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Comparison of cold and traditional storage methods on the storability of selected onion (*Allium cepa* L.) cultivars

Abd Elgadir D. Ahmed[1], Mohammed E. Elkashif [2] , Osman M. Elamin and Haroun I. Mahmoud[3]

[1]Faculty of Agriculture, University of Sinnar, Abu Naama. Sudan.
[2]Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan.
[3]The National institute for the Promotion of Horticultural Exports, University of Gezira, Wad Medani, Sudan.

ABSTRACT

Onion is a perishable crop which is traditionally stored in the open field. Hence, losses can reach up to 40% or more. Therefore, the objective of this study was to determine the effects of some storage methods on the storability of selected onion cultivars. This study was carried out at the National Institute for the Promotion of Horticultural Exports Research Farm, University of Gezira, Wad Medani, Sudan and at a commercial refrigerator at Wad Medani and at Hasahisa, in the seasons of 2011 and 2012. Treatments consisted of two types of storage methods, namely, storage in the open field and refrigerated storage, and three onion cultivars, namely, Fadasi, Kamleen Yellow and Baftaim. Onion bulbs from the three cultivars were bagged in jute sacks and then stored under the mentioned storage methods for 5 months. Treatments were arranged in a split plot design with three replicates. Storage methods were assigned to the main plots and cultivars to the sub-plots. Fresh weight was determined at the beginning of the storage period and then at monthly intervals. Sorting was carried out every month to calculate percentages of rotted, sprouted and green bulbs. Results showed that weight loss, rotting, sprouting, greening, and total loss percentages were significantly affected by storage methods and onion cultivars. Refrigerated storage resulted in the minimum weight loss compared to the traditional storage. Fadasi had the least weight loss, followed by Kamleen Yellow, and finally Baftaim which recorded the highest weight loss. Generally, rotting was negligible in the refrigerated

storage, whereas the traditional storage had the highest percentage of rotted bulbs. Baftaim cultivar recorded the highest percentage of rotted bulbs, followed by Kamleen Yellow, and finally Fadasi. The refrigerated storage had higher percentage of sprouted bulbs compared to the traditional one. However, Baftaim had the highest percentage of sprouted bulbs as compared to the other cultivars which were comparable. Bulb greening was negligible in the refrigerated method, while the traditional method recorded higher percentage of green bulbs. Generally, greening was negligible in Fadasi and Baftaim, whereas Kamleen Yellow recorded the highest. The minimum total loss percentage was recorded in the refrigerated storage as compared to the traditional one. However, Fadasi had the least total loss percentage, followed by Kamleen Yellow, and finally Baftaim. Hence, it is recommended to store onion bulbs of Fadasi and Kamleen Yellow cultivars using refrigerated storage.

INTRODUCTION

Onion (*Allium cepa* L.) is one of the oldest bulb crops known to mankind and consumed worldwide. It is a member of the family Alliaceae and believed to be originated in Central Asia (Kukanoor, 2005). It is a major bulb crop among vegetables and is of global commercial importance (Anisuzzaman *et al.,* 2009). A global review of area and production of major vegetables shows that onion ranks second in area and third in production of the total vegetables in the world. China is first in area and production while India occupied second position in production (Chandrashekhars, 2007). The leading onion production countries are China, India, United States, Turkey and Pakistan (Shaheen, *et al.,* 2011). The area cultivated with onion in the world was estimated to be 4.4 million hectares and the production was estimated to be 86.3 million tonns (FAO, 2013).

Onion is the most important and popular vegetable crop and is produced in all regions of the Sudan (Abdelaziz, 2008). In recent years, there is an increasing interest in the production of onion for both the traditional home markets and export (Abu-Sarra, 2007). The area cultivated with onion in the Sudan was estimated to be 58.6 thousand hectares, and the production was estimated to be 1.1 million tonns (FAO, 2013).

Onion is a delicate and perishable commodity, hence difficult to store for long durations at room temperature, especially in tropical and subtropical countries, due to its high water content (Kukanoor, 2005). The aim of onion storage is to extend its availability to consumers all year round. Storage plays a very important role in the marketing of onion and helps in the adjustment of supply and demand.

