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ON FARM STORAGE OF ONION AND GARLIC: SUCCESS STORY

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Onion and garlic are important spice commodities consumed in India almost every day in every house. Unlike other vegetables their requirement is daily in the kitchen and therefore, augmentation of daily supply in the market at reasonable prices for both producers as well consumers is highly essential. However, they are harvested twice or thrice in a year. Unless stored for some time, daily supply, irrespective of season is not possible. Therefore, storage of onion and garlic becomes inevitable for regular supply to consumers as well as value addition for farmers and exercising control over price fluctuations. In India onion is grown over 13.05 lakh hectares area with the production of 224.2 lakh tones. Maharashtra and Madhya Pradesh are the leading states in India contributing more than 45 % of both area and production. The other major onion growing states are Karnataka and Gujarat, while garlic is grown over 3.20 lakh hectares area with the production of 116.93 lakh tones. Rajasthan and Madhya Pradesh are the leading states in India contributing more than 45 % of both area and production. The other major garlic growing states are Uttar Pradesh and Gujarat (NHDRF website, 2016).

Need for storage

Country produces around 224 lakhs tonnes of onion. Among the total production 70% is used for domestic consumption, 22% goes as waste during storage and handling. 5% is used for export, 3% for processing and 1% bulbs are used for seed production. Country needs almost 15 lakh tonnes of onion every month. Garlic production is to the tune of 16.93 lakh tonnes. About 90% garlic is consumed domestically, 10% goes as waste in handling in transport and storage. The total production of onion is available in three different seasons. About 20% production is from (monsoon kharif crop in the month of October-November, 30% onion is available as late kharif crop during January-February. and 50% produce is available as winter (rabi) crop or main

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crop countrywide during April-June. Kharif and late Kharif produce is consumed during one or two months as there is heavy demand from domestic market as well as export and therefore, does not require storage. Further, the produce, of kharif and late kharif has no storage capacity and hence required to be marketed immediately. Rabi harvest is from April to June and is in high quantity available countrywide. Since availability and supply is more, the rates are law from April to July. Since, there is no next harvest till November; these bulbs need to be stored for augmenting regular supply till November and further till February, if kharif fails due to monsoon vagaries. The farmers, if they sell during April to July are looser as the prices are low. They need to store their produce to add value on it.

Garlic is produced only in rabi season in plains. It comes from MP in February and continues up to March-April. In Southern hills particularly Nilgiri hills garlic is cultivated in two seasons i.e. March-April to July-August and sometimes also in October to March-April. In Northern hills it is cultivated in one season i.e. October to June. Since, garlic is produced mostly in March and April and since it is used every day in kitchen, it has to be stored for augmenting continuous supply for market. During the period of storage, 30-40%, losses occurs mainly due to loss of moisture, sprouting and rotting in onion. In case of garlic, it is harvested from March-May almost all over major producing belts. Almost 90% produce is required to be stored for continuous supply till next harvest. There is constant demand of garlic in the market as it is required daily in small quantity in almost all houses. Further, there is glut in the market during the harvest season. As a result farmers do not get the appropriate prices and they are forced to sale their produce at lower price. Thus it becomes essential to store garlic for regular supply in the market and to stabilize the price. Therefore, storage of onion and garlic becomes absolutely necessary for management of supply chain, price stabilization for consumers and value addition for farmers. It is estimated that around 80 lakh tons of onion and 10-15 lakh tons of garlic need to be stored to fulfill the domestic and export demand.

Reasons for storage losses

Onion and garlic are respiring commodities like other vegetables. However, after harvest and drying they develop dry skin cover which reduces respiratory losses. Yet they are influenced by climatic factors such as temperature, humidity and fungal attack. In the case of onion weight loss physiological weight loss is to the tune of 20-25 percent from May to November. High

temperatures during April to June increase respiration and there is weight loss. During July to September due to high humidity and warm temperature fungal diseases get activated and create rotting to the tune of 10-12 percent. During October – November low night temperatures help releasing gibberelic acid in bulbs which breaks dormancy of bulbs and there is sprouting of bulbs. This is qualitative loss which accounts for 10-20%. In short, total storage losses are to the tune of 40 to 49 percent. In case of garlic, storage losses are to the tune of 10-20 percent only. Low losses are due to high TSS and low water percentage in the bulbs. These losses occur under normal storage conditions with average cultural practices and normal genotypes.

