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Assessment of harvest and post-harvest losses of major pulses in India

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Abstract A concurrent, national-level survey covering 14 agro-climatic zones (ACZ) was conducted in 2012-14 to quantitatively assess the harvest and post-harvest losses in pulses. The loss, estimated at INR 38.77 billion, was due mainly to inappropriate harvesting and poor post-harvest management—the use of improper threshers, delayed harvesting, and improper storage practices. To reduce the losses, harvesting and threshing practices should be standardized and machines refined and proper storage infrastructure provided; and farmers, traders, and processors need to be trained in scientific storage practices.

Keywords Agro-climatic zone (ACZ), harvest loss, post-harvest loss, pulses, storage loss

JEL classification Q01, Q10, Q16

Pulses, a rich source of protein content (20%–30%) and amino acids, provide substantial quantities of minerals and vitamins and supplement cereal diets by improving their protein-nutritive values (Darmadi-Blackberry et al. 2004; Belitz, Grosch, and Schieberle 2009). Pulses contribute towards food and nutrition security, soil health, and sustainability of agricultural production systems. Growing urbanization and rising disposable incomes have rapidly raised the consumption of pulse-based fortified snacks, and the consumption of pulses is expected to increase to 10.9 kg by 2020–21 from 9 kg per capita per year in 2007–08 (Joshi 2009). Pulses occupy a central place in the research and development (R&D) agenda and food policy debate, and these have been gaining greater attention recently in the fight against malnutrition.

India is the largest producer, consumer, and importer of pulses. Production increased to 25.23 million tonnes in 2017–18 (DES 2018), but there is still a huge shortage of pulses in fulfilling nutrition requirements, and by 2020–21 the demand–supply gap may increase to 6.8 million tonnes (Joshi 2009; Roy, Joshi, and Chandra 2017). As India becomes richer and more income accrues to poor households, the demand for primary and secondary processed pulse products is expected to increase further (Joshi, Kishore, and Roy 2017) and have a cascading effect on prices, unless availability increases.

In outlining strategies to increase availability of pulses at affordable prices, the major emphasis is on raising the domestic production of pulses, and little attention is paid to estimating the losses from production to processing or to avoiding these losses. While increasing production is one aspect of fulfilling food demand, preventing losses in the field, and post-harvest handling, transport, storage, retailing, and processing without straining our fields, water, and environment, seem the much better option, as 'A grain saved is a grain produced'.

In the early 1960s, the Government of India appointed the Panse Committee to assess the post-harvest losses in food grains. The committee reported that these losses accounted for 9.5% of the total pulse production, and these occurred mainly during threshing, transport, and storage (MFA 1971). In developing countries, 25% of the food losses occur at the field level, 15% due to storage loss, 7% during handling and processing, and 3% because of other factors (Majumdar and Parpia 1976). A survey conducted by the Directorate of Marketing and Inspection in 1996–97 revealed that post-harvest losses of pulses at the farm level ranged between 2.20% (pigeon pea) and 7.14% (lentil) (DMI 2002).

Food loss and waste is common worldwide. The volume of food loss and wastage is higher downstream of the food chain in high-income countries; in low-income countries, however, most of the loss takes place upstream (FAO 2013). Some researchers have developed a methodology to estimate food loss at the farm level and along the supply chain, and also examined the factors of such loss (FAO 1980; Ali 1983; Narain and Khosla 1983; Basavaraja, Mahajanashetti, and Udagatti2007; Nanda et al. 2012; Jha et al. 2015).

The extent of loss depends on farm-level unit operations and post-harvest activities. During storage, pulses are prone to damage due to insects (5%)—more so than wheat (2.5%), paddy (2%), and maize (3.5%) (Deshpande and Singh 2001). Harvest and post-harvest losses have been estimated on the basis of personal interviews and observations in all the country's ACZs, as defined by the Planning Commission of India (Nanda et al. 2012; Jha et al. 2015). In 2005–06, the losses reported at the national level for chick pea, pigeon pea, green gram, and black gram ranged from 4.28% to 6.04% (Nanda et al. 2012). Losses at the farm level depend on methods of harvesting, maturity status of the crop, moisture content at the time of harvest, type and method of threshing, cleaning/winnowing, type of threshing floor, and mode of transportation. Losses at the post-harvest stage depend upon handling, transportation, storage conditions, type of storage structure, insects, moulds, fungi, birds, spillage, pilferage, and rodents (DMI 2002).

Reliable estimates of the quantity and value of loss at the stages are critical from the R&D and policy perspectives, therefore, a study was conducted to concurrently assess the quantitative harvest and post-harvest losses in all major pulses. The study identified the reasons of loss also to provide information for taking curative measures to curtail the losses. The existing losses in pulses were compared with a study (Nanda et al. 2012) to assess the change over nearly a decade.

