Journal of Applied Horticulture, 9(1): 37-40, January-June, 2007

Effect of cultivars on storage losses in onion under hot conditions

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Abstract

In Khuzestan (South Iran), onion bulbs are usually formed and harvested in spring and consumed either in the same season or during summer while some of these are kept for seed production. In order to study the losses in onion bulbs under hot store conditions, an experiment was conducted in autumn 2002 and spring 2003. The data were collected on five cultivars being produced at Shahid Chamran University, two local cultivars and three of those under commercial cultivation. The collected bulbs were kept in 30 x 50cm boxes, 15 cm in height. The experiment was replicated three times in completely randomized design. Data on change in number, weight of the healthy bulbs and decayed bulbs were recorded every 15 days. No bulb root was produced during the storage when maximum, average and minimum temperature were 48, 33 and 25°C, respectively with the average relative humidity (RH) of 30%. As far as storage life was concerned, there was a significant difference among the varieties. Compared to both the local and market bulbs, those produced at Shahid Chamran University showed more storage life. Another important finding of this research was that 50% of the local and university bulbs remained unspoiled after 120 days, whereas the Taxes Yellow Grano, Taxes Early Grano and G1 had the short storage life; 50% of the stock were destroyed after 60 days. In the present study, *Aspergillus niger* was found to be the most important factor responsible for onion decay in hot stores of Khuzestan.

Key words: *Allium cepa*, *Aspergillus niger*, cultivars, life storage, onion

Introduction

Onion is one of the strategic crop in Iran. Khuzestan province ranks fifth in producing onion with the average of 95514 tons per year. However, since there are no store-rooms equipped with temperature control system to keep vegetables in Khuzestan, the surplus produce is not harvested at the time of production; thus the products are kept under hot conditions.

Bulb is the edible part of the onion which naturally dormants after juvenile period under inappropriate environmental conditions (light, temperature, humidity and their interaction effects) and after some time, the bulbs start to grow. Unsuitable time for onion to grow is either hot summer or cold winter. Therefore bulbs are the reserved organs of the onion which are ready to keep the product for a long time (Brewster, 1994). Different studies have been carried out on the physiology of the onion dormancy and parameters such as changes in carbohydrate content of onion bulbs (Benkeblia and Shiomi, 2004; Grevsen and Sorensen, 2004 and Benkeblia *et al.*, 2005). The cultural management and harvest practices effectively influence the life of bulb in storage (Roos and Fouyer, 2005). Moreover, the diseases, sprouting or root production in the bulbs are the reasons of their short storage life (Lee *et al.*, 2004).

Temperature is most important parameter influenceing the storage period. The best temperature for sprouting of bulbs is between 10 to 15°C. Under this condition, the bulbs sprout faster than the other hot or cold treatments (Abdalla and Mann,1963). After sprouting, the leaves of the bulbs, which have been kept under 15 °C become longer and thus the leaves grow faster than those bulbs kept under 30°C. So, the sprouting of bulbs is not similar to other physiological processes which are acceleratred with temperature increase (Brewster, 1994).

The bulbs which produce roots sprout fast. The reason lies in the fact that the roots induce the production of cytokinin (Miedema, 1994b) and both the dormancy and the sprouting are controlled by the balance between growth promoters and inhibitors within the bulb (Komochi, 1990). The use of some chemical substances stops both the production of the root and the activation of sprouts (Benkeblia, 2004). The above mentioned outcomes indicate that at the high temperature of store, the growth preventing factors cause decrease in cytokinin activity.

During the storage and dormancy of the bulbs when temperature increases up to 25°C the sprouting is also accelerated. If, immediately after the harvest, the bulbs are kept under high temperature conditions, the rate of bulb sprouting is increased. The high temperature is usually used for curing the bulbs. Therefore it is obvious that the high temperature possibly may decrease the storage life of the bulbs (Benkeblia, 2004). In different cultivars, the resting period and their storage life are generally different. This period can be improved by curing practices. In fact, storage potential of the bulb, depends on dry matter content, pungency and the number of the thin scales (Currah and Proctor, 1990).

In humid conditions, if the bulbs are kept under 10-15°C temperature conditions, bulbs produce roots for several days, they produce roots faster than at 30 °C (Tanaka *et al.*, 1985). During storage period, as the storage length increases, the respiration rate increases too. At 40 °C, respiration rate is highly accelerated (Brewster, 1994). If the outer hard skin of the onion is removed or cracked, the respiration rate doubles and the rate of the water loss also increase (Apeland, 1971). Under this condition, the bulbs will sprout faster than those with intact skins. The outer skin of the onion acts as a barrier against the intrusion of the gas (Ladeinde and Hicks, 1988). The effect of the hole or damage to the outer skin is the same as skin removal. This causes the change in air within the bulb and thus bulb sprouts faster (Boswell, 1924).

