Photo: CRS- Afghanistan

Quality potato seed in Ghor Province, Afghanistan, through improved production and storage

Introduction

Ghor Province, in the central highlands of Afghanistan, typifies many highland areas in Central and South Asia. The terrain is semi-arid and mountainous with limited irrigated land. Forty percent of the rural population is unable to meet its annual household consumption needs. Potato is the principle staple along with wheat, grown by 80% of households as an important winter food and the main income-generating crop. Most farmers produce 10–15 metric tons (MT) of potato annually, based on average yields of 8–12 MT per hectare and average land allocations of 1–1.5 hectares. More than 15% of total irrigated land in Ghor Province, 43,696 hectares, is devoted to potato. Few inputs are used in production due to cost and availability.

The average household size in the central highlands of Afghanistan is seven, and most family members are involved in key household enterprises like crop production, livestock rearing, and firewood collection. However, a division of labor exists which reflects both inter-household economics and social norms. With potato, men prepare the land, assist with planting, lift the potatoes at harvest, transport potatoes to stores, and sell them in the market. Women are responsible for selecting seed tubers at planting, planting the seed, and sorting and grading the potatoes at harvest. Potatoes have a high return per unit of land and are a promising crop for both home consumption and income generation.

Farmers store their potatoes during winter months in pits, 1.5–2.0 meters deep and 1.5 meters in length and width, usually near the field from which they were harvested, and directly covered with 30 centimeters (cm) of soil. Seed and ware (eating) potatoes are generally stored together throughout the winter, when temperatures can be as low as -30°C. Farmers typically store 2–3 tons per pit, based on the volume of the store. Farmer stores often suffer from ventilation issues due to poorly designed or malfunctioning vents and over packed stores. Losses by the following spring generally exceed 30% and can amount to total loss. Storage affects tuber quality, which is often poor due to fungal and bacterial rot as well as excessive sprouting. Seed is selected from the surviving tubers but the following crop shows reduced vigor and growth as a result.

Opening the communal potato storage pit in Lal after six months storage. The interest of the community was palpable!

Photo: CRS- Afghanistan

Materials & Methods

This project targeted a total of 1,680 households in Chaghcharan and Lal Wa Sarjangal (Lal) districts of Ghor Province with training on potato selection, handling, and on-farm storage through introducing minimal-cost ventilation systems to traditional pits. Poor sorting of potatoes prior to storage and poor ventilation of potato pits were identified as major contributors to high storage losses. Households were encouraged to carefully select and gently handle their potatoes to minimize tuber damage. The main modifications to traditional storage included ensuring air space of 30 cm above the potato stack, promoting the use of two aluminum vents to promote air circulation and a wooden rack on the floor to ensure air flow under the potato stack.

At the time of this project, there were also on-going community storage programs taking place in a neighboring province. These involved community stores capable of storing 20 tons, sufficient for up to 20 farmers, and costing on average US$8,000. The community stores were not well received. Their scale and cost made them beyond the reach of communities without significant external assistance. Similarly, previous efforts to introduce formal and informal potato seed schemes have failed due to lack of trust between producers and buyers and because households did not have the assets to regularly purchase seed potatoes.

Storage structure: Pits are an ideal cost-effective means of storing potatoes during the cold Afghan winter when temperatures can fall to -30oC. Simple ventilation ducts alone were not considered sufficient to draw air through the potato stack. It was hypothesized that if a pocket of warm air could be captured above the stack, the forces generated upon the release of this air to the atmosphere would be sufficient to draw in cool ambient air. The mid-day air temperature in winter, 4–6°C, is ideal for potato storage, and so an appropriate ventilation mechanism was designed to disperse cool ambient air through the potato stack. To develop the concept in association with the targeted communities, communal pits (Figure 1) were constructed by a group of 35 households in six villages of the two target districts.

