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Foliar Nutrition and Post-Harvest of Onion Seed: Effects of storage temperatures, storage period and foliar nutrition

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Abstract: The aim of onion bulb storage is to meet consumer demand for extended availability of onions whilst maintaining product quality. The principal biological factors leading to onion bulb deterioration are respiration, resumption of growth and pathogen attack. In onion bulbs a dormant period, when sprouting and rooting cannot be induced, is followed by a period of internal changes that prepare the bulb for breaking of dormancy and subsequent growth. Out of storage, the bulb then proceeds towards flowering and seed production.

Two successive winter seasons of 2008/2009 and 2009/2010 were conducted under sandy soil conditions to study the effect of spraying with 12 commercial compounds on yield and yield components of onion seeds and storage The seed yield of each commercial compounds plot from previous experiment was divided into two groups, storage under room temperature and 5°C. Seeds transferred immediately after drying to Increasing Export Competition of Some Vegetable Crops Project Laboratory located in Faculty of Agriculture, Cairo University. The effects of storage temperature, storage period and foliar with some commercial compounds on onion seed quality were considered. Storage in 5°C had the higher germination percentage than storage in room temperature. Results indicated that as storage period increased the germination percent decreased. The treatment with boron or amica in the first season had the highest germination percentage. While, the treatment with union Zn, union feer, union Mn, boron, elga 600, caboron, amica, hummer or amino X had the highest germination percentage in the second season. Storage in 5°C resulted in higher moisture content than storage in room temperature. Regarding the effect of storage period on moisture content, the water content was significantly increased with prolongation of storage period. The lowest values of water content were recorded for treatments with union feer, shams K or boron in the first season, and union feer, shams K, boron, magnesium, shetocare or hummer in the second one. Catalase activity was significantly decreased as storage period increased. The treatment with shams K, boron, shetocare or amino X had the highest catalase activity in both seasons. Peroxidase activity was significantly decreased as storage period increased. Foliar application with boron had the highest peroxidase activity in both seasons. Seed stored in room temperature had the higher malondialdehyde content than those stored in 5°C in the second season. The malondialdehyde content increased as storage period increased. The treatment with magnesium, caboron and the control in the first season, and the treatment with magnesium and the control in the second season had the highest malondialdehyde content.

Keywords: Onion; pre-harvest; post-harvest, foliar application, seeds production, modified atmosphere packages

Introduction

The postharvest life of fruits and vegetables has been traditionally defined in terms of visual appearance (freshness, color, and absence of decay or physiological disorders) and texture (firmness, juiciness, and crispness). Although this concept involves aesthetic appeal and mechanical properties associated with quality, it disregards flavor and nutritional quality (***Ayala-Zavala et al. 2004***). Flavor plays an important role in consumer satisfaction and influences further consumption of fruits and foods in general (***Pelayo et al. 2003***). Fruits form an important part of our diet mainly as a source of energy, vitamins, minerals, and antioxidants. Postharvest losses in nutritional quality, particularly vitamin C content, can be substantial and are enhanced by physical damage, extended storage duration, high temperatures, low relative humidity, and chilling injury of chilling-sensitive commodities (***Navarro et al. 2006; Kevers et al. 2007***).

Many biochemical characteristics change during storage of onion. These include changes in water content, the concentrations of flavor-related compounds (***Uddin and MacTavish, 2003***), organic acids, carbohydrates (***Benkeblia et al. 2005***), plant growth regulators and phenolics (***Benkeblia, 2000***). Biochemical changes during storage are likely to be linked with respiration. All nutrients required for growth of the sprout must come from within the bulb; therefore, changes in certain key characteristics might be used to predict the onset of sprouting. Maximal and minimal concentrations of certain substances are known to coincide with sprouting, but there is currently no biochemical assay that anticipates sprouting. During storage a gradual change in the relative composition of plant growth regulators occurs as the concentrations of growth promoters and/or growth inhibitors rise or fall, respectively. The growth inhibitory substance, detected by **Thomas and Isenberg (1972)**, is widely believed to be abscisic acid (***Chope et al. 2006***).

The temperature at which onion sets are subjected in storage has a significant influence on bulb yield. Low storage temperature (0 ºC) leads to the highest bulb yield but this was reduced as the storage temperature was raised from 0 to 5 ºC. In general, high temperature storage (above 20 ºC) results in increased total bulb yields while very high temperature (25.5– 31 ºC) or below 0 ºC slightly depressed yield by delaying sprouting after planting the bulbs, thus shortening the period available for growth. On the other hand, storage of sets at mild temperatures (5–15 ºC) usually results in lower marketable yields than do lower and higher storage temperatures (***Khokhar et al. 2007***). Many studies have stated that cold storage (about 0 ºC) prevents subsequent flowering and improves bulb yield, but leads to crops maturing earlier than those stored at high temperatures (about 25 ºC) (***Khokhar, 2009***).

Accelerated ageing of seeds induced by several days of exposure to high temperature and humidity is recognized as an accurate indicator of seed viability and storability (***Delouche and Baskin, 1973***). Artificial accelerated ageing enables to understand the possible sequence of causes and reasons of seed deterioration at faster rate, thus helps in formulating counteractive priming treatments and appropriate storage practices. Rapidly deteriorating seeds show decline in their ability to emerge into vigorous seedlings (***McDonald, 1999***). Some of the deleterious effects of ageing are associated with damages occurring at membrane, nucleic acids and protein levels (***Fujikura and Karssen, 1995***). Peroxidation of unsaturated fatty acids is considered to be one of the main reasons for loss of storability, which occurs due to decreased levels of antioxidants, reduced activity of free radical and peroxide scavenging enzymes, and increased lipid peroxidation vis-à-vis malondialdehyde content (***Bailly et al. 1996***). Standardization of appropriate seed conditioning, packaging and storage conditions could ensure satisfactory planting quality of onion seeds at the time of sowing. In the present study, experiments were conducted to find out possible ways to improve storability of onion seeds with respect to packaging and storage conditions. Germination performance, activities of antioxidant enzymes and lipid peroxidation products were analyzed in rapidly aged onion seeds (***Rao et al. 2006***).

Onions (*Allium cepa*) are widely used around the world in food as seasoning with well known health benefits (***Wood, 2008***). However, onions are also reported to be susceptible to microbial contamination during postharvest storage (***Calvin et al. 2004***). Three microbial food-borne outbreaks in the USA, including four deaths and several illnesses, were associated with the consumption of imported onions of poor hygienic quality (***Calvin et al. 2004***). Along with hygienic concerns, sprouting is also a big problem in the long-terms to rage of onions (***Ahn et al. 2012***).

Onion is a species of the *alliaceae* family it is of great economic importance in Egypt. It is the most important cash crop after rice in Egypt. The total planted area for onion seed production is 2752 fed (ha = 2.4 fed). Producing 742 tons with an average of 270 kg fed^{-1} according to the Egyptian Ministry of Agriculture report (2008). Increasing its yield with consequent economic return is the major concern of the farmers (***Abd El-Gawad, 2012***). Egypt is considered the 4th producer of dry onion in the world, where it produce about 2,208,080 ton, average yield per hectare is 358833 kg ha^{-1} and the total harvested area from dry onion 61535 ha in 2010 (***FAO, 2012***).

The seed production programs depend upon quality of seeds, agronomic practices and plant protection measures taken to produce the healthy and vigorous crop. Among the agronomic practices nutrient management through organic sources is considered as an important factor for production. The problem of high cost of chemical fertilizers fully meet out nutrient requirement of crop by single source therefore integrated nutrients management such as organic matters like farmyard manure, vermicompost, poultry manure and biofertilizers use has become necessary (***Bendegumbal, 2007***).

Therefore, the aim of this study was to investigate the effect of foliar application with 12 commercial compounds on onion growth, seed production and its longevity. Also, the study aimed to investigate storage conditions such as storage temperature, storage period and foliar with some commercial compounds on onion seed quality.

Materials and Methods

Experimental design

The aim of this investigation was to study the effect of foliar application with 12 commercial compounds and untreated treatment (foliar with water) on onion seed production under sandy soil conditions (**Fig. 1**). These commercial compounds are listed in **Table 1**. The seeds for this study produced at Waddy Elnatron farm, Agricultural Experimental Station of the Faculty of Agriculture, Cairo University. This study conducted in two successive seasons in 2008/2009 and 2009/2010. Waddy Elnatron farm is reclaimed sand soil, its chemical and physical analysis is presented in **Table 2** and water chemical analysis is presented in **Table 3**.

Table 1: Commercial compounds, their structures and using rate of them

Compound	Company	Compound structure	Using rate
Shetocare	Kemia Masr	1000 ppm N + 500 ppm K + 100 ppm Zn + 50 ppm Cu + 500 ppm P + 100 ppm Fe + 50 ppm Mn + 50 ppm B	1ml l^{-1}
Amica	Technogreen	10% amino acid + 5% total nitrogen + 14% calcium + 7% organic matter	1ml l^{-1}
Caboron	Technogreen	6% chelate calcium + 1.5% chelate B + 20% calcium oxide	1ml l^{-1}
Amino X	UAD	80% total amino acid + 16% free amino acid + 10% organic nitrogen + 2.5% potassium oxide	1g l^{-1}
Elga 600	Technogreen	1% N + 18% potassium oxide + 2% S	1g l^{-1}
Hummer	UAD	Humic acid containing 6% potassium oxide + 86% potassium hummat	1g l^{-1}
Union Zn	UAD	12% Zn chelated on amino and organic acids	1g l^{-1}
Union Mn	UAD	13% Mn chelated on amino and organic acids	1g l^{-1}
Union Feer	UAD	6% Fe chelated on amino and organic acids	1g l^{-1}
Shams K	UAD	50% potassium oxide + 1% magnesium oxide	
Boron	UAD	–	0.5 g l^{-1}
Magnesium	UAD	–	0.5 g l^{-1}
Untreated		sprayed with water	–

* UAD = Union for Agricultural Development

Table 2: Physical and chemical analysis of the experimental soil in 2008/2009 and 2009/2010 seasons

Season	Soil texture	Soluble cations (meq l^{-1})				Soluble anions (meq l^{-1})		
		K^+	Na^+	Ca^{++}	Mg^{++}	HCO_3^-	SO_4^{+2}	Cl^-
2008/2009	Sandy	10.0	17.52	16.11	6.37	1.33	21.67	18.0
2009/2010	Sandy	10.8	40.83	64.37	50.78	5.90	21.34	31.5

Table 2: Cont.