Sampling and data

Sampling design

The survey covered 14 of the 15 ACZs in India (Basu and Guha 1996) (Table A 1). The survey was carried out in 107 districts of 20 states covering the 14 selected ACZs. Two ACZs—Zone 1 (western Himalayan region) and Zone 2 (eastern Himalayan region)—were excluded from the final analysis, because green pea is the main pulse crop grown for vegetable purposes in these zones. The data collected from 88 districts of 15 states from 12 ACZs were used for analysis and drawing inferences.

The data for estimating harvest and post-harvest losses of pulses—pigeon pea, chick pea, black gram, and green gram—were collected through an all-India survey by both observations and interviews of key informants. Losses were estimated for different harvesting and post-harvesting operations—collection, threshing, winnowing/cleaning, drying, packaging, and transport—and during storage in the movement of the produce along the marketing chain. The quantitative losses as estimated in this study are defined as any reduction in the weight of the produce available for human consumption (Hodges, Buzby, and Bennett 2011). The stratified multi-stage random sampling method is used (Ahmad et al. 2016), considering the ACZs as strata, to select respondents for collecting data on losses. Districts in each stratum are taken as first-stage units; blocks within each selected district as second-stage units; villages from each of the selected block as third-stage units; and, finally, farmers from each of selected village as fourth-stage units. In each ACZ, the number of districts for data collection was allocated based on their contribution towards the total production of pulses in the country. The districts (irrespective of states) in each ACZ were selected using the simple random sampling without replacement (SRSWOR) method.

Two blocks from each of the selected districts, five villages from each block, and ten farmers from each village were selected for data collection. Out of the ten farmers selected from each village, data were collected from ten farmers by personal interview and from two out of ten selected farmers by the observation method. Thus, the ultimate sample comprised 10,700 farmers.

Data on losses during storage were collected. Both personal interviews and observations were used. Using the SRSWOR method, two stakeholders (wholesalers, retailers, warehouses and processors) were selected for each crop in each market from each selected district. Covering one crop cycle per crop, data collection from the identified key informants commenced in December 2012 and completed in February 2014. Data on some crops from some ACZ could not be obtained as the area under these crops was too small for the sample size to be adequate.

Data collection by personal interview

The information on the loss of pulses at the farm level was collected only once, starting at the time of harvest, with the help of an interview schedule developed by Nanda et al. (2012) and refined by Jha et al. (2015). Data were collected every month for a year on losses during storage at the farmer's household, mandi (wholesale market), retail market, processing units, and warehouses.

Data collection by observation

A pro forma (Nanda et al. 2012) was modified and used to collect data on losses based on observations. To estimate the losses in farm-level operations (harvesting, threshing, and cleaning), a plot of 5 m×5 m (for plain regions) or 2 m×10 m (for hilly regions) was selected in the identified field. The crop was harvested using the method followed by the farmer and kept separately. The losses during threshing and cleaning were estimated by collecting random samples at the end of each unit operation and analysing these samples. The grain or pod and straw obtained after threshing or cleaning were weighed separately for each operation. A sample of 250 g from straws was drawn and analysed. The number or weight of seeds in the straw was counted or weighed. For estimating losses during storage in movement along different market points, 50–100 g of samples were taken at monthly intervals. The samples were analysed for moisture content, 1,000 grain mass, number of undamaged grains and infested/damaged grains, and their weight was recorded to compute the loss during storage.

Analytical tools

The data collected separately through personal interview and observations at the district level were pooled by assigning appropriate weights (production of the crop) to get the estimated losses of the produce at higher levels (ACZ and the country). To obtain the total percentage loss at the ACZ level, the inverse variance method was used to optimally combine the estimates of personal interviews and observation data (Nanda et al. 2012; Jha et al. 2015; Ahmad et al. 2016). Statistical analysis software and MS-Excel were used for the data analysis. The total loss of a pulse crop in all farm operations was calculated as the arithmetic sum of losses in individual operations. However, to estimate the total loss during storage, the quantities retained in each market point (Table A 2) were considered. The overall total loss (percentage) was estimated using the following equation:

$$\hat{L}_{\mathrm{TS}} = \frac{\hat{L}_F \times \hat{R}_F + \hat{L}_G \times \hat{R}_G + \hat{L}_W \times \hat{R}_W + \hat{L}_R \times \hat{R}_R + \hat{L}_P \times \hat{R}_P}{100}$$

where $\hat{L}_F$, $\hat{L}_G$, $\hat{L}_W$, $\hat{L}_R$ and $\hat{L}_P$ are the estimated loss percentage of the crop during storage at farm, at warehouse, at wholesaler, at retailer, and at processing unit, respectively, while $\hat{R}_F$, $\hat{R}_G$, $\hat{R}_W$, $\hat{R}_R$ and $\hat{R}_P$ are the estimated percentage retention of the crop for storage at farm, at warehouse, at wholesaler, at retailer, and at processing unit, respectively.