Training on seed handling and storage: Concurrent with the promotion of the store, good seed selection and handling practices were promoted through a series of training courses held at the appropriate time of the cropping season. These courses were aimed at men and women from the same household to not only ensure that the person most likely to carry out a task was knowledgeable, but also that household members could discuss the practices confidently and plan their work together. Training was kept to five key topics and limited to 30 minutes to accommodate for participant time. Topic areas were (a) timely cessation of irrigation and dehaulming (cutting back the stem) pre-harvest, (b) rigorous sorting at harvest, (c) gentle handling, loading the pit and curing, (d) ventilation management, and (e) opening the pit and seed preparation. Intensive follow-up visits were carried out as farmers were in the field carrying-out the practices in question.

Storage management: Each participating household brought their selected seed potatoes to the communal pit for loading. Potatoes were loaded into labeled open-weave net bags. Weights were recorded, and the bags were then placed in the pit and covered with surplus sorted potatoes. Following curing, which involves closing the pit for 10 days to allow the gentle build-up of heat and moisture to hasten the suberization process (healing of wounds on the potato skin), the pits were regularly vented by opening

the inlet and exit vents. The vents allowed warm exiting air to draw in cool ambient air. Ventilation was controlled by condensation, aided by the surface of a cool shiny metallic object placed at the exhaust vent to condense warm, humid, exiting air. When condensation ceased, air movement stopped and the vents closed automatically. Upon opening the pit in spring, the tubers from each bag were sorted so the healthy and rotten tubers could be weighed separately. Healthy tubers were then planted. During the cropping season all participants were trained to select healthy plants from which to select seed for the following season using the seed plot technique.

Monitoring activities: Participating farmers planted the tubers from the communal pit alongside those stored in the traditional manner. All cultural practices were the same for both parcels. Days to 50% crop emergence, emergence percentage, plant vigor using a scale of 1 to 3 (1 = poor vigor, 2 = moderate vigor, 3 = vigorous) and sample harvest yields from two randomly selected plots (10 square meters in size) within each parcel were recorded. Issues and suggestions on seed selection, handling, and the modified pit storage technology were openly discussed with farmers and changes were incorporated in the second season. In addition, another 12 groups were formed in different villages and they completed one cycle using practices refined during the course of the project. In May 2013, a sub-set of participating households were surveyed to understand the impact of improved seed selection handling, principle uses of the increased production and income, key take-home messages from the project, and factors affecting their decision to adopt the stores.

Results & Discussion

In total, 840 households and 1,680 individuals (a male and a female member from each household) took part in the project. Across both sites there was a marked reduction in storage losses, an increase in plant vigor, and an increase in reported yields. Feedback from the final project assessment consistently mentioned that training was not time-consuming and that follow-up was field based and personal. The "doing is believing" approach helped participants better understand and adopt improved selection, handling, and storage practices. Participants also noted that the simplicity of the storage modification and the low cost (US$10 in materials) made adoption easy.

Storage design: The stores proved practical, easy to operate and overall significantly reduced losses. In the exceptionally cold winter of 2011–2012, however, condensation formed on the roof of many pits and dripped on the potato stack below. There was no apparent spoilage, but it was recommended to improve the insulation by increasing soil cover from 30 cm to 50 cm. Excessive condensation was a reoccurring issue in pits that were not completely filled, thus in Season 2 all pits were filled to within 40 cm of the top to generate enough heat to drive the system. It was further recommended to ventilate twice per week in order to expel excessive humid air and reduce the condensation effect. Most heat and moisture is generated in the first few weeks after curing. In Season 2, many farmers left their pits open until the first frosts, from which time regular biweekly ventilation was implemented. Some pits had damp walls at the time of filling and hence experienced higher levels of condensation. In Season 2,

