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ENGINEERING STUDIES ON STORAGE OF ONION CROP

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ABSTRACT

A study was carried out to compare and evaluate three different storage methods of onion (traditional storage, ventilated storage and cold storage). The ventilated storage method was studied under two different types of vertical storage bins (concrete and metal), while the cold storage method was proceeded in a refrigerated chamber using three different types of storage sacks (poly-ethelene, purlap, and strip plastic) and three different types of packing boxes (pamboo, wood, and plastic). The evaluation basis included assessment of bulbs deterioration, weight loss and sprouting percentage. The results showed that, the traditional storage method recorded the highest deterioration and accumulative weight losses followed by the ventilated and cold storage methods respectively. On the other hands, the ventilated masonry storage bin showed lower deterioration and accumulative weight loss as compared to the ventilated metal bin. Meanwhile, the cold storage in poly-ethelene sacks and plastic boxes showed the lowest deterioration and accumulative weight loss as compared to other studied materials. Also, both traditional and ventilated storage methods showed no sprouting of onion bulbs, while the cold storage method recorded a sprouting percentage ranged from 4.5 to 7.2 % due to higher level of air relative humidity inside the cold storage chamber.

INTRODUCTION

Onion is considered as one of the most important crops in all countries of the world. In Egypt, onion rank fourth after cotton, rice, and citrus. It is grown as a winter, summer and inter planted crop for mature dry bulbs and small green amounts as a source of protein, mineral salts, and vitamins. In Egypt, onion is cultivated not only for local consumption, but also for export. Most of the cultivated area devoted for export is located in middle and upper Egypt. All production of the Delta area is mainly used for domestic consumption (Musa *et al.*, 1994).

Egyptian onion is successfully exported to European markets, especially in spring and early summer, as the European onion can not compete with the Egyptian onion during this period because Egyptian farmers produce early crop for export by early direct seeding in regions characterized with high temperature (Salama *et al.*, 1990).

Handling and storage processes are considered as the most important operations affecting quality of onion after harvesting. The preliminary surveying for the currently used system of onion storage in Egypt shows that, the bulk of onions is stored in the field where kept under the climatic conditions in a piles covered with rice straw for 5 months. The dimensions of these piles vary from a farmer to another and from a place to another. The total weight losses of onions using this method of storage reaches a maximum value of (50%) which are mostly due to moisture loss and deterioration by insects and microorganisms, Bahnasawy *et al.*, (1998) . For sound storage of onions, important factors such as cultivation practices, harvesting and curing method, temperature and air relative humidity in the store, structure design of the store and application of sprout-inhibiting chemicals play a major roles, Fustos *et al.*, (1994). Onions as perishables have an optimum temperature range for storage, above which they respire at unacceptably high rates and are more susceptible to ethylene and disease damage. According to most horticultural commodities respire at rates which double, triple, or even quadruple for every (10°C) increase in temperature (Robinson *et al.*, 1975; Wang, 1982; and Kader, 1986).

Improvement of the current traditional storage method and /or developing a new methods of storage may led to a marketable reduction in both quantity and quality losses of onion. The general objective of the current study is to compare and evaluate three different storage methods of onion (traditional storage, ventilated storage, and cold storage). The evaluation basis included, assessment of bulbs deterioration, weight loss and sprouting percentage.

MATERIAL AND TEST PROCEDURE

The experimental work was carried out at the Research Station of Rice Mechanization Center (R.M.C), Kafr El- Sheikh governorate, the storage period was extended to about 22 weeks during 2003 onion harvesting season, starts from 11 June to 15 Nov. 2003.
Three different methods of onion storage were evaluated and compared. These methods included traditional storage, ventilated storage in vertical concrete and metal bins, and cold storage in a refrigerated chamber using three different types of storage sacks (polyethylene, burlap and strip plastic) and three different types of packing boxes (bamboo, wood and plastic).

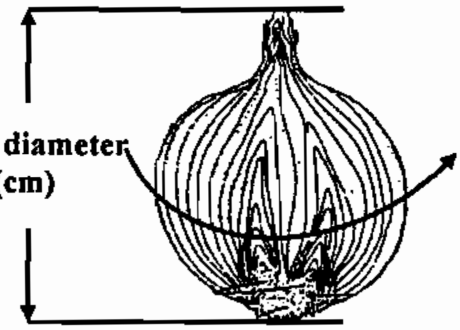
Preparation Of Onion Samples:

A local onion cultivar var. (El Behery) which usually grown in Kafr El-Sheikh governorate was harvested during 2003 onion harvesting season. Polar and equatorial diameters, average weight and initial moisture content before storing were measured and presented in Table (1). These characteristics were used for assessment of both deterioration and weight losses.

Table (1): Some physical characteristics of onion var. (El Behery) used for the experimental work.

Measuring parameters	Polar diameter (cm)	Equatorial diameter (cm)	Bulb weight (g)	Moisture content (% w.b)
Maximum	5.7	6.3	215	88.69
Minimum	3.1	3.7	60	85.80
Mean	4.38	4.7	125	87.59

The values are the average of 10 measurements in three replicates.



Methods of storage:

1. Traditional storage method:

After the inspection of onion bulbs for damages, they were piled loosely on dried soil and covered by a layer of rice straw as usually practiced by Egyptian farmers. The dimensions of the pile were 150 cm long, 80 cm wide and 80 cm high. The thickness of rice straw cover was 15 cm. Temperature and relative humidity readings of ambient air were taken daily at various locations of the onion pile and straw cover (east- centre-west). The moisture content and quality changes of the stored onion bulbs were determined every two weeks.

2. Ventilated storage method:

Two identical cylindrical bins were constructed, one bin was fabricated of a 2 mm thick galvanized iron sheets and the other was fabricated of 150 mm thick concrete masonry. Each bin having a gross dimensions of 0.75 m diameter and 1.5 m high with a false bottom forming a plenum chamber of 0.2 m high. Each type of experimental bins (metal and concrete) were connected to a 0.25 kW centrifugal fan using 0.05m diameter and 0.30m long pvc pipe. Fan operation of each bin was automatically controlled using a differential thermostat adjusted to operate the fan when the temperature of the stored onion bulbs is higher than the ambient air temperature by about 5°C. Air flow rate used for the ventilation process in both types of bins was 0.2 m^3 h.kg as recommended by (Musa et *al.*, 1994). Fig.(1) shows a schematic diagram for the experimental storage bin. Bulk temperature, moisture content and other quality changes of the stored onion were measured at top, middle and bottom layers of each bin every two weeks while air temperature and relative humidity were daily measured.

3. Clod storage method:

A full insulated refrigeration chamber accompanied with a 4 tons refrigeration unit model MITSUBISHI (R.F-310) was used for cold storage method. The dimensions of the refrigerated chamber were 3.2 m long, 2.6 m wide and 3.7 m high with a full floor area of 8.32m^2. The chamber arranged with metal shelves to accommodate the product containers.

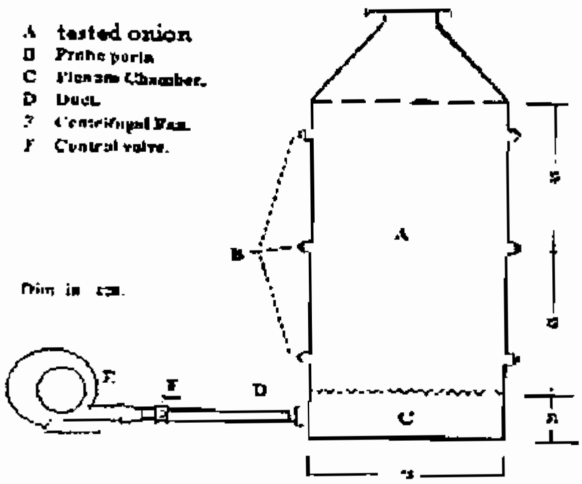


Fig. (1): Schematic diagram of the storage bin used for the ventilated storage method.

