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Improvement of Storability of BaftaimOnion (Allium cepa L.) Cultivar by Crossing with Abufrewa

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INFORMATIONs

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ABSTRACT

Onion is one of the most important horticultural crops in the Sudan with regard to production and consumption. It has played an important role in human nutrition and medicine. The objective of this research was to determine the storability of some onion genotypes under direct sunshine, shade or refrigerated storage conditions. This research was conducted at the Faculty of Agricultural Sciences, University of Gezira, Wadmedani, Sudan during the seasons of 2014to 2017.Crosses were made between *Baftaim* and *Abufrewa*and F_1 was produced. Then, F_1 was selfed to produce F_2 in the second season. Intensive selection was practiced for the desirable traits of parent *Abufrewa*and for the general features of parent *Baftaim.* Also, the F_1 (*Baftaim x Abufrewa*) was backcrossed to *Baftaim* to obtain BC_1. Then, the F_1 (*Baftaim x Abufrewa*) was backcrossed to *Abufrewa* to obtain BC_2. Genotypes consisted of two parents and four crosses. Samples of 5 kg of bulbs were taken randomly from each genotype and packed in jute bags. Onion bulbs from the genotypes were stored under three types of storage methods, namely, traditional storage under sun shine (control), shade storage and refrigerated storage (0- 2.5ºC and 70-75% RH). A split-plot design with storage methods as the main plots and genotypes as the sub-plots was used and replicated two times for each method for six genotypes, namely, *Baftaim*,*Abufrewa*, F_1, F_2, BC_1 and BC_2. The experiment was terminated after five months of storage from June to October for two seasons. Data were taken on total losses which consisted of weight loss (%), rotted bulbs (%), sprouted bulbs (%) and green bulbs (%).Results indicated highly significant differences among storage methods on total losses (%) in both seasons. The lowest losses percentages were recorded in the refrigerated method, followed by the shade method and the highest losses were recorded in the traditional method in both seasons. Results also indicated highly significant differences among onion genotypes on total losses (%) in both seasons. The least losses were recorded for *Abufrewa* followed by F_2, BC_2, F_1 and then BC_1, while the highest losses were recorded for *Baftaim* in both seasons. In conclusion, it is recommended to continue backcrossing with *Abufrewa* cultivar to produce genotypes with good storability and use refrigerated storage to reduce post-harvest losses in onion.

1. INTRODUCTION

Onion is one of the most important horticultural crops in the Sudan with regard to production and consumption. Onion has played an important role in human nutrition and medicine. It is very essential for the preparation of food and is eaten fresh or cooked with a mixture of other vegetables. It is very widely used as a vegetable by almost all classes of societies (Abu-Goukh *et al.*, 2001).

Onion is produced in all regions of the Sudan. In recent years, there is an increasing interest in the production of onion in large areas for both local consumption and export (Elkashif *et al*., 2006). The area cultivated with onion in the Sudan was estimated at 58.6 thousand ha and the production was estimated at 1.1 million tons (FAO, 2019).

Onion is a delicate and perishable commodity, hence it is difficult to store for long durations at room temperature, especially in tropical and subtropical countries due to its high water content (Kukanoor, 2005). Storage plays a very important role in marketing of onion. It helps in the adjustment of supply and demand in the market. The aim of onion storage is to extend its availability to consumers for a long time and to stabilize prices. Storage temperature and relative humidity have been found to be correlated with sprouting, rotting, greening and physiological loss in weight and these are further correlated with storage period (Downes *et al*., 2010:Ahmed *et al*., 2015c).

Storage methods have great effect on post harvest life and keeping quality of onion. Normally, in the Gezira State onion is stored in the open field 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 (Ahmed *et al*., 2015a).

Onion perishability and lack of modern storage facilities in the Sudan lead to low prices during the harvest season. Being a cool season crop, onion floods the local market during the period from April to June resulting in low prices which increase steadily to reach their maximum during the off-season (Sorensen and Grevsen, 2001; Ahmed *et al*., 2015b).

