Global Advanced Research Journal of Agricultural Science (ISSN: 2315-5094) Vol. 3(8) pp. xxx-xxx, August, 2014.
Available online http://garj.org/garjas/index.htm

Full Length Research Papers

Effect of potassium applied with foliar spray of yeast on sugar beet growth and yield under drought stress

***Neseim, M.R, *Amin, A.Y. and **El-Mohammady, M.M.S.**

*Department of Agricultural Botany, Plant Physiology Division, Faculty of Agriculture, Cairo University
**Department of Agricultural Botany, Plant Physiology Division, Faculty of Agriculture, Cairo University

Accepted 10 August, 2014

The effect of potassium fertilization and foliar spray of yeast on vegetative growth, chemical composition and sugar beet yield as well as its attributes under drought stress were investigated. In this study, three potassium sulphate 48% doses (50, 75 and 100 kg/Fed) were applied after 30 days after planting and foliar spray of yeast (0, 10 or 14 g/l) was repeated two times at 45 and 60 days after planting as sub-plot of two irrigation treatments, i.e. control (10 irrigation times) and low water level (6 times). Two samples were taken at 130 and 180 days from planting for morphological and chemical studies. At harvest, sugar beet yield is determined and their attributes at 205 days. Drought stress significantly reduced all root and leaves morphological growth characters, chlorophyll a and total chlorophyll concentrations, root yield and white sugar/Fed in both samples. While the total soluble phenols and free amino acids concentrations in leaves and roots were significantly increased. Meanwhile, no significant differences found in the percentage of sodium, potassium, alpha-amino nitrogen, impurities, sucrose, sucrose recovery, sugar loss molasses (SLM), purity (PUR) and total soluble solids (TSS). Finally, the recommended K dose (75 kg/Fed) in combination with yeast (14 g/l) recorded the highest yield, sucrose %, water use efficiency and the lowest impurities % under drought stress. Also, the application of 100 kg/Fed potassium fertilization in combination with 10g/l yeast recorded the highest root yield and white sugar yield, water use efficiency as well, under sufficient irrigation.

Keywords: Beta vulgaris, sugar beet, growth, yield, chemical composition, drought, Potassium fertilization, white sugar, drought stress, foliar spray of yeast, physiological properties

INTRODUCTION

Sugar beet, (*Beta vulgaris*, L) is the main commercial root sugar crop all over the world, especially in Egypt. Sugar beet is a member of Amaranthaceae. The sugar world is about 140 million tons (Mt) 2004 then, 168 Mt in 2011. FAO 2013 estimated 2% annual increase in sugar production to reach 212 Mt at 2022. In Egypt, raw sugar production from beet and cane was about 1083 and 917 thousand tons in 2012/2013 and 850 and 950 thousand tons in 2011/2012, respectively. The number depicts an increase in beet sugar production and a decrease in sugar cane production, which is attributed to high sugar concentration (13-18%) compared to cane (10%) and low water consumption. In the last years, Egypt has been suffering from severe water scarcity. Unequally water

*Corresponding Author's E-mail: Mohamed.saad@agr.cu.edu.eg; mmsaad87@gmail.com; Tel:+201140044484.

distribution, misuse of water resources and inefficient irrigation techniques are major factors playing a role in water scarcity. The River Nile is the country lifeline as it services the country's industrial, agricultural demand and the primary drinking water source (Dakkak, 2013). Nile water represents 97% of water availability in Egypt; its annual flow is 55.5billion m^3/year. The other water resources rainfall, fossil groundwater extraction, as well as, the reuse of spilled water resources. Egypt, annually, is going on a water deficit around 7 billion m^3. In fact; the United Nations is already warning that Egypt could run out of water by the year 2025, (Texas Water Report, 2014).

Furthermore, the most prominent challenge is Ethiopia Renaissance Dam which will cause for Egypt a huge water share reduction. Due to the threats surge concerning water in Egypt, the country seeks in decrease sugar production-consumption gap either by growing area of cultivated lands or selection of better cultivars. In addition, Egypt seeks to reduce the water misuse and increase the water use efficiency.

Brown *et al.* (1987) mentioned that leaf water potential decreased with drought stress, which influenced leaf expansion through leaf turgor that led to a reduction in plant growth. Hang, and Miller (1986b) indicated that dry matter production increased with increasing water applied, and Clover et al. (1999) mentioned that drought reduced total plant weight due to the reduction in light interception. Wang et al. (2013) affirmed that plants subjected to the drought stress resulted to formation of ROS that led to leaf damage and decreasing crop yield. Grzebisz et al. (2013) stated that the roots of the plant subjected to the drought stress tended to grow faster to create more favourable conditions to get water and nutrient supply. There is some evidence supported the role of potassium fertilization to enhance the plant growth under stress. Wang *et al.* (2013) and Salami and Saadat (2013) pointed out that K played an essential roles in enzyme activation, protein synthesis, photosynthesis, osmoregulation, stomata movement, energy transfer, phloem transport, cation-anion balance and stress resistance. Also, some natural bio-substances, i.e. yeast have stimulating, nutritional and protective functions on the plant against many abiotic stresses. Shehata *et al.* (2012) mentioned that yeast is an enriched source of phytohormones especially cytokinins, vitamins, enzymes, amino acids and minerals as well as has a stimulatory effect on the cell division and enlargement, protein and nucleic acids synthesis, chlorophyll formation and protective role against different stresses. Therefore, the increasing of potassium fertilization level and as using foliar spray of yeast was investigated to have an increase in the sugar beet yield productivity as well as sugar quality under drought stress conditions.

MATERIALS AND METHODS

Two field experiments were carried out in The Agricultural Research And Experimental Station, Faculty of Agriculture, Cairo University, Giza, Egypt during the two successive seasons 2011/2012 and 2012/2013. The study included the application of basal potassium fertilization and foliar spray of dry active yeast on sugar beet vegetative growth and yield, subjected to drought stress. Sugar beet seeds (*Beta vulgaris* L. var. Pleo) were obtained from Sugar Crops Research Institute, Agricultural Research Centre, Giza, Egypt. Seeds were sown on 19th October in the two successive seasons.

Soil samples were randomly taken each year before cultivation, at the depth of 0-60 cm and were subjected for physical and chemical analysis according to Jackson (1973).

The mean values of soil mechanical and chemical analysis as well as available water, field capacity and wilting point percentage of applied water under different soil depths were illustrated in Tables (1, 2).

Soil was mechanically ploughed and irrigated after a one week, and then it was mechanically ploughed again to eliminate weeds growth. Then, it was harrowed and plotted. All the agricultural practice was applied according to the recommendation of Agricultural Ministry. 80 kg/Fed of ammonium nitrate (34.4% N) was supplied to soil in two equal separate doses. In addition, 50 kg/Fed calcium super-phosphate was applied before planting during soil preparation.

A randomized complete block design experiments were designed with three replicates in a split plot design. They contained 18 experimental units, in which each one represented a treatment, and it composed of three rows, where each row has 3 meters length and 0.60 m width, which represented a one replicate. Irrigation was the main treatment, designed as control (100%) and drought (55%). The quantities and timing of irrigation schedule during different stages of sugar beet plant were shown in figure 1 and 2. The sub-plot treatments included three doses of applied basal potassium sulphate 48% K_2O (50, 75 or 100 kg/Fed) after 30 days after planting. Foliar applications of dry active yeast (0, 10 or 14 g/l) were repeated twice at 45 and 60 days after planting.

In both seasons, two samples, i.e. at 130 and 180 days after planting were collected from each treatment, in which each one was represented by three replicates for the morphological studies, and chemical analysis. In each sampling date, the following growth characters were measured, i.e. root length (cm), root diameter (cm), root fresh weight (g), root dry weight (g), shoot fresh weight (g), shoot dry weight (g) and number of leaves.

At harvest, a third sample was taken for recording root yield (ton/Fed) and white sugar yield (ton/Fed) at 205 days after planting, as well as, for determination sugar yield recovery % and sugar beet quality.

a) Chemical analysis; an ethanol extract, for determination of reducing, non-reducing, total sugars, total

Table 1. Mechanical and chemical analysis of the soil experimental site.