The refrigerated chamber temperature was adjusted at 3±1°C as recommended by (Iglesias *et al.*, 1987 and Bertolini, 1983). Three different types of storage sack (polyethylene, burlap and strip plastic) and three different types of boxes (bamboo, wood and plastic) were employed during the experimental work. Onion bulk temperature of each treatment, ambient air temperature and air relative humidity were daily measured, while onion moisture content and quality change of the stored onion were measured every two weeks.

Equipment and Experimental Measurements:

Air temperature and relative humidity:

Ambient air temperature and air relative humidity were measured using a temperature and relative humidity meter SATO (model SK- 73D). Measurements were carried out every 6 hours, and the mean values were calculated every week.

Onion bulk temperature:

The universal digital measuring system model (Kaye Dig. 14) connected to a 36 channels scanning box with thermocouples (Iron-constantan) was used to measure onion bulk temperature at different positions of each treatment.

Onion moisture content.

Onion samples were weighted before and after drying. The drying process was conducted using an electrically heated oven with a temperature control thermostat and a fan to circulate the hot air around the samples. The oven adjusted at 105°C and operated until a constant weight of samples was obtained as recommended by (Bahnasawy *et al.*, 1998).

Air flow rate adjustment:

For the ventilated storage method, the volumetric air flow rate of each storage bin was measured and adjusted using a (K.D.G 2000) digital fan anemometer Model (R.A.B. 14728). This meter measures the air speed in m/s and the readings were converted to m^3/h.

Onion deterioration loss:

A samples of stored onion were taken every two weeks to determine the percent of deterioration loss. The spoiled onions were counted and removed every time. The total weight of deteriorated onion was calculated based on the average weight of 125 g for one bulb of onion as presented in Table (1). The accumulative losses due to deterioration was computed every two weeks until the end of storage period.

Onion weight loss:

The total weight loss included moisture content, deterioration loss and dry matter loss due to respiration. For all storage methods, the sound stored onion were weighed every 2 weeks to determine the percent of total weight loss. A precise digital electronic balance with accuracy of 5 g was used for weighing process. The weight loss was calculated using the following equation:

$$\text{Total weight loss} = \frac{Tw - T_{wi}}{Tw} \times 100 \quad (1)$$

Where:

Tw is the total weight, before storage, g;

T_{wi} is the total weight after storage, g.

Onions sprouting:

Onion sprouting was measured by visual inspection of all bulbs. The bulbs having sprouts at the neck were discarded. The sprouting percentage was computed on the base of number of sprouted bulbs as related to total number of bulbs using the following equation:

$$\text{Sprouting \%} = \frac{\text{No. of sprouted bulbs}}{\text{Total no. of bulbs}} \times 100 \quad (2)$$

RESULTS AND DISCUSSION

Traditional Storage Method:

Onion bulk temperature:

Figs. (2) and (3) show the average onion bulk temperature as related to storage time during daylight and at night times, respectively. At night time, the temperature gradient increased from outside (lower temp.) towards the center (higher temp.). The average onion bulk temperature was 31.75°C in the center while it was 27.15°C and 27.39°C, at the east and west sides, respectively. Also, the average ambient air temperature was lower than the overall temperature of the pile by about 5.39°C which means that, heat dissipated from the stored onion due to respiration (10.67 kJ/ ton.h) increased the stored onion bulk temperature over the ambient air temperature.

Whilst, the average onion bulk temperature during daylight time was 21.52°C at the center of the pile and it was 28.58 and 27.99 °C at east and west sides, respectively. This difference in bulk temperature can be attributed to the effect of solar radiation flux incident on the sides of the pile during the daylight time. Also, the average ambient air temperature during the daylight time (30.3°C) was higher than the overall average bulk temperature of the onion pile by about 4.27°C. This is due to the evaporation of moisture from the onion on the boundary of the pile which conducive to water vapor pressure difference between the air surrounding the onion bulbs and ambient air around the pile.

Onion moisture content:

The average onion moisture content as related to storage time is plotted in Fig. (4). The results show that, onion moisture content decreased from an initial level of 87.59 % (w.b.) to a final level of 82.58 % (w.b.) after 22 weeks of storage. Also, the onion moisture content decreased in a higher rate during the first four weeks of storage (0.72 % per week) and then starts to decrease during the next eight weeks by (0.17 % per week), while it was remained nearly constant with an average loss rate of (0.05 % per week) till the end of storage period. This means that, most of the moisture loss occurred during the first period of storage. The reason for high moisture loss during this period is not only due to the skin still permeable to water, but also due to moisture transpiration through cuts and bruises which are inevitably present during harvesting and transportation as confirmed by (Misener and Shove, 1976).

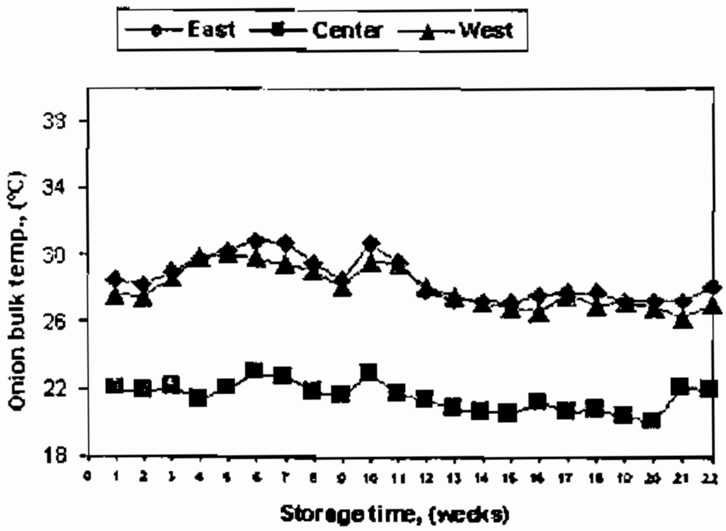


Fig. (2): The weekly average onion bulk temperature during daylight time of the traditional storage method.

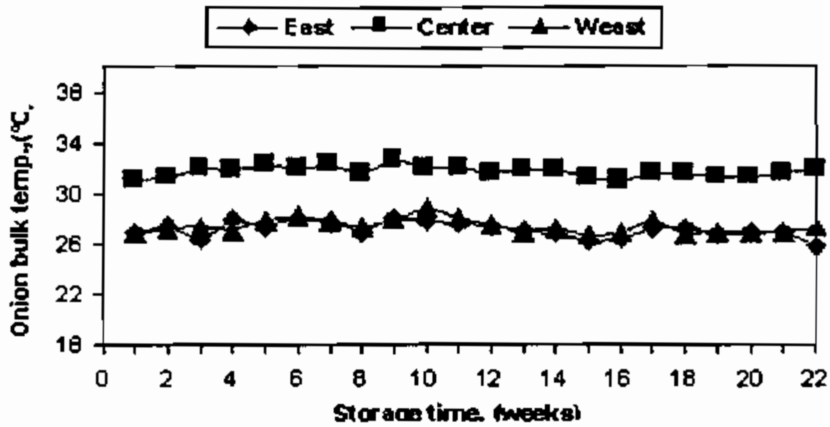


Fig. (3): The weekly average onion bulk temperature during night time of the traditional storage method.

