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Development of on Farm Ventilated Storage System for Aggregatum Onion

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A B S T R A C T

In forced ventilated storage method the physiological weight loss was recorded highest in top compartment as 27.41 per cent and least at 27.29 per cent in bottom compartment during 90 days of storage. During the 90 days of storage, sprouting loss was 5 per cent in natural ventilated structure was observed as minimum loss and maximum loss was recorded in 11.5 per cent in forced ventilated storage structure. The minimum decay per cent of bulbs was recorded as 3.8 per cent in forced ventilated storage structure and maximum decay percent of stored aggregatum onion is observed as 13 per cent. The minimum and maximum value of moisture content in natural ventilated storage structure was recorded as 79.57 and 82.49 per cent. And in forced ventilated storage structure the minimum and maximum moisture content was observed as 79.80 and 79.85 per cent.

Introduction

Onion is commercially cultivated, in over one hundred countries of the world. India stands first in production, sharing eight per cent of the world production. In India, during 2012-2013, onion is produced in an area of 1.051 million hectares, with an annual production of 16.813 million metric tons (Anonymous, 2013). The varieties belonging to multiplier onion and shallot sub groups are classified as small onions. These two sub groups are the most important in *Aggregatum* group of *Allium cepa* L.

The storage of onion in India is done under ambient conditions, where there is difficulty in controlling temperature and humidity.

Presently, about 35-40 percent of the onion is estimated to be lost during postharvest handling. In general, the losses due to reduction in weight, sprouting and rotting (decay) were found to be 20 to 25, 4 to 5 and 10 to 12 per cent respectively. Curing is the most important operation in the post-harvest technology of onion. The purpose of curing is to dry the thin outer layers of the bulb to form one or more complete outer skins. These outer skins act as a barrier against water loss and infection from fungal pathogens such as *Botrytis allii* (neck rot). Low cost farm level storage technology is therefore, required to extend the shelf life of onion to increase its marketability and to make fresh onion available to the consumer round the year at a reasonable price.

Materials and Methods

Curing of onion

The onion variety used for the present study was Co 4 (*Allium cepa* L. var. *aggregatum*). Curing of onions is one of the most important methods of reducing post-harvest losses. It is a natural wound healing process which in onion replaces and strengthens damaged areas by forming a corky layer which protects against water loss and infection by decay organisms.

Design of natural aerated structure

The structure was made up of casuarinas wooden pole frame**,** split areca wood walls, split areca wood floor (45 cm above the ground) and the roof was covered with dried coconut thatches. In this structure, top, bottom or both sides ventilation were provided. This storage structure is mainly designed based on the wind speed of that particular area.

The overall size of the storage structure is 1.8×1.0×2 m (l×b×h) with 4 compartments 1.8×1.0×0.2 m (l×b×h). The spacing between the each compartment is 0.1 m for provision of air circulation and depth of compartment is 0.2 m with the capacity of 200 kg of onion storage (Figure 1). Cleaned and cured onions were stored on the each compartment.

Design of forced air ventilation system

The storage structure is similar as natural ventilated structure but here the forced air circulation is provided with help of blower of 0.5 hp and perforated pipes (Figure 2). Facilitating forced air circulation through the storage will remove respiration heat as well as prevent concentration of humid air inside the heap and prevent condensation of moisture. Therefore, an air blower system of 0.5 hp was introduced in the normal natural ventilated storage structure to help air circulation through the onion storage by providing two perforated pipes with perforation dimensions of (3 mm), into the compartments with the appropriate velocity to circulate the air inside compartment (Figure 2). The centrifugal blower was operated for a period of 6 h/day (9 am to 5 pm) of everyday with the humidity maximum during the day.

Moisture content

Onions were peeled manually by removing the skin and the first layer, and sliced using a kitchen knife. The slices, 1 mm thick, were then placed on the perforated trays made of stainless steel, and dried in a hot air oven at 105°C for 3 hours (AOAC, 1990). The samples were recorded and weighed on a electronic balance and also replicated. The moisture content was calculated using the following equation.

$$M.C\,(wb\,\%) = \frac{Initial\ weight(g) - Final\ weight\,(g)}{Initial\ weight\,(g)} \times 100 \qquad ...(1)$$

Physiological loss in weight (PLW)

Onions were weighed in an electronic balance before and after storing of onions in storage structure. Physiological loss in onion weight was calculated by the formula given below,

$$PLW(\%) = \frac{Initial\ weight(g) - Final\ weight(g)}{Initial\ weight(g)} \times 100 \qquad ...(2)$$

Sprouting loss

The sprouted bulbs were taken from the storage structure and weighed at 7 days interval in an electronic balance (Make: Avery, Model: OC-51) and the sprouting loss was worked out from the initial weight and the sprouted bulbs weight as given below. It is expressed in percentage.