Onion cultivars differ in their storability. Generally, cultivars with high total soluble solids (TSS) and dry matter contents and high pungency have longer shelf lives compared to mild cultivars with low TSS (Elkashif *et al*., 2006). Storage temperature and relative humidity have significant effects on onion sprouting, rotting, greening and loss in weight and these are correlated with storage period (Kukanoor, 2005).Storage methods have great impacts on post harvest life and keeping quality of onion. Traditionally, in the Sudan, in the Gezira State, onion is stored in open-air in jute sacks placed upside down on a cushion of cotton stalks. Onions are exposed to direct sunlight, winds and rains. Consequently, post harvest losses of 40% or more are not uncommon. Onion perishability and lack of modern storage facilities in the Sudan lead to low prices during the harvest season (Musa, 1999). Being a cool season crop, onion floods the local market in the Sudan during the period from April to June resulting in low prices which increase steadily to reach their maximum during the off-season (October to December). There is a great need to seek ways and means to extend the storage life of onion, minimize storage losses, in addition to evaluate onion cultivars for their storability to facilitate its marketability at a reasonable price. Therefore, the objectives of this study were to reduce storage losses of onion and to evaluate the keeping quality of three onion cultivars under two types of storage methods.

MATERIALS AND METHODS

This study was carried out at the National Institute for the Promotion of Horticultural Exports (NIPHE) research farm, University of Gezira, Sudan and at commercial refrigerators at Wad Medani and Hasahisa, in the seasons of 2011/12 and 2012/13. Three onion cultivars, namely, Fadasi, Kamleen Yellow and Baftaim were used in this study because of their high acceptability to farmers and consumers. These cultivars were grown at NIPHE research farm prior to storage. They were subjected to standard

cultural practices after which they were harvested, cured and placed into jute sacks (50 kg weight). Onion bulbs from the three cultivars were stored under two types of storage methods:

1. Traditional storage, i.e. under sunshine (control).
2. Refrigerated storage.

A split-plot design with storage methods as the main plots and cultivars as the sub- plots was used with three replicates. The experiment was terminated after five months of storage.

Total soluble solids (TSS) and dry matter contents (DM) were determined for the three cultivars at the beginning of the experiment. Total soluble solids were determined using a hand refractometer. For the determination of dry matter content, 100 g of fresh onion slices were placed in an oven at 80°C and weighed every day till a constant weight was obtained. Percent dry matter was determined as follows:

$$\text{Dry matter (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

The fresh weight of the sacks was determined at the beginning of the storage and then at monthly intervals and weight loss was determined as follows:

$$\text{Weight loss (\%)} = \frac{\text{Initial weight} - \text{monthly weight}}{\text{Initial weight}} \times 100$$

Sorting was carried out every month. Sprouted, rotted and green bulbs were isolated, weighed, recorded and discarded. Final weights were recorded and were considered as the initial weights for the following month. Calculations were done as follows:

$$\text{Rotten bulbs (\%)} = \frac{\text{Weight of rotten bulbs (kg)}}{\text{Initial weight (kg)}} \times 100$$

$$\text{Sprouted bulbs (\%)} = \frac{\text{Weight of sprouted bulbs (kg)}}{\text{Initial weight (kg)}} \times 100$$

$$\text{Green bulbs (\%)} = \frac{\text{Weight of green bulbs (kg)}}{\text{Initial weight (kg)}} \times 100$$

Total loss = weight loss (%) + rotten bulbs (%) + sprouted bulbs (%) + green bulbs (%).

Statistical analysis

Data were analyzed using standard analysis of variance procedures. Treatment means were separated using Duncan's Multiple Range Test at 5% level of significance.

RESULTS AND DISCUSSION

Since, there were no significant differences between the results of the two seasons, so only the results of the first season will be presented.

Weight loss

Figure 1 (A) shows the effects of storage methods on weight loss (%) of onion during storage. There were highly significant differences in weight loss (%) between the two storage methods. Minimum weight loss percentages were recorded when the bulbs were stored in the refrigerated method compared to the traditional method. The minimum weight loss under the refrigerated method was probably due to the low water loss under the conditions of low temperature and high relative humidity, whereas the maximum weight loss may be due to the high temperature and low relative humidity which prevailed under the traditional method that led to high water loss. Similar results were obtained by Kaul and Mehta (1988) and Mangal *et al.* (1999) under evaporative cooled potato store. Matson *et al.* (1978) stated that the ideal temperature for onion storage is about 0°C or near 0°C with 60% –70% relative humidity.

