ABSTRACT

Onion storage is widely practised worldwide in accordance to their cultural and economical practice. In India, method of storage adopted mostly depends on the traditional knowledge and commonly practised methods are bag, pucca/room, tat storage, bamboo, chawl structure and the losses associated are quite higher. Sprouting, desiccation and microbial spoilage are often observed in storage and it compels to choose advanced techniques like modified ventilated structures, modified atmospheric (MA) and controlled atmospheric (CA) storage. The CA and MA storage reduces the application of chemicals for sprout inhibition by manipulating the gas composition to extend the storage period of the onions.

Key words: Chawl storage, Modified ventilated structures, Onion, Sprouting, Sprout inhibition.

Onion (Allium cepa L.) is one of the oldest bulb crops, known to mankind and consumed worldwide. It is one of the most important commercial vegetable crop grown in India and believed to be originated in Central Asia. It is valued for its distinct pungent flavour and is an essential ingredient for the cuisine of many regions. Onion is the queen of kitchen (Selvaraj, 1976).

India ranks second in the production of onions next to China. It contributes about 19.25 % of total world production (FAO, 2012). The compound annual growth rate of production area, is steadily increasing from 1974-75 to 2011-12 by 3.36 per cent to 5.95 per cent, production by 4.94 per cent to 7.07 per cent and productivity by 0.51 to 3.4 per cent respectively. The productivity of country is 14.35 t/ha which is at least 5 times less compared to Republic of Korea (66.16 t/ha), about 4 times less than USA (56.13 t/ha), Spain (55.21 t/ha), Netherland(51.64t/ha)andMyanmar(46.64t/ha) (Chengappa et al. 2012)

Onion is cultivated throughout India; during 2012-13 the area of cultivation is 0.992 million hectares with production of 16.65 million metric tonnes. Maharashtra’s stand alone contribution is 32.6 per cent in total production and the rest shared by Karnataka, Gujarat and Madhya Pradesh in India (NHRDF, 2012).

Despite the achievements in production technology, the post-harvest losses during storage still pose a great problem. Onion is a seasonal crop and bulbs are usually stored until the harvest of next season crop or for longer period due to seasonal glut in the market. Significant losses in quality and quantity of onion occur during storage. Storage of onion bulbs has, therefore, become a serious problem in the tropical countries. The post-harvest losses, viz., sprouting, rotting and physiological loss in weight pose a great problem. Bhagachandani et al. (1980) reported that annual storage losses were over 40% and between 40 to 60% in India (Maini et al. 1984).

It is estimated that out of the total production of 41 lakh tonnes of onion, 40 to 50 per cent valued at more than Rs 600 crores are lost due to desiccation, decay and sprouting in storage (Kukanoor, 2005). This results in raise in their price to the tune of four to five times when they are in short supply. The situation can be improved by extending the storage of onions during lean periods.

*Corresponding author’s e-mail: sinija@iicpt.edu.in
Keeping this in view, efforts are made to review all possible methods of onion storage and in this way it could be possible to quest for exact needed facility to reduce the rate of deterioration. This paper deals with two sections, application of spray chemicals or growth hormones prior to harvest and the effect of storage structures; methods on storability of onions.

**Seasons for cultivation of onions in India:** India’s climatic condition supports the growth of short day variety of onions. Crops are sensitive to temperature and rainfall pattern, northern part of country grows onion as rabi (winter) season crop, whereas Tamil Nadu, Karnataka, Andhra Pradesh, Gujarat and Maharashtra grows both in rabi (winter) and kharif (rainy) seasons (Table 1).