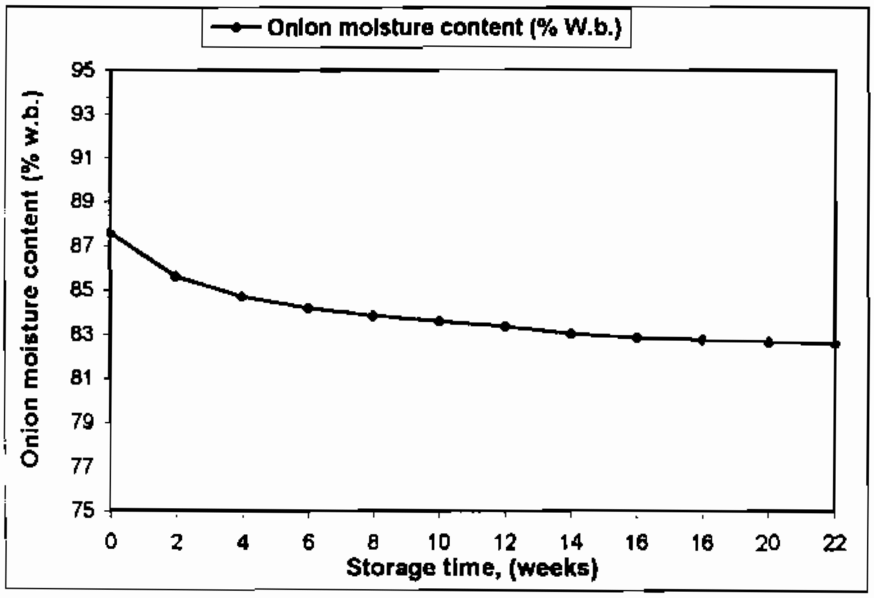


Fig. (4): Onion moisture content as related to storage time for the traditional storage method

Onion deterioration loss:

Fig.(5) presents the deterioration loss of onion as related to storage time for the traditional storage method. Initially, there was no deterioration noticed during the first two weeks of storage. By the fourth week, a deterioration loss of (2.4%) was observed, and then increased with the increase of storage period up to a maximum value of (3.6% w/w).

After ten weeks of storage, the onion deterioration loss was decreased again to (2.9 %) due to the decreasing in onion moisture content. In general, the accumulative loss due to the deterioration of onion at the end of storage period reached (20.7%).

The observed deterioration loss of onion during the first period of storage may be due to the high temperature results from respiration, accumulation of moisture due to the lack of ventilation inside the onion pile (because of straw cover) and the high fluctuation in the ambient air temperature which caused condensation of water vapor existing in air surrounding the onion bulbs and creating a suitable conditions for micro organisms to induce onion deterioration.

Onion Weight loss:

The total weight losses and the accumulative losses of onion stored under the traditional storage method are presented in Fig. (6). The total weight loss of onion was increased from a level of 2.79 % (w/w) to the highest level of 4.21% (w/w) after 10 weeks of storage and starts to decrease gradually up to a level of 1.23% (w/w) at the end of storage period. In general, the total weight loss follows the changes in bulbs moisture loss and the deterioration loss until reaching an accumulative weight loss of 29.38% (w/w) at the end of storage period.

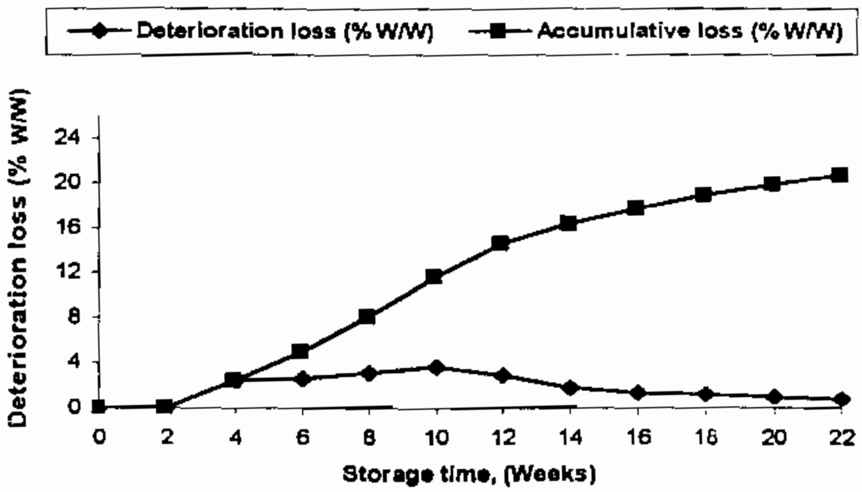


Fig. (5): Deterioration loss and accumulative loss of onion stored under traditional storage method.

Onion Sprouting:

No Sprouted bulbs were observed for the onion stored under the traditional storage method during the entire period.

Ventilated Storage Method:

Onion bulk temperature:

The weekly average onions bulk temperature during storage period for the two different types of storage bins (concrete masonry and metal) are presented in Figs. (7) and (8), respectively.

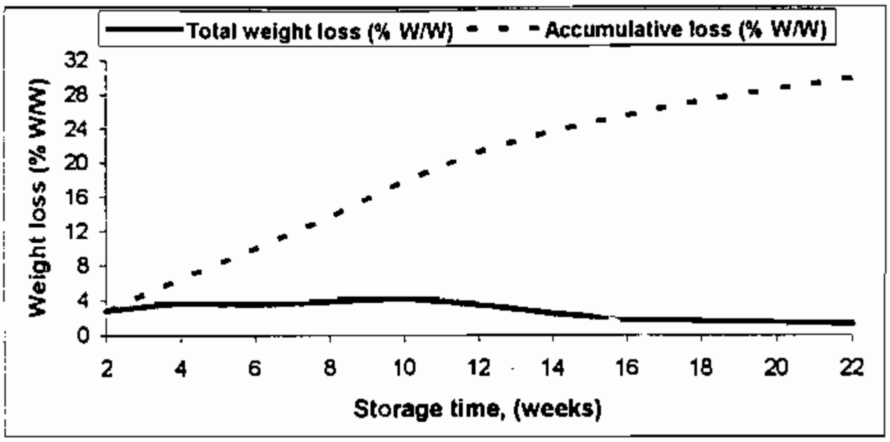


Fig. (6): Total weight loss and accumulative loss of onion stored under traditional storage method.

As shown in the Figures, onion bulk temperature decreased at a higher rate during the first four weeks of storage due to the evaporative cooling of onion results from higher rate of moisture loss, and then starts to fluctuate based on the changes in the ventilating air temperature. For the ventilated metal and concrete masonry bins the average onion bulk temperatures were 26.43°C and 24.8°C, respectively. This means that, the metal bin may give a chance for the heat resulted from solar energy incident over the bin surface to heat the stored onion especially during the daylight time, while it give a chance for the heat generated from bulbs respiration to dissipate outside the bin at night time.

Inversely, the concrete masonry bin insulated the onion bulk and prevent heat flow through the bin surface during the daylight time while it may prevent heat of respiration to dissipate outside the bin at night time.