Two data sets—one for 2005–07 (Nanda et al. 2012), and the present study for 2012–14 (Jha et al. 2015)—were utilized to assess the change in losses of pulses over half a decade in India. Both studies used the same methodology, sampling plan, and selection of districts except for a few changes in block selection. The Z-test was used to test for significant statistical difference between losses for individual stakeholders in the marketing chain. An analysis of variance was conducted to test the overall difference between the percentage of loss between the two studies. In this case, the year was considered as treatment, or one source of variation, and the market point was considered as blocks, or the second source of variation. The total,

national-level crop loss was calculated by adding the total loss in farm operations and total loss during storage in crop movement across market points. The monetary value of losses was estimated on the basis of overall loss (percentage), pulse production (in 2012–13), and average prices in 2014.

Harvest and post-harvest losses in pulses at agro-climatic zones (ACZ)

Losses in chick pea

The extent of losses in farm operations was calculated for the selected pulses in different ACZs (Figures 1–4). Losses vary by region and farm operation. The survey for estimating the loss in chick pea covered six ACZs.

The highest loss estimated was 10.75% in western Madhya Pradesh and eastern Rajasthan (Zone 8, the central plateau and hill region) and 5.24% in southern Madhya Pradesh and northern Maharashtra (Zone 9, western plateau, and hill region). The loss was lower (2.08%) in the coastal regions of Odisha, Tamil Nadu, and Andhra Pradesh (Zone 11, east coast plains and hill regions) (Figure 1).

In Zone 8, the highest share of total loss occurred during threshing (3.75%) and harvesting (2.37%). No thresher is available specifically for chick pea, and using high-capacity wheat threshers without changing machine parameters breaks the grain. These grains are carried away with straw. There is a need to design and develop crop-specific pulse thresher. The multi-crop thresher (7 hp motor, peg type, double blower) developed by the ICAR-Central Institute of Agricultural Engineering has been reported to be successful in threshing pulse crops, with some degree of variation in grain recovery (Lal and Verma 2007), but farmers need to be taught to use such machines and make adjustments according to the crop. Losses in harvesting and collection were caused mainly by delays in harvesting; and threshing, harvesting, and collection operations caused the major portion of losses in farm operations for chick pea in all ACZs.

The losses at farm level storage were high in all zones except Zone 11. Farmers store small quantities of chickpea in gunny bags for their own consumption; the attack of bruchids (*Callosobruchus maculatus* F.) during the rainy season may be the main reason for such losses. The losses caused by bruchids range

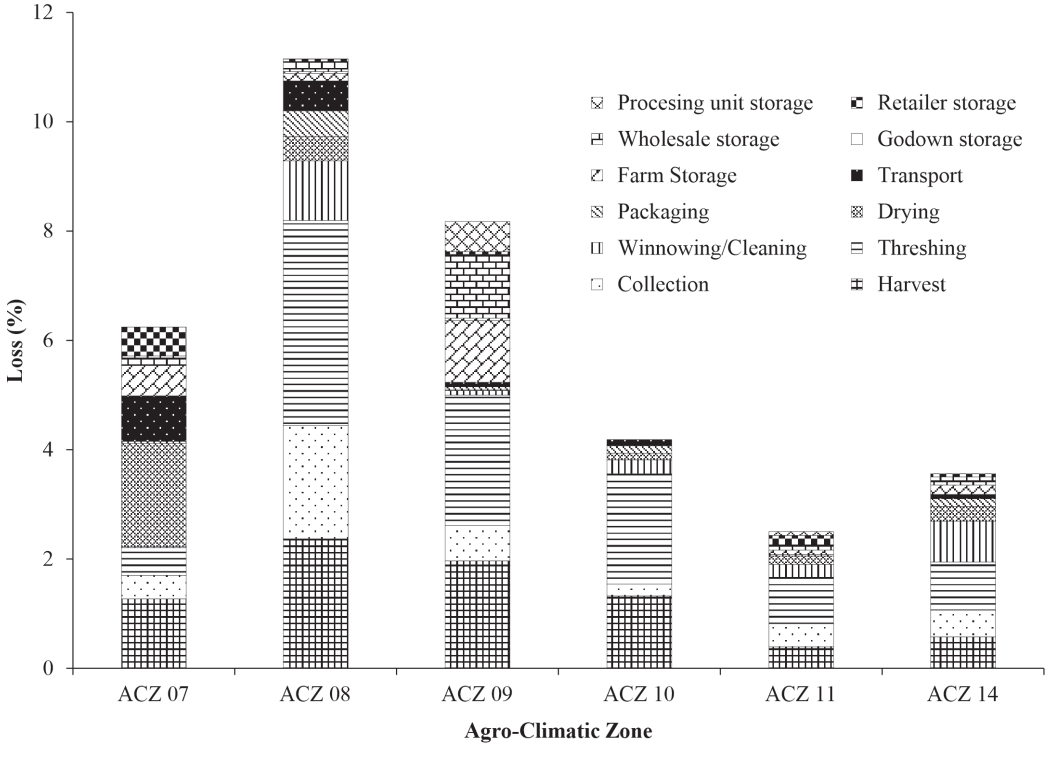

Figure 1 Loss of chick pea by stage and agro-climatic zone (ACZ) (2012–14)

