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Effects of Yeast Extract and GA_3 on Water Status, Growth, Productivity and Quality of Sweet Potato Grown in Sandy Soils

[1]El-Tohamy, W.A., [1]H.M. El-Abagy, [2]M.A. Badr, [1]S.D. Abou-Hussein, [1]Y.I. Helmy and [1]M.R. Shafeek

[1]Vegetable Research Department, National Research Center, Dokki, Cairo, Egypt
[2]Plant Nutrition Department, National Research Centre, Dokki, Cairo, Egypt

ABSTRACT

The aim of this study was to examine the water status, growth, some physiological characters, and productivity of sweet potato plants (*Ipomoea batatus* L.) in response to foliar applications of yeast extract and low concentrations of Gibberellic acid (GA_3) under sandy soil conditions of new-reclaimed areas in West Delta Region of Egypt. Sweet potato plants responded positively to applications of yeast and GA_3 under sandy soil conditions. The results revealed that all plant growth parameters and productivity were improved in response to the treatments. In addition, total chlorophyll content, relative water content (an indicator of plant water status) of leaves, and total soluble solids of roots were significantly higher in plants treated by yeast and GA_3 compared to control plants. The possible explanations of the effects of treatments on growth, productivity and physiological changes are discussed.

Key words: Water relations, Sandy soil, Relative water content, Chlorophyll content

Introduction

Sweet potato is one of the important vegetables grown in Egypt and world-wide. However, new-reclaimed lands are mostly sandy in texture and present various adverse conditions, such as e.g. poor fertility and low water holding capacity. These and other unfavorable environmental conditions can limit growth and productivity of plants. Special requirements combined with good agricultural practices are needed, in order to make sure a rentable production and a safety product quality.

Recently, the application of environmentally-safe methods are attracting the interest of growers. One of them, the application of yeast extracts is indicated to improve the negative effects of unfavorable environmental conditions such as drought and increased yield of wheat plants (Hammad and Ali, 2014). Yeast application is also found to enhance growth, yield and other plant parameters of snap bean plants (Abdel-Hakim *et al*., 2012).

Moreover, Gibberellic acid (GA_3) is a plant growth hormone ($C_{19}H_{22}O_6$) that regulates seed germination, stem elongation, leaf expansion, fruit development, flowering and stimulation of secondary metabolite production in plants (Ahmad Dar *et al*. 2015). Exogenous application of GA_3 can affect different plant parameters. El-Tohamy *et al*., (2012) reported that application with low concentrations of GA_3 increased vegetative plant growth parameters, yield, total soluble solids (T.S.S.) of fruits, and total chlorophyll content of leaves of cape goosberry plants. The foliar application of GA_3 affected growth and product quality of spinach plants (Shehata *et al*., 2001), and in combination with soil applied phosphorus enhanced growth, biochemical attributes and yield of fenugreek (Ahmad Dar *et al*. 2015). Other authors reported an improvement on the tolerance to adverse conditions such as water deficit in many plants including maize (Kaya *et al*., 2006), lettuce (Abdel-Kader, 2001) and fenugreek plants (Alhadi *et al*., 1999) by using this plant hormone.

To our knowledge, very few studies have been carried out to investigate the effect of yeast extracts and/or GA_3 on water status of sweet potatoes. The aim of the study was to explore the effects of yeast extracts, as an environmentally and healthy safe method and of low concentrations of plant hormone GA_3 on water status, growth, productivity and quality of sweet potato plants. Our hypothesis was that this these substances could improve plant grown and product quality of sweet potatoes, cultivated under sandy soils conditions.

