STORABILITY AND SPROUTING BEHAVIOUR OF MICRO-TUBERS OF SOME INDIAN POTATO CULTIVARS

Ashwani K Sharma¹, EP Venkatasalam² and Vinod Kumar¹

ABSTRACT: Storability and sprouting behaviour of four grades of micro-tubers (large, medium, small and micro-tubers with burst lenticels) from six Indian potato cultivars was studied under following storage regime: refrigerated (4°C) conditions for 3 months followed by 2-week storage at 22±2°C and 2-weeks under ambient conditions (about 18°C). It was found that viability, sprouting percent; number of sprouts per micro-tuber as well as physiological loss in weight were affected significantly by the genotypes as well as by the size and physiological stage of micro-tubers. Increasing size of the micro-tuber resulted in a significant increase in the viability and sprouting ability of micro-tubers with reduced durations of dormancy and weight loss at the end of storage. Micro-tubers with burst lenticels were the least storable due to the weight loss and poor sprouting. The proportion of viable micro-tubers was the highest in Kufri Badshah (68.4%), followed by Kufri Surya and Kufri Bahar, whereas, percent sprouting was maximum (>96%) in Kufri Bahar and Kufri Badshah, closely followed by Kufri Anand and minimum in Kufri Pukhraj (81.6%). Dormancy duration varied between 99 days (Kufri Pukhraj) to 114 days (Kufri Chipsona 1). The best results were achieved by Kufri Badshah, whereas, Kufri Pukhraj showed the poorest storability with maximum loss in weight and viability of micro-tubers during storage.

KEYWORDS: micro-tubers, storability, sprouting, viability, burst lenticels, cultivars

INTRODUCTION

Production of healthy seed tubers in vegetatively propagated crop like potato is of utmost significance as seed alone accounts for about 40-50% of total cost of cultivation (Kumar et al., 2007). At present, the state and central seed production agencies of India are able to meet only 20-25% requirement of quality seed potatoes. For bridging this wide gap, large scale integration of conventional and innovative methods like micro-propagation at commercial level is needed (Pandey, 2006). Two alternative propagule types of potatoes can be produced from micro-culture; transplants derived from shoot cultures and micro-tubers. Micro-tubers are convenient to handle, can be transported over long distances and like in vitro plantlets don’t require hardening periods (Singh et al., 2007).

However, micro-tubers are very small tubers, generally weighing less than 1g and thus should be stored carefully while they are dormant. The storability of micro-tubers determines their future use. Only about 50% of the total micro-tubers produced can be utilized at the end for the production of mini-tubers in the nursery beds (Singh et al., 1994). One of the barriers to the efficient production and utilization of micro-tubers is the small size of the resultant propagules (Seabrook et al., 1993). Loss of micro-tubers largely depends on the size of micro-tuber with considerable loss in the smallest fraction of 2-4 mm (Tabori et al., 1999). Larger (>0.04 g) micro-tubers had higher rates of survival (71.4%) than the smaller ones (28.8%) and such large tubers can be produced by growing potato plantlets in liquid cultures (Leclerc et al., 1994), however, micro-tubers

¹Central Potato Research Station, Kufri, Shimla–171 012, Himachal Pradesh, India.
E-mail: ashwanicpri@gmail.com
²Central Potato Research Institute, Shimla–171 001, Himachal Pradesh, India.
from liquid cultures do not store well and tend to be very soft with open lenticels. For micro-tubers, timing of sprouting after natural breaking of dormancy can be critical for good emergence and early development. So, it is very important to obtain micro-tubers with predictable dormancy, because breaking of their dormancy can be a problem (Garner and Blake, 1989).

