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Effect of different irrigation levels on quality and storability of kohlrabi (*Brassica oleracea* var. gongylodes,L.)

Ashmawi,E.A[1] and Abd Elwahed, A. H. M[1]

Department of Horticulture, Faculty of Agriculture, AL-Azhar University, Cairo.

Abstract

This investigation was conducted at the Faculty of Agriculture, AL-Azhar University, Nasr City, Cairo, Egypt during the two winter seasons of 2012-2013 and 2013-2014 to study the effect of different irrigation levels (100,75and 50% from crop evapotranspiration) on quality of the kohlrabi tuber of the hybrid Grand Duke and its behavior during cold storage at 5c° and 90-95% RH or under the conditions of room temperature at ± 2 c° and 55-58%RH. The results indicated that the highest significant tuber fresh weight, size, diameter and total yield resulted from the irrigation with the level of 100% from Etc and the greatest significant solidness was obtained from the level 50%. From the chemical point of view, the tuber contents of total soluble solids, ascorbic acid and total acidity increased with the decrease in the irrigation levels up to 50% as compared with the level 100%. On the other hand, storage of the kohlrabi tubers showed that the minimum loss in weight and the unmarketable percentage were found in the irrigation level of 100% from Etc during the final storage periods of cold and room temperature storage at the same time irrigation of 50% hold the higher concentrations of T.S.S, ascorbic acid and total acidity in the stored tubers during storage periods in the two sort of storage with the prevalence of cold storage. Therefore, cold storage was the most obvious in retaining tuber quality much better than those stored under room temperature.

Key words: kohlrabi, irrigation levels and storability.

Introduction

Kohlrabi (*Brassica oleracea var. gongylodes*,L.) belongs to the family Cruciferae and considers as cool season crop .The edible portion of this plant is the tuber which represent the thickened stem **(Salunkhe and Kadam,1998).** This part of the plant can be used raw in salad or stew **(Escalona*et al.*, 2003)**. Although kohlrabi is grown in very limited scattered areas in Egypt but some care to this crop perhaps open many pathways for local consumption and exportation .The importance of this crop is due to its appreciated taste and nutritive value beside its numerous medicinal contents. Therefore, it was characterized with vitamins such as vitamin C and A, minerals including potassium, calcium, magnesium and iron and antioxidant substances which may delay or prevent the formation of cancer **(Gaweda andZofia, 2011).** In the field of economy, kohlrabi have high economic rank due to the short period of growth and lovely characteristics which push this crop to be one of the important vegetables in the foreign markets **(Uddin *et al.*, 2009).**

High quality of this vegetable crop depends largely on the preharvest culture practices specially irrigation. Indeed, irrigation has a great impact on the growth, yield and quality of this vegetable depending on the amount of water applied **(Kere*et al.*, 2003).**Therefore, it was shown that the fluctuations or the non-accurate levels of water irrigations may lead the tuber to become tough and woody **(Salunkhe and Kadam, 1998).**Hence, as the desired attribute for both growers and consumers is the good quality of the tuber, itis easy to say that this goal can be reached by some cultural practices mainly the irrigation levels which affect this quality and its storability. Thus, this investigation was established to put spot light on the effect of water irrigation levels on the tuber quality and its behaviour during storability.

Materials and Methods

This trail was done at the Faculty of Agriculture, Al-Azhar University, Nasr city, Cairo, Egypt during the two winter seasons of 2012-2013 and 2013-2014. Seeds of the hybrid Grand Duke of kohlrabi were sown in seedbed on September 26th and 28th in the first and second seasons, respectively. Seedling were transplanted after 40 days from sowing where plant spacing took place at 60cm. between rows and 30 cm. between plants .Drip irrigation was applied at three irrigation levels including 100%,75%and 50% from crop evapotranspiration (Etc) which was determined by using Penman Montieth equation **(Allen et al., 1998**). The kohlrabi tubers were harvested in each treatment at 60 days age from transplanting **(El-sayed, 2011**) where both leaves and roots were removed. Nine samples of the harvested tubers were taken randomly to study the effect of irrigation levels on the physical and chemical characteristics. The physical characteristics included fresh weight, size, diameter and firmness while the chemical characteristics comprised total soluble solids, ascorbic acid and total acidity beside the determination of the total yield in weight. With respect to storability, samples from each irrigation treatment were weighted and placed in cardboard carton boxes (30x20x20cm) then stored in refrigerator at 5c° and 90-95% RH as well as another samples were stored under room temperature conditions at ± 22 c° and 55-58%RH. Three samples of each treatment were taken every 7 days during storage to examine the changes occurred in the following physical and chemical characteristics. The physical ones comprehended the loss in weight, firmness and unmarketable tubers while the chemical ones confined total soluble solids, ascorbic acid and total acidity.

