ON-FARM HEAP STORAGE OF POTATOES: EVALUATION IN NORTH-EASTERN PLAINS OF INDIA

Ashiv Mehta¹, PC Bhagwati², PC Satpathy³, A Konar⁴, YK Gupta¹, PS Naik⁵ and BP Singh⁶

ABSTRACT: An improved heap storage technology with the use of sprout inhibitor CIPC (isopropyl N-(3-chlorophenyl) carbamate) has been recommended for short-term storage of table and processing potatoes. Trials were conducted in Eastern plains to study the storage environment in the heap and evaluate storability and processing quality of potatoes up to 90 days. Inside the heap, maximum temperatures were lower (by 1-4°C) and mean relative humidity was higher (by 1-10%) as compared to the ambient. Sprouting in tubers was inhibited and losses in potatoes were reduced by 45-47% at two out of three locations in CIPC treated heaps. Reducing sugar content remained low (<128 mg/100 g fresh weight), chip colour improved during storage and was highly acceptable in CIPC treated potatoes. Results suggest a great potential for heap storage of potatoes in Eastern plains to get remunerative prices.

KEYWORDS: Heap, processing quality, potato, sprout inhibition, storage losses

INTRODUCTION

Potato crop is harvested at the beginning of the summer i.e. February-March in the major potato (Solanum tuberosum L.) growing areas of India. Seasonal production patterns, limited alternative market outlets (e.g. processing) and inadequate cold storage capacity often result in market gluts and heavy price reduction during the main harvesting months. Farmers use indigenous storage practices like heaps, pits and trenches to hold some of their produce for short terms to get higher prices (Dahiya et al., 1997). Heap storage of potatoes is commonly practiced in many states but losses due to shrinkage, sprouting and attack by microorganisms are generally enormous (15-25%) (Mehta et al., 2001). Extensive studies have been conducted in Northern plains to improve the storage efficiency of heaps (Mehta et al., 2010; 2011). An improved heap storage technology involving pre and postharvest measures along with the use of CIPC has been recommended for short-term storage of table and processing potatoes to avoid distress sale at harvest (Mehta et al., 2011). The ambient relative humidity (RH) during the storage period remains low in plains of Punjab and Uttar Pradesh, where the technology has been tested and validated on large scale, but its performance under high RH is not known. Therefore, trials were laid at three locations in Eastern plains namely Kalyani (West Bengal), Jorhat (Assam) and Bhubaneswar (Odisha) to study the storage environment inside the heap and evaluate storability and processing quality of potatoes up to 90 days.

MATERIAL AND METHODS

Seed tubers weighing 45-60 g of cv. Kufri Jyoti were planted in the field between 7-25

¹Central Potato Research Station, Jalandhar-144 003, Punjab, India. Email: ashivmehtacprs@gmail.com
²Assam Agricultural University, Jorhat-785 013, Assam, India.
³Orissa University of Agriculture and Technology, Bhubaneswar-751 003, Odisha, India.
⁴Bidhan Chandra Krishi Vishwavidyalaya, Kalyani-741 235, West Bengal, India.
⁵Indian Institute of Vegetable Research, Varanasi-221 005, Uttar Pradesh, India.
⁶Central Potato Research Institute, Shimla-171 001, Himachal Pradesh, India.
On-farm heap storage of potatoes

November, 2010 at three locations. Fertilizers were applied at the recommended dose of 150 kg N, 80 kg P₂O₅, and 100 kg K₂O/ha. Half the nitrogen was applied at planting and the remaining half at earthing up stage. All other recommended cultural practices were followed for raising the crop. Crop was dehaulmed at 85-90 days after planting and harvested after 10-15 days of skin curing at all the locations. The harvested tubers were kept in covered heaps for 7-10 days for wound healing and curing. Undamaged, apparently healthy and well cured potatoes were selected for the study.