Materials and Methods

The experiments were carried out at the experimental research station of the National Research Center in Nubaria, West Delta Region of Egypt. Cuttings of sweet potato *cv.* ‘Abees’, were grown during the 2^{nd} week of April 2012 and 2013. A drip irrigation system was used. The soil of the experimental site was deep and well-

Corresponding Author: El-Tohamy, W.A., Vegetable Research Department, National Research Center, Dokki, Cairo, Egypt.
E-mail: waeleltohamy27@gmail.com

drained with 85.5% sand, 11.7% silt and 2.8% clay, an alkaline pH of 8.2, an EC of 0.85 dS m^{-1}, and with 1.5% $CaCO_3$. The average available N, P and K in 30 cm top soil was 0, 2 and 17 mg kg^{-1} soil, respectively before the onset of the experiment. After three weeks, plants were sprayed twice at 14 days intervals with yeast at a concentration of 5 and 10 g/L or GA_3 at a concentration of 100 and 200 ppm, respectively. Control plants were only sprayed with water. All agricultural practices required for sweet potato production in sandy soils were followed as recommended by the ministry of agriculture in Egypt.

Preparation of the Yeast
Active dry yeast were dissolved in water followed by adding sugar at ratio 1:1 and kept overnight for activation and reproduction of yeast.

Measurements
The following parameters were recorded:
Plant growth, quality and yield. Plant length, number of branches, fresh weight of plants, root length, root diameter and total yield were measured at the end of the experiments.

Physiological measurements. Total chlorophyll content of leaves, using a TYS-A chlorophyll Meter (Zhe Jang Top Instrument Co. LTD., China) was measured. In addition, relative water content (RWC) was determined. For this reason, leaf discus of 14 mm diameter punched from the 2^{nd} fully expanded leaves of intact plants were used, according to the method described by Turner (1981).

T.S.S. of roots was measured by a portable refractometer at the end of the experiments.

Statistical analysis:
The experiments were arranged in a completely randomized block design with 4 replicates and analysis of variance was calculated according to Snedecor and Cochran (1967). Least significant difference (L.S.D.) at 5% was used to compare between means.

Results and Discussion

The influence of yeast and GA_3 on physiological parameters of sweet potatoes

Chlorophyll content of sweet potato leaves changed markedly in response to yeast or GA_3 applications (Figure 1). Yeast at a concentration of 10 ml/L and GA_3 at a concentration of 200 ppm had pronounced effects on total chlorophyll of leaves and improved it. The effects of yeast extract on total chlorophyll content of sweet potato plants are in agreement with the results obtained by Amer (2004), who found that applying yeast significantly increased chlorophyll content of bean plants, most likely due to its content in cytokinins (Kraig and Haber 1980, Spencer *et al.* 1983).

On the other hand, Kaya *et al*. (2006) stated that exogenous application of GA_3 improved the water stress tolerance in maize plants by maintaining membrane permeability and enhancing chlorophyll concentration as well as some macro-nutrients in leaves. Ahmad Dar *et al* (2015), found in experiments with *Trigonella foenum-graecum* L., commonly known as fenugreek and used as an antidiabetic plant, that combination of GA_3 and phosphorus significantly increased the activities of nitrate reductase and carbonic anhydrase enzymes that in turn also enhanced the content of total chlorophyll and carotenoids. The authors stated that the increased contents of chlorophyll could, possibly, be attributed to the enhancement of ultrastructural morphogenesis of plastids by GA_3 as suggested by Arteca (1996).

Similar trend was observed regarding the RWC of leaves (Figure 2). Compared to control, the application of yeast extract and GA_3 resulted in a significant improvement of RWC of leaves in both seasons. Hammad and Ali (2014) found similar effect in wheat. In addition to RWC, the authors reported that yeast extract significantly increased photosynthetic pigments, total free amino acids, enzymes activities, and NPK concentrations and uptakes. These results indicated that the application of natural substances like yeast led to overcome the deleterious effect of drought and consequently resulted in improved the productivity of wheat and its grain quality.

Alhadi *et al*. (1999) applied GA_3 to fenugreek seeds before sowing. They observed that different changes in growth, physiological, and biochemical parameters, such as e.g. a decreasing of leave area by reducing the number and volume of cells, were shown under water deficit conditions, while GA_3 treatment promote the growth processes. Also, Kaya *et al*. (2006) indicated that water stress reduced the total dry weight, chlorophyll concentration, and leaf RWC and found that GA_3 concentrations largely improved these physiological parameters.