Determination procedures:

A- Physical characteristics. 1) Fresh weight was determined in g by a balance. 2) Size was estimated in cm³ by measuring the water volume displaced by immersing the tubers in a graduated jar filled with water. 3) Diameter was estimated in cm by using Bioclase. 4) Firmness was determined in (kg/cm²) by using the pressure tester (digital force-Gouge model FGV-0.5 A to FGV-100 A. Shimpo Instruments). 5) Loss in weight (%)was calculated by the equation: loss in weight at the sampling date / the initial weight of the tubers X 100 and 6) Unmarketable tubers (%) was counted by the equation : Number of unmarketable tubers during storage periods / Initial numbers of tubers X 100.

B- Chemical characteristics.1) Total soluble solids (%)were determined by Abb refractometer according to **A.O.A.C (1980).** 2) Ascorbic acid(mg./100g.fresh weight) was determined according to **A.O.A.C (1980)** and 3) Total acidity (mg./100g.fresh weight) was determined by the method published in **A.O.A.C (1990)**.

C- Total yield of tubers in kg per plot was weighted at harvesting after 60 days from transplanting.

Results

A- The effect of different irrigation levels on the tubers characteristics:-

a- Physical characteristics:-

The obtained results about the effect of the various irrigation levels on the tuber physical characteristic at harvest (Fig.1) indicated that the highest significant values 0f tuber fresh weight, size and diameter resulted from using the irrigation level of 100% from Etc meanwhile the greater significant solidness resulted from the level of 50%. On the other hand, the lowest values of fresh weight, size and diameter exerted from the level of 50% from Etc whereas the smallest significant firmness was recorded from both the levels of 100% and 75%.

b- Chemical characteristics:-

In the view of the chemical characteristics (Fig.3), the highest significant figures of tuber total soluble solids (T.S.S), ascorbic acid and total acidity were obtained from the irrigation with the level of 50% from Etc. Contrarily, the minimum figures of T.S.S, ascorbic acid and total acidity content existed from the level of 100% from Etc.

B- Yield:-

The picture caught up from the harvested tuber total yield (in weight) was shown in (Fig 2) which reflect that the heaviest one came from using the irrigation level of 100% from Etc and the lightest resulted from the level of 50%.

C- Storability:-

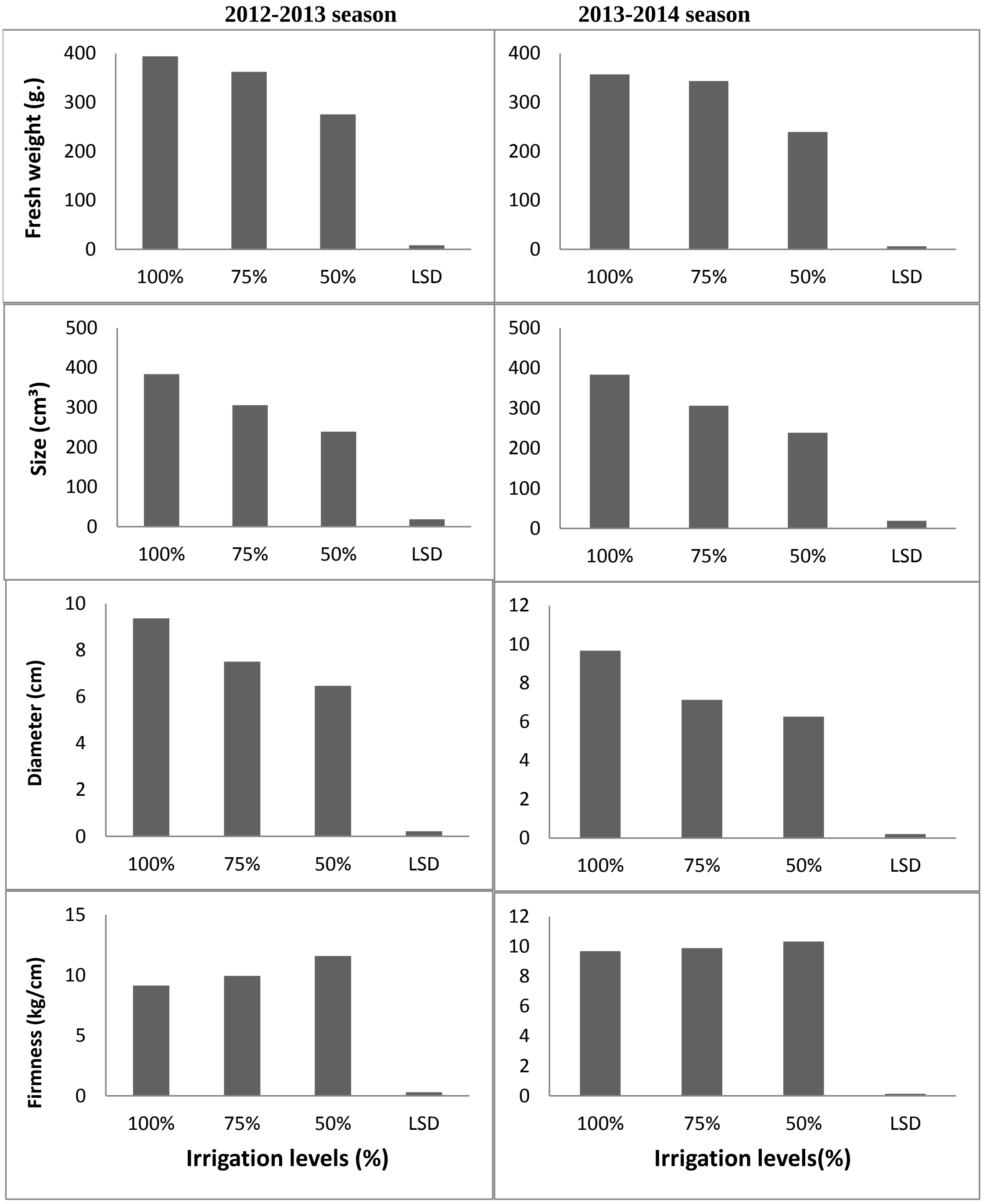
The effect of the different irrigation levels on the physical and chemical changes occurred in the stored tubers during cold and room temperature storage were summarized in the following results.

