VERTICAL 1

Improvement in the design of storage structures

Onion is a semi perishable vegetable and is harvested during *rabi* season accounts 65% of onion production, hits the markets from April to May. The same crop must continue to meet the consumer demand till the month of October-November every year before the *kharif* crop is harvested and brought to the market. *It is therefore vital to successfully store onion in order meet the regular supply.* It is observed that nearly 30-40% of the crop is lost during storage due to the various reasons in form of physiological weight loss, rotting, sprouting etc. In unexpected situations such as natural calamities, the losses even go beyond 50% creating heavy stress both on demand and supply sides. The losses occurred during storage are in terms of qualitative as well as in quantitative ways. Hence, it is imperative to take some crucial steps pertaining to onion storage with minimum losses to ensure the adequate supply to the market there by reducing the price fluctuations.

Table 1: Current Quantitative losses and Expected Targets

	Type of loss	**Reported losses**	**Expected loss with potential solutions**
1	Physiological weight loss (PLW)	20-25%	15-20%
2	Rotting/ decay	10-12%	≤ 7-10%
3	Sprouting	8-10%	≤ 6-7%

Qualitative losses:

1. Black mold : 25-30% reduction in market value
2. Outer skin removal : 25-30% reduction in market value

Various abiotic factors like temperature, relative humidity affects the health of onions hence their balance is must needed to store the crop with minimum losses.

- High temperature (Above 32°C) + Low RH (Less than 60%) = **Weight loss**
- Low temperature (0 - 2°C) + Low RH (Above 70%) **= Sprouting**
- High Temperature (Above 32°C) + High RH (Above 70%) = **Rotting**

- Temperature (25-30°C) + RH (60-65%) = ***Recommended***

  OR

  *Temperature (0-5°C) + RH (65-70%) = ***Recommended***

Note* 1 - When removing the onions from cold storage, they must be heated up/conditioned to the outside temperature to avoid post-storage sprouting and the decay temp should not increase more than 2°C/day. *This process of conditioning requires great energy and a lot of time where the scope of improvement is needed.*

Note 2- The irradiation treatment of onion bulbs in which sprouting has not been initiated is recommended during the vernalization process at low temperature before storage, otherwise it makes black colour spot inside the bulb.

Scope of improvement

1. Optimization of various abiotic factors during tempering / conditioning.
2. Development of sensor based detection system of onion weight loss/ rotting/ sprouting/ decaying etc.

Status of established onion storage structures and challenges

i. *Naturally ventilated structures (Kandha Chawl):*

Kandha Chawl are the naturally ventilated structure, a scientific onion hut to minimize the losses due to storage. In India, the onions are mostly stored in such structures without any control of temperature and relative humidity. The farmers construct different types of Kandha Chawl based on the capacity required.

Low cost thatched roof bamboo storage structure: This type of storage structure is usually constructed with bamboo framework having the roof made up with sugarcane leaves and is preferred for 'on-farm' storage of onions. This is a single row storage structure that can be made of 5 to 10 tones capacity. The structure is constructed with bamboo rafters. The whole solid bamboos are used for pillars and roof beams. Half split bamboos are used for floor while the sidewalls are made by split bamboos (1/6). The pillars of whole bamboos are erected at five feet distance. The iron angle provide support to all pillars. The bottom ventilation is provided with bricks fixed at the base of all iron angle pillars. The roof is usually made with sugarcane leaves but similar type of grass-can be used for this purpose. Inner lining of gunny cloth is provided to

check the leakage of rainwater. This type of structure should be made in North to South direction. This type of storage structure is low cost and easy to construct, but leads up to 40-42% losses of onion during four months of storage. The durability of the structure is low due to use of organic material / bamboo. The temperature and humidity cannot be controlled since it works on natural ventilation mechanism.

Fig. 3. Low volume structure

Table 2: Challenges in the current designs and expected Targets

Challenges in current designs	**Scope of Improvement in current design**
1. Durability and strength of storage structure	Material used in construction (decided by participants as per challenges)
2. 40-42% losses	Loss reduction range must be: 20-25%
3. Low storage duration (as onions can be efficiently stored upto 3-4 months)	Extension of storage period with minimum loss
4. Abiotic factors	• Control of environmental parameters and ventilation. If needed cost friendly accessories like Fan, tubelight etc. can be used in the storage structure. • 65-70 % RH • Temperature : 25-32 °C

Bottom and side ventilated storage structure: This has provision ventilated floor made of wooden bantams, central ventilated pathway and extended roof. **The framework of the structure was constructed with galvanized iron channels.** The floor and sides walls were made with wooden bantam of 2.5 cm thickness and gap of 2.5 cm in kept between the bantams. **The roof is constructed with asbestos sheets.** The roof was extended to 1 meter to avoid splashes of rain. This type of structure has a provision of ventilation from bottom and sides.

Fig. 4. High volume structure

These current prevailing structures that may vary in their capacity as well as the cost to fulfil the requirements of all income groups of farmers/traders. Though these naturally ventilated storage structures are well adopted, still considerable losses occur as there is no control of temperature, relative humidity and airflow which are very important for successful storage of onion with minimum losses. The construction of the 50 MT double row modified bottom and side ventilated storage structure needs approximately Rs. 7 lakhs.

Majority of the farmers in India store the onion in this type of naturally ventilated storage structures but such structures are not suitable in regions with extreme high temperatures, and high relative humidity / high temperatures with low relative humidity or low temperatures with high relative humidity. ***There is a scope to improve this structure by providing proper ventilation, controlling temperature in extreme summer conditions, reducing relative humidity with suitable materials and other means***.