The highly developed methods of harvesting, curing and keeping bulb have been evolved during the last 20 years. In recent past, the bulbs were kept after harvest at the depth of 3m for months (Brewster, 1994). Two methods are used to keep the bulbs in store: (1) Keeping the bulbs at a low temperature. In this method, the temperature should not be lower than 2 ºC because it may cause chilling injury, (2) Keeping the bulbs at a high temperature. This method is unique in hot areas. Due to the high electricity cost, keeping the bulbs in cold storage is not often recommended. Physical phenomena such as temperature, water vapours within the store have mutual effects (Currah and Proctor,1990).

The sprouting of the bulbs causes both heat production and increase in respiration rate in CO_2 and water environment (Burton, 1982). The decay in bulb caused by diseases increases with both the water loss and the respiration rate. Increase in environmental humidity also increase respiration rate and causes temperature increase of the environment. Under hot conditions of the store, the amount of decay caused by pathogens such as *A. niger* increase (Tyson and Fullerton, 2004). The onion skin plays a basic role in physical and chemical processes during storage (Brewster, 1994). Relatively low RH in store causes cracks of the skin. Most researchers have emphasized the appropriate RH of the stores to be between 65 and 75% (Apeland, 1971; Mettananda and Edirimanna, 1999). Under this condition, the skin of the onion remains fresh and intact. Onion bulbs which are kept in controlled environment should be kept under the same condition after they are taken out of the store (Smittle, 1988).

The aim of this study was to investigate the effect of high temperature and relatively low RH on the storage life of some onion cultivars in Khuzestan.

Materials and methods

In order to study losses in onion hot stores, 10 genotypes among the most important cultivars and types existing in Khuzestan were planted and harvested in fall 2002. Five genotypes from Shahid Chamran University of Ahwaz (R1, B1, G1, Peri 79 and Peri 80), 2 of the most famous of local onions (Behbahani and Ramhormozi), three exotic cultivars existing in market (Perimavara, Texas Yellow Grano and Texas Early Grano) were used. One month after the harvest, the onion bulbs were kept in store till the curing process was over. After a month, this experiment was replicated three times in completely randomized design, each time with 50 bulbs of a diameter more than 3 cm. The bulbs were placed in boxes of 10 x 30 x 50 cm. First, they were weighed, and then the changes in the number of undamaged bulbs were recorded every two weeks. During this period, the temperature change and the RH were recorded. Finally, the collected data were analyzed using SPSS software. In order to analyze the effect of cultivar on the decrease in number the onion bulb, the linear equation $Y = a + bx$ or nonlinear $Y = a + bx + cx^2$ were used.

Results and discussion

The data available on the temperature changes in summer 2003 showed that it was lowest in April and highest in July, August and September. During the storage period, the monthly average temperature was higher than 30 ºC. The highest temperature in April was 40 ºC followed by 45 ºC in other months. The minimum temperature (24 ºC) started in April and extended to 27 ºC in July and September. The relative RH was 30% from April to September (data not presented). The temperature higher than 40 ºC caused increase in respiration rate in bulbs, and relative RH less than 65% caused the outer skin to separate. Accordingly, the evaporation from the surface of the bulbs increased (Tyson and Fullerton, 2004).

The RH and temperature of the store create an ideal condition for pathogens especially black mold (*A. niger*) and bacteria like *Pseudomonas allicola* to attack the bulbs. In such conditions, the losses of bulbs will be high. The most important factor responsible for destroying the bulbs in hot stores are *A. niger* and *P. allicola* (Brewster, 1994). *A. niger* acts in either of the following ways: (A) Simultaneous attack of black mold and bacteria (which mostly occurs via false stem to the bulbs). The black mold attack occured more and faster in cultivars with big bulbs and almost thick neck. Bacteria also intrude in the same way. At the early stages of the experiment, the simultaneous attack of these two pathogens to the bulbs caused the most losses to the cultivars of Texas Early Grano, G1 and Texas Yellow Grano. (B) Attack through the scales was as soon as the dry scales either died or got cracks due to dry weather and the black mold attack became severe. At the early stages of storage periods, due to the health of the scales, the attack in this way was not so remarkable. However, with advancement of time and destruction of the scales, the attack of the pathogens through this way increased. At the final stages of the experiment, the decay rate of the bulbs was more apparent in all cultivars especially the local ones. In this way, except for a black mass of mold, nothing was left in the bulbs.

After 30 days of storage period, the significant difference in the weight of the retained bulbs of the experimental cultivars was observed. In other words, the Texas Early Grano and G1 cultivars were bigger than the others, although they were not statistically different with Ramhormozi and R1 cultivars. The G1 and Texas Early Grano had superiority up to the end of the experiment. During the middle of the experiment, the average weight of Texas Early Grano decreased, but at the end it again increased. The reason could be traced back to the destruction of the big bulb cultivar which had relatively thick neck and had high disease incidence. Accordingly, the general and medium bulbs make the most of the bulb mass and the average weight decreases. At the end of the experiment, only bulbs which were physiologically mature remained in the store. The Behbahani, Ramhormozi, B1 and R1 cultivars had statistically no change. However, the bulbs of B1 and R1 cultivars were of better storage potential in the experiment (Table 1).

