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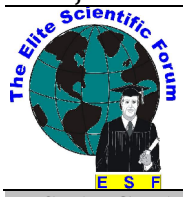

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RESEARCH ARTICLE

A Study on Root Growth of Onion (*Allium cepa* L.) Under Storage Conditions

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ABSTRACT
A study was conducted under storage conditions to examine root growth pattern of three onion bulb sizes (small, medium and large) of cultivar Swat-I as influenced by different durations of field curing (0, 3, 6, 9, 12, and 15 days) and root burning vs non-burning treatments. Bulbs cured for different durations produced 17.75 to 30.90% roots in 90 days of storage whereas different bulbs sizes showed 21.47 to 26.68% of root growth. It was also observed that burning of roots of bulbs prior to storage resulted in decrease in root growth. On the other hand, bulbs after 105 days of storage showed higher percentage of fresh root growth such as maximum percentage of root growth was found after 15 days of field curing and the root growth decreased linearly with the decrease in field curing time. About 45.40 to 60.36% of bulbs showed root growth in three different sizes. Burning roots resulted in less root growth than non-burnt bulbs after 105 days of storage. This native method has been emerged as low-cost, non-hazardous one, which can be recommended at local community level.

INTRODUCTION

One of the most simple and effective way to reduce water loss and decay during post harvest storage of onion is curing. Field curing is a common practice when onion bulbs are placed on mats in the field after harvest to get them dried for 5-10 days (depending on ambient temperature) before topping (Valenzuela, 1999). If such method (field curing) is not practiced then onion bulbs' shelf-life would be substantially decreased. After curing, onion bulbs are generally stored in warehouses or storage rooms where temperature and humidity is controlled to prevent roots and shoots initiation (Gopalakrishnan, 2007).

It is observed that the quality of marketable onion bulbs (including weight loss) decreased by 12-25% per month when stored at room temperature (Smittle, 1988). Working on the environmental factors which affect rooting and sprouting of onion bulbs, Mandel and Pramank (1992) suggested that bulbs should be kept at low temperature (<15°C) and low RH (50-70%). Similarly, findings of Garcia and Reyes (1985) revealed that onion cultivar Santa Cruz can be stored at 10-25°C with RH of 50-80% for 286 days however 77-80% bulbs were sprouted after this duration when stored at 25°C. Comparing the effects of different temperatures on rooting and sprouting characteristics of onion bulbs, Salama and Hicks (1987) observed that the percentage of both variables was highest when onion bulbs were stored at 15°C whereas bulbs stored at 0°C and 30°C showed minimum percentage of sprouting and rooting. Similarly, Yoo et al. (1989) suggested that the most desirable onion bulbs storage temperature should be 13-20°C for 4-6 weeks of storage.

Storage quality of onion bulbs can be improved by standardizing the curing time, controlling the temperature and adjusting cultural practices (Chang et al. 1987). It is reported that the total weight loss percentage of onions is positively correlated with thick neck, bulb diameter, weight loss, sprouting and decaying (Path and Kale, 1984). Similarly, maximum post harvest weight loss of onion bulbs was observed after 50-90 days of storage at temperature of 3±1°C and 75-85% RH (Khurana and Singh, 1984). Studying same dimensions, El-Emery (1987) reported that onion cultivars Aroma and Alsogodi can be stored at 0±1°C and 95% RH with minimum post harvest losses. Similarly, Rajapaksi et al. (1992) observed that onion cultivar Texas Grano had the lowest total weight loss (30%) while cultivars Selection-1438 and Burgandi lost <35% after 100 days.

However, many farmers of Pakistan can not install such storage structures due to high input costs and low return of their produce. Therefore, it is needed to find out other technique to increase shelf-life of onions. It comes to our knowledge that now-a-days in many villages of Pakistan a practice is gaining attention i.e. burning of roots and neck of onion bulbs to minimize post harvest storage losses. This practice is carried out to slow down the process of bulbs sprouting and emergence of roots which eventually increases the storage life of onions (Baloch et al. 2000). The assumption drawn through root and neck burning practice is that most of the active and viable root and shoot cells are burnt during the process therefore their emergence is delayed. No mentionable scientific literature is available on the root emergence response of field curing duration, bulb sizes and root burning technique on onion shelf-life. Therefore, a research study was designed to find out an appropriate duration of field curing of different bulb sizes with or without root burning technique to minimize root growth and to enhance onion shelf-life under ambient environmental conditions.