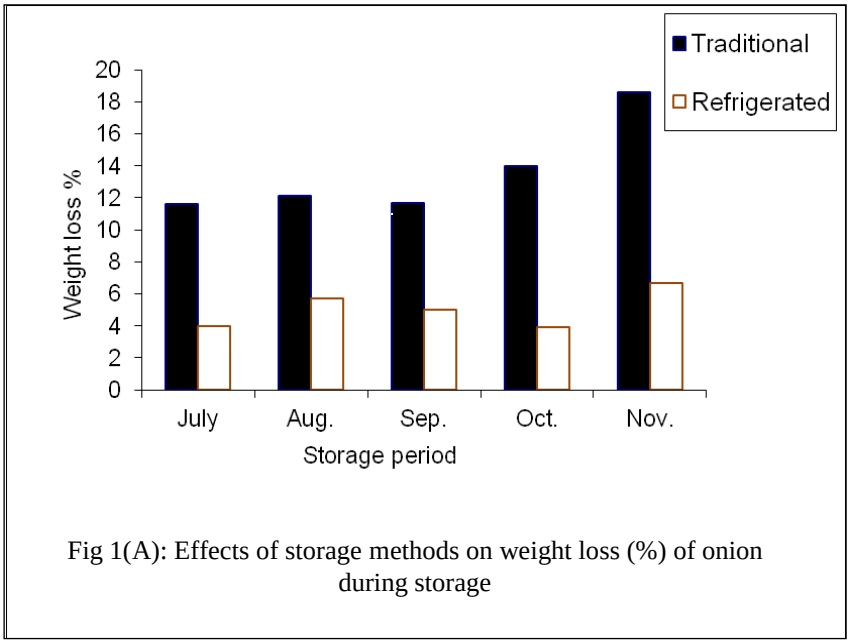

Fig 1(A): Effects of storage methods on weight loss (%) of onion during storage

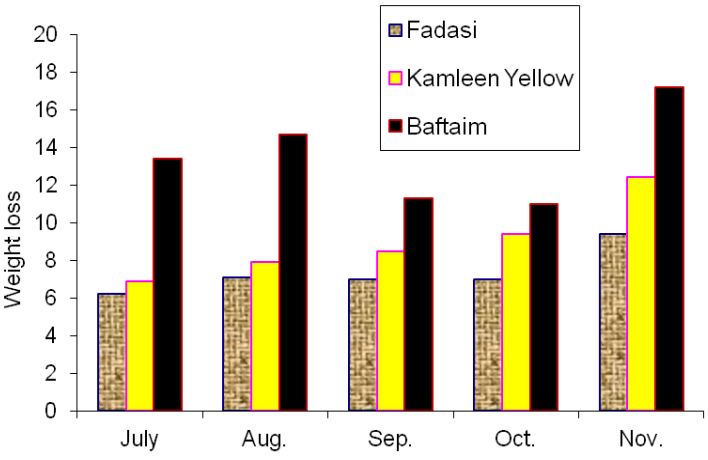

Fig 1(B): Effects of onion cultivars on weight loss (%) of onion during storage

The effects of onion cultivars on weight loss (%) of onion during storage are presented in Figure 1 (B). Results indicated highly significant differences between onion cultivars in weight loss (%). The least weight loss was recorded for Fadasi, while the highest weight loss was recorded for Baftaim. This can be explained by the fact that Fadasi had higher dry matter and total soluble solids contents compared to Baftaim (Table 1). These findings are in conformity with the reports of Ryall and Lipton (1983) who reported that the characteristics which enhance superior storage quality of onion are high total soluble solids, high dry matter content (more than 15%) and high pungency.

Rotting of bulbs

The effects of storage methods on rotting of bulbs (%) during storage are shown in Figure 2 (A). Results illustrated highly significant differences between the two storage methods in rotting (%) of bulbs. It is interesting to note that rotting was negligible in the refrigerated method of storage in all months except the first month (July). This was due to the fact that the rate of cooling during July was not fast enough to cool the bulbs to the desired temperature required to reduce rotting. This indicates the superiority of the refrigerated method of storage as compared to the traditional one. The low temperature of the refrigerated method suppressed pathogen development, while the high temperature in the traditional method favoured the growth of pathogenic organisms. These results are in conformity with those reported by Matson *et al.* (1978) who stated that the ideal temperature of onion storage is about 0°C or near 0°C with 60–70% relative humidity. Ko *et al.* (2002) reported that in warm climates, such as the tropics, open-air storage is a practical option in the absence of refrigerated storage, but involves a compromise between sprouting and rotting losses.

The effects of onion cultivars on rotting of bulbs (%) of onion during storage were significant (Figure 2, B). The lowest percentages of rotting were recorded for Fadasi, while the highest percentages were recorded for Baftaim. Fadasi had the highest dry matter content and strongest pungency, followed by Kamleen Yellow, and finally Baftaim (Table 1). This data show that cultivars having high TSS, dry matter contents and high pungency are less susceptible to attack by pathogens and *vice versa*. These results are in agreement with those reported by Hurst *et al.* (1985) who stated that varieties of low dry matter content and less pungent are grown for the fresh market for raw consumption and generally do not store very well.