**Onion varieties grown in India:** About 30 varieties of onions were cultivated in India before 1986 which included the famous multiplier CO-1 and CO-2 varieties. Due to lower yield and less pest resistance extant varieties like Bhima Red, Bhima Raj, Bhima Super, Bhima Kiran, Bhima Shakti, Bhima Shubra, Bhima Shweta, Bhima Dark Red, Baswant-780, Pusa Madhavi, Arka Niketan, Arka Kalyan, Arka Bindu, Arka Pragati, Arka Lalima (F1 hybrid), Arka Kirtiman (F1 hybrid), Phule Safed, Phule Suwarna, Phule Samarth, HOS-1, Agrifound Dark Red, Agrifound Light Red, Agrifound White, L-28, Agrifound Rose, Agrifound Red (Multiplier), Line-355, Udaipur 102, Udaipur 103, Punjab Naroya, Punjab White, VL-3 (Long day), Akola Safed, Rajasthan Onion-1 and Aprita (RO-59) are grown (DOGR,2013)

The size of the bulb except for Akola safed (4.9-6.5 cm) is in average of 4-6 cm and globular in shape. White onions are suitable for dehydration purposes. Pusa White Flat and Pusa White Round varieties have drying ratios of 9:1 and 8:1 respectively. Early Grano, yellow bulb variety has 7-8 cm bulb size. The bulb size and shape influence the bulk density and thus gains greater importance in design of bulk storage structures.

**Application of pre-harvest and spray chemicals for onion storage:** Maleic hydrazide (MH, l,2-dihydropyridazine-3-6-dione), a chemical as pre-harvest spray considerably prolongs the shelf life of onions. The effectiveness of maleic hydrazide depends on its translocation into the inner meristem or growth points where it could act upon, and thereby inhibit sprouting. The chemical is applied to the crop, usually 2 to 3 weeks before harvest when enough green foliage is present to facilitate its absorption and translocation. (Isenberg, 1956; Wittwer et al. 1950).

Thomas (1969) reported that maleic hydrazide application does not result in good sprout control when storage is at higher ambient temperatures. Maleic hydrazide does not have universal clearance and so as an alternate Pedeliski, 1973, used ethephon (2-chloroethyl phosphonic acid) as pre-harvest spray to keep the bulbs dormant for longer period. Bufler (2009) found that Copra onion variety held in continuous ethylene (10.6 mL L\(^{-1}\)) had reduced sprout growth compared with those held in air.

Adamicki, (2004) reported that the application of ethephon to onion plants 2 weeks prior to harvest was found to reduce sprout incidence by 5% after 32 weeks of storage at 0°C; however, no significant reduction in rooting was observed.

Cools et al. (2011) reported that ethylene can suppress sprouting while the ethylene-binding inhibitor 1-methylcyclopropene (1-MCP) can also suppress sprout growth; yet, it is unknown how ethylene and 1-MCP elicit the same response. In this study, onions were treated with 10 mL L\(^{-1}\) ethylene or 1 mL L\(^{-1}\) MCP individually or in combination for 24 h at 20°C before or after curing (6 weeks) at 20°C.

### TABLE 1: Seasons calendar for onion cultivation in India

<table>
<thead>
<tr>
<th>Seasons</th>
<th>Time of Sowing</th>
<th>Time of Transplanting</th>
<th>Time of Harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maharashtra and some parts of Gujarat</td>
<td>May-June</td>
<td>July-Aug</td>
<td>Sept-Dec</td>
</tr>
<tr>
<td>1. Kharif</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Early Rabi or late kharif</td>
<td>Oct-Nov</td>
<td>Sept-Oct</td>
<td>Jan-Mar</td>
</tr>
<tr>
<td>3. Rabi</td>
<td></td>
<td></td>
<td>Apr-May</td>
</tr>
<tr>
<td>Tamil Nadu/ Karnataka A.P.</td>
<td>Mar-Apr</td>
<td>May-June</td>
<td>Nov-Dec</td>
</tr>
<tr>
<td>1. Kharif</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Early Rabi or late kharif</td>
<td>Sept-Oct</td>
<td>June-Oct</td>
<td>Mar-Apr</td>
</tr>
<tr>
<td>3. Rabi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rajasthan/Haryana/Punjab/ Uttar Pradesh and Bihar</td>
<td>May-June</td>
<td>July-Aug</td>
<td>Nov-Dec</td>
</tr>
<tr>
<td>1. Kharif</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Rabi</td>
<td>Oct-Nov</td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Bengal and Orissa</td>
<td>J une</td>
<td>Aug-Sept</td>
<td>Nov-Dec</td>
</tr>
<tr>
<td>1. Kharif</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Rabi</td>
<td>Aug-Sept</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hills</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Summer (long day type)</td>
<td>Nov-Dec</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source – Market Intelligence system baseline data for potato and onion (April 2012)
or 28°C and then stored at 1°C. Following curing, a subset of these same onions was stored separately under continuous air or ethylene (10 mL L⁻¹) at 1°C. Onions treated with ethylene and 1-MCP in combination after curing for 24 h had reduced sprout growth as compared with the control after 25 weeks harvest. Sprout growth following storage beyond 25 weeks was only reduced through continuous ethylene treatment. Unlike ethephon treatment, continuous ethylene exposure has been found to increase shelf life after 14 d at 20°C (Johnson, 2006).