MATERIALS AND METHODS

Onion bulbs of variety Swat-I were grown under sub-tropical climatic conditions and the whole crop received same cultural practices as recommended for this area. Onion bulbs were harvested at right stage after attaining the physiological maturity and were left in the field for curing for following periods:

T_1 Without Field Curing (Control).
T_2 Field Curing (Sun drying) for 3 days.
T_3 Field Curing (Sun drying) for 6 days.
T_4 Field Curing (Sun drying) for 9 days.
T_5 Field Curing (Sun drying) for 12 days.
T_6 Field Curing (Sun drying) for 15 days.

Bulbs in T_1 were shifted to the storage room just after harvesting without curing. Rest of the crop was transferred after giving them respective field curing periods needed for each treatment as mentioned above. Onion bulbs before being transferred to the storage room, were graded into three standard sizes, i.e. small (diameter of up to 3 cm horizontally), medium (diameter 3-6 cm) and large (diameter above 6 cm) by using 'Manual Hand Grader'. All the graded bulbs were sub-divided into two lots to assign the sub-treatments i.e. root burning and non root burning (control). Before shifting the bulbs to storage room, roots of the bulbs of one lot (100 bulbs in each grade) were burnt by keeping them on a hot iron plate (120±2°C) for five seconds whereas the other lot (100 bulbs in each grade) was left non-burnt. The experiment was laid out on 3-factor Completely Randomized Design with three replicates in each treatment. In factor-A the duration of field curing, in factor-B different bulb sizes and in factor-C root burning and non-burning factors were studied. Data was subjected to analysis of variance using SAS statistical software (SAS Institute Inc. North Carolina, USA) to determine whether the treatments effects were significant. The treatment means were separated using the least significant differences (LSD) test at 5% probability level. Percentage of root growth was calculated as:

$$\text{Root growth (\%age)} = \frac{\text{Number of bulbs initiated roots in each grade}}{100}$$

RESULTS AND DISCUSSION

Onion root growth after 90 days of storage: A significant ($P<0.001$) difference was observed among durations of field curing (0, 3, 6, 9. 12 and 15 days) regarding onion bulbs root growth. Minimum onion bulbs (17.75%), which were cured for 6 and 9 days produced roots after 90 days of storage, whereas maximum number of bulbs (30.90%) initiated roots which were cured for 3 days (Fig. 1). However, there was a non-significant ($P<0.005$) difference among three bulb sizes regarding root growth parameter i.e. 26.68% large sized bulbs, 21.47% medium and 21.67% small sized bulbs produced roots. Interaction of field curing and bulb size showed significant ($P<0.001$) difference regarding root growth parameter. Maximum number of large sized bulbs (33.90%) produced roots with no curing (control) whereas minimum number of medium sized bulbs (10.32%) and small sized bulbs (13.77%) produced roots when cured for 9 days. Root growth of onion bulbs cured for different time intervals and subjected to root burning treatment is shown in Fig. 2. Effect of curing durations was significant ($P<0.001$) on root growth. Maximum number of bulbs (29.48%) emerged roots when cured for 15 days followed by bulbs in control treatment (28.04%) followed by bulbs cured for 3 days (26.05%). However, bulbs cured for 9 days showed minimum root growth (13.31%) followed by bulbs cured for 6 days (16.73%). Root growth of non-burnt bulbs is presented in Fig. 3 which showed a significant ($P<0.001$) effect of field curing duration. Maximum number of bulbs (35.73%) produced root growth when cured for 3 days while minimum number of bulbs (20.31%) initiated root growth when cured for 6 days. There was a non-significant ($P<0.005$) effect of field curing duration on bulb sizes. However, the interaction of curing duration and bulb sizes was statistically significant ($P<0.001$) and minimum number of small and medium sized bulbs (12.31%) produced roots after 9 days of curing. Similarly, Fig. 4 showed that the root growth of bulbs significantly ($P<0.001$) affected by root burning treatment after 90 days of storage. It was observed that the root growth of bulbs cured up 12 days and received root burning treatment was decreased linearly from 24 to 17% whereas a decrease of 28 to 23% was noticed in non-burning treatment.