Mechanical analysis

Coarse sand %	Fine sand %	Silt %	Clay %	Texture class
1.5 – 6.0	37.0 – 41.2	22.0 – 26.1	31.2 – 35.0	Clay loam

Chemical analysis

pH	EC	Soluble anions (meq/l)			Soluble cations (meq/l)			
7.9	2	HCO_3^-	Cl^-	SO_4^{-2}	Na^+	K^+	Ca^{+2}	Mg^{+2}

Table 2. The percentages of available water, field capacity and wilting point of the applied water under different soil depths.

Soil depth (cm)	Field capacity %	Wilting point %	Available water
0-20	38.78	16.19	22.59
20-40	38.43	17.36	21.07
40-60	36.34	17.22	19.12

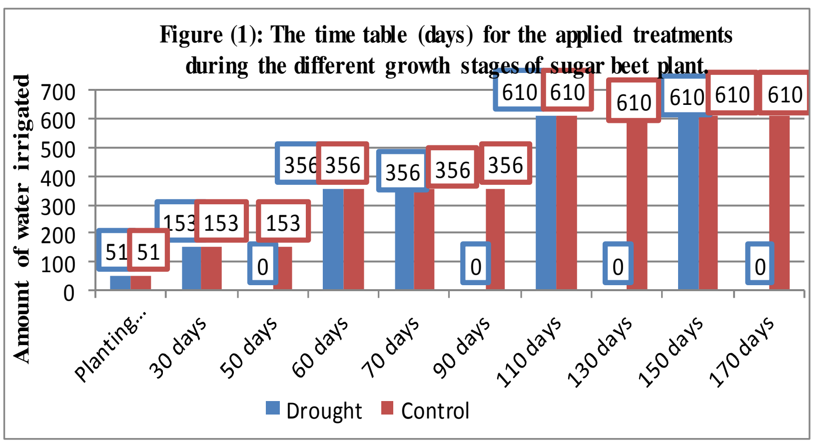
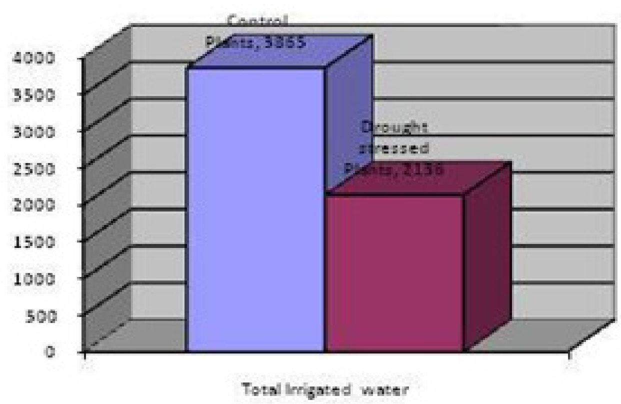


Figure (1): The time table (days) for the applied treatments during the different growth stages of sugar beet plant.



soluble phenols and free amino acids, which was prepared by extracting 2.5 g plant fresh material with 50 ml boiled ethanol.

a. **Reducing, non-reducing and total sugars concentrations:** In ethanol extract, the reducing, non-reducing, and total sugars in the both plant shoot and root parts were determined by phosphor-molybdic acid method according to A. O. A. C. (1975).

b. **Total soluble phenols concentration:** In ethanol extract, the total soluble phenols were determined using the folin-Ciocalteau colorimetric method Swain and Hillis (1959).

c. **Total free amino acids concentration:** In ethanol extract, the total free amino acids were determined by using ninhydrin reagent according to Moore and Stein (1954).

d. Plant Pigments: The photosynthetic pigments (chlorophyll a, chlorophyll b, total chlorophylls and total carotenoids) concentrations were determined in leaf fresh samples according to Nornai (1982).

b) Sugar yield and juice quality character:

All sugar quality parameters were determined at harvest in the Delta Sugar Company, Kafr El-Sheikh, Egypt, according to Le Docte (1927), where root samples were cleaning, and then passed through machine with knifes to give macerated roots. Then, 40 g of macerated roots mixed with 165 ml lead acetate (5%) solution by magnetic stirrer and then filtrate to determine sugar beet yield quality.

a. Total soluble solids (TSS %) = (Sucrose %) / (Purity %) as described by Brown and Serro (1954)

b. Sucrose percentage % was determined as described by Watts and Tempany (1908).

c. Potassium and sodium concentration was determined using flame photometer (mg/100 g sugar beet).

d. Alpha amino nitrogen concentration (mg/100 g sugar beet) was determined using Kjeldahl wet oxidation process as described by Blakemore *et al.* (1987).

e. Impurities percentage % = {(K + Na) x 0.0343) + (alpha amino – **N** x 0.094) + 0.29}

f. Purity percentage % = {((Sucrose % - Impurities %) x 100 / sucrose %} as described by Carruthers *et al.* (1962)

g. Sucrose loss to molasses percentage (SLM %) = {(0.343 (Na + K) + 0.094 (alpha amino- **N**) – 0.31} as outlined by Cook and Scoot (1993) who cited from Reinefeld *et al.* (1975).

h. Sucrose Recovery % (RS%) = { Sucrose % - 0.29 – (0.343 (Na + K) -0.094 (alpha amino-**N**)} as outlined by Cook and Scoot (1993) who cited after Reinefeld *et al.* (1975).

Statistics analysis

All data recorded were subjected to normal statistical analysis as described by Snedecor and Cochran (1980). Comparison among means was done using LSD at 5% level of probability. All statistical analysis was performed by using analysis of variance technique of Mstat-C computer software package.

RESULTS

Growth characters

The results mentioned in figure (3) showed that drought stress has significantly reduced the root length, both fresh and dry weights of roots and leaves at 130 days from planting. While the root diameter and number of leaves/plant did not show any significant differences between both irrigation levels at the same age. In addition at 180 days from planting, drought significantly decreased the entire root and leaves growth characters, i.e. root diameter, fresh and dry weight of both roots and leaves, whereas the root length was not affected.

The mean effects of potassium fertilization and foliar spray of yeast on sugar beet had a similar trend in both samples (130 and 180 days after planting), as it was found that the K1 dose, which represented the lowest applied dose, increased the number of leaves when applied in combination with foliar yeast spray (FYS) at 10 g/l or 14 g/l concentration at 130 and 180 days from planting. Meanwhile, increasing the potassium dose to K2 in combination with FYS at concentration of 10 g/l has increased the root diameter, fresh and dry weights, as well as leaves fresh and dry weights. However, the increasing of potassium application doses to K3 increased root length, growth and root to shoot ratio.

Considering the combination effect of both potassium fertilization and foliar spray of yeast on sugar beet leaves and roots grown under drought stress, it was found that increasing the applied dose of potassium fertilizer from 50 kg/Fed (control) to 75 kg/Fed in combination with foliar yeast spray at concentration of 14 g/l increased root and leaves growth; fresh and dry weights of roots and leaves, root diameter and number of leaves as well as root to shoot ratio at 130 and 180 days from planting.

Chemical analysis

a. Reducing, non-reducing and total sugars concentrations

The results mentioned in Figure(4) revealed that the non-reducing and total sugar concentrations in roots were significantly decreased under drought stress at 130 days from planting, whereas there is no significant difference was recorded for reducing, non-reducing and total sugar concentrations at 180 days from planting. In addition, the reducing and total sugar concentrations were significantly decreased in leaves under drought stress at 130 days and 180 days from plant.