Table 1. Total soluble solids and dry matter contents of tested onion cultivars.

Cultivar	Total soluble solids (%)	Dry matter (%)
Fadasi	18	20
Kamleen Yellow	18	19
Baftaim	15	15

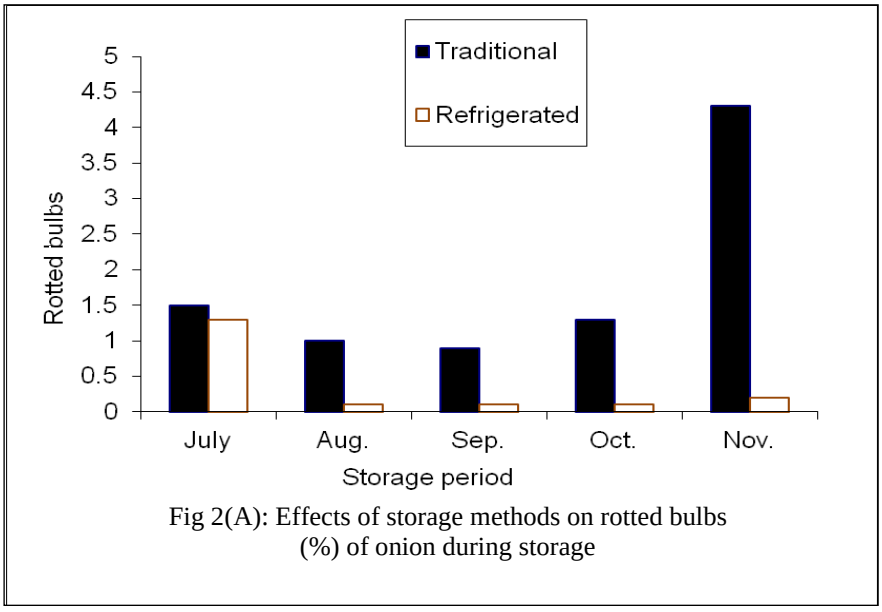

Fig 2(A): Effects of storage methods on rotted bulbs (%) of onion during storage

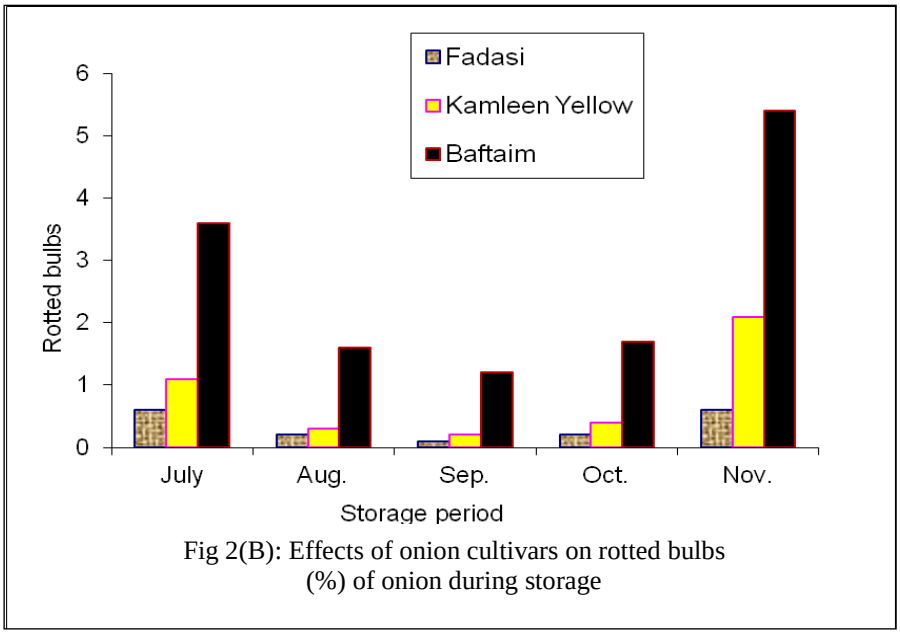

Fig 2(B): Effects of onion cultivars on rotted bulbs (%) of onion during storage

Sprouting of bulbs

The effects of storage methods on sprouting of bulbs (%) of onion during storage are shown in Figure 3 (A). Results indicated significant differences in sprouting of bulbs (%) between the two storage methods in the last three months of the storage period. Sprouting was not observed in the first month of the storage period in the two methods of storage. This was mostly due to the dormancy of onion bulbs which prevented sprouting. In the last two months of the storage period, higher sprouting percentages were observed in the refrigerated method compared to the traditional method. This is because the high relative humidity and the lack of optimum temperature (8–10^{0}C) in the refrigerated method encouraged sprouting of bulbs, whereas the open-air high temperature of the traditional method suppressed bulb sprouting. These results agree with those reported by Musa *et al.* (1994) who found that sprouting losses in "Wad Ramli" cultivar were caused by high relative humidity, and these losses were negligible if bulbs were kept under high temperature and low relative humidity. Abdalla and Mann (1963) reported that the optimum temperature for storage of onion is at or near 0°C and relative humidity between 60%–70%; and if relative humidity rises above 80%, root growth is promoted.