between 1.06% (if the chick pea is stored in earthen pots) and 3.06% (if the chick pea is stored in jute bags) (Maini, Bilaiya, and Bilaiya 2017). In godown storage, the practice of fumigation kept losses to the bare minimum (0.03%–0.05%). At the wholesale level, storage losses ranged between 0.1% in Zone 11 to 1.17% in Zone 9. In retail markets, the loss, due mainly to pests (rats), ranged from 0.05% to 0.53%. The loss during storage at processing units was the highest (0.55%) in Zone 9. Thus, the problem of loss during the storage of chickpea occurred most in the western plateau and hill regions, which are the major chick pea producing and processing regions. Harvest and post-harvest losses were lower overall in Zones 11 and 14 (the dry western region of Rajasthan).

Losses in pigeon pea

In all ACZs, the losses in farm operations of pigeon pea were due mainly to threshing and harvesting operations, and harvesting losses ranged between 0.51% and 1.56% (Figure 2). Unexpected rainfall at harvest time, and the resulting delay in harvesting, caused the higher losses (1.56%) in the tribal regions of Madhya Pradesh and in the states of Chhattisgarh, Jharkhand, Maharashtra, Odisha and West Bengal (Zone 7: eastern plateau and hill regions).The loss due to threshing operations in this region was the highest at 5.08%; the second-highest loss (2.56%) was in Zone 4 (middle Gangetic plain), comprising Bihar, and eastern Uttar Pradesh. The total loss during farm operations was the highest in Zone 7 (8.30%) and Zone 8 (5.46%), and the loss was the least (3.23%) in Zone 10 (Southern Plateau and hill regions, comprising the southern regions of Karnataka and Tamil Nadu).

Efficient threshing machines are not available, and the use of inappropriate threshers was the main reason for the loss during threshing. In almost all zones, the highest losses took place during storage at the farm and at the retailer (Figure 2). The farm-level storage loss was highest (1.84%) in Zone 7 and least (0.25%) in Zone 5 (western region of Uttar Pradesh). Pigeon pea is not usually stored at godowns on a large scale; therefore, the storage loss was limited to 0.15%.

Because pigeon pea is consumed soon after processing (Vishwakarma et al. 2017), the bulk of the crop is usually sold immediately to processing industries. It is stored for less than a month, and the storage loss at