Season	Soil EC (dS m^{-1})	Soil pH	Available nutrients (mg kg^{-1})					
			N	P	Fe	Cu	Zn	Mn
2008/2009	4.20	7.70	18.0	28.2	17.5	1.20	2.40	5.20
2009/2010	3.90	8.35	18.9	35.4	16.2	1.55	3.18	6.28

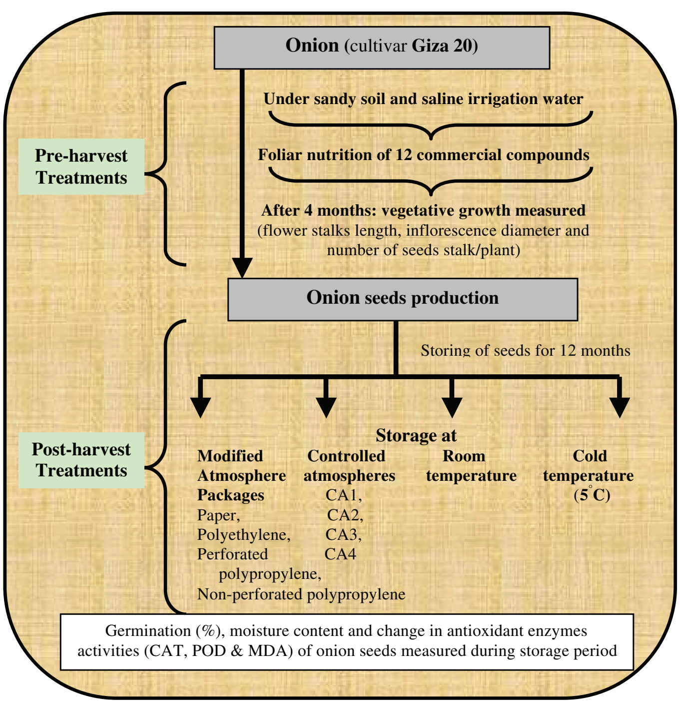

Figure 1: Experimental design

One commercial onion cultivar was selected for this study, viz., Giza 20. Bulbs were brought from Agricultural Research Center, Giza. Bulbs were sown on Dec. 18th and 14th in 2008 and 2009, respectively. Seeds were harvested on June, 14 and 7 in 2009 and 2010, respectively when the open capsules reached to 5 % of total capsules. The area of each plot was 16 m^2 (4 rows × 4 m long × 1 m width). Bulbs were sown on the center of the ridge and spaced 25 cm between each bulb in four replicates using standard commercial practices. The method of irrigation was drip. A completely randomize blocks design (CRBD) was used with four replicates. The commercial compounds were treated three times during the season of growth at vegetative growth, flowering and flower set (after two months of sowing date, one month later and one month later, respectively).

Biochemical assessments of onion seed

Two grams of seeds were ground in a mortar and homogenized in 20 ml of 0.1 M phosphate puffer (pH 7.8) containing 0.4 g polyvinyl pyrrolidone, 2 mM dithiotheitol and 0.1 mM EDTA followed by centrifuging at 16,000 × g for 15 min at 4°C (***Rao et al. 2006***).

Table 3: Chemical analysis of irrigation water

Water EC (dS m^{-1})	Water pH	Soluble cations (meq l^{-1})				Soluble anions (meq l^{-1})		
		K^+	Na^+	Ca^{++}	Mg^{++}	CO_3^{--}	SO_4^{+2}	Cl^-
3.9	7.5	0.39	29.88	2.16	7.15	4.04	12.71	22.83

Table 4: Some vegetables, their storage conditions, and material used for analysis (adapted from ***Kevers et al. 2007***)

Vegetable	Storage		Material used
	Condition	Duration (days)	
Asparagus	4 °C	22	All material
Broccoli	4 °C Packaged with polypropylene films	27	All material
Carrot	4 °C	51	Without peel
Celery	4 °C	8	Without peel
Cherry	Room temperature	7	Without hard core
Cucumber	4 °C	8	With skin
French bean	4 °C	8	All material
Garlic	Room temperature	30	Without peels
Green pepper	4 °C	14	Without pips
Lettuce	4 °C Packaged in sealed polypropylene bags	8	All material
Onion	Room temperature	23	Without peel
Red pepper	4 °C	14	Without pips
Spinach	4 °C Packaged in sealed polypropylene bags	19	All material
Tomato	4 °C	36	All fruit
Yellow pepper	4 °C	34	Without pips

Catalase activity (CAT)

Catalase was assayed by measuring the decrease in absorbance due to disappearance of H_2O_2 at 240 nm according to ***Chance and Maehly (1955)***. The enzyme extract (100 µl) was added to 100 µl of 100 mM H_2O_2 and the total volume was made up to 1 ml by 250 mM phosphate buffer pH 6.8. The decreasing in optical density at 240 nm against blank was recovered every minute. For reproducible results, the absorbance at 240 nm should be between 0.450- 0.500 and start decrease by adding enzyme extract.

Peroxidase activity (POD)

This enzyme assayed spectrophotochemically according to **Amako *et al.* (1994)**. The assay was carried out at 25°C in 1.0 cm light bath cuvette and the reaction mixture was consisted of 1500 µl phosphate buffer, 1000 µl pyrogallol and 480 µl H_2O_2 solution. After mixing, the reaction was initiated by adding the enzyme extract (20 µl) and increasing in optical density at 430 nm against blank (without extract) was continuously recorded every minute for three minutes. The calculation was per enzyme unit (EU), where this unit definition (EU) is defined as the amount of enzyme required to cause an increase in the optical density at 430 nm /min at 25°C under standard conditions (0.01OD=1 EU).

Malondialdehyde content (MDA)

Seed material (0.5 g) was homogenized in 5 ml of 0.1% trichloroacetic acid (TCA) and centrifuged at 20,000 × g for 10 min to 1 ml of extract, 4 ml of 0.5% (w/v) thiobarbituric acid (TBA) in 20% (w/v) TCA was added. The homogenate was incubated at 95°C for 30 min. cooled on ice and centrifuged at 16,000 × g for 30 min and MDA content (mmol g^{-1} fw) was spectrometrically determined at 452 nm according to **Health and Parker (1968)**.

Effect of storage temperatures, storage periods and foliar application with some commercial compounds on onion seeds quality

This part of the investigation aimed to study the effect of different commercial compounds and two storage temperatures (room temperature and 5°C) on germination, moisture content and change in antioxidant enzymes activity of onion seeds during storage period. The seeds were transferred immediately after drying to Increasing Export Competition of Some Vegetable Crops Project laboratory located in Faculty of Agriculture, Cairo University. Seed yield of each commercial compound plot was divided into two groups, storage under room temperature and 5°C. Seeds were stored for one year. Number of treatments was 104 (12 commercial compounds + control × 2 storage temperatures × 4 replicates). All treatments were stored in non perforated polypropylene bags. The following parameters were measured after harvest and every 4 months: seed water content, seed germination, chemical analysis and biochemical assessment (CAT, and POD and MDA content).

Statistical analysis

Data were organized in a completely randomized block design (CRBD). Analyses of variance (ANOVA) were obtained using M. State statistical software. The new LSD

Table 5: Antioxidant Capacity (DPPH and ORAC) and vegetable content in total phenolics, ascorbic acid, and total flavonoids* (adapted from ***Kevers et al. 2007***)

Vegetable	**Total phenolics** (mg of CAE 100 g^{-1} of FW)	**DPPH** (μM TE 100 g^{-1} of FW)	**ORAC** (μM TE 100 g^{-1} of FW)	**Ascorbic acid** (mg of AA 100 g^{-1} of FW)	**Total flavonoids** (mg of QE 100 g^{-1} of FW)
Red pepper	296 ± 13	1207± 48	875 ± 152	165.6 ± 15.8	4.8 ± 0.5
Yellow pepper	284 ± 10	1207 ± 124	1011 ± 120	171.3 ± 18.9	2.3 ± 0.1
Green pepper	215 ± 31	1163 ± 104	907 ± 196	135.3 ± 12.9	2.1 ± 0.4
Spinach	177 ± 2	184 ± 4	1558 ± 64	12.4 ± 0.5	6.6 ± 0.5
Broccoli	127 ± 32	188 ± 8	1586 ± 328	15.2 ± 4.2	0.3 ± 0 0
Garlic	113 ±4	60 ± 4	1370 ± 392	4.9 ± 0.7	0.2 ± 0
Leek	77 ± 3	180 ± 4	675 ± 44	21.9 ± 1.2	0.4 ± 0 1
Celery	75 ± 4	60 ± 4	679 ± 68	0.5 ± 0.1	0.2 ± 0.1
Onion	53 ± 7	60 ± 4	739 ± 144	7.0 ± 0.7	3.3 ± 0.4
Asparagus	44 ± 4	72 ± 4	296 ± 68	9.2 ± 0.5	0.2 ± 0.1
Tomato	35 ± 2	84 ± 4	216 ± 4	8.2 ± 1.2	2.3 ± 0.2
French bean	34 ±1	68 ± 4	511 ± 88	0.5 ± 0	5.0 ± 0.2
Lettuce	32 ± 1	56 ± 4	184 ± 12	0 ± 0	2.6 ± 0.3
Cucumber	20 ± 2	0 ± 0	160 ± 32	0.4 ± 0.3	0.2 ± 0.0
Carrot	0 ± 0	0 ± 0	276 ± 100	1.6 ± 0.2	0.7 ± 0.1

* Assays were run immediately after vegetables were obtained from distribution center
Abbreviation: DPPH = 2,2-diphenyl-1-picrylhydrazyl TE = Trolox equivalents
ORAC = oxygen radical absorbance capacity CAE = chlorogenic acid equivalents
QE = quercetin equivalents

method (***Waller and Duncan, 1969***) was used for testing the significance of means in all experiments conducted.