Available information on micro-tuber dormancy is contradictory. Micro-tubers have been reported to exhibit no dormant period (Hussey and Stacey, 1981); germinate prematurely in vitro (Harvey et al., 1991) or have dormant periods of 1 to 7 months (Thieme, 1992). Although several authors have reported that the length of dormancy decreases with an increase of tuber size (Lommen and Struik, 1990; Leclerc et al., 1995), but, Tabori et al. (1999) could not find any significant differences in the dormancy duration between different size-groups of micro-tubers. Moreover, van Ittersum (1992) found that the relation between dormancy and tuber weight can be cultivar dependent. Length of dormancy is cultivar specific (Ranalli et al., 1994a) and it can be affected by environmental conditions during growth and storage, although Bottini et al. (1982) found that the tuber dormancy was relatively un-sensible to environmental influence. The number of sprouts is affected by the size of tuber and larger micro-tubers produce more stems. According to Tabori et al. (1999) differences in the number of sprouts per micro-tuber could be due to the differences in the physiological age of tubers.

Considering the fact that no information is available on the storability and sprouting behaviour of Indian potato cultivars and contradictions exists in the literature regarding the dormancy and sprouting behaviour of micro-tubers, the present work was undertaken to study the storability and sprouting behaviour of micro-tubers of some potato varieties, which are commercially important in Indo-Gangetic plains. Such information will be of great help in the advance planning for production of healthy seed potatoes by predicting the anticipated losses in micro-tubers of different potato cultivars.

MATERIALS AND METHODS

Shoot cultures of six potato cultivars (Kufri Anand, Kufri Badshah, Kufri Bahar, Kufri Chipsona-1, Kufri Pukhraj and Kufri Surya) were produced using 10 double node segments in 250 ml capacity conical flasks containing 25 ml of MS (Murashige and Skoog, 1962) liquid media under aseptic conditions. These flasks were kept in the culture room under 16 h photoperiod of 3000-4000 lux light using standard florescent tubes (40 watts), at day and night temperatures of 22 ± 2°C, for 25-28 days until sufficient multi-nodal shoots were formed for mass-tuberization.

The experiment was conducted at Central Potato Research Institute, Shimla, HP, India, during 2007 and 2008; in completely randomized block design (CRD) with 4 replications in each genotype. Each replication consisted of 3-flasks. The four replications in each genotype were placed in four different racks/benches representing four locations of height.

After 28 days, culture medium was replaced with 35 ml of tuber induction medium (MS basal salts and vitamins supplemented with 10 mg/1 benzyladenine (BAP) and 8% sucrose at 5.8 pH) per flask under sterile conditions and micro-tubers were induced by incubating the cultures under continuous darkness at 16 ± 1°C for 70 days. Before harvest, greening of micro-tubers was done by keeping flasks under 16 hour photoperiod at 22 ± 1°C for one week. The harvest of different flasks was bulked replication-wise before grading of micro-tubers into four grades viz., large (>300 mg), medium
(100-300 mg), small (<100 mg) and micro tubers with burst lenticels. Micro-tubers were rinsed with water to remove any excess sugars and salts, and shade dried on soft sterile tissue paper for 24 hrs. Surface dried micro-tubers of all the six genotypes were packed grade and replication-wise in perforated polythene bags with 0.5% venting area. Uniform sample (10 g) was taken in each replication for storage studies. Polythene bags containing micro-tubers were kept inside a perforated thin cardboard box which was immediately stored in a refrigerator under continuous darkness at a temperature of 4°C and relative humidity of 85-90%, for three months. After three months, micro-tubers were shifted to incubation (culture) room at a temperature of 22 + 2°C for 2 weeks followed by storage for 2-weeks at room temperature (about 18°C) for sprouting.

Data were collected separately for all grades of micro-tubers. Physiological loss in weight (%) at 15 days interval starting from the first day of storage in refrigerator (4°C) up to 90 days was recorded. Dormancy duration (when 50% of micro-tubers had started sprouting), proportions of viable micro-tubers, sprouting percent and number of sprouts per micro-tuber at the end of storage were also observed. The average of two years data was analyzed statistically by analysis of variance (ANOVA) as described by Gomez and Gomez (1984). Mean values were calculated and separated using F-test at 5% level of significance.

