*2014 2nd International Conference on Sustainable Environment and Agriculture*
*IPCBEE vol. 76 (2014) © (2014) IACSIT Press, Singapore*
*DOI: 10.7763/IPCBEE. 2014. V76. 6*

# Potential of Unrefrigerated Storage of Onions in the Western Mountain (WM) Region of Libya

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**Abstract.** Potential use of unrefrigerated means for onion storage in the WM region of Libya was investigated. Two onion cultivars; Red Amposta and Yellow Spanish were stored in shade and underground bunker-like traditional house (UGH). Temperature and relative humidity profile for both sites were recorded throughout the storage period. Temperature and relative humidity inside UGH were stable while those measured in the shade exhibited wide variations. UGH conditions reduced losses and maintained good quality, yet did not prevent sprouting, perhaps due to the cultivar itself. Red Amposta onions were kept in both sites for 100 days, mass losses were about 27% and 21% in shade and in UGH, respectively. However, Yellow Spanish onions were better in term of losses and storage duration in both sites, they kept sprout free for 152 days, mass losses were 18% and 16% in shade and in UGH, respectively. Onion storage in larger scales using shed structure and ventilated UGH in the WM region of Libya may deserve further investigations.

**Keywords:** Onions, Storage, Shade, Underground, Cultivars.

## 1. Introduction

Dry onion *Allium cepa* L. is an important crop in the north western region of Libya. It is cultivated several time per year, most important are two crops; first includes short and medium day cultivars, generally harvested after 15 to 17 weeks between May and July, while the second crop includes long day cultivars, these harvested after 12 to 14 weeks between September and October. According to FAO statistics, in 2012 Libya produced more than 207 thousand metric tons of dry onions, covering most local market needs [1]. Nonetheless, shortage in supply for few months is normally experienced, and thus market needs are met by either storing from autumn harvest, transporting from other Libyan regions especially the southern region 'Fezzan', or imports from neighboring countries and overseas. Locally, storage is still very much developing with increasing trends, mostly carried out in mechanically refrigerated facilities scattered in the coastal region. However, storage operation is believed to be quite expensive, energy demanding, and responsible for high losses due to poor practices; such as uncontrolled relative humidity, deprived curing and lack of using anti-sprouting agents. unrefrigerated and field storages are carried out in small scales in the coastal region, but generally are unsuccessful, whereas sprouting and diseases occur due to high temperature and relative humidity in autumn months. In contrast, the WM region is quite cooler, drier, and about 100km away from growing area and market; making it rather suitable for successful unrefrigerated onion storage. No such investigation addressed the potential of storing agricultural products in the WM region has been reported. Unrefrigerated and field storage of onions are wieldy used in several developing countries, such as India and several African countries [2], [3], also high elevation storage is recommended by [4]. As far as storage conditions are concerned, relative humidity and curing are critical [5], good curing results leads to less susceptibility to several postharvest diseases [6], relative humidity is also responsible for sprouting and disease spread [7]. This paper reports investigating the potential of storing two onion varieties in the WM

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region of Libya; first is shaded place under a tree, and second is a traditional underground bunker like house (UGH) known locally as Damos (i.e cave).

# 2. Materials and Methods

## 2.1. Storage Conditions

The WM region consists of mountain chain elevated about 800 meters above sea level, located south of Tripoli and extended west for 235km up to Tunisian border. In summer, average daytime temperatures remain near 30 ℃, while nighttime temperatures maintain close to 20 ℃, whereas winter daytime temperature are less than 15 ℃ and nighttime temperatures fall lower than 10 ℃, whereas relative humidities are about 50% and 70% in summer and winter, respectively. WM region is also distinguished for its traditional dwellings; known as underground bunker- like houses (UGH), locally called Gar or Damos. In Arabic "Gar" means cave and "Damos" means dark and damp. In most of the WM region, especially its plateaus, top soil is quite shallow laying on about 1m limestone layer under which deep and soft lime (Calcium carbonate) profile and water table is very low. In most WM towns and villages, UGHs were inhabited until late seventies when locals abandoned them and built modern houses, mainly because of economical growth and government encouraging policies. UGHs were made in heights by digging out a trench to proper depth, its front was used as stairs, then widen, and rooms were opened up by digging out the soft lime in three direction under the solid limestone layer. Above the ground level a structure was built at proper height and roof was installed covering stairs, also windows were installed for ventilation and light. Rooms were plastered with gypsum or sand-lime mix, and coated with slaked lime (Calcium Hydroxide) for the purposes of sanitation and enhancing lightening. Although such dwellings are not currently used, some locals still take care of them, mainly as a component of their heritage. Generally, houses are much cooler in summer and warmer in winter, they were traditionally used not only as residence but also for storing food such as olive oil, Figs, dates and cereals.