Commercial product of CIPC (Oorja, UPL, Mumbai) was uniformly sprayed on potatoes @ 25 mg a.i /kg of potatoes in methanol in the first week of March, 2011 (Mehta et al., 2011). Potatoes after spray were stored in bulk (0.7 to 0.8 t) and in 3 replications of 10 kg each in nylon bags inside the heaps of size about 4 ft length x 3 ft width x 3 ft height. One perforated plastic pipe of 4 inch diameter with perforations of approx. 12 mm size at equilateral distance of 3-4 inches was placed vertically in each heap for providing ventilation. Size of the heap and number and diameter of plastic pipes can however, vary depending upon the availability of pipes and quantity of potatoes stored in heaps. Heaps were then covered with >1.5 ft thick rice straw under a shed and left undisturbed for storage up to 90 days. Control (untreated) heaps were also laid under the same shed.

The maximum and minimum temperatures and relative humidity (RH) were recorded daily during the entire storage period in heaps and the ambient. Final observations on number of sprouted tubers, loss in weight due to tuber rotting and total weight loss (physiological + pathological + sprout loss) were recorded in bulk as well as in the nylon bags after 75 and 90 days of storage (DOS). Per cent sprouting was calculated on number basis and each tuber having at least one sprout measuring 0.2 cm or more in length was recorded as sprouted. Tubers with slight evidence of decay were weighed to represent loss due to tuber rotting. Tubers were assessed for reducing sugar and sucrose contents as per standard methods at 0, 75 and 90 days of storage (Mehta and Singh, 2004).

Potatoes were hand peeled and cut into slices of 1.4 mm thickness with a semi-automatic slicing machine. The slices were washed thoroughly in cold water, air dried and immediately fried in groundnut oil at 180°C till the bubbling on the chip surface stopped. Chip colour was scored on 1-10 scale of increasing colour using the chip colour cards (Ezekiel et al., 2003a). Chip colour score up to and including 4 was considered acceptable. All the estimations were done in three replicates and the data was statistically analyzed using completely randomized design.

RESULTS AND DISCUSSION

Storage environment

Temperature and RH in the ambient condition at the three locations ranged between 17.8-36.4°C and 53-97.6%, while in North-western plains, the ambient temperatures were higher (14-43°C) and RH remained much lower (38-78%) during the storage period (Mehta et al., 2011). Storage in heap reduced the diurnal variation in temperatures and the atmosphere was quite stable inside the heap (Fig. 1). Maximum temperatures inside the heap were lower by 2.9-4.7°C as compared to the ambient atmosphere at the three locations. Ambient temperatures ranged between 24.3-33.9°C at Bhubaneswar, 21.2-35.9°C at Kalyani and 17.8-32°C at Jorhat, whereas corresponding temperature inside the heaps were recorded as 27.5-33.5°C, 21.1-31.3°C and 19.8-27.9°C.
Fig. 1. Mean temperatures (T) in heap and the ambient (Amb) during March to June (SMW 9-21) at three locations.
Mean RH was higher (by 1-9%) in the heap as compared to ambient at the three locations (Fig. 2). Ambient RH ranged between 53-92.8% at Bhubaneswar, 72-97.6% at Kalyani and 65-90.6% at Jorhat, whereas corresponding humidity of 60.3-93.5%, 82.7-98.5%, and 72.8-95.3% were recorded inside the heaps.

**Sprouting and storage losses in potatoes**

Tubers showed differences in dormancy. Sprouting in control (untreated) potatoes differed significantly with respect to location with minimum mean sprouting recorded at Bhubaneswar. Sprouting in control potatoes was much delayed at all the locations (Table 1) as compared to North-western plains where 100% sprouting was recorded after 75 days of storage in heaps (Mehta et al., 2011). Slight reduction in sprouting at 90 days vis-à-vis 75 days (CIPC Jorhat) might be due to sprout breakage. Similarly, in case of Control (Jorhat) the slight reduction in rotting might be due to the fact that data were recorded in separate replicated bags at 75 and 90 days of storage and the variation in rotting depends upon tuber size. Higher rotting in Bhubaneswar vis-à-vis Jorhat was due to infiltration of rain water inside the heaps. The innate dormancy differences could be associated with physiological condition of tubers as influenced by growing conditions at different locations (Lewis et al., 1997). Sprouting was further inhibited with CIPC treatment with maximum reduction (94.5%) in number of sprouted tubers at Kalyani after 90 days of storage. Data confirmed the sprout inhibition efficiency of CIPC under heap storage in North-Western plains (Mehta et al., 2010; 2011).

