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RESEARCH PAPER

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Development of night time on-farm ventilated potato storage system in Nilgiri Hills of Southern India

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SUMMARY :

Post harvest losses of potatoes can be minimized by maintaining proper temperature and relative humidity in storage environment and removing the respiratory heat and carbon dioxide. As the farmers in Nilgiri district do not have access to cheaper cold storages, alternative methods of storage taking advantage of prevailing weather conditions were investigated. The diurnal variation in temperature at the place of study was in the range of -3 to 14°C in November and 12 to 28°C in February. Ventilation at flow rate of 0.14 m^3/ min was adequate to cool the bulk of 250 kg of potatoes to safer limits. The total weight loss at the end of the storage period on the 120^{th} day was highest in ambient storage and least in cold storage. The weight losses were 53, 9.8, 3.6, 14.4, 27.7 and 2.6 per cent under ambient storage, ventilated storage, ventilation with evaporative cooled storage, simple ventilation in pits, traditional storage pit and cold storage, respectively. A similar trend was observed on the physiological loss of weight in the above listed trails. Rotting and sprouting levels were highest in ambient storage and were observed to be 40 per cent and 100 per cent, respectively on the 120^{th} day.

KEY WORDS : Potato storage, Ventilated storage, On-farm storage, Night time ventilation

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In Tamil Nadu, potato was grown in an area of 5034 hectares with an annual production of 0.074 million tonnes and the productivity is 14.90 tonnes/ha. It is grown as rainfed crop in Nilgiris, Dindigul, Krishnagiri and Erode districts during June-September (*Kharif*) and as an irrigated crop during November- February (*Rabi*). The major potato producing district of Tamil Nadu is Nilgiris district, which alone contributes 0.043 million tonnes with a productivity of 22.54 tonnes/ha and shares 60 per cent of the total production in the state (Anonymous, 2010). The potatoes harvested during November were sold immediately to the vendors at low price. As the atmospheric temperature from November to February is low, the natural air can be used for three months of ventilated storage. The average temperature in Nilgiri district during day time is around 14 to 28°C and the night temperature vary from -3 to 14°C. As temperature during the night time is low, it can be used as source of cold air for ventilated potato storage. While natural air is ventilated to potato storage, it removes heat and CO_2 produced as a result of metabolic activities of potatoes.

EXPERIMENTAL METHODS

The study area, Karada village is located in Ketti valley near Coonoor in Nilgiri hills. Geographically, Karada village is located at 11.37° North latitude, 76.72° East longitudes and at an elevation of 1285.1 m above Mean Sea Level. The mean annual rainfall is 1601.4 mm which is well distributed between June and October months. The mean maximum and minimum temperatures during the storage period were 30°C and -3°C, respectively. The mean maximum and minimum relative humidity during the storage period were 100 per cent and 42 per cent, respectively. During November to February the temperature in day time reaches upto 30°C and reduced to -3°C at night time. The temperature falls below 0°C for four hours a day. Therefore the natural air can be used for ventilation to remove the metabolic heat produced in the storage during night time.

Experimental details :

Freshly harvested, sound potato tubers collected from potato farmers of Nilgiri district were used for storage study. To compare the effect of storage environment, storage temperature and relative humidity, 50 kg of potatoes was placed under above mentioned storage treatments. The storage study was conducted for 120 days. For treatment T_1 namely storage under traditional pit storage method, potatoes were placed under constructed traditional pit and covered using shade net. For treatment T_2 namely storage under traditional pit storage with ventilation, potatoes were placed under constructed traditional pit and natural night time air is circulated during 11 PM to 5 AM. For treatment T_3 namely storage under ventilated chamber, potatoes were placed under constructed storage chamber and ventilation of natural air was made during night time form 11 PM to 5 AM. For treatment T_4 namely storage under ventilated chamber with evaporative cooling, potatoes were placed under constructed storage chamber and humidified cool air form the evaporative cooling unit is circulated throughout the storage period. For treatment T_5 namely storage under ambient condition, potatoes were tied inside jute bag and placed in field itself without any storage treatment. Heating coil arrangement for circulation of hot air during curing is shown in Fig. A. Ventilation of evaporative cooled air and atmospheric air arrangements are shown in Fig. B. For treatment T_6 namely cold storage treatment, potatoes were placed in private cold storage, Ooty main road, in Mettupalyam throughout the storage period.