$$\text{Sprouting loss}(\%) = \frac{\text{Weigt of the sprouted bulb }(g)}{\text{Initial weight of bulb}(g)} \times 100 \qquad \dots(3)$$

Decay percentage

The decayed bulbs from the different storage methods were taken out and weighed at 7 days interval in an electronic balance (Make: Avery, Model: OC-51) and the decay percentage was calculated from the initial weight and the decayed bulbs weight as given below. It is expressed in percentage

$$\text{Decay}(\%) = \frac{\text{Weigt of the decayed bulb }(g)}{\text{Initial weight of bulb}(g)} \times 100 \qquad \dots(4)$$

Results and Discussion

Curing is the one of the important post-harvest technologies where excess moisture is removed from the outer skin and neck of the onion to reduce the post-harvest losses due to sprouting, rooting and rotting. The quality parameters of fresh and cured onion are presented in Table 1. After the curing of aggregatum onions, the quality parameter like firmness, total soluble solids and colour have increased and decreased moisture content and pyruvic acid were observed.

From table 1, the colour value (a*), total soluble solids and firmness increased after curing. This is may be due to the reduction of moisture content and tightening the neck of the bulbs. Moisture content and pyruvic acid decreased from the fresh sample to cured sample.

Effect of natural and forced air ventilated storage methods on moisture content

Table 2, shows the changes in moisture content of aggregatum onion which was stored in the natural and forced ventilated storage structures at ambient temperature during the period of 90 day. The maximum decrease in the moisture content was measured as 79.45 per cent at natural ventilated storage structure while in the forced ventilated storage structure it was measured as 79.83 per cent. The decrease in moisture content of aggregatum onion may be due to increase in ambient temperature and also the decrease in moisture content leads to increase in physiological loss in weight of aggregatum onions.

Moisture content of aggregatum onion with respect to storage structure, compartment position and storage period were statistically analyzed and presented in Table 3. The results indicated that the variables and their interactions for all the treatments were significant at one per cent level. This may be due to storage of onion in both natural and ventilated structure at ambient condition where it attains the equilibrium moisture content with atmosphere.

Effect of natural and forced air ventilated storage methods on physiological loss in weight

Onion bulbs in storage undergo loss in weight due to physiological changes like moisture loss, sprouting, rooting, rotting and nutritional and other bio-chemical changes resulting in desiccation. In the present study, weight loss in bulbs was found to increase with increase in the storage period in aggregatum onion Pramanick *et al.*, (1999).

Cured onions stored under different ventilated storage conditions have shown significant influence on physiological loss in weight (Table.4). The minimum physiological loss in weight was recorded as 34.47 per cent and the maximum of 35.10 per cent for the onion at naturally ventilated storage after 90 days of storage. Also the onions stored under forced ventilated storage structure in ambient temperature for 90 days of storage period have shown significant influence on physiological loss in weight (Table.5). The minimum physiological loss in weight of 27.29 per cent and the maximum of 27.41 per cent at forced ventilated storage structure were observed.

The bulbs stored in the forced ventilated storage structure recorded that lowest physiological loss in weight; this might be due to proper aeration, causing decreased temperature and humidity inside the structure. This physiological loss in weight in both the structure includes with sprouting and rotting. The break of dormancy of onion bulbs in storage revealed that the stored bulb starts sprouted only after a month of storage which is shown in Figure 3.

