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INFLUENCE OF PLANTING AND HARVEST DATES ON THE PRODUCTIVITY AND STORAGE ABILITY OF TWO SWEET POTATO CULTIVARS TO FACE THE CLIMATE CHANGES.

2- STORABILITY AND STORAGE ROOT QUALITY

Shereen S. F. EL-Sayed[1#] and Nermeen A. E .Abd El Wadod[2]

1Vegetable Crops Department, Fac. Agric., Cairo University, Giza, Egypt, 12613
2 Potato and Vegetatively Propagated Vegetables Dep., Hort. Res. Inst., A. R. C., Egypt
#Corresponding author email: Sherine.fathy@agr.cu.edu.eg Phone:01016440182

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ABSTRACT

Sweet potato (*Ipomoea batatas* (L.) Lam.), one of the most substantial tuber crops in tropical and subtropical countries, was selected to study the influence of climate alteration, in the form of higher temperatures, on crop storage. Two sweet potato cultivars (Menofia and Mabrouka) were cultivated in two different dates [23 April (the current recommended planting date) and 29 July (climate change planting date scenario)] and harvested after 169 day from planting the stem cuttings. Climate change, by changing planting date to hot months negatively affects root weight during storage, dry matter percentage and carotenoids, but showed a higher iron content and score of general appearance of storage roots than those produced at the recommended planting date. At the end of storage, 'Munofia' showed lower values of carbohydrates, Fe, Ca, K, P in the first planting date, and the lower value of zinc in the second planting date, while 'Mabruka' showed lower values of general appearance in the first planting date and zinc in the second planting date.

Phosphorus and potassium, calcium, iron, carotenoids, carbohydrate contents, the score of general appearance of storage roots and zinc significantly declined, while Hue angle continuously increased with prolongation of the storage period.

Keywords: Cultivars, Planting Dates, Storage Roots, Storage, Sweet Potato, Climate change

INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) is one of the most substantial tropical tuber crops of Convolvulaceae family. It is grown in different ecological zones due to its adaptability to unstable climatic conditions (**Dash et al., 2020).** It is considered the seventh important food crop. It comes after wheat, rice, corn, potatoes, barley and cassava in the world **(FAO, 2016)**. It is mainly consumed by low-income people because it is one of the cheapest rich sources in carbohydrates, being mainly starch, and it contains a considerable level of soluble sugars, provitamin A (β-carotene), vitamins (B1, B3, E, and C), minerals (manganese, potassium, copper, iron and zinc), and other nutrients, **(Maddipatla et al., 2017; Neela and Fanta 2019).** With an average yield of about 12.1 tons per hectare, sweet potatoes are cultivated on about 7.4 million hectares around the world **(FAOSTAT, 2022).** In Egypt sweet potato crop was grown on an area of over 13154 ha in 2020, produced about 450985 tons **(FAOSTAT, 2022).** Throughout the growing season, air temperatures between 24 and 35 °C are ideal for sweet potato growth. **(Romero & Baigorria, 2008)**. At mid- and late-season high temperatures (35°/27° and 40°/32° C) encouraged more shoot but less root growth, which had an impact on the final storage root production. **(Gajanayake et al., 2015).**

The increase in temperature and the impacts of greenhouse gases are among the most important issues associated with climate change. Studies have shown that high temperatures not only adversely affect the production and quality of fresh fruit and vegetable crops under field conditions **(Moretti et al., 2010)**, but also they influence the vegetable quality during storage **(Mohammed et al., 1996).** Under field conditions, high temperatures can cause morphologic, anatomical, physiological, and ultimately, biochemical changes in plant tissues and, as a consequence, can affect plant growth and reproduction **(Thole et al., 2021).** The field changes resulted from high temperatures are attributed to increased photosynthesis and respiration that affect membrane stability as well as levels of plant hormones **(Bewley, 1997).** On the other hand, little researches have studied the changes in postharvest quality of vegetable crops associated with pre-storage. In this respect **Mohammed et al. (1996)** recorded changes in physical, physiological and chemical characteristics of the fruits during storage due to field heat stress. **Woolf and Ferguson (2000)** proved that preharvest high temperatures affected inner quality, such as sugar contents of mineral and sugar, tissue firmness, and levels of oil. **Thole et al. (2021)** noticed that when field temperature increased from 18–20 °C to 26 °C reduced average shelf life of fruits and increased fungal susceptibility for 41 tomato accessions. According to the results of **Rosero et al. (2020)** genetic and environmental factors influenced the chemical composition and root quality of sweet potato at harvest; however, no study has assessed climate change impacts on the storage of sweet potato. Therefore, the current study's objective is to ascertain the impact of climate change in the form of planting at unsuitable high temperatures (through planting in July), comparing to the recommended planting time (in April) on storability of two sweet potato cultivars

MATERIAL AND METHODS

This planting of experiment was conducted in the summer seasons of 2019 and 2020 at Agricultural Experimental Station, Faculty of Agricultural, Cairo University, Giza. Stem cuttings of two sweet potato cultivars; namely Mabrouka and Menofia, were planted in two different planting dates (23/4 and 29/7). Middle stem cuttings 30 cm long were cultivated in rows at a distance of 25 cm apart. Each plot involved of 5 rows, each 4 m in length and 70 cm in width. The area of each plot was (14 m^2). Cultural practices for sweet potato production were implemented as recommendations of the Egypt Ministry of Agriculture. The Central Laboratory for Agricultural Climate (CLAC), ARC supplied the climatic data of the Experimental site as shown in (Fig. 1)

Storage roots were harvested 169 days after planting. After harvesting, the storage roots were taken to the Potato and Vegetatively Propagated vegetable department – Horticulture Research institute- Agriculture Research Center. Only uniform roots in size, weight, color and free from any visible defects were selected from each experimental treatment, then were cured at 30^0 C for 10 days. Roots were stored in net bag (1 kg) then put in plastic boxes (45 × 35 × 25 cm) in a single layer and were stored at 13^o C in store room for 4 months. Each treatment consisted of 6 net bags. The experiment was

Set in a split-split plot design. The main plot was the two different planting dates (23/4 and 29/7), sub plot was two different cultivars Mabrouka and Menofia), while sub-sub was 1, 2, 3 or 4 months storage periods.

Sweet potato storage roots quality parameters were analyzed at the initial and end of every month of storage period as follows:

a. Weight loss percentage

Storage roots weight loss were calculated as percentage of initial weight using the following formula:

$$\text{Weight loss \%} = \frac{\text{Storage roots initial weight} - \text{Storage roots weight at each sampling date}}{\text{Storage roots initial weight}} \times 100$$

b. Sensory analysis

It included visual quality and decay. This was evaluated by offering samples to a member of 10 panel experienced in judging sensory analysis of sprouts. Samples were identified with random numbers and arranged on individual plates. Samples were rated using score system as described by Kader et al. (1968) as follows.