Fig. A : Heating coil arrangement for circulation of hot air during curing

Fig. B : Ventilation of evaporative cooled air and atmospheric air

Total storage loss (%) :

It was calculated from the initial and final weight of the tubers during the storage period.

$$\text{Total storage loss (\%)} = \frac{\text{(Initial weight of tubes - Final weight of tubers}}{\text{Initial weight of tubers}} \times 100 \quad \text{...... (1)}$$

Physiological loss in weight (PLW) :

Weight loss during storage may be due to physiological reasons like dehydration and respiration and also due to rotting and rat damage. The physiological loss in weight was calculated by deducting weight loss due to rotting from total weight loss and was estimated using the following formula:

$$\text{Physiological loss in weight (\%)} = \frac{\text{(Initial weight - Final weight) - (Rotted weight)}}{\text{(Initial weight of the tubers)}} \times 100 \quad ......(2)$$

Weight loss due to rotting (%) :

Weight of rotted tubers was taken and percentage of loss due to rotting was calculated using the following formula:

$$\text{Weight loss due to rotting (\%)} = \frac{\text{Weight of tubers rotted}}{\text{Initial weight}} \times 100 \quad ...... (3)$$

Sprouting (%) :

The tubers having at least one sprout longer than 5 mm was counted as sprouted tuber and sprouting percentage was calculated using the following formula:

$$\text{Sprouting (\%)} = \frac{\text{Number of sprouted tubers}}{\text{Total number of tubers}} \times 100 \quad ...... (4)$$

EXPERIMENTAL FINDINGS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Cooling potential of night time air :

The average temperature in Nilgiri district during day time is around 14 to 28°C and the night temperature vary from -3 to 14°C during the period of study. As temperature during the night time is low, it can be used as source of cold air for ventilated potato storage. While natural air is ventilated in potato storage, it removes heat and CO_2 produced as a result of metabolic activities of potatoes. Variation in natural air temperature during different stages of storage period is shown in Fig. 1, 2, and 3, respectively.

During the first month of storage, the temperature of atmospheric air reached below 12°C for more than eight hours from mid night to early morning. Provision for night time ventilation during the first month of storage is high. The minimum temperature during the first month of storage was 2.7°C which was used to remove the field heat and heat accumulated during curing period. The temperature of atmospheric air during the second month reached below 12°C for more than 10 hours from mid night to early morning. A minimum temperature of 1.3°C in the early morning and maximum temperature of 20.4°C in the late afternoon were recorded. The atmospheric air temperatures in the second month reached below 12°C for more than 10 hours a day. A minimum temperature of 6°C during early morning and maximum temperature of 20°C were recorded. Temperature during third month of storage reached below 12°C for 5 hours a day. Five hours of atmospheric air ventilation from 2 AM to 7 AM was used to remove heat produced due to respiration and reduce the temperature inside the storage.

During the first storage month of November 2011 the potential of the night time air to remove heat from the