Results and Discussions

Storage of onion seed under cold temperature

Storage of fresh fruits and vegetables prolongs their usefulness. The principal goal of storage is to preserve the commodity in its most useable form for the consumer. The extension of storage life and the improvement of quality of fresh fruits and vegetables can be supplied by harvesting at proper maturity, control of post-harvest diseases, chemical treatments, refrigeration, controlled and modified atmospheres. The main goals of storage are to (1) slow the biological activity of fruits and vegetables (2) slow the growth of microorganisms (3) reduce transpirational losses. In general, fruits and vegetables visually spoil before any significant antioxidant capacity loss occurs. Nevertheless, it could be stressed that, in general, polyphenolic content increased. Increased levels of antioxidant capacity generally accompanied this increase, which should be considered as an important assurance for the impact of storage evolution of phenolics on the nutritional value of fruits and vegetables (**Tables 4 and 5**).

Germination percent

Effect of storage temperature on germination percent

Storage temperature had a significant effect on germination percent of onion seeds in both seasons. Storage at cold temperature had the higher germination percent than storage at room temperature (**Table 6**). These results are in agreement with those obtained by **Garg and Pitam (2005)** and **Lazarenko and Bezrukov (2008)** as they found that the germination percentage decreased as storage temperature increased.

Effect of storage periods on germination percent

Regarding the effect of storage period on germination percentage, data in **Table 6** show that germination percentage decreased as storage period increased. These results are in agreement with those obtained by **Muhammad and Anjum (2002)**, **Sharma *et al*. (2002 and 2004)** and **Gaviola *et al*. (2006)**. These results may be attributed to the decrease of antioxidant enzyme activity as storage period increased and the increasing of water content and malondialdehyde content as storage period increased.

Effect of foliar application with commercial compounds on germination percent

Concerning the effect of foliar application with commercial compounds on germination percentage, data in **Table 6** show that the treatment with boron or amica in the first season had the highest germination percentage. While, the treatments with union Zn, union feer, union Mn, boron, elga 600, caboron, amica, hummer or amino X had the highest germination percentage in the second season. These results may be due to the fact that these treatments had the highest values of enzymes activity and the lowest malondialdehyde content. These results are in agreement with **Xin and Wang (2006)** and **Demirkaya *et al*. (2010)**. They found highly positive correlation between the loss of seed viability and the decreases that occurred in catalase (CAT), peroxidase (POD) and superoxide dismutase

Table 6: Effect of storage temperature, storage period and foliar application with commercial compounds on **germination (%)** and **water content (%)** of onion seeds during seasons of 2008 / 2009 and 2009 / 2010

Treatments	**Germination (%)**		**Water content (%)**	
	2008/2009	**2009/2010**	**2008/2009**	**2009/2010**
Storage temperature				
Room temperature	81.32 b	83.38 b	4.145 b	4.586 a
Cold temperature (5° C)	85.66 a	86.83 a	5.191 a	4.572 a
LSD $_{0.05}$	2.784	1.260	0.013	N.S.
Storage period (month)				
0	94.46 a	94.10 a	4.179 d	4.200 d
4	86.62 b	90.04 b	4.473 c	4.960 a
8	78.93 c	81.39 c	5.272 a	4.666 b
12	73.96 d	74.90 d	4.747	4.490 c
LSD $_{0.05}$	0.6131	1.008	b 0.068	0.0441
Foliar application				
Union Zn	84.72 c-d	85.19 a-c	4.62 b-e	4.65 a-b
Union Feer	85.19 b-c	87.00 a	4.59 d-e	4.57 c-e
Union Mn	84.63 c-d	86.25 a-b	4.68 a-e	4.61 b-d
Shams K	81.63 e-f	84.28 b-d	4.60 c-e	4.50 e-g
Boron	87.41 a	86.69 a	4.57 e	4.51 e-f
Magnesium	79.09 g	81.53 e	4.66 a-e	4.44 g
Elga 600	82.78 d-e	84.84 a-d	4.67 a-e	4.60 b-d
Caboron	84.16 c-d	86.41 a-b	4.64 a-e	4.65 a-b
Amica	86.84 a-b	86.09 a-b	4.74 a	4.68 a
Shetocare	80.28 f-g	83.59 c-e	4.72 a-c	4.45 f-g
Hummer	83.28 c-e	85.44 a-c	4.72 a-b	4.54 d-e
Amino X	84.84 b-d	86.31 a-b	4.69 a-d	4.62 a-c
Untreated	80.56 f-g	82.78 d-e	4.73 a-b	4.64 a-c
LSD $_{0.05}$	2.093	2.235	0.114	0.074

Details of treatment listed in Table 3

Table 7: Effect of the interaction between storage temperature and storage period on germination percentage of onion seeds during seasons of 2008/2009 and 2009/2010

Storage period (month)	**Storage temperature**			
	Room temperature	**Cold temp. (5°C)**	**Room temperature**	**Cold temp. (5°C)**
	Season 2008/2009		**Season 2009/2010**	
0	94.48 a	94.48 a	94.0 a	94.0 a
4	84.77 c	88.46 b	88.4 c	91.65 b
8	75.37 f	82.50 d	79.34 e	83.44 d
12	70.67 g	77.25 e	71.67 f	78.13 e
LSD $_{0.05}$	0.8671		1.425	

Table 8: Effect of the interaction between storage temperature and foliar application with commercial compounds on germination percentage of onion seeds during seasons of 2008/2009 and 2009/2010

Treatments	**Storage temperature**			
	Room temperature	Cold temp. (5°C)	Room temperature	Cold temp. (5°C)
	Season 2008/2009		**Season 2009/2010**	
Union Zn	82.9 f-h	86.5 b-d	83.63 f-i	86.75 a-f
Union Feer	84.9 c-h	85.4 c-f	84.63 d-h	89.38 a
Union Mn	82.1 h-j	87.1 b-c	85.69 b-g	86.81 a-e
Shams K	79.3 k-l	86.5 b-c	84.06 e-h	84.50 d-h
Boron	83.0 e-i	91.7 a	85.38 b-g	88.00 a-c
Magnesium	74.3 l	83.8 d-i	79.56 j	83.50 g-i
Elga 600	79.6 j-k	85.8 c-f	80.75 i-j	88.94 a
Caboron	83.8 d-i	84.4 c-h	84.63 d-h	88.19 a-b
Amica	84.3 c-h	89.3 a-b	83.88 e-i	88.31 a-b
Shetocare	78.1 k	82.3 g-j	82.25 h-j	84.94 c-h
Hummer	85.1 c-g	81.3 i-j	84.00 e-h	86.88 a-e
Amino X	83.6 d-i	86.0 c-e	85.38 b-g	87.25 a-d
Untreated	78.0	83.1 e-i	80.19 j	85.38 b-h
LSD $_{0.05}$	2.960		3.161	

Details of treatment listed in Table 3

Table 9: Effect of the interaction between storage period and foliar application on **germination percentage** of onion seeds during 2008 / 2009 and 2009/2010 seasons

Treatments	**Storage period (month)**							
	0	**4**	**8**	**12**	**0**	**4**	**8**	**12**
	Season 2008/2009				**Season 2009/2010**			
Union Zn	93.7 b-f	89.1 g-k	80.5 o-r	75.5 t-x	93.0 a-e	88.8 f-i	81.2 k-o	77.6 n-q
Union Feer	96.5 a-b	87.7 h-l	80.7 o-r	75.7 s-w	95.5 a-b	91.2 b-g	85.0 i-k	76.2 p-q
Union Mn	95.2 b-d	87.6 h-l	80.1 o-r	75.5 t-x	94.7 a-c	90.1 d-h	81.2 k-o	78.8 m-p
Shams K	91.5 d-h	86.0 j-n	76.7 r-l	72.2 x-z	95.5 a-b	91.1 b-g	79.5 l-p	71.0 r
Boron	99.5 a	88.6 g-k	83.5 m-p	78.0 r-u	96.7 a	91.1 b-g	81.6 k-o	77.2 n-q
Magnesium	91.0 e-i	83.5 m-p	73.5 w-x	68.3 z	92.5 a-e	87.7 h-j	76.5 l-p	69.3 r
Elga 600	94.5 b-e	86.1 j-n	77.7 r-v	72.7 w-y	94.2 a-d	89.1 e-i	82.7 k-n	73.2 q-r
Caboron	96.0 a-c	85.8 k-n	79.8 p-s	74.8 u-x	94.2 a-d	92.2 b-g	81.5 o-q	77.6 n-q
Amica	93.7 b-f	90.1 f-j	84.2 l-o	79.2 q-t	93.5 a-e	90.1 d-h	83.6 k-m	77.1 o-q
Shetocare	95.5 a-d	83.1 n-q	73.7 v-x	68.7 y-z	94.2 a-d	90.3 c-h	79.3 l-p	70.3 r
Hummer	92.5 b-f	87.2 i-m	79.1 q-t	74.2 u-x	93.0 a-e	89.7 e-h	82.8 k-m	76.1 p-q
Amino X	96.2 a-b	87.6 h-m	80.8 o-r	74.6 u-x	93.2 a-e	90.7 c-h	83.6 j-l	77.6 n-q
Untreated	92.0 c-g	83.2 n-q	75.3 t-w	71.6 x-z	92.7 a-e	87.8 g-j	79.2 l-p	71.2 r
LSD $_{0.05}$	**4.186**				**4.470**			

Details of treatment listed in Table 3

(SOD) activity in the seeds and negative correlation between the loss of seed viability and the increases that occurred in malondialdehyde content in the seeds.