(1) Visual quality score system

9 = excellent, 7 = good, 5 = fair, 3 = poor, 1 = unsalable.

This scale relies on the morphological defects, such as softening, shriveling and decay

(2) Decay score system

1 = none, 2 = slight, 3 = moderate, 4 = moderately severe, 5 = severe injured or spoiled roots due to bacterial or fungus, shriveling and any visible defects.

b. Skin color was determined by using a color meter (Minolta Chroma Meter CR-400, Minolta-Konica, Japan). Color changes were quantified in hue angle (h^o).
c. hue angle is defined as a color wheel, with red purple at an angle of 0^o,

yellow at 90^o, bullish- green at 180 ^{o} and blue 270 ^{O} and was calculated by $h^o = \tan^{-1}(b/a)$ (Perkins-Veazie, 1992).

C-Chemical constituents:

The chemical constituents were included N, P, K, Ca, Fe, and Zn, total carbohydrates and total carotenoids.

N, P, K, Ca, Fe, and Zn concentrations in sweet potato storage roots were determined in the dry material at harvest and at the end of every month of storage. The determinations were done as described by Kalra (1998) using the modified- micro-Kjeldahl method for total nitrogen, the chlorostannous molybdophosphoric blue color method in sulphuric acid for Phosphorus, the flame photometer apparatus (CORNING M 410, Germany) for Potassium and Atomic Absorption, Spectrophotometer with air-acetylene, fuel (Pye Unicam, model SP-1900, US) for Calcium, Iron and Zinc.

Total carbohydrates were evaluated calorimetrically according to Duboies *et al*. (1956).

Total carotenoids were extracted by *N*,*N*-dimethylformamide from storage roots and evaluated according to (Moran, 1982).

RESULTS

Weight loss:

Data presented in Fig. 2 show the impact of planting dates on weight loss of storage roots of the two sweet potato cultivars throughout 4 months storage. Storage roots produced in the second planting date lost higher weight during storage than those produced in the first planting date, but differences between both planting dates was not significant in the first season.

"Menofia" showed better storability and less weight loss as compared to "Mabrouka" in both planting dates in the second season and in the second planting date in the first season.

Weight loss of storage roots increased continuously during the storage period, regardless of planting dates and cultivars

Concerning the interaction among planting date, cultivars and storage period, the highest weight loss percent was noticed after 4 months storage in "Mabrouka" produced in the second planting date.

Dry matter:

Data shown in Fig. 3 cleared the impact of planting dates on dry matter of storage roots of the two sweet potato cultivars throughout 4 months storage. Regarding planting date, storage roots harvested from plants grown in April contained significantly a higher dry matter percentage as compared to those obtained from July planting date.

Storage roots of "Mabrouka" surpassed those of “Menofia " in the dry matter within both planting dates.

Dry matter declined with progress of the storage, within any planting date and any cultivar.

The highest dry matter was recorded in "Mabrouka" grown in the first planting date at harvest, while the lowest dry matter was recorded in both cultivars grown in the second planting date after 4 months of storage.

Hue angle:

The impacts of planting dates and cultivars and their interaction on hue angle were not significant, except in the second planting date, where "Mabrouka" recorded higher hue angle value than "Menofia " in the first season (Fig. 4).

Hue angle continuously increased with prolongation of the storage regardless of planting date and cultivars, which refers to the storage roots becoming light red color during storage.

Concerning the interaction among cultivars, planting date and the storage period, the highest value of hue angle was in "Mabrouka" grown in in July planting date after four months of the storage

General appearance (score):

Impact of planting date on general appearance was not significant in the first season, but in the second season, the score of general appearance of storage roots produced in the second planting date was higher than those produced in the first planting date.

Impact of cultivars and the interaction between planting date and cultivars was not significant in the second season, while "Menofia " surpassed "Mabrouka" in score of general appearance within any planting date in the first season.

The score of general appearance significantly decreased with prolongation of the storage, regardless of planting dates and cultivars

With regard to the interaction among planting date, cultivars and storage period, the lowest score value of general appearance 4 months after storage was exhibited in "Mabrouka" grown in April (Fig. 5).

Chemical components of storage roots during storage

The impact of planting dates, cultivars and storage periods on the Chemical components of storage roots I shown in Figs. 6-12. All treatments had no any significant impact on the nitrogen content of storage roots (data not shown).

The impact of cultivation date, cultivars and their interaction on phosphorus, potassium, zinc, calcium and carbohydrate contents of storage roots were not significant in both seasons. On the other hand, the impact of planting dates and cultivars on iron (in the first season) and carotenoids (in both seasons) contents of storage roots were significant. Plants grown at the second planting date (in July) had a higher iron content and lower carotenoids as compared with those cultivated at the first planting date (in April).

"Mabrouka" contained higher iron content and lower carotenoids as compared with "Menofia ". The interaction of cultivation date and cultivars on iron content was not significant, while the interaction of cultivation date and cultivars on carotenoid content was significant. "Menofia " surpassed "Mabrouka" in carotenoid content at April

planting in both seasons, while "Mabrouka" "surpassed "Mabrouka" in carotenoid content at July planting date, only in the first season.

Regarding the storage period, phosphorus and potassium, calcium, iron, carotenoids and carbohydrate contents of storage roots significantly declined with elongation of the period of storage in both seasons, but zinc significantly declined only in the first season with elongation of the period of storage

Data of the interaction between cultivation date and the period storage indicated no significant impact on P in both planting dates (in both seasons) and K contents at the second planting date (in both seasons), Fe content at the second planting date (in the first season), Carbohydrates and Fe contents at both planting dates in the second season. On the other hand, K and carbohydrate contents at the first planting date (both seasons) and Fe (in the first season) significantly decreased with the progress of the storage. Similarly, Ca and carotenoids contents significantly declined during storage, of regardless planting dates.

The interaction between planting date and the period storage significantly influenced Zn content, but only during storage at the second planting date in the first season, where it significantly decreased under such condition.

With regard to the interaction between cultivars and the storage periods, it was no significant impact on P in both seasons, Ca content of "Mabrouka" in the first season, K, Fe and carbohydrate contents of "Mabrouka" in both seasons, Zn content in the second season, and Zn content of "Menofia “in the first season. On the other hand, K, Fe, Ca and

carbohydrate contents significantly decreased in "Menofia " with the progress of the storage in both seasons, but Zn content significantly declined in "Mabrouka" with elongation of the storage period in the first season.

Ca content (in the second season) and Carotenoids (both seasons.) significantly declined during storage, regardless of cultivar.