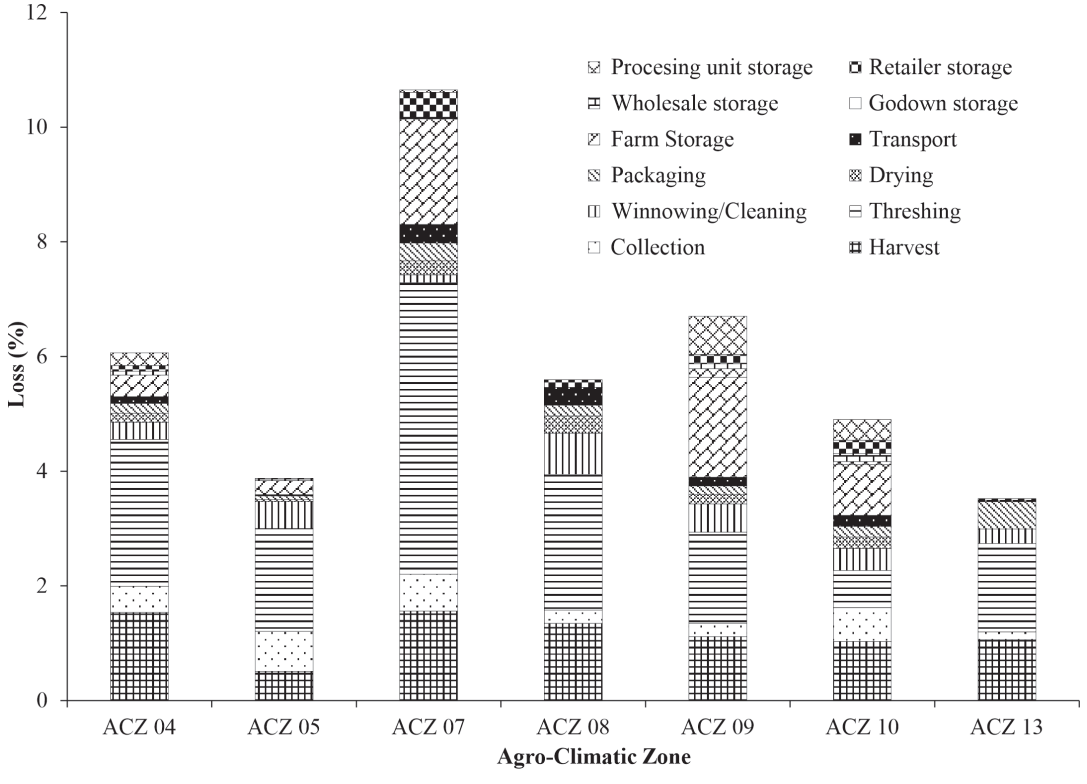

Figure 2 Loss of pigeon pea by stage and agro-climatic zone (ACZ) (2012–14)

wholesale and retail markets was low in almost all zones. The storage loss at processing units were the highest in Zone 9 (0.66%) and Zone 10 (0.36%), the major pigeon pea–producing areas. The loss during storage occurs mainly in the rainy season due to the attack of bruchids.

Losses in black gram

The loss in farm operations in black gram was the highest in Zone 8 (10.11%), followed by 6.41% in Bihar and eastern Uttar Pradesh (Zone 4: middle Gangetic plain region). The losses in farm operations were minimum in Zone 10 (1.40%) (Figure 3). Zone 8 recorded the highest loss (2.88%) during harvesting followed by Zone 7 with 2.70%. In Zone 8, the use of wheat threshers for threshing led to the highest threshing loss. In all ACZs, harvesting and threshing operations contributed the most to the total loss in farm operations, and the loss during storage at the farm exceeded that at any other point in the marketing chain except in Zone 13, the Gujarat plains and hill regions (Figure 3). The loss during storage ranged between 0.43% (in Zone 3, the lower Gangetic plain region comprising the western part of West Bengal) to 2.02% (in Zone 7). The loss due to storage in godowns was the lowest (0.04%). At wholesale markets, the loss owing to the attack of bruchids during the rainy season ranged between 0.34% and 0.59%. At retail markets, the losses were negligible as the storage period was very short. The loss during storage at processing units was the highest (0.47%) in Zone 9.

Losses in green gram

The extent of losses in green gram farm operations (Figure 4) ranged between 2.28% (Zone 3) and 6.10% (Zone 7), and threshing and harvesting led to the most losses. The losses from threshing ranged from 0.58% (Zone 3) to 2.69% (Zone 4). Famers are mechanizing operations, but they do not have the appropriate post-harvest machinery or the skill to reap its benefits fully. Storage loss at the farm was high in all seven zones; it ranged from 0.73% (Zone 9) to 1.07% (Zone 7). The eastern plateau and hill regions of India (Zone 7) is the tribal region. Here, green gram is stored unscientifically in earthen storage structures, and insect attacks raise losses.

Losses were very little in godown storage; therefore, bulk storage facilities for pulses are needed. The loss