Chope et al. 2007, reported that treatment with 1-MCP for 24 h after curing (6 weeks at 28°C prior to cold storage) reduced sprout growth in SuperSweet1 onions when stored at 4°C or 12°C. Mahadevsamy (1984) observed that maleic hydrazide @ 800 ppm sprayed bulbs stored in polyethylene bags recorded lower rotting (15.8%) as compared with the untreated bulbs (17.6%). The same treatment recorded less sprouting and sprout length as compared with control.

Bulbs fumigated with sulphur dust before storage under natural ventilation were found to have better shelf life for 16 weeks (Abbey, 2000).

Among the physiological factors which affect storage of bulbs, sprouting is the most obvious manifestation of deterioration. Sprouting does not start immediately after harvest and there is usually a time lag, the dormant period, which may last several weeks before growth resumes. The dormancy period depends on variety, climatic conditions during growth, harvest maturity, mechanical damage, microbial infections, and the storage environment particularly the temperature. Sprouting of onions is devastating at temperature in between 5 - 15°C and gets most vulnerable when accompanied with relative humidity above 85 % (Karmarkar and Joshi, 1941).

Practices of onion storage: In India, different storage methods are practiced by the farmers. Among those, Charches method of storage is practiced in the Ladakh and Odisha region of India. This method involves storage of fresh onion by hanging them from ceiling. The onion crop is harvested when the bulb is matured and leaves are green. For storage in charches, the bunch of onion is tied together in the form of knot with the help of green leaves. Long sticks strong enough to bear the load of the onion bunches are hanged parallelly on the ceiling of an unheated storehouse using rope hooks. Bunches of onions are carefully hanged on the sticks. Utmost care is taken to keep the onion untouched after hanging (Figure 1a). Repeated hand touching and hard pressing spoils the bulbs. As per requirement the bulbs are plugged from one end without disturbing the entire lot.(Ali et al. 2012; Babu et al. 2013). Hanging method of storage was effective for short period of storage (45 days), whereas cage method was effective for longer periods (90 days) in minimising bulb rots caused by Aspergillus niger (Chavan et al. 1992).

Storage structures

Bamboo structures: Krishnamurthy et al., (1987) suggested that split bamboo storage structure with central hallow was found better and lesser extent of losses by way of spoilage and sprouting during storage. In ventilated bamboo storage structure for onion, the total losses reduced to 39.23 per cent compared to conventional storage structure having 53 per cent after five months storage (Subbaram et al. 1990).

Vengaya pattarai: Vengaya pattarai is constructed in levelled fields by placing equal sized rectangular stones to act as load barrier kept at a distance of 2 feet in-between each stones. The custom made neem wooden board are placed over the stones and all three sides are covered with manually woven bamboo sheets. The structure is filled with onions and the fourth side is either be covered with jute gunny bags or bamboo sheets as per convenience of the farmer. The top portion of the pattarai (Figure 1b) is covered with coconut thatches to prevent from rainfall, excess sunlight, also facilitates ventilation to the stored onions (Karthikeyan et al. 2009).