Concerning the interaction among planting date, cultivars and the storage period, the greatest P, K, Ca and Fe contents were exhibited in "Mabrouka" grown in the second

planting date at harvest, while the greatest Zn content was exhibited in "Mabrouka" grown in the first planting date at harvest.

On the other hand, the greatest carbohydrate content was shown in "Mabrouka" grown in the second planting date at harvest in the first season and grown in the first planting date

At harvest in the second season. Meanwhile, "Menofia " grown in the first planting had the greatest content of carotenoids

DISCUSSION

Storage experiment

Planting date had significant impact on storage of sweet potato storage roots. Storage roots produced from April planting date were stable against storage damages. These roots showed less weight loss, higher dry matter and carotenoids content and better appearance, but less iron content during storage than those obtained from July planting date, Otherwise , the impact of planting date on phosphorus, potassium, zinc, calcium and carbohydrate contents of storage roots was not significant in both seasons. Generally, the present research showed the storage root quality produced from April at harvest exhibited higher quality and dry matter contents comparing with produced from July planting, that were subjected to rain during the last two months before harvesting. Therefore, the healthy storage roots maintained their good quality (higher dry matter and carotenoids content, better appearance,) during storage. The current findings supported those of **Roberts & Russo (1991)**, who found that flooding at midseason decreased marketable production by 36% to 53% and decreased the No. 1 grade yield by 46% to 57%.

Cultivars influenced significantly iron and carotenoids contents of storage roots. Storage roots of "Menofia" showed good storability, higher carotenoids and dry matter better general appearance as well as less weight loss, but lower iron content as compared with "Mabroka". **Krochmal-Marczak et al., (2020) and Bhattarail et al., (2021)** were shown that weight loss and dry matter during storage were significantly affected by the genetic characteristics of the cultivars of sweet potatoes.

Concerning storage period, weight loss, hue angle value significantly increased, while dry matter, general appearance, phosphorus and potassium, calcium, iron, zinc, carotenoids and carbohydrate contents of storage roots significantly declined, with the progression of the storage period, regardless of planting date and cultivars. Respiration may be to blame for the decrease in dry matter, which resulted in a greater loss of weight for the sweet potato root at the end of storage. **(Emam and Attia, 2010; El- Sayed et al., 2013).** Dry matter content significantly decreased during the storage period in sweet potato **(Erturk and Picha, 2007)**. Similarly, **Nurfarhana et al., (2019)** revealed that the hue increased linearly over time of storage. Storage roots' diminished overall appearance may be caused by internal and exterior changes brought on by weight loss from respiration and transpiration**. (El- Sayed et al., 2013).** The general reduction in appearance of store roots may be caused by internal and external alterations brought on by weight loss from respiration and transpiration. **Erturk and Picha (2007),** concerning mineral content and **Tumuhimbise et al., (2010) and Bhattarail et al., (2021)**, concerning carotene in sweet potato storage roots during storage.

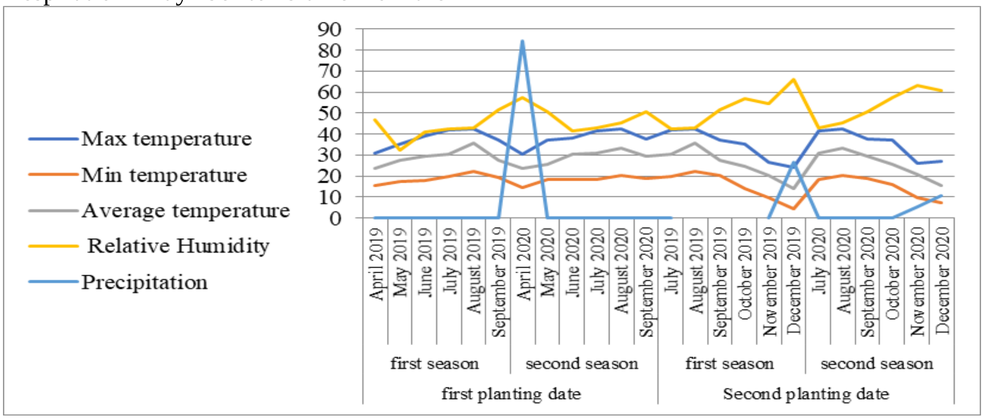


Fig. 1: Monthly minimum, maximum and average temperature, (°C), average relative humidity (%) and precipitation.

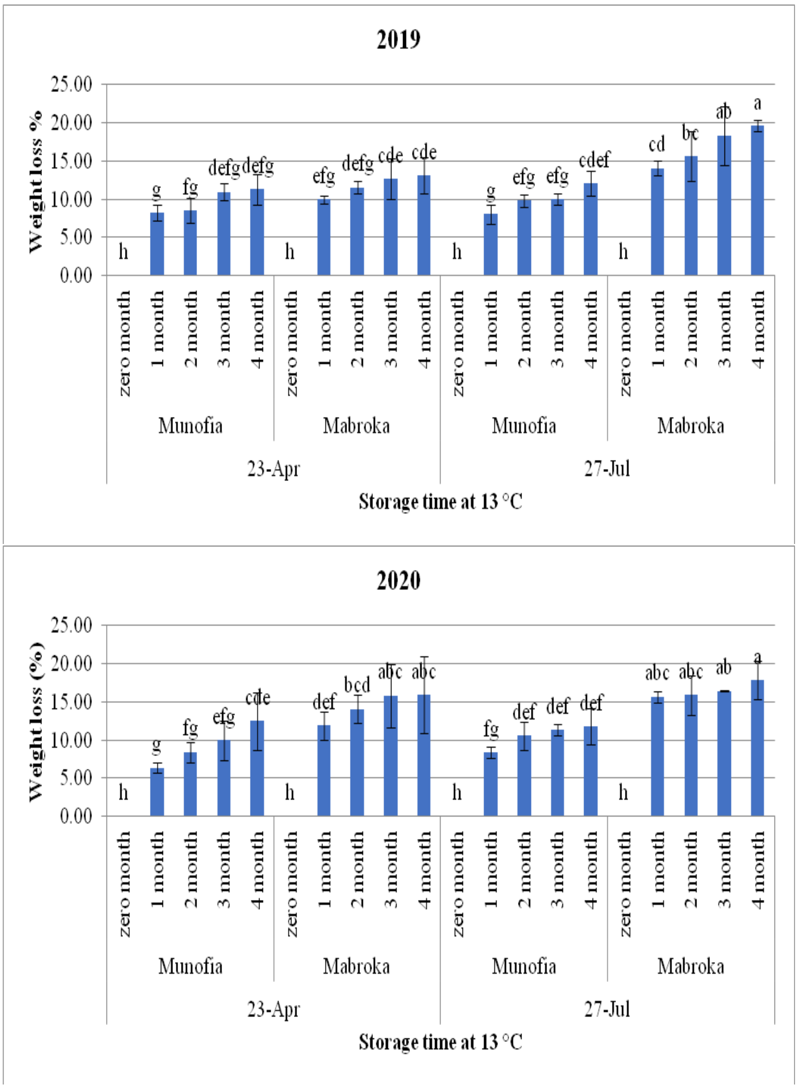


Fig. 2. Impact of planting dates, cultivars, storage period and their interaction on weight loss of sweet potato storage root.