Onion cultivars differ in their storability. Generally, cultivars with high total soluble solids and dry matter content and high pungency such as *Abufrewa* cultivar have a longer shelf life compared to mild cultivars with low total soluble solids such as *Baftaim* cultivar (Yoo *et al*., 2006: Mohamed, 2008; Mohamedali, 2009)

The cultivar *Baftaim* is a high yielder but it is highly perishable. However, the cultivar *Abufrewa* has a good storability but a low yielder. So, if crosses are made between *Baftaim* and *Abufrewa*, new genotypes which have both high yields and good storability can be produced. Therefore, the objective of this research was to determine the storability of some onion genotypes under direct sunshine, shade and refrigerated storage conditions.

2. MATERIALS AND METHODS

Field experiments were conducted during the winter seasons of 2014/15, 2015/16 and 2016/17 at the University of Gezira, Wad Medani, Sudan. The climate is tropical with hot summer (21°C to 41°C) and mild winters 14°C to 33°C). Relative humidity ranges between 16% in summer to 70% during the rainy season and rainfall ranges between 300 to 350mm.

Seeds of *Baftaim* and *Abufrewa* cultivars were sown in 120 cm beds in the nursery of the Department of Horticultural Sciences, Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan, on the first week of September in 2014.The land was plowed, harrowed, leveled and made into 80 cm ridges. Seedlings of both cultivars were transplanted on the last week of October in 2014. Spacing was 10 cm between seedlings. Treatments were arranged in a completely randomized block design with three replications. Superphosphate was applied before transplanting at the rate of 40 kg P_2O_5/ha. Nitrogen was applied at the rate of 86 kg N/ha in the form of urea. It was split into two equal doses, the first dose was applied one month after transplanting and the second was applied one month after the first dose. Weeds, insects and diseases were controlled as required. Fully mature bulbs were harvested. The roots were removed and the tops were cut 2 cm above the bulbs. The bulbs were cured in the field for a period of 10 days and stored at 4^oC till November 2015. Bulbs of both cultivars were planted in 80 cm ridges in the first of November 2015 and all cultural practices were carried out as required. When the crop reached the flowering stage, crosses were made between *Baftaim* and *Abufrewa* and F_1 was produced. Then, F_1 was selfed to produce F_2in the second season. Intensive selection was practiced for the desirable traits of parent *Abufrewa* and for the general features of parent *Baftaim.* Also, the F_1 (*Baftaim x Abufrewa*) was backcrossed to *Baftaim* to obtain BC_1. Then, the F_1 (*Baftaim x Abufrewa*) was backcrossed to *Abufrewa* to obtain BC_2. Genotypes consisted of two parents and four crosses.

Samples of 5 kg of bulbs were taken randomly from each genotype and packed in jute bags.Onion bulbs from the genotypes were stored under three types of storage methods; traditional storage under sun shine (control),Shade storage (rain proof shade covered with zinc roof) and refrigerated storage(0- 2.5ºC and 70-75% relative humidity).

A split-plot design with storage methods as the main plots and genotypes as the sub plots was used and replicated two times for each method for the six genotypes; *Baftaim,Abufrewa*, F_1, F_2, BC_1 and BC_2. The experiment was terminated after five months of storage from June to October in both seasons.

Bulbs were weighed initially and monthly. Weight of onion bulbs was calculated using the following formula:

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

Data were also taken on rotted, sprouted and green bulbs. Total losses(%) consisted of weight loss(%), rotted bulbs(%), sprouted bulbs (%) and green bulbs(%).

Statistical analysis

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

3. RESULTS AND DISCUSSION

Onion losses (%) during of storage

Figs. 1, 2 and 3 show the effects of storage methods on losses (%) of onion during 5 months of storage. There were highly significant differences in losses (%) among the three storage methods in both seasons.

