multan	664750	72.01	478686.48	2.38	11392.74
21.	Vehari	493180	72.01	355138.90	2.38	8452.31
22.	Muzaffar Garh	405630	72.01	292094.20	2.38	6951.84
23.	Layyah	262150	72.01	188774.22	2.38	4492.83
24.	D.G.Khan	205860	72.01	18621.79	2.38	443.20
25.	Rajanpur	108280	72.01	77972.43	2.38	1855.74
26.	Bahawalpur	353580	72.01	254612.90	2.38	6059.90
27.	Rahimyar Khan	564830	72.01	406734.10	2.38	9680.27
28.	Bahawal Naghar	408780	72.01	294362.40	2.38	7005.83
Total		10431630	77.24	8056960.40	3.70	296278.39

Table 3. Estimates of public sector storage losses in various provinces of Pakistan.

Province	Average storage period (months)	Loss (%)			Total
		Insect		Mould	
		Pre-storage	Storage		
Sindh	6.4	0.1	2.9	0.3	3.3
Punjab	6.3	0.1	1.8	0.3	2.2
NWFP	6.5	2.9	2.6	0.7	6.2
Baluchistan	2.6	0.5	1.2	0.5	2.2
Pakistan	5.4	0.9	2.1	0.4	3.5

uted. Training was provided to about 500 selected farmers. To emphasise the importance of loss prevention, posters and exhibits were displayed in all the villages in the pilot areas. These posters also explained precautionary measures. Leaflets describing new techniques were also distributed in each house of the selected villages. The evaluation of technology transfer showed that 83% of the farmers were prepared to pay the subsidised cost for metal bins and 23% were prepared to pay the full amount. The metal bins were found to be not only more durable and saved grain from insects but rodent damage was also prevented. The wheat thus stored was mostly used for seed purposes. Evaluation survey showed that great awareness was created in the farmer community.

Resistance to pesticides

Of the 33 strains of *Sitophilus oryzae* collected 13, 39.4% were resistant to malathion. Resistance was comparatively more prevalent in public sector (66.67%) than at farm level storage (29.1%). In the public sector malathion had been commonly in use in the past. None of the 40 strains of *Tribolium castaneum* collected was susceptible to malathion

Table 4. Public sector storage loss measured by releases of wheat in different provinces.

Province	Loss (%)	Quantity released (Mt)	Quantity lost (Mt)
Sindh	3.2	0.842	0.0277
Punjab	2.2	1.603	0.0352
NWFP	6.2	1.149	0.0712
Baluchistan	2.2	0.342	0.0075
Pakistan		3.936	0.1416

Total weight loss of 0.1416 Mt of wheat for an average storage period of 5.4 months

which has been in use in public storage of wheat for about 20 years. One strain of *Tribolium castaneum* from public sector storage was found to be susceptible to fenitrothion. Five strains of *T. castaneum* were resistant to phosphine while one strain of *Oryzaephilus surinamensis*, 13 of *T. castaneum* and 4 each of *Rhyzopertha dominica* and *S. oryzae* were susceptible. Resistance to phosphine was encountered in the public sector storage only. It can be concluded that resistance to different pesticides is prevalent in Pakistan, therefore there is a need to apply these chemicals with caution. Resistance to phosphine is dangerous as alternative fumigants are not available.

Table 5. Weight loss (%) in wheat in different treatment in unirrigated and irrigated areas.

Area	Type of storage	Treatment	Loss in survey number							
			1	2	3	4	5	6	7	8
Unirrigated										
	Sack	Treated	1.01	1.06	0.88	0.98	0.71	0.76	0.80	1.27
		Untreated	1.51	1.65	1.45	2.57	2.58	2.68	2.81	3.50
	Metal bins	Treated	0.82	0.72	0.75	0.81	0.82	0.86	0.85	0.84
		Untreated	0.86	1.04	1.26	1.36	1.51	1.62	1.81	2.12
	Open room	Treated	1.14	1.06	0.98	1.35	1.66	1.82	2.27	2.38
		Untreated	2.09	2.74	2.25	1.95	2.32	2.89	2.17	3.70
Irrigated										
	Sack	Treated	1.02	1.06	1.01	1.05	1.04	1.08	1.04	1.08
		Untreated	2.59	2.85	3.84	3.87	4.03	4.29	4.82	5.23
	Metal bin	Treated	0.97	0.98	0.93	0.94	0.96	0.95	0.97	0.99
		Untreated	0.94	1.11	1.36	1.56	1.76	2.06	2.22	2.14
	Mud bin	Treated	1.40	1.96	2.46	2.81	3.14	3.81	3.69	4.12
		Untreated	1.50	2.61	3.30	3.72	4.09	4.64	4.76	5.19

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