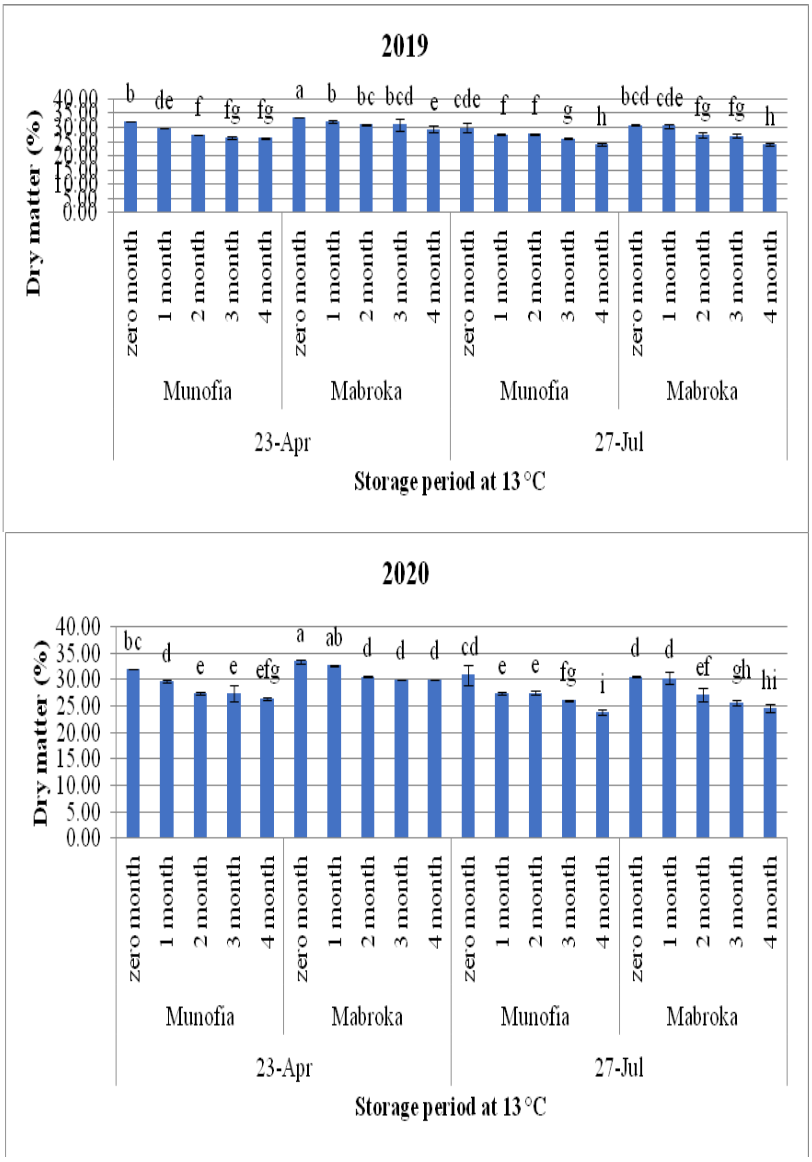


Fig. 3. Impact of planting dates, cultivars, storage period and their interaction on dry matter of sweet potato storage roots

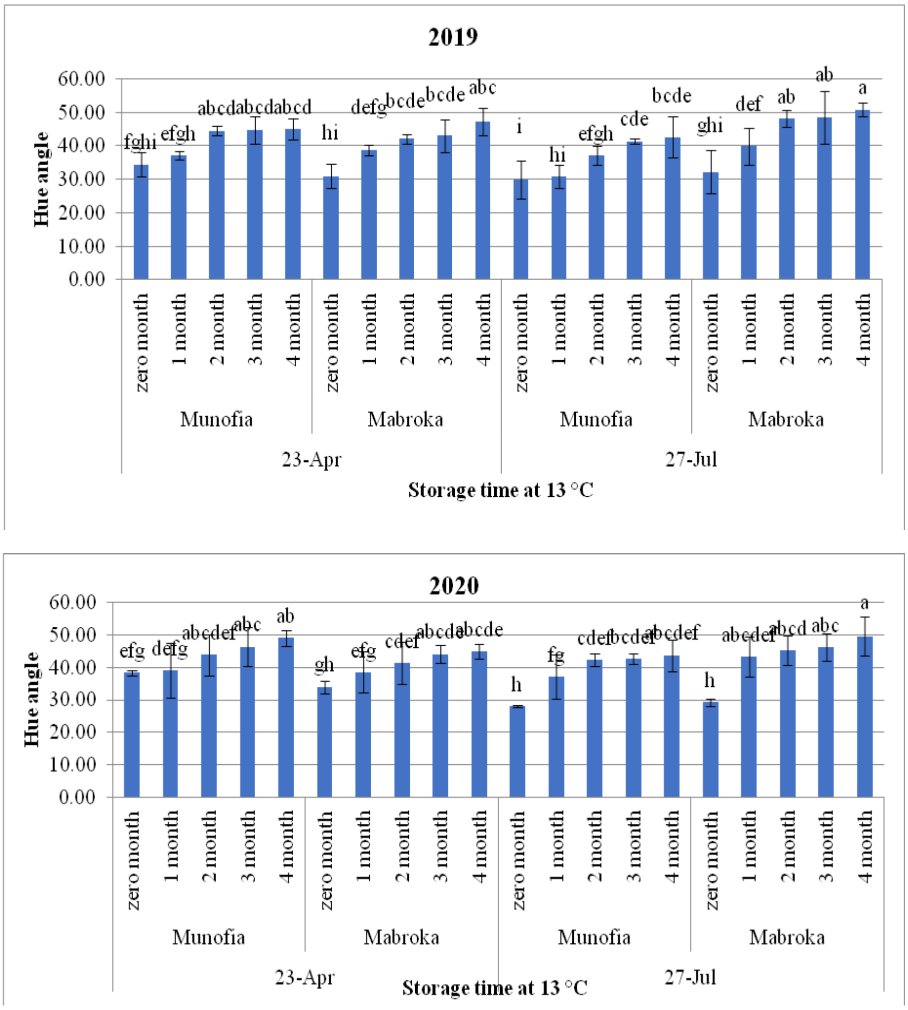


Figure 4. Impact of planting dates, cultivars, storage period and their interaction on hue angle of sweet potato storage roots

