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Modern NHRDF onion storage structure under sub-tropical conditions

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Abstract

In India onion is produced in three season's *kharif*, late *kharif* and *rabi*, in which *rabi* harvest have good keeping quality and can be stored for longer period up to 5-6 months. Over a period of storage, there is a gain of three to four times profit in market due to non-availability of onion. Hence, the storage of onion is very essential to maintain regular supply to the consumer till November. Due to improper storage, more losses arise in farmer's storage method due to higher sprouting, rotting and physiological loss in weight, which leads to heavy stress on both demand and supply resulting in a steep rise in the price. Scientifically developed storage facilities will help in checking the supply volatility and rise in onion prices. Under existing ambient conditions, NHRDF has developed a ventilated conventional onion storage structure providing proper aeration and ventilation without any control on temperature and humidity. This storage structure is popularized in major onion growing states in India. Recently, the NHRDF has developed an improved storage structure designed to maintain the constant temperature and relative humidity throughout the storage period. After six months of storage, highest quality bulb recovery (21.40 ton), with lowest rotting (0.69%), physiological loss of weight (13.83%) and total loss (14.52%) were recorded in NHRDF improved onion storage structure. Due to highest bulb recovery, highest net returns are obtained. While in NHRDF conventional ventilated storage structure, moderate quality bulb recovery (16.70 ton), sprouting (2.50%), rotting (10.10%), physiological loss of weight (20.80%) and total losses (33.40%) were recorded. The lowest quality bulb recovery, highest sprouting, rotting, physiological loss of weight and total loss were recorded in farmer's storage structure. Apart from these, NHRDF improved onion storage structure has several advantages over cold storage structure, conventional ventilated storage structure and farmer's storage structure.

Keywords: Humidity, losses, NHRDF, onion, rotting, storage structure, temperature

Introduction

Onion is a widely consumed spicy vegetable used throughout the year in almost every kitchen of the country. It is highly valued vegetable as compared to other fresh vegetables due to its pungency, flavour and nutritional value in supplying minor constituents of minerals and trace elements (). It also contains phenolics and flavonoids that have potential anti-inflammatory, anti-cholesterol, anticancer and antioxidant properties. India contributes about 20% of total world onion production, which is next only to China. The country annually produces around 233 lakh ton of onion out of which about 70% of onion is used for domestic consumption, 5% is used for export, 3% is for processing, 1% for bulb to seed production and the remaining 22% is going to waste as loss during the storage period. Maharashtra is the state which contributes about 38.06% of total Indian onion production and the area under onion crop is approximately 5.07 lakh ha with production of about 88.54 lakh MT and contributes 80-85% in the total Indian export (Database NHRDF 2017).

Importance of storage: In India, production of onion contributes as 10-15%, 30-40% and 50-60%, in three seasons *i.e*. *kharif*, late *kharif* and *rabi* respectively in annual production. The *kharif* produced onion does not have keeping quality, however, late *kharif* produced onion have medium keeping quality. Therefore, these onions are not suitable for storage for longer period. Hence, farmers immediately bring the produce to the market for sale after harvests. The *rabi* onion is harvested in the month of April-May and the produce is in very huge quantity countrywide. Due to maximum availability as well as supply to the market, onion rates lowers down from April to July month every year. Over a period, the stored onion gains three to four times more profit due to

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non- availability in the market because there is no next harvest till October to December and high consumer demand during the period. Hence, the storage of onion bulb is very essential to maintain regular supply to the consumer till November, and further till February also, if *kharif* crop fails due to abnormal monsoon vagaries.

Reasons for losses: Onion is a perishable commodity and deteriorates very fast due to desiccation and various vital activities even after harvest. Like other vegetables, onion cannot be stored for longer period. Due to various factors about 30-40% of the crop gets lost during the storage which may go up to 70-80% due to inappropriate and inadequate storage facilities. The losses arise during storage period is due to sprouting, rotting, root growth, physiological loss in weight, diseases, accumulation of sugars and loss of pyruvic acid which leads to heavy stress on both demand and supply. This results in a steep rise in the price of onion and eventually affect the consumers end. Bulb respiration continues after harvest and gives off water. More the respiration, more the water loss from bulb resulting in weight loss during the storage (Brewster, 1; Wang *et al*., 3). The storage quality of onion is an inherent character which varies from variety to variety. The bulb dormancy is the main factor which determines that how long the bulbs can be stored. Externally, the climatic factors like temperature and humidity also influence the storage of bulb during longer period. Variation in temperature and relative humidity drastically influences bulb keeping quality due to sprouting, rotting and physiological loss in weight. Under low temperature condition (0-4°C) in cold storage, the dormancy can be enhanced which leads to cease initiation of sprouting and rotting and it could be possible to keep the bulb healthy and suitable for storage up to 12 months. As the temperature increased (> 30°C), the dormancy breaks resulting in sprouting and rotting. The high temperature accompanied with high humidity reduces water loss, while higher humidity increases the sprouting and rotting. Therefore, for equilibrium of temperature and relative humidity, sufficient aeration and ventilation is essential in storage environment for longer period in onion storage structures.