Effect of the interaction between storage temperature and storage period

Regarding the effect of the interaction between storage temperatures and storage period, the highest germination percentage after 12 months of storage was recorded at cold storage temperature (5°C). The germination percentage was decreased by increasing storage period in the two storage temperatures, but the germination percentage still higher in cold storage temperature than in room temperature at all storage periods in both seasons (**Table 7**).

Effect of the interaction between storage temperature and foliar application with commercial compounds

Concerning the effect of the interaction between storage temperature and foliar application with commercial compounds, the highest germination percentage was recorded for the treatment with union Zn, union Mn, shams k, boron, amica or amino X at 5°C in the first season and the treatment with union feer or elga 60 at 5°C in the second season as shown in **Table 8**.

Effect of the interaction between storage period and foliar application with commercial compounds

Data in **Table 9** show that germination percentage decreased as storage period increased in all foliar treatments. The highest germination percentage at the end of storage period was recorded for the treatment with boron or amica in the first season and the treatment with union Zn, union Mn, boron, caboron or amino X in the second season. These results may be due to that these treatments had the highest germination percentage after harvest (**Table 7**).

Effect of the interaction between storage temperatures, storage period and foliar application with commercial compounds

The triple interaction between storage temperature, storage period and foliar application had a significant effect on germination percentage in both seasons. The highest germination percentage was recorded for the treatment with boron or amica in all storage periods at 5°C compared with all other different treatments in the first and second seasons, respectively as shown in **Table 10**.

Water content

Effect of storage temperature on water content

Storage temperature had a significant effect on water content of seeds in both seasons of the study. Storage at 5°C resulted in higher water content than storage at room temperature as shown **Table 7**. These results are in agreement with those obtained by **Stanwood and Sowa (1995) and Yanping *et al.* (1999)**.

Effect of storage period on water content

It is clear from data presented in **Table 7** that the water content was significantly increased with prolongation of the storage periods. The water content started to increase slowly and successively increased till the end of storage. These results are in agreement with those obtained by **Kavak and Eser (2009)** who found that water content of onion seed had raised from 9 % to 13 % during storage at 25°C for 10 weeks.

Effect of foliar spraying with commercial compounds on water content

Concerning the effect of foliar application with commercial compounds on water content of seeds, data in **Table 7** show that the lowest values of water content was

Table 10: Effect of the interaction between storage temperature, storage period and foliar application with commercial compounds on **germination (%)** of onion seeds during seasons of 2008/2009 and 2009/2010

Interactions	**Storage period (month)**							
	0	**4**	**8**	**12**	**0**	**4**	**8**	**12**
	Season 2008/2009				**Season 2009/2010**			
	Room temperature							
Union Zn	93.75	88.0	77.5	72.5	93.00	85.75	79.00	76.75
Union Feer	96.50	87.2	80.5	75.5	95.50	89.00	83.25	70.75
Union Mn	95.25	85.5	76	71.7	94.75	87.75	80.00	80.25
Shams K	91.50	82.5	78.5	64.5	95.50	90.75	80.25	69.75
Boron	99.50	84.2	76.7	71.7	96.75	89.25	80.00	75.50
Magnesium	91.25	79.0	66.2	61.0	92.50	86.25	73.75	65.75
Elga 600	94.50	83.7	72.2	67.7	94.25	85.75	78.50	64.50
Caboron	96.00	85.5	79.5	74.5	94.25	91.50	77.75	75.00
Amica	93.75	88.7	80	75	93.50	90.00	80.25	71.75
Shetocare	95.50	81.2	70.5	65.5	94.25	89.75	78.50	66.50
Hummer	92.50	89.2	82	77	93.00	87.00	82.25	73.75
Amino X	96.25	87	78.2	73.2	93.25	89.75	82.75	75.75
Untreated	92.00	80	71.2	68.7	92.75	87.00	75.25	65.75
Cold temperature (5 ºC)								
Union Zn	93.75	90.2	83.5	78.5	93.00	92.00	83.50	78.50
Union Feer	96.50	88.2	81	76.0	95.50	93.50	86.75	81.75
Union Mn	95.25	89.7	84.2	79.2	94.75	92.50	82.50	77.50
Shams K	91.50	89.5	85	80.0	95.50	91.50	78.75	72.25
Boron	99.50	93	90.3	84.2	96.75	93.00	83.25	79.00
Magnesium	91.25	88	80.7	75.7	92.50	89.25	79.25	73.00
Elga 600	94.50	88.5	82.7	77.7	94.25	92.50	87.00	82.00
Caboron	96.00	86.2	80.2	75.2	94.25	93.00	85.25	80.25
Amica	93.75	81.5	88.5	83.5	93.50	90.25	87.00	82.50
Shetocare	95.50	85.0	77	72.0	94.25	91.00	80.25	74.25
Hummer	92.50	85.2	76.2	71.5	93.00	92.50	83.50	78.50
Amino X	96.25	88.2	83.5	76	93.25	91.75	84.50	79.50
Untreated	92.00	86.5	79.5	74.5	92.75	88.75	83.25	76.75

Details of treatment listed in Table 3

Table 11: Effect of the interaction between storage temperature and storage period on **water content** (%) of onion seeds during seasons of 2008/2009 and 2009/2010

Storage period (month)	**Storage temperature**			
	Room temperature	**Cold temp. (5°C)**	**Room temperature**	**Cold temp. (5°C)**
	Season 2008/2009		**Season 2009/2010**	
0	4.17 e	4.17 e	4.20 f	4.20 f
4	4.52 c	4.42 d	5.08 a	4.83 b
8	4.17 e	6.36 a	4.66 c	4.67 c
12	3.69 f	5.79 b	4.39 e	4.58 d
LSD $_{0.05}$	**0.0975**		**0.0624**	

recorded for treatments with union feer, shams K or boron in the first season, and union feer, shams K, boron, magnesium, shetocare or hummer in the second season.

Effect of the interaction between storage temperature and storage period

The effect of the interaction between storage temperature and storage period on water content, data in **Table 11** shows that water content (%) increased and reached to the maximum value after 4 months of storage at room temperature and after 8 months of storage at 5°C in the first season. Meanwhile, water content increased and reached to the maximum value after 4 months of storage at both storage temperatures in the second season.

Effect of the interaction between storage temperature and foliar application with commercial compounds

It is clear from data presented in **Table 12** that water content at 5°C is higher than that at room temperature in all tested treatments. The highest water content was recorded for the control at 5°C in the first season and union Zn, amica or the control at 5°C in the second season.

Effect of the interaction between storage periods and foliar application with commercial compound

With respect to the effect of the interaction between storage periods and foliar application on water content, data in **Table 13** show that water content gradually increased in all tested treatments as storage period increased. The

Table 12: Effect of the interaction between storage temperature and foliar application with commercial compound on **water content** (%) of onion seeds during seasons of 2008/2009 and 2009/2010

Treatments	**Storage temperature**			
	Room temperature	**Cold temp. (5°C)**	**Room temperature**	**Cold temp. (5°C)**
	Season 2008/2009		**Season 2009/2010**	
Union Zn	4.13 f-g	5.11 c-e	4.60 a-g	4.71 a
Union Feer	4.02 g	5.15 b-e	4.57 b-h	4.57 b-h
Union Mn	4.13 f-g	5.23 a-c	4.61 a-f	4.60 a-g
Shams K	4.21 f	5.00 e	4.46 h-j	4.55 c-i
Boron	4.08 f-g	5.05 d-e	4.53 e-i	4.49 f-j
Magnesium	4.10 f-g	5.23 a-c	4.48 g-j	4.40 j
Elga 600	4.10 f-g	5.24 a-c	4.67 a-d	4.53 e-i
Caboron	4.18 f-g	5.10 c-e	4.66 a-e	4.60 a-e
Amica	4.21 f	5.27 a-b	4.67 a-d	4.70 a-b
Shetocare	4.20 f	5.23 a-c	4.43 i-j	4.48 g-i
Hummer	4.16 f-g	5.28 a-b	4.50 f-j	4.58 a-g
Amino X	4.16 f-g	5.21 a-d	4.70 a-b	4.54 d-i
Untreated	4.15 f-g	5.32 a	4.68 a-c	4.60 a-d
LSD $_{0.05}$	**0.161**		**0.132**	

Details of treatment listed in Table 3

Table 13: Effect of the interaction between storage period and foliar application with commercial compounds on **water content** (%) of onion seeds during 2008/2009 season

Treatment	**Storage period (month)**							
	0	**4**	**8**	**12**	**0**	**4**	**8**	**12**
	Season 2008/2009				**Season 2009/2010**			
Union Zn	4.25 j-n	4.42 g-k	5.17 a	4.65 b-g	4.27 p-r	5.06 a	4.75 e-h	4.55 i-n
Union Feer	3.92 o	4.32 i-m	5.23 a	4.87 b	4.07 t-v	4.97 a-c	4.72 f-i	4.52 j-n
Union Mn	4.15 m-o	4.38 h-l	5.38 a	4.80 b-c	4.22 q-u	4.98 a-b	4.72 f-i	4.52 k-o
Shams K	4.25 j-n	4.47 f-j	5.17 a	4.53 d-i	4.05 u-v	4.91a-e	4.68 f-k	4.38 n-q
Boron	4.02 n-o	4.40 h-l	5.20 a	4.66 b-f	4.17 r-v	4.83b-f	4.61 g-l	4.43 l-p
Magnesium	4.12 m-o	4.46 f-j	5.22 a	4.86 b	4.12 s-v	4.78 d-g	4.51 k-o	4.33 o-r
Elga 600	4.12 m-o	4.40 h-l	5.40 a	4.76 b-d	4.20 r-v	4.98 a-b	4.68 f-k	4.55 i-n
Caboron	4.17 l-n	4.52 e-i	5.21 a	4.65 b-g	4.40 m-q	4.96a-d	4.68 f-k	4.58 h-l
Amica	4.27 j-m	4.51 e-i	5.33 a	4.86 b	4.451 m-p	5.08 a	4.71 f-i	4.50 l-o
Shetocare	4.22 k-n	4.57 c-h	5.32 a	4.76 b-d	4.02 v	4.80 c-f	4.56 i-n	4.43 l-o
Hummer	4.32 i-m	4.53 d-i	5.31 a	4.72 b-e	4.12 s-v	5.00 a-b	4.57 h-m	4.46 l-o
Amino X	4.25 j-n	4.46 f-j	5.25 a	4.80 b-c	4.22 q-u	5.03 a	4.70 f-j	4.52 j-o
Untreated	4.22 k-n	4.66 b-f	5.39 a	4.76 b-d	4.25 q-t	5.03 a	4.72 f-i	4.56 i-o
LSD $_{0.05}$	**0.228**				**0.186**			

Details of treatment listed in Table 3

highest water content was recorded for all tested treatments after 8 months of storage and the treatment with union feer, magnesium or amica after 12 months of storage in the first season. The highest water content after 12 months of storage was recorded for the treatment with union Zn, elga 600 or the control in the second season.