The mean effects of potassium fertilization and foliar spray of yeast on reducing (RS), non-reducing (NRS) and total sugars (TS) concentrations in plant roots and leaves indicated that the increase in applied potassium dose from 50 (the control) to 75 kg K_2O/Fed led to an increase concentration in RS of roots at 130 days and then decreased at 180 days, however, it decreased at 130 days and increased at 180 days in the plant leaves (Figure. 4). In addition, increasing the potassium dose to 75 or 100 kg K_2O/Fed increased the NRS and TS concentrations in

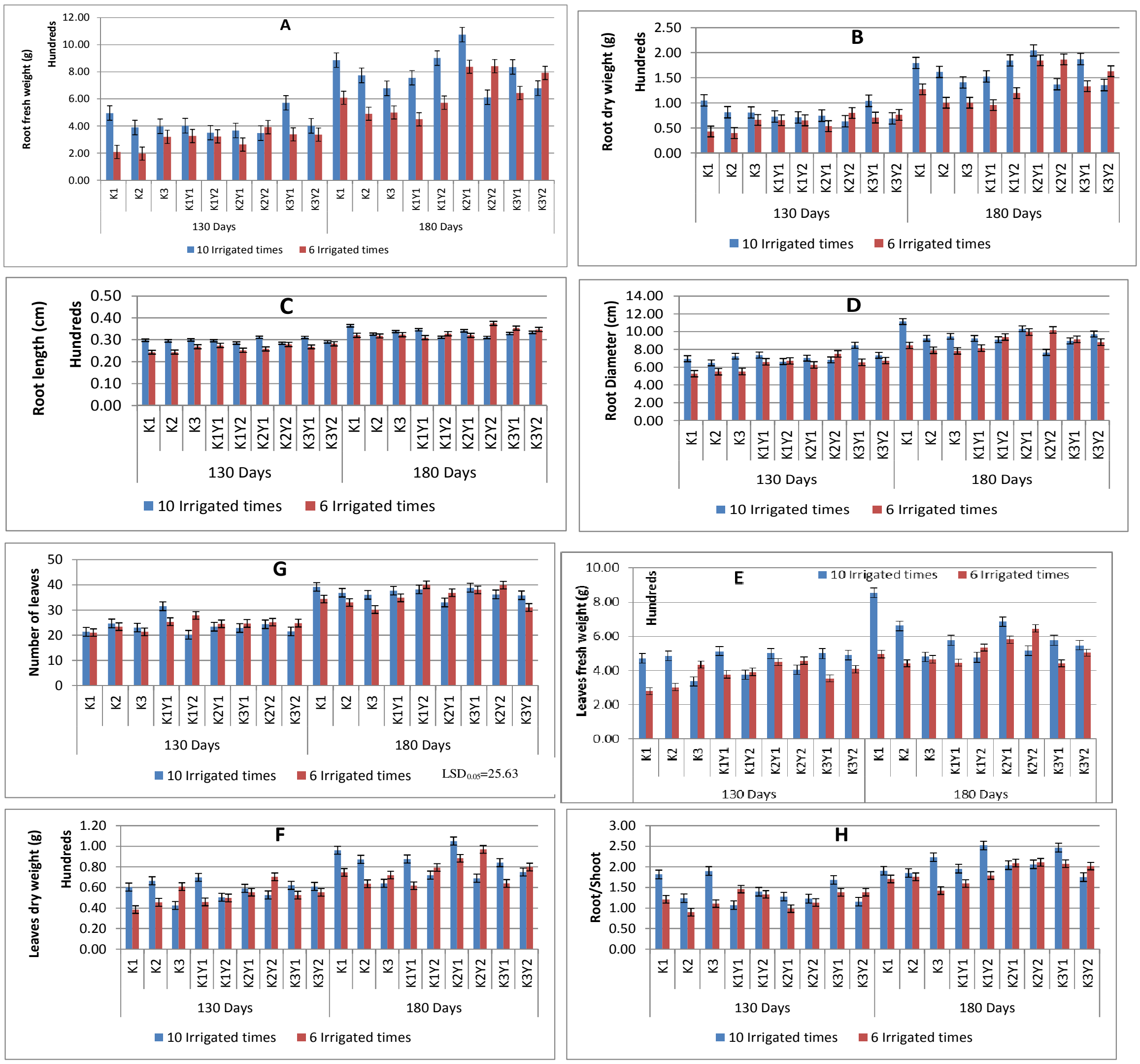


Figure 3. Effect of potassium fertilization and foliar yeast spray on sugar beet (a) root fresh weight, (b) root dry weight, (c) root length, (d) root diameter, (e) leaves fresh weight, (f) leaves dry weight, (g) number of leaves of sugar beet and (h) root to shoot ratio of sugar beet under normal and drought stress. K1 = 50 kg K_2O, K2=75 kg K_2O, K3= 100 kg K_2O, Y1=10g yeast/l, Y2=14g/l.

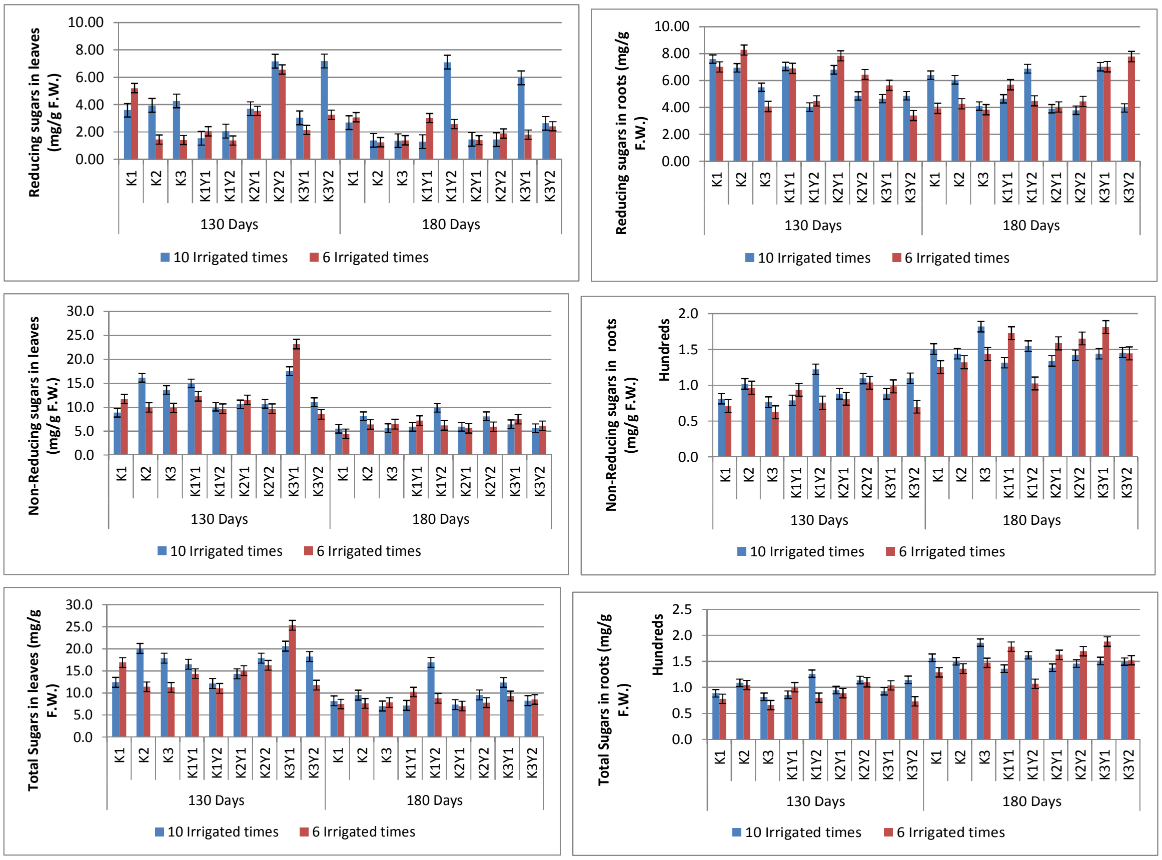


Figure 4. Effect of potassium fertilization and foliar yeast spray on (a) reducing sugars in leaves, (b) reducing sugar in root, (c) non-reducing sugars in leaves, (d) non-reducing sugar in root, (e) total sugars in in leaves, (f) total sugars in roots of sugar beet under normal and drought stress.
K1 = 50 kg K_2O, K2=75 kg K_2O, K3= 100 kg K_2O, Y1=10g yeast/l, Y2=14g/l

roots and leaves at 130 and 180 days from planting. Furthermore, the foliar spray of yeast at 10g/l concentration (K1Y1) increased the NRS at 130 days and then decreased at 180 days in leaves. On the other hand, the NRS concentration decreased at 130 days and then increased at 180 days in roots.. These results indicated that the sugar translocation from the source leaves to the sink organs would be enhanced.