Need of scientifically developed storage structures: There is an urgent need to develop a scientifically constructed storage structures for long term storage of onion that can help in maintaining the temperature, relative humidity and ventilation required for reducing storage losses of onion. Scientifically developed storage facility will help in checking the supply volatility and steep rise in onion prices. NHRDF has developed a ventilated conventional onion storage structure providing proper aeration and ventilation without any control of temperature and relative humidity (Fig. 1). Under existing normal climatic conditions, these storage structures were popularized among the onion farming community in major onion growing states like Maharashtra, Gujarat, Karnataka etc. The NHRDF is promoting scientifically developed onion storage structures to onion growers for adoption and implementation of proper storage with minimum expenditure which will minimize the storage losses and quality deterioration of the onion, which will in turn help the farmers to fetch better price of their produce. In India most of the onion grower's store their produce in small scale traditional storage structures resulting in substantial losses during storage. To avoid such problems, the NHRDF is popularizing the technologies through its extension centers which are located in almost every state all over the country.

Improved onion storage structure modulated by NHRDF: Recently, the NHRDF has developed an improved storage structure with an objective to minimize the storage losses under affordable cost which is suitable for every small-scale onion producer. The structure was designed to maintain the constant temperature and relative humidity throughout the storage period under sub-tropical climatic conditions.

Design of Storage Structure with capacity 25 metric tons: The improved NHRDF onion storage structure with 25 MT capacity was constructed under well ventilated, well drained and easily accusable location at an altitude of about 560 m above mean sea level, latitude of 19 º 72' N and has longitude of 74º 05' E at Regional Research Station, Sinnar, National Horticultural Research and Development Foundation, Nashik (Maharashtra). For this purpose, rectangular shape room was constructed with an interior area of 35'x14' length and width storage room with concrete roof, and the walls were well plastered with cement and the interior foundation area of structure was about 2' from the ground level. At a height of 6 inches, iron angle battens were fixed with welding over floor of the structure with an area of 30'x14', the remaining area of 5.0'x14' was used as working place for loading and unloading of onion. The iron mesh wire panels with hole size 20 × 20mm frame was fixed on iron battens already placed with an area of 30'×14', the iron mesh facilitates to avoid the fall down of small onion bulbs from the wire mesh frame and circulate the air from the bottom side of the structure to all directions (Fig. 2 & Plate. 1). The height of roof of onion storage structure was kept on 6' above the onion bulb, which have already been stored at the height of 4'. For aeration and ventilation eight holes have been made four on each side of the wall of size 6 inches for two sides from West and East for flow of wind and

in the direction of storage structure right angle to the wind direction. Four exhaust fans were fixed on four cylindrical shaped plastic frames and placed on wire mesh frame at 6 feet distance from each other. Fans were connected with power supply to rotate and blow the air towards the bottom direction of the wire mesh. The continuously rotating fans throughout the day maintained the relative humidity of the room constantly. The two mercury lamps were fixed in structure to maintain the constant temperature as low as enough in storage structure during the entire storage period. However, under conventional storage structure, the ambient temperature and relative humidity is not constant. The economics for construction of NHRDF improved onion storage structure having 25MT capacity with a life time of 25 years is given in Table 1 and the construction of 25MT capacity NHRDF conventional storage structure with a life time of 25 years is given in Table 2. The temperature and relative humidity were recorded daily and the average monthly temperature and relative humidity in both *i.e.* NHRDF conventional storage structure under ambient conditions as well as NHRDF improved onion storage structure are given in Table 3 and Table 4, respectively.