a- Physical characteristics:-

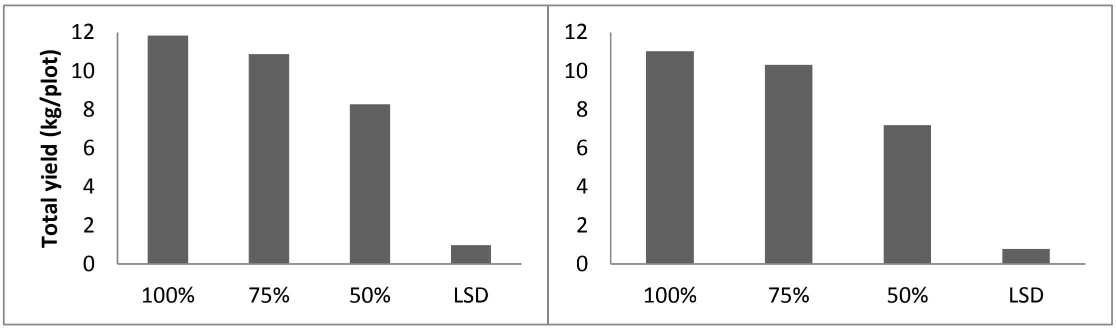
The effect of irrigation levels on the tubers loss in weight percentage during cold and room temperature storage (Fig.4) indicate that a continuous loss in weight occurred in all the stored tubers with the extend of storage periods. Hence, the loss in weight was significantly less in the tubers developed under the irrigation level of 100% from Etc during the final storage periods as compared with the other tubers produced from the other levels.Nevertheless, the cold storage reduced efficiently the weight loss percentage during the various storage periods than the other type of storage under the room temperature conditions. So the stored tubers under cold storage kept longer than the room temperature storage.Concerning the characteristic of firmness, the effect of the various irrigation levels on this status during cold and room temperature storage (Fig.4)reflect that the tuber firmness decreased progressively and gradually with the elongation of the two types of storage in plants which irrigated with the different irrigation levels.

However, applying the irrigation level of 100% from Etc put forth to the greatest tuber solidness during the last storage periods in comparison with the other levels. Furthermore, those tubers stored under cold storage kept the higher values of solid texture than those stored under room temperature storage. From another point of view, the response of the unmarketable percentage to different irrigation levels during the periods of the two kinds of storage (Fig.5) showed that the deterioration in the tubers increased with the reduction in the irrigation level and also with the prolongation of both types of storage. Therefore, irrigation of the plants with 100% from Etc proved to be the most favorable in minimizing the unmarketable percentage in the stored tubers under the condition of both types of storage.

