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Effects of Foliar Nutrition on Onion Seed Storage under Modified Atmosphere Packages

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Summary: Modified atmosphere packaging (MAP) and controlled atmosphere storage techniques to reduce the oxygen around the food are largely used for the preservation of fresh produce. There have been great technological advances in this area of preservation, particularly as it refers to improving the quality and shelf-stability of highly perishable food products, such as produce. 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 onion seeds storage under modified atmosphere packages. Germination percent of seeds decreased in 5°C than storage in room temperature. Germination percent of seeds was gradually decreased with increasing the storage period. Packaging treatments had a significant effect on germination percent of seeds. All the packaging treatments had the higher germination percent than the paper package (control). The highest germination percent after 12 months of storage was recorded for the treatment with non perforated polypropylene in room temperature and polyethylene and non perforated polypropylene in 5°C. Catalase activity decreased with the prolongation of storage period. The non perforated polypropylene package had the highest catalase activity. The treatment with non perforated polypropylene had the highest catalase activity after 12 months of storage in both room and 5°C temperatures. Peroxidase activity of seeds was gradually decreased with increasing the storage period. The highest peroxidase activity after 12 months of storage was recorded in non perforated polypropylene in both storage temperatures.

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

Introduction

Fruits and vegetables constitute a vital part of the human diet, with their per capita consumption rate steadily increasing in recent years. Traditionally, fruits and vegetables have been regarded as microbiologically safer than other unprocessed foods, such as meat, milk, eggs, poultry and seafood. Modified atmosphere packaging (MAP) and controlled atmosphere (CA) storage techniques to reduce the oxygen around the food are largely used for the preservation of fresh produce (***Kurubar, 2007***). The pre- and post-harvest application of chemicals is known to influence the quality and shelf-life of fruits during storage. A brief review of work carried out on the influence of pre- and post-harvest application of calcium compounds on fruits during storage is furnished here. Physiological loss in weight of fruit is mainly due to evaporation, respiration and degradation process occurring during post-harvest handling of fruits. Moisture content of the most of fruits is high and weight loss during transport and storage is an economic factor to be considered especially when sold by weight in market (***Kurubar, 2007***).

Onion (*Allium cepa* L.) is one of the oldest bulb crops, known to mankind and consumed worldwide. It is one of the most important commercial vegetable crops grown in Egypt and believed to be originated in Central Asia. It is valued for its distinct pungent flavor and is an essential ingredient for the cuisine of many regions. Onion is the queen of the kitchen (***Selvaraj, 1976***). 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. 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 as pre-harvest treatments on storage temperature and modified atmosphere packages on onion seed longevity as post-harvest.

Materials and Methods

Experimental design

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***). Catalase (CAT), and peroxidase (POD) activity and malondialdehyde (MDA) content were determined according to **Chance and Maehly (1955), Amako *et al.* (1994)** and **Health and Parker (1968),** respectively. For more details about the enzyme activities, it could be seen **Shehata et al. (2013)**.

Storage of onion seed under modified atmosphere packaging (MAP)

This study was conducted to know more information on the storage life of onion seed beyond 12 months and their behavior after this period in relation to possible release for sowing and sale. This part of the investigation aimed to study the effect of different four modified atmosphere packages (paper bags, polyethylene bags, perforated polypropylene bags and non perforated polypropylene bags) and two storage temperatures (5°C and room temperature) on seed germination, moisture content and change in antioxidant enzymes activity of onion seeds during storage period. Number of treatments was 96 (4 packages × 2 storage temperatures × 4 replicates × 3 storage periods). Seeds for this investigation were produced at the Agricultural Experiment Station of the Faculty of Agriculture, Cairo University, Waddy Elnatron farm, Egypt, using standard commercial practices without any additional treatments. Thirty two replicates were prepared for each type of MAP and control treatments. Each experimental unit consisted of 75 g of seeds, and all packages were stored at 5°C and room temperature for 12 months. 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).