Losses were higher in the first season compared to the second one in the three methods of storage. This was due to the low rainfall and high temperatures in the first season that led to high losses. High rainfall and high relative humidity in the second season led to low losses (data on temperature and rainfall are not shown). The lowest losses percentages were recorded in the refrigerated method (23.0%, 18.5%) in both seasons, followed by the shade method (42.7%, 37.4%) and the highest losses were recorded in the traditional method (52.8%, 47.6%) in both seasons, respectively. The minimum total losses under the refrigerated method were most probably due to the prevailing storage conditions of low temperature and high relative humidity which slowed down all physiological and biochemical processes in onion bulbs. These results agreed with those of Ahmed *et al*., (2015a; 2015c) who stated that the ideal temperature for onion storage is about 0ºC with 60%-70% relative humidity. The high losses observed under the sunshine conditions during October were most probably due to the high temperature and low relative humidity which prevailed under the open field conditions. Total losses during August were lower than those of September and October. This was most probably due to the high relative humidity which prevailed during the rainy season. These findings agreed with those of Sorensen and Grevsen (2001) and Elkashif *et al*. (2006).

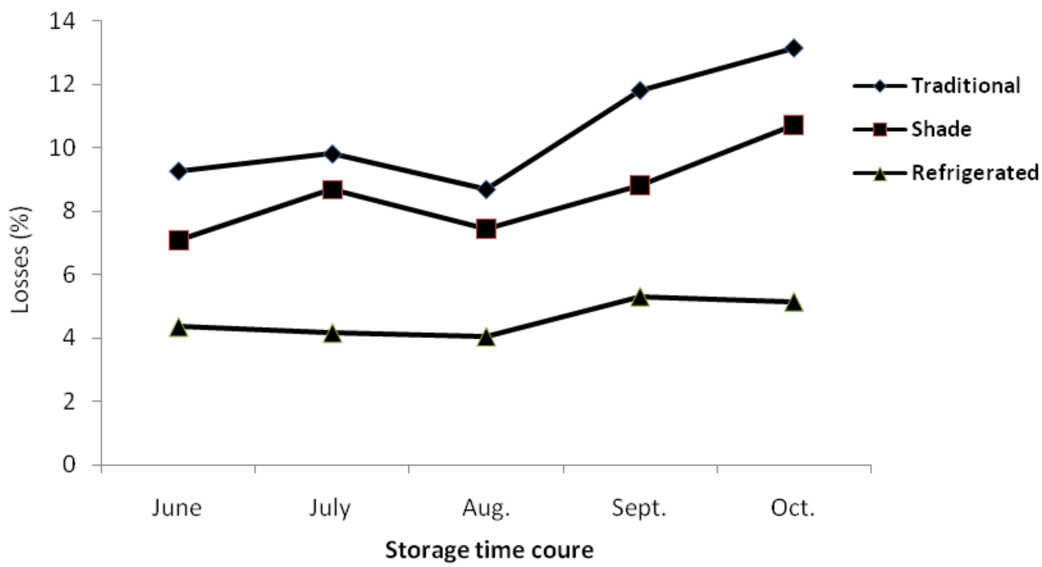

Fig1. Effects of storage method on losses (%) during storage, season 2015/16

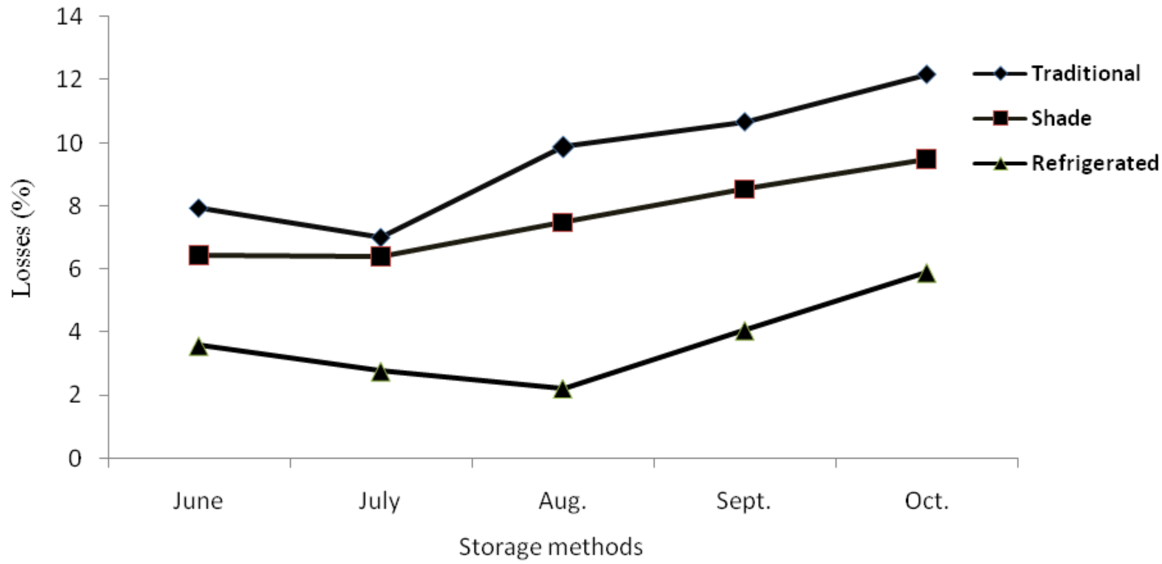

Fig. 2. Effects of storage method on losses (%) of onion during storage, season 2016/ 17

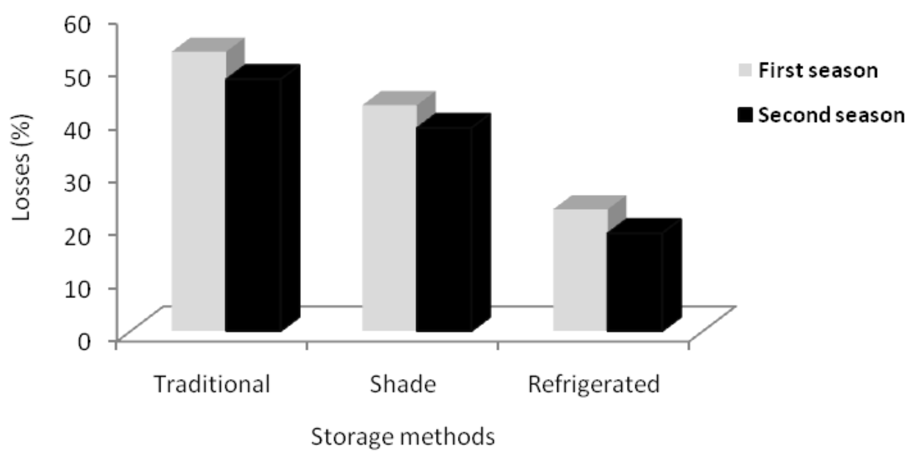

Fig 3. Effects of storage methods on total loss (%) after five month of storage

Tables 2 and3 show the main effects of onion genotypes on total losses (%) during 5 months of storage. Results indicated highly significant differences among onion genotypes on total losses (%) in both seasons. The least losses were recorded for *Abufrewa* followed by $F_{2,}$ $BC_{2,}$ F_1 and then $BC_{1,}$ while the highest losses were recorded for *Baftaim* in both seasons. This can be explained by the fact that the local cultivar *Abufrewa* had a higher dry matter content, higher total soluble solids and higher pungency which are important characteristics for longer storage life. On the other hand, *Baftaim* cultivar had low dry matter content, low total soluble solids and low pungency which are conducive to short storage life (Table 1). These findings are in conformity with the reports of Yoo *et al*. (2006) and Mohammed (2008).