Storage is a function of genotypes, cultural practices and storage environment maintained during storage time. There are genotypic differences about storage. Certain varieties that are specifically bred for winter season have better storage than monsoon season varieties. For higher yield and better storage varieties like Bhima Kiran, Bhima Shakti, AFLR, Pusa Red, Arka Niketan should be used. Cultural practices like fertilizer doses and quality fertilizers along with irrigation scheduling decide the storage behavior. Low nitrogen more of sulphur, moderate irrigation through drip, withholding of irrigation 15-20 days before harvest, field curing of bulbs along with tope, cutting of tops with long neck, grading and shed curing for 15 days enhance the storage life. And finally the storage environment mainly decides the storage behavior.

The assessment of various type of storage losses i.e. weight loss, rotting, sprouting and black mould , in onion produced in all three seasons i.e. Kharif, late Kharif and Rabi season revealed that kharif season onions have higher percent of sprouting and almost 30 percent of the bulbs sprouted within four month of storage. The occurrence of rotting was also high in kharif season onion. The total losses after two months were more than 70 percent while, after four months of storage the losses reached almost 100 percent (Table 1.1). In late kharif season (Jan –Feb. harvested onion), the sprouting and rotting was less in first 4 months of storage. The losses after four month of storage were almost 50 per cent but theses losses particularly sprouting increased rapidly thereafter with onset of monsoon and losses after 5 months were almost 85 percent (Table 1.2). April - May harvested (Rabi season) onion; the weight loss, sprouting and rotting were less as compared to other seasons. The bulbs remained in good condition up to September – October. The losses after four month were 38 per cent while, after five months, these were around 48 per cent (Table 1.3). Overall the onion of Rabi season performed better than other season onion. As far as the variety is concerned, the dark red variety i.e. Baswant –780 used for

the trial in Kharif and late kharif season showed more losses as compared to Rabi season light red cultivar .N-2-4-1.

Like onion, in garlic, several factors which are also associated with storage losses. Generally management of storage losses is initiated after the harvest of the crops. There are many pre harvest aspects which affect the storage of garlic. These includes genetic makeup of cultivars, type of manure and fertilizer and their time of application and quality ,quantity, method and time of application of water, pre harvest treatments, harvesting time etc. Post harvest factors include field curing, drying, store environment, storage structures etc. The retention of leaves in garlic in associated with better storage.

Storage conditions in India

Although onion and garlic are being grown in India since ancient time, storage of onion on large scale from trading point of view was not a major concept. However, with increased domestic as well as export, storage became essential. There are two distinct temperature regimes where losses are minimum. One is high temperature regime, where storage temperature is 25-30^{0}C and another is low temperature regime, where temperature is maintained 0 to 2^{0}C. Best results under both the temperature regimes are obtained when humidity is maintained at 65 to 70 %. The storage losses in high temperature conditions (25-30^{0}C) are high (30-35%) but storage cost is low. While in low temperature conditions (0-2^{0}C) or cold storage conditions losses are minimum (0.5%) and storage period is longer. However, storage cost is high. Higher temperature (more than 30^{0}C) in ambient storage structures lead to higher weight loss while lower temperatures (less than 10^{0}C) enhance sprouting losses. Higher humidity (more than 70%) coupled with higher temperature enhance storage diseases, while lower humidity enhance weight loss. Every farmer used to store these commodities in small scale for their home consumption. Anything in excess used to be sold in weekly bazaars in bigger villages and towns. Slowly storing of onion during monsoon season and selling during lean period in the country or export to gulf countries started by traders might have compelled farmers and traders to hold the stock for some time till prices rise. Initially the storage conditions and structures were very primitive and mostly unscientific.