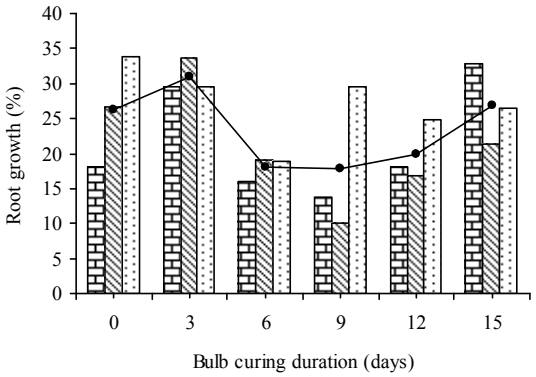

Fig. 1: Percent root growth as influenced by different field curing durations (0, 3, 6, 9, 12, and 15 days) and bulb sizes (small sized, brick bars; medium sized, diagonal lines bars; and large sized, dotted bars) after 90 days of storage. Line graph (●) represents the average root growth percentage of three bulb sizes.

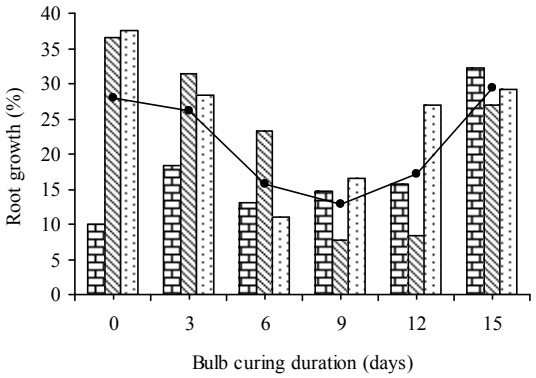

Fig. 2: Percent root growth, after burning the roots before storage, as influenced by different field curing durations (0, 3, 6, 9, 12, and 15 days) and bulb sizes (small sized, brick bars; medium sized, diagonal lines bars; and large sized, dotted bars) after 90 days of storage. Line graph (●) represents the average root growth percentage of three bulb sizes.

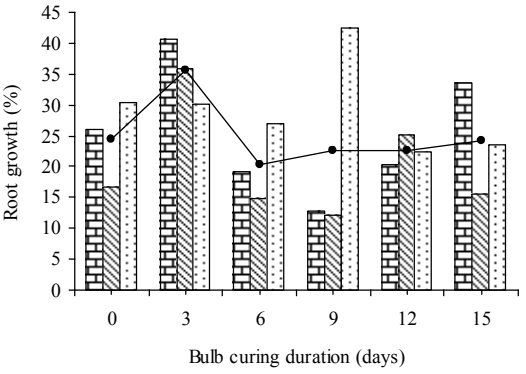

Fig. 3: Percent root growth, left non-burnt at the time of storage, as influenced by different field curing durations (0, 3, 6, 9, 12, and 15 days) and bulb sizes (small sized, brick bars; medium sized, diagonal lines bars; and large sized, dotted bars) after 90 days of storage. Line graph (●) represents the average root growth percentage of three bulb sizes.

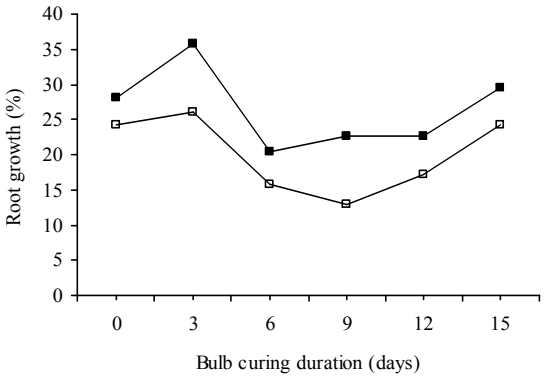

Fig. 4: Percent root growth as affected by root burnt (□) and non-burnt (■) treatments at different field curing durations (0, 3, 6, 9, 12, and 15 days) after 90 days of storage.