Table 1. Dry matter content, total soluble solids and pungency of onion genotypes**.**

Genotypes	Dry matter (%)		TSS (%)		Pungency	
	Season		Season		Season	
	2015/16	2016/17	2015/16	2016/17	2015/16	2016/17
Baftaim	15.0d	15.5d	14.0c	15.0 c	1.0d	1.0d
Abufrewa	22.0a	22.5 a	20.0a	21.0 a	3.0a	3.0a
F_1	16.3c	17.0 c	15.5c	16.5 c	2.0bc	2.0bc
F_2	18.0b	19.0b	17.5b	18.0 b	2.5ad	2.5ad
BC_1	16.5c	17.5 c	15.5c	16.5c	1.5cd	1.5cd
BC_2	17.5b	18.5 b	17.5b	18.5b	2.0b	2.2b
Mean	18	18.3	17	17.1	2.1	2.2
CV%	3.8	3.4	4.6	4.2	25.7	25.2
Sing. level	**	**	*	**	**	**

Means in columns followed by the same letters(s) are not significantly different at P ≤0.05 level according to Duncan's Multiple Range Test.
* and ** indicate significance at 5% and 1% levels, respectively.
Pungency scale: 1= low, 2= moderate, 3 = high.

Table 2. Main effects of onion genotypes on losses (%) during five months of storage.

Genotypes	Season 2015/16				
	June	July	Aug	Sept	Oct
Baftaim	9.25 a	9.25 a	10. 13 a	11.05 a	12.67 a
Abufrewa	4.70 f	4.05 g	5.65 f	6.00 g	6.90 e
F_1	5.96 d	6.08 d	7.28 d	7.45 d	7.31 d
F_2	5.55 e	5.70 f	5.90 e	6.45 f	7.68 c
BC_1	6.72 c	7.35 c	7.60 c	7.78c	8.85 b
BC_2	5.15 e	5.51 e	6.50 d	7.55 e	7.53 c
CV(%)	1.0	1.3	2.2	1.2	1.8
Sig. level	***	***	***	***	***

Means in columns followed by the same letters (s) are not significantly different at P≤0.05 level according to Duncan's Multiple Range Test.

*** indicate significance at 0.1% level.

Table 3. Main effects of onion genotypes on losses (%) during five months of storage.

Genotypes	Season 2016/17				
	June	July	Aug	Sept	Oct
Baftaim	8.02 a	8.05 a	9. 02 a	10.08 a	11.23 a
Abufrewa	3.10 f	3.60 f	4.31 f	5.10 g	6.50 f
F_1	5.62 c	4.47 d	6.36 d	6.71 d	8.18c
F_2	4.48d	3.38 d	5.28 d	5.45 e	7.51 d
BC_1	5.68 c	4.98 c	6.60 c	8.06 c	9.25c
Bc_2	4.90 e	4.90 e	5.85 e	6.30 f	7.08 e
CV(%)	1.4	1.9	1.3	1.0	1.1
Sig. level	***	***	***	***	***

Means in columns followed by the same letters(s) are not significantly different at P ≤0.05 level according to Duncan's Multiple Range Test. indicate significance at 0.1% level.

Indicate significance at 0.1% level.

Fig. 4 shows the main effects of onion genotypes on total losses after five months of storage during both seasons. The cultivar *Abufrewa* showed the lowest total losses after five months of storage, whereas *Baftaim* recorded the highest losses. The other genotypes showed intermediate values. These results are consistent with the data presented in Tables 2 and 3 and with those of Ahmed *et al*. (2015b)