Effect of the interaction between storage temperature, storage period and foliar application with commercial compounds

The triple interaction between storage temperature, storage period and foliar application had a significant effect on water content in both seasons. The highest water content of onion seeds was recorded for treatments with union Mn, elga 600, amica, shetocare, hummer, magnesium or the untreated in the first season after 8 months of storage at 5°C. Meanwhile, the highest water content in the second season was recorded for treatments with elga 600, amica, amino X or the untreated after 4 months of storage at room temperature as shown in **Table 14**.

Storage of onion seed and antioxidants

Consuming vegetables and fruits may reduce the risk of chronic diseases, including cardiovascular disease, stroke, neurodegeneration, and type II diabetes. Substantial recent research has been performed to investigate the potential health benefits of antioxidants in food. Antioxidants can inhibit oxidative reactions *in vivo*, and aid in functional performance of enzyme systems for self-defence mechanisms within cells. Among all vegetables, onion is a species consumed widely across the world and possesses a high content of flavonoid compounds. Onions contain high levels of flavonoids, a major class of non-nutrient antioxidants (quercetin glycosides), anthocyanins (cyaniding glycosides) and sulphur compounds (i.e. thiosulphinates), both of which have a high level of antioxidant activity These compounds are effective scavengers of free radicals that are thought to induce DNA damage and tumor promotion. Flavonoids, in general, also have preventive effects on a

Table 14: Effect of the interaction between storage temperature, storage period and foliar application with commercial compounds on **water content (%)** of onion seeds during seasons of 2008/2009 and 2009/2010

Interactions	Storage period (month)							
	0	4	8	12	0	4	8	12
	Season 2008/2009				Season 2009/2010			
	Room temperature							
Union Zn	4.25	4.50	4.17	3.62	4.275	5.175	4.625	4.350
Union Feer	3.92	4.32	4.17	3.67	4.075	5.100	4.700	4.425
Union Mn	4.15	4.52	4.25	3.60	4.225	5.075	4.750	4.425
Shams K	4.25	4.60	4.25	3.75	4.050	4.950	4.575	4.300
Boron	4.02	4.42	4.17	3.72	4.175	4.950	4.675	4.350
Magnesium	4.12	4.50	4.02	3.75	4.125	4.925	4.525	4.350
Elga 600	4.12	4.42	4.17	3.67	4.200	5.200	4.750	4.550
Caboron	4.17	4.55	4.20	3.80	4.400	5.075	4.725	4.475
Amica	4.27	4.70	4.15	3.75	4.450	5.200	4.725	4.325
Shetocare	4.22	4.67	4.25	3.67	4.025	4.925	4.450	4.325
Hummer	4.32	4.55	4.12	3.65	4.125	5.125	4.500	4.250
Amino X	4.25	4.50	4.17	3.75	4.225	5.200	4.825	4.550
Untreated	4.22	4.55	4.20	3.62	4.250	5.200	4.775	4.500
Cold temperature (5 ºC)								
Union Zn	4.25	4.35	6.17	5.67	4.275	4.950	4.875	4.750
Union Feer	3.92	4.32	6.30	6.07	4.075	4.850	4.753	4.625
Union Mn	4.15	4.25	6.52	6.00	4.225	4.900	4.700	4.600
Shams K	4.25	4.35	6.10	5.32	4.050	4.875	4.800	4.475
Boron	4.02	4.37	6.22	5.60	4.175	4.725	4.550	4.525
Magnesium	4.12	4.42	6.42	5.97	4.125	4.650	4.500	4.325
Elga 600	4.12	4.37	6.62	5.85	4.200	4.775	4.625	4.550
Caboron	4.17	4.50	6.22	5.50	4.400	4.850	4.650	4.700
Amica	4.27	4.32	6.52	5.97	4.450	4.975	4.700	4.675
Shetocare	4.22	4.47	6.40	5.85	4.025	4.675	4.675	4.550
Hummer	4.32	4.52	6.50	5.80	4.125	4.875	4.650	4.675
Amino X	4.25	4.42	6.32	5.85	4.225	4.875	4.575	4.500
Untreated	4.22	4.77	6.40	5.90	4.250	4.875	4.675	4.625

Details of treatment listed in Table 3

number of degenerative pathologies such as cardiovascular and neurological diseases, and other dysfunctions related to oxidative stresses (***Lu et al. 2011***).

There has been increasing interest for the inclusion of fresh fruits and vegetables in the human diet, mainly for the health benefits associated with their consumption. A major benefit from a higher intake of fruits and vegetables may be the increased consumption of vitamins (vitamin C, vitamin A, vitamin B6, thiamin, and niacin), minerals, and dietary fiber. Other constituents that may lower the risk of cancer and heart disease as well as prevent degenerative diseases include antioxidant compounds such as carotenoids, flavonoids, and other phenolics. These compounds are found ubiquitously in edible plants and are important constituents of the human diet. Epidemiologic studies that analyze the health implications of dietary components must estimate the intake in sample populations. Therefore, the availability of appropriate and complete food composition data is crucial. Due to the chemical diversity of antioxidant compounds present in foods, complete databases on food antioxidant content are not yet available (***Kevers et al. 2007***).

Several studies have addressed the changes in the phenolic compounds during storage of different fruits and vegetables. Generally, these results show that antioxidant activity and concentration of phenolics often increases during storage (***Zhang et al. 2008***; ***Kevers et al. 2007***), although a few studies report constant or decreasing levels during storage (***Rodrigues et al. 2010***).

Catalase activity

Effect of storage temperature on catalase activity

It is clear from data presented in **Table 15** that there was non significant difference of storage temperature on catalase activity in both seasons but there was a slight increase in catalase activity in seed stored at 5°C than in room temperature. These results are in agreement with those of **Yanping *et al.* (2000)** and **Demirkaya *et al.* (2010)**. They found that the antioxidant enzymes activity was higher in cold storage than in room temperature.

Effect of storage period on catalase activity

Storage period had a significant effect on catalase activity in both seasons. It is clear from data presented in **Table 15** that catalase activity was significantly decreased as storage period increased. These results are in agreement with **Golovina *et al*. (1997)** and **Demirkaya *et al*. (2010)**.

Effect of foliar application with commercial compounds on catalase activity

Concerning the effect of foliar application with commercial compounds on catalase activity, data in **Table 15** show that the treatment with shams K, boron, shetocare

Table 15: Effect of storage temperature, storage period and foliar application with commercial compounds on catalase and peroxidase activity of onion seeds during seasons of 2008 / 2009 and 2009/2010

Treatments	**Catalase activity (enzyme unit)**		**Peroxidase Activity (enzyme unit)**	
	2008/2009	**2009/2010**	**2008/2009**	**2009/2010**
Storage temperature				
Room temperature	12.98	13.08	8.573	8.578
Cold temperature (5 ºC)	13.71	14.24	8.833	9.117
LSD $_{0.05}$	**N.S.**	**N.S.**	**N.S.**	**N.S.**
Storage periods (month)				
0	17.79 a	16.54 a	11.19 a	10.66 a
6	13.40 b	12.80 b	8.863 b	8.600 b
12	8.832 c	11.65 c	6.059 c	7.281 c
LSD $_{0.05}$	**0.908**	**0.8871**	**0.6195**	**0.9159**
Foliar application				
Union Zn	11.53 d-f	14.23 b-e	7.487 d-e	7.576 d-f
Union Feer	13.81 b-d	13.13 d	10.43 a-b	9.434 a-c
Union Mn	12.09 c-f	12.97 d	9.733 a-c	11.02 a
Shams K	14.55 a-b	15.85 a-b	8.359 c-d	8.918 b-d
Boron	16.96 a	16.82 a	10.69 a	10.61 a
Magnesium	10.84 e-f	10.20 e	5.853 e	6.704 ef
Elga 600	10.25 f	12.94 d	9.363 a-c	9.616 a-c
Caboron	14.05 b-c	12.75 d	8.289 c-d	6.120 f
Amica	14.12 b-c	12.06 d-e	8.404 c-d	8.861 c-d
Shetocare	14.67 a-b	15.67 a-c	9.491 a-c	10.55 a-b
Hummer	12.85 b-e	12.06 d-e	7.423 d-e	7.972 c-e
Amino X	14.60 a-b	15.47 a-c	8.754 b-d	9.616 a-c
Untreated	11.12 d-f	13.45 c-d	8.858 b-d	8.117 c-e
LSD $_{0.05}$	**2.462**	**2.219**	**1.749**	**1.650**

Details of treatment listed in Table 3

Table 16: Effect of the interaction between storage temperature and storage period on **catalase activity** of onion seeds during seasons of 2008/2009 and 2009/2010

Storage period (month)	**Storage temperature**			
	Room temperature	**Cold temp. (5 ˚C)**	**Room temperature**	**Cold temp. (5 ˚C)**
	Season 2008 / 2009		**Season 2009 / 2010**	
0	17.79 a	17.79 a	16.54 a	16.54 a
6	13.42 b	13.38 b	12.43 b	13.17 b
12	7.724 d	9.941 c	10.27 c	13.02 b
LSD $_{0.05}$	**1.285**		**1.254**	

or amino X had the highest catalase activity in both seasons. These treatments had the highest catalase activity after harvest and they had an important role on enzyme activation. These results are in agreement with those of **Ilbi and Eser (2002)**, **Pablo and William (2005)** and **Heidari and Jamashidi (2011)**.