Survey of pre and post harvest handling practices and storage losses

Pre and post harvest practices play an important role in the storage life, weight losses, rotting and sprouting of onions. The various factors such as variety, nutrition, time and method of harvesting removal of leaves, curing etc. influence the storage behavior of onion. Thus the pre and post harvest handling practices were surveyed in major onion growing areas of Maharashtra, Gujarat and Karnataka. Most of the farmers in all three states are still using the locally self-produced seeds of unknown parentage. The cultivation of recommended /released varieties is very limited. In Maharashtra only 5.02 per cent of the surveyed farmers were found to grow Onion cv. N-2-4-1, the best variety as far as storage life is concerned. Thirty per cent farmers of Karnataka are growing rose type varieties of onion. In Gujarat the percentage of farmers growing local strains is lesser than other states .The fall of neck is considered as major indication of maturity by majority of the farmers in Maharashtra and Gujarat. But in Karnataka yellowing of leaves or duration of crop is considered as major indication of maturity. The manual uprooting is used by majority of the farmers (84.89%) in Maharashtra. While only 15.83 percent farmers were found to use hand hoe for harvesting. Contrary to this 61.97 percent farmers in Gujarat are using hand hoe for harvesting. In Karnataka majority of the farmers are harvesting onion by manual uprooting but strangely 2.85 per cent farmers are using wooden plough for harvesting of onions. Majority of the farmers in Maharashtra and Karnataka are not adopting field curing. The majority of the farmers of Gujarat are keeping onion for field curing for more than 10 days. The pit curing of onion is also prevalent in some areas. This is said to increase the colour development in onion. The practice of grading onion at farmer's field is followed by and large. The farmers of Maharashtra are little bit ahead. 48.2 per cent farmers in Maharashtra are performing grading as compared to 30.99 percent farmers of Gujarat. Only 7 per cent farmers in Karnataka follow the practice of grading. The majority of farmers are removing the foliage after one to five days but some farmers are keeping foliage for longer period. The practice of keeping onion in heaps and covering them with onion leaves or grass is commonly adopted in many parts of Maharashtra and Karnataka. The shade curing practice is performed by most of the farmers of Maharashtra but the duration of shade curing varies from 1 to 20 days, but in Gujarat this practices is not adopted by 91.55 per cent farmers. The reason may be the climatic factors of Gujarat, which provides drying, and removal of moisture in the field itself. In Karnataka most of the farmers do curing foe 1to 5 days. Most of the farmers in all three states are not using any packing material for onion. The

common practice is that farmers use to carry their produce in tractor trolley or bullock carts, etc and sell in nearby market. Only 1.44 per cent farmers in Maharashtra and 30.99 percent farmers in Gujarat were found to use hessian cloth bags as packing material . The farmers of Gujarat and Karnataka opine that the poor variety is one of the main reasons for more storage losses. The farmers of Maharashtra and Gujarat consider the rains during or after harvesting as important factor. The leaking of water in storage structure and high temperature during storage period is also considered as important factor responsible for high losses.

Storage structures in major onion growing areas of India

The survey onion storage structures in Maharashtra, Karnataka and Gujarat revealed that the temporary, semi permanent and permanent storage structure are used for the storage of onion. Out of 270 structures of the farmers in three states, 34.4 percent structures were permanent, 30.74 per cent were semi permanent and 38.52 per cent were temporary. Over all only 22.96 per cent structures were bottom ventilated. Fifty six per cent permanent structures were bottom ventilated, while only 8.43 per cent semi permanent structures and mere 0.2 per cent temporary structures were bottom ventilated. As far as capacity is concerned, majority of temporary structures were less than 10 tones capacity, while majority of permanent structures were more than 30 tones capacity. Out of the storage structure surveyed in Maharashtra, 44.6 per cent structure were temporary type, 30.2 per cent were permanent and remaining 25.2 per cent were semi permanent. The temporary structures were made of wooden logs with thatched roof (24.19%) and thatched roof with polyethylene covers (75.8%). The sidewalls of temporary structures were made with pigeon pea stalks (30.6%) or wheat straw (64.51%). The floor of these structures was *kuchcha* but raised, in many cases (51.61%). Semi permanent structures were made with wooden logs or galvanized iron pipes/angles. Most of the semi permanent structures were built on raised platform, which is either *kuchcha* (50%) or filled with coarse sand (41.6%). The side walls of these structures were made of pigeon pea stalks (57.14%), wooden bantams (25.71%) and bamboos (5.71%). The roof the majority of the semi permanent structures was made with Mangalore tiles (77.14%) while 11.42% had thatched roof. The permanent structures were constructed with galvanized iron pipes/angles, R.C.C pillars. The roof of these structures was made of galvanized iron sheet (73.8%), asbestos sheets (21.4%). The sidewalls were made of wooden bantam (52.38%), chain link (26.19%) and Bamboo (19.04%). As far as the storage capacity of the structure is concerned, almost 75.0 per cent

