*Research article*

# Measurement of Postharvest Losses of Sesame (*Sesamum indicum* L.) from Harvesting to Storage at Farm Level

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**Abstract** During a crop's transition from farm to consumer, much of the crop is lost due to several factors, including improper handling, inefficient processing facilities, and biodegradation due to microorganisms and insects. This study was conducted with two objectives: to measure the extent of postharvest losses of pre-monsoon and post-monsoon sesame in field operations, i.e. in the harvesting, stacking, drying of stalks, threshing and winnowing processes, and also to determine the quantity lost with the use of different types of packaging materials used for storage. The research was conducted in Pwintphyu and Pakokku Townships, Magway Region, Myanmar in July and December 2016. The postharvest losses were measured at harvesting, stacking, stalk drying, threshing and the winnowing stages on the farms. When comparing postharvest losses, losses were higher in pre-monsoon sesame than post-monsoon sesame, except at the harvesting stage. The total losses were found to be more in the pre-monsoon crop (21.34%) compared to the post-monsoon crop (11.88%). In regard to contribution to total losses, the storage loss accounted for the major part (71.42%) of the total postharvest losses in pre-monsoon sesame. For the remaining losses, 22.35% occurred during stalks drying and threshing process, 3.47% when stacking, with 1.45% of loss during harvest and 1.31% at winnowing. For post-monsoon sesame, storage losses comprised 91.08% of total losses, followed by harvest loss (6.48%), stalks drying and threshing (1.68%), winnowing (0.59%) and stacking (0.17%). To assess the storage losses resulting from the use of different packaging materials, two types of packaging materials were tested. The harvested sesame seed was stored in pioneer superbags and woven polypropylene bag for eight months at farmers' houses. At the end of this period, weight losses for the pre-monsoon sesame occurred in sesame stored in both superbags and woven polypropylene bags. However, losses for the post-monsoon sesame occurred only the woven polypropylene bag.

**Keywords** sesame, postharvest, losses, stacking, stalks drying, storage

## INTRODUCTION

Reducing postharvest losses, especially in developing countries, could be a sustainable solution to increase food availability, reduce pressure on natural resources, eliminate hunger and improve farmers' livelihoods (Hodges et al., 2011). During the crop transition from farm to consumer, it undergoes several operations such as harvesting, threshing, cleaning, drying, storage, processing and transportation. During these processes, crop is lost due to several factors. These include improper handling, inefficient processing facilities, biodegradation due to microorganisms and insects, etc. (Kumar and Kalita, 2017). Postharvest losses increase with an increase in area under crop and with increased time of storage, while they decrease with improvements in the type of storage and method of storage (Nag et al., 2000).

Postharvest losses in less developed countries have been subject to a relatively small number of studies, and are mostly guesstimates derived from questionnaires rather than actual measurements. However, this approach may be misleading because postharvest losses may be due to a variety of factors which varies from commodity to commodity, from season to season, and to the variety of circumstances under which commodities are grown, harvested, stored, processed and marketed (Tyler, 1982). Therefore, it is important not only to work with figures that are good estimates related to a particular crop, time and place, but also to be aware that there will be variations at other times and in other situations.

## OBJECTIVES

The study was conducted with two objectives: to measure the extent of postharvest losses of pre-monsoon and post-monsoon sesame in field operations and to determine the quantity losses associated with the use of different types of packaging materials used during storage.

# METHODOLOGY

### Field Experiment

The research was conducted in Pwintphyu and Pakokku Townships which are situated in the Magway Region of Myanmar, in July 2016 and December 2016. The experiments were carried out in six farmers' fields in Pwintphyu Township for the pre-monsoon sesame crop and in six farmers' fields in Pakokku Township for the post-monsoon sesame. The plot size was 15m x 15m with two plots in each farmer's field. The variety of sesame grown in this study was black sesame (Samou Nei). The postharvest losses were measured at the harvesting, stacking, stalks drying, threshing and the winnowing stages on the farms.

### Determination of Quantity Losses

**Harvest losses:** The sesame plants in the experimental plots were harvested according to normal practice (using a sickle). Left over sesame pods on the harvested plots (both on the ground and on unharvested standing plants) were thoroughly collected, cleaned, dried, weighed and stored separately in paper bags. Losses for each plot are determined by the following equation (Appiah et.al., 2011).

Harvesting losses = Weight of left over grains / Total weight of harvested grains × 100

**Stacking losses:** The harvested sesame stalks are placed on plastic nets. Stalks were separately piled for each plot, and this method was used in the field stacking. After removing the stalks for drying, all the grains remaining on plastic nets were collected, cleaned, dried and kept in paper bags for each plot. If farmers used a threshing floor, the stalks were piled on the floor directly and the grains on the floor were collected by the farmers. After the farmers' had finished the stacking stage, the grains remained on threshing floor were collected to determine losses (Appiah et.al., 2011).