Figure 3 (B) shows the effects of onion cultivars on sprouted bulbs (%) during storage. Results showed significant differences in sprouting bulbs (%) among the different onion cultivars. Sprouting was not noted in the first month of storage in all cultivars. In the last two months of storage, Baftaim recorded the highest percentage of sprouted bulbs as compared to the other cultivars which were comparable. This was due to the low dry matter content and total soluble solids of Baftaim. These findings were consistent with those reported by Sandhu *et al.* (1976) who found that sprouting losses were more in varieties with low percentage of dry matter and total soluble solids contents. Patil and Kale (1989) concluded that higher contents of dry matter and TSS were associated with better storage quality of onion.

Greening of bulbs

The effects of storage methods on green bulbs (%) of onion during storage are shown in Figure 4 (A). There were highly significant differences in green bulbs (%) between the two storage methods. Bulb greening was negligible in the refrigerated method during all months of storage because of the dark conditions in the cold room. Storage under the traditional method recorded higher percentage of green bulbs in all months as compared to the refrigerated method. The high percentage of green bulbs

under the traditional method was due to bulb exposure to direct sunlight which resulted in the biosynthesis of chlorophyll. Similar results have been reported by Elkashif *et al*. (2006) for shade and sunshine methods of onion storage.

The effects of onion cultivars on green bulb (%) were highly significant (Figure 4, B). Bulb greening was observed in Kamleen Yellow during storage, whereas in Fadasi and Baftaim greening was negligible in all months of storage. This was probably due to the opaque nature of the red outer scale which hindered light transmittance and hence prevented chlorophyll biosynthesis. However, the highest percentages of green bulbs were shown by Kamleen Yellow because of the transparent nature of the outer scale. These findings were in agreement with those reported by Elkashif *et al*. (2006).

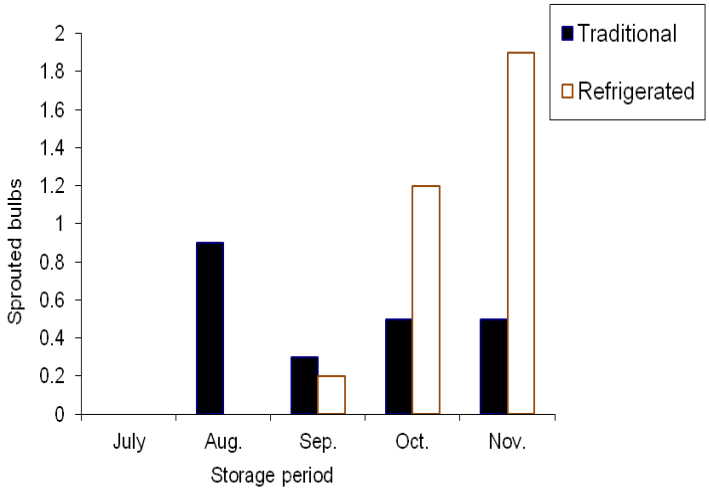

Fig 3(A): Effects of storage methods on sprouted bulbs (%) of onion during storage

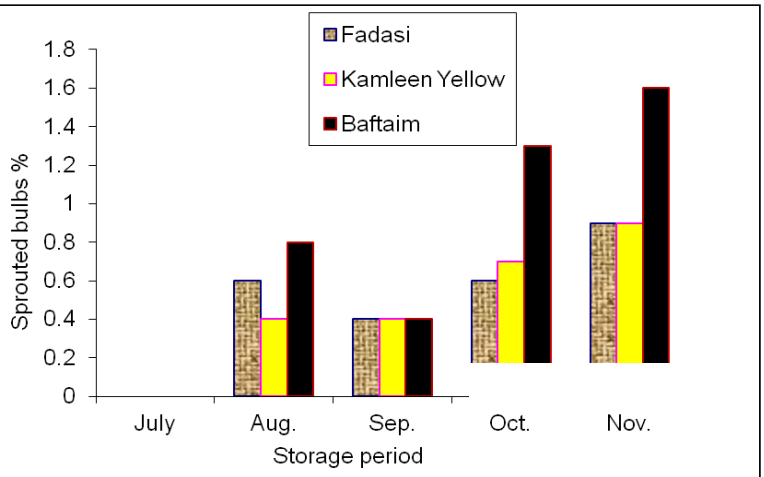

Fig 3(B): Effects of onion cultivars on sprouted bulbs (%) of onion during storage