Losses due to rotting and total weight loss were minimum at Jorhat and maximum at Bhubaneswar at 90 days of storage due to infiltration of rain water inside the heaps. Sprouting, rotting and total weight loss in potatoes was significantly reduced in CIPC treated heaps as compared to the control. Though high rotting in tubers (40.5%) resulting in higher total losses (51.5%), were recorded at 90 days at one location (Bhubaneswar), total weight loss (evaporative + respiratory + pathological + sprout loss) remained significantly reduced (by 45-47%) in CIPC treated heaps as compared to control at other two locations. Nevertheless, even untreated (control) potatoes, when raised following recommended pre and post harvest measures, could be safely stored in heaps up to 75 days with acceptable total losses (<10%), the level of loss considered to be the threshold at which potato tubers loose marketing value.

<table>
<thead>
<tr>
<th>Location (L)</th>
<th>Treatment (T)</th>
<th>Sprouting (%)</th>
<th>Rotting (%)</th>
<th>Total weight loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage days (S)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kalyani (WB)</td>
<td>CIPC</td>
<td>1.0</td>
<td>2.3</td>
<td>0.77</td>
</tr>
<tr>
<td>Control</td>
<td>3.5</td>
<td>42.0</td>
<td>3.00</td>
<td>16.00</td>
</tr>
<tr>
<td>Jorhat (Assam)</td>
<td>CIPC</td>
<td>20.0</td>
<td>18.7</td>
<td>0.50</td>
</tr>
<tr>
<td>Control</td>
<td>22.6</td>
<td>23.7</td>
<td>2.80</td>
<td>2.00</td>
</tr>
<tr>
<td>Bhubaneswar (Odisha)</td>
<td>CIPC</td>
<td>1.0</td>
<td>1.0</td>
<td>3.96</td>
</tr>
<tr>
<td>Control</td>
<td>1.5</td>
<td>7.8</td>
<td>4.13</td>
<td>*42.00</td>
</tr>
<tr>
<td>CD (0.05)</td>
<td>L=1.76; S=1.46; T=1.46; LxSxT=3.80</td>
<td>L=3.01; S=2.46; T=2.46; LxSxT=6.03</td>
<td>L=2.16; S=1.78; T=1.78; LxSxT=4.33</td>
<td></td>
</tr>
</tbody>
</table>

*Higher rotting in potatoes was due to infiltration of rain water.
Fig. 2. Mean relative humidity (RH) in heap and the ambient (Amb) during March to June (SMW 9-21) at three locations.
On-farm heap storage of potatoes

(Burton, 1989). When weight losses exceed 10%, tubers become increasingly flaccid and unacceptable for marketing as they result in high peeling losses (Booth and Shaw, 1981). Potatoes with less than 10% weight loss do not suffer sufficient moisture loss to affect tissue turgor, and consequently, these can be sold for prices comparable to tubers from refrigerated cold stores (Mehta and Ezekiel, 2010). Higher losses (19.8%) have however been reported in cv. Kufri Jyoti up to 75 days of storage at room temperature in Modipuram (Kumar and Minhas, 2003).

Processing quality of potatoes

Initial (0 day) reducing sugar concentration in potatoes was low (66-104 mg/100g fresh weight) at the three locations. While higher contents (151-211 mg/100 g fresh weight) are earlier reported in Kufri Jyoti raised in North-western plains (Mehta et al., 2011), due to increased invertase activity under low temperature conditions (<10°C) during the crop growth, particularly in the months of December and January (Marwaha, 1998). Significant differences in reducing sugar contents were recorded between different locations with minimum contents at Jorhat and maximum at Bhubaneswar (Table 2). Environmental and cultural factors are reported to affect the resulting sugar accumulation in freshly harvested tubers (Sowokinos, 1973). Trend of changes in reducing sugar contents during storage also differed at different locations. The contents in CIPC treated tubers decreased during storage at Kalyani and Jorhat and remained at par in Bhubaneswar. The decrease could be due to the reconditioning effect of high temperature under heap storage compared to refrigerated storages. Higher rates of starch resynthesis and respiration during high temperature storage are responsible for this decrease (Hughes and Fuller, 1984). Reduction in reducing sugar contents in heaps is reported earlier also (Mehta et al., 2010; 2011).