Fig. 1: Waddy Elnatron farm, Agricultural Experimental Station of the Faculty of Agriculture, Cairo University, where onion seed production under reclaimed sandy soil and high temperature. After 4 months, vegetative growth measured such as flower stalks length, inflorescence diameter and number of seeds stalk/plant (photo by K. Abd El-Gawad)

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

Results

Storage of onion seed under modified atmosphere packaging

Seeds of this investigation were produced at the Agricultural Experiment Station of the Faculty of Agriculture, Cairo University, Waddy Elnatron farm, Egypt using standard commercial practices without any additional treatments to study the effect of different modified

Table 1: Effect of storage temperature, storage period and packaging material on germination (%), water content (%), O_2 and CO_2 percentages of onion seeds

Treatments	Germination (%)	Water content (%)	Oxygen (%)	Carbon dioxide (%)
Storage temperature				
Room temperature	81.81 a	4.39 b	19.06 a	0.66 a
Cold temperature (5 °C)	79.50 a	4.86 a	19.05 a	0.65 a
Storage period (month)				
4	88.34 a	4.52 b	19.7 a	0.307 c
8	79.41 b	4.76 a	19.2 b	0.629 b
12	74.22 c	4.59 a-b	18.1 c	1.054 a
Packaging treatments				
Paper	77.63 b	4.81 a	20.9 a	0.030 c
Polyethylene	82.21 a	4.48 b	18.5 b	0.825 b
Perforated polypropylene	81.38 a	4.79 a	18.5 b	0.812 b
Non-perforated polypropylene	81.42 a	4.41 c	18.2 c	0.987 a

atmosphere packages (MAP) and two storage temperatures on seeds storage quality. Onion seeds were stored in different package materials (paper, polyethylene, perforated and non perforated polypropylene) to study the effect of different modified atmosphere packages at two storage temperatures (room temperature and 5°C) on seeds germination, moisture content and change in antioxidant enzymes activities of onion seeds during the storage period.

Germination percent

I. *Effect of storage temperature on germination percent*

Most packs for MAP products are made from one or more of four polymers: polyvinylchloride (PVC), polyethylene terephthalate (PET), polyethylene (PE) and polypropylene (PP) depending on the features desired for the intended use (***Das, 2004***).

It appears from data in **Table 1A** that germination percent of seeds decreased in cold temperature (5°C) than storage in room temperature. These results disagree with those obtained by **Lazarenko and Bezrukov (2008)** as they found that higher seed viability was observed after cold temperature storage compared with storage at room temperature. These results may be due to the increase of water content in the seeds which stored at 5°C than at room temperature. These results also are agreed with those of **Muhammad and Anjum (2002)**. They reported that water content of the atmosphere is the most critical factor influence the longevity of onion seeds in the storage and a rise in air moisture being more damaging than raising temperature. Similar results were also obtained by **Bass (1981)** who reported that the water content is the most important factor involved in the deterioration of seeds.

II. *Effect of storage period on germination percent*

Concerning the effect of storage period on germination percent, data in **Table 1A** shows that germination percent of seed was gradually decreased with increasing the storage period. These results are in agreement with those obtained by **Muhammad and Anjum (2002)**, **Sharma *et al*. (2004)** and **Gaviola *et al*. (2006)** as they found that the percentage of germination decreased as storage period increased. They also added that days to 50% of final germination increased with increasing storage period.

III. *Effect of packaging treatments on germination percent*

Polyethylene is one of the most important packaging materials of the present time. It is a hydrocarbon polymer with the nominal formula –$(CH_2\text{-}CH_2)$n-. The simplest of all monomers as far as chemical structure concerned is ethylene. Commercial polyethylenes are produced with a variable amount of branching within this nominally linear polymer (***Das, 2004***).

Packaging treatment had a significant effect on germination percent of seeds. All the packaging treatments had the higher germination percent than the paper package. These results may be due to that packages had lower water content than the paper bag and that these packages had the lowest oxygen and the highest carbon dioxide percentages (**Table 1A**). These results are in agreement with those obtained by **Caneppele *et al*. (1995)** and **Stanwood and Sowa (1995)**.