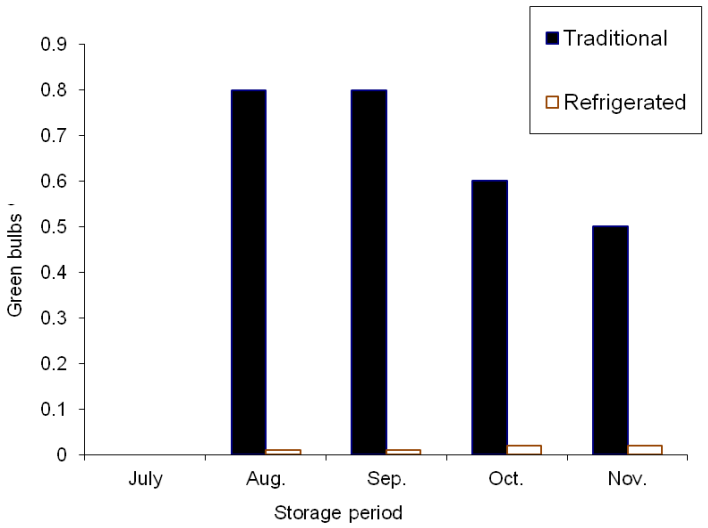

Fig 4(A): Effects of storage methods on green bulbs (%) of onion during storage

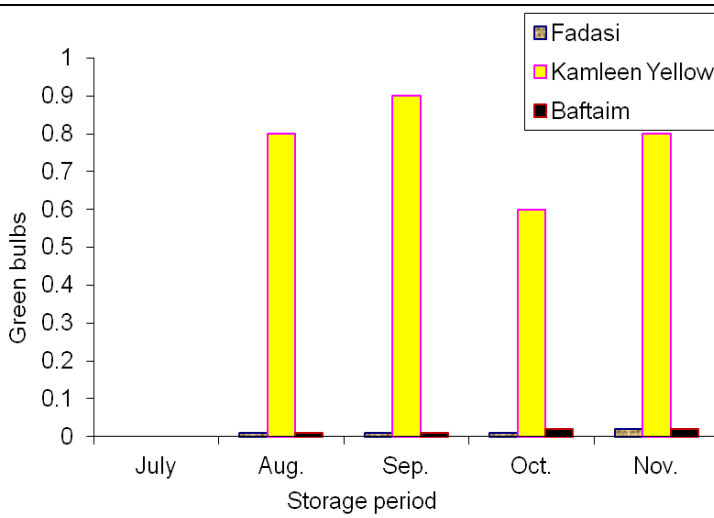

Fig 4(B): Effects of storage methods on green bulbs (%) of onion during storage

Total loss

The effects of storage methods on total loss (%) were highly significant (Figure 5/A). The minimum total loss percentage was recorded in the refrigerated method compared to the traditional one. This was because the refrigerated method had the lowest weight loss percentage, no rotted and no green bulbs, whereas, the traditional one had the highest weight loss percentage and had more green and rotted bulbs percentages. Tucker (1974) reported that, since the rate of respiration rises with increasing temperature, a lower storage temperature is generally more desirable due to slower consumption of stored metabolites and reduced loss of moisture.

Figure 5 (B) shows the effects of onion cultivars on total loss (%) of onion during storage. There were highly significant differences in the total loss (%) among the different onion cultivars. The lowest total loss percentage was recorded for Fadasi cultivar, whereas the highest was scored by Baftaim. Fadasi cultivar had the highest dry matter and total soluble solids contents and higher pungency, while Baftaim had the lowest dry matter and total soluble solids contents and the mildest pungency (Table 1). These results are in line with the reports of Ryall and Lipton (1983) who found that the characteristics which enhanced superior storage quality of onion were high total soluble solids, high dry matter content of more than 15% and high pungency. Hurst *et al.* (1985) reported that varieties of low dry matter content and less pungent are grown for the fresh market for raw consumption and generally do not store very well.