RESULTS AND DISCUSSION

Viability

Viability of micro-tubers was affected significantly by the size of micro-tuber as well as by the potato genotypes. A gradual increase in the viability was observed with the increasing size of micro-tubers as only about half (50%) of the micro-tubers were found viable in small grade, while the viability was about 70 and 80% in medium and large micro-tubers, respectively (Table 1). Earlier authors have also reported similar findings (Singh et al., 1994; Tabori et al., 1999). Such response can be attributed to the increased susceptibility of smaller micro-tubers to low temperatures during storage due to their immature state (Tabori et al., 1999), as well as to the excessive exhaustion of food reserves in small tubers on account of longer storage intervals. Proportions of viable micro-tubers at the end of storage was the highest (68.4%) in Kufri Badshah and the lowest (26.5%) in

<table>
<thead>
<tr>
<th>Variety</th>
<th>Large</th>
<th>Medium</th>
<th>Small</th>
<th>Burst lenticels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kufri Anand</td>
<td>84.6</td>
<td>73.1</td>
<td>49.7</td>
<td>14.7</td>
<td>55.5</td>
</tr>
<tr>
<td>Kufri Badshah</td>
<td>92.4</td>
<td>87.5</td>
<td>67.6</td>
<td>26.4</td>
<td>68.4</td>
</tr>
<tr>
<td>Kufri Bahar</td>
<td>85.6</td>
<td>75.7</td>
<td>62.5</td>
<td>30.1</td>
<td>63.5</td>
</tr>
<tr>
<td>Kufri Chipsona-1</td>
<td>73.9</td>
<td>67.9</td>
<td>55.5</td>
<td>14.0</td>
<td>52.8</td>
</tr>
<tr>
<td>Kufri Pukhraj</td>
<td>54.6</td>
<td>39.6</td>
<td>11.2</td>
<td>0.8</td>
<td>26.5</td>
</tr>
<tr>
<td>Kufri Surya</td>
<td>88.9</td>
<td>74.4</td>
<td>54.9</td>
<td>41.5</td>
<td>64.9</td>
</tr>
<tr>
<td>Mean</td>
<td>80.0</td>
<td>69.6</td>
<td>50.2</td>
<td>21.2</td>
<td></td>
</tr>
</tbody>
</table>

CD (0.05) Variety (V) 0.9
Grade (G) 0.8
V x G 1.9

Table 1. Proportions of viable micro-tubers in different grades after 120 days storage.

Large micro-tubers (>300 mg), medium (100-300 mg), small (<100 mg)
Kufri Pukhraj, which can be attributed to the better quality of micro-tubers with intact lenticels in Kufri Badshah and vice-versa in Kufri Pukhraj.

**Dormancy duration**

Dormancy duration of micro-tubers was also influenced significantly by genotypes as well as by the size of micro-tubers. A gradual increase in the dormancy duration with the decreasing size of micro-tubers was observed (Table 2). These results are in close conformity with the findings of earlier workers (Lommen and Struik, 1990; Seabrook et al., 1993; Ranalli et al., 1994a; Leclerc et al., 1995). Dormancy duration for large, medium and small micro-tubers was found to be 105, 110 and 115 days, respectively. Micro-tubers with burst lenticels had the minimum dormancy duration of 97 days. Reduced dormancy duration in micro-tubers with burst lenticels may be due to the increased biochemical activities of tubers, which resulted in behaviour similar to the conventional tubers with physical injury. Among the potato varieties, maximum duration of dormancy of 114 and 112 days in Kufri Chipsona 1 and Kufri Surya, respectively and minimum in Kufri Pukhraj (99 days) can be attributed to specific genotypic behaviour of these cultivars. Das et al. (2004) have also observed significantly long dormancy duration in Kufri Chipsona 1 than Kufri Pukhraj and Kufri Badshah during storage under room temperature. Various other workers have also reported that the dormancy period of micro-tubers is influenced by the cultivar (van Ittersum, 1992; Leclerc et al., 1995; Tabori et al., 1999). A similarity in the micro-tuber dormancy duration of cultivars to the normal tuber dormancy periods in a cultivar specific manner has already been known to exist (Leclerc et al., 1995; Tabori et al., 1999).