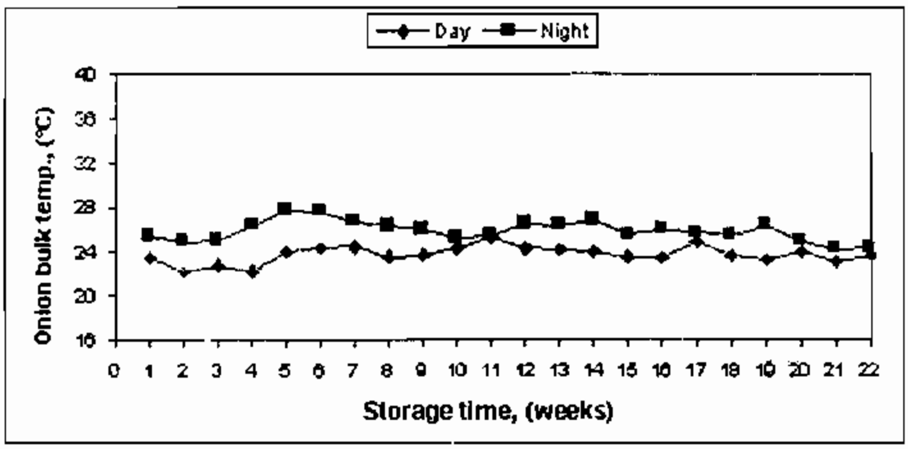


Fig. (7): Overall average onion bulk temperature during daylight and at night times for the ventilated concrete masonry bin.

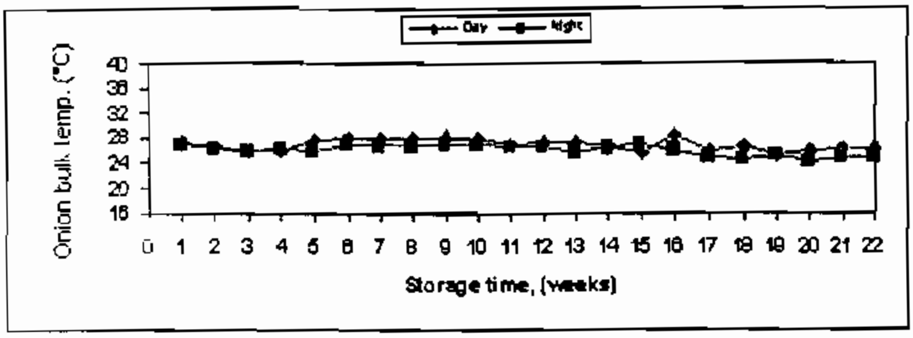


Fig. (8): Overall average onion bulk temperature during daylight and at night times for the ventilated metal bin.

Onion moisture content:

Figs. (9) through (11) present the change in onion moisture content as related to storage time for onion bulbs stored in concrete masonry and metal bins, respectively.

As shown in Fig. (9), the average initial moisture content of onion decreased from an initial level of 87.59 % to a final levels of 81.49% and 77.9% after 22 weeks of storage for the concrete masonry and metal Lins, respectively. The Fig. also shows that, most of onion moisture loss was occurred at the first four weeks of storage, while it was decreased gradually till the end of storage period. The higher moisture reduction rate of onion stored in the metal bin as compared with the concrete masonry bin may be attributed to the higher rate of heat transfer through the wall surface of metal bin to the stored onion bulbs especially during the daylight time. This condition increased the temperature and decreased the relative humidity of air inside the voids between the onion bulbs and finally increased the drying potential of onion bulbs as indicated by (El-Mesery, 2003).

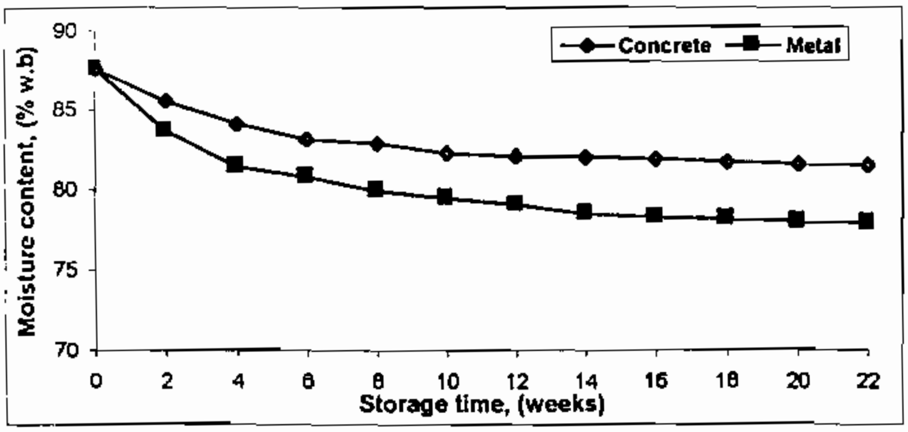


Fig. (9): Overall average onion moisture content as related to storage time for the ventilated concrete masonry and metal bins.

The changes in onion moisture content at different layers of storage bins were also investigated and presented in Figs. (10) and (11) for onion stored in concrete masonry and metal bins, respectively.

As shown in the Figures, for both types of bins, the moisture reduction rate was higher at the bottom layers as compared to middle and top layers due to the upward air flow during the ventilation process.

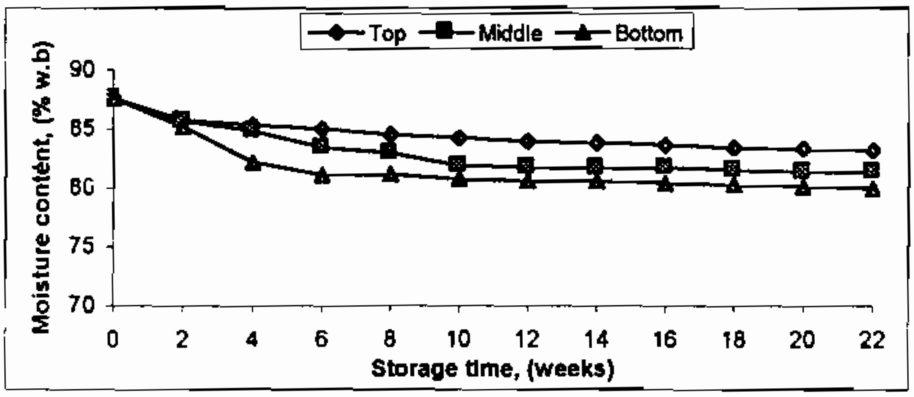


Fig. (10): Onion moisture content at different layers of the ventilated concrete masonry bin.

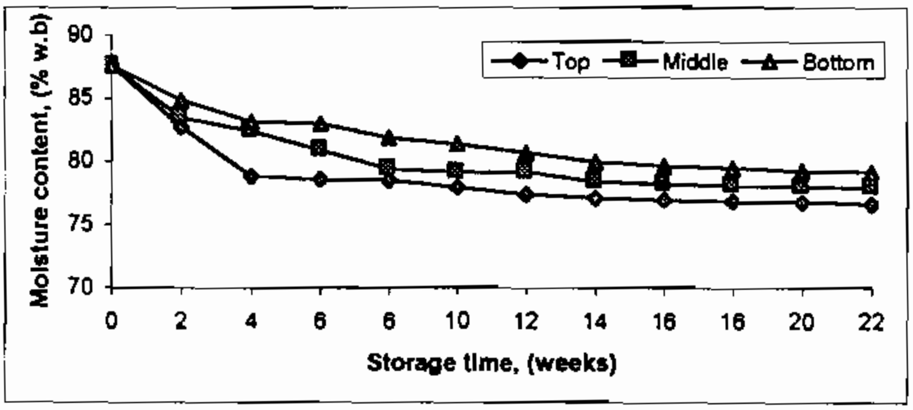


Fig. (11): Onion moisture content at different layers of the ventilated metal bin.