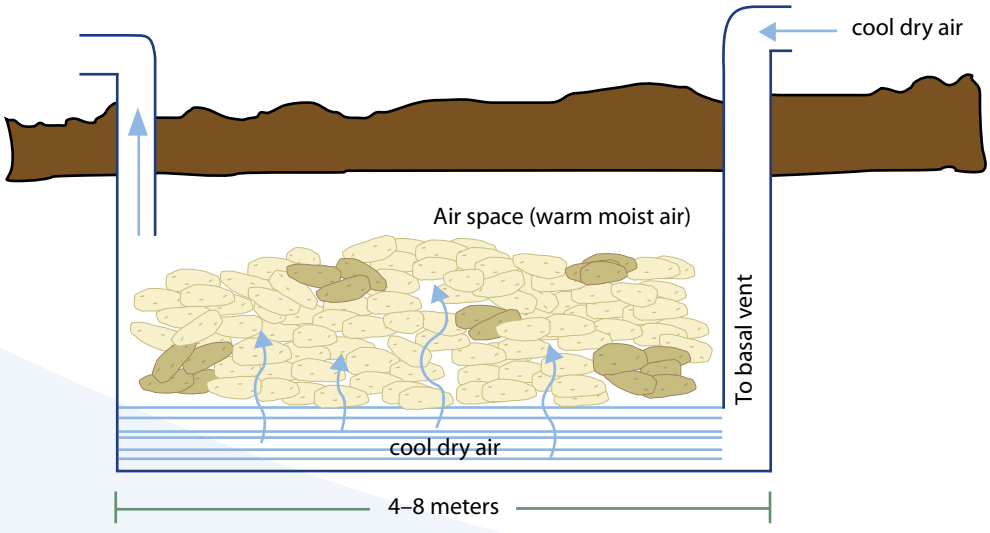

Figure 1: Prototype village communal store

all pits were constructed well in advance to allow pit walls to thoroughly dry and to be able to absorb considerable moisture during the winter. It was also noted that a few communities lined their pit roof with plastic, which prevented the soil in the roof from absorbing moisture and greatly increased condensation. In Season 2, plastic was not used. The Season 2 modifications resulted in significant reductions in losses, as reflected in Table 1.

Storage losses: Average losses in the community pits, where the improved storage technology was demonstrated, are shown for each district and participating village in Table 1. Across two seasons, the reported losses with improved storage technology was under 5% in both districts, an over 80% reduction compared to losses in farmers' own pits. Based on assessing five farmer stores near each target village, approximately 30 per district, the average reported farmer losses were 35% in Chaghcharan district and 21% in Lal district.

Losses reported in Table 1 are equally attributable to loss in tuber weight and loss due to disease, notably Fusarium spp. There were also marked differences in losses due to rot which were attributed to differences in selection practices. At the time of loading, some seed was not well selected and the resultant losses served as a good demonstration of the importance of selection. Losses during the second storage season were uniformly less than in the first season, presumably due to lessons learned and improvements to store design and operation. Second season losses were minimal and almost entirely attributable to loss in weight from respiration rather than rotten tubers.

Crop development and yields: Surprisingly, there was no significant difference in days to 50% emergence between farmer traditional practices and the improved storage technology, both averaging 28 days. However, there were large differences between farmers within a village using the same improved storage technology. This is attributed to the depth of planting which varied from 10 cm to >25 cm; the timing of the first irrigation which ranged from pre-planting to one month post-planting; and tuber sprouting as most tubers had no sprouts at planting and thus took longer to emerge. There were marked differences in plant vigor between farmer traditional practices and the improved storage technology. Using a scale of 1 to 3; farmers in both districts reported an increase of 25% to 45% in plant vigor. Chaghcharan farmers rated plant vigor from improved store seed at 2.48 as compared to 1.70 for the farmers' own seed (45%), while in in Lal the figures were 2.78 to 2.15 (25%). Table 2 compares yields across both districts for a single season and shows that crop yields were higher and damaged tubers lower when planting seed potato from improved stores.