Water content

The majority of seeds come into equilibrium between their internal water content and the relative humidity of the atmosphere in which they are stored, and as a general rule within the usual limits of moisture for storage, the life of the seed is halved for each 1% increase in water content of the seeds. In another studies, **Stumpf *et al.* (1997)** found that seeds stored with low water content in hermitic containers may maintain viability for three years. **Yanping *et al.* (2000)** reported that several indices of seed vigour, including dehydrogenase activity, germination energy, vigour index and emergence percent of the seeds declined as seed water content increased. When the seeds were stored at room temperature or 6°C for two years, the indices were significantly influenced by the seed water content. The increase of seed water content resulted in the significant decrease of the indices, some of which were reduced to zero. Onion seeds have a short life and can not store for more than 4 months when the water content is higher than 10% (**Rocha, 1959**). Thus, the seed require reduction of the water content to less than 7.5% in order to minimize the deterioration process. In open environmental conditions, onion seed equilibrate their water content at 60% R. H. to more than 7.5%. Thus, in order to keep the water content low, it is necessary to store them in hermetic moisture containers (***Deluche and Baskin, 1973***).

I. *Effect of storage temperature on water content*

It appears from data in **Table 1** that the water content of seeds increased in 5°C than storage in room temperature (4.86 and 4.39, respectively). These results are in agreement with those obtained by **Stanwood and Sowa (1995)** and **Yanping *et al.* (1999)**.

II. *Effect of storage period on water content*

Table 1 show that water content of seeds was gradually increased with increasing the storage period and reached its maximum peak after 8 months of storage and then decline after 12 months of storage (4.52, 4.76 and 4.59, respectively) but the decline was insignificant. These results are in agreement with those obtained by **Kavak and Eser (2009)** who found that the water content of onion seed had raised from 9% to 13% during storage.

III. *Effect of packaging treatment on water content*

Packaging treatment had a significant effect on water content of seeds. The lowest values of water content were observed in non perforated polypropylene and polyethylene (4.41 and 4.48 %, respectively, **Table 1**). This reduction of water content was due to that the non perforated polypropylene and Polyethylene film packaging which did not allow moisture to transpire from the atmosphere to the seeds. These results are in agreement with those of **Shelar *et al* (1992)** as they reported that the difference in performance of onion germination and seedling which stored in impermeable packaging was due to changes in seed water content and to the degree of hygroscopic equilibrium between seeds and their surroundings.

Oxygen percentage

It appears from data in **Table 1** that there was non significant difference between storage temperatures on oxygen percentage inside all tested packages. Concerning the effect of storage period on oxygen percentage, data in **Table 1** shows that oxygen percent inside the package of seeds was gradually decreased with increasing the storage period. The reduction in oxygen during storage could be due to respiration process of onion seeds. The treatment of non perforated polypropylene had the lowest oxygen percentage compared to all other tested treatments followed by the treatment of perforated polypropylene and polyethylene packages, meanwhile, the paper bag showed the highest oxygen percentage.

The results illustrated in **Table 2** show that percent of oxygen at both storage temperatures decreased as storage period increased. The lowest oxygen percentage was recorded after 12 months of storage at both storage temperatures (18.19 for room and 5 °C temperature). The treatment of non perforated polypropylene had the lowest oxygen percentage at both storage temperatures compared with all other tested treatments (18.2 %, **Table 1**).