Onion deterioration loss :

As shown in Figs. (12 and 13), the deterioration loss of onion stored in concrete masonry bin was lower than that stored in metal bin. Also, for both types of bins, there was no deterioretion loss noticed during the first two weeks of storage. Following this period, the, loss due to deterioration increased and reaching 1.95% w/w and 2.98% w/w after ten weeks of storage for the concrete masonry and metal bins, respectively. By the end of storage period the accumulative losses of 7.81% w/w and 10.45% w/w were observed for the concrete and metal ventilated bins, respectively.

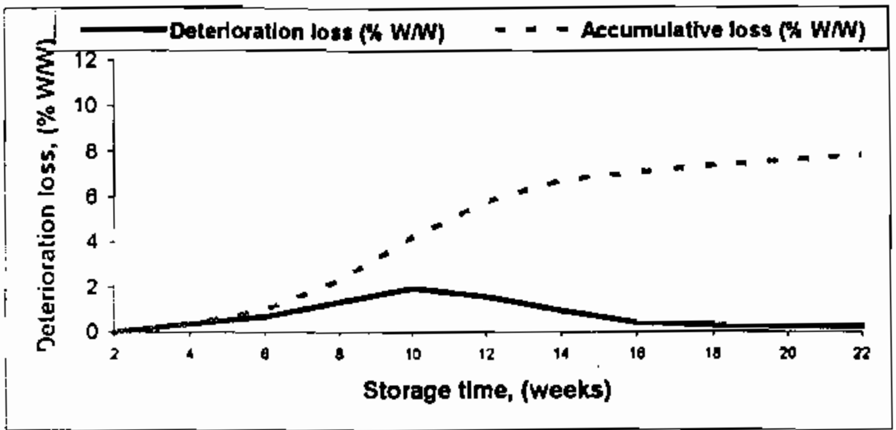


Fig. (12): Deterioration and accumulative deterioration loss of onion stored under ventilated concrete masonry bin.

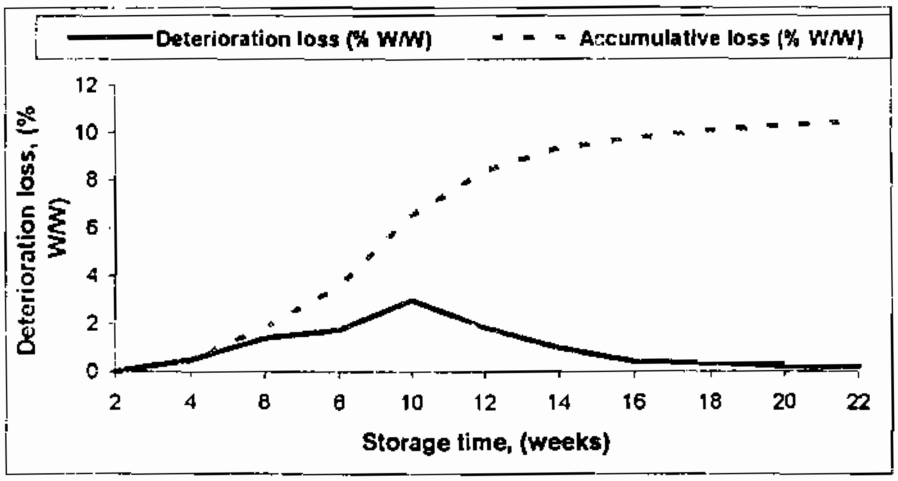


Fig. (13): Deterioration and accumulative deterioration loss of onion stored under ventilated metal bin.

Onion weight loss :

Onion weight loss and the accumulative weight loss are presented in figs. (14) and (15) for the ventilated concrete masonry and metal bins, respectively. For the metal bin, the total weight loss approaches the highest value of 3.15% w/w after 10 weeks of storage and then starts to gradually decrease up to a level of 0.52% w/w at the end of storage period. The corresponded total weight loss values for the concrete masonry bin were 2.98%w/w and 0.43% w/w, respectively. Meanwhile, the accumulative weight losses at the end of storage period for the ventilated metal and concrete bins were 22.39 and 16.91% w/w, respectively. This means that, longer period of ventilation and higher bulk temperature of onion stored in the ventilated metal bin causes higher water and deterioration loss and finally increased the accumulative total weight loss of onion.

Onion Sprouting:

For both type of storage bins, no sprouted bulbs were observed at the end of storage period.

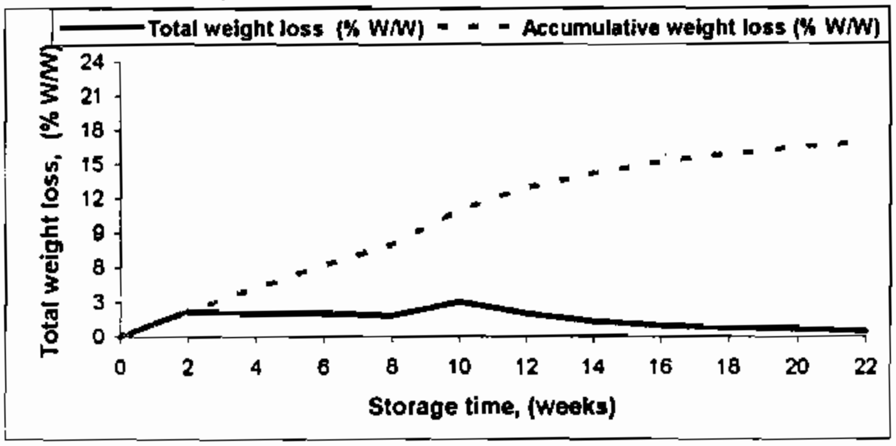


Fig. (14): Total weight loss and accumulative weight loss of onion stored under ventilated concrete masonry bin.

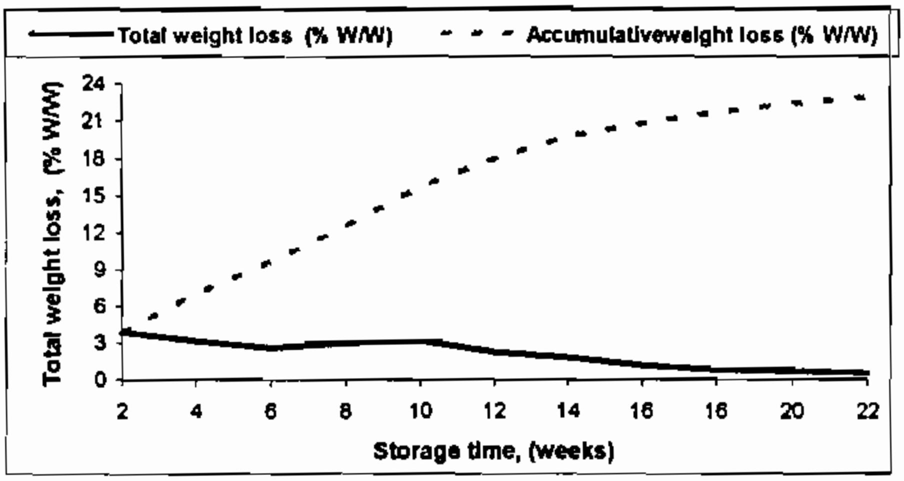


Fig. (15): Total weight loss and accumulative loss of onion stored under ventilated metal bin.

Cold Storage Method:

Onion bulk temperature:

Onion bulk temperature as related to storage time using different types of sacks and boxes are plotted in Figs. (16 and 17), respectively.