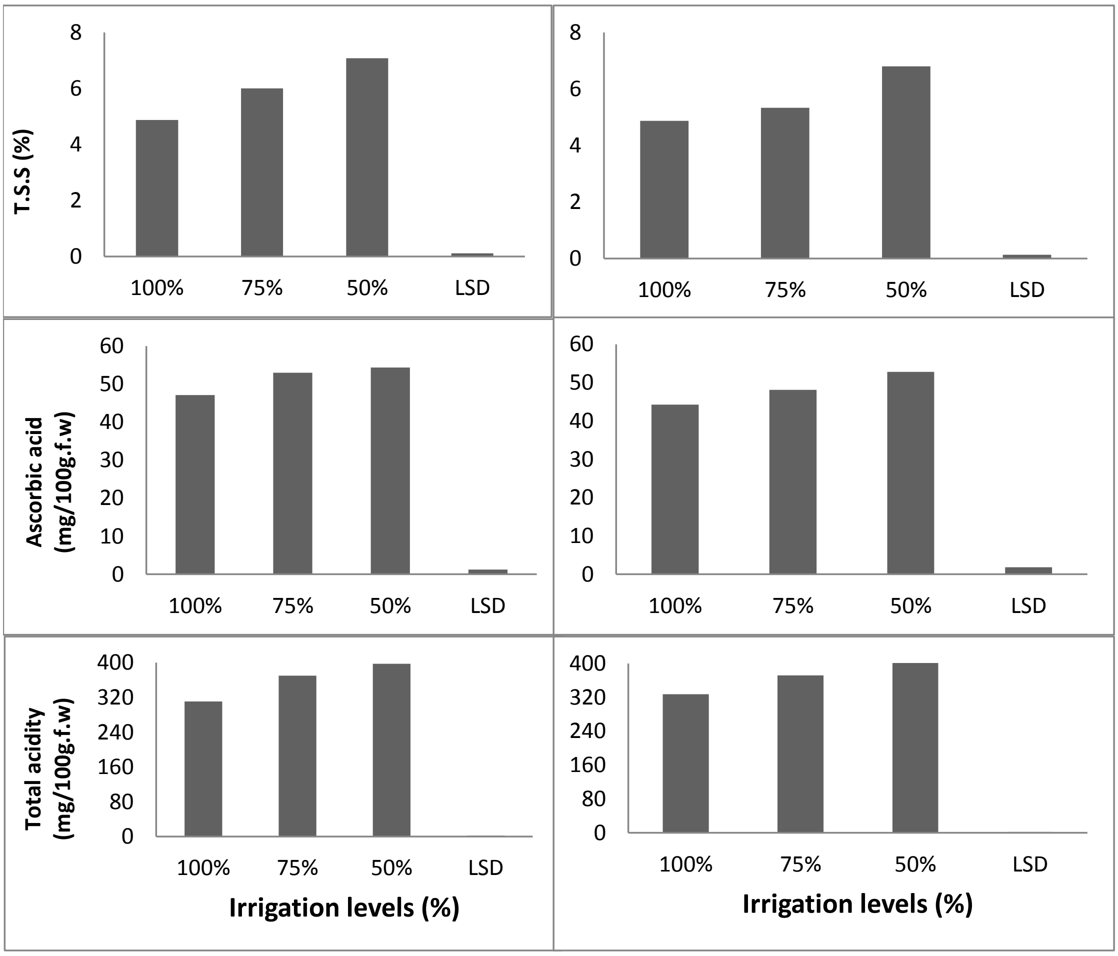
Fig(1): Effect of different irrigation water levels on the physical characteristics of kohlrabi tuber during 2012-2013 and 2013-2014 seasons



Fig(2): Effect of different irrigation water levels on total yield in weight per plot of kohlrabi tuber during 2012-2013 and 2013-2014 seasons



Fig(3): Effect of different irrigation water levels on the chemical characteristics of kohlrabi tuber during 2012-2013 and 2013-2014 seasons



On the other hand,cold storage was much better in lessening the unmarketable tubers than the room temperature storage.

b- Chemical characteristics :-

The content of total soluble solids in the tubers as affected by the various irrigation levels during the two types of storage (Fig.6) exhibited a general direction of increase in these contents with the decrease in the irrigation levels and with the proceed in the cold and room temperature storage periods. This picture indicate clearly that irrigated tubers with the level of 50% kept the highest concentration of T.S.S during the various cold and room temperature storage periods .On the other side, during cold storage a gradual increase happened in T.S.S content but in lower speed than that occurred during storage in room temperature. Regarding the content of ascorbic acid (Fig.7), the effect of the different irrigation levels on the tubers content during storage under the conditions of cold and room temperature storage gave rise to a general trend of increase in this vitamin with the reduction in the irrigation levels during the various periods of both types of storage. In other words, the irrigation level of 50% from Etc exerted the highest content during the storage periods. Evidences from cold and room temperature storage indicate that this content was reduced with the elapse of storage periods but cold storage was the more pronounced in retarding the degradation of ascorbic acid than storage under the condition of room temperature during the various storage periods. Further look to the effect of the various irrigation levels on the tuber content of the total acidity stored under the conditions of the two kinds of storage (Fig.7)indicated that this characteristic increased with the decrease of the irrigation levels and the opposite was true with extend of the periods either in cold or room temperature storage. However, stored tubers which irrigated with 50% from Etc hold more total acidity content than those irrigated with the level of 100%. On the other hand, during cold storage periods a gradual drop occurred in total acidity content but in lower speed than that happened in room temperature storage.

Discussion

On discussing the effect of different irrigation levels on the tuber changes of the physical and chemical characteristics at harvest, our results indicated that the highest significant tuber fresh weight, size, diameter and total yield resulted from the irrigation with the level of 100% from Etc and the greatest significant solidness was obtained from the level 50%. On the contrary, the least physical parameters were obtained from the level of 50% but the smallest firmness recorded from the level of 100%. It is quite possible to say that the increase in the physical parameters of kohlrabi tubers which gave rise to best results from using the irrigation level of 100% may due to the effect of water efficiency on the quantitative and qualitative changes in certain metabolic processes in the plant cell which led to the enhancement of cell division and enlargement and this in turn might contribute much for the increase in the tuber quality **(Hammad, 1991).** In more detail , the efficient water supply during cell enlargement greatly increase the edible part of kohlrabi plant , turgid of guard cell, continuity of open stomates, , high rate of photosynthesis, normal rate of respiration and excess of dry matter accumulation which reflect the best yield and good tuber quality **(Kramer,1977)**. Regarding the increase in tuber firmness as a results of using the level of 50%, this result may be attributed to the diminution of the fruit size **(Hegde and Srinivas,1990)** resulting from the reduction of fruit water content **(Kramer,1977).** From the chemical point of view , the tuber contents of total soluble solids, ascorbic acid and total acidity increased with the decrease in the irrigation levels up to 50%.Contaraily, the least figures in T.S.S , ascorbic acid and total acidity were obtained from using the level of 100%. Therefore, the recognized result on T.S.S, ascorbic acid and total acidity which correlated with the decrease in irrigation levels may be due to the fact that the shortage of irrigation water in the soil led to changes in the physiological responses such as the decrease in photosynthesis due to the close of stomata. Hence, turgor pressure decrease is thought to be one of the controlling factors in these changes **(Osmond, 1980)**. For this reason, osmotic adjustment isregarded to be important under the shortage of water conditions **(Agbemafle*et al.,* 2014)**.