The storage loss of onion during the storage period depends on pre-harvest as well as post-harvest factors. The pre-harvest cultural operations followed as per recommendations and the crop was harvested after maturity. After proper drying, curing, sorting and grading of onion variety NHRDF Red 3 was kept for storage in the month of April for a period of six months storage during *rabi,* 2017-18 and *rabi,* 2018-19 in three different storage structures. The two years storage data were combined and presented in Table 5. The data revealed that, after six months storage, the highest quality bulb recovery (85.50%& 21.40 ton), with least rotting (0.69%), PLW (13.83%) and total loss (14.52%) were recorded in NHRDF improved onion storage structure. The lowest losses are due to the temperature and relative humidity maintained constantly during day and night during the entire storage period. The maintained average temperature of two seasons for six months was 28.86°C during day time and 26.64°C during night time, while the relative humidity maintained during day time was 76.93% and night time 79.29%. During the entire storage period, due to constant temperature, relative humidity and continuous aeration, the sprouting was not initiated even after six months of storage (Plate 1&2). Based on results, it can be concluded that combination of temperature and relative humidity are two important factors which reduces losses during storage in onion and hence, these factors must be taken into consideration for prolonged storage successfully. Islam *et al*. (2) also proved that relative humidity and temperature combined effect influences storage of onion for longer period successfully. In NHRDF Conventional ventilated storage structure, the good bulb recovery, sprouting, rotting, PLW and total losses were recorded as 66.60% & 16.70 ton, 2.50%, 10.10%, 20.80% and 33.40%, respectively (Table 5). In this structure during the entire storage period the average temperature of two seasons during day time was 30.19°C and at night time 20.99°C, while

Table 1: A detailed economic analysis for construction of 25MT capacity NHRDF improved onion storage structure.

S. No.	Description	Amount (Rs.)
1	Construction of room with length 35', width 14' and height 10'	2,50,000
2	Wire meshes panels for bottom: Galvanized weld mesh (Size 20 × 20 mm)	16,000
3	Exhaust fans (4) with size (1400 RPM 410 W, 18 inch)	4500
4	Mercury lamps (2)	1500
5	Palates: Fabricated square pipe (Size = 3m x 1m x 0.152 m)	5000
6	Exhaust fans fixing columns (4)	2000
7	Plywood for walls covering	4000
8	Power connection to the structure	3500
9	Power charges for six months throughout storage period	11280
	Total	**2,97,780/-**

Table 2: A detailed economic analysis for construction of 25MT capacity NHRDF conventional onion storage structure.

S.No.	Description	ate(Rs.)	Unit	otal quantity	Amount (Rs.)
1	Excavation for foundation	125	m^3	35.64	4455
2	P.C.C. 1:4:8 in foundation	4800	m^3	5.346	25660.8
3	R.C.C. 1:2:4 for column's and footings	2000	m^3	7.07	14,140
4	Nominal Reinforcement to columns	75	kg	320	24,000
5	Structural steel works	90	kg	1200	1,08,000
6	A/C Sheet Roofing	250	Sq M	83.2	20,800
7	A/C Sheet Ridge	250	Rmt	13.0	3250
8	2" Dia 1/2 Bamboo strips @ 3" C/C	20	Rmt	14,54.4	29,088
	Total				**2,29,394/-**

Table 3: Temperature data of ambient conditions and NHRDF improved onion storage structure conditions at NHRDF, RRS, Sinnar during *rabi,* 2017-18 and 2018-19.

Months	Conventional storage structure						Improved storage structure					
	Ambient temperature (°C)						Temperature (°C)					
	2017-18		2018-19		Average		2017-18		2018-19		Average	
	Day	Night	Day	Night	**Day**	**Night**	Day	Night	Day	Night	**Day**	**Night**
May	34.29	21.84	35.70	22.09	35.00	21.97	31.16	26.12	32.6	28.7	31.88	27.41
June	28.62	21.84	29.71	21.25	29.17	21.55	28.14	26.04	29.5	26.1	28.82	26.07
July	28.88	20.94	27.99	20.72	28.44	20.83	26.74	26.11	27.21	25.74	26.98	25.93
August	29.56	21.26	30.50	21.10	30.03	21.18	29.52	27.62	30.0	27.0	29.76	27.31
September	30.12	22.25	28.98	20.82	29.55	21.54	28.62	25.84	27.8	26.8	28.21	26.32
October	28.24	18.76	29.65	19.01	28.95	18.89	27.82	27.02	27.26	26.55	27.54	26.79
Average	**29.95**	**21.15**	**30.42**	**20.83**	**30.19**	**20.99**	**28.67**	**26.46**	**29.06**	**26.82**	**28.86**	**26.64**

Table 4:Relative humidity data of ambient conditions and NHRDF improved onion storage structure conditions at NHRDF, RRS, Sinnar during *rabi,* 2017-18 and 2018-19.