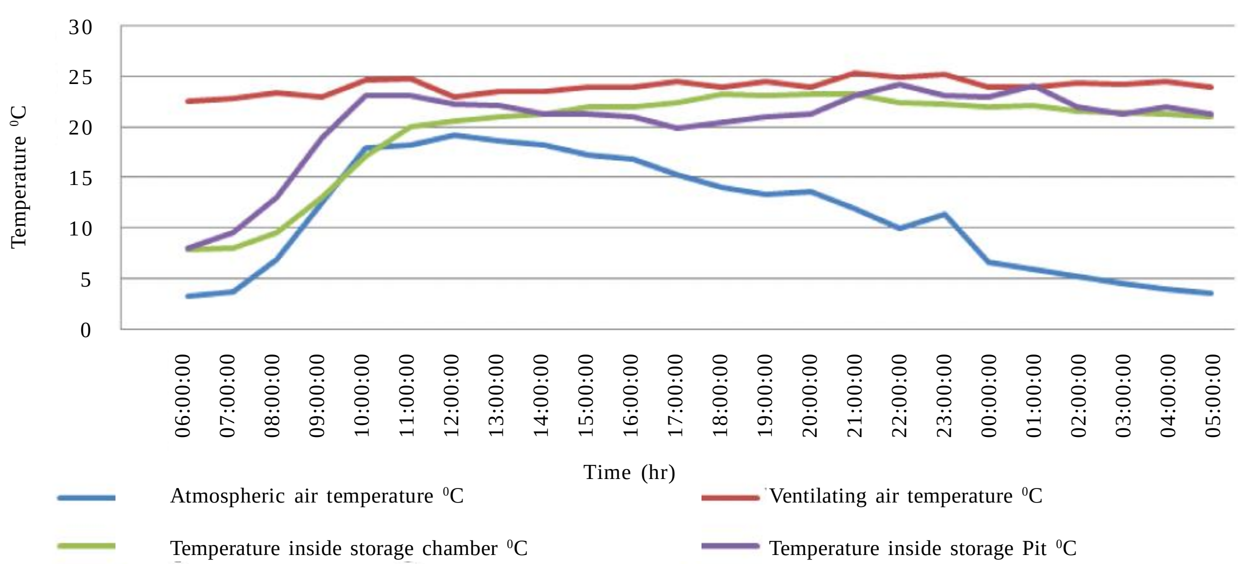

Fig. 1 : Comparison of temperature variation during curing phase

potato bulk was low. The night time air during first month of storage reached minimum temperature only for a short period of time. Compared to first month of storage, during the next two months namely December and January, the cooling potential of atmospheric air to remove heat from the potato bulk had increased greatly.

The night time atmospheric air reached low temperature for more time than in first month of storage so the effectiveness of cooling is high during next two months. During February, atmospheric air reached low temperature only for a short period of time. The last month of storage has similar effect on cooling as first month of storage. Physiological changes after 120 days storage in different treatments was given in Table 1.

Total weight loss (%) :

Among the different storage treatments the cold storage was superior followed by evaporative cooled storage and ventilated storage. It was found that the storage period was significant at each interval of ten days. The weight loss per cent was higher as the storage period increases and there was significant difference at each interval of 10 d. The total weight loss varied from 0.4 per cent in cold storage to 53.0 per cent in ambient storage