temporary structure and 42.86 per cent semi permanent structure were of less than 10 tones capacity. Contrary to this 90% of the permanent structures were of more than 10 tones capacity. The total losses in the permanent structures were less despite of longer period of storage. The percentage of recommended bottom ventilated type structure is 38 in permanent type while in semi permanent it is 11 per cent. In Gujarat 22.54 % onion storage structures are temporary type while 14.0% of the structures are semi-permanent type. The majority of storage structures are permanent type (63.38%). The 82.22 percent permanent structures are bottom ventilated but the bottom ventilated type of structures were different than of the recommended type. Majority of the temporary structures (93.75 %) were up to 10 tones capacity. While 60 % semi permanent structures were found to have less than 10 tones capacity. Contrary to this, majority of the permanent structures have more than 10 tones capacity. The majority of permanent structures were constructed on raised platform. The 70 percent semi permanent structures and 51.61 percent temporary were constructed on raised platform. But height of platform was less in temporary structures. The floor of non-bottom ventilated upraised structures was *kuchcha* or filled with coarse sand. In bottom ventilated structures bamboos, wooden logs or wooden bantams are the main construction materials in all type of structures. The majority of the temporary roofs were built with grasses with or without polyethylene covers. The Mangalore tiles were main roofing material in 90.0percent semi permanent structures and 51.11 percent permanent structures. Asbestos sheet were also used as roofing material in 26.67 percent permanent structures. The use of galvanized iron sheets in roofs was very limited (2.22%). In Karnataka, 37.14 percent storage structures were Temporary type while 54.29 percent structures were semi-permanent. Only 8.57 percent structures were permanent. None of these structures was bottom ventilated. Majority of the temporary structures (72.5%) were up to 20 tones capacity. While 54 percent semi permanent structures were found to have less than 20 tones capacity. Contrary to this, majority of the permanent structures have more than 20 tones capacity. The 42 percent temporary structures and 30 percent semi permanent structures were less than 30 feet long while all the permanent structures were more than 45 feet in length. Around 95 percent temporary structures were found to have less than 6 feet width. Seventy two percent semi permanent structures were 6 to 12 feet wide. All the permanent structures were 6 to 12 feet wide. The majority of permanent structures were constructed on raised platform. The 68.52 percent semi permanent structures and 51.61 percent temporary were constructed on

raised platform. But the height of platform in majority of the semi permanent and temporary structures is less than 15 cm. The permanent structures have platform height either 2 feet or more than 2 feet. As far as the bottom ventilation is concerned, none of the storage structure was having bottom ventilation facility. The floor of non-bottom ventilated un-raised structures was *kuchcha* or filled with coarse sand.. The roofs of majority of the temporary and semi permanent structures were built with grasses/ banana/coconut leaves with or without polyethylene covers. Galvanized iron sheets and asbestos sheets were major were main roofing material in permanent structures. The use of Mangalore titles as roofing material was negligible (Tripathi et al, 2003; 2004).

Reduction in losses by modification in storage environment

Various types of onion storage structures, Traditional double row storage structure. Modified bottom ventilated storage structure, Modified bottom ventilated storage structure with chain link on side , Top and bottom ventilated storage structure, Traditional single row storage structure, Bottom ventilated single row storage structure and Low cost Bottom ventilated single row storage structure, were designed and constructed at National Research Centre for onion and Garlic, Rajgurunagar. These structures are constructed on the basis of the survey made at farmer's field. Apart from these, lots of designs of ventilated onion storage structures have been recommended by various organizations. The onion storage structures of NRC onion and garlic are designed to overcome the problems in exiting storage structures in onion growing areas and the earlier recommended onion storage structures. These are single row type or double row type with or without bottom ventilation according to the storage capacity and the requirements of the farmers. These structures vary in their capacity and cost to fulfill the required of all income groups of farmer's viz. small, marginal and big farmers /traders. These structures were evaluated for their performance for the storage of onion and garlic (Tripathi and Lawande , 2004,2015).

Out of these, low cost bottom ventilated storage structure for small and marginal farmers and Top and bottom ventilated mud plastered structures for hot and humid areas and modified bottom ventilated structure with extended roof have found promising. The low cost bottom ventilated storage structure is constructed with bamboo and has thatched roof. The life span of this structure is 3 to 5 years. This suites well to small and marginal farmers (Fig 1). The Top and bottom ventilated structures is constructed with iron frame work and asbestos roof. The sidewalls of this structure is constructed with bamboo plastered with mud. The life span of this

structure is more than 20 years. This structure has control flaps, which can open or closed as per requirement. This structure sited well for hot and humid conditions(Fig2). Modified bottom ventilated structure with extended roof is improvement over bottom ventilated structure. It has extended roof to protect from rain splashes. The life span of this structure is more than 20 years (Fig 3).