Stacking losses = Weight of left over grains / Total weight of harvested grains × 100

**Stalk drying and threshing losses:** The ground was covered with canvas and the stalks were placed upright and dried on these canvases. This method was used for in-field processing but not for those dried on a threshing floor. After drying, stalks were moved and threshed on another canvas ground cover. The sesame grains for each plot that remained on all canvases were collected, cleaned, dried and kept in paper bags. Where farmers did their drying on a threshing floor, the stalks were dried on the floor directly and the grains on the floor were then collected by farmers. After they had completed this process, the grains remaining on the threshing floor were collected to determine losses (Appiah et.al., 2011).

Drying and threshing losses = Weight of left over grains / Total weight of collected grains × 100

**Winnowing losses:** Two canvasses were spread on the floor, one for the winnowed grain and the other for the discarded chaff. Grains from the discarded chaff were collected, cleaned, dried and weighed the grain to determine losses (Appiah et.al., 2011).

Winnowing losses = Weight of grains collected from chaff / Total weight of collected grains × 100

**Storage losses:** Two different packaging materials were used to store the grain; woven polypropylene bag and pioneer superbags, with storage in six farmers' houses for a period of eight months. The quantity loss was determined at two-month intervals during this storage period. Quantity losses is calculated using the formula (Appiah et.al., 2011).

Storage losses = (Initial weight of grains – Final weight of grains) / Initial weight of grains × 100

## RESULTS AND DISCUSSION

### Total Postharvest Losses for Pre-monsoon and Post-monsoon Sesame

When comparing postharvest losses, the losses were higher in pre-monsoon sesame than post-monsoon sesame except in regards to harvesting losses. The losses that occurred on farm before storage were found to be at a maximum in the stalks drying and threshing stage (4.77%) followed by stacking losses (0.74%), harvest losses (0.31%) and winnowing losses (0.28%) for the pre-monsoon crop. In post-monsoon sesame, the maximum quantity losses were found at the harvest stage (0.77%) followed by the stalks drying and threshing process (0.2%), winnowing (0.07%) and stacking (0.02%). The total losses were greater in the pre-monsoon crop (21.34%) than the post-monsoon crop (11.88%) (Table 1). The losses during harvesting and stacking showed a highly significant difference between the two different crops. Also, stalks drying and threshing losses, winnowing losses and total losses showed a significant difference, but storage losses were non-significant between the pre and post-monsoon crops (Table 1).

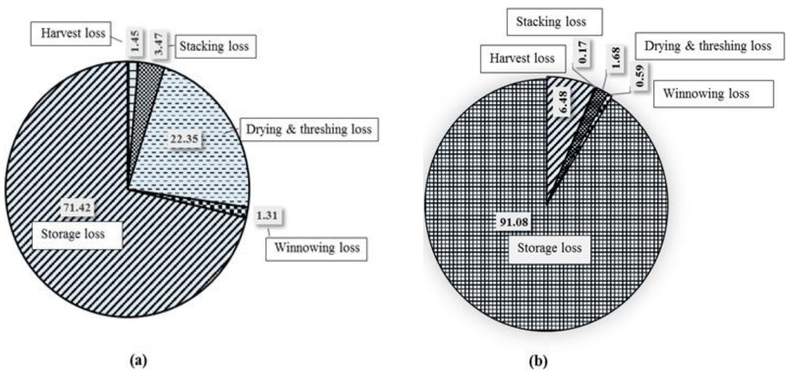


**Fig. 1 Proportion of postharvest losses of (a) pre-monsoon (b) post-monsoon sesame**

In regard to total losses, storage loss comprised the major part with 71.42% of the total postharvest losses for pre-monsoon sesame. The remaining losses consist of, 22.35% in stalks drying and threshing process, 3.47% during stacking, 1.45% at harvest loss and 1.31% of during winnowing (Fig. 1 a). In post-monsoon sesame, storage losses represented 91.08% of total losses, followed by harvest loss at 6.48%, stalks drying and threshing loss with 1.68%, and winnowing loss at 0.59% of total losses. The loss during the stacking process was only 0.17% of total losses (Fig. 1 b). The losses during storage are a result of several factors, both biotic (insects, pests, rodents, fungi) and abiotic (temperature, humidity, rain) (Abedin et al., 2012). In India, the postharvest losses of sesame were estimated at different stages across four different marketing channels. The total losses at farm level were 46.75%, 37.58%, 35.85% and 51.84% respectively as part of the total losses in supply chain. Harvest losses of sesame in four different marketing channels were 10.57%, 9.32%, 6.72% and

16.54% of total losses. Collection losses were 4.88%, 4.66%, 5.88% and 9.93% of total losses; while 8.94%, 5.59%, 6.16% and 8.46% of total losses occurred at the threshing stage. Winnowing losses of sesame, 8.13%, 7.45%, 6.72% and 4.78% were found in these four marketing channels, and a considerably high amount of losses occurred in drying/packaging with these being 8.94%, 7.45%,7% and 8.09% respectively. The storage losses at the processing level in the four marketing channels were 15.04%, 8.07%, 8.12% and 12.13% of total losses in the supply chain (Kumarasamy and Sekar, 2014).