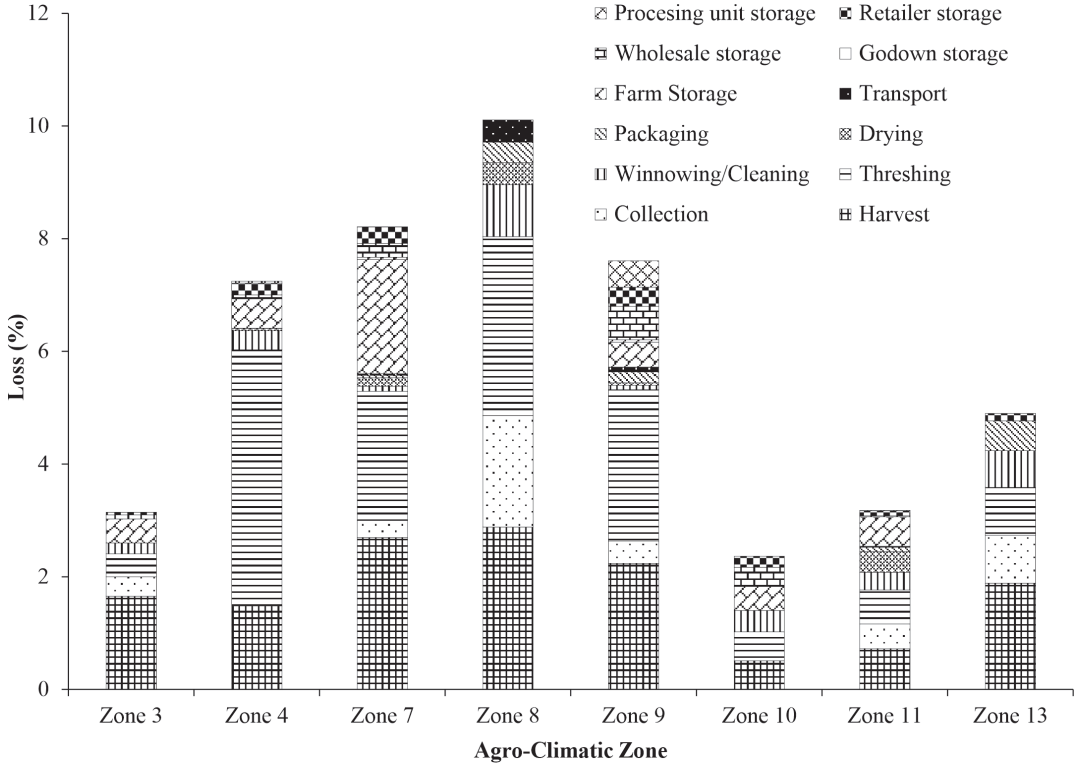

Figure 3 Loss of black gram by stage and agro-climatic zone (ACZ) (2012–14)

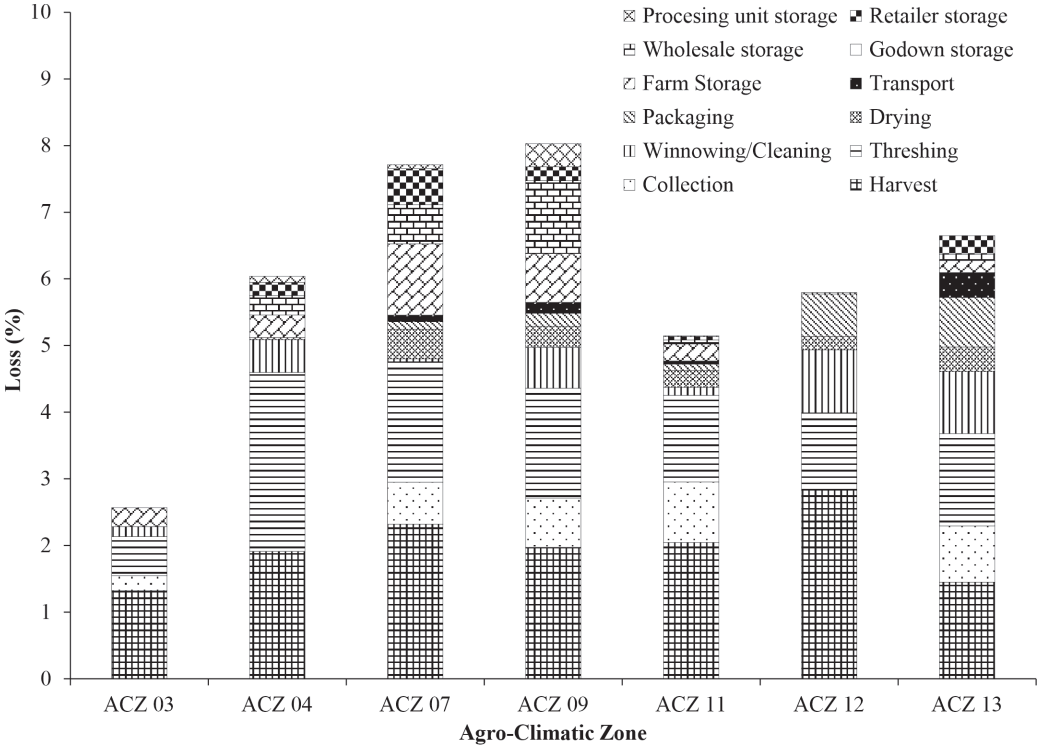

Figure 4 Loss of green gram by stage and agro-climatic zone (ACZ) (2012–14)

at the wholesale level was highest (1.09%) in Zone 9, which indicates poor storage facilities in markets and mandis. At the retailer level, the loss was highest (0.54%) in Zone 7 followed by Zone 13 (0.28%). At the level of processing unit storage, the loss was highest (0.35%) in Zone 9 (Figure 4). The storage loss at the processing unit was higher in the main pulse-processing region of India. Overall, losses were higher in ACZs 4, 7, 8, and 9.

National-level post-harvest losses during farm operations and storage

At each ACZ, personal interviews and structured observations yielded the data on loss during farm operations and during storage at the main points in the marketing chain. Pooling these data yielded the national-level estimates of harvest and post-harvest losses of pulses in 2012–14: 8.41% (chick pea), 6.36% (pigeon pea), 7.07% (black gram), and 6.60% (green gram) (Table 1). In 2005–06 (previous study), the corresponding figures were 4.28% (chickpea), 5.39% (pigeon pea), 6.06% (black gram), and 5.51% (green gram) (Nanda et al. 2012). The losses at the wholesale level have increased considerably for all the pulses except pigeon pea, because losses during threshing have risen. In 2005–06, pulses were threshed manually; now, high-capacity wheat or multi-crop threshers are used in the main pulse-growing regions. Chick pea is stored for long periods at godowns and processing units, and bruchid attacks cause losses.