Table 1: Summary of % storage losses by weight

District	Number of households storing	Village*								
		1	2	3	4	5	6	7	8	Mean
Season 1										
Chaghcharan	166	13	3	8	7	5	10	–	–	6
Lal	312	6	1	3	5	5	2	–	–	3
Season 2										
Chaghcharan	183	4	4	6	3	1	–	–	–	3
Lal	273	0	0	0	2	0	3	1	3	1

** NB: Villages not the same in each year in each district*

Table 2: Harvest yields (kg/10m^2) and % rotten/damaged tubers – Season 1

District	Store type	Number of samples	Total harvest (kg)	Weight healthy tubers (kg)	% Rotten/damaged tubers
Chaghcharan	CRS	7	44.3	37.0	16%
Chaghcharan	Farmer	19	28.2	19.7	30%
% increase			57%	47%	
Lal	CRS	23	95.1	84.6	11%
Lal	Farmer	23	83.8	73.4	12%
% increase			13%	15%	

Training in good seed selection practices targeted men and women from the same household to not only ensure that the person most likely to carry out a task was knowledgeable, but also that household members could discuss the practices confidently and plan their work together.

No data was available for Season 2 due to extreme drought conditions and the failure of irrigation supplies. In Chaghcharan, there were also significantly more rotten tubers in the farmer plots (30%) than those from the improved stores (16%) and the total harvest was 57% more when fields were planted with seed originating from improved stores. In Lal, differences in yield and tuber loss from seed originating from improved storage technology were small because the overall yields were very good due to favorable growing conditions.

Storage unit production costs: Labor and material costs for each unit are an estimated US$22. It is estimated that each storage unit requires at least 3 days of labor and the daily labor rate is approximately US$4 (US$80 per month). Ventilation pipes cost approximately US$5 and timber for roofing is also estimated to cost US$5. Digging the storage hole requires two laborers for 1/2 day, while constructing the storage roof and installing the ventilation (pile or chimney) also requires two laborers for 1/2 day. An additional day of labor is required for acquiring materials, which includes accessing piping or building chimneys for ventilation and recycling beams or cutting fresh beams from trees for the storage roof.

Livelihood impact: The fact that seed and ware (consumption) potatoes are stored together rendered it impossible to look at seed in isolation. Households quickly appreciated the value of improved storage technology, reflected in Table 3, summarizing how farmers in each district used the extra income derived from the combination of reduced storage losses and improved yields. Seven major uses for the increased production were identified by respondents with marked differences between men and women.

Table 3: Use of increased production and income (% respondents identifying each category)

Reported use	Women		Men	
	Chaghcharan	Lal	Chaghcharan	Lal
Home consumption	80	98	100	100
Sold for food (rice, oil, tea)	80	43	95	4
Sold for wheat	53	47	71	19
Purchased clothes	73	73	43	35
Purchased production inputs	13	16	86	12
Repaid debt at harvest	40	19	29	7
Pay school fees	27	23	24	23

In both districts, nearly all male and female respondents thought that safe storage would permit increased consumption within the household. More than 50% of male and female respondents in Chaghcharan reported that they would sell potatoes to buy rice, oil, tea, or wheat. Respondents were more likely to report using the increased income to repay debt at harvest in Chaghcharan. Roughly one quarter of respondents reported that the increased income would be used to pay for school fees. In both districts, women were more likely than men to purchase clothing. In the more commercially-oriented Chaghcharan district, 86% of men but only 13% of women envisaged using the increased income to purchase inputs for the following season, reflecting their respective roles in the production cycle.

Communities need to be encouraged to use the extra yields as an opportunity to diversify their cropping system and improve resilience. The increased potential and reliability of the potato crop could encourage farmers to expand production and disrupt the established rotation of wheat, potato and a nitrogen-fixing fodder crop (alfalfa or clover) leading to pest and disease consequences. Pressure for food crops is already seeing a reduction in fodder crops and soil fertility. An expansion of potato production could exacerbate this.

Factors influencing technology adoption: Provincial agricultural extension services in Afghanistan are limited due to lack of staff, low levels of training, and a lack of mobility. For new technology to be quickly shared over a wide area, innovative approaches will be needed as well as a thorough understanding of household motives for adoption. Eleven key factors influencing farmer adoption of improved storage and handling practices were identified through discussion with farmers in both districts, listed in Table 4 below. Farmers in both districts reported the flexibility in selling and consuming potatoes to be a paramount factor influencing the adoption of improved storage and handling technologies. Nearly all male and female respondents in Chaghcharan noted that reduced need to purchase seed was a key influencing factor. Over both districts, nearly all households surveyed said that they will use the improved practices for the following season and virtually all farmers indicated that they prefer individual stores to using community stores.