**Table 1 Postharvest losses of pre-monsoon and post-monsoon sesame**

| Activity | Pre-monsoon | Post-monsoon |
|---|---|---|
| | Percentage of losses | Percentage of losses |
| Harvest losses | | |
| Average | 0.31 | 0.77 |
| Range | 0.11 to 0.71 | 0.58 to 1.17 |
| | *t = -3.788, P = 0.004**, df = 10* | |
| Stacking losses | | |
| Average | 0.74 | 0.02 |
| Range | 0.24 to 1.11 | 0.01 to 0.06 |
| | *t = 4.195, P = 0.008**, df = 5.021* | |
| Stalks drying and threshing losses | | |
| Average | 4.77 | 0.20 |
| Range | 1.91 to 10.09 | 0.04 to 0.37 |
| | *t = 3.582, P = 0.016*, df = 5.021* | |
| Winnowing losses | | |
| Average | 0.28 | 0.07 |
| Range | 0.09 to 0.56 | 0.03 to 0.09 |
| | *t = 3.148, P = 0.024*, df = 5.225* | |
| Storage losses | | |
| Average | 15.24 | 10.82 |
| Range | 7.63 to 21.93 | 3.19 to 23.43 |
| | *t = 1.235, P = 0.245ns, df = 10* | |
| Total losses | | |
| Average | 21.34 | 11.88 |
| Range | 11.18 to 29.99 | 4.42 to 24.41 |
| | *t = 2.27, P = 0.047*, df = 10* | |

*Note: **significant at 1% level; *significant at 5% level; ns = non-significant*

### Effects of Packaging Materials and Storage Durations on Total Weight of Stored Sesame

The harvested sesame seed/grain was dried, weighed and stored in two types of packaging materials, pioneer superbags and woven polypropylene bag, for eight months at the farmers' houses. Every two months during this period, samples were taken, cleaned and weighed. Pests were found in the stored sesame, therefore, one of the main factors causing reduction in weight may be pest infestations during the storage period. Insects alone can cause 36 to 43 percent storage loss (Bala et al., 1990). Sufficiently airtight storage systems, although allowing insects and other aerobic organisms to initially survive, oxygen concentrations are decreased below those permitting further insect development (Chanda, 2013). In pre-monsoon sesame, the weight of stored seed/grain (500 g) decreased significantly in two months (482.88 g) a trend that continued until four months (477.96 g), and which then again significantly decreased by six months, with a loss of 464.97 g and on into the eighth month, when sesame weight decreased to 446 g. In post-monsoon sesame, the initial stored weight (500 g) was not significantly reduced in the first two months (497.19 g), or for the periods following (in four months (494.45 g), in six months (494.24 g), but it then decreased significantly in the six to eight month period to 469.84 g. Therefore, it can be seen that storage losses of pre-monsoon sesame (10.8%) was higher than post-monsoon sesame (6.03%) in the eight months of storage (Table 2).

**Table 2 Mean effects of packaging materials and durations on total weight of stored sesame**

| Treatment | Stored weight (g) | |
|---|---|---|
| | Pre-monsoon sesame | Post-monsoon sesame |
| Packaging materials (P) | | |
| Superbag | 484.01 a | 497.12 a |
| Woven polypropylene bag | 464.72 b | 485.17 b |
| $LSD_{0.05}$ | 6.46 | 5.93 |
| Storage duration (D) | | |
| Initial storage | 500.00 a | 500.00 a |
| 2 months | 482.88 b | 497.19 a |
| 4 months | 477.96 b | 494.45 a |
| 6 months | 464.97 c | 494.24 a |
| 8 months | 446.00 d | 469.84 b |
| $LSD_{0.05}$ | 10.22 | 9.38 |
| Pr > F | | |
| P | 0.0000 | 0.0002 |
| D | 0.0000 | 0.0000 |
| P × D | 0.0003 | 0.0000 |
| CV (%) | 2.62 | 2.32 |

*Note: In each column, means with the same letter are not significantly different at 5 % level*