Fig.1 Natural ventilated storage structure

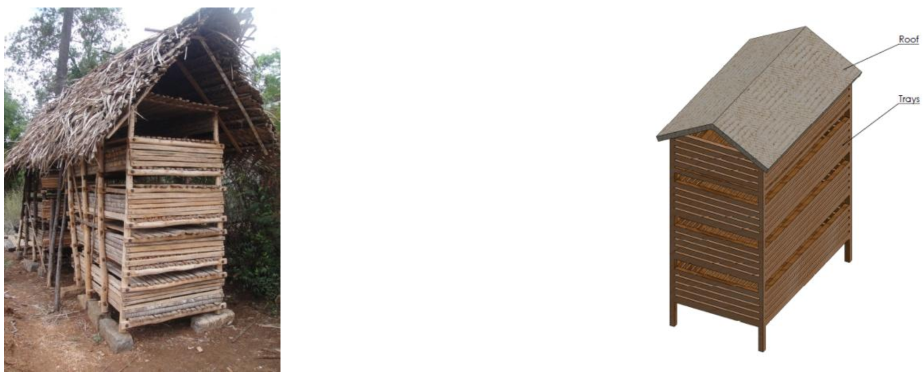

Fig.2 Forced air ventilated storage

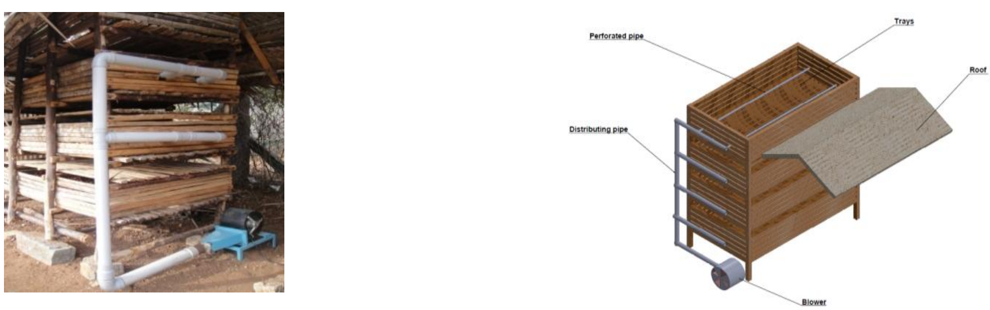

Fig.3 Sprouting percentage of aggregatum onion in ventilated storage methods

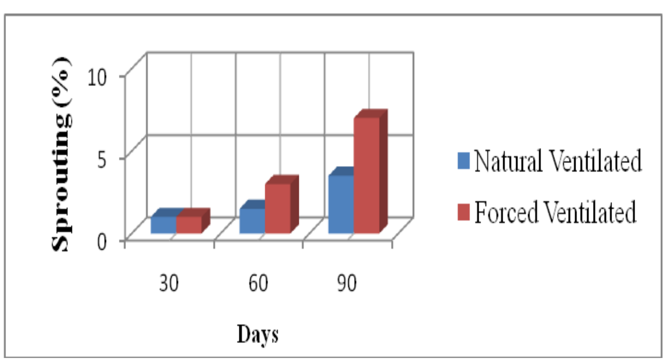

Fig.4 Decay percentage of aggregatum onion in ventilated storage methods

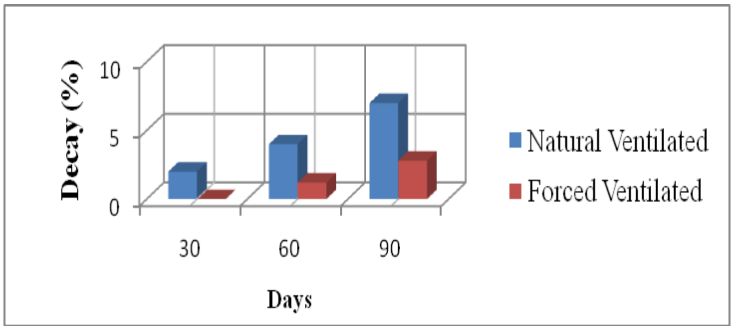

Table.1 Quality parameters of fresh and cured onion sample

Particulars	Fresh onion	Cured onion
Moisture Content (w.b %)	84.212±0.57	82.57±0. 71
Firmness (N)	81.80±3.68	82.97 ±2.86
Total Soluble solids (%)	15.28±1.28	16.7 ± 1.63
Colour (a^*)	14.64±0.89	16.95±0.75
Pyruvic acid (µmol/g)	2.44±0.33	2.38 ±0.52

Table.2 Moisture content of aggregatum onion in natural and forced ventilated storage

	Moisture content (w.b %)			
	Natural ventilation		**Forced ventilation**	
Days	**Top compartment**	**Bottom compartment**	**Top compartment**	**Bottom compartment**
0	82.12	82.49	82.74	82.93
7	82.04	82.37	82.69	82.88
14	81.92	82.29	82.62	82.81
21	81.65	81.96	82.52	82.62
28	81.32	81.69	82.40	82.51
35	80.96	81.25	82.24	82.33
42	80.52	80.89	81.89	82.18
49	80.39	80.42	81.81	81.52
56	79.92	80.29	80.6	81.15
63	79.87	79.95	80.71	80.9
70	79.53	79.90	80.64	80.83
77	79.58	79.76	80.35	80.54
84	79.44	79.81	79.91	80.1
90	79.32	79.57	79.85	79.80

Table.3 ANOVA for moisture content of aggregatum onion under natural and Forced ventilated storage

Source	Degrees of freedom	Sum of Squares	Mean sum of squares	F- ratio
Treatment	55	211.49	3.84	6071.56 **
Storage structure (V)	1	27.97	27.97	44164.50 **
Compartment position (R)	1	2.052	2.05	3241.02 **
Storage period (D)	13	176.68	13.59	21459.69 **
V×R	1	0.19	0.19	315.07 **
R×D	13	0.69	0.05	84.73 **
V×D	13	3.69	0.28	446.77 **
V×R×D	13	0.21	0.01	25.34 **
Error	112	0.071	0.00063	1.00
Total	167	211.56	1.27	2000.28