Chawl structures: Thomas et al. (1986) studied the storage trials at pimpalgaon in Maharashtra in a traditional storage shed known as chawl and modeled stores for rabi onion and revealed that after five months storage period, the storage losses were 70 per cent in poorly ventilated chawl compared with 50 per cent in better ventilated model store.

Ranpise et al. (2001) used the conventional onion storage structure called chawl which has no aeration at bottom and onion can be stored upto
1.5 to 2.0 metre height, resulting into lot of bruising and decay, and also reported onion stored in modified improved storage structure with bottom and central ventilation with raised floor (60 cm) of structure above ground reduced the storage losses from 99.2 to 70.0 per cent during five months storage. The storage temperature of 15°C along with relative humidity of 50 to 70 per cent could be helpful to reduce the rotting and desiccation to a desired level to lengthen the storage life of onion bulbs in storage.

**Tat storage:** Singh and Singh (1973) found that tat storage with brick base was comparatively better than other local methods of onion storage. Storage in crates at room temperature and storage in tat with ground base was not economical. The onion bulbs stored in a shed lost 25.75 per cent after 90 days of storage compared to 48.42 per cent in onion stored in room without ventilation and also found that with increase in ventilation by partitioned the ‘tat’ (Figure 1c) the per cent of loss in weight was decreased as compared to the completely filled tat without gap (Khurana and Singh, 1984).

Bhatnagar et al. (1989) suggested that the designing of low cost farm level storage structure capable of reducing losses in stored onion could be helpful in encouraging onion storage by the farmers. The total storage loss at the end of five months in Nasik type storage structure was 21 per cent in cv. Ballary Red which was considered acceptable (Murthy et al., 1988).

**Pucca floor/Room storage:** Out of different storage methods, dry sand on pucca floor (Fig 1) was the best method with respect to lowest physiological loss in weight, rotting, sprouting and total loss in weight during 150 days of storage (Deka et al., 1995). In Sudan, mud or straw cottage was used for storing onions. Straw cottage was constructed in such a way that, they were ventilated by the prevailing wind passing through them. After five months of storage by this method, 50 to 60 per cent of bulbs were marketable. The higher temperature of 30 and 35°C caused less sprouting but higher rotting and loss in weight was observed compared to lower temperature (20-25°C) (Maini and Chakrabarti, 2000).

Arora et al. (1993) reported that the minimum sprouting (60.5%), rotting (15.0%) and total loss (35.0%) in wire mesh shed storage compared to ordinary room storage of onion bulbs (77.5, 20.5 and 72.7%, respectively).

**Bag storage:** Iordachescu and Nihaiescu (1979) observed the lowest losses in the onion stored in ventilated structure (11.80%) and highest in those kept in bags (17.2%) for 180 days for storage. Increase in rotting was observed in onion stored under tarapaulin cover (150-180 cm) and in open field (30-60 cm) layer compared to proper ventilated bamboo storage structure and two tier onion storage structure (Datar and Mulekar, 1989). Mukeshkumar and Kumar (1991) reported that composition of onions like fructans gradually increased with an increase in storage duration irrespective of storage method but were significantly lower for onion kept in 30 per cent perforated brown paper packets followed by hanging in bunches.

Warade et al. (1997a) found that storage loss were least in gunny bags (Figure 1d) which were stored in two horizontal layers (34.7%) and highest in control (52.6%). Storage losses from most of the high yielding cultivars were very high, reacting 80 to 90 per cent within the 16 weeks period when stored in a simple structure with natural ventilation under ambient condition (Rajkumar et al. 1998).

**Modified ventilated storage:** Iordachescu et al. (1983) studied six methods of onion storage in low cost modified structure with the cv. Staltgart Giant. In the variants under natural ventilation on all sides of the structure, the storage period lasted five months with storage losses of 4.18 to 4.71 per cent, whereas in forced ventilation, the storage period was extended to eight months with 2.21 to 2.25 per cent losses. The lesser losses are reported because the variety is less prone to spoilage and thickness of bed is kept minimum to avoid internal heat generation. Kepka et al. (1989) concluded that bulk storage of onion with forced air ventilation was better than bulb storage in boxes with natural ventilation.