The level of reducing sugars in potato tuber is an important factor affecting the colour of processed products (Roe et al., 1990) due to Maillard reaction with free amino acids at higher frying temperatures (Habib and Brown, 1957). The contents of reducing sugars should be below 0.2% of tuber fresh weight for producing acceptable quality chips while for French fries the upper limit may be as high as 0.5% (Ezekiel et al., 2003b). The contents in treated/untreated tubers after storage remained well within the acceptable limits (less than 150 mg/100 g fresh weight) at all locations (Table 2).

Table 2. Processing quality of potatoes stored in heaps at three locations.

<table>
<thead>
<tr>
<th>Location (L)</th>
<th>Treatment (T)</th>
<th>¹Reducing sugar</th>
<th>²Sucrose</th>
<th>³Chip colour score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0  75  90</td>
<td>0  75  90</td>
<td>0  75</td>
<td>0  75  90</td>
</tr>
<tr>
<td>Kalyani (WB)</td>
<td>CIPC</td>
<td>94.4 122.3 72.9</td>
<td>225.1  515.5 312.0</td>
<td>5.25  5.38 4.75</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>94.4  87.6 53.2</td>
<td>225.1  347.7 332.0</td>
<td>5.25  4.38 4.63</td>
</tr>
<tr>
<td>Jorhat (Assam)</td>
<td>CIPC</td>
<td>66.5  79.8 45.9</td>
<td>275.5  480.8 242.5</td>
<td>6.00  3.63 2.88</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>66.5 108.9 123.1</td>
<td>275.5  378.2 399.0</td>
<td>6.00  4.75 4.88</td>
</tr>
<tr>
<td>Bhubaneswar (Orissa)</td>
<td>CIPC</td>
<td>103.8  89.7 108.6</td>
<td>252.1 239.9 352.0</td>
<td>4.50  5.75 3.63</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>103.8  96.1 126.6</td>
<td>252.1 223.4 346.8</td>
<td>4.50  4.13 4.63</td>
</tr>
<tr>
<td>CD (0.05)</td>
<td>L=3.28; S=3.28; T=2.68; LxSxT=8.35</td>
<td>L=11.93; S=11.93; T=9.84; LxSxT=29.23</td>
<td>L=0.21; S=0.21; T=0.18; LxSxT=0.51</td>
<td></td>
</tr>
</tbody>
</table>

¹mg/100g fresh weight)
²On a 1-10 scale of increasing dark colour, chip colour score up to 4.0 was acceptable
Sucrose concentration increased during storage in treated and untreated tubers at all the locations (Table 2) due to the inhibition of invertase activity or synthesis of invertase inhibitor at higher temperature (Uppal and Verma, 1990). Though sucrose is not directly involved in Maillard reaction, it can serve as a substrate for reducing sugar production via the storage activated invertase enzyme (Pressey, 1969). The CIPC treatment did not show any consistent effect on reducing sugar and sucrose concentration of stored potato tubers.

Colour of fresh fried chips before storage was unacceptable at all the locations. Chip colour improved during storage and was highly acceptable in CIPC treated potatoes stored at Jorhat and Bhubaneswar and slightly dark at Kalyani, where they can be used in French fry Industry or in cottage industry for chips. The lighter chip colour after storage in heaps v/s before storage is in agreement with earlier research (Mehta et al., 2010; 2011).

CONCLUSION

Results suggest a great potential for heap storage of potatoes in Eastern plains to get remunerative prices and for glut crisis management, for which evaluations on large scale are needed. The findings have great significance as the farmers can store their produce on-farm for short periods in near sprout free condition to get remunerative prices. The profits can be higher if the potatoes are sold to a processing industry. The use of stored potatoes in cottage level industries for production of good quality fresh fried or dehydrated chips also has high prospects.

LITERATURE CITED


On-farm heap storage of potatoes


Sowokinos JR (1973) Maturation of *Solanum tuberosum* 1. comparative sucrose and sucrose synthetase levels between several good and poor processing varieties. *Am Potato J* **50**: 234-47


MS received: 12 October 2013; Accepted: 07 June 2014