Table 3: Challenges in the Current designs and Expected Targets:

Challenges	Scope of Improvement in current design
1. Reduction in cost	Cost should reduce (below 4-5 Lakhs)
2. Durability and strength of storage structure	Material used in construction (decided by participants as per challenges)
3. Reduction in storage losses (Current losses: ~ 46% in 4 months)	Losses up to 20-25 % in four months' storage
4. Abiotic factors	Control of environmental parameters and ventilation (natural convective air circulation) • 65-70 % RH • Temperature : 25-32 °C
5. Material used in construction (Currently, roof is of asbestos sheets)	The roof of material should be environmental friendly and prevent heat built-up at the top of the structure.
6. Environmental sustainability issue	Alternate to wood battens can be used in structure

ii. Controlled onion storage structures

Although cold storage systems are used in certain countries for onion, which is rarely adopted in India due to poor economics and lack of cold chain facilities required to maintain the quality in the high ambient temperature prevalent in our country. *Onion storage in ventilation condition is quite satisfactory when the temperature is maintained between 25^{o}C to 30^{o}C with a relative humidity range of 65-70%.* In controlled onion storage structures, the onions are stored at 0-5°C and 60-65% RH that leads to much lesser losses as compared to ventilated storage structure. The cost of construction (approx. 20-25 lakhs/ 20 tons) and running cost (i.e. Rs 0.60-0.65/ Kg/ month) are very high as energy required to maintain the storage facility in the temperature range of 0-5°C is high. The other problems are condensation and require lot of energy and time. The bulbs start sprouting immediately after they are removed from the cold storage.

Fig. 5. Controlled storage structure

Table 4: Economics of cold storage

Sl.No.	**Particular**	**Cost of onion storage/ton**	**Cost of onion storage/ 2000 ton**
1	Total storage capacity (tones)	1	2000
2	Value of onion @ Rs 2000/ton	2000	4000000
3	Cost of storage of onion (Rs/year)/ Repayment	900	1800000
4	Cost of sorting @Rs 70/ton	70	140000
5	Cost of electricity charges	200	400000
6	Maintenance and interest on capital	500	1000000
7	Cost of irradiation	15	30000
A. Total expenditure (Rs)		3685	7370000
	Total salable good bulbs (ton)	0.95	1900
	Total salable Sprouted and black mould bulbs (ton)	0	0
B. Total Returns (Rs)	Onion @ Rs 6000/t	5700	11400000
	Sprouted & black mould affected bulbs @ Rs1000/ton	0	0
	Total value (Rs)	5700	11400000
8	Net profit (Rs) (B-A)	2015	4030000
9	Net Profit (Rs/t)	1.0075	2015

Table 5: Challenges in the Current designs and Expected Targets:

Challenges	Scope of improvement
1. Proper circulation of cold air inside the structure	Forced circulation of cold air Temperature optimization • Ambient temp. storage: 25-32°C • Cold storage: 0-5°C • 65-70 % RH
2. High capital investment and operating cost	Should be cost effective (below 10-12 Lakhs/20 tons)
3. High energy requirement and power failure affect the storage life of onions.	Method adopted must enable constant and cost effective power supply (e.g. Solar energy etc.)
4. Environmental sustainability issue.	Must provide an alternative to refrigeration system (like cooling towers etc.)
5. Required highly skilled manpower	Less skilled manpower requirement (by making the system user friendly)
6. Durability and strength of storage structure	Material used in construction (local agri material, decided by participants as per challenges)

Table 6: Economic Evaluation of Kanda Chawl

Particulars	**Low cost thatched roof storage structure**	**Modified bottom ventilated double row storage structure**	**Modified Bottom ventilated storage structure chain linked side walls**
Other/ Common names	**Low cost thatched roof bamboo storage structure**	Bottom and side ventilated (Two row subsidised structure)	Bottom and side ventilated structure fabricated with chain link/ wire mesh
Cost of construction (Lakh Rs)	0.05	1.9	1.25
Length (m)	4.9	9.9	9.9
Width (m)	1.2	6.0	3.6
Side height (m)	1.6	2.25	2.25
Central height (m)	1.9	4.5	4.0
Storage capacity (tones)	5	42	25
Expected life (years)	5	20	20
Cost of storage (Rs. /Kg/month)	~0.20	~0.23	~0.25
Economics of storage of onion			
Total expenditure (Rs)	12850	109040	82090
Total expenditure (Rs/ton)	2570	2596	2565
Total Return #(Rs)	18884	123210	98068
Net Profit (Rs)	6034	14170	15978
Net Profit (Rs/ton)	1207	337	499

#Cost of onion: A grade- @ Rs 5500/t, Sprouted & black mould affected-@ Rs1500/t.

Several losses have been reported pertaining to PLW, Rotting, scale removal, sprouting and black mould when onions are stored in storage structures like Low cost thatched roof structure, Modified bottom ventilated double row storage structure or structure with structure chain linked side walls etc.

Table 7: Different types of losses (average) are reported in Rabi Onion that are stored in different storage structures and expected outcomes from potential solutions.

	Current status (averages losses)					**Expected Outcomes**				
	PLW (%)	**Rot (%)**	**Scale removal (%)**	**Sprouting (%)**	**Black mould (%)**	**PLW (%)**	**Rot (%)**	**Scale removal (%)**	**Sprouting (%)**	**Black mould (%)**
Low cost Thatched roof structure	17.4	10.8	0.34	1.35	2.11	Minimum 40-55 % reduction in all category losses in comparison to the existing loss				
Modified bottom ventilated double row storage structure	19.4	17.94	0.32	37.69	11.6					
Modified Bottom ventilated storage structure chain linked side walls	22.7	14.19	0.38	3.29	5.58					