**Sprouting behaviour (sprouting percent and No. of sprouts per micro-tuber)**

The statistical analysis of the data on sprouting percent and number of sprouts per micro-tuber reveals significant differences in the sprouting behaviour of micro-tubers of different sizes and genotypes (Tables 2 and 3). The rate of sprouting and number of sprouts per micro-tuber showed a gradual increase with the increasing size of micro-tubers. Sprouting was maximum (98.8%) in large micro-tubers, 85% in medium, 83.9% in small micro-tubers and was minimum (73.7%)

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**Table 2. Dormancy duration and percent sprouting in different grades of micro-tubers.**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Dormancy duration (no. of days after harvest)</th>
<th>% Sprouting in viable micro-tubers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Large</td>
<td>Medium</td>
</tr>
<tr>
<td>Kufri Anand</td>
<td>105</td>
<td>110</td>
</tr>
<tr>
<td>Kufri Badshah</td>
<td>107</td>
<td>110</td>
</tr>
<tr>
<td>Kufri Bahar</td>
<td>98</td>
<td>105</td>
</tr>
<tr>
<td>Kufri Chipsona-1</td>
<td>114</td>
<td>117</td>
</tr>
<tr>
<td>Kufri Pukhraj</td>
<td>98</td>
<td>104</td>
</tr>
<tr>
<td>Kufri Surya</td>
<td>110</td>
<td>112</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>105</td>
<td>110</td>
</tr>
</tbody>
</table>

**CD (0.05)**

| Variety (V) | 1.8 |
| Grade (G)   | 1.5 |
| V x G       | 3.7 |

Large micro-tubers (>300 mg), medium (100-300 mg), small (<100 mg)
Storage and sprouting behaviour of potato micro-tubers

in micro-tubers with burst lenticels. Among the cultivars, sprouting percent was maximum in Kufri Bahar (97.6%), closely followed by Kufri Badshah (96.2%) and minimum in Kufri Pukhraj (65.5%). Number of sprouts per micro-tuber also showed a trend similar to the sprouting potential. It were maximum (1.5) in large micro-tubers, followed by medium micro-tubers (1.2 sprouts/tubers) and were minimum in small grade and in micro-tubers with burst lenticels (Table 3). Among the cultivars, the number of sprouts/micro-tuber were maximum in Kufri Bahar and Kufri Badshah (1.3/tuber) and minimum in Kufri Anand and Kufri Surya (1.1/tuber). Das et al. (2004) have also reporeted significant differences in the number of sprouts per tuber among different potato cultivars during storage of tubers at ambient conditions of eastern Indian plains. The potato varieties and size of micro-tuber interacted significantly for sprouting per cent as well as for number of sprouts per micro-tuber.

Higher rate of sprouting in larger micro-tubers may be attributed to the decreased duration of dormancy, however, increasing number of sprouts with the increasing size of micro-tuber can be attributed to the more number of eyes in large micro-tubers with larger surface area. Significantly higher sprouting percent as well as more number of sprouts per micro-tuber in Kufri Bahar and Kufri Badshah, and minimum in Kufri Chipsona 1 and/or Kufri Surya can be attributed to the specific genotypic responses as well as to their corresponding durations of dormancy. The results are in close conformity with the findings of Tabori et al. (1999), who have also reported early and higher sprouting with more number of sprouts in larger micro-tubers than smaller ones, while, Vecchio et al. (2000) have reported that sprouting was influenced by potato varieties under different culture conditions.

Significant interactions between potato varieties and size of micro-tubers found in the present study for dormancy, viability, sprouting percent and number of sprouts per micro-tuber show that all these characters of different grades of micro-tubers were affected significantly by potato genotype.