Effect of the interaction between storage temperature and storage period

The results illustrated in **Table 16** indicate that catalase activity in all storage periods decreased as storage temperature increased in both seasons. The lowest value of catalase was recorded after 12 months of storage at room temperature in both seasons.

Effect of the interaction between storage temperature and foliar application with commercial compounds

Concerning the effect of the interaction between storage temperatures and foliar application on catalase activity, the highest value of catalase was recorded for boron treatment at both storage temperatures in the first season, and the treatment with boron or shetocare at 5˚C in the second season as shown in Table **17**.

Effect of the interaction between storage period and foliar application with commercial compounds

Data in **Table 18** show that the interaction between storage period and foliar application had significant effect on catalase activity. Catalase activity in different treatments of foliar spray was gradually decreased as storage period increased. The highest catalase activity after 12 months of storage was recorded for the treatment with boron or amica in the first season, and the treatment with boron in the second season.

Effect of the interaction between storage temperature, storage period and foliar spraying with commercial products

The effects of interaction between storage temperature, storage period and foliar application with commercial compounds on catalase activity are shown in **Table 19** show

Table 17a: Effect of the interaction between storage temperature and foliar application with commercial compounds on **catalase** and **peroxidase activity** of onion seeds during growing seasons

Treatment	Catalase activity (enzyme unit)				Peroxidase activity	
	Room temp.	5 °C	Room temp.	5 °C	Room temp.	5 °C
	Season 2008 / 2009		Season 2009 / 2010		Season 2008 / 2009	
Union Zn	11.65 f-h	11.41 f-h	14.82 b-f	13.65 c-g	7.02 f-h	7.94 c-h
Union Feer	13.88 a-g	13.73 a-g	13.15 c-h	13.12 c-h	10.35a-c	10.51 a-b
Union Mn	11.86 e-h	12.31 d-h	12.61 e-i	13.33 c-h	9.92a-c	9.54 a-e
Shams K	13.72 a-g	15.38 a-d	15.81 b-d	15.89 b-c	7.90c-h	8.81 a-f
Boron	16.73 a-b	17.19 a	13.91 c-g	19.74 a	10.26a-c	11.12 a
Magnesium	10.59 g-h	11.10 f-h	9.91 i	10.48 h-i	5.84h	5.86 g-h
Elga 600	9.461 h	11.04 f-h	12.35 e-i	13.54 c-h	9.47a-f	9.25 a-f
Caboron	13.76 a-g	14.34 a-f	12.73 d-g	12.76 c-h	8.58 b-f	7.99 c-h
Amica	14.03 a-g	14.20 a-f	11.88 f-i	12.24 f-i	8.33b-g	8.47 b-f
Shetocare	14.13 a-f	15.21 a-e	13.79 c-g	17.55 a-b	9.08a-f	9.89 a-d
Hummer	12.78 c-h	12.92 c-h	11.08 g-i	13.04 c-i	7.42d-h	7.41 e-h
Amino X	13.26 b-g	15.94 a-c	15.47 b-e	15.48 b-e	8.59b-f	8.91 a-f
Untreated	11.86 c-h	12.39 b-g	12.55 e-i	14.35 c-g	8.55 b-f	9.06 b-f
LSD $_{0.05}$	3.481		3.139		2. 474	

Details of treatment listed in Table 3

Table 17b: Effect of the interaction between storage temperature and foliar application with commercial compounds on **peroxidase** and **malondialdehyde content** of onion seeds during growing seasons

Treatment	Malondialdehyde content				Peroxidase activity	
	Room temp.	5°C	Room temp.	5°C	Room temp.	5°C
	Season 2008/2009		Season 2009/2010		Season 2009/2010	
Union Zn	16.29	15.85	16.95 a-e	14.61 e	7.37e-h	7.77 -h
Union Feer	16.93	14.59	17.45 a-d	16.07 c-e	9.40a-e	9.46a-e
Union Mn	15.92	13.19	15.93 c-e	14.95 de	10.53a	10.5a-c
Shams K	15.50	14.59	17.83 a-c	16.83 a-e	8.44c-g	9.39a-e
Boron	17.67	13.70	17.95 a-c	14.76 e	9.94a-d	11.2 a-b
Magnesium	18.90	17.50	19.43 a	18.76 a-b	6.36gh	7.04 f-i
Elga 600	14.55	13.21	15.44 c-e	15.16 d-e	9.26a-f	9.96 a-d
Caboron	17.42	17.19	17.83 a-c	16.59 b-e	5.959 h	6.28 g-h
Amica	15.81	14.73	16.04 c-e	15.62 c-e	8.36c-g	9.35 a-f
Shetocare	15.62	14.48	17.23 a-e	14.85 d-e	10.5a-c	10.5 a-c
Hummer	16.81	14.50	16.64 b-e	15.67 c-e	7.48e-h	8.45 c-g
Amino X	15.48	14.18	17.05 a-e	15.78 c-e	9.03b-f	9.99 a-d
Untreated	18.76	18.34	18.86 a-b	18.74 a-b	7.81d-h	8.42c -g
LSD $_{0.05}$	N.S		2.650		2.333	

Details of treatment listed in Table 3

that the lowest value of catalase was observed for the control after 12 months of storage at both storage temperatures in both seasons. On the other hand, the highest catalase activity was recorded at the treatment with boron after 6 months of storage at 5°C storage temperature.

Peroxidase activity

Effect of storage temperatures on peroxidase activity

Results obtained on the effect of storage temperatures on peroxidase activity are presented in **Table 15**. Storage temperature had non significant effect on peroxidase activity but there was a slight increase in peroxidase activity at 5°C than at room temperature. These results are in agreement with those of **Doijode (1990)**, **Siegenthaler and Douet (1994)**, **Yanping *et al.* (1999)** and **(2000)** and **Demirkaya *et al.* (2010).** They found that antioxidant enzymes activity was higher in cold storage than in room temperature.

Effect of storage period on peroxidase activity

Storage period had a significant effect on peroxidase activity in both seasons. It is clear from data presented in **Table 15** that the peroxidase activity was significantly decreased as storage period increased. These results are in agreement with **Golovina *et al.* (1997)** and **Demirkaya *et al.* (2010)**.

Effect of foliar application with commercial compounds on peroxidase activity

Foliar application with boron had the highest peroxidase activity in both seasons as shown **Table 15**. This treatment had the highest peroxidase activity after harvest and had an important role as a functional, structural or regulatory factor of enzymes. These results are in agreement with those obtained by **Prasad (2003)** and **Chatterjee *et al.* (2006)**.

Table 18: Effect of the interaction between storage period and foliar application with commercial compounds on **catalase activity** of onion seeds during 2008/2009 season

Interactions	Storage period (month)					
	0	6	12	0	6	12
	Season 2008 / 2009			Season 2009 / 2010		
Union Zn	18.13 a-d	11.76 g-l	8.700 o	17.04 b-e	15.82 b- f	9.842 k-n
Union Feer	19.24 a-c	13.22 f-j	8.963 j-o	19.11 a-c	12.25 f-l	8.037 m-n
Union Mn	16.48 b-f	11.81 g-l	7.972 l-o	15.82 b-f	11.97 g-l	11.11 i-n
Shams K	21.36 a	13.59 e-i	8.698 k-o	21.40 a	14.21 d-i	11.95 h-l
Boron	20.16 a-b	17.61 a-e	13.11 f-j	19.29 a-b	13.79 d-j	17.38 b-d
Magnesium	13.21 f-j	10.19 h-m	9.120 j-n	14.09 d-j	8.783 l-n	7.722 n
Elga 600	13.96 d-g	10.94 h-l	8.855 n-o	15.80 b-g	11.46 i-n	11.57 h-m
Caboron	18.87 a-c	13.61 e-i	9.660 i-n	13.67 d-j	12.81 f-k	11.77 h-m
Amica	15.30 c-g	14.14 d-h	12.92 f-k	14.82 d-i	11.45 i-n	9.903 k-n
Shetocare	21.43 a	16.50 b-f	6.075 m-o	17.10 b-e	15.41 c-h	14.50 d-i
Hummer	16.42 b-f	13.82 e-i	8.322 m-o	13.56 d-k	12.55 f-l	10.08 j-n
Amino X	19.87 a-b	15.23 c-g	8.703 k-o	19.22 a-c	13.67 d-k	13.52 e-k
Untreated	14.87 b-f	11.78 g-l	6.720 m-o	14.15 d-i	12.22 f-l	7.99 n

Details of treatment listed in Table 3

Table 19: Effect of the interaction between storage temperature, storage period and foliar application with commercial compounds on **catalase activity** of onion seeds during two seasons

Interactions	Storage period (month)					
	0	6	12	0	6	12
	Season 2008/2009			Season 2009/2010		
	Room temperature					
Union Zn	20.13	12.89	9.927	19.04	17.87	9.557
Union Feer	19.24	14.24	8.163	19.11	12.66	7.673
Union Mn	16.48	13.04	6.060	15.82	11.65	10.36
Shams K	21.36	14.04	10.75	21.40	14.14	11.90
Boron	20.16	16.87	13.16	19.29	11.12	11.30
Magnesium	13.21	9.673	8.877	14.09	8.340	7.323
Elga 600	13.96	10.39	9.033	15.80	10.58	10.66
Caboron	18.87	13.26	9.157	17.34	13.32	11.21
Amica	15.30	14.05	12.74	14.82	11.24	9.573
Shetocare	21.43	16.06	9.880	17.10	12.42	11.85
Hummer	16.42	14.26	7.667	13.56	12.37	7.320
Amino X	19.87	14.03	8.877	19.22	13.97	13.21
Untreated	16.87	11.59	5.12	14.15	11.89	6.62
Cold temperature (5 ºC)						
Union Zn	20.13	10.63	7.473	19.04	13.77	10.13
Union Feer	19.24	12.20	9.763	19.11	11.84	8.400
Union Mn	16.48	10.57	9.883	15.82	12.29	11.87
Shams K	21.36	13.13	11.64	21.40	14.28	12.01
Boron	20.16	18.35	13.07	19.29	16.45	13.46
Magnesium	13.21	10.72	9.363	14.09	9.227	8.120
Elga 600	13.96	11.49	7.677	15.80	12.35	9.47
Caboron	18.87	13.97	10.16	17.34	12.29	9.33
Amica	15.30	14.23	13.09	14.82	11.67	10.23
Shetocare	21.43	16.93	7.270	17.10	18.40	17.16
Hummer	16.42	13.38	8.977	13.56	12.73	8.84
Amino X	19.87	16.42	11.53	19.22	13.37	8.84
Untreated	16.87	11.97	6.32	14.15	12.55	6.36

Details of treatment listed in Table 3

Effect of the interaction between storage temperature and storage period

Regarding to the effect of the interaction between storage temperature and storage period on peroxidase activity, data in **Table 20** show that peroxidase activity decreased in both storage temperatures as storage period increased in both seasons. The lowest value of peroxidase was recorded after 12 months of storage at both storage temperatures in both seasons.