On the other hand, the increase in foliar spray of yeast concentration to 14 g/l (K1Y2) increased the NRS at 130 days, and then decreased at 180 days in the roots. However, the RS in roots and leaves and the NRS in leaves decreased at 130 days and then increased at 180 days.

Finally, it was found that the application of 75 kg K_2O/Fed combined with 14g/l foliar spray of yeast, (K2Y2) was the highest significant value in NRS and TS concentration in roots at 130 and 180 days from planting. In addition, the NSR concentration in leaves was significantly decreased at 130 days and then increased at 180 days. On the other hand, the RS concentration was significantly increased at 130 days in leaves, and then significantly was decreased in the roots and leaves at 180 days from planting.

b. Total soluble phenols and free amino acids concentrations

The total soluble phenol concentrations were significantly increased in roots and leaves at 130 and 180 days from planting under drought stress. On the contrary, the free amino acids concentrations were significantly decreased in the roots at 130 days and increased in both roots and leaves 180 days under drought stress (Figure.5).

Considering the mean effects of potassium fertilization, it was indicated that increasing the dose of potassium resulted in an increase of phenol concentration in leaves at 130-180 days. On the other hand, the free amino acids concentration was increased in plant leaves at 130 days and then decreased at 180 days whereas it decreased in the plant roots at 130 or180 days.

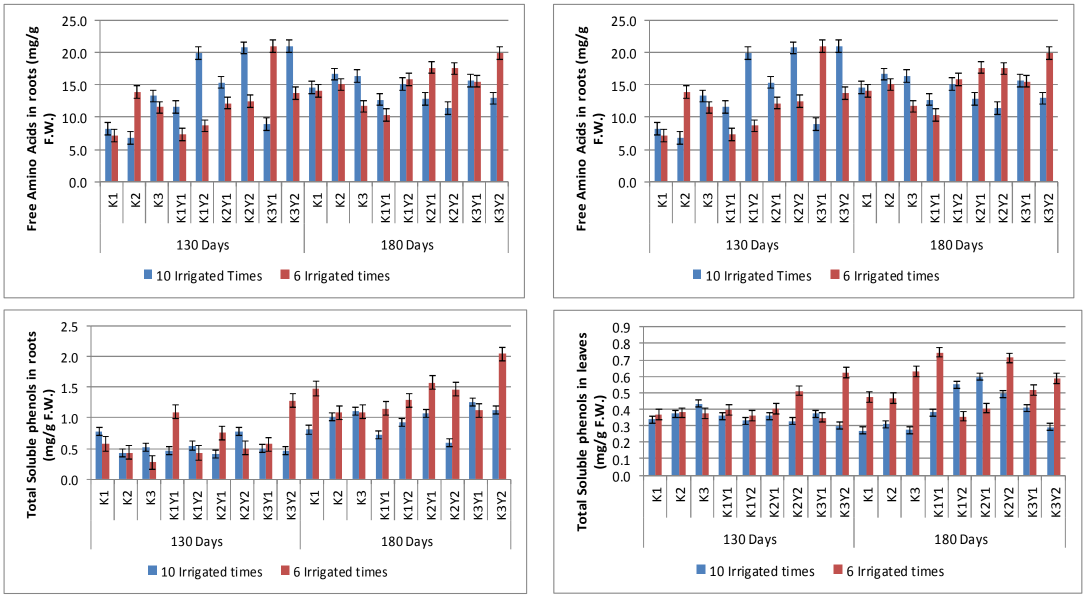


Figure 5. Effect of potassium fertilization and foliar yeast spray on free amino acids in sugar beet (a) leaves, (b) root, and total soluble phenols in (c) leaves (d) root of sugar beet under normal and drought stress.
K1 = 50 kg K_2O, K2=75 kg K_2O, K3= 100 kg K_2O, Y1=10g yeast/l, Y2=14g/l

Furthermore, foliar yeast spray at concentration of 10g/l increased total soluble phenols and free amino acids concentrations in both leaves and roots at 130 days from planting. While they are increased in leaves and decreased in roots at 180 days from planting. In addition of yeast concentration to 14g/l resulted in an increase in total soluble phenols concentrations in both roots and leaves at 130 days while it decreased in roots at 180 days. Furthermore, the free amino acids were increased in roots at 130 and 180 days from planting, while it increased in leaves at 180 days from planting. Finally the treatment K2Y2 significantly increased the total soluble phenols concentrations in sugar beet roots and leaves at 130 days. However, the total soluble phenols and free amino acids significantly recorded higher values in plant leavesthan in roots at 180 days from planting. Under drought stress, the application of treatment K2Y2 resulted in a significant increase in total soluble phenols and free amino acids concentrations the roots and leaves at 130 days whereas, they increased in leaves only at 180 days and decreased in roots.

c. Chlorophyll a, b, total chlorophylls and total carotenoids concentrations

The results affirmed that drought stress has significantly decreased the chlorophyll a and total chlorophyll concentrations in leaves at 130 and 180 days. Meanwhile, no significant differences were obtained in chlorophyll b and total carotenoids concentrations between both irrigation treatments were found at 130 and 180 days. Also, the results revealed that the treatments K2Y2 and K3Y1 had the highest significant concentrations of chlorophyll b, total chlorophyll and total carotenoids at 130 days. On the other hand, no significant differences in chlorophyll a, b and total chlorophyll as well carotenoids concentrations were found among the studied treatments at 180 days.

Meanwhile, the effect of applied potassium and the foliar spray of under drought stress indicated that there were no significant differences among the applied treatments on chlorophyll a, b, and total chlorophylls as well as total carotenoids concentrations in both roots and leaves at 130 and 180 days from planting.

d. Sugar beet root yield and white sugar yield

In a respect to the mean effect of irrigation treatment, drought stress has significantly decreased the white sugar yield/Fed, and beet root yield/ Fed. Furthermore, the results revealed that the increasing in potassium dose has reduced the root weight and white sugar yields. Nevertheless, the addition of yeast at concentration 14g/l, increased both yields. Thus, both treatments K3Y1 and K2Y2 recorded the highest significant root and white sugar yields per Feddan.

Also, the results indicated that the highest significantly root and white sugar yields / Fed were recorded under sufficient irrigation by K3Y1. Meanwhile, under drought stress, the treatment K2Y2 recorded the highest significant root and white sugar yields per Feddan.

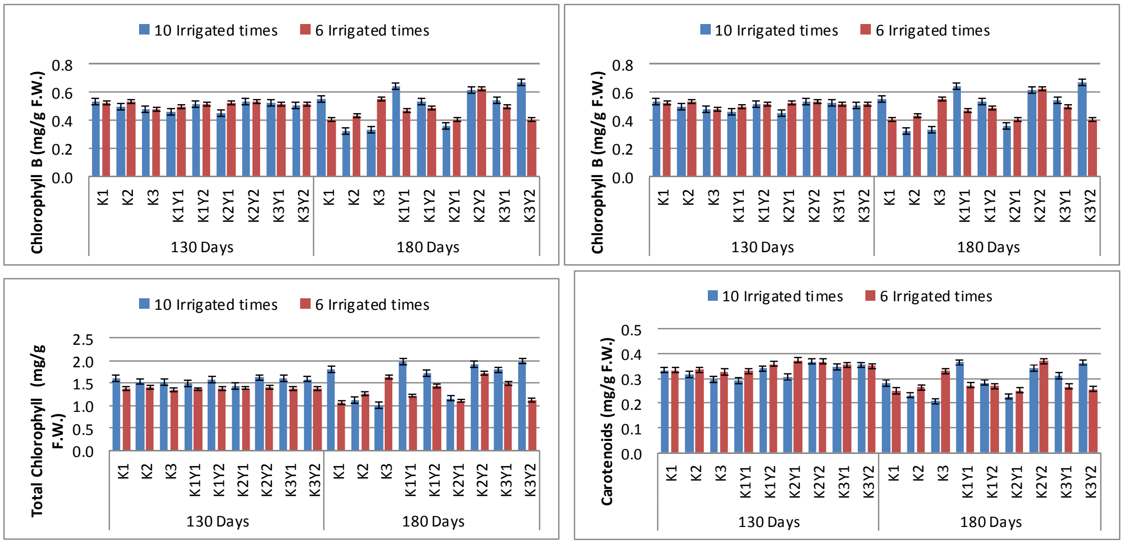


Figure 6. Effect of potassium fertilization and foliar yeast spray on (a) chlorophyll a, (b) chlorophyll b, (c) total chlorophyll, and (d) total carotenoids concentrations in sugar beet leaves under normal and drought stress.
K1 = 50 kg K_2O, K2=75 kg K_2O, K3= 100 kg K_2O, Y1=10g yeast/l, Y2=14g/l