Fig 1. Low cost bottom ventilated storage structure

Fig 2. Top and bottom ventilated mud plastered structures

Fig 3. Side and bottom ventilated double row storage structure

Performance of onion storage structures

Rabi onion cv. N-2-4-1 were stored in storage structures from May to October and the various types of losses were recorded. The results revealed that among the double row type of onion storage structures, Top and Bottom Ventilated and mud plastered storage structure was found more efficient in reducing Physiological Loss of Weight (PLW) and rotting as compared to Modified bottom ventilated storage structure. The losses in traditional type of storage structures

were highest. Among single row type storage structures, low cost bottom ventilated thatched roof storage structure was found better over bottom ventilated Mangalore tiled single row storage structure and traditional Mangalore tiled storage structure. The results of the performance evaluation of these structure for storage of rabi onions for three years shows that the total losses in low cost bottom ventilated storage structure are 30-35% as compared to 40 to 45 % in recommended storage structures .The total losses in Top and bottom ventilated mud plastered storage structure were around 28to 30 % as compared to 40 to 45 % in recommended storage structures.

During February to June, onions of Late Kharif season were stored in three double row storage structures evaluated for their performance. The results revealed that the mud plastered top and bottom ventilated storage structures showed lower physiological weight losses as compared to Modified bottom ventilated storage structure, Modified bottom ventilated storage structure with chain linked sidewalls while the rotting losses were lower in modified bottom ventilated storage structure. Overall, the mud plastered top and bottom ventilated storage structure was found better than others.

The economics of onion storage structure was calculated. It was found that top and bottom ventilated onion storage structure was found more profitable than others. Among the double row storage structures, net profit was highest in bottom cum top ventilated mud-plastered structure (Rs. 1585/t),While it was Rs 829 /t in Modified bottom ventilated storage structure. Among the single row storage structure highest net profit was in Low cost thatched storage structure (Rs 1932/T) which was higher than Bottom ventilated Single row storage structure with Mangalore tiles roof and Traditional Single row storage structure with Mangalore tiles roof than all other storage structures. Over all, Top and bottom cum top ventilated mud-plastered structure and Low cost bottom ventilated single row storage structure were found most profitable (Tripathi, et al 2004 &2015).

These storage structures were evaluated for the storage of garlic. Among various storage structures tested, structure with bottom and side ventilation of 10, 25, and 50 tons capacity are recommended. Low volume structures are with single chawl, while high volume are with double row and a gangway between two row. In humid areas, plastering of side walls and provision of top ventilation is recommended (Tripathi and Lawande, 2009). Studies on width and height of

heap revealed that 120 cm staking width and 150 cm of height is most appropriate. Any increase beyond this recommendation increases storage losses.

Reduction in losses by low temperature storage and irradiation

Rabi Onion cv N-2-4-1 was stored under ambient condition and low temperature conditions (0-2^{0}C &65-70%RH) from May to October. The results revealed that total losses in cold stored onions at the time of taking out were only 6.41 per cent as compared to 33.35 per cent in onions stored under modified bottom ventilated storage structure. As far as the physiological loss in weight is concerned, it was lowest (6.41%) in cold stored onions while higher in ambient-stored onions (33.35 %). There was no rotting of bulbs, sprouting and black mould infection in cold stored onions at the time of taking out from cold store. As far as the post – cold storage behavior is concerned; the total losses after four-month room temperature storage were higher in cold stored onions as compared to ambient-stored onions. The major cause of higher losses in cold stored onion was sprouting. There was no sprouting in cold-stored onions at the time of taking it out, but it increased very rapidly to 43.3 per cent after one month of room temperature storage in untreated onions. The irradiation before cold storage completely eliminated the post cold storage sprouting and there was only 4.7 per cent sprouting in irradiated cold-stored onion even after four months of taking it out from the cold store. The onion of kharif and late kharif season showed similar results with slightly higher weight loss. The gama irradiated onion were packed in hessian cloth and netlon bags and stored at two temperature conditions., ambient (atmospheric) and low temperature for four months. It was found that the storage losses in cold store ware very low (5 to 6 percent) as compared to ambient storage (20-25%). There was no rotting, sprouting and black mould infection in cold storage, while considerable amount of rotting and black mould was noticed in ambient stored onions in stored in storage structure. In irradiated bulbs there was no sprouting irrespective of storage conditions. The cold stored onions were kept under ambient temperature there was lot of sprouting in un-irradiated onions. But there was almost no sprouting in gamma irradiated cold stored bulbs during four month of post cold storage. Thus the cold storage of onion combined with irradiation technology can reduced the storage losses by 15 to 20 percent for 8 months storage.