Effective extension campaigns identify practices which have been successfully transferred and those which may need further attention. Table 5 presents the principal take home messages as noted by male and female participants in both districts.

Among the nine principal take-home messages, planting depth and fertilizer placement were not included in training but were frequently discussed at meetings. The importance of ceasing irrigation early, sorting and store management were well noted but surprisingly ventilation of the store did receive universal mention. This may be because the stores were communal and often managed by one person, thus many participants had not actually carried-out the practice. There were key differences between the sexes concerning emphasis on activities often not related to their role in the production cycle. For example, men in Chaghcharan emphasized the importance of female activities like sorting and planting while women emphasized the importance of male activities like irrigation, dehaulming, and ventilating the store.

Table 4: Factors influencing adoption of improved storage and handling practices (number (N) of respondents identifying each category)

Reported influencing factor	Women		Men	
	Chaghcharan	Lal	Chaghcharan	Lal
	N=81	N=2	N=90	N=94
Flexibility in selling and consuming potatoes	63	0	90	94
No need to purchase seed at planting	81	0	77	0
Improved stores are simple to operate	44	1	77	27
Reduced seed storage losses	81	1	50	56
Increased yields from the stored seed	19	1	67	52
More food available in the spring	38	0	47	9
Reduced ware storage losses	19	2	53	6
All improvements (selection, handling, storage) are based on current practices	56	0	40	0
Provides income for other essentials	13	1	47	24
Improved seed quality	44	0	23	36
No new structure needed with the improved seed storage technology	38	0	23	18

Table 5: Principal take-home message for improved seed selection, handling, and storage (% of respondents identifying each category)

Principal take-home message	Women		Men	
	Chaghcharan	Lal	Chaghcharan	Lal
Store must be ventilated	50	64	42	67
Must sort at harvest	61	2	95	7
Cease irrigation early	78	17	74	7
Dehaulm early	44	0	16	0
Sort before planting	39	19	79	37
Less deep planting	22	0	37	0
Use fertilizer	39	0	26	0
Storage management	67	41	74	33
Seed selection in field	44	98	68	100

Conclusions & Recommendations

Low-cost improved ventilation of traditional potato storage pits is a practical and highly effective intervention to reduce high storage losses while improving crop yields, food security, and marketing options. Throughout the project, losses have been consistently reduced under a range of adverse conditions.

Project interventions should focus on a few key related topics rather than all aspects of storage. Adaptations should be simple, built upon existing practices and economically feasible. Training should be short and focused to respect participants' other responsibilities; timely, focused follow-up is essential.

In targeting beneficiaries it is essential to include male and female members from each household in all activities. This is because men and women not only play different roles in the production cycle, but also receive and prioritize messages differently. Ensuring that both male and female family members are trained facilitates inter-household discussion and increases the likelihood that practices are carried-out in an appropriate and timely manner.

It is recommended that extension material for store construction, management, and crop handling are included in a technical manual. Such a manual is being prepared in collaboration with the University of California, Davis. The manual will be translated into Dari and published on a website. Subsequent outside funding has permitted the production of a video on potato storage which is intended for extension workers in Afghanistan.

In terms of adoption and impact, more than 300 non-participating households are known to have constructed storage pits for the 2013 harvest and farmers are now storing onions and garlic in sacks above their potatoes. A pilot conducted by CRS has shown that apples can be stored above the potatoes, and a small demonstration is currently being conducted in Herat province with onions, a crop for which lack of in-country storage is the major constraint to famer income. With the Office of U.S. Foreign Disaster Assistance (OFDA) funding, studies are beginning in Malawi and Ghana to adapt the ventilation concept to storing sweet potato under hot conditions. Further studies are required to evaluate in more depth the applicability of the concept over a wider range of crops.

Traditional storage pits (above) are not ventilated resulting in frequent losses of 30–100%.

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