The loss during farm operations, ranging from 4.69% (pigeon pea) to 7.23% (chick pea), was due mainly to threshing, followed by harvesting and collection. Natural calamities such as Cyclone Phalin in Odisha raised harvest-level losses in the coastal and tribal regions. Some of these losses are avoidable if harvest and post-harvest technological interventions, that keep pace with climate change and the changing production scenario, are improved.

The national-level losses incurred during the movement of produce along the market chain are estimated from the data obtained through observation (Table 2). Storage losses in pigeon pea are more than for other pulses at all market points except the wholesale level. Chick pea, black gram, and green gram are consumed without dehulling also; therefore, wholesalers retain these pulses for long periods, and losses may be higher

Table 1 Harvest and post-harvest losses of pulses (%)

Crop	Operations							Total loss in farm operations	Contribution to post-harvest losses in storage along market Chain					Total loss in storage	Overall total loss
	Harvesting	Collection	Thresh-ing	Winnowing/ cleaning	Drying	Packag-ing	Trans-port		Farm	Godown	Whole-saler	Retailer	Process-ing unit		
Chick	1.87	1.19	2.60*	0.58	0.40	0.25	0.35	7.23*	0.41	0.04*	0.34	0.17	0.21*	1.18	8.41*
pea	(14.41)	(16.68)	(11.57)	(17.06)	(30.65)	(16.73)	(11.65)	(2.66)	(13.03)	(12.50)	(15.71)	(14.10)	(8.45)	(4.21)	(1.56)
Pigeon	1.18	0.39	2.13*	0.41	0.18	0.22	0.19	4.69	1.02	0.10*	0.08#	0.16	0.32	1.67	6.36
pea	(16.60)	(37.97)	(17.03)	(72.93)	(50.91)	(60.45)	(86.62)	(4.85)	(7.45)	(15.60)	(23.81)	(16.58)	(8.72)	(3.99)	(2.44)
Black	1.82	1.01	1.94	0.48	0.26	0.23	0.15	5.89	0.62	0.04*	0.20	0.19	0.13	1.18	7.07
gram	(11.87)	(27.68)	(27.25))	(33.11)	(50.13)	(7.82)	(14.97)	(4.57)	(16.40)	(28.26)	(13.40)	(12.88)	(4.07)	(6.57)	(2.80)
Green	2.00	0.76	1.54	0.36	0.33	0.22	0.14	5.37	0.41	0.00	0.39	0.31	0.13*	1.24	6.60
gram	(9.95)	(13.28)	(28.47)	(73.22)	(49.56)	(6.93)	(12.05)	(4.45)	(21.33)	(0.00)	(14.98)	(14.33)	(14.99)	(6.08)	(2.72)

Note Figures in parenthesis shows the percentage standard error of estimate
*Estimated losses are significantly higher ($p \le 0.05$) in comparison to losses observed in 2005-07
Estimated losses are significantly lower (($p \le 0.05$) in comparison to losses observed in 2005-07 (previous study)

than for pigeon pea. Much of the produce is lost during storage at all market points; all along the market chain, therefore, proper storage infrastructure and facilities are needed. For all pulses, storage loss was highest at the farm level, although the loss was less than in 2005–07 (Nanda et al. 2012). The infrastructure has improved, and storage loss decreased considerably at godowns and processing units. The storage loss at the wholesale and retail market level is comparable with the loss during 2005–07 (Nanda et al.2012), and the total storage loss is similar to that in the previous study in 2005–06.

This quantitative study estimates the national-level harvest and post-harvest losses of pulses at INR 38.77 billion per annum at the average annual prices of 2014 (Table 3). The loss ranged between 6.36% (pigeon pea) and 8.41% (chick pea). Chick pea contributed to 63.27% of the total monetary value of pulses lost, and pigeon pea 24.71%. About 88% of the monetary loss accrues from chick pea and pigeon pea because the percentage of harvest-level loss is higher and more of these crops are produced than other pulse crops.

Conclusions

The losses during harvesting, threshing, and storage at farm and processing units are quite high. The losses are caused primarily by inappropriate and delayed harvesting and poor post-harvest management. Threshing and harvesting contribute most towards total losses during farm operations, due primarily to the use of inappropriate machines. Existing wheat and multi-crop threshers are not suitable or efficient for pulses, and threshers for specific crops and pulses need to be developed urgently. Harvesting and threshing practices should be standardized and farmers need to be trained. Unscientific storage practices at households, farms, and godowns contribute to the losses. Farmers, traders, and processors need to be trained in scientific storage practices, and scientific bulk storage facilities need to be developed.