Fig (4):Effect of different irrigation water levels on loss in weight (%) and firmness (Kg/cm²) in kohlrabi tuber stored under cold storage (5c⁰ and 90-95 % RH) and room temperature (±22c⁰ and 55-58% RH)during 2012-2013 and 2014-2015 seasons.

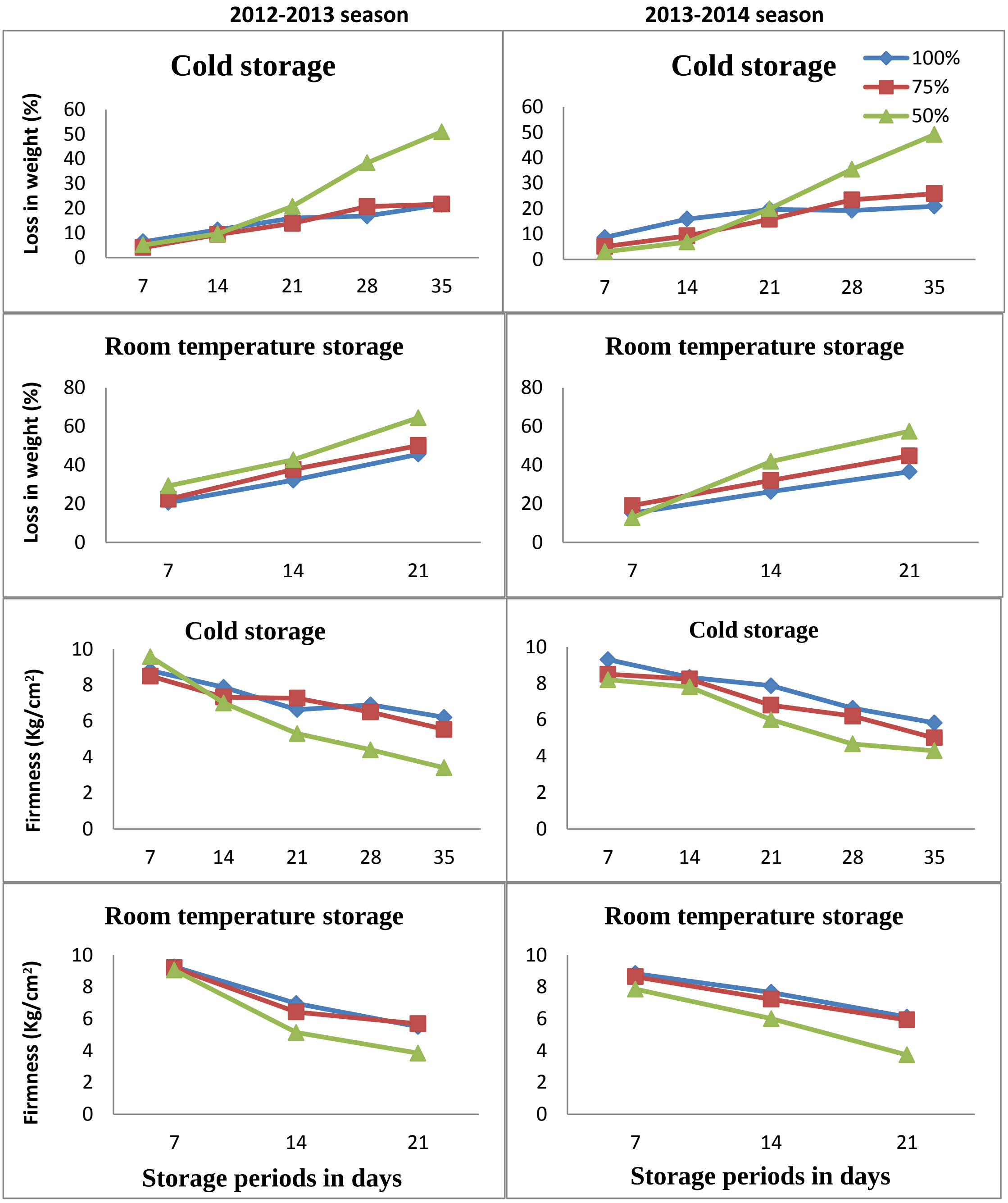


Fig (5):Effect of different irrigation water levels on unmarketable tubers kohlrabi (%) stored under cold storage (5c^0 and 90-95 % RH) and room temperature (±22c^0 and 55-58% RH) during 2012-2013 and 2014-2015 seasons.