Sugar beet yield attributes

The results showed in figure (8) revealed that there were no significant differences between both irrigation treatments on the sodium percentage, potassium percentage, alpha-amino nitrogen percentage, Impurities%, sucrose%, sucrose recovery%, sugar loss molasses (SLM)%, purity (PUR)% and total soluble solids (TSS)%. In addition, the treatment K2Y1 has the highest significant sodium, potassium, and alpha-amino nitrogen percentage as well as sugar loss molasses percentages, and the lowest significant value in purity percentage. It could be concluded that sodium, potassium and alpha amino nitrogen percentage - impurities percentage - were directly proportional with sugar loss molasses percentage, while the latter has an inversely relationship with the sugar purity percentage as the results indicated that K2Y1 recorded the lowest significant values in sucrose and sucrose recovery percentage. On the other hand, the treatment K1Y1 was completely opposite to the K2Y1 regarding the previously mentioned parameters. Meanwhile, the treatment K2Y2 recorded the highest significant sucrose and sucrose recovery percentage under drought stress. Likewise, the treatment K1Y1 increased the sucrose and sucrose recovery percentage as well as a significant higher purity% under drought stress. Also, K1Y1 and K2Y2 recorded the significantly lowest sugar loss molasses, sodium, potassium, alpha amino nitrogen and the impurities percentages under normal irrigation.

e. Water use efficiency

The results in figure 9 revealed that drought stressed sugar beet had higher significantly record in water use efficiency than those normally irrigated. Also, the results affirmed that the treatment K2Y2, and then K3Y1 showed the highest water use efficiency than the other studied treatments. Finally, the application of the treatment K2Y2 showed the highest significant record in water use efficiency in plants subjected to drought stress. Meanwhile, the treatment K3Y1 recorded the highest significant water use efficiency under sufficient irrigation as compared to other studied treatments under the normal irrigation.

DISCUSSION

1. The effect of drought stress

The results in figure (3) revealed that the plant fresh weight was reduced under drought stress which could be attributed to the foliage and root fresh weight reduction, which was related to the turgor pressure fall, leading to a

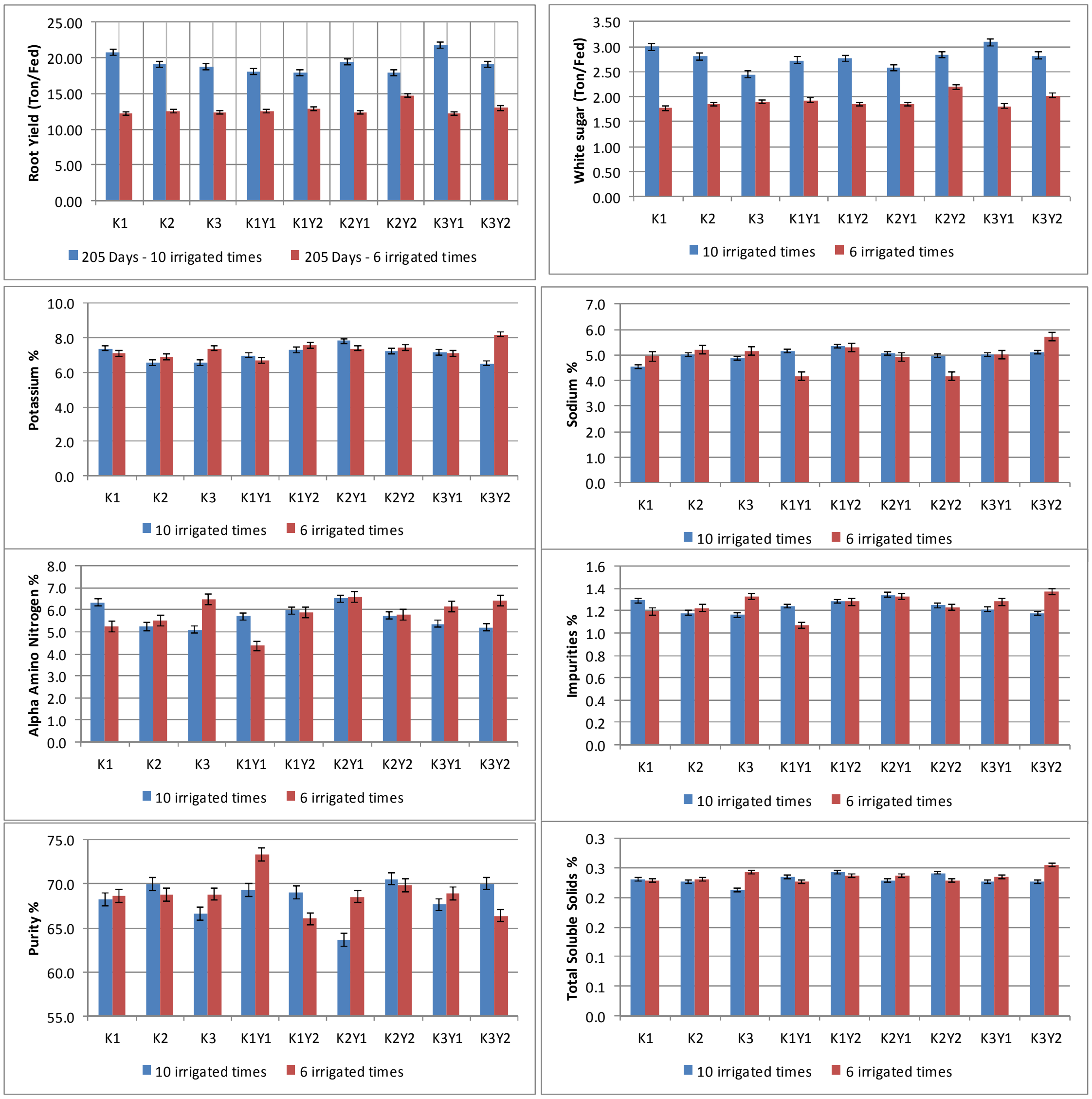


Figure 7. Effect of potassium fertilization and foliar yeast spray on sugar beet (a) root yield/ Fed, (b) white sugar yield/ Fed, (c) K%, (d) Na%, (e) alpha amino-nitrogen, (f) impurities%, (g) purity%, (h) total soluble solids under normal and drought stress
K1 = 50 kg K2O, K2=75 kg K2O, K3= 100 kg K2O, Y1=10g yeast/l, Y2=14g/l

decrease in cellular expansion and resulted in a reduction in leaf area and size. Consequently, the exposed leaf area to the light is decreased leading to a reduction in dry matter light conversion coefficient. Furthermore, the results in figure (3) indicated that the increase in dry matter partitioning towards the storage root was at the expense of leaves growth under drought stress. These results are in agreement with those obtained from Kant and Kafkafi (2001), Bloch *et al.*(2006a), Bloch *et al.*(2006b), . In addition, the Hoffmann (2010)mentioned that most of cambium rings were formed within 10 weeks (70 days) after sowing, while the other two novel ones formed at final harvest. So, drought stress did not affect the root diameter at 130 days after planting. Also, Clarke *et al.* (1993), Dreesmann *et al.* (1994) and Bloch *et al.* (2006a) mentioned that drought stress decreased the photosynthetic rate, transpiration rate and stomatal conductance of sugar beet which resulted in a reduction in reducing sugars, as well as non-reducing sugars (include sucrose). Vassey and Sharkey (1989) mentioned that the extractable activity of SPS (sucrose phosphatase enzyme) was inhibited by more than 60% in water stressed plants. The results in figure (4) indicated an insignificant differences of reducing, non-reducing and total sugar concentrations in roots, at 180 days from planting, between well-irrigated and drought stress plants which might be