## 2.2. Plant Materials

Two cultivars were used in the study; red onion bulbs cultivar Red Amposta and yellow bulbs cultivar Yellow Spanish. Fully mature onions were collected from the wholesale market located in southwest of the capital Tripoli in July15 $^{th}$, 2013 and transferred to the town of Zintan at 146km south west of Tripoli in the same day. Samples were weighed (about 1250g each) using an accurate digital scale with two decimal resolution, marked and filled in meshed bags. Four replicates were used for each variety. Firstly, curing process was carried out for two weeks, samples for the two treatments were placed in the southern side under an olive tree, subjected to open air and direct sun in the morning and late afternoon for two weeks. Afterwards, samples were placed in UGH and in the shade under a tree facing north. Periodical inspection for mass losses using was performed, also disease cases and sprouting were monitored, diseased bulbs were considered part of mass loss, while sprouting was considered a criteria for discarding the experiment. This mainly due to the fact that sprouting is physiological, once occur in one set others would normally follow.

## 2.3. Temperature and Relative Humidity Data Collection

Temperature and relative humidity were measured using wireless data logger (Model USB-502, temperature and relative humidity logger (Measurement Computing Corporation MCC, Norton, MA, 02766. USA). Logger was configured to collect data at 30 minute intervals, placed in the location of the treatment, relative humidity and temperature were saved in comma separated values (csv) file format. Periodical downloading was carried out, temperature and relative humidity data were imported into Microsoft Excel and used for further analysis.

# 3. Results and Discussions

## 3.1. Temperature and Relative Humidity

Temperature and relative humidity profiles for shade and underground locations are given in their monthly means and standard deviations in Table 1 and Table 2. Mean day and night temperature and relative humidity were separated between 6:00AM and 6:00PM. There is about 10˚C difference between day and

nighttime temperatures for the shade treatment, while undergrounded temperature was stable during day and night with small difference at 0.5˚C. Thus, underground mean monthly temperatures and relative humidity were taken for 24h period. Considering the field storage conditions for onions reported by [5], and taking into consideration recorded temperatures herein, shade storage has high temperature conditions during warm months (August, September and October) combined with low relative humidity at daytime (<40%), while at nighttime temperature drops by about 10˚C, whereas relative humidity increases near 60% with high deviations. During cold months (November and December) however, temperature drops to (<15) daytime and (<10) nighttime, but relative humidity increased (>70%). This indicates that onions may subject to high moisture loss at daytime, but increased relative humidity above recommended limit may promote disease infestation and sprouting, especially with presence of light. On the other hand UGH conditions exerted stable temperature (25˚C) and relatively stable relative humidity (near 50%) with minor deviation during warm months, while in cold months temperature continued reduction and relative humidity remained low and stable, combined with low relative humidity. In addition, UGH has the advantage of darkness, and therefore, sprouting can be delayed. Such conditions are indeed well supported in literature, experimental investigations suggested temperatures below 40˚C and relative humidity less than 75% had little effect on mass loss of onions [8]. Also, early published literature addressed underground storage of fruits and vegetables in cold regions [9], [10].

Table 1: Mean monthly temperature during storage period

| ***Shade daytime temperature (℃)*** | | | | | |
|---|---|---|---|---|---|
| **Month** | **August** | **September** | **October** | **November** | **December** |
| **Mean** | 31.75 | 31.30 | 27.07 | 14.94 | 12.03 |
| **STD** | 2.90 | 3.39 | 4.22 | 3.86 | 1.61 |
| ***Shade nighttime temperature (℃)*** | | | | | |
| **Mean** | 21.72 | 21.16 | 18.01 | 8.39 | 6.51 |
| **STD** | 2.48 | 2.13 | 3.86 | 3.15 | 2.56 |
| ***UGH day temperature (℃)*** | | | | | |
| **Mean** | 25.74 | 25.82 | 24.41 | 20.23 | 16.95 |
| **STD** | 0.29 | 0.48 | 0.87 | 1.70 | 0.62 |

Table 2: Mean monthly relative humidity during storage period

| ***Shade daytime relative humidity (%)*** | | | | | |
|---|---|---|---|---|---|
| **Month** | **August** | **September** | **October** | **November** | **December** |
| **Mean** | 33.42 | 35.61 | 44.15 | 72.24 | 84.09 |
| **STD** | 10.69 | 13.47 | 22.18 | 20.09 | 10.15 |
| ***Shade nighttime relative humidity (%)*** | | | | | |
| **Mean** | 59.40 | 62.14 | 43.06 | 56.73 | 73.84 |
| **STD** | 17.34 | 18.76 | 14.09 | 20.93 | 15.40 |
| ***UGH day relative humidity (%)*** | | | | | |
| **Mean** | 47.77 | 49.41 | 40.64 | 40.85 | 52.92 |
| **STD** | 4.80 | 6.97 | 6.76 | 7.08 | 3.63 |

## 3.2. Onion Cultivars Response to Storage Conditions

Accumulative mass loss during storage period for both cultivars is presented in Table 3. and Fig. 1. Red Amposta cultivar showed the same mass loss for more than two months, after that outside treatment exhibited high loss. This mainly due to sprouting in both treatments, yet outside stored onions started sprouting first, perhaps related to the cultivar itself, however, sunlight and high relative humidity at nighttime indeed have a sprout promoting effect. Although, even underground stored onions started sprouting at about the same time, by November 10$^{th}$ bulbs were completely sprouted, at storage duration of 100 days.