Carbon dioxide percentage

It appears from data in **Table 1** that there was non significant difference between storage temperatures on carbon dioxide (%) inside the package of seeds. Concerning the effect of storage period on carbon dioxide percentage, carbon dioxide percentage inside the package of seeds was gradually increased with the prolongation of storage period. Packaging treatments had a significant effect on carbon dioxide percentage (**Table 1**). The treatment of non perforated polypropylene packaging had the highest carbon dioxide percent compared with all other treatments followed by perforated polypropylene and polyethylene (0.987, 0.825 and 0.812, respectively). The results illustrated in **Table 2** show that the percent of carbon dioxide at both storage temperatures increased as storage period increased. The highest percentage of carbon dioxide was recorded after 12 months of storage at both storage temperatures (1.07 and 1.03 % for room and 5 °C temperature, respectively).

Effects on biochemical assessments

Catalase activity

I. *Effect of storage temperature on catalase activity*

The results illustrated in **Table 2** show that storage temperature had insignificant effect on catalase activity, but there was a slight increase in catalase activity at room temperature than at 5°C. These results disagree with those of **Demirkaya *et al.* (2010)**. They found a significant effect of storage temperature on antioxidant activity and they reported that as storage temperature increased the catalase activity decreased.

Table 2: Effect of storage temperature, storage period and packaging material on catalase and peroxidase activities and malondialdehyde

Treatments	Catalase activity (µmol H_2O_2 consumed /mg protein /min)	Peroxidase activity (enzyme unit)	Malondialdehyde content (mmol g^{-1} fw)
Storage temperature			
Room temperature	15.59 a	10.56 a	17.30 b
Cold temperature (5 ˚C)	14.09 a	9.83 a	18.42 a
Storage period (month)			
0	20.37 a	14.05 a	13.80 c
6	12.79 b	8.88 b	18.48 b
12	11.36 b	7.65 b	21.30 a
Packaging treatments			
Paper	14.14 b	9.61 a	19.19 a
Polyethylene	14.34 ab	10.32 a	17.23 c
Perforated polypropylene	15.01 ab	10.58 a	17.99 b
Non-perforated polypropylene	15.89 a	10.28 a	17.02 c

II. ***Effect of storage period on catalase activity***

Concerning the effect of storage period on catalase activity, data in **Table 2** show that the catalase activity decreased with the prolongation of storage period (20.37, 12.79 and 11.36 µmol H_2O_2 consumed mg^{-1} protein min^{-1} for 0, 6 and 12 month, respectively). These results are in agreement with those obtained by **Xin and Wang (2006)** and **Demirkaya *et al*. (2010)**.

III. ***Effect of packaging treatment on catalase activity***

These results indicated that the packaging had a significant effect on catalase activity. The non perforated polypropylene had the highest catalase activity followed by perforated polypropylene and polyethylene (15.89, 15.01 and 14.34 µmol H_2O_2 consumed mg^{-1} protein min^{-1}, respectively; **Table 2**). These results may be due to that this package had the lowest water content and oxygen percentage and the highest carbon dioxide percent (**Table 1**). These results are in agreement with **Ilbi and Eser (2006)** and **Xin and Wang (2006)**.

Peroxidase activity

I. *Effect of storage temperature on peroxidase activity*

The results illustrated in **Table 2** show that the storage temperature had insignificant effect on peroxidase activity. These results disagree with those of **Yanping *et al.* (2000)** and **Demirkaya *et al.* (2010)**. They found that as storage temperature increased the peroxidase activity decreased (10.56 and 9.83 enzyme unit for room and 5 °C temperature, respectively).

II. *Effect of storage period on peroxidase activity*

Concerning the effect of storage period on peroxidase activity, data in **Table 1** show that peroxidase activity of seeds was gradually decreased with increasing the storage period (14.05, 8.88, and 7.65 for 0, 6 and 12 month, respectively). These results are in agreement with those obtained by **Xin and Wang (2006)** and **Demirkaya *et al*. (2010)**.