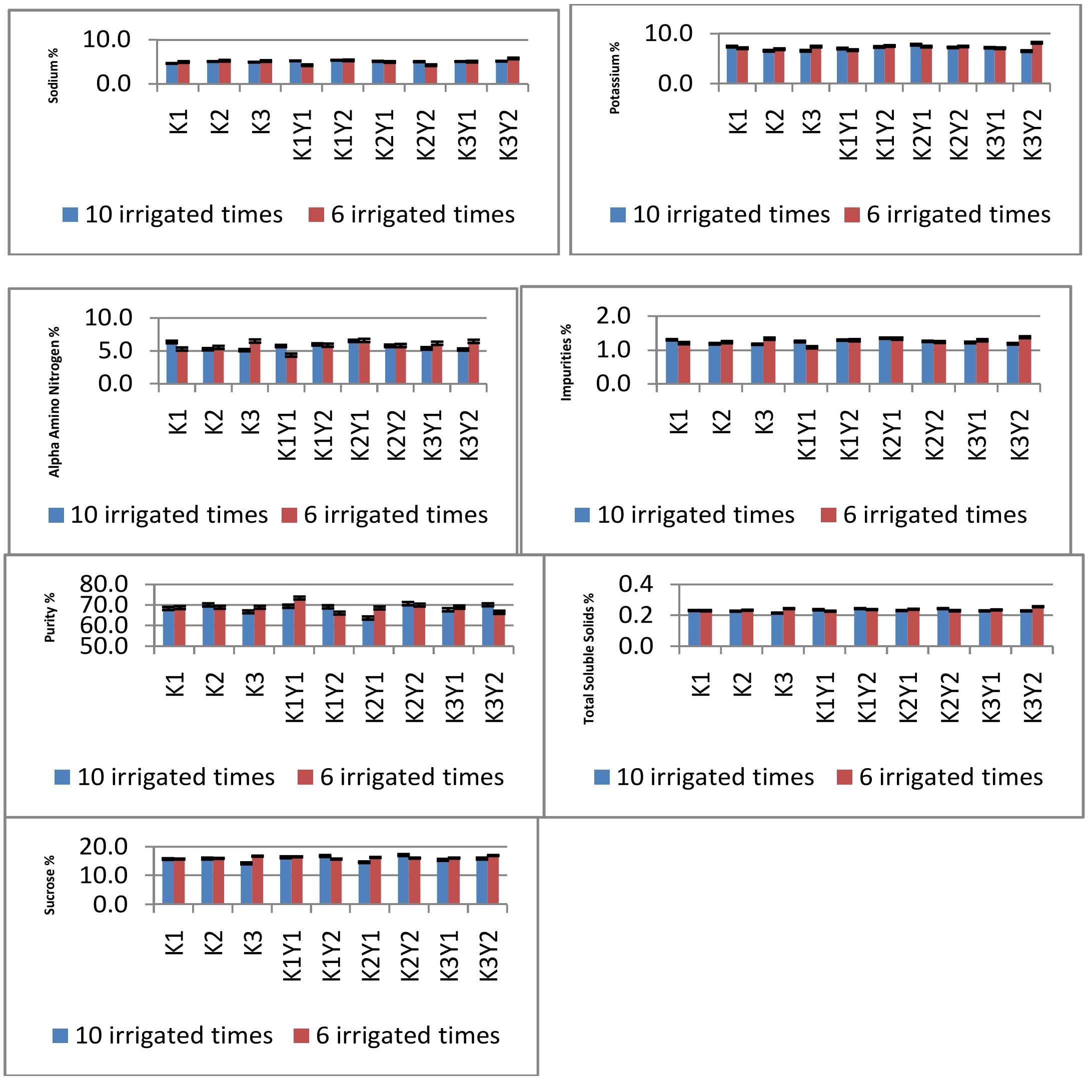


Figure 8. Effect of potassium fertilization and foliar yeast spray on (a) sodium %, (b) potassium %, (c) alpha-amino nitrogen, (d) impurities %, (e) purity %, (f) total soluble solids %, (g) sucrose %, (h) total soluble solids in the sugar beet roots under normal and drought stress.
K1 = 50 kg K_2O, K2=75 kg K_2O, K3= 100 kg K_2O, Y1=10g yeast/l, Y2=14g/l

attributed to the age factor as mentioned by Giaquinta (1979), who found that the source leaves exported about 40 % of the fixed carbon, 70% from them was transferred to the beet root and the remaining transferred to the sink organs, i.e. young leaves and petioles. So, as the plant early aged due to drought stress, less young leaves are formed and the partitioning towards the beet root increased.

Marur *et al.* (1994) observed a sharply increase in proline in plants under drought stress. In addition, the amino acids accumulation increased in the drought stressed plants 107% and 126% than control plants in the plant roots and leaves, respectively. Navari-Izzo *et al.* (1990) mentioned that protein was decreased under drought stress with an increase in accumulation of amino acids, which could reflect either diminishing synthesis or breaking down, leading to increase in amino acids. In addition, Blum and Ebercon (1976) suggested that proline participated as a source of energy, carbon and nitrogen for tissues recovering from water deficit. According to Steward and Lee (1974) proline induced osmotic adjustment of the cell.

The results in figure (6) were in harmony with Xiang *et al.* (2013); Chutia and Borah (2012) who mentioned that chlorophyll b was decreased under drought stress. Drought stress caused a degradation in chlorophyll a. Cha-um and Kirdmanee (2008) found that low water availability induced pigment degradation and total chlorophyll reduction in sugarcane leaves. Rahdari and Hoseini (2012) and Anjum et al. (2011) mentioned that the decrease in chlorophyll content under drought stress is considered a typical

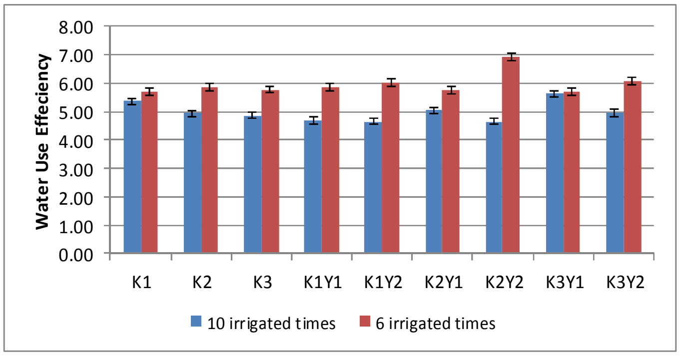


Figure 9. (A) Effect of potassium fertilization and foliar yeast spray on water use efficiency under normal and drought stress. K1 = 50 kg K2O, K2=75 kg K2O, K3= 100 kg K2O, Y1=10g yeast/l, Y2=14g/l

symptom of pigment photo-oxidation and chlorophyll degradation. Chutia and Borah (2012) found that a significant decrease in the chlorophyll a and chlorophyll b as well as total chlorophylls content in the plants subjected to drought stress.

The results in figures (7-9) revealed that the white sugar yield reduction could be attributed to the reduction in root yield/Fed rather than the reduction in sucrose %. This result was in agreement with those of Brown *et al.* (1987) and Bloch et al. (2006), who illustrated that drought stress decreased the sugar beet final sugar yields. In addition, Clover *et al.* (1999) found that drought stress reduced total final root yield, due to root weight reduction rather than sugar concentration.

2. Effect of potassium and foliar spray of yeast

Kant and Kafkafi (2002), Hanahan and Weinberg (2011), Salami and Saadat (2013) and Wang *et al.* (2013) mentioned that potassium plays significant roles in increasing the root elongation, depth, enlarging root absorptive surface, maintaining turgor by reducing water loss and wilting and maximizing water retention in plant tissue, nutrients uptake, phloem unloading, and it enhances the photosynthetic products translocation from the source leaves to the sink organs which subsequently increases the plant dry matter and leads to an increase in the storage root growth. In addition, Draycott (2006) mentioned that K played an essential roles in enzyme activation, protein synthesis, photosynthesis, osmoregulation, stomata movement, energy transfer, phloem transport, cation-anion balance and stress resistance. Abd-El-Hadi *et al.* (1995) mentioned that potassium nutrition improved water use efficiency by its involvement in stomata regulation and so affecting the plant growth and dry matter production. Grzebisz *et al.* (2013) mentioned that the reduction in the root elongation could be referred to the reduction in soil moisture which could influence potassium uptake and its rate of diffusion which in turn reduced the root elongation. This could be the reason for the accumulation of potassium ions by plants before stress initiation which might be considered as insurance strategy to allow the plant to survive the sudden abiotic environmental stresses, This strategy was supposed by Salami and Saadat (2013). Also, Taiz and Zeiger (2002) mentioned that the osmotic adjustment role of potassium accomplished through its ability to form electrostatic bonds with the carboxylic group of organic compounds in the cytosol and cell vacuole.