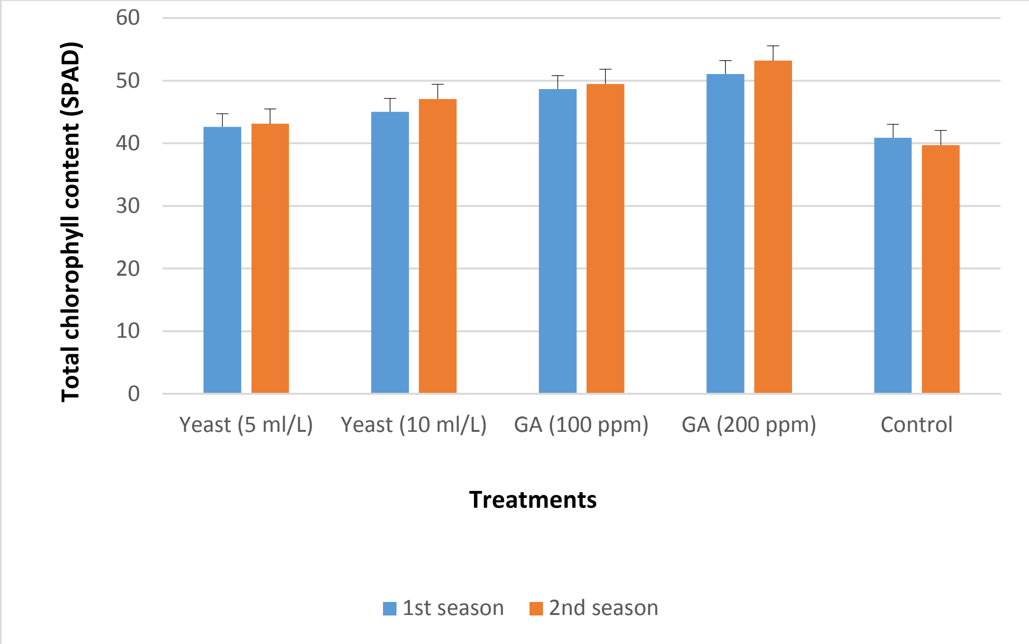

Fig. 1: Effects of yeast and GA_3 on total chlorophyll content of sweet potato leaves (Length of vertical bars present LSD values at 5%).

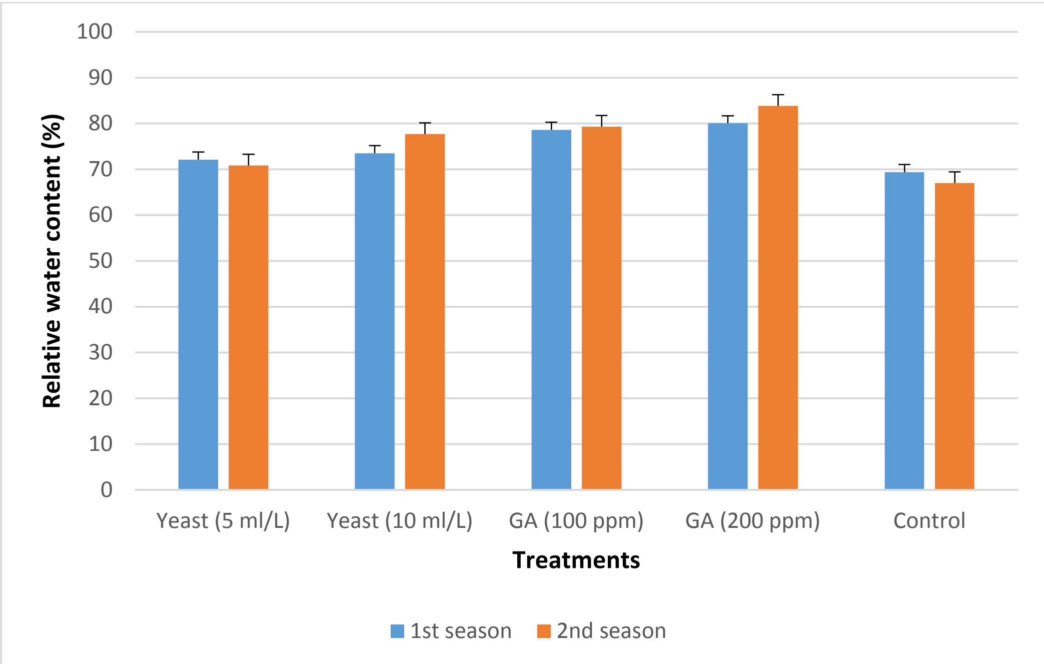

Fig. 2: Effects of yeast and GA_3 on relative water content of leaves of sweet potato plants. (Length of vertical bars present LSD values at 5%).