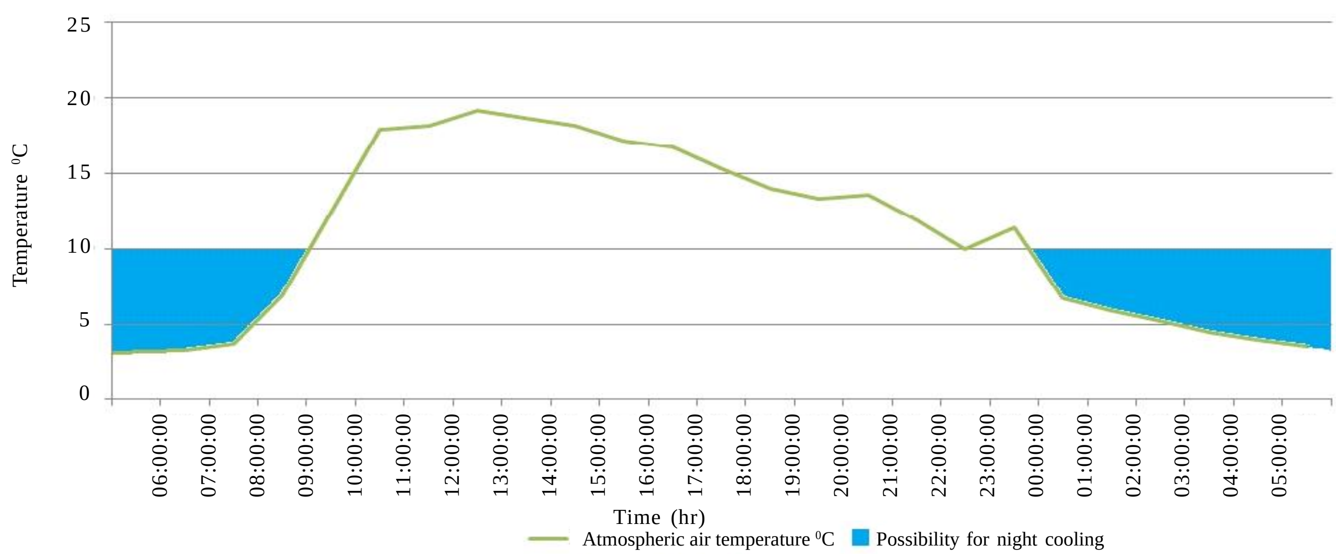

Fig. 2 : Provision for night time ventilation in Nilgiri hills

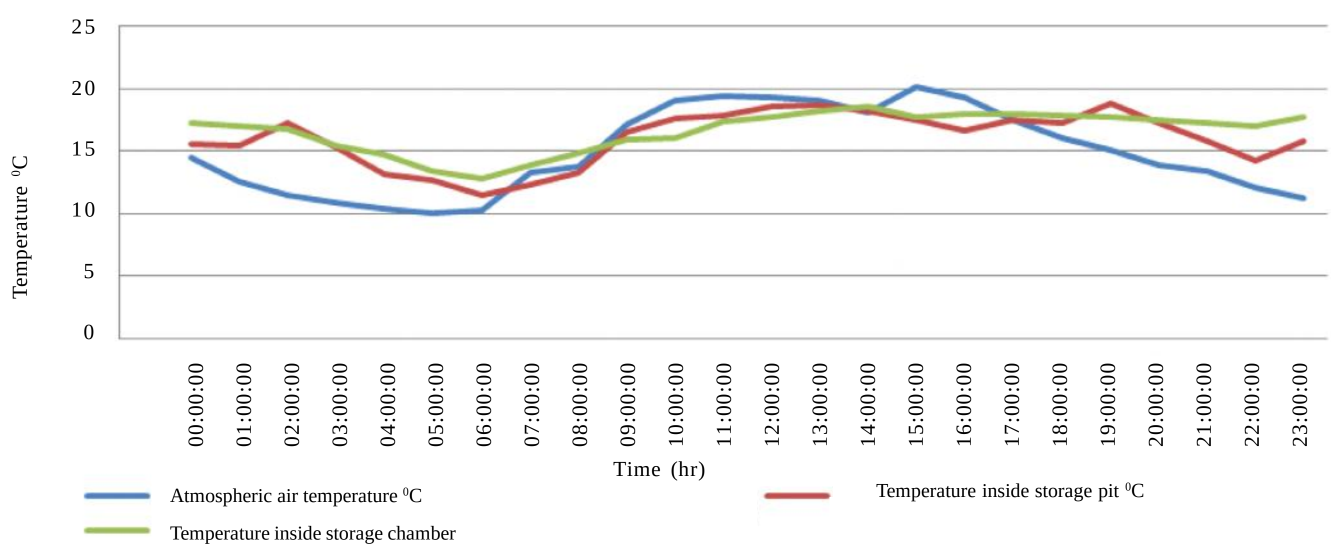

Fig. 3 : Comparison of temperature variation during night time ventilation

from initial day of storage to final day of storage. The total weight loss on the 120th day of storage was 9.8 per cent, in ventilated cooled storage; 3.2 per cent in evaporative cooled storage; 14.4 per cent in ventilated pit storage; and 27.7 per cent in traditional pit storage. The total weight loss was 53 per cent in ambient storage as compared to a weight loss of 0.4per cent in cold storage. ANOVA for effect of storage treatment (T) and storage period (S) of potatoes is presented in Table 2. Similar results were reported by Mehta and Singh (2004), the mean weight loss of tubers was comparatively low when stored at evaporative cooled conditions than tubers stored in gunny bags at room temperature.