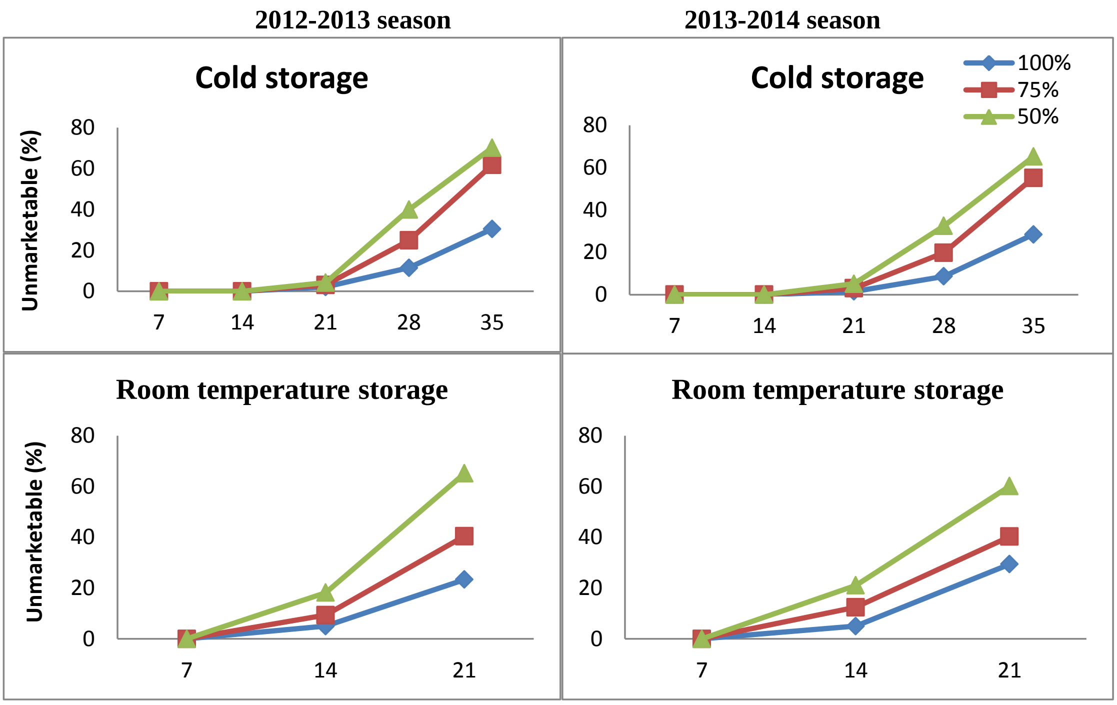


Fig (6):Effect of different irrigation water levels on T.S.S (%) tuber kohlrabi stored under cold storage (5c^0 and 90-95 % RH) and room temperature (±22c^0 and 55-58% RH) during 2012-2013 and 2014-2015 seasons.