For onion stored under different types of storage sacks, Fig. (16) show that, burlap sacks recorded the highest onion bulk temperature followed by polyethylene and strip plastic sacks. The recorded average onion bulk temperature for polyethylene, burlap and strip plastic sacks were 3.62, 3.88 and 3.46°C, respectively. storage sacks, Fig. (16) show that, burlap sacks

However, for onion stored under different types of boxes, fig.(17)shows that wooden boxes recorded the highest temperature due to the insulation effects of wooden materials, while, plastic boxes recorded the lowest bulk temperature due to the higher percentage of vents/total area. The recorded overall average temperatures for bamboo, wood and plastic boxes were (3.42), (3.74) and (3.36)°C, respectively.

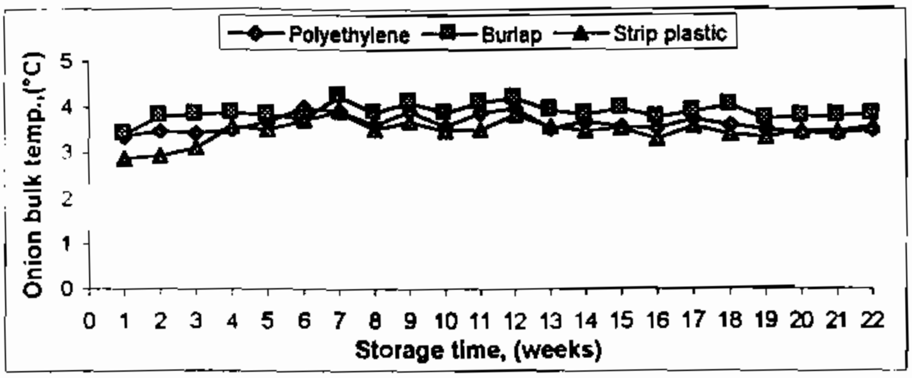


Fig. (16): Average onion bulk temperature for the cold storage method using different types of sacks.

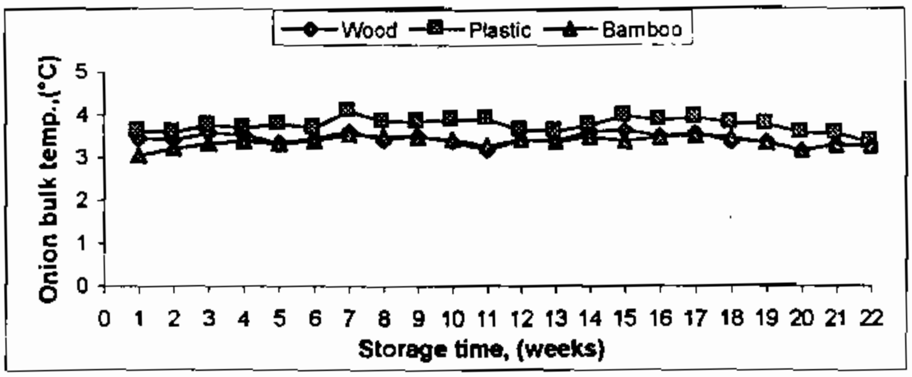


Fig. (17): Average onion bulk temperature for the cold storage method using different types of boxes.

Onion moisture content:

The changes in average onion moisture contents as related to storage time are presented in figs. (18 and 19), respectively. For all treatments, the moisture contents of onion initially decreased at a higher rate during the first four weeks of storage and starts to decrease in a lower rates during the following period until become near constant at the end of storage period. The reduction rate of moisture content was varied with the type of storage sacks and boxes. As shown in Fig. (18), the moisture content decreased from an initial level of (87.59%) to a final levels of (86.48%), (86.41%) and (85.76%) for polyethylene, burlap and strip plastic sack, respectively. These results show that, polyethylene sacks provided the highest resistance to mass exchange between the stored onion and the surrounding air followed by strip plastic and burlap sacks respectively.

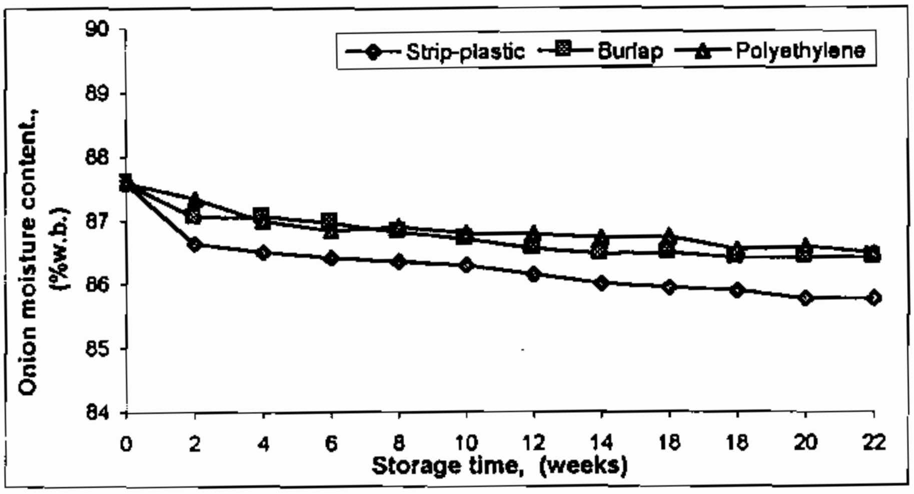


Fig. (18): Onion moisture content as related to storage time for cold storage method using different types of storage sacks.

For the onion stored under different types of storage boxes, fig. (19) shows that, onion moisture content decreased from an initial level of 87.59% to a final levels of 86.07%, 85.91% and 86.07% for the onion sorted in bamboo, wood and plastic boxes, respectively. This also means that, the pamboo boxes causes the highest moisture loss due to the higher percentage of vents area/ total area which allow higher rate of moisture loss from the onion bulbs to the surrounding as compared to wooden and plastic boxes.

Onion deterioration loss:

Deterioration loss and the accumulative loss of onion stored under different types of storage sacks and boxes are presented in figs. (20) and (21), respectively. For the storage sacks, fig. (20) shows that, burlap sacks recorded the highest deterioration loss followed by strip plastic and polyethylene sacks. The recorded final accumulative loss for burlap, strip-plastic and polyethylene sacks were 2.35 %, 2.11 and 1.82 % w/w, respectively. This means that, polyethylene sacks could eliminate the presence of oxygen while increases Co_2 around the onion bulbs which finally decreases the chance for rotting diseases as compared with other types of storage sacks.

For different types of storage boxes, Fig. (21) shows that, deterioration loss of onion starts after four weeks of storage for bamboo boxes and after 6 weeks of storage for wood and plastic boxes. The recorded final accumulative deterioration losses of onion stored in bamboo, wood and plastic boxes were 2.79, 2.31 and 1.99% w/w, respectively. This means that, the lower bulk temperature and the proper percentage of vents/ total area of the plastic boxes decreases the chance for onion rotting and disease attack in comparison with other types of boxes.