As indicated in Figure 3, T.S.S. of sweet potato were significantly improved especially by the high concentration of yeast and both GA_3-treatments, respectively compared to control plants, indicating that treatments could improve the quality of roots. These results agreed with Hammad and Ali (2014), who found that yeast extract significantly increased T.S.S. of wheat. El-Tohamy *et al*. (2012), reported that GA_3 could promoted high amounts of assimilates which in turn played an important role in increasing yield and improving fruit quality of Cape gooseberry, indicated by T.S.S. of fruits.

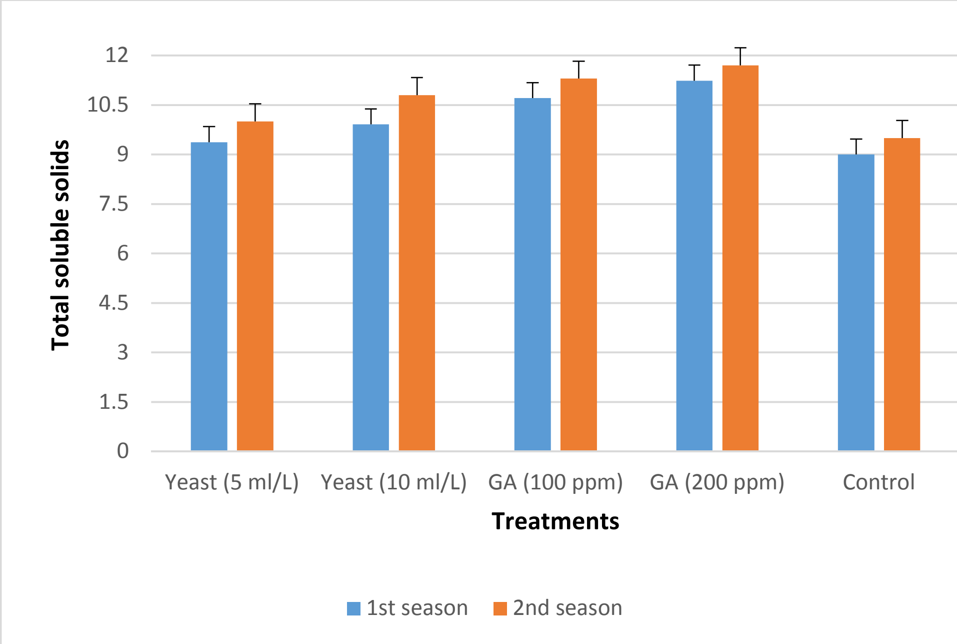

Fig. 3: Effects of yeast and GA_3 on total soluble solids of sweet potato roots. (Length of vertical bars present LSD values at 5%).

Plant growth and productivity

Generally, the application of yeast and GA_3 significantly improved sweet potato growth and yield, cultivated under sandy soil conditions. The results for plant height, number of branches, fresh weight of plants and total yield as well as for some root characters, such as e.g. root length and diameter are presented in Table 1 and 2. Only yeast at 5 ml/L in the 1st season had no significant effect on total yield compared to control. For all other parameters a significant improvement on plant growth and yield was found.