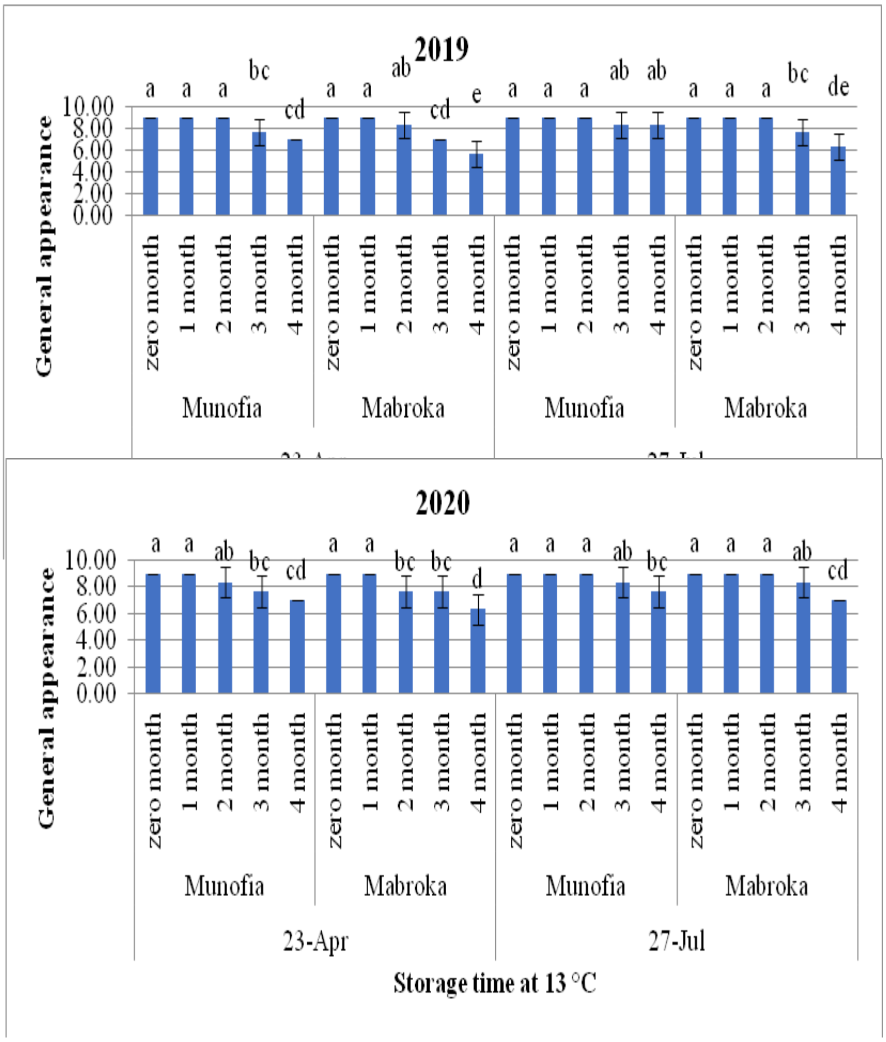


Figure 5. Impact of planting dates, cultivars, storage period and their interaction on general appearance of sweet potato storage roots

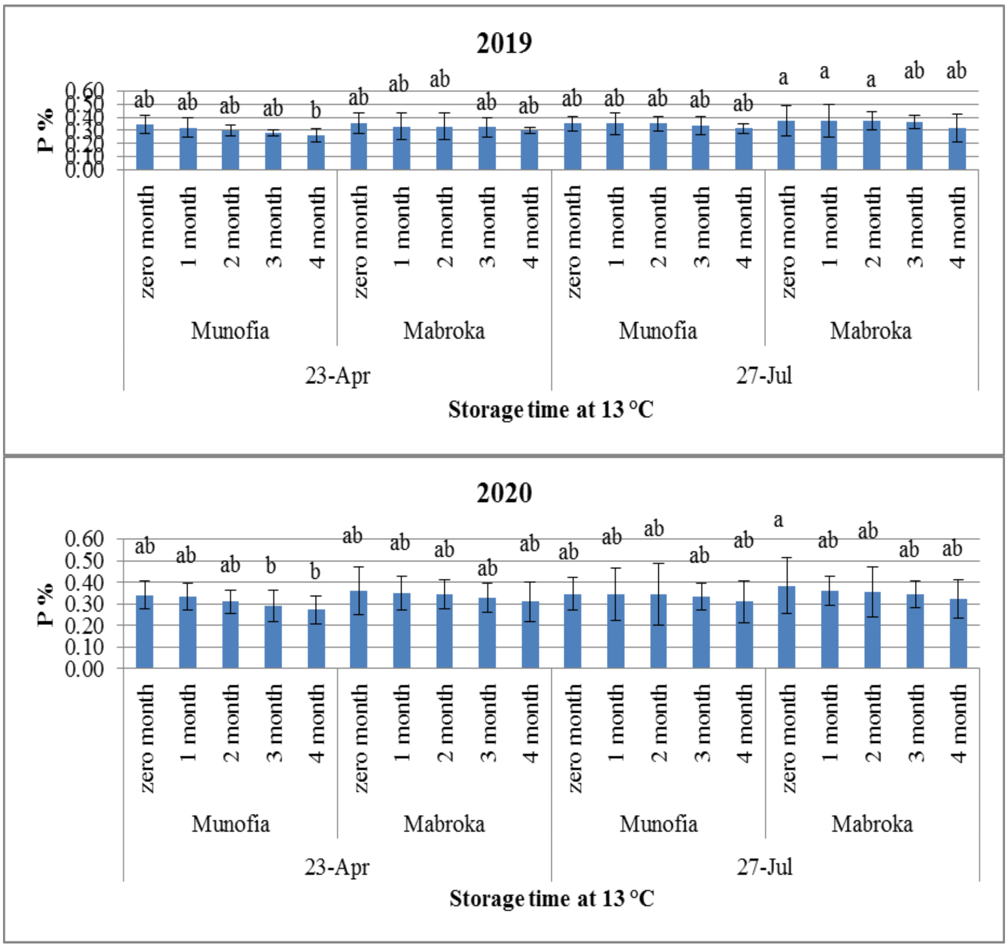
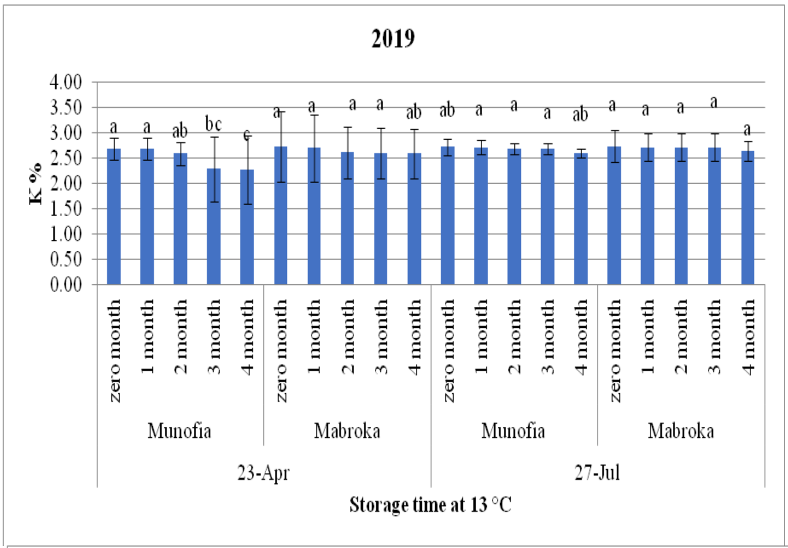