In addition, the reduction of the reducing sugar in leaves might be resulted from an increase in its conversion to non-reducing sugars, as the main sugar for translocation in beet plant. Potassium enhances the translocation of sugars into sink roots. In this concern, Grzebisz *et al.* (2013) mentioned that the transportation of assimilates in the phloem is also K concentration-dependent. Hong-juan *et al.* (2012a) mentioned that potassium fertilization increased the sweet potato yield, the soluble sugar content, SPS (sucrose phosphate synthase), SS (sucrose synthase) activities and consequently, the transportation of photosynthate from functional leaves to storage roots are improved.

On the contrary, increasing the reducing sugars in the plant roots might refer to the occurrence of the respiration process in the plant roots which resulted in conversion of the non-reducing sugars (sucrose) to reducing sugars in force to obtain energy, which might indicate for insufficient non-reducing sugars translocation. Huber and Huber (1992) mentioned that the degradation of sucrose is essential for providing the metabolic energy and the substrates for the synthesis of the cellular components. Finally, it could conclude that increase in the potassium fertilization mainly increased the conversion of reducing to non-reducing sugar and their translocation to some extent to the beet roots under drought stress.

Bhattacharya *et al.* (2010) mentioned that phenolic compounds in plant have several physiological roles in plant development particularly in lignin and pigment biosynthesis in addition to providing the structural integrity and scaffolding support to plants as well as for plant protection against stresses. Rispail *et al.* (2005) mentioned that phenols have antioxidant actions due to its tendency to chelate with the metals. Phenols might inactivate the iron ions by chelating and suppressing the superoxide driven by Fenton reaction which is believed to be the most important source of ROS-species.

The results in figure (6) were in harmony with Eisa et al. (2012) who mentioned that applying of potassium tended to accelerate the photosynthetic activity in sugar beet under salt stress. In this regards, Salami and Saadat (2013) observed that the increase in root yield is attributed to the stimulatory effect of potassium fertilizer on the rate of photosynthesis.

The results in figures (7-9) were in harmony with Emami (1999) and Seadh (2012) who mentioned that sugar percentage and sugar yield were significantly increased by potassium increase. on the contrary, Salami and Saadat (2013) mentioned that the increased of cations contents might be associated with a decrease in the sucrose and purity percentage. In addition, EL-Taweel (1999) and Tawfic and Mostafa (2012) observed that 24 kg K_2O/Fed was enough to produce the highest value of juice quality as sucrose percentage, purity percentage, root and sugar beet yield, whereas EL-Shafai (2000) mentioned that juice purity was not significantly affected by potassium level.. Hong-juan et al. (2012) reported that potassium increased the sweet potato yield and increased the soluble sugar content and storage roots components. Moreover, the sucrose phosphate synthase (SPS) activity and sucrose content of functional leaves are increased significantly. Additionally, the sucrose synthase (SS) activity and insoluble acid invertase activity of storage roots are increased observably indicating for the transportation of photosynthate from functional leaves to storage roots are improved.

Shehata *et al.* (2012), mentioned that dry yeast as a natural bio-substance has stimulating, nutritional and protective functions when it is used on vegetables. Its protective and stimulatory effects might be attributed to its content that enriched with the sources of phyto-hormones especially cytokinins, vitamins, enzymes, amino acids and minerals. Kraig and Haber (1980) and Castelfranco and Beale (1983) confirmed that dry yeast has stimulatory effects on cell division and enlargement, protein and nucleic acid synthesis and chlorophyll formation and increased photosynthetic process. El-Tohamy and El-Greadly (2007) found that bean and snap bean plants treated by yeast increased significantly the chlorophyll content. El-Tohamy et al. (2008) pointed out that spraying yeast increased chlorophylls, proteins and nucleic acids contents due to its mineral and hormonal content.

CONCLUSION

The increase in potassium fertilization from 50 to 75 Kg K_2O/Fed in combination with foliar spray of yeast at concentration of 14g/l, enhanced the root and leaves as well as overall plant growth under drought stress. In addition, it enhanced the sugar translocation to sink organs at different growth stages. The plant recorded the highest water use efficiency under drought stress with K2Y2 treatment also, it recorded the highest white sugar and root yields under drought stress. On the other hand, the treatment K3Y1 significantly recorded the highest root and white sugar yields under sufficient water irrigation.

ACKNOWLEDGMENTS

I wish to thank everyone who helped me in complete this dissertation. Without their continued help and support, I would have not been able to bring my work to a successful completion, Dr. Ahmed Hussein, professor of plant physiology, who helped me in doing the chemical analysis and Madam Kawther, technical engineering in plant physiology lab.

REFERENCES

Abd-El-Hadi AH, Awad AM, El-Shebeny GM (1995). Effect of potassium on the drought resistance in crop production under the Egyptian conditions, Soil, Water and Enviroment Research Istitute, ARC, Egypt.

Anjum S, Xie X, Wang L, Saleem M, Man C, Lei W (2011). Morphological, physiological and biochemical responses of plants to drought stress. J. African. Agri. Res., 6(9):2026–2032.

AOAC (1975). Official methods of analysis of the association of official analyses chemist. 12th ed., Published by A.O.A.C. Washington D. C.

Bhattacharya A, Sood P, Citovsky V (2010). The roles of plant phenolics in defence and communication during Agrobacterium and Rhizobium infection. Molecular Plant Pathology, 11(5):705–719.

Blakemore LC, Searle PL, Daly B (1987). Methods for chemical analysis of soils, New Zealand Soil Bureau Scientific Report 80.

Bloch D, Hoffmann CM (2005). Seasonal development of genotypic differences in sugar beet (Beta vulgaris L.) and their interaction with water supply. J. Agron. Crop Sci., 191:263–272.

Bloch D, Hoffmann CM, Marlander B (2006). Impact of water supply on photosynthesis, water use and carbon isotope discrimination of different sugar beet genotypes. Eur. J. Agron., 24:218–225.

Blum, A. and Ebercon, A.(1976). Genotype responses in sorghom to drought stress. III- Free proline accumulation and drought resistance. Crop Science, 16:428–431.

Brown, K.F.; Messem, A.B.; Dunham, R.J. and Biscoe, P.V.(1987). Effect of drought on growth and water use of sugar beet. J. Agr. Sci. Camb., 109:421–435.

Brown, R.J. and Serro, R.F.(1954). A method for determination of thin juice purity from individual mother beets. Proc. Am. Soc. Sugar Beet Techno., 8(2):274–278.

Carruthers, A.; Oldfield, J.F.T. and Teague, H.J.(1962). Assessment of beet quality. In The 15th Annual Technical Conference. British Sugar Corporation Ltd., p. 28.

Castelfranco, P.A. and Beale, S.I.(1983). Chlorophyll biosynthesis recent advances and areas of current interest. Ann. Rev. Plant Physio., 34:241–278.

Cha-um, S. and Kirdmanee, C.(2008). Effect of osmotic stress on proline accumulation, photosynthetic abilities and growth of sugar canr plantlets (*Saccharum officinarum L .).* Pak. J. Bot., 40(6):2541–2552.

Chutia J, Borah SP (2012). Water stress effects on leaf growth and chlorophyll content but not the grain yield in traditional rice (*Oryza sativa Linn .)* genotypes of assam , India II . Protein and Proline Status in Seedlings under PEG Induced Water Stress. American Journal of Plant Sciences, 3:971–980.

Clarke N, Hetschkun H, Jones C, Boswel E., Marfaing H (1993). Identification of stress tolerance traits in sugar beet. M. B. Jackson and C. R. Black, eds. Interacting Stresses on Plants in a Changing Climate ., 16:511–524.