III. *Effect of packaging treatment on peroxidase activity*

These results indicated that the packaging treatment had insignificant effect on peroxidase activity (**Table 2**). These results are disagreeing with those obtained by **Ilbi and Eser (2006).** They found a significant effect of modified atmosphere package on peroxidase activity. The perforated polypropylene had highest peroxidase activity followed by polyethylene and non perforated polypropylene (10.58, 10.32 and 10.28 enzyme unit, respectively; **Table 2**)

Malondialdehyde content

I. *Effect of storage temperature on malondialdehyde content*

Results illustrated in **Table 2** show that storage temperature had a significant effect on malondialdehyde content. Room temperature had the lower malondialdehyde content than 5˚C. These results disagree with those of **Yanping *et al.* (2000)** and **Demirkaya *et al.* (2010)**. They found that as storage temperature increased the malondialdehyde content increased. These results may be due to increasing the water content in the seed stored at cold temperature than at room temperature.

II. *Effect of storage period on malondialdehyde content*

With respect to the effect of storage period on malondialdehyde content, data in **Table 2** show that malondialdehyde content increased as storage period increased (from 13.8, 18.48 and 21.3 mmol g^{-1} fw for 0, 6 and 12 month, respectively). These results agree with those of **Xin and Wang (2006)** and **Demirkaya *et al*. (2010)**.

Table 3: Effect of the interaction between storage temperature and storage period on germination (%) water content (%), oxygen and carbon dioxide percentages, catalase and peroxidase activities malondialdehyde content of onion seeds

Storage temperature	Storage period (month)					
	4	8	12	4	8	12
	Germination (%)			Water content (%)		
Room temperature	90.38 a	80.13 c	74.94 d	4.46 d	4.71 b	4.00 e
Cold temperature (5 °C)	86.31 b	78.69 c	73.50 d	4.59 c	4.81 b	5.18 a
	Oxygen (%)			Carbon dioxide (%)		
Room temperature	19.6 a	19.3 b	18.19 d	0.30 d	0.62 c	1.07 a
Cold temperature (5 °C)	19.7 a	19.2 c	18.19 d	0.30 d	0.63 c	1.03 b
	Catalase activity			Peroxidase activity		
Room temperature	20.37 a	13.98 b	12.42 bc	14.05 a	9.55 b	8.05 b-c
Cold temperature (5 °C)	20.37 a	11.61 bc	10.29 c	14.05 a	8.21 b-c	7.24 c
	Malondialdehyde content (mmol g^{-1} fw)					
Room temperature	13.80 e	17.51 d	20.59 b			
Cold temperature (5 °C)	13.80 e	19.45 c	22.01 a			

III. *Effect of packaging treatment on malondialdehyde content*

These results indicated that the packaging treatment had a significant effect on malondialdehyde content. The lowest malondialdehyde content (17.02 mmol g^{-1} fw) was found in non perforated polypropylene and polyethylene packages (17.23 mmol g^{-1} fw) (**Table 2**).

Discussion

The onion is preferred mainly because of its green leaves, immature and mature bulbs are either eaten raw or cooked as a vegetable. Mild flavored or colorful bulbs are often chosen for salads. The bulbs are used in soups, sauces, condiments, spice, in medicine, seasoning of many foods and for the preparation of value added edible products like powder, flakes and salts. Onion has many uses as folk medicine and recent reports suggests that onion plays an important role in preventing heart diseases and other ailments (***Kukanoor, 2005***). Quality optimization and loss reduction in the postharvest chain of fresh fruits and vegetables are the main objectives of postharvest technology. Temperature control and modification of atmosphere are two important factors in prolonging shelf life. Modified atmosphere packaging (MAP) of fresh produce relies on modification of the atmosphere inside the package, achieved by the natural interplay between two processes, the respiration of the product and the transfer of gases through the packaging, that leads to an atmosphere richer in CO_2 and poorer in O_2. This atmosphere can potentially reduce respiration rate, ethylene sensitivity and production, decay and physiological changes, namely, oxidation (***Gorris and Tauscher, 1999***).