The maximum and minimum decrease in weight was observed in Texas Early Grano and G1, respectively. Generally, the exotic cultivars were of higher weight at the early stages of the study. The rate of the decrease in their weight was however two times as the local cultivar. As far as the damaged bulbs in the first 60 days after the growth period are concerned, the most losses refer to the Texas Early Grano, G1, Texas yellow Grano and Perimavara; but after that almost no serious difference was observed among them (Table 3). Sixty days after the storage period, 50% of Texas Early Grano, G1 and Texas yellow Grano were diseasesed and were

Table1. Effect of storage time on average bulb weight of cultivars

Genotypes	Days						
	30	45	60	75	90	105	120
R1	69.6ab*	66.2b	61.0b	58.6b	46.2b	48.5b	46.7b
B1	63.5b	60.4b	57.7b	53.8b	52.4ab	48.4b	44.8b
Peri 80	60.6b	58.5b	64.0ab	52.8b	38.7b	47.6b	46.1b
Peri 79	60.4b	58.2b	54.5b	50.7b	49.4b	47.1b	41.5b
G1	76.6a	79.6a	77.0a	74.3a	71.9a	69.7a	70.3ab
Texas Yellow Grano	65.5b	62.5b	60.0b	57.8b	55.6b	55.3b	54.0b
Texas Early Grano	78.9a	74.8ab	69.2ab	64.0b	58.0b	68.0a	80.0a
Perimavara	64.5b	60.2b	54.5b	53.5b	50.4b	48.5b	46.0b
Ramhormozi	65.4ab	62.2b	59.6b	57.0b	53.2b	49.4b	46.4b
Behbahani	62.5b	59.0b	55.6b	54.6b	50.3b	46.9b	43.8b

*Within each column, a different letter above indicates a significant difference by the Duncan's Multiple Range Test (*P*=0.05)

removed. It took 90 days for other cultivars such as Perimavara, Peri 79, and 105 days for Peri 80. In other words, each of these cultivars had 50% of its bulb loss at a certain time. The equation coefficients of the removed bulbs is given in Table 4. From the beginning of the study to the end, the losses of Ramhormozi, Behbahani, B1 and R1 cultivars did not exceed 50%. However the regression line slope of the equation of the damaged bulbs in both B1 and R1 was less than that of the local ones. In other words, some of the improved cultivars, at the university had higher storage life.

In the light of the above findings, it can be concluded that bulb did not develop roots during hot store conditions. There was difference among the cultivars with regard to storage life. The short storage life was in Texas Early Grano, Texas yellow Grano and Peri 79. In B1, R1, Ramhormozi and losses were the least. Behbahani in increasing order. The most important factor responsible for decay in the onion bulbs in the hot stores of Khuzestan was *Aspergillus niger*.

Table 2. Coefficients of linear and nonliner models for decrease in onion bulb weight of cultivars in hot stores ($Y= a+bx$ or $Y= a+bx+ cx^2$)

Genotypes	Coefficients			
	a	-b	c	r
R1	78.4	0.29		0.95
B1	69.67	0.20		0.99
Peri 80	68.71	0.21		0.77
Peri 79	66.68	0.20		0.99
G1	81.15	0.09		0.90
Texas Yellow Grano	68.9	0.13		0.97
Texas Early Grano	107.11	1.01	0.0069	0.88
Perimavara	69.83	0.21		0.97
Ramhormozi	71.77	0.20		0.99
Behbahani	68.44	0.20		0.99

Table 4. Coefficients of regression equation fitted for decrease in bulb number of cultivars in hot stores for linear model ($Y= a +b x$)

Genotypes	Coefficient		
	a	b	*r*
R1	19.11	0.449	0.96
B1	-17.857	0.435	0.97
Peri 80	-23.00	0.730	0.99
Peri 79	-24.85	0.778	0.98
G1	-15.30	0.944	0.95
Texas Yellow Grano	-14.71	0.983	0.94
Texas Early Grano	-16.35	0.948	0.97
Perimavara	-20.32	0.755	0.98
Ramhormozi	-22.19	0.580	0.98
Behbahani	17.88	0.475	0.98

Acknowledgments

I thank Dr. V. Minasian, Professor, Department Plant Pathology for identification of *Aspergillus niger* and Dr. R. Chinipardaz, Dean of Research, Shahid Chamran University, for financial support to this project.

Table 3. Percentage decrease in number of onion bulbs of differnt cultivars in hot store

Genotypes	Days						
	30	45	60	75	90	105	120
R1	0	0b*	5d	10c	19c	30b	38b
B1	0	1b	4d	12c	19c	30b	37b
Peri 80	0	7b	22bc	32b	44bc	55b	65ab
Peri 79	0	25a	54a	66a	76a	83a	87a
G1	0	7b	23bc	34b	55ab	59ab	63ab
Texas Yellow Grano	0	23a	56a	66a	76a	80a	86a
Texas Early Grano	0	31a	45ab	61	75a	83a	88a
Perimavara	0	14b	25bc	35b	55ab	60ab	65ab
Ramhormozi	0	1b	11cd	17bc	33bc	42b	46b
Behbahani	0	3b	8d	14c	26c	34b	40b

*Within each column, a different letter above indicates a significant difference by the Duncan's Multiple Range Test (*P*=0.05)

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