Clover GRG (1997). Effects of beet yellow virus and drought on the growth of sugar beet. PhD. thesis, University of Nottingham.

Clover GRG, Smith HG, Azam-Ali SN, Jaggard KW (1999). The effects of drought on sugar beet growth in isolation and in combination with beet yellows virus. Journal of Agricultural Science, 133:251–261.

Cook DA, Scoot RK (1993). Root quality and processing. In The Sugar Beet Crop. p. 581.

Dakkak A (2013). Water Crisis in Egypt. EcoMENA- Eco Sustainability:2.

Draycott AP (2006). Sugar Beet, UK: Blackwell publishing.

Dreesman DC, Harn C, Daie J (1994). Expression of genes encoding rubisco in sugarbeet (*Beta vulgaris . L*) plants subjected to gradual desiccation. Plant cell physiology, 35(4):645–653.

Eisa SS, Ibrahim A, Khafaga HS, Shehata SA (2012). Alleviation of Adverse Effects of Salt Stress on Sugar Beet By Pre-Sowing Seed. Journal of Applied Sciences Research, 8(2):799–806.

EL-Shafai AMA (2000). Effect of nitrogen and potassium fertilization on yield and quality of sugar beet in Sohag.Egypt. J. Agric. Res., 78(2):759–767.

EL-Taweel FMA (1999). Response of some sugar beet varieties to potassium and magnesium fertilizers. Ph.D. Thesis. Fac. Agric. Moshtoh or Zagazig Univ., Egypt.

El-Tohamy WA, El-Abagy HM, El-Greadly NHM (2008). Studies on the Effect of Putrescine, Yeast and Vitamin C on Growth , Yield and Physiological Responses of Eggplant (*Solanum melongena L* .) Under Sandy Soil Conditions. Australian Journal of Basic and Applied Sciences, 2(2):296–300.

El-Tohamy WA, El-Greadly NHM (2007). Physiological Responses , Growth , Yield and Quality of Snap Beans in Response to Foliar Application of Yeast , Vitamin E and Zinc under Sandy Soil Conditions. Australian Journal of Basic and Applied Sciences, 1(3):294–299.

Emami MA (1999). Influence of nitrogen, potassium and boron fertilizer levels on sugar beet under saline soil conditions. J. Agric. Sci. Azad University, 24:1573–1581.

Giaquinta RT (1979). Sucrose Translocation and Storage in the Sugar Beet '. Plant Physiology, 63:828–832.

Grzebisz W, Gransee A, Szczepaniak W, Diatta J (2013). The effects of potassium fertilization on water-use efficiency in crop plants. Journal of Plant Nutrition and Soil Science, 176(3):355–374.

Hanahan D, Weinberg RA (2011). Hallmarks of cancer: the next generation. Cell, 144(5):646–674.

Hang AN, Miller DE (1986). Responses of sugar beet to deficit, high-frequency sprinkler irrigation. II. Sugar beet development and partitioning to root growth. Agronomy Journal, 78(1):15.

Hoffmann CM (2010). Sucrose Accumulation in Sugar Beet Under Drought Stress. Journal of Agronomy and Crop Science, 196:243–252.

Hong-juan L, Chun-yu S, Li-ming Z, Hai-feng Z, Zhen-zhen W, Sha-sha C (2012). Effect of potassium on related enzyme activities in sugar metabolism of edible sweet potato. Acta Metallurgica Sinica, 18(3):724–732.

Huber SC, Huber JL (1992). Role of Sucrose-Phosphate Synthase in Sucrose Metabolism in Leaves. Plant Physiology, 99:1275–1278.

Jackson ML (1973). Soil chemical annalysis, Printice-Hall of India. Private Limited, New Delhi.

Kant S, Kafkafi U (2002). Potassium and Abiotic Stresses in Plants. In N. Pasricha & S. Bansal, eds. Potassium for sustainable crop production. Potash Institute of India, Gurgaon, pp. 233–251.

Khedr ZMA, Farid S (2002). Response of naturally virus infected tomato plants to yeast extract and phosphoric acid application. Annals of Agric. Sci. Moshtohor Egypt, 38(2):927–939.

Kraig E, Haber JE (1980). Messenger ribonucleic acid and protein metabolism during sporulation of Saccharomyces cerevisiae. Journal of bacteriology, 144(3):1098–1112.

Le Docte A (1927). Commerical determination of sugar beet root using the sachr- Le-Docte process. Sugar J., 29:488–492.

Marur CJ, Sodek L, Magalhes AC (1994). Free amino acids in leaves of Cotton plants under water deficit. R.Bras. Fisiol. Veg., 6(2):103–108.

Moore S, Stein WH (1954). A modified ninhydrin reagent for the photometric determination of amino acids and related compounds. J. Biol. Chem., 211:907–913.

Navari-Izzo F, Quartacci MF, Izzo R (1990). Water-stress induced changes in protein and free amino acids in field-grown maize and sunflower. Plant physiology and biochemistry, 28:531–537.

Nornai R (1982). Formula for determination of chlorophyllous pigments extracted with N.N.dimethyl formamide. Plant Physiology, 69:1371–1381.

Pavlinova OA, Balakhontsev EN, Prasolova MF, Turkina MV (2002). Sucrose-Phosphate Synthase , Sucrose Synthase , and Invertase in Sugar Beet Leaves. Russian Journal of Plant Physiology, 49(1):68–73.

Rahdari P, Hoseini SM (2012). Drought Stress : A Review. Inter. J. Agronomy and Plant Production., 3(10):443–446.

Reinefeld E, Emmerich A, Baumgarten G, Winner C, Beiss U (1975). Zur voraussage des Melassezuckers aus Rubenanalysen. Zucker, 27:2–15.

Rispail N, Morris P, Webb KJ (2005). Phenolic compounds: Extraction and Analysis. In A. J. Marquez, ed. Lotus japonicus Handbook. pp. 349–355.

Salami M, Saadat S (2013). Study of potassium and nitrogen fertilizer levels on the yield of sugar beet in jolge cultivar. Journal of Novel Applied Sciences, 2(4):94–100.

Seadh SE (2012). Maximizing sugar beet yields with decreasing mineral fertilization pollution. Inter. J. Agric. Sci., 4(7):293–298.

Shehata SA, Fawzy ZF, El-ramady HR (2012). Response of Cucumber Plants to Foliar Application of Chitosan and Yeast under Greenhouse Conditions. Australian Journal of Basic and Applied Sciences, 6(4):63–71.

Snedecor GW, Cochran WG (1980). Statistical Methods 7th ed. Iowa Stat Univ., ed., USA: Press Amer, Iowa,.

Steward CR, Lee JA (1974). The role of proline accumulation in halophytes. Planta, 120:279–289.

Swain T, Hillis WF (1959). The quantitative analysis of phenolic constituent. J. Sci. Food Agric., 10:63–69.

Taiz L, Zeiger E (2002). Plant Physiology 3rd ed., Sinauer Associates.

Tawfic SF, Mostafa SMI (2012). Nitrogen and potassium fertiization in relation to qualitative and quantitative traitsof two sugar beet varities. J.of Agric. Res. Kafr El-Sheikh Univ., 38(4):489–504.

Texas Water Report(2014). Going Deeper for the solution, Available at: http://www.window.state.tx.us/specialrpt/water/96-1746.pdf.

Vassey TL, Sharkey TD (1989). Mild Water Stress of Phaseolus vulgaris plants leads to reduced starch synthesis and extractable sucrose phosphate synthase activity1. Plant Physiology, 89:1066–1070.

Wang M, Zheng Q, Shen Q, Guo S (2013). The critical role of potassium in plant stress response. International journal of molecular sciences, 14(4):7370–7390.

Watts F, Tempany HA (1908). The polarimetric determination of sucrose. The effect of clarification with basic lead acetate on the optical activity and copper reducing power of sugar solutions. J. Chem. Technol. Biotechnol., 27:53–58.

Xiang D-B, Peng L-X, Zhao J-L, Zou L, Zhao G, Song C (2013). Effect of drought stress on yield, chlorophyll contents and photosynthesis in tartary buckwheat (*Fagopyrum tataricum*). Food, Agriculture and Environment (JFAE), 11(3-4):1358–1363.