Physiological loss in weight (%):

The physiological weight loss was observed to be 2.6 and 3.6 per cent on 120th day of cold storage and evaporative cooled storage, respectively. The physiological weight losses in traditional pit storage, ventilated pit storage, ventilated storage, and ambient storage were 22.2, 9.6, 7.6, and 13.9 per cent, respectively. ANOVA for effect of storage treatment (T) and storage period (S) of potatoes is presented in Table 3. Similarly Katiyar *et al.* (2000) reported that the physiological loss in farm stores ranged from 13 to 24 per cent, whereas it was only 4 to 5.6 per cent in cold stores. Physiological weight loss when compared to ambient storage was less in cold storage and evaporative cold storage. In the same way Singh *et al.* (2001) has also reported that physiological loss in weight was 2.5 to 5 per cent at evaporative cooled chamber when stored for 6 months.

Weight loss due to rotting (%) :

The rotting was significantly different among the storage treatments. Rotting was high in ambient storage at 40 per cent followed by traditional pit storage at 5.5 per cent, ventilated pit storage at as 4.8 per cent and ventilated storage at 2.2 per cent, respectively. There is no significant rotting observed in evaporative cooled storage and cold storage. The extent of rotting increased with the passage of time significantly. The death or decay of plant tissue accompanied by dark brown discoloration, softening and disintegration of tissue as a result of bacterial infection was considered as rotting. ANOVA for effect of storage treatment (T) and storage period (S) of potatoes

Table 1 : Physiological changes after 120 days storage in different treatments

Storage treatments	Total Wt loss %	Physiological Wt loss %	Wt loss due to rottening %	Sprouting %
T_1	27.6	22.2	5.4	54
T_2	14.4	12	2.4	29.1
T_3	9.2	4.4	4.8	12.5
T_4	3.6	3.6	0	4.34
T_5	53	11	42	100
T_6	2.6	2.6	0	0

Table 2 : ANOVA for effect of storage treatment (T) and storage period (S) on total tuber weight loss percentage

Source	df	SS	MS	F	Prob
TOT	155	25083.4474	161.8286	252.4528	
Rep	1	0.6410	0.6410	1.0000	
Trt	77	25033.4474	325.1097	507.1711	0.00**
Err	77	49.3589	0.6410	1.0000	
T	5	15588.9551	3117.7910	4863.7540	0.00**
S	12	4125.7174	343.8097	536.3433	0.00**
TS	60	5318.7748	88.6462	138.2881	0.00**
Err	77	49.3589	0.6410	1.0000	
	S.E.D	C.D. (P=0.05)	C.D. (P=0.01)		
T	0.22206	0.44218	0.58651		
S	0.32686	0.65087	0.86331		
TS	0.80064	1.59429	2.11468		

** indicates significance of value at P=0.05

is presented in Table 4. Thomas *et al.* (1979) reported that the major loss factor in potato during storage under tropical ambient conditions was spoilage due to bacterial soft rot. More than 50 to 70 per cent of the initial weight of the stored tubers was lost within a period of 3 to 4 months on account of bacterial soft rot at 27 to 32°C.

Table 3 : ANOVA for effect of storage treatment (T) and storage period (S) on physiological weight loss percentage

Source	df	SS	MS	F	Prob
TOT	155	13163.4	84.9253	101910.4	
Rep	1	0.0108	0.01	13.0	
Trt	77	13163.3	170.9	205143.1	0.00**
Err	77	0.06	0.0008	1.0000	
T	5	7873.5	1574.7	1889653.7	0.00**
S	12	1377.7	114.8	137778.9	0.00**
TS	60	3912.0	65.20	78240.1	0.00**
Err	77	0.0641	0.0008	1.00	
	S.E.D	C.D. (P=0.05)	C.D. (P=0.01)		
T	0.0080	0.01594	0.02115		
S	0.0117	0.02347	0.03113		
TS	0.0288	0.05748	0.07625		

** indicates significance of value at P=0.05

Table 4 : ANOVA for effect of storage treatment (T) and storage period (S) on rottening weight loss percentage