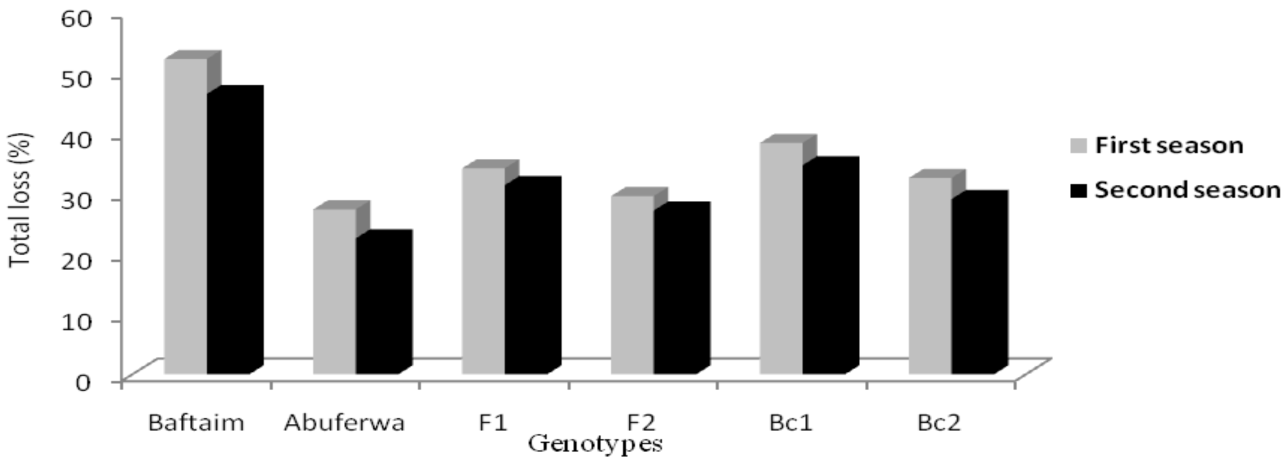

Fig 4. Total loss (%) of onion genotypes after five months of storage.

Table 4 shows significant interaction effects of storage methods and onion genotypes on losses (%) of onion during five months of storage. The highest losses percentages were obtained by *Baftaim* (65.3%, 47.0%), followed by BC_1 (48.2%, 45.9%), F_1 (45.2% ,42.8%), BC_2 (38.3%, 36.9%) then F_2 (37.4%, 35.1%) and finally the genotype *Abufrewa* (35.6%,32.3%) under the traditional method in the first and second seasons, respectively. This result agreed with that of (Kukanoor, 2005) who reported that storage temperature and relative humidity had significant effects on onion sprouting, rotting, greening and weight loss and these were further correlated with storage period. The shaded method of storage resulted in medium total loss percentages. The highest losses were obtained by *Baftaim* cultivar (56.8%, 53.8%), followed by BC_1 (41.35%, 38.9%), F_2 (33.8%, 28.65%) and the lowest losses were obtained by *Abufrewa* (30.1%, 26.0%) in the first and second seasons, respectively. Similar results were reported by Elkashif *et al*., 2006).

The refrigerated method of storage resulted in the lowest total loss percentages in all genotypes. This is because cooling slows down all physiological processes in vegetables and fruits. The highest total loss was obtained by *Baftaim* (35.8%, 30.5%), BC_1 (21.7%, 18.2%), F_2 (15.4%, 13.6%) and the lowest losses were obtained by *Abufrewa* (14.0%, 11.6%) in the first and second seasons, respectively. These results are consistent with the previously mentioned data in this study. They are also in agreement with those of Ahmed *et al*. (2015a; 2015c) who reported that the ideal temperature for onion storage was 0ºC with 60%-70% relative humidity. The choice of storage regime depends on cultivar, target storage period and cost of storage (Benkeblia *et al*., 2002).

Table 4. Interaction effects of storage methods and onion cultivars on total loss (%) after five months of storage.

Storage methods	Total loss%		
	Genotypes	First season	Second season
Traditional	*Baftaim*	60.3	57.0
	Abufrewa	35.6	32.3
	F_1	45.2	42.8
	F_2	37.4	35.1
	Bc_1	48.2	45.9
	Bc_2	38.3	36.9
Shade	*Baftaim*	56.8	53.8
	Abufrewa	30.1	26.0
	F_1	37.9	35.2
	F_2	33.8	28.6
	Bc_1	41.3	38.9
	Bc_2	35.6	32.9
Refrigerated	*Baftaim*	35.8	30.5
	Abufrewa	14.0	11.6
	F_1	20.1	15.4
	F_2	15.4	13.6
	Bc_1	21.7	18.2
	Bc_2	17.5	14.8

In conclusion, it is recommended to continue backcrossing with *Abufrewa* cultivar to produce genotypes with good storability and use refrigerated storage to reduce post-harvest losses in onion

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