Figure 6. Impact of planting dates, cultivars, storage period and their interaction on phosphorus content of sweet potato storage roots



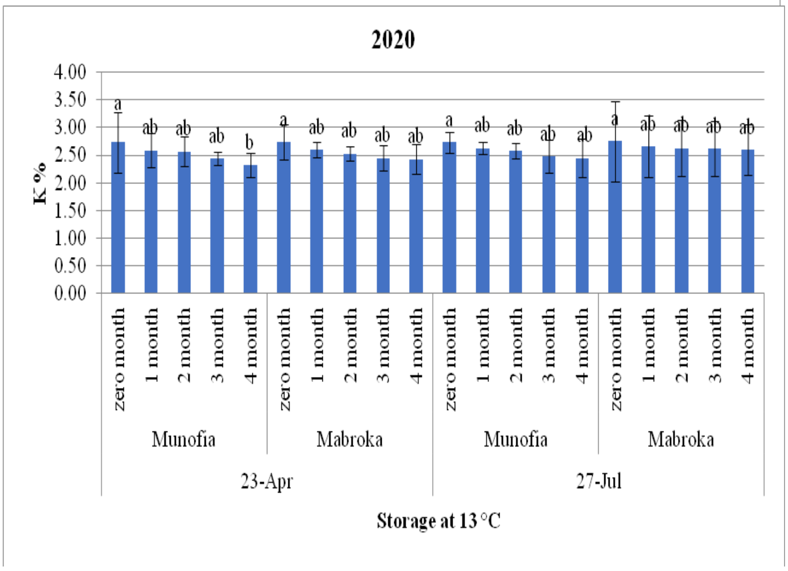
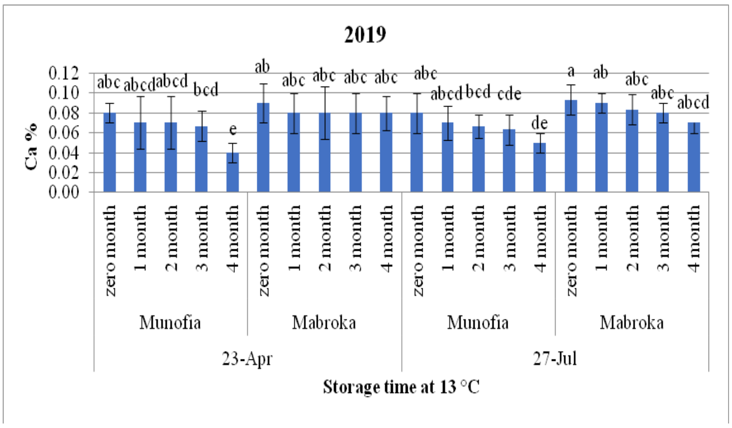


Figure 7. Impact of planting dates, cultivars, storage period and their interaction on potassium content of sweet potato storage roots



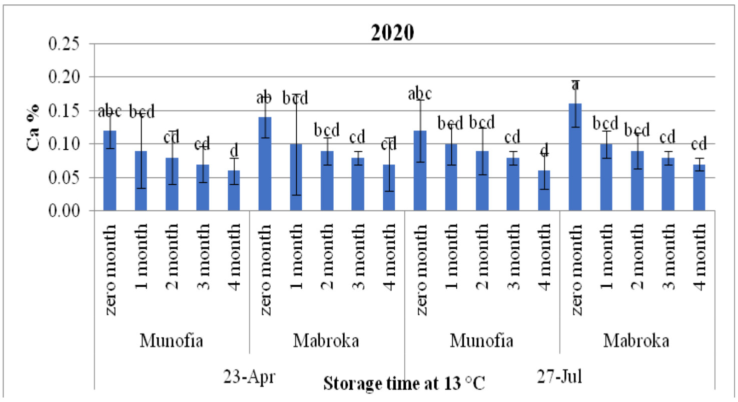


Figure 8. Impact of planting dates, cultivars, storage period and their interaction on calcium content of sweet potato storage roots