Months	Conventional storage structure						Improved storage structure					
	Ambient relative humidity (%)						Relative humidity (%)					
	2017-18		2018-19		Average		2017-18		2018-19		Average	
	Day	Night	Day	Night	**Day**	**Night**	Day	Night	Day	Night	**Day**	**Night**
May	87.23	59.84	89.33	60.30	88.28	60.07	76.62	83.66	77.47	85.2	77.05	84.43
June	94.55	83.22	92.16	79.03	93.36	81.13	78.74	81.69	80.42	87.48	79.58	84.59
July	84.26	84.38	87.13	85.58	85.70	84.98	76.92	79.88	77.03	80.45	76.98	80.17
August	91.15	78.66	92.00	74.00	91.58	76.33	72.24	75.62	76.0	72.0	74.12	73.81
September	88.92	81.39	89.53	83.17	89.23	82.28	76.82	74.26	75.8	76.07	76.31	75.17
October	87.74	73.88	90.26	79.26	89.00	76.57	78.82	77.92	76.32	77.26	77.57	77.59
Average	**88.98**	**76.90**	**90.07**	**76.89**	**89.52**	**76.89**	**76.69**	**78.84**	**77.17**	**79.74**	**76.93**	**79.29**

Table 5: Comparison of storage losses of onion in different onion storage structures at NHRDF, RRS, Sinnar during *rabi,* 2017-18 and 2018-19.

***Rabi*, 2017-18 (six months after storage)**							
Type of storage structures	Quantity of stored bulbs (ton)	Sprouting (%)	Rotten (%)	PLW (%)	Total loss (%)	Good bulb recovery (%)	Good bulb recovery (ton)
NHRDF Conventional ventilated storage	25.0	2.0	10.0	20.00	32.00	68.00	17.00
NHRDF improved onion storage	25.0	0.0	0.90	13.70	14.60	85.40	21.36
Farmers storage	25.0	3.0	12.0	22.50	37.50	62.50	15.63
***Rabi*, 2018-19 (six months after storage)**							
NHRDF Conventional ventilated storage	25.0	3.0	10.20	21.60	34.8	65.20	16.30
NHRDF improved onion storage	25.0	0.0	0.50	14.00	14.50	85.60	21.39
Farmers storage	25.0	4.0	12.60	22.80	39.40	60.60	15.15
Mean average of *rabi*, 2017-18 and *rabi*, 2018-19							
NHRDF Conventional ventilated storage	25.0	2.50	10.10	20.80	33.40	66.60	16.65
NHRDF improved onion storage	25.0	0.00	0.69	13.83	14.52	85.50	21.37
Farmers storage	25.0	3.50	12.30	22.65	38.45	61.60	15.39

Rabi, 2017-18 (six months after storage)
PLW - Physiological loss in weight

Table 6. Comparison of economics between different onion storage structures.

Name of onion storage structure	Year	Date of Storage	Market prices (Rs./q) at storage time	Market value (Rs.) of 25 MT at the time of storage	Good bulb recovery after 6 months of storage (ton)	Market price (Rs./q) at six months after storage	Market value (Rs.) of stored bulb after six months	Mean average of market value(Rs.) of stored bulb after six months
NHRDF Conventional ventilated storage	2017-18	17.04.2018	600	1,50,000	17.00	1600	2,72,000	4,53,850
	2018-19	24.04.2019	800	2,00000	16.30	3900	6,35,700	
NHRDF improved onion storage	2017-18	17.04.2018	600	1,50,000	21.36	1600	3,41,760	5,87,985
	2018-19	24.04.2019	800	2,00000	21.39	3900	8,34,210	
Farmers storage	2017-18	17.04.2018	600	1,50,000	15.63	1600	2,50,000	4,20,425
	2018-19	24.04.2019	800	2,00000	15.15	3900	5,90,850	

the relative humidity was 89.52% at day time and 76.89% during night time. In farmers storage structure lowest quality bulb recovery, highest sprouting, rotting, PLW and total loss were recorded as 61.60% & 15.40 ton, 3.50%, 12.30%, 22.65% and 38.45%, respectively, which is due to improper storage condition. In NHRDF improved onion storage structure, the bulbs can be stored for a longer period with lowest sprouting, rotting and PLW and total loss, while the cost of storage is high over NHRDF conventional ventilated storage structure as well as farmer storage structures. However, after six months of storage due to highest good bulb recovery, the highest net return was recorded in NHRDF improved onion storage structure (Table 6).