Several proven post-harvest technologies and practices can be used at the farm level. Solar heating, and packing chick pea and pigeon pea in transparent polyethylene bags, will reduce pest infestation (Vales et al. 2014). The All India Coordinated Research Project on Post-Harvest Engineering and Technology, UAS Bangalore centre has standardized the sand layer method of storing

Table 2 Extent of losses during storage in movement of the produce along market chain (%)

	Crop	Farm	Godown	Wholesaler	Retailer	Processing unit
1	Chick pea	1.77	0.49	0.93	1.26	1.17
		(13.03)	(12.50)	(15.71)	(14.10)	(8.45)
2	Pigeon pea	1.77	2.20	0.78	1.56	1.78
		(7.45)	(15.60)	(23.81)	(16.58)	(8.72)
3	Black gram	1.23	0.67	1.14	1.47	1.01
		(16.40)	(28.26)	(13.40)	(12.88)	(4.07)
4	Green gram	1.24	0.85	1.29	1.13	1.40
		(21.33)	(56.77)	(14.98)	(14.33)	(14.99)

Note Figure in parentheses shows the percentage standard error of estimates

Table 3 Monetary value of harvest and post-harvest losses of pulses in India

Sl. no.	Pulse crops	Production (million tonnes), 2012–13	Price at 2014 (INR/tonne)	Overall loss (%)	Monetary value of loss (INR, crore)
1	Chick pea	8.88	32,838	8.41	2,453 (63.27)
2	Pigeon pea	3.07	49,028	6.36	958 (24.71)
3	Black gram	0.83	48,159	7.07	282 (7.27)
4	Green gram	0.46	60,912	6.60	184 (4.75)
	Total				3,877 (100)

Source Author's calculations
Note Figures in parentheses indicate percentage of the total

pulses safely (Dixit, Jha, and Kudos 2015); it needs to be popularized on a large scale. Mechanization is low in Chhattisgarh, Jharkhand, West Bengal, Madhya Pradesh, Maharashtra, and the tribal regions of Odisha; these regions need attention. Efficient infrastructure facilities are required, particularly in the eastern and western plateau and hill regions, at each level to reduce losses, along with a pulses supply chain. Farmers should be trained in harvesting, threshing, packing, storage, and marketing practices.

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Annexure

Table A 1 States and districts selected under each agro-climatic zone

ACZ (no.)	ACZ	Number of districts selected from each ACZ	Selected districts cover states
1	Western Himalayan region	4	Uttarakhand
		4	Himachal Pradesh
		3	Jammu and Kashmir
2	Eastern Himalayan region	7	Assam
		1	Eastern region of West Bengal
3	Lower Gangetic plain region	4	Coastal and central region of West Bengal
4	Middle Gangetic plain region	5	Bihar
		2	Eastern region of Uttar Pradesh
5	Upper Gangetic plain region	5	Western region of Uttar Pradesh
6	Trans Gangetic plain region	2	Haryana
		3	Punjab
7	Eastern plateau and hill regions	5	Chhattisgarh
		2	Jharkhand
		1	Tribal region of Madhya Pradesh
		1	Tribal region of Maharashtra
		2	Tribal region of Odisha
		1	Tribal region of West Bengal
8	Central plateau and hill regions	3	Southern region of Madhya Pradesh
		7	Northern region of Rajasthan
9	Western plateau and hill regions	3	Southern region of Madhya Pradesh
		5	Western region of Maharashtra
10	Southern plateau and hill regions	6	Northern region of Karnataka
		3	Northern region of Tamil Nadu
11	East coast plains and hill regions	4	Coastal region of Odisha
		3	East coastal region of Tamil Nadu
		2	Coastal region of Andhra Pradesh
12	West coast plains and ghat regions	5	Kerala
		3	Coastal region of Karnataka
		3	West coastal region of Tamil Nadu
13	Gujarat plains and hill regions	6	Gujarat
14	Western dry region	2	Western region of Rajasthan
Total	ACZ=14	107	

Note (i) ACZ was considered for selection of districts. (ii) Farmers in Zone 1 and 2 are selling green pea as vegetable and not included for analysis. ACZ.

Table A 2 Pulses storage (%) at points of market chain at national level

Sl. no.	Crop	Retained by farmer	Stored in godown	Retained by wholesaler	Retailer level storage	Stored in processing unit
1	Chick pea	23.5	8.1	37.2	13.5	17.7
2	Pigeon pea	57.7	4.5	9.7	10.0	18.1
3	Black gram	50.8	6.6	17.4	12.6	12.6
4	Green gram	33.2	0.5	30.0	27.2	9.1

Source Nanda et al. (2012)