Warade et al. (1995) found that the provision of bottom ventilation to storage structure reduced the storage losses from 54 to 39 per cent after 150 days of storage. Maini et al. (1997) reported that two tier system was better than single or bamboo storage structure for physiological loss in weight and storage point of view.

Warade et al. (1997b) investigated the effect of different recommendations on storability of onion bulbs cv. N-2-4-1 for six months under modified storage structure with bottom and central ventilation.
and observed that the modified storage structure had reduced losses 32 per cent as compared to the conventional method (52%).

Medlicott et al. (1995) observed that forced air storage bins resulted in higher quality bulbs even after 13 weeks of storage. The per centage of marketable bulbs in forced air storage bins were 82 per cent compared with control stored under ambient condition 37 per cent for Granex 33.

Shukla et al. (1994) evaluated two perforated concentric type storage structure made of 25 x 25 x 25 mm welded wire mesh, each having capacity of one tonne. One of the structures was used for natural ventilation, whereas other was attached to a blower to circulate air. Onion bulbs quality evaluated after three months storage in both structures are considered and suitable for adoption at the farm level.

The physiological loss in weight was least in two tier storage system (26%) followed by single tier (38%) and conventional bamboo storage structure (47%) during storage period of 100 days. Maximum retention quality was observed in two tier system (Maini et al., 1997).

Tripathi and Lawande (2003) reported that the total losses in low cost Mangalore tile bottom ventilated structures (Figure 1g) are much lower (35.17%) than recommended bottom ventilated structure (44.96%). The sprouting and black mould infection was also lower in low cost storage structure. The per quintal net returns were maximum (Rs. 52.37) for stored onion than that of non-stored (Rs. 10.96) onion. The net returns per rupee spent were also higher (1.14) for stored onion than that of non-stored onion (1.04) (Bhor, 2003).

**Controlled atmospheric storage:** Robinson et al. (1975) reported that low O₂ levels in storage reduced the respiration rate (ml/kg.hr) of bulbs at all temperatures studied (Table 2). However, controlled atmospheric (CA) storage conditions (Figure 1e) gave variable success for the gas composition of 5% CO₂ + 3% O₂, was shown to reduce sprouting and root growth (Hardenberg et al. 1990).

Sea Land (1991) recommended 0% CO₂ with 1-2% O₂ for storage of onions. Typical storage conditions were given as 0°C and 65–75% rh with 5% CO₂ and 3% O₂ by Bishop (1996). Monzini and Gorini (1974) recommended 4°C in 5-10% CO₂ + 3-5% O₂ for 6 months. Fellows (1988) recommended a maximum of 10% CO₂ and a minimum of 1% O₂. Kader (1985) recommended a temperature range of 0-5 °C and 75% rh in 1-2% O₂ + 0% CO₂.

In later work Kader (1989) recommended 0-5 °C in 0-5% CO₂ + 1-2% O₂. Saltveit (1989) recommended 0-5 °C in 0-5% O₂ and 0-1% O₂, which was claimed to have had only a slight effect. He also found that CA storage gave better results when they were stored early in the season just after curing in bulk storage.

Smittle (1988) found that more than 99% of the bulbs of the cultivar Granex were marketable after 7 months of storage at 1 °C in 5% CO₂ + 3% O₂, although the weight loss was 9%. Bulbs stored at 1 °C in 5% CO₂ + 3% O₂ kept well when removed from storage, while bulbs from 10% CO₂ + 3 and 5% O₂ became unmarketable at a rate of about 15% per week, due to internal breakdown during the first month of storage. Bulb quality, as measured by low pungency and high sugar, decreased slowly when onions were stored at 27 °C or at 1 or 5 °C at 70–85% rh in CA. Quality decreased rapidly when the cultivar Granex were stored in air at 1 or 5 °C.