Total loss (%) after 5 months of storage

Table 2 presents the interaction effects of storage methods and onion cultivars on total loss (%) of onion after 5 months of storage, which were significant. The highest total loss percentages were obtained by Baftaim (67.4%, 50.0%), followed by Kamleen Yellow (49.2%, 37.3%), and the least by Fadasi (41.1%, 35.2%) under the traditional method in the first and second seasons, respectively. The refrigerated method resulted in the lowest total loss percentages in the three cultivars *viz.* Fadasi (18.9%, 12.8%), Kamleen Yellow (21.6%, 15.9%), and finally Baftaim (35.0%, 30.1%) in the first and second seasons, respectively. These results are in agreement with those reported by Patil and Kale (1989 and Maini and Chakrabarti (2000).

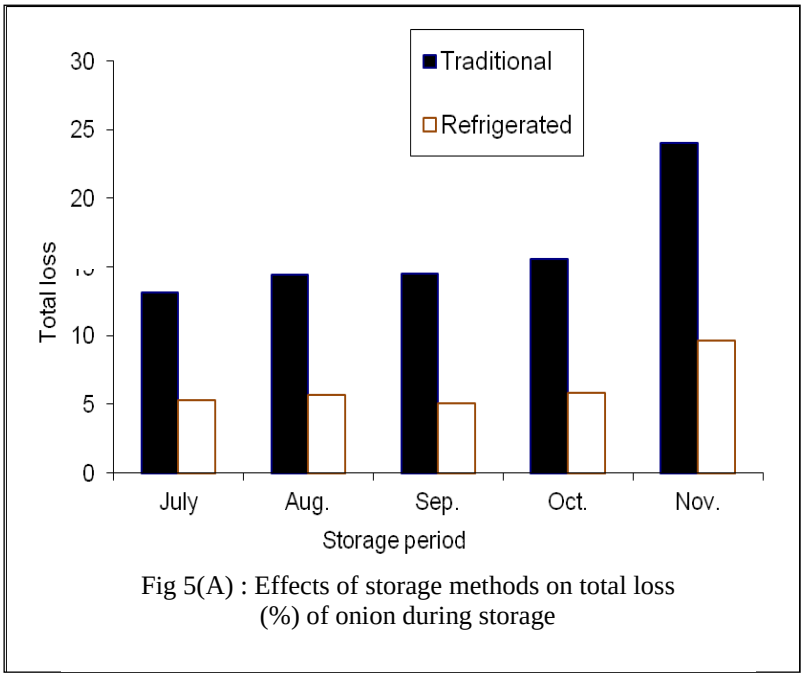

Fig 5(A) : Effects of storage methods on total loss (%) of onion during storage

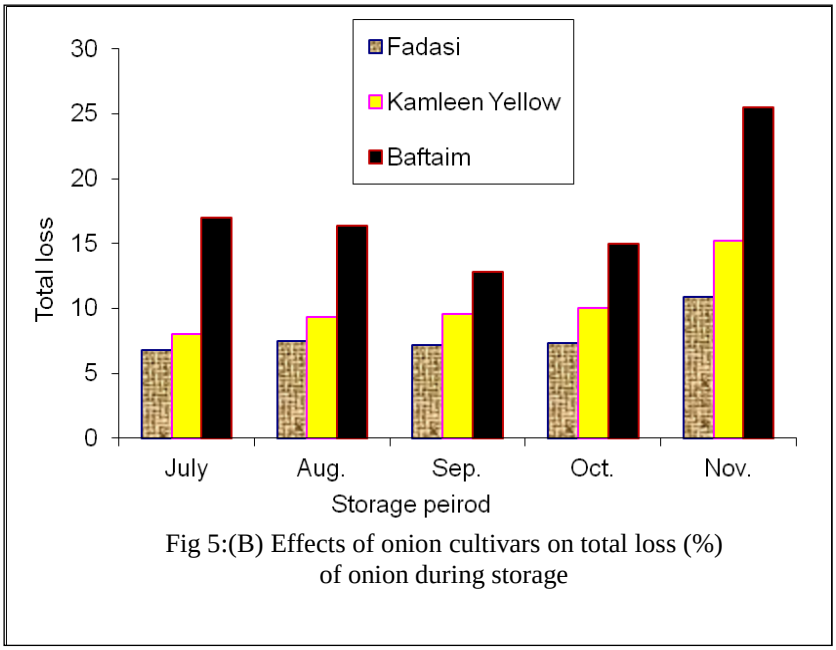

Fig 5:(B) Effects of onion cultivars on total loss (%) of onion during storage

Table 2. Interaction effects between storage methods and onion cultivars on total loss (%) after 5 months of storage.