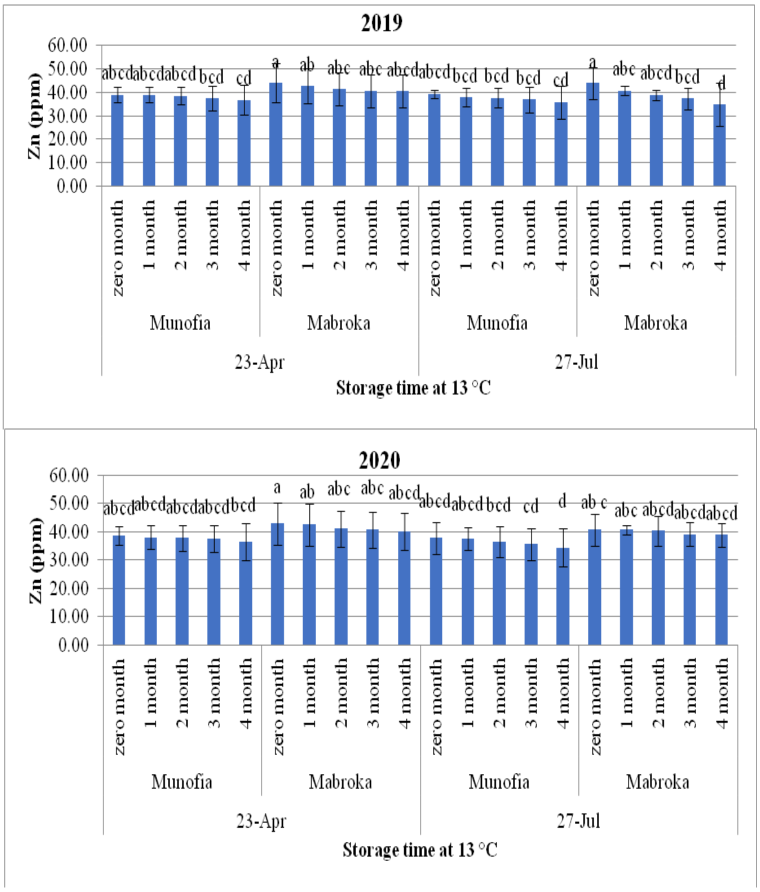
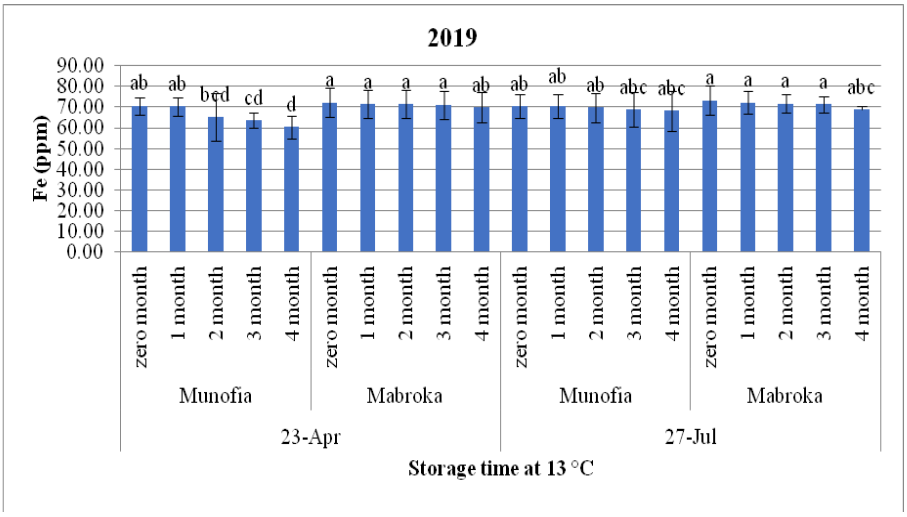


Figure 9. Impact of planting dates, cultivars, storage period and their interaction on Zn content of sweet potato storage roots



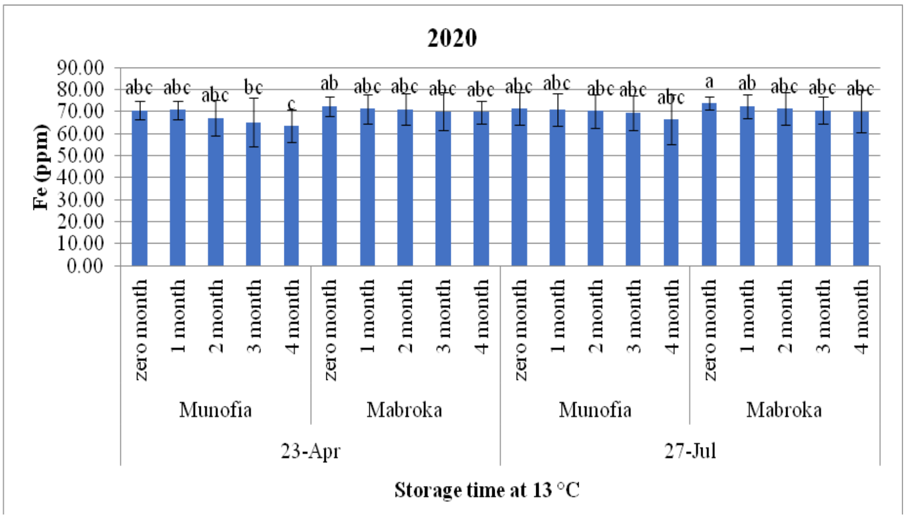


Figure 10. Impact of planting dates, cultivars, storage period and their interaction on Fe content of sweet potato storage roots.

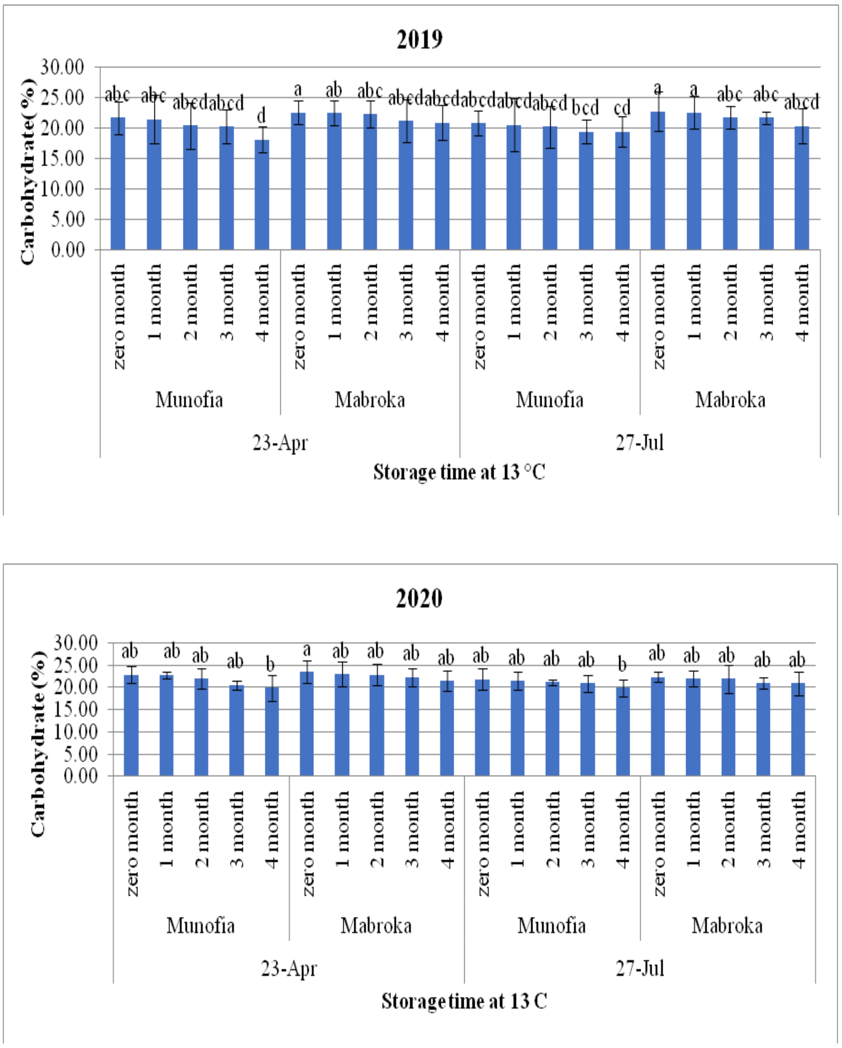


Fig. 11. Impact of planting dates, cultivars, storage period and their interaction on carbohydrate content of sweet potato storage roots