Effect of the interaction between storage temperature and foliar application with commercial compounds

As shown in **Table 17**, data indicate that peroxidase activity decreased in all foliar application treatments as storage temperature increased. The highest value of peroxidase was recorded for boron treatment at 5°C in the first season, and the treatment with boron at 5°C and union Mn or shetocare at both temperatures in the second season.

Table 20: Effect of the interaction between storage temperature and storage period on **peroxidase activity** of onion seeds during seasons of 2008/2009 and 2009/2010

Storage period (month)	Storage temperature			
	Room temperature	Cold temp. (5 °C)	Room temperature	Cold temp. (5 °C)
	Season 2008/2009		Season 2009/2010	
0	11.19 a	11.19 a	10.66 a	10.66 a
6	8.513 b	9.214 b	8.050 bc	9.149 b
12	6.020 c	6.098 c	7.022 c	7.539 c
$LSD_{0.05}$	**0.876**		**1.295**	

Table 21: Effect of the interaction between storage period and foliar application with commercial compounds on **peroxidase activity** of onion seeds during two season

Interactions	Storage period (month)					
	0	6	12	0	6	12
	Season 2008 / 2009			Season 2009 / 2010		
Union Zn	9.983 c-g	8.942 e-k	5.537 p	8.513 g-o	7.403 i-p	6.812 k-p
Union Feer	16.68 a	8.392 e-m	6.218 j-p	11.98 a-c	9.548 c-k	6.775 k-p
Union Mn	12.56 b-c	10.68 c-e	5.968 k-p	14.28 a	9.955 c-j	8.825 e-n
Shams K	10.41 c-f	8.835 e-l	5.837 l-p	11.30 b-g	9.293 c-l	6.165 n-p
Boron	12.17 b-d	10.75 b-e	9.163 d-j	11.71 a-d	10.44 c-h	9.695 c-j
Magnesium	6.650 h-o	6.228 j-p	4.680 n-p	7.193 j-p	6.532 l-p	6.388 m-p
Elga 600	13.71 a-b	6.738 h-o	7.640 f-n	14.00 a-b	8.122 h-o	6.723 k-p
Caboron	10.55 c-f	9.808 c-g	4.512 o-p	7.267 j-p	6.157 n-p	4.937 p
Amica	9.507 b-h	9.355 d-i	6.350 i-p	10.15 c-i	9.048 d-m	7.383 i-p
Shetocare	11.99 b-d	9.523 d-h	6.963 g-o	11.66 a-e	10.55 c-h	9.437 c-k
Hummer	8.790 e-l	7.848 e-m	5.630 m-p	8.627 g-n	8.182 h-o	7.108 j-p
Amino X	10.38 c-f	9.355 d-i	6.528 h-p	10.36 c-h	9.455 c-k	8.723 f-n
Untreated	12.06 b-d	8.775 e-l	5.740 m-p	11.56 a-f	7.115 j-p	5.677 o-p
$LSD_{0.05}$	**3.030**			**2.857**		

Details of treatment listed in Table 3

Effect of the interaction between storage period and foliar application with commercial compounds

It is clear from data presented in **Table 21** that peroxidase activity was decreased in all foliar application treatments as storage period increased. The highest value of peroxidase activity after 12 months of storage was recorded for boron treatment in the first season, and boron or shetocare treatments in the second season.

Effect of the interaction between storage temperature, storage period and foliar application with commercial products

Regarding the of interaction between storage temperature, storage period and foliar application with commercial compounds on peroxidase activity, data in **Table 22** show that the highest value of peroxidase was observed in the treatment with union Mn or boron at room temperature and shams K or boron at 5°C in the first season. Meanwhile, the treatment with union Mn, boron or shetocare at room temperature and the treatment with boron, shetocare or amino X at 5°C had the highest peroxidase value in the second season.

Malondialdehyde content

Effect of storage temperature on malondialdehyde content

Storage temperature had non significant effect on malondialdehyde content in the first season, but there was significant effect of storage temperature on malondialdehyde content in the second season. Seed stored at room temperature had the higher malondialdehyde content than which stored at 5°C (**Table 23**). These results may be due to that room temperature had the lower catalase and peroxidase activity than 5°C. These results are in agreement with those obtained by **Yanping *et al.* (2000)** and **Demirkaya *et al.* (2010).** They found that as storage temperature increased the malondialdehyde content increased and antioxidant activity decreased.

Effect of storage period on malondialdehyde content

Regarding the effect of storage period on malondialdehyde content, data in **Table 23** show that malondialdehyde content increased as storage period increased. These results are in agreement with those obtained by **Golovina *et al.* (1997)** and **Demrikaya *et al.* (2010).** They reported that the malondialdehyde content increased as storage period increased.

Effect of foliar application with commercial compounds on malondialdehyde content

Concerning the effect of foliar application with commercial compounds on malondialdehyde content**,** data in **Table 23** show that the treatment with magnesium, caboron and the control had the highest malondialdehyde content in the first season, and the treatment with magnesium and the untreated in the second season. These treatments had the lowest antioxidant activity. These results may be due to the fact that there was a negative correlation between antioxidant activity and malondialdehyde content (***Xin and Wang, 2006***).

Table 22: Effect of the interaction between storage temperature, storage period and foliar application with commercial compounds on **peroxidase activity** of onion seeds during seasons of 2008/2009 and 2009/2010

Interactions	**Storage period (month)**					
	0	**6**	**12**	**0**	**6**	**12**
	Season 2008/2009			**Season 2009/2010**		
	Room temperature					
Union Zn	9.983	8.557	6.540	8.513	7.080	6.543
Union Feer	16.68	8.180	6.187	11.98	8.970	7.277
Union Mn	12.56	11.70	9.507	14.28	10.72	9.622
Shams K	17.01	8.490	4.817	11.30	8.357	5.667
Boron	12.17	10.53	8.090	11.71	9.293	8.827
Magnesium	6.650	5.887	4.983	7.193	6.367	5.547
Elga 600	13.71	7.280	7.423	14.00	7.633	6.157
Caboron	10.55	8.980	6.217	7.267	6.123	4.487
Amica	9.507	8.910	6.590	10.15	7.737	7.217
Shetocare	11.99	8.143	7.133	11.66	10.26	9.637
Hummer	8.790	7.623	5.867	8.627	7.367	6.463
Amino X	10.38	8.793	6.610	10.36	9.000	7.733
Untreated	12.06	7.597	5.297	11.56	6.867	5.017
Cold temperature (5 ºC)						
Union Zn	9.983	9.327	7.533	8.513	7.727	7.080
Union Feer	16.68	8.603	6.250	11.98	10.13	6.273
Union Mn	12.56	9.653	6.430	14.28	10.31	6.933
Shams K	17.01	9.180	6.857	11.30	10.23	6.663
Boron	12.17	10.97	10.24	11.71	11.59	10.56
Magnesium	6.650	6.570	5.377	7.193	6.697	5.230
Elga 600	13.71	6.197	7.857	14.00	8.610	7.290
Caboron	10.55	10.64	6.807	7.267	6.190	5.387
Amica	9.507	9.800	6.110	10.15	10.36	7.550
Shetocare	11.99	10.90	6.793	11.66	10.83	9.237
Hummer	8.790	8.073	5.393	8.627	8.997	7.753
Amino X	10.38	9.917	6.447	10.36	9.910	9.713
Untreated	12.06	9.953	5.183	11.56	7.363	4.337

Details of treatment listed in Table 3

Table 23: Effect of storage temperature, storage period and foliar application with commercial compounds on **malondialdehyde content** of onion seeds during seasons of 2008 / 2009 and 2009/2010

Treatments	**Malondialdehyde (mmol g^{-1} fw)**	
	2008/2009	**2009/2010**
Storage temperature		
Room temperature	16.44	17.28 a
Cold temperature (5 ºC)	16.00	16.03 b
LSD $_{0.05}$	N.S.	0.887
Storage periods (month)		
0	12.02 c	12.81 c
6	16.17 b	17.00 b
12	20.46 a	20.15 a
LSD $_{0.05}$	2.934	0.650
Foliar application		
Union Zn	15.07 b	15.78 c-e
Union Feer	15.76 b	16.76 c-e
Union Mn	14.55 b	15.44 d-e
Shams K	15.05 b	17.33 a-c
Boron	15.68 b	16.36 c-e
Magnesium	18.20 a	19.09 a
Elga 600	13.88 b	15.30 e
Caboron	16.80 a	17.21 b-d
Amica	15.27 b	15.83 c-e
Shetocare	15.05 b	16.04 c-e
Hummer	15.66 b	16.16 c-e
Amino X	14.83 b	16.42 c-e
Untreated	18.05 a	18.80 a-b
LSD $_{0.05}$	**2.81**	**1.874**