No investigation on local storage of the cultivar has been found, nonetheless, sprouting as related to cultivar, storage and field conditions and well addressed by [11]-[14]. Personal contacts with local farmers revealed to Red Amposta is a cultivar that gives multiple sprouts, it is mostly used for producing green

onions in the coastal region in September and October. Early sprouting occurs in the coastal region due to high relative humidity, whereas in this study, this cultivar was stored at drier conditions and therefore sprouting delayed. Generally, the cultivar can be stored under the tested conditions for more than two months at accumulative losses about 20%. Losses were mainly due to respiration and moisture losses as no disease occurrence was noticed, possibly due to proper curing and low relative humidity.

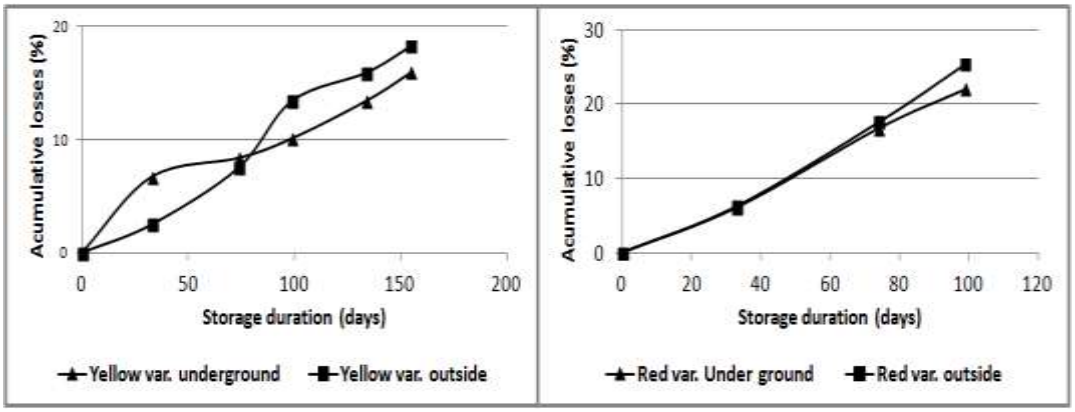


Fig. 1: Accumulated mass loss for the two cultivars stored in the shade and in UGH

Table 3: Mean mass loss for the two cultivars stored in shade and UGH

| Treatment | Shade | Storage duration (days) | UGH | Storage duration (days) |
|---|---|---|---|---|
| Red Amposta | | | | |
| Mean | 27.37 | 100 | 21.99 | 100 |
| STD | 6.5 | | 5.7 | |
| Yellow Spanish | | | | |
| Mean | 18.29 | 152 | 15.98 | 152 |
| STD | 5.40 | | 9.81 | |

Yellow Spanish cultivar exhibited different response to storage conditions, both treatment extended for 152 days as the first sprouting case was noticed by the end of December in the shade treatment. Underground treatment exhibited higher variations, due to occurrence of few disease cases after one month in storage. It is mainly due lack of ventilation inside UGH and the fact that most disease cases came from the field. On the other hand, shade stored onions exhibited mass losses higher than those stored in UGH, as shown in Table 3, nonetheless, no disease cases were observed. This perhaps due to exposure to high temperature and low relative humidity at daytime, in addition to wind effect that increases mass losses and prevented disease occurrence. Nevertheless, other quality related considerations such as color difference were observed, onions stored in UGH retained better color than those stored in the shade.

## 4. Conclusions

The potential for storing two onion cultivars under unrefrigerated conditions in the Western Mountain region of Libya was demonstrated. Two storage conditions were tested, a traditional underground bunker-like house (UGH) and shaded place. UGH showed good storage potential, its temperature and relative humidity were stable during storage period, cooler than outside during warm months, and less humid during cold months; giving relatively suitable condition for short term storage of onions. Red Amposta cultivar was found susceptible to sprouting, its storage duration was about 100 days, with overall losses determined at 27% and 21% for shade and UGH conditions, respectively. Yellow Spanish on the other hand was kept for 150 days, accumulative losses were 21% and 16% mass in shade and UGH, respectively. Further investigations of more onion cultivars and the potential use of shed structure and testing its performance in the WM region worth further investigation.

## 5. Acknowledgements

The author acknowledges the Libyan National Agency for Scientific Research for providing funding for sensors used in this investigation.

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