Advantages of NHRDF improved onion storage structure (temperature 28 ± 2°C and relative humidity 78.0% ± 2.0%) over cold storage, conventional ventilated storage developed by NHRDF and farmers storage are; In NHRDF improved onion storage structure, after six months of storage, the highest onion bulb recovery was noted over other storage structures, while construction cost is comparatively a little higher over conventional and farmer storage structures, except cold storage, in which the losses were very low but its construction cost is very high over NHRDF improved onion storage structure. NHRDF improved onion storage structure can be constructed with minimum storage quantity even for 5 ton, whereas the same is not feasible in cold storage. It is also possible in conventional ventilated storage structure. NHRDF improved onion storage structure can be constructed by farmers in their home premises with low to high capacity to avoid distress sale during main season in the May and June months, especially where temperature reaches e" 40°C and storage of onion is extremely difficult, however, the use of above ground metal ventilation is an affordable and very effective way of ventilating to the stored onion by maintaining optimum temperature and relative humidity. During the lean period i.e. November to April, it is possible to remove metal frames of NHRDF improved onion storage structure and the complete floor of the storage structure can be utilized for some other agricultural activities, which is not possible in other storage structures.

सारांश

भारत में प्याज का उत्पादन तीन मौसमों– खरीफ, देर खरीफ और रबी में किया जाता है, जिसमें रबी में अच्छी गुणवत्ता के कारण ज्यादा उत्पादन किया जाता है और इसे लंबे समय (5–6 महीनें तक) तक संग्रहित किया जा सकता है। भण्डारण अवधि में प्याज की अनुपलब्धता के कारण बाजार में 3–4 गुना अधिक लाभ प्राप्त होता है। इसलिए, नवम्बर तक उपभोक्ता को नियमित आपूर्ति बनाये रखने के लिए प्याज का भण्डारण बहुत आवश्यक है। अनुचित भण्डारण के कारण वजन में अधिक अंकुरण, सड़न और दैहिक नुकसान के कारण एवं प्राचीन विधि में अधिक नुकसान होता है, जिससे माँग और आपूर्ति दोनों पर भारी तनाव पड़ता है, परिणामस्वरूप कीमत में तेजी से वृद्धि होती है। वैज्ञानिक रूप से विकसित भण्डारण सुविधाओं से आपूर्ति की अस्थिरता और प्याज की कीमतों में वृद्धि की जाँच करने में मदद मिलेगी। मौजूदा परिवेश की परिस्थितियों में राष्ट्रीय बागवानी अनुसंधान एवं विकास प्रष्ठिान (एन.एच.आर.डी.एफ.) ने एक हवादार पारंपरिक प्याज भण्डारण संरचना विकसित की हैं, जो तापमान और आर्द्रता के नियंत्रण के बिना उचित वातायनन और हवादार स्थिति (वेंटिलेशन) प्रदान करता है। यह भण्डारण संरचना प्याज उगाने वाले प्रमुख राज्यों में ज्यादा लोकप्रिय है। हाल ही में राष्ट्रीय बागवानी अनुसंधान एवं विकास प्रष्ठिान ने एक बेहतर भण्डारण संरचना विकसित की है जिसे भण्डारण अवधि के दौरान निरंतर तापमान और सापेक्ष आर्द्रता बनाए रखने के लिए योजना (डिजाइन) तैयार किया गया है। भण्डारण के छः महीने बाद सबसे अच्छे शल्ककंद (बल्ब) की प्रतिलाभ/रिकवरी (21.40 टन) सबसे कम सड़ने के साथ (0.69 प्रतिशत), वजन का दैहिक नुकसान (13.83 प्रतिशत) और कुल नुकसान (14.52 प्रतिशत) राष्ट्रीय बागवानी अनुसंधान एवं विकास प्रष्ठिान में दर्ज किया गया, जिसमें भण्डारण की संरचना में सुधार हुआ और उच्चतम शुद्ध प्रतिफल प्राप्त हुआ। जबकि, राष्ट्रीय बागवानी अनुसंधान एवं विकास प्रष्ठिान में पारंपरिक हवादार भण्डारण संरचना, मध्यम अच्छा शल्ककंद (बल्ब) प्रतिलाभ/रिकवरी (16.70 टन), अंकुरित (2.50 प्रतिशत), सडांध (10.10 प्रतिशत), वजन का दैहिक नुकसान (20.80 प्रतिशत) और कुल नुकसान (33.40 प्रतिशत) पाया गया। किसान के भण्डारण ढांचे में सबसे कम अच्छा बल्ब, उच्चतम अंकुरित सड़ांध, दैहिक नुकसान और कुल नुकसान दर्ज किया गया। इनके अलावा, राष्ट्रीय बागवानी अनुसंधान एवं विकास प्रष्ठिान ने शीतगष्ह संरचना (कोल्ड स्टोरेज), पारंपरिक हवादार भंडारण संरचना और किसान की भण्डारण संरचना पर प्याज भण्डारण संरचना में अनेकों सुधार किया।

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