MAP was first recorded in 1927 as an extension of shelf life of apples by storing them in atmospheres with reduced O_2 and increased CO_2 concentrations. In the 1930s, it was used as modified atmosphere storage to transport fruits in the holds of ships and increasing the carbon dioxide concentration surrounding beef carcasses transported long distances was shown to increase shelf life by up to 100 %. However, the technique was not introduced commercially for retail packs until the early 1970s in Europe (***Das, 2004***). MA packages should be carefully designed, as a system incorrectly designed may be ineffective or even shorten the shelf life of the product. The design should take into consideration not only steady-state conditions, but also the dynamic process, because if the product is exposed for a long time to unsuitable gas composition before reaching the adequate atmosphere, the package may have no benefit. The design of an MA package depends on a number of variables: the characteristics of the product, its mass, the recommend atmosphere composition, the permeability of the packaging materials to gases and its dependence on temperature and the respiration rate of the product as affected by different gas composition and temperature. Thus, respiration rate modeling is central to the design of MAP for fresh fruits and vegetables (***Fonseca et al. 2002***).

An important goal in some modified atmosphere packaging systems is to generate an atmosphere sufficiently low in O_2 to influence the metabolism (e.g., softening, chlorophyll degradation, tissue browning, senescence) of the product being packaged such that storability and/or shelf life is extended. For some products, modifying both O_2 and CO_2 may be desirable and indeed, when the O_2 partial pressure in packages is altered, so too must be that of CO_2 by virtue of the system (***Beaudry, 2000***). Modified atmospheres can be created either passively by the commodity or intentionally through active packaging. Modified atmospheres can passively evolve within a hermetically sealed package as a consequence of a commodity's respiration, i.e. O_2 consumption and CO_2 evolution. The rate of change of the composition of the modified atmosphere will depend largely on the packaged product and the permeability of the packaging material (***Das, 2004***).

As mentioned before, packaging treatment had a significant effect on germination (%) of seeds and all the packaging treatments had the higher germination (%) than the paper package. These results may be due to that packages had lower water content than the paper bag and that these packages had the lowest oxygen and the highest carbon dioxide percentages (**Table 1A**). These results are in agreement with those obtained by **Caneppele *et al*. (1995)** and **Stanwood and Sowa (1995)**. Similar results were obtained by **Promila *et al.* (1999)** as they found that seed with higher moisture content between 7.0 % - 10.9 % and stored in cloth bags showed more abnormal cells for a given decrease in germination ability upon storage than seeds with reduced water and stored in polythene bags or paper lined aluminium bags. They also reported that the difference was due to changes in seeds water content in impermeable packages and to the degree of hygroscopic equilibrium between seeds and their surrounding. The results had the same trend with **Karim *et al*. (2006)** and **Rao *et al*. (2006)**. In general, the perforated polypropylene or non perforated polypropylene were the most suitable for modified atmospheric packages after foliar nutrition of onion seeds under sandy soil and saline irrigation water in Egypt, whereas they had the highest germination percent and enzyme activity and the lowest moisture and malondialdehyde content during all storage periods.

Conclusion

Modified atmosphere packaging (MAP) was first recorded in 1927 as an extension of shelf life of apples by storing them in atmospheres with reduced O_2 and increased CO_2 concentrations. In the 1930s, it was used as modified atmosphere storage to transport fruits in the holds of ships and increasing the CO_2 concentration surrounding beef carcasses transported long distances was shown to increase shelf life by up to 100 %. However, the technique was not introduced commercially for retail packs until the early 1970s in Europe. MAP techniques are now used on a wide range of fresh or chilled foods, including raw and cooked meats and poultry, fish, fresh pasta, fruit and vegetables, and more recently, coffee, tea and bakery products.

Onion seeds were stored in different package materials (paper, polyethylene, perforated and non perforated polypropylene) to study the effect of different modified atmosphere packages at two storage temperatures (room temperature and 5°C) on seeds germination, moisture content and change in antioxidant enzymes activities of onion seeds during the storage period. The non perforated polypropylene and polyethylene packages had the highest germination percent and enzyme activity and the lowest moisture and malondialdehyde content during all storage periods.

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