The highest growth and productivity were obtained by the high level of GA_3. However, the high level of yeast had also significant values compared to control plants. The enhancement of growth parameters and yield in response to yeast application was proved in vegetable plants such as bean (El-Tohamy and El-Greadly, 2007) and eggplants (El-Tohamy *et al*., 2008). Yeast is as a natural source of cytokinins as it enhances cell division, enlargement and protein, chlorophyll and nucleic acid synthesis (Kraig and Haber 1980), Spencer *et al* 1983, Castelfranco and Beale 1983, and Fathy and Farid 1996). Yeast is also known for its mitigation of the harmful effects of adverse conditions such as drought and in turn increased the yield of plants such as wheat (Hammad and Ali, 2014). Moreover, Abdel-Hakim *el al*. (2012) found that yeast enhanced growth, yield and yield components along with the chemical composition of fresh and/or dry plants and green pods of snap bean plants. The authors stated that such substances play a role in cold stress tolerance of snap bean plants, promote plant growth and increase marketable yield. The improvement of snap bean growth in response to the foliar application of active dry yeast may be attributed to its contents of different nutrients, higher percentage of proteins, higher values of vitamins, especially vitamin B, which may play an important role in improving growth and controlling the incidence of fungi diseases as mentioned by Meyer and Phaff (1969) and Subba Rao (1984). In a previous study by El-Tohamy *et al*. (2014), Abees variety responded differently compared to the present study regarding growth and productivity of plants. Moreover, this may be due to climatic fluctuations as both studies were conducted in different seasons. However, it seems that the climatic fluctuations were not very clear in the present study as plants responded in the same trend in both seasons.

On the other hand, GA_3 application enhanced vegetative growth and yield of Cape gooseberry plants (El-Tohamy *et al*., 2012). Shehata *et al*. (2001) also found that GA_3 stimulated growth and improved quality of spinach plants. Foliar application of GA_3 progressively improved the growth and yield attributes of fenugreek, such as e.g. shoot and root length, leaf number and area, shoot and root fresh and dry, seed and biological yield, harvest index, 1,000 seed weight, pod length and number of pods per plant (Ahmad Dar *et a*l. 2015). The authors see the above-mentioned improvements on increased CO_2 fixation and leaf area and changes in plant enzymatic activity. Abdel-Kader (2001) found that the treatment with gibberellic acid alleviated the adverse effects of drought stress on lettuce plants.

Table 1: Effects of yeast and GA_3 on some vegetative growth parameters of sweet potato plants.

Treatments	Plant length (cm)	Number of branches / plant	Plant fresh weight (g/plant)
	1st season		
Yeast (5 ml/L)	126.25	3.50	429.93
Yeast (10 ml/L)	162.25	4.25	511.75
GA_3 (100 ppm)	161.50	4.50	407.55
GA_3 (200 ppm)	170.10	4.75	590.10
Control	120.75	2.25	250.90
L.S.D. at 5%	4.99	0.82	11.25
	2nd season		
Yeast (5 ml/L)	131.88	3.75	440.75
Yeast (10 ml/L)	164.58	4.75	513.25
GA_3 (100 ppm)	163.45	4.75	408.00
GA_3 (200 ppm)	169.25	5.25	605.38
Control	121.25	2.75	254.40
L.S.D. at 5%	5.82	0.77	16.70

Table 2: Effects of yeast and GA_3 on some root quality characters and yield of sweet potato plants.

Treatment	Root diameter (cm)	Root length (cm)	Yield (g/plant)
	1st season		
Yeast (5 ml/L)	6.35	16.38	1450.63
Yeast (10 ml/L)	7.58	17.58	1611.30
GA (100 ppm)	8.03	17.08	1693.48
GA (200 ppm)	8.93	18.48	1832.07
Control	5.63	15.40	1269.00
L.S.D. at 5%	0.51	0.54	184.10
	2nd season		
Yeast (5 ml/L)	6.58	16.45	1582.73
Yeast (10 ml/L)	7.95	17.83	1768.99
GA (100 ppm)	8.13	17.48	1797.19
GA (200 ppm)	9.43	18.75	1914.63
Control	5.85	15.60	1371.23
L.S.D. at 5%	0.66	0.49	204.20

In conclusion, it could be stated that the application of yeast extracts as an environmentally-safe method and low concentrations of the plant growth regulator GA_3 could improve water status, maintained higher chlorophyll content of leaves and subsequently had positive effects on growth, productivity and quality of sweet potatoes under sandy soil conditions.

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