** Significant at 1% level; * Significant at 5% level; NS-Non Significant

Table.4 Physiological loss in weight of aggregatum onion in natural and Forced ventilated storage methods

	Physiological weight loss (%)			
	Natural ventilation		Forced ventilation	
Days	**Top compartment**	**Bottom compartment**	**Top compartment**	**Bottom compartment**
0	0	0	0	0
7	6.32	6.19	5.22	5.10
14	9.35	9.22	7.24	7.12
21	13.10	12.97	9.78	9.66
28	16.30	16.17	12.72	12.60
35	19.71	19.58	15.31	15.19
42	21.69	21.56	16.65	16.53
49	25.11	24.98	18.14	18.02
56	27.91	27.78	19.30	19.18
63	29.37	29.24	21.04	20.92
70	30.18	30.05	23.18	23.06
77	32.25	32.12	24.53	24.41
84	33.43	33.30	26.25	26.13
90	35.10	34.97	27.41	27.29

Table.5 ANOVA for physiological loss in weight of aggregatum onion under natural and Forced air ventilated storage

Source	Degrees of freedom	Sum of Squares	Mean sum of squares	F- ratio
Treatment	55	15960.57	290.19	38582.06 **
Storage structure (V)	1	1141.45	1141.45	151760.97 **
Compartment position (R)	1	0.565848	0.56	75.23 **
Storage period (D)	13	14505.19	1115.78	148347.41 **
V×R	1	0.000905	0.00	0.1204 NS
R×D	13	0.043527	0.00	0.4452 NS
V×D	13	313.30	24.10	3204.21 **
V×R×D	13	0.00	0.00	0.0007 NS
Error	112	0.84	0.00	1.00
Total	167	15961.41	95.57	12707.33

Effect of natural and forced air ventilated storage methods on sprouting

Cured onions stored under different ventilated storage structures have shown significant influence on sprouting (Figure 3). The minimum sprouting and the maximum sprouting observed was 1 and 3.7 per cent at naturally ventilated storage structure. Also in forced ventilated storage structure, the minimum and maximum sprouting of onions observed was 1 and 7.3 per cent after 90 days of storage.

Among the overall methods given to the onion, the minimum sprouting was observed as 5 per cent in natural ventilated storage and the maximum sprouting was 11.2 per cent at forced ventilated storage structure after 90 days of storage. The sprouting percentage was higher in forced ventilated storage structure than the natural ventilated storage structure because of the higher relative humidity of the environment that ranged from minimum and maximum of 50.96 per cent and 89.01 per cent during storage of onion in forced ventilated structure. These results are in line with the findings of Tanaka *et al.,* (1995).

Effect of natural and forced ventilated storage methods on decay during storage period

Decay of onion bulbs is normally met during storage due to the pathogens, *viz*., *Botrytis allii* and *Pseudomonas alliicola* causing neck rot and soft rot developed due to excess moisture and high humidity in the storage environment and mechanical damage during handling cause considerable loss to growers.

Onions stored under different storage conditions have shown significant influence on decay (Figure 4). In natural ventilated storage structure, the minimum and the maximum decay observed was 2 per cent and 7 per cent of onion respectively after 90 days of storage in ambient condition. Also in forced ventilated storage structure the minimum decay observed was 1.2 per cent and the maximum decay observed was 2.6 per cent after 90 days of storage in ambient condition. In the present study, the forced ventilated storage structure recorded reduced decay percentage probably due to good aeration leading to reduced humidity and temperature inside the structure when compared to the natural ventilated structure or outside environment. Similar views were also expressed by Wright *et al.,* (2004).

Curing is a partial drying process intended to dry off the necks and outer scale leaves of the bulbs to prevent the loss of moisture and the attack by decay during storage. In forced ventilated storage method the physiological weight loss was recorded highest in top compartment as 27.41 per cent and least at 27.29 per cent in bottom compartment during 90 days of storage.

During the 90 days of storage, sprouting loss was 5 per cent in natural ventilated structure was observed as minimum loss and maximum loss was recorded in 11.5 per cent in forced ventilated storage structure. However, maximum moisture content was observed in bulbs stored under forced ventilated storage structure might have accelerated the sprouting. The decay percentage was observed more in both the ventilated storage methods for up to 90 days of storage. The minimum decay per cent of bulbs was recorded as 3.8 per cent in forced ventilated storage structure and maximum decay percent of stored aggregatum onion is observed as 13 per cent. The minimum and maximum value of moisture content in natural ventilated storage structure was recorded as 79.57 and 82.49 per cent. And in forced ventilated storage structure the minimum and maximum moisture content was observed as 79.80 and 79.85 per cent.

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