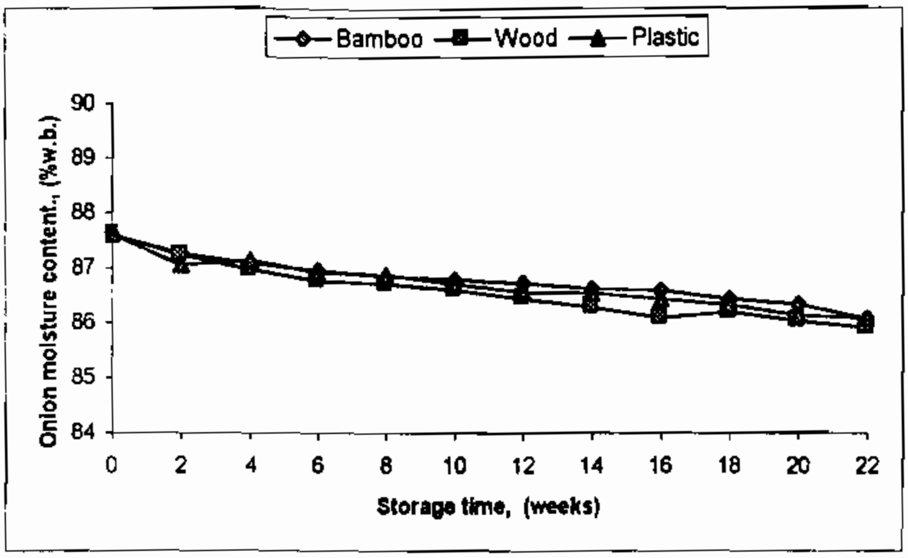


Fig. (19): Onion moisture content as related to storage time for cold storage method using different types of storage boxes.

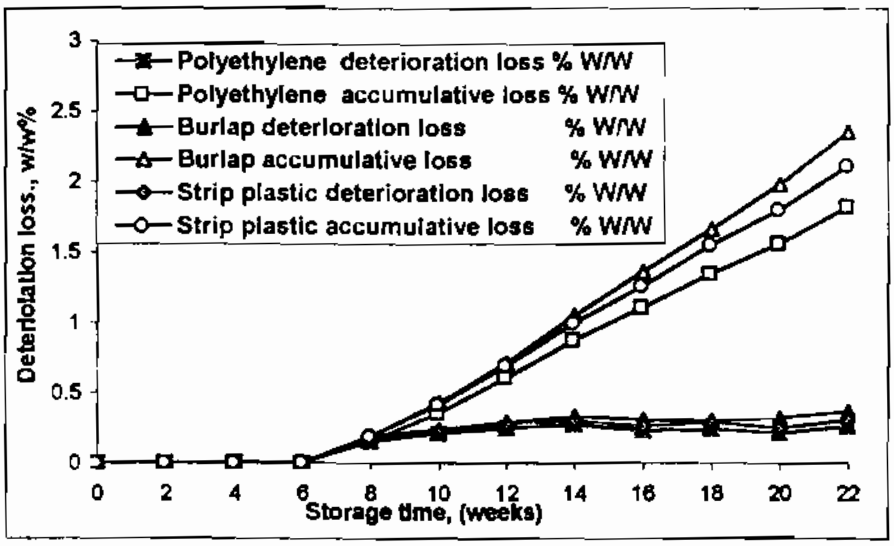


Fig. (20): Deterioration loss and accumulative loss of onion stored under cold storage method in (sacks).

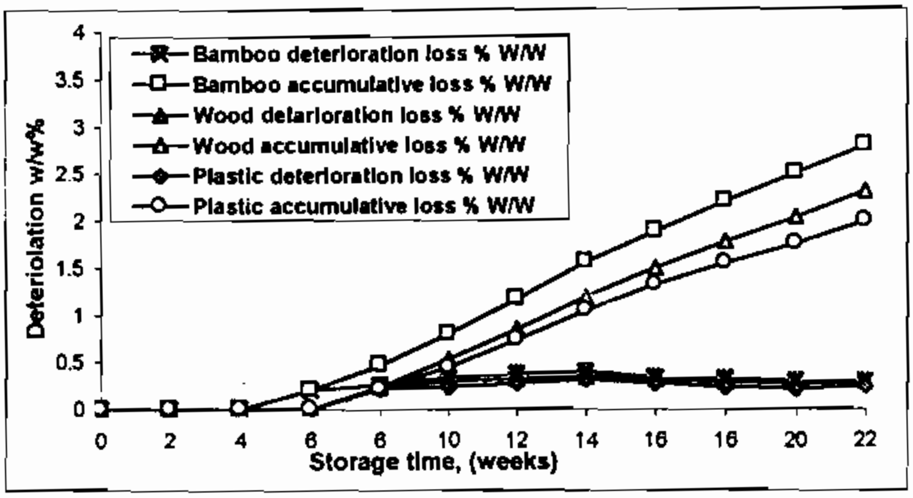


Fig. (21): Deterioration loss and accumulative loss of onion stored under cold storage method in (boxes).

Onion weight loss:

Onion weight losses are presented in figs. (22) and (23) for sacks and boxes, respectively. The recorded accumulative weight loss at the end of storage period were 2.93, 3.59 and 3.94% w/w for polyethylene, burlap and strip plastic sacks, respectively, and the corresponded values for plastic, wood and bamboo boxes were 3.49, 3.99 and 4.53 % w/w, respectively.

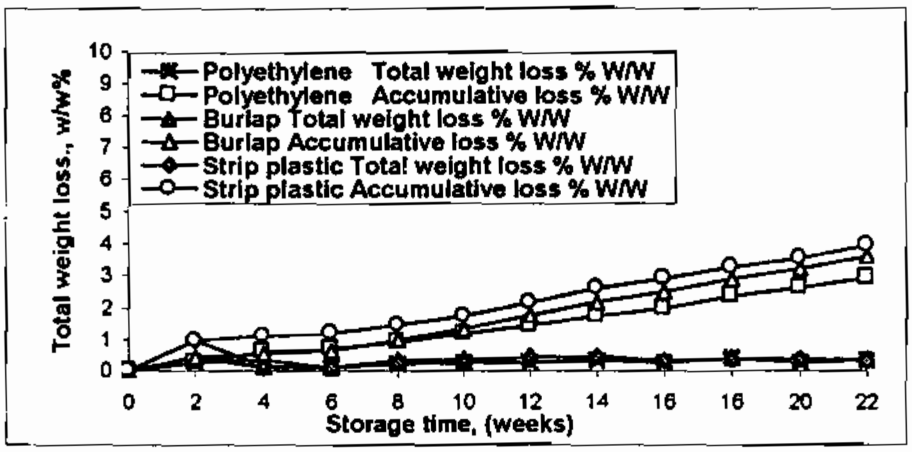


Fig. (22): Total weight loss and accumulative loss of onion stored under cold storage method in (sacks).

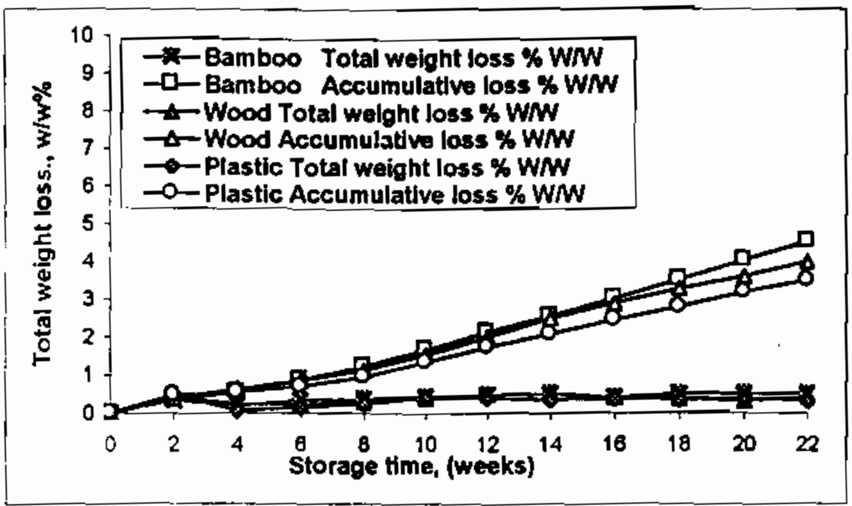


Fig. (23): Total weight loss and accumulative loss of onion stored under cold storage method in (boxes).