Adamicki (1989) also described successful storage of onions at 1 °C in 5% CO₂ + 3% O₂. Adamicki and Kepka (1974) found that there were no changes in the colour, flavour or chemical composition of onions after 2 months storage, even in 15% CO₂.

**TABLE 2:** Effects of temperature and reduced O₂ levels on the respiration rate on Bedfordshire Champion onions

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Storage Method</th>
<th>Respiration Rate (ml/kg.hr), air</th>
<th>Respiration Rate (ml/kg.hr), 3% O₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>

Source - Robinson et al. (1975)
Chawan and Pflug (1968) examined storage of the cultivars Dowing Yellow Globe and Abundance in several combinations of 5 and 10% CO$_2$, 1, 3 and 5% O$_2$ at 1.1, 4.4 and 10 °C. The best combination was 10% CO$_2$ + 3% O$_2$ at 4.4 °C, and the next best was 5% CO$_2$ + 5% O$_2$ at 4.4 °C. Internal spoilage of bulbs was observed in 10% CO$_2$ + 3% O$_2$ at 1.1 °C but none at 4.4 °C.

Adamicki and Kepka (1974) also observed a high level of internal decay in bulbs stored in 10% CO$_2$ + 5% O$_2$ at 1 °C, but none at 5 °C in the same atmospheric composition. The number of internally decayed bulbs increased with length of storage. Their optimum results for long-term storage were in 5% CO$_2$ + 3% O$_2$ at either 1 °C or 5 °C. Stoll (1974) stated that there were indications that the early-trimmed lots did not store as well in CA conditions as in conventionally refrigerated rooms, and he reported better storage life at 0 °C rather than at 2 or 4 °C when 8% CO$_2$ + 1.5% O$_2$ atmosphere was used.

Sitton et al. (1997) also found that storage in high CO$_2$ caused injury, but neck rot (Botrytis sp.) was reduced in CO$_2$ levels of greater than 8.9%. They found that bulbs in storage in 0.5–0.7% O$_2$ were firmer, of better quality and had less neck rot than those stored in O$_2$ levels of less than 0.7%.

Yamashita et al. (2009) tested 1 °C and 80% rh in 1% O$_2$ + 1% CO$_2$ for storage up to 196 days and found that sprouting and root growth were inhibited in CA storage and 98.2% were considered marketable, compared with 69.2% for those stored at -0.5 °C and 80% rh in air.

**Physiological disorders in CA storage:** CO$_2$ injury or internal spoilage of onion bulbs is a physiological disorder that can be induced by elevating the CO$_2$ concentration around the bulbs. This effect was aggravated by low temperature (less than 5 °C).

Chawan and Pflug (1968) observed internal spoilage of bulbs in storage at 1.1 °C in less than 10% CO$_2$ + 3% O$_2$, but there was no spoilage in the same CA at 4.4 °C. It was stated that internal spoilage of the bulbs was due to an adverse combined effect of temperature, gas concentration and relatively long storage period (Adamicki and Kepka, 1974).

Adamicki and Kepka (1974) reported that for the cultivars Ogata and Inoue there was very strong internal spoilage at concentrations of 10% CO$_2$ and above. They also found that after storage at 1 °C for 220 days there were 23–56% of internally spoiled bulbs when CO$_2$ concentrations were 10% or higher.

Smittle (1989) found that the cultivar Granex stored at 5 °C in 10% CO$_2$ + 3% O$_2$ for 6 months had internal breakdown of tissue due to CO$_2$ toxicity.

**Sprouting inhibition in CA storage:** CA storage is being increasingly used for onions since it can replace maleic hydrazide, which is used for sprout suppression. Previously, Isenberg (1979) concluded that CA storage is an alternative to the use of sprout suppression in onions, but stressed the need for further testing of the optimum condition of O$_2$ and CO$_2$ required for individual varieties.