The well cured garlic bulbs can be stored in cold store at 0-2^{0}C temperature and 65-70% relative humidity from May to January. The results revealed that total losses in cold storage were significantly lower (11.5%) than ambient condition (33.9%) after 5 months storage. Physiological

weight loss was 14.8% in ambient stored garlic, while it was only 5.5 % in cold stored garlic. Diseases such as blue mould, gray mould causing softening and drying of cloves was higher (16.5 %) in ambient stored treatments, while it was only 5.0 % in cold stored treatments. Similarly the black mould infection was lower in cold stored bulbs than ambient stored ones. No sprouted bulbs were found in cold storage. However, when these cold stored bulbs were taken out from cold store and kept at ambient storage conditions, rapid sprouting was recorded and it was 13.3 per cent after 20 days and further increased. But this sudden rise in sprouting was not noticed in irradiated and cold stored bulbs. The results suggested that cold storage of garlic can successful be done in Indian conditions when bulbs irradiated. The high cost on cold storage can only be justified with high premium obtained in the market from October to January (Tripathi and Lawande, 2007).

Success stories of onion storage

- **Onion storage -Experience of Dr. Dattatreya Vane, Rahuri Dist. Ahmadnagar**

Dr. Dattatreya Vane ,Village –Manori, Talluka- Rahuri Dist. Ahmadnagar is a medical professional but he is enjoyed farming. He is progressive farmers who grows onion and other crops. He constructed bottom ventilated storage structures for storage of onion. He could store his onion for 5-6 months with lesser losses.

- **Onion storage -Experience of Chaitanya Farmers Club**

Chaitanya farmers club, Otur, under the leadership of Mr Vikram Awchat, constructed ventilated onion storage structures for storage of onion. This area is famous for growing high quality onion with longer storage life. The use of ventilated storage structures enhanced the storage life of their produce.

- **Onion Storage Structures Under RKVY Success Story**

Mr. Devidas Nimba Sawkar, Address At/p. Joram, Tal. Satana, Dist. Nashik constructed 25 metric tonnes capacity Onion Storage Structure with subsidy of Rs. 87500/- funded through Rashtriy Krushi Vikas Yojana (RKVY). Now he sells stored onion as per market requirement. He sells onion in distant market also. Now he is getting more benefit from onion than before..

- **Onion storage experience of Tamil Nadu farmer's**

The farmers of Perambalur district which is a major producer of shallot (small onions) , follow conventional method of storing onion in Pattarai which protects the onion from rain

and Sun shine. The base of the pattarai is at an elevated position and is covered with bio-material such as thatches and bamboos. It is covered with hay from sides. This cannot withstand in heavy downpour. Under the pilot scheme, a permanent shed is built over and above the pattarai with subsidy. These structures have come up in Padalur (two godowns of 12 tonne and five tonne capacity), Nallur near Veppur (eight tonne capacity), and Pommanpadi (five tonne capacity). When the prices are not remunerative, farmers preserve the onions in pattarai and wait for the right time to sell it. While, the pattarai can protect the produce for three months, the duration of storage under the ventilated structure is doubled.

- **Onion storage experience of Najafgarh farmer**

It is about the experience of Sh. Ram Kishore Tyagi, village Shikarpur, Najafgarh who gained economic mileage from the improved low cost storage structure for onion and become a source of inspiration to others farmers of the area. Due to lack of latest knowledge on onion storage and the traditional practices adopted at his farm, he was not getting the good return in comparison to his investment. During interaction with KVK scientists he was guided to go for low cost Panipat type onion storage structures, in which onion can be stored up to 5-6 months which can fetch higher price during lean period. After storage for 4-5 months he sold the onions twice than he sold the onion as fresh. This was a record income in his and nearby villages. This step was the turning point for him as well as for other farmers to fetch higher price from stored onion.