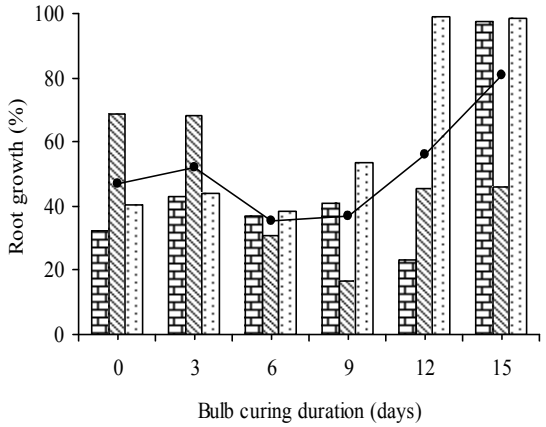

Fig. 5: Percent root growth as influenced by different field curing durations (0, 3, 6, 9, 12, and 15 days) and bulb sizes (small sized, brick bars; medium sized, diagonal lines bars; and large sized, dotted bars) after 105 days of storage. Line graph (●) represents the average root growth percentage of three bulb sizes.

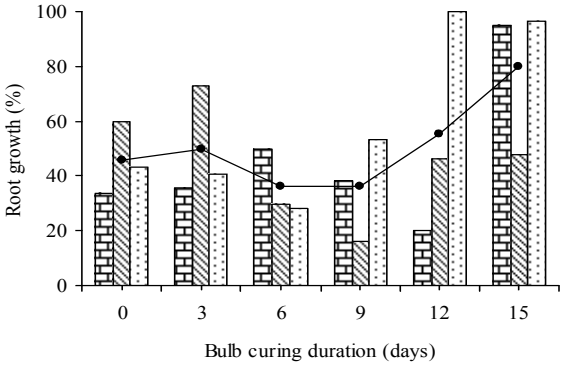

Fig. 6: Percent root growth, after burning the roots before storage, as influenced by different field curing durations (0, 3, 6, 9, 12, and 15 days) and bulb sizes (small sized, brick bars; medium sized, diagonal lines bars; and large sized, dotted bars) after 105 days of storage. Line graph (●) represents the average root growth percentage of three bulb sizes.

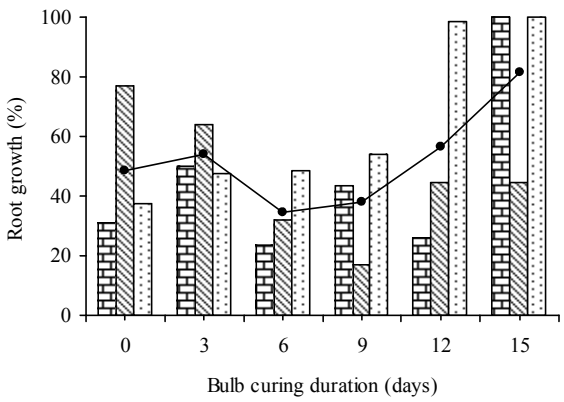

Fig. 7: Percent root growth, left non-burnt at the time of storage, as influenced by different field curing durations (0, 3, 6, 9, 12, and 15 days) and bulb sizes (small sized, brick bars; medium sized, diagonal lines bars; and large sized, dotted bars) after 105 days of storage. Line graph (●) represents the average root growth percentage of three bulb sizes.