Adamicki and Kepka (1974) also reported that onions stored in an atmosphere with 5–15% CO$_2$ at room temperature showed a decrease in the percentage of bulbs that sprouted. They also reported that bulbs of cultivar Wolska stored for 226 days in 5% CO$_2$ + 3% O$_2$ and then transferred to 20 °C sprouted about 10 days later than those transferred from air storage. There is evidence that CA storage can have residual effects after they have been removed from store.

Yamashita et al. (2009) reported that storage at 1 °C and 80% rh in 1% O$_2$ + 1% CO$_2$ for up to 196 days inhibited sprouting and root growth.

Chawan and Pflug (1968) found that bulbs showed no sprouting after 34 weeks, while bulbs stored in air had 10% sprouting for Dowing Yellow Globe and 15% for Abundance. Gadalla (1997) found that all the cultivars stored in CA combinations, 1, 3 or 5% O$_2$ + 0 or 5% CO$_2$, reduced sprouting, but those combinations that included 5% CO$_2$ were the most effective. Also, the residual effects of CA storage were still effective after 2 weeks at 20 °C. No external root growth was detected when bulbs were stored in 1% O$_2$ compared with 100% for the bulbs in air. There was also a general trend to increased rooting with increased O$_2$ over the range of 1 to 5%. Bulbs stored in 5% CO$_2$ had less rooting than those stored in 0% CO$_2$. Both these latter effects varied between cultivars. Most of the cultivars stored in 1% O$_2$ + 5% CO$_2$ and some cultivars stored in 3% O$_2$ + 5% CO$_2$ were
FIGURE 1: a) Hanging method b) Vengaya Pattarai c) Tat Storage d) Bag storage e) Controlled atmospheric storage f) Modified Ventilated Storage g) Mangalore tile storage h) Pucca/floor storage (Adapted from internet resources, links provided in reference)
considered marketable after 9 months storage. He also found that CA storage was most effective when applied directly after curing, but a delay of 1 month was almost as good. It was therefore concluded that, with a suitable cultivar and early application of CA, it is technically possible to store onions at 0 °C for 9 months without chemical sprout suppressants.

**Modified atmospheric storage:** Packing bulbs in plastic film is uncommon because the high humidity inside the bags can cause rotting and root growth. Hardenburg (1955) packed onions of 1.36 kg in 150 gauge polyethylene film bags in non-perforated bags tended to produce 71% roots because of the higher humidity (98%) inside bags, but when the bags were perforated 36, 40, 8, 16 and 32 numbers of sizes 1.6, 3.2, 6.4, 6.4 and 6.4 mm respectively. The percentage of roots promisingly reduced to 59, 40, 24, 17 and 4 per cent. Though the polybags are convincing the onions stored in kraft bags had no rots observed but on other hand it encountered 3.4% weight loss.

Adamicki et al. (1977) found that internal breakdown was observed in 68.6% of the bulbs when they were stored at 1 °C in sealed PE bags with a CO₂ concentration higher than 10%; they also found a similar disorder in bulbs stored at 5 °C in sealed PE bags, and this was probably due to the very high concentration of CO₂ of 28.6%.

**CONCLUSION**

The storage of onions in well ventilated structure prolongs the storage life. Though the application spray chemicals like MH followed by traditional storage structure is routine practise to manage the loss, it is more difficult as it is vulnerable for climatic changes. The MH controls sprout growth only when temperature is below 20°C and for tropical country like India it worth to go for ethylene releasing sprout controller. Also, the Farmers adopt high temperature open ventilated sheds whereas for bulk storage it is recommended to store at 0°C, the former is susceptible for desiccation which leads to microbial decay. To reduce losses during storage modified and/or controlled atmospheric storage with proper temperature management, shall control sprouting and weight loss against the pre-harvest chemical spray and prolong the time of onion storage.

**REFERENCE**


Date accessed on 01.07.13


Hanging storage of onions http://sallygardens.typepad.com/sallygardens. Date accessed on 04.03.2014