Ventilated onion storage structures developed in Maharashtra, Gujarat, MP, Odisha, Karnataka as per DOGR recommendations

Maharashtra state agricultural Marketing board initiated scheme for promotion of scientific onion storage structure designed by National Research Centre for Onion and Garlic, Rajguru nagar with the help of NABARD to promote onion producers for scientific onion storage. The Maharashtra Rashtriya Krishi Vikas Yojana and National Horticulture Mission created 42,282 low cost onion storage structures having a capacity of 9.65 lakh tonnes. Some of the scientific storage structures were constructed in Karnataka and Gujarat. But the scientific storage structures in Madhya Pradesh and Odisha are very limited. Although, the subsidy of onion storage structure is given thorough NHB, NHM and RKVY. Some of the structures are built with modification as per farmers

innovations using bamboo, sieved RCC floor, iron angles, chain linked, extended roofs etc. But the basic concept of bottom ventilation exists in all these structures.

Present policies about on farm storage

The various agencies of Government of India and State Government have several schemes to promote storage of onion. The subsidies are being given to the farmers for construction of farm storage structure. There are schemes for construction of cold storages for these commodities. In Maharashtra, under Rashtriya Krishi Vikas Yojana and National Horticulture Mission, created 42,282 low cost onion storage structures having a capacity of 9.65 lakh tons. MSAMB has formulated the subsidy scheme for scientific onion storage. On the same line, Department of Agriculture, Maharashtra State is also implementing the subsidy scheme for scientific onion storage. To get benefit of this scheme farmer should erect onion storage structure according to proposed plan only. The construction cost of the onion storage structure is assumed at Rs. 6000/- per MT for this scheme. As per the scheme, subsidy to the extent of Rs.1500/- per MT storage capacity is given. The onion storage structures of 5, 10, 15, 20, 25 & 50 MT capacity are eligible for subsidy. Agriculture department is giving subsidy of Rs. 1000/- per MT for onion storage and after that MSAMB gives Rs. 500/- subsidy for above mentioned capacity of onion storage.

Limitations of on- farm storage

The major limitation of on-farm storage is that they are of smaller capacity and several structures are required to store large quality of the commodities. Further, control temperature and humidity beyond certain limit is not possible in these structures. The other limitation is the extra cost of handling of onion and garlic in loading, mid- term sorting and unloading. The increased cost of construction, theft, fire, spoilage due to uncertain weather conditions etc, are other limitations. Further, the on farm storage structures remain vacant for 4-5 months. The maintenance and alternate utilization of these structures is a challenge for the farmers.

On -farm storage vs commodity storages / cold storage

The on-farm storage reduces the cost of transportation to commodity storage or cold storage. In community storage, the farmers are not able to inspect their produce at regular intervals. The marketing of the bulbs is also difficult. Further, the cost of constriction of community storage/cold storage is very high. There are several examples where the farmers burnt their

finger due to storage in community storages. The community storage may be good for traders or Government agencies but may not be suitable to small and marginal farmers.

Way forward for further improvement in on-farm storage

On- farm storage face lot of technical guidance, financial support and lack of marketing intelligence. Several farmers constructed these structures with several lacunae which not only increase the losses but also damage the stored commodities. The subsidies provided by the departments are somehow not sufficient for the construction of structure. The market related information should be provided to farmers to sell their products at right time in right market. The survey on the present status of on farm storage in major onion growing areas may be conducted to find out the problems and to make improvements in present designs.

Problems with cold storages

There is no doubt , cold storage reduces storage loss of onion and garlic to 4-5% for 4-5 months, when stored at $0^{o}C$ +- $2^{o}C$ temperature and 65-70 per cent relative humidity. But fluctuations in temperature to $4\text{-}5^{oc}$ causes lot of sprouting in onion. Further, the cold stored onions sprout rapidly and sprouting losses may be 100%. Although gama irradiation check the sprouting in cold stored onion but the gamma irradiation facilities are available at few places. Therefore, complete cool chain market system is required for cold stored onion to avoid sprouting which is difficult and costly in tropical regions.

Prospects of high temperature controlled storages

The higher temperature controlled storage (25^{o} C +- $5^{o}C$) and 65 +- 5% relative humidity may be good option for tropical region. Although, there will be 15-20% storage losses for a period of 4-5 months. This storage with force ventilation and moisture control system may be a cheaper option. This may be suitable for both on farm and community storage. There is need to design and evaluate force ventilated controlled atmosphere storage structures.

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