Storage methods	Onion cultivars	Total loss (%)	
		First season	Second season
Traditional	Fadasi	41.1 c	35.2 b
	Kamleen Yellow	49.2 b	37.3 b
	Baftaim	67.4 a	50.0 a
Refrigerated	Fadasi	18.9 f	12.8 d
	Kamleen Yellow	21.6 e	15.9 d
	Baftaim	35.0 d	30.1 c
Significance level		**	*

Means in columns followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test.
* and ** indicate significance at 5% and 1% levels, respectively.

REFERENCES

Abdalla, A.A. and L.K. Mann. 1963. Bulb development in the onion (*Allium cepa* L.) and the effect of storage temperature on bulb rest. Hilgardia 35: 85 –112.

Abdelaziz, H.H. 2008. Economics of onion production in the northern part of Omdorman Province, Khartoum State. Albuhuth 12(1): 42–51.

Abu-Sarra, A.F. 2007. Effects of mother bulb size and nitrogen nutrition on production of red onion seeds at Rahad Scheme. Sudan Journal of Agricultural Research 9: 33–39.

Anisuzzaman, M., M. Ashrafuzzaman, M.R. Ismail, M.K. Uddin and M.A. Rahim. 2009. Planting time and mulching effect on onion development and seed production. African Journal of Biotechnology 8(3) : 412 – 416.

Chandrashekhars, K. 2007. Analysis of onion production and marketing behaviour of farmers in Gadag District, Karnataka. M.Sc. Thesis, University of Agricultural Sciences, Dharwad, India.

Elkashif, M.E., O.M. Elamin and S.A. Musa. 2006. Effect of storage under sunshine or shade on quality and storability of onion bulbs. Gezira Journal of Agricultural Science 4(1): 38-48).

FAO. 2013. Agricultural Production Statistics Database (FAO STAT). Rome, Italy.

Hurst, W.C. R.L. Shewfelt and G.A. Schuler. 1985. Shelf - life and quality changes in summer storage onions (*Allium cepa* L.). Journal of Food Science 50: 761 – 763.

Kaul, H.N. and A. Mehta, 1988. Evaluation of passive evaporative cooling for storage of potato (*Solanum tuberosum* L.). Indian Journal of Agricultural Sciences 58: 928 – 931.

Ko, S.K., W.N. Chany, J.F. Wang, S.J. Cherng and S. Shanmugasundaram. 2002. Storage variability among short- day onion cultivars under high temperature and high relative humidity, and its relationship with disease incidence and bulb characteristics. Journal of the American Society for Horticultural Science 127: 848 – 854.

Kukanoor, L. 2005. Post-harvest studies in onion cv. N. 53. Ph.D. Thesis, University of Agricultural Sciences Dharwad, India.

Maini, S.B. and A.K. Chakrabarti. 2000. Post-harvest management of onions and garlic. Souvenir, National Symposium on Onion and Garlic Production and Post-harvest Management: Challenges and Strategies, 19–21 November 2000, National Research Centre for Onion and Garlic, Rajgurunagar, Nasik, pp. 25–32.

Mangal, J.L., J.K. Sandojta, R.K. Bhutani and S.C. Khurana. 1999. Comparative performance of seven potato cultivars in evaporative cool chamber and ambient condition. In: Global Conference on Potato, 6 – 11 December, Delhi, India.

Matson, W.E, N.S. Mansour and D.G. Richardson. 1978. Onion Storage: Guide lines for commercial growers. extension circular 948, Oregon State University Extension Service, 15 pp.

Musa, S.A. 1999. Effects of environment, packing material and cultivar on the storability of onion (*Allium cepa* L.). M.Sc. Thesis, University of Gezira, Sudan.

Musa, S.K., Y.M. Abdalla, E. Haimoura and Y. Sulieman. 1994. Improvement of onion storage in the Sudan. Tropical Science 34(2): 185–190.

Patil, R.S. and P.N. Kale. 1989. Screening of onion cultivars for storage quality. Vegetable Science 16(1): 56–61.

Ryall, A.L. and W.J. Lipton. 1983. Handling, transportation and storage of fruits and vegetables. AVI Publishing Company, Inc. West Port, Connecticut Vol. (1), 3rd edn. 587 pp.

Sandhu, J.S., J.C. Thakur and K.S. Nandpuri.1976. Studies on the storage quality of red and white onion (*Allium cepa* L.) varieties. Journal of Research 13(3): 279–282.

Shaheen, A.M.; F.A. Rizk, F.S. Abdel-Aal and H.A.M. Habib. 2011. Production of safe and economic onion bulbs. International Journal of Academic Research 3(1): 527–532.

Tucker, W.G. 1974. Onion respiration during long term storage. Acta Horticulture 38: 127–129.