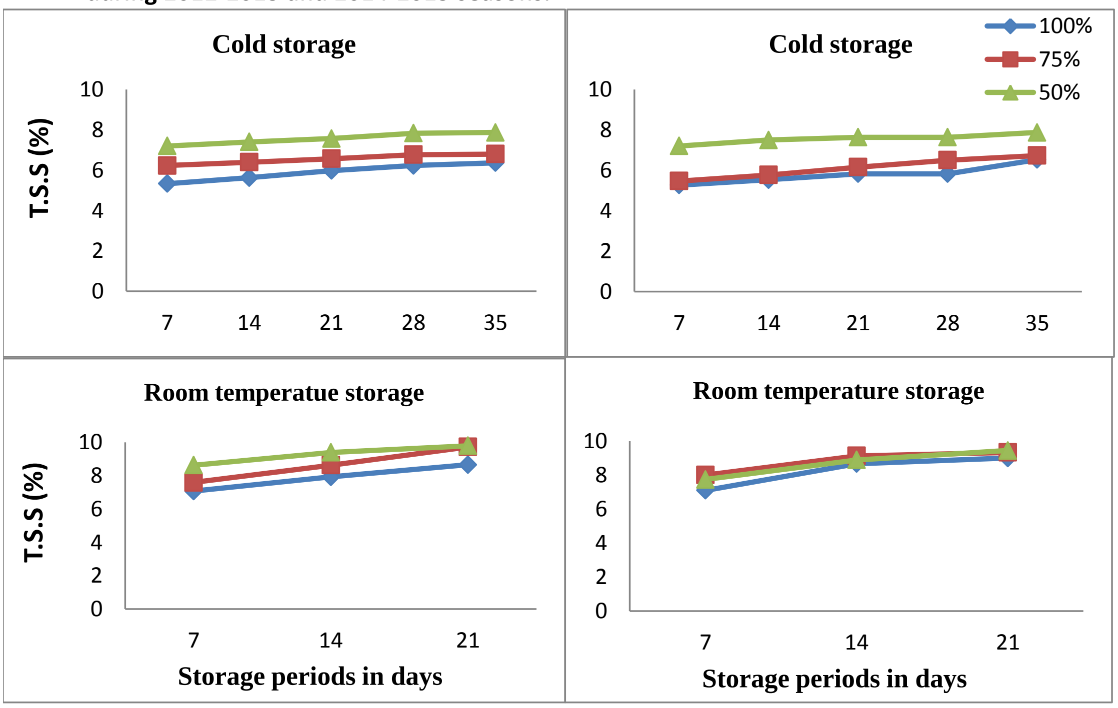
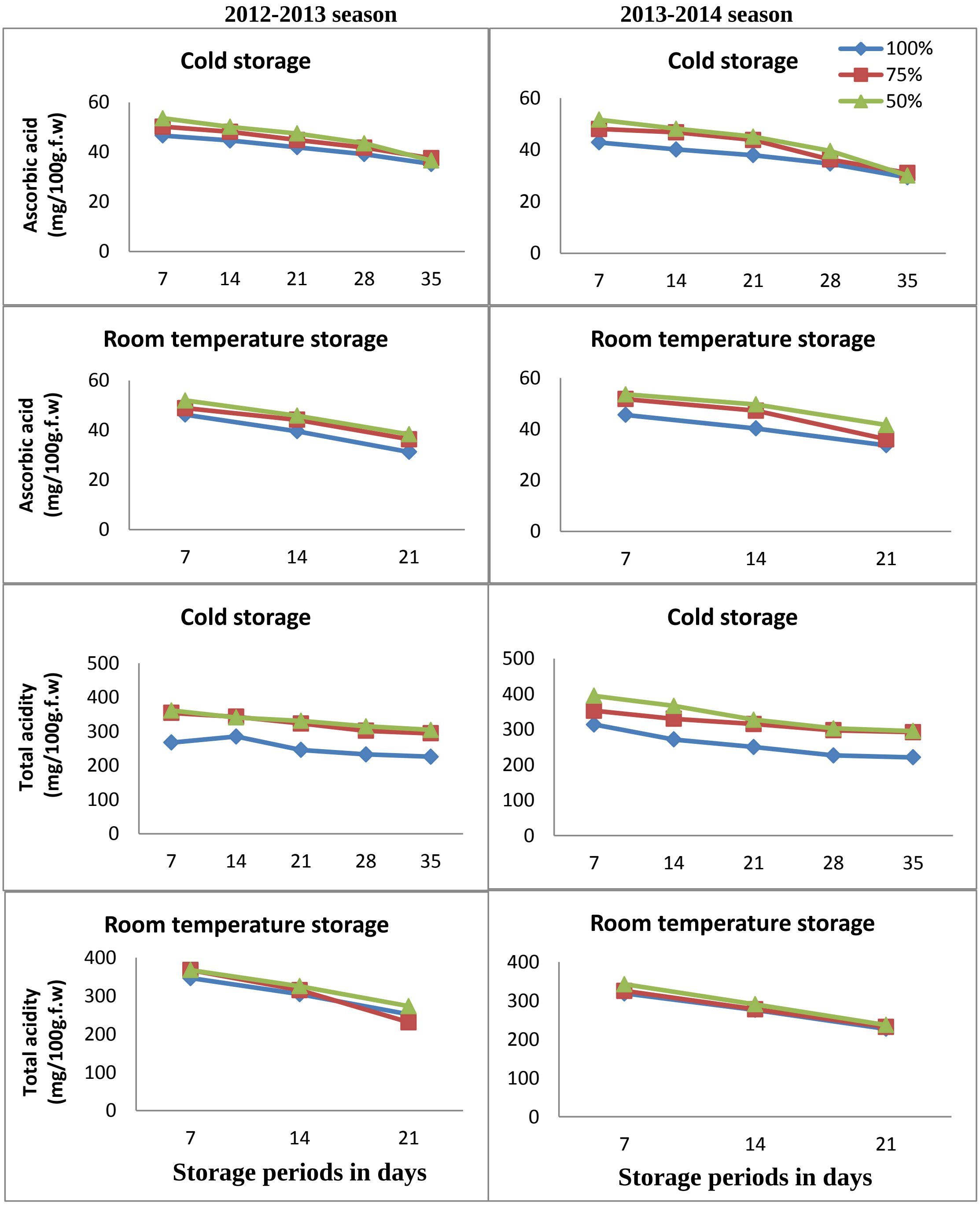


Fig (7):Effect of different irrigation water levels on ascorbic acid (mg/100g.f.w) and total acidity (mg/100g.f.w)tubers kohlrab stored under cold storage (5c⁰ and 90-95 % RH) and room temperature (±22c⁰ and 55-58% RH) during 2012-2013 and 2014-2015 seasons.