Onion sprouting:

In general, sprouting of onion bulbs started after 8 weeks of storage and it was varied for all treatments. At the end of storage period, fig. (24) shows that, the recorded sprouting percentage of onion stored in poly-ethylene, strip plastic and burlap sacks were 4.5, 5.4 and 7.1 % w/w, respectively. The observed lower sprouting percentage of polyethylene sacks may be attributed to the presence of CO_2 inside the polyethylene sacks which causes a dormancy of the stored bulbs and a corresponded lower sprouting percentage. However, for boxes storage method Fig. (25) shows that bamboo

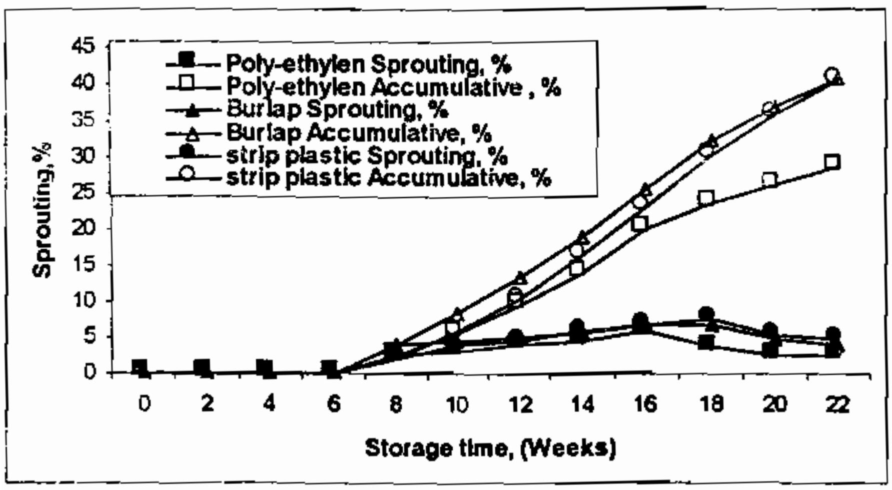


Fig. (24): Sprouting and accumulative sprouting of onion stored under cold storage method in (sacks).

boxes recorded the highest sprouting percentage of (7.2%) followed by wood and plastic boxes (6.4) and (5.6) % respectively. The higher sprouting percentage of onion stored in bamboo boxes may be due to the higher percentage of vents/total area which give a chance for onion bulbs to receive more light and moisture condensation over the onion bulbs and finally enhanced the sprouting of bulbs. In general, the lower ambient air temperature (> 5 °C) and the higher level of relative humidity (over 75%) in cold storage method did not suppress the dormancy of onion bulbs. This means that, controlling the air relative humidity inside the cold storage chamber to be lower than 60% and using sprouting inhibitors may prevent onion sprouting as mentioned by (Dannis, 1981; Modal and Pramanik, 1992).

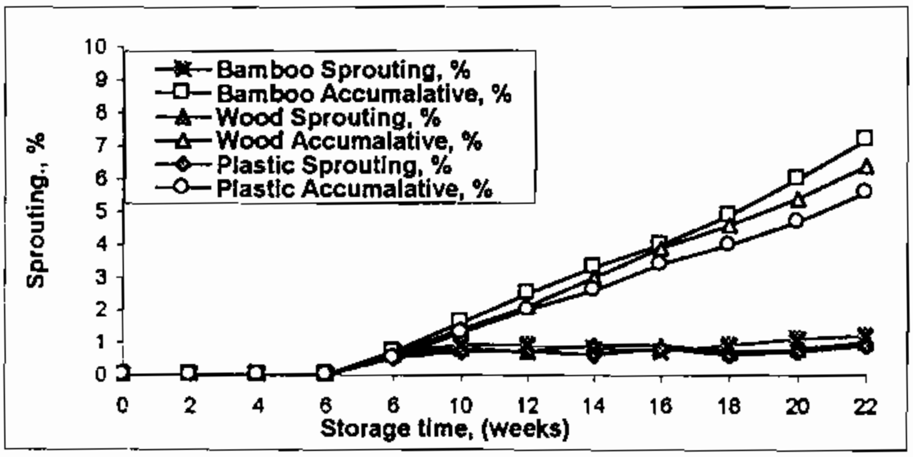


Fig. (25): Sprouting and accumulative sprouting of onion stored under cold storage method in (boxes).

CONCLUSION

1- Traditional method of onion storage showed the highest deterioration and accumulative weight losses of (20.7 and 29.88 % ww) respectively, at the end of storage period.

2- The ventilated concrete masonry storage bin showed lower accumulative deterioration and weight losses of (7.81 and 10.45 % w/w), respectively as compared to (16.91, 22.89 % w/w) for the metal storage bin at the end of storage period.

3- Cold storage in polyethylene sacks and plastic boxes showed the lowest accumulative deterioration losses of 1.82 and 1.99 % w/w respectively,. and the lowest weight losses of 2.93 and 3.49 % w/w, respectively at the end of storage period.

4- No sprouting of onion bulbs was observed for both traditional and ventilated storage methods, while the cold storage method showed sprouting percentage ranged from 4.5 to 7.2 %, at the end of storage period due to the higher air relative humidity inside the cold storage chamber.

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دراسات هندسية على تخزين محصول البصل

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أجريت تلك الدراسة بهدف مقارنة وتقييم ثلاث طرق مختلفة لتخزين البصل (الطريقة التقليدية ، طريقة التخزين في المخازن الرأسية المهواه ، وطريقة التخزين داخل الثلاجات التجارية عند درجة حرارة ٣ْم). وتضمنت أسس التقييم معدل تلف البصل ، معدل الفقد الكلي في الوزن ، نسبة التزريع لكل طريقة من طرق التخزين التي تم دراستها.

أظهرت النتائج المتحصل عليها ما يلي :

١- سجلت الطريقة التقليدية لتخزين البصل أعلى نسبة للفساد والفقد في الوزن الكلي وصلت إلى حوالي ٢٠,٧ ، ٢٩,٨٨% على التوالي في نهاية مدة التخزين.

٢- انخفضت نسبتي الفساد والفقد في الوزن الكلي للبصل المخزن داخل المخازن الرأسية المهواه والمصنعة من الطوب والأسمنت حتي وصلت الى ٧,٨١ ، ١٠,٤٥% على التوالي فى نهاية مدة التخزين بالمقارنة بالمخازن الرأسية المهواه والمصنعة من الصاج المجلفن والتي وصلت الى ١٠,٨١ ، ٢٢,٨٣% على التوالي .

٣- أعطت طريقة التخزين المبرد داخل الأجولة المصنعة من البولي ايثيلين ، والصناديق المصنعة من البلاستيك أقل نسبة للفساد والفقد في الوزن الكلي حيث وصلت نسبة الفساد في نهاية مدة التخزين إلى حوالي ١,٨٢ ، ١,٩٩ % على التوالي بينما وصلت نسبة الفقد فى الوزن الكلى إلى حوالي ٢,٩٣ ، ٣,٤٩% على التوالي .

٤- لم تسجل كلا من طريقتى التخزين التقليدية والتخزين داخل المخازن الرأسية المهواة أى نسبة تزريع بينما أظهرت طريقة التخزين المبرد نسبة تزريع تراوحت بين ٤,٥ إلى ٧,٦% فى نهاية مدة التخزين نتيجة لارتفاع الرطوبة النسبية للهواء عن ٧٥% داخل حجرة التبريد.