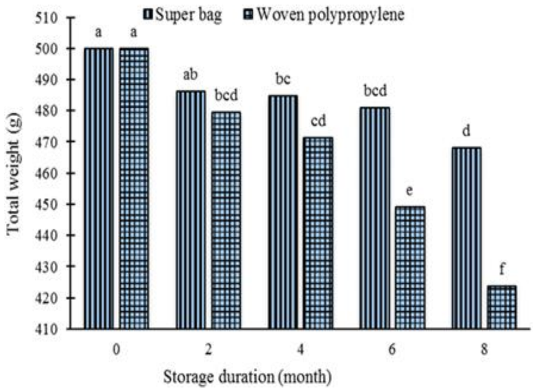


**Fig. 2 Combination effect of packaging materials and storage durations on the total weight of stored pre-monsoon sesame**

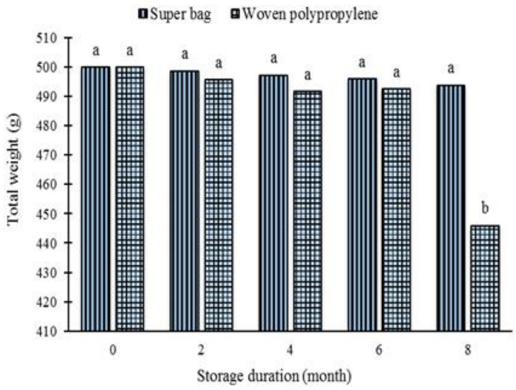


**Fig. 3 Combination effect of packaging materials and storage duration on total weight of post-monsoon sesame stored pre-monsoon sesame**

The combination effect of packaging materials and storage durations on the total weight of stored pre-monsoon sesame is shown in Fig. 2. In the first two months of storage, the weight of seed/grain stored in the superbags did not fall, whereas seed stored in the woven polypropylene bags was significantly reduced. After four months storage, the weight of sesame stored in the superbags was significantly different to the weight at initial storage. The weight of stored sesame in the woven polypropylene bags was also not significantly different than the weight of stored seed/grain weight for two months, however, it was significantly different to the weight of sesame after six months storage. From six months to eight months storage, the weight of sesame stored in superbags did not significantly decrease, while the weight of sesame stored in woven polypropylene bag had decreased significantly by eight months from the weight at six months (Fig. 2). By the end of the storage period measured (eight months), the weight loss of pre-monsoon sesame stored in superbags was 6.36%, while for sesame in woven polypropylene bag there was a loss of 15.24%.

The combination effect of packaging materials and storage durations on the total weight of stored post-monsoon sesame is shown in Fig. 3. The weight of stored sesame in superbags did not significantly decrease over eight months storage, while the weight of sesame stored in woven polypropylene bag maintained similar weights for the first six months and then decreased significantly at eight months storage with a 10.82% weight loss (Fig. 3). As the packaging materials are airtight, insects and aerobic microorganisms creates an inhibitory environment over time by increasing carbon dioxide concentration and decreasing oxygen due to their respiratory metabolism (Adler et al., 2000). If the weight loss of pre-monsoon and post-monsoon sesame during storage is compared, losses of pre-monsoon sesame occurred in both the superbags and woven polypropylene bags, however, losses of the post-monsoon sesame were found only in the woven polypropylene bags. This might be due to the initial seed moisture content at time of storage, as the initial moisture content of pre-monsoon sesame was higher than that of post-monsoon sesame. When using airtight storage methods, it is important to have a very well dried product at the beginning of the storage period (Hayma, 2003). Also Ben et al. (2009) reported that one of the main challenges of using hermetic bags is that the grain to be stored should be thoroughly dried to avoid mold and the rotting of grains.

## CONCLUSION

The range of the total postharvest losses of pre-monsoon sesame and post-monsoon sesame were (11.18% to 29.99%) and (4.42% to 24.41%). Storage losses were the highest contributor to losses among all the postharvest processes for sesame in both seasons. Storage losses can be mitigated by use of efficient storage technology, and upgrading both infrastructure and storage practices. When comparing postharvest losses, the losses were higher in pre-monsoon sesame than for post-monsoon sesame, except for harvest losses. Although the losses in harvesting, stacking, stalk drying and threshing, winnowing and total post-harvest losses were significantly different, the difference in the amount lost during the storage stage for pre and post-monsoon crops were non-significant. The differences of losses that occurred during stacking, stalk drying and threshing and winnowing were due to the different handling practices of farmers. Therefore, if farmers had a good threshing floor, post-harvest losses would be reduced and a better quality product produced. In regard to the packaging materials, a significant difference of total weight of stored sesame that was lost can be seen for the different packaging materials surveyed. Storage in superbags resulted in far less sesame weight loss than storage in woven polypropylene bags.

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