The obvious advantage of osmotic adjustment is the enhancement of the capacity of plant to maintain positive turgor, particularly in root **(Oosterhuis, 1987)**.Therefore, the plant push to regulate certain metabolic activity under the shortage of water by degradation of polysaccharides to simple sugars thereby arise in T.S.S beside the increase in organic acids transformation rate and amount that act as osmotica and play an important role in osmotic adjustment in plant **(Agbemafle*et al.*, 2014)**.

On discussing the effect of various irrigation levels on the stored tubers under cold and room temperature storage, the view of our results reflect that the favorite results came from using the irrigation level of 100% during the final storage periods of cold and room temperature storage which exhibit the minimum loss in weight and the unmarketable percentage beside the greatest solidness with the prevalence of cold storage. Hence, the general picture reflect a continuous loss in weight with the extend of the storage periods due to the loss of water by transpiration**(Hulme, 1970)**. On the other hand, the reduction in firmness of tubers during storage resulted from the loss of water as well as enzymatic changes which induce the loss of cell texture by converting, for example, the solid hemicellulose and protopectin to more soluble complexes **(Agbemafle*et al.*, 2014)**.The appearance of the unmarketable tubers during the various periods of storage was expected. Therefore, this feature may related to the continuous chemical and biochemical changes happened in tubers during storage which led to moisture condensation and transformation of complex compounds to simple forms of more liability to these infections such as the changes from the solid protpection to the soluble pectin form**(Said,1990)**. In an attempt to explain the preceding cited chemical changes during storage , it is of particular interest to say that the content of T.S.S increased either from the decline in the irrigation levels or with the extend of cold and room temperature storage periods . This depended largely on the balance among mainly the rate of respiration, the conversion of insoluble solids to soluble ones and the speed of moisture loss **(Awad, 1984)**.Regarding the content of ascorbic acid, it was shown that this vitamin decreased with the increase in the irrigation levels and with the elongation of the storage periods during both types of storage. In this concern,this drop in ascorbic acidcontent may result from the important role played by this vitamin as a catalyst in respiration beside the vital part in the biological and biochemical oxidation reductions during the various processes occurring in stored fruits **(Hulme, 1970)**.To show the consideration of the changes on total acidity during storage, it is clear that a drop in this content happened with the increase in the irrigation levels or with the elongation of the storage periods . Hence, this reduction exerted because acids are the substrates of respiration **(Agbemafle*et al.*, 2014)**.

The view show that cold storage was the most favorable than room temperature in minimizing both loss in weight and unmarketable percentage beside kept comparatively more solidness and amounts of T.S.S, ascorbic acid and total acidity contents which in turn reflect on extending the life of stored tubers. This may be due to its effect on reducing respiration rate, evaporation from plant tissues **(Kader, 2011)**, reducing metabolic reaction, controllingenzymatic activity **(Pittia*et al.*, 1999)** and slows ascorbic degradation through prevention of oxidation **(Lee and Kader, 2000)**.

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تأثير مستويات الري المختلفة علي الجودة و القدرة التخزينية للكرنب ابو ركبة

عشماوي السيد عشماوي[1] و أحمد حمدي محمد عبد الواحد[1]

1- قسم البساتين- كلية الزراعة – جامعة الازهر- القاهرة

الملخص العربي

أجريت هذة الدراسة في مزرعة كلية الزراعة جامعة الأزهر بمدينة نصر بالقاهرة خلال الموسم الشتوي لعامي 2012-2013 و 2013- 2014 لدراسة تأثير مستويات ماء الري المختلفة(100و75و50%من البخر نتح المحصولي) علي كلا من جودة درنات كرنب ابو ركبة هجين جراند دوك وسلوك الدرنات أثناء التخزين المبرد علي درجة حرارة 5 درجة مئوية و رطوبة نسبية 90-95 % والتخزين علي درجة حرارة الغرفة ±22 درجة مئوية و رطوبة نسبية 55-58% . تشير النتائج ان ثقل وزن طازج وأضخم حجم وأكبر قطرو أعلي وزن كلي للمحصول معنويا نتج من استخدام مستوي الري 100% وأكثرها صلابة من مستوي الري 50% .علي الجانب الاخر وضح أن أعلي محتوي معنوي من المواد الصلبة الذائبة الكلية و حمض الاسكوربيك و الحموضة الكلية نتج من مستوي الري 50% مقارنة بمستوي الري 100% . بخصوص تخزين الدرنات وجد أن أقل فقد في الوزن والدرنات الغير الصالحة للتسويق نتج من مستوي الري 100% اثناء فترات التخزين الاخيرة لكل من التخزين المبرد و درجة حرارة الغرفة و في نفس الوقت، أحتفظ الري بمستوي 50% علي أعلي التركيزات من المواد الصلبة الذائبة الكلية و حمض الاسكوربيك و الحموضة الكلية في الدرنات المخزنة اثناء فترات التخزين لكلا من نوعي التخزين مع تفوق التخزين المبرد .علي ذلك كان التخزين المبرد الافضل من التخزين في درجة حرارة الغرفة في المحافظة علي جودة درنات الكرنب ابو ركبة.