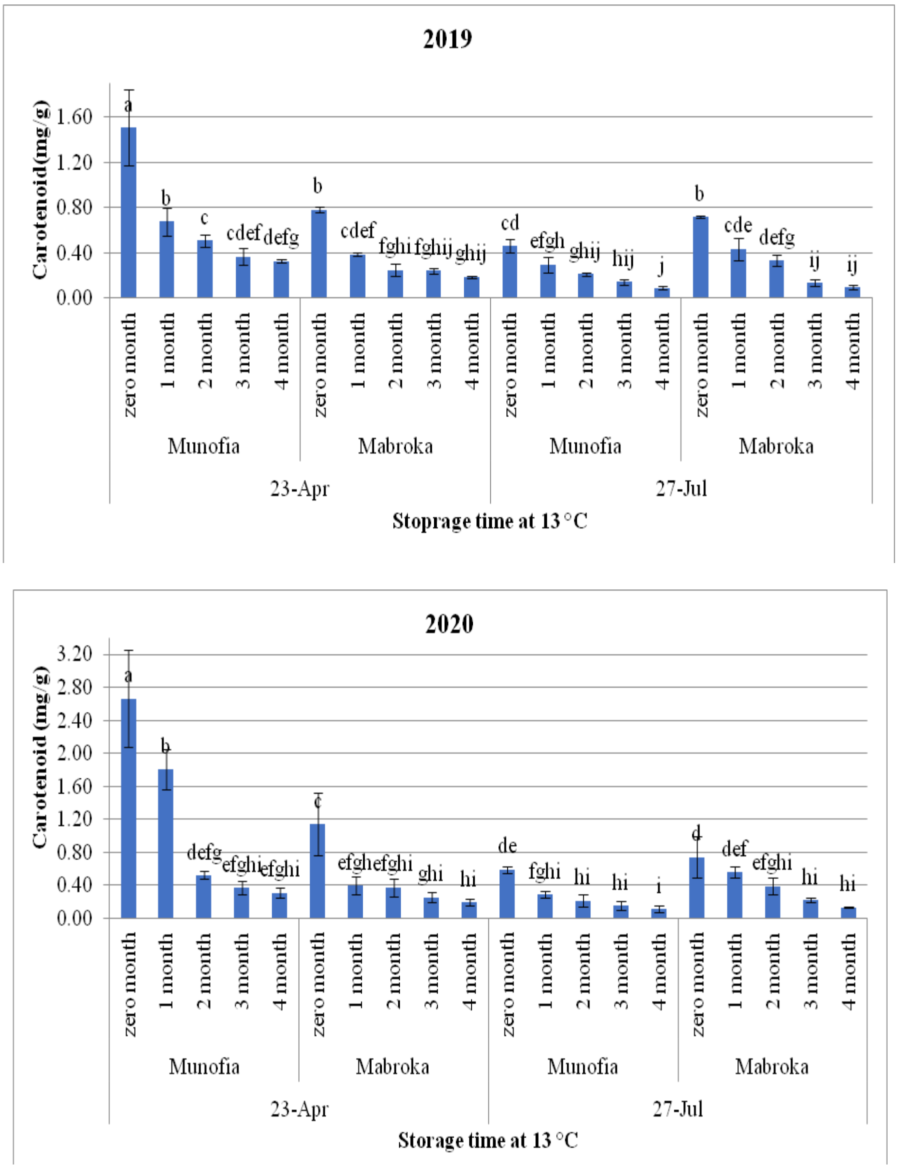


Figure 12. Impact of planting dates, cultivars, storage period and their interaction on carotenoid content of sweet potato storage roots

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الملخص العربي

تأثير مواعيد الزراعة والحصاد على الإنتاجية والقدرة التخزينية لصنفين من أصناف البطاطا الحلوة لمواجهة التغيرات المناخية

2- القدرة التخزينية وجودة الجذور المتضخمة

شيرين سيد فتحى السيد [1]، ونرمين عبد التواب المنادي عبد الودود [2]

[1] قسم الخضر - كلية الزراعية - جامعة القاهرة - الجيزة - مصر، 12613

[2] قسم بحوث البطاطس والخضر خضرية التكاثر، معهد بحوث البساتين- مركز البحوث الزراعية– مصر

تم اختيار البطاطا (*Ipomoea batatas* (L.) Lam.) كأحد أهم المحاصيل الدرنية في البلدان الاستوائية وشبه الاستوائية ، تم اختيارها لدراسة تأثير التغيرات المناخية في شكل درجات حرارة أعلى على تخزين المحصول، تم زراعة صنفين من البطاطا الحلوة (المنوفية والمبروكة) في تاريخين مختلفين [23 أبريل (تاريخ الزراعة الحالي الموصى به) و 29 يوليو (تاريخ الزراعة المحاكي لتغير المناخ)] وتم حصادهما بعد 169 يومًا من زراعة الشتلات ، حيث يؤثر تغير المناخ ، بتحويل تاريخ الزراعة إلى الأشهر الحارة ، سلبًا على وزن الجذور أثناء التخزين ، ونسبة المادة الجافة والكاروتينات ، ولكنه أظهر نسبة أعلى من الحديد ودرجة المظهر العام لجذور التخزين عن تلك المنتجة في تاريخ الزراعة الموصى به (أبريل) ، قد أظهر الصنف المنوفية في نهاية التخزين قيم أقل من الكربوهيدرات ، الحديد ، الكالسيوم ، البوتاسيوم ، الفسفور في تاريخ الزراعة الأول ، و قيم أقل من الزنك في موعد الزراعة الثاني ، بينما أظهر الصنف مبروكة قيم أقل للمظهر العام في موعد لزراعة الأول ، وقيم أقل للزنك في موعد الزراعة الثاني ، وقد نخفض الفوسفور والبوتاسيوم والكالسيوم والحديد والكاروتينات والمحتوي من الكربوهيدرات ودرجة المظهر العام لجذور التخزين وكذلك الزنك انخفاض معنويًا ، بينما زادت Hue angle باستمرار مع إطالة فترة التخزين

الكلمات المفتاحية: الأصناف، مواعيد الزراعة، جذور التخزين، التخزين، البطاطا الحلوة، التغيرات المناخية