Details of treatment listed in Table 3

Table 24: Effect of the interaction between storage temperature and storage period on **malondialdehyde content** of onion seeds during seasons of 2008/2009 and 2009/2010

Storage period (month)	Storage temperature			
	Room temperature	Cold temp. (5 °C)	Room temperature	Cold temp. (5 °C)
	Season 2008/2009		Season 2009/2010	
0	12.02 c	12.02 c	12.81 e	12.81 e
6	17.19 ab	15.16 bc	18.13 c	15.87 d
12	20.83 a	20.09 a	20.89 a	19.41 b
LSD $_{0.05}$	4.149		0.9200	

Table 25: Effect of the interaction between storage period and foliar application with commercial compounds **on malondialdehyde** content of onion seeds during two seasons

Treatments	Storage period (month)					
	0	6	12	0	6	12
	Season 2008/2009			Season 2009/2010		
Union Zn	10.08 c-e	16.23 b-e	19.91 a-c	11.11 m-o	16.95 di	19.28 a-f
Union Feer	12.66 b-e	16.41 b-e	18.22 b-e	12.71 lo	16.64 ei	20.93 a
Union Mn	9.353 d-e	16.20 b-e	18.11 b-e	9.920 no	17.23 ci	19.17 a-g
Shams K	12.71 b-e	14.88 b-e	17.55 b-e	14.94 hl	16.33 fj	20.72 a
Boron	8.840 e	13.09 b-e	19.12 b-d	9.667 o	15.04 hl	19.36 a-f
Magnesium	15.45 b-e	18.50 b-e	20.64 a	15.97 gk	20.13 ad	21.19 a
Elga 600	8.527 e	15.38 b-e	17.75 b-e	9.820 o	15.48 hl	20.59 a-b
Caboron	14.11 b-e	16.84 b-e	19.46 a-c	13.13 jn	18.99 ag	19.51 a-f
Amica	12.76 b-e	14.06 b-e	18.99 b-d	12.71 lo	14.44 hl	20.33 a-c
Shetocare	12.92 b-e	14.10 b-e	18.14 b-e	14.11 im	13.10 jn	20.90 a
Hummer	13.02 b -e	14.44 b-e	19.51 b-c	14.11 im	15.35 hl	19.01 a-g
Amino X	10.85 b-e	15.06 b-e	18.58 b-e	12.82 ko	17.44 bh	18.99 a-g
Untreated	15.04 b-e	19.09 bd	20.02 a-c	15.55 hl	19.87 ae	20.98 a
LSD $_{0.05}$	10.06			3.246		

Details of treatment listed in Table 3

Effect of interaction between storage temperature and storage period

With respect to the effect of the interaction between storage temperature and storage period on malondialdehyde content, data in **Table 24** show that malondialdehyde content increased as storage period increased at both storage temperatures in both seasons. The highest malondialdehyde content was recorded after 12 months of storage at both storage temperatures in the first season, and at room temperature in the second season.

Effect of the interaction between storage temperature and foliar application with commercial compounds

Regarding the effect of the interaction between storage temperatures and foliar application, data in **Table 17** indicate that the malondialdehyde content at room temperature is higher than that at 5 °C in all tested treatments in both seasons. The statistical analysis showed non significant effect of the interaction between storage temperature and foliar spray treatments on malondialdehyde content in the first season. The highest malondialdehyde content was recorded for magnesium and the untreated at both storage temperatures in the second season.

Effect of the interaction between storage period and foliar application with commercial compounds

As shown in **Table 25** data indicate that malondialdehyde content increased as storage period increased in all tested treatments in both seasons. The highest value of the malondialdehyde was recorded after 12 months of storage for union Zn, magnesium, caboron and the control in the first season, the control showed the highest malondialdehyde content after 6 months of storage. Regarding the effect of the interaction between storage period and foliar spraying at 12 months of storage, data showed that all tested treatments had the highest malondialdehyde content.

Effect of the interaction between storage temperature, storage period and foliar application with commercial compounds

The interaction between storage temperature, storage period and foliar application with commercial compounds on malondialdehyde content was presented in **Table 26**. The highest malondialdehyde content was recorded for magnesium, hummer and the control after 12 months of storage at room temperature in the first season, and for treatment with union feer, shams K, magnesium, elga 600, amica or shetocare at room temperature and the untreated at both storage temperatures in the second season. It could be summarized that foliar spraying of onion plants by magnesium or by water (untreated treatment) gave the highest malondialdehyde content and the lowest catalase and peroxidase activity of onion seed.

Nitrogen and sulfur availability affect growth, yield, flavor and quality of onion. Potassium plays an important role in promotion of enzymes activity and enhancing the translocation

Table 26: Effect of the interaction between storage temperature, storage period and foliar application with commercial compounds on **malondialdehyde content** of onion seeds during seasons of 2008/2009 and 2009/2010

Interactions	Storage period (month)					
	0	6	12	0	6	12
	Season 2008/2009			Season 2009/2010		
	Room temperature					
Union Zn	10.08	19.27	19.53	11.11	20.05	19.69
Union Feer	12.66	18.81	19.33	12.71	17.88	21.75
Union Mn	9.353	18.34	20.05	9.920	18.65	19.22
Shams K	12.71	15.29	18.50	14.94	17.15	21.39
Boron	8.840	15.75	18.43	9.667	21.65	20.53
Magnesium	15.45	19.22	22.01	15.97	20.46	21.86
Elga 600	8.527	16.23	18.91	9.820	15.45	21.03
Caboron	14.11	15.97	19.17	13.13	19.64	20.72
Amica	12.76	14.31	20.36	12.71	14.68	20.72
Shetocare	12.92	15.40	18.55	14.11	15.92	21.65
Hummer	13.02	14.62	22.79	14.11	15.55	20.26
Amino X	10.85	16.02	19.58	12.82	18.65	19.69
Untreated	15.04	18.24	21.00	15.55	19.94	21.08
Cold temperature (5 ºC)						
Union Zn	10.08	13.18	16.87	11.11	13.85	18.86
Union Feer	12.66	14.00	17.10	12.71	15.40	20.10
Union Mn	9.353	14.05	16.17	9.920	15.81	19.12
Shams K	12.71	14.47	16.59	14.94	15.50	20.05
Boron	8.840	16.43	15.81	9.667	16.43	18.19
Magnesium	15.45	17.78	19.27	15.97	19.79	20.52
Elga 600	8.527	14.52	16.59	9.820	15.50	20.15
Caboron	14.11	17.72	19.74	13.13	18.34	18.29
Amica	12.76	13.80	17.62	12.71	14.21	19.94
Shetocare	12.92	12.79	17.73	10.11	14.28	20.15
Hummer	13.02	14.26	16.23	14.11	15.14	17.77
Amino X	10.85	14.11	17.57	12.82	16.23	18.29
Untreated	15.04	19.95	20.05	15.55	19.79	20.87

Details of treatment listed in Table 3

of assimilates. K deficiency dramatically reduces dry matter accumulation and affects assimilate partitioning among plant tissues. Onion pungency was affected by application of high levels of nitrogen; it can be attributed to the role of nitrogen in the amino acids and pyruvic acid production. Significant variation in the pyruvic acid content among clones under the high S nutrition reported by **Hamilton et al. (1997)**; however under the low S treatment, it was not significant. There is a positive correlation between the amount of vitamin C and sulfur availability. However, increasing the amount of nitrogen availability may reduce the amount of vitamin C. Application of K_2SO_4 fertilizer affects accumulation of total soluble solids in onion (**El-Bassiony, 2006**). Increase in sulfur dose tended to decrease dry matter accumulation (***Nasreen et al. 2003***). **Abd El-Al et al. (2005)** found that increasing of the soil potassium content had a significant effect on growth characters of onion (***Bolandnazar et al. 2012***).

Conclusion

Onion has great importance in the diet of Iranian people. Because, onion has vitamins such as A, B1, B2, C, nicotinic acid, pantothenic acid and important substances such as protein, calcium, phosphorus, potassium and traces of Fe, Al, Cu, Zn, Mn and I. Moreover, it has anti-fungal and anti-bacterial properties. Onion contains an acrid volatile oil with a pungent smell. Researchers showed that onions with higher pungency have better capacity to prevent tumor growth and also, it can protect against heart attack. It has been shown that, using of sulfur could increase onion pungency. Both pungency and volatile S in onions were increased in response to increasing the elemental S applications.

Storage in 5°C had the higher germination percentage than storage in room temperature. Results indicated that as storage period increased the germination percentage decreased. The treatment with boron or amica in the first season had the highest germination percentage. While, the treatment with union Zn, union feer, union Mn, boron, elga 600, caboron, amica, hummer or amino X had the highest germination percentage in the second season. Storage in 5°C resulted in higher moisture content than storage in room temperature. Regarding the effect of storage period on moisture content, the water content was significantly increased with prolongation of storage period. The lowest values of water content were recorded for treatments with union feer, shams K or boron in the first season, and union feer, shams K, boron, magnesium, shetocare or hummer in the second one. The results showed that there was non significant effect of storage temperature on catalase activity in both seasons, but there was a slight increase in catalase activity in seed stored in 5°C than in room temperature.

Catalase activity was significantly decreased as storage period increased. The treatment with shams K, boron, shetocare or amino X had the highest catalase activity in both seasons. Storage temperature had non significant effect on peroxidase activity, but there was a slight increase in peroxidase activity in 5°C than in room temperature. Peroxidase activity was significantly decreased as storage period increased. Foliar application with boron had the highest peroxidase activity in both seasons. Seed stored in room temperature had the higher malondialdehyde content than those stored in 5°C in the second season. The malondialdehyde content increased as storage period increased. The treatment with magnesium, caboron and the control in the first season, and the treatment with magnesium and the control in the second season had the highest malondialdehyde content.

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