Source	df	SS	MS	F	Prob
TOT	155	6441.1	41.5560	2.0821	
Rep	1	20.174	20.1744	1.0108	
Trt	77	4884.1	63.4311	3.1781	0.00**
Err	77	1536.8	19.9587	1.0000	
T	5	2249.6	449.9357	22.5433	
S	12	1002.7	83.5647	4.1869	0.00**
TS	60	1631.7	27.1956	1.3626	0.00**
Err	77	1536.8	19.9587	1.0000	NS
	SED	C.D. (P=0.05)	C.D. (P=0.01)		
T	1.2390	2.4673	3.2726		
S	1.8238	3.6317	4.8172		
TS	4.4675	8.8960	11.7997		

** indicates significance of value at P=0.05 NS= Non-significant

Table 5 : ANOVA for effect of storage treatment (T) and storage period (S) on sprouting percentage

Source	df	SS	MS	F	Prob
TOT	155	74586.1	481.20	1844996.1	
Rep	1	0.0004	0.0004	1.7917	
Trt	77	74586.1	968.65	3713952.2	0.00**
Err	77	0.0200	0.0002	1.0000	
T	5	18131.4	3626.2	13903759.9	0.00**
S	12	21143.7	1761.9	6755675.6	0.00**
TS	60	35310.9	588.51	2256456.9	0.00**
Err	77	0.0200	0.0002	1.0000	
	S.E.D	C.D. (P=0.05)	C.D. (P=0.01)		
T	0.0044	0.0089	0.0118		
S	0.0065	0.0131	0.0174		
TS	0.0161	0.0321	0.0426		

** indicates significance of value at P=0.05

Sprouting loss :

The sprouting was highest in ambient condition followed by traditional pit storage method. It was significantly different among different storage treatments. During the storage period, the sprouting loss increased from 0.4 to 100 per cent and the same was found to be significant on each storage intervals. Mehta and Ezekiel (2010) reported the sprouting was more in ambient storage condition and followed by all other storage treatments. On the 120th day of storage treatments, sprouting was 100 per cent in ambient condition, 54 per cent in traditional pit storage, 29.1 per cent in ventilated pit storage, 12.5 per cent in ventilated storage and 4.34 per cent in evaporative cooled storage, respectively and no sprouting was observed in cold storage. ANOVA for effect of storage treatment (T) and storage period (S) of potatoes is presented in Table 5. Sprouting was also low under evaporative cooled chamber than storing potatoes in gunny bags at room temperature.

Conclusion :

The relative effectiveness of night time ventilation and ventilation with evaporate cooling, were studied for storing potato bulks both above ground and inside pits. In addition to these potato bulks were stored in ambient conditions and also in a cold storage. These experiments were conducted for a period of 120 days using the potato variety Kurfi Jothi, harvested in October 2011 in the region of Othagamandalam. Trials ware evaluated based on physiological weight loss, total weight loss, loss due to rotting and sprouting and changes in biochemical properties of potatoes such as total sugar, reducing sugar, starch and phenol levels.

The weight loss was highest at 53 per cent in ambient storage and least at 2.6 per cent in cold storage on the 120th day. Weight loss in ventilated cooled storage, evaporative cooled storage, ventilated pit storage, and traditional pit storage were 9.8 per cent, 3.2 per cent, 14.4 per cent and 27.7 per cent, respectively. The physiological weight loss had a linear relationship with storage period. Among the treatments, maximum weight loss was observed in pit storage and least loss was observed I pit storage and least loss was observed in cold storage. The physiological weight losses were 22.2, 13.9, 9.6, 7.6, 3.6 and 2.6 per cent in traditional pit storage, ventilated pit storage, ventilated storage, and ambient storage, respectively. Rotting of potatoes was observed in all treatments except cold storage and evaporative cooled storage with ventilation. This was caused by the bacterium *Erwinia carotovora* sub sp. Rotting loss was highest at 40 per cent in ambient stored potato bulk and least at 2.2 per cent in ventilated bulk. The rotting level in traditional pit storage and ventilated pit storage were 5.5 and 4.8 per cent, respectively.

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