Physiological loss in weight (PLW)

The observations recorded during refrigerated storage (4°C) of micro-tubers on the physiological loss in weight (PLW) in different grades of micro-tubers of different genotypes revealed significant differences in all the grades of each potato cultivar at all the storage intervals (Fig. 1 (a-d) and Table 3). A gradual increase in PLW was noticed in all the grades and varieties with the increasing storage intervals as well as with the decreasing size of the micro-tubers. Among varieties, PLW was the least in Kufri Surya and the highest in Kufri Pukhraj in all the grades of micro-tubers. Significantly higher PLW in Kufri Pukhraj than Kufri Chipsona 1 as observed in the present study has also been reported to occur during storage of tubers of these cultivars at room temperature (Kumar et al., 2005).

Gradual and consistent weight loss in all the grades of micro-tubers commensurate with advancing storage period observed in the present study is obvious and can be attributed to the degradative and natural senescence due to respiration and other metabolic processes in the living tissues of micro-tubers during storage. Significantly higher physiological loss in weight of small micro-tubers and a gradual decrease in weight loss with increasing size of micro-tubers noticed in the present study can be attributed to the larger surface area per unit weight as well as to the immature state of smaller micro-tubers than larger ones. Higher weight loss in small micro-tubers than large ones have already been reported by earlier
Fig. 1 (a-d): Physiological loss in weight (PLW) in different grades of micro-tubers at fortnightly intervals during storage at 4°C.

CD (0.05)
Variety (V) 0.4 0.3
Interval (I) 0.4 0.3
V x I 0.9 0.7
Storage and sprouting behaviour of potato micro-tubers

Significantly more weight loss in Kufri Pukhraj in all the grades of micro-tubers may be due to the more openings of lenticels than other varieties, whereas, the minimum weight loss in Kufri Surya may be due to better integrity of skin tissues of this genotype. Poor storability of micro-tubers produced in liquid culture on account of their extra softness and open lenticels have also been reported to occur (Leclerc et al., 1994).

Significant interactions for weight loss between the potato varieties and storage intervals reveal that the extent of weight loss varies significantly among the potato varieties at the same and different storage intervals.

CONCLUSIONS

It can be concluded, that attempts should be made to increase the size of micro-tubers in order to reduce their storage losses as the larger the micro-tuber the better is its viability, sprouting characters and storability. Moreover, significant differences among the cultivars for these characters reveal the need to study the storage and sprouting behaviour of micro-tubers of each genotype and to modify the induction media resulting in heavy losses. The poorest performance of Kufri Pukhraj during the present study necessitates the improvement of tuber induction medium for this potato cultivar for reducing the excessive loss of micro-tubers during storage.

LITERATURE CITED


Table 3. Number of sprouts and physiological loss in weight (PLW) in different grades of micro-tubers after 120 days of storage.

<table>
<thead>
<tr>
<th>Variety</th>
<th>No. of sprouts/micro-tuber</th>
<th>PLW (%) after 120 days of storage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Large</td>
<td>Medium</td>
</tr>
<tr>
<td>Kufri Anand</td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>Kufri Badshah</td>
<td>1.7</td>
<td>1.3</td>
</tr>
<tr>
<td>Kufri Bahar</td>
<td>1.9</td>
<td>1.4</td>
</tr>
<tr>
<td>Kufri Chipsona-1</td>
<td>1.5</td>
<td>1.1</td>
</tr>
<tr>
<td>Kufri Pukhraj</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>Kufri Surya</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Mean</td>
<td>1.5</td>
<td>1.2</td>
</tr>
</tbody>
</table>

CD (0.05) Variety (V) 0.05
Grade (G) 0.04
V × G 0.10

Large micro-tubers (>300 mg), medium (100-300 mg), small (<100 mg)


Van Ittersum MK (1992) Variation in the duration of tuber dormancy within a seed potato lot. *Potato Res* 35: 261-69


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