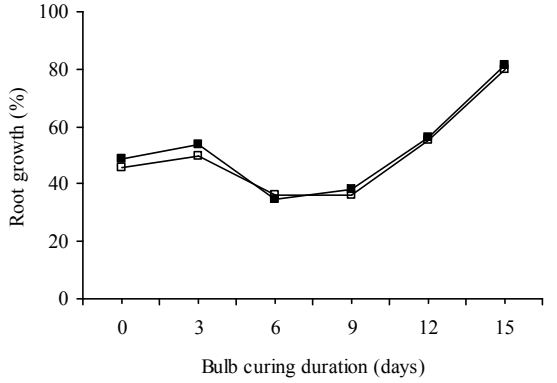

Fig. 8: Percent root growth as affected by root burnt (□) and non-burnt (■) treatments at different field curing durations (0, 3, 6, 9, 12, and 15 days) after 105 days of storage.

Onion root growth after 105 days of storage: Root growth of onion bulbs was significantly ($P<0.001$) affected by the duration of field curing (Fig. 5). Maximum number of bulbs (80.64%) initiated root growth when cured for 15 days in the field followed by 55.85% bulbs cured for 12 days. However, root growth was minimum in bulbs cured for 6 days in the field (35.53%). In contrast to 90 days storage studies, there was a significant ($P<0.001$) difference among three sizes of onion bulbs when stored for 150 days. Large sized bulbs showed maximum root growth (63.36%) as compared to medium (45.60%) and small sized bulbs (45.93%). These results are in-line with O'Connor (1979) who suggested that large sized and thick-necked onion bulbs should not be kept for storage because of the large proportion of organic matter, relative humidity and temperature increased around bulbs which subsequently leads to roots initiation. Similarly, Brice et al. (1997) reported that there was always more risk for root emergence and bulb decay in large sized bulbs due to higher water contents. Data regarding root growth of onion bulbs cured for different duration and received root burnt treatment before storage is presented in Fig. 6 which was statistically significant ($P<0.001$). Maximum number of bulbs initiated root growth (79.74%) when cured for 15 days in the field while minimum bulbs initiated root growth (35.96%) when cured for 9 days. Again large sized bulbs showed the highest root growth (60.36%) whereas small and medium sized bulbs produced 45.51 and 45.40% root growth, respectively. Bulbs cured for various durations and not received root burning treatment is given in Fig. 7 which showed significant ($P<0.001$) difference among means. Highest number of bulbs (81.54%) initiated root growth when cured for 15 days in the field followed by 56.27% bulbs cured for 12 days and 53.82% bulbs cured for 3 days. Onion bulbs (34.67%) cured for 6 days produced lowest root growth. As far as the bulb size is concerned, large sized bulbs (64.34%) showed maximum root growth whereas root growth in small (45.67%) and medium (46.46%) sized bulbs were statistically at par. It was observed that burning of roots did not cause significant ($P<0.005$) decrease in root growth after 105 days of storage i.e. 50.44% roots burnt bulbs produced roots whereas 52.16% bulbs which did not receive root burning treatment emerged roots (Fig. 8). The interaction reflected that in case of non-burnt root bulbs minimum root growth (34.67%) was observed after 6 days of curing, while it was maximum (81.54%) in 15 days cured bulbs. On the other hand, in root burnt case, minimum root growth (35.96%) was recorded in 9 days cured bulbs, closely related to 6 days of curing treatment (35.99%) while maximum (79.74%) root growth was observed in 15 days cured bulbs. In a non-traditional study Tanaka et al. (1996) reported that sprouting and root growth were inhibited and storage life was extended to a greater extent for onion cultivar 'Momiji No. 3' stored in the controlled atmosphere storage system with 1% O_2 and 1% CO_2 than for bulbs stored at room temperature under ambient conditions. I can be assumed that the storage life of short-stored cultivars might be prolonged by slow decline in ABA concentration (Chope et al. 2006). This could help to extend the period for supplying these onions from temperate regions. However, in present study a new and native method has been reported which is being traditionally used in local farming community but has not been scientifically tested. Therefore, it was concluded from present study that medium sized onion bulbs should be cured up to 9 days in the field prior to storage. Moreover, root burning technique can be applicable for medium sized bulbs up to 90 days of

storage which is not only significantly delayed root initiation but also is a nature friendly, economical and non-toxic method.

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