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EFFECT OF APPLICATION OF YEAST EXTRACT ON HYDROPONIC TOMATO PLANTS GROWN IN A SOILLESS CULTURE SYSTEM

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Abstract

A hydroponic experiment was conducted to investigate the effect of yeast extract at different concentrations (1, 2, 3, 4 and 8 g/L) on growth, photosynthetic pigments, fruit yield and quality. Significant increases in photosynthetic pigments (Chl. a, chl. B, carotenoids and total pigments) of tomato plants were achieved by concentrations till 4g/L as compared to control non-treated tomato plants. There were significant increases of fresh and dry weights of shoots and roots, fruit number and thickness and average fresh and dry weights of fruits. Supplementation the soilless culture system with different concentrations of yeast extract caused increases in vitamin C, lycopene, carotenoid contents, total acidity, total soluble sugars, total carbohydrates, total protein content of the produced hydroponic tomato fruits. 3g/L was the best effective. 8g/L concentration showed a retarding effect on growth and quality of the produced fruits compared to control plants. According to these results, it could be suggested that yeast extract especially at 3g/L could be used for increasing growth, fruit productivity and quality of stomato plants grown in a soilless culture system.

Key words: Tomato*, Lycopersicum esculentum*, growth, yeast extract, Flower quality, Photosynthetic pigments, Yield.

Introduction

Tomato (*Lycopersicum esculentum*) belongs to the family Solanaceae and it is one of the most consumed and commercially produced vegetable all over the world (Ensminger *et al.,* 1994). It is the third most popular fresh market vegetable behind potato and onion and used in various forms, such as fresh salad, cooked foods, ketchup, paste etc. It is rich in antioxidants, vitamins and minerals. Including tomato in the diet can help in slowing down cellular aging and protect against cancer and cardiovascular risk, maintain healthy blood pressure and reduce blood glucose in people with diabetes. It contains key carotenoids such as lycopene and lutein, which are active compounds can protect the eyes against light induced damage (Di Cesare *et al.,* 2012; Abdel-Monaim 2012).

Bread yeast (*Saccharomyces cerevisae*) is one of the bio-fertilizers that provide safe plant nutrition and free of any environmental damaging products. It is very rich in amino acids and when yeast is put in water, it hydrolyses (*i.e.* formed extracted as a result of internal enzymes activity without the addition of external enzymes) to a large number of vitamins and mineral salts, amino acids, but what is the most important of them all is the cytokinin hormone, which is considered to activate the roots and increase the vegetative growth rate in the first ages of the plant life (Neklyudov *et al.,* 1993). Yeast is considered as a new promising plant growth promoting yeast for different crops. Recently, it became a positive alternative to chemical fertilizers safely used for human, animal and environment (Omran *et al.,* 2000). Khalil and Ismael (2010) reported that treatment of Lupinus termis plants with yeast increased growth parameters resulting in an increase in yield and yield attributes. Barnett *et al.,* 1990 was attributed the beneficial role of yeast on vegetative and reproductive growth to its high auxin and cytokinin contents and enhancement of carbohydrate accumulation. In addition, El- Desouky *et al.,* 1998; Wanas, 2002 and 2006 stated that foliar application with yeast gave the highest significant values of nitrogen, protein and carbohydrate percentages. Also, it has stimulatory effects on cell division and enlargement, protein and nucleic acid synthesis and chlorophyll formation. In addition, Mahmoued (2001) reported that, yeast extract contains protective agent, *i.e.* sugars, protein, amino acid and also several vitamins. In addition, improving growth, flowering and fruit setting of some plants by using a foliar application with yeast extract was reported by Abou-Aly (2005) and

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Wanas (2006). Furthermore, many investigations indicated that yeast is a natural source cytokines of cytokinins and has stimulatory effects on bean plants (Amer, 2004) and Wanas (2006). Furthermore Abou El-Yazied and Mady (2011) indicated that foliar application of yeast increased the number of branches and leaves, leaf area and leaf dry weight of Lycopersicum esculentum and obviously increased photosynthetic pigments, N, P, K, Fe, Zn, Mn, total carbohydrates and crude protein concentrations in leaves of treated plants as compared with those of untreated ones. Also, all treatments increased auxin, gibberellin and cytokinin levels in tomato shoots In addition, the chemical composition of minerals and some bioconstituents such as carbohydrates, vitamin C and total soluble solids in tomato fruits were also increased at the same treatments.

Hydroponic culture is the production of plants by suspending the their roots in a nutrient-rich, oxygenated solution for rapid growth, stronger yields and superior quality. This usually dampens any harmful effects of pH issues, overfeeding and overwatering. The plant's root system is exposed directly to water and nutrition. The root energy which was expended for acquiring food and water can be redirected into the plant's maturation (Gericke and William, 1937). As a result, leaf growth flourishes as does the blooming of fruits and flowers. Under water shortage and weather dryness in the world, aquaculture methods may be a promising way to grow some crops. Literature records several investigations for aquaculture applications in many countries of the world (Victor, 2017). Therefore, it is important to seek ways to increase production of hydroponics for important crops used extensively moreover it is desirable that these methods are considered safe from environmental and health perspectives. Organic fertilizers such as adding useful types of certain fungi has been found to increase productivity (Kaewchai *et al.,* 2009). Growing tomatoes hydroponically allow the grower to raise them in a controlled environment with less chance of disease, faster growth and greater fruit yield (Andrew Carberry, 2020).

Table 1: Effect of yeast extract on growth of hydroponic tomato plants grown in a soiless culture system.

Parameters	Yeast extract concentration g/L					
	0.0	1	2	3	4	8
Shoot height (cm/plant)	28.46^{f}	30.6^{e}	32.56^{d}	41.4^{a}	35.3^{c}	18.4^{b}
Shoot fresh wt.(g/plant)	31.5^{f}	35.7^{e}	42.3^{d}	60.8^{a}	50.7^{c}	20.5^{b}
Shoot dry wt.(g/plant)	3.9^{e}	4.6^{de}	5.5^{d}	11.3^{a}	6.7^{c}	2.7^{b}
Root fresh wt.(g/plant)	8.7^{f}	15.6^{e}	24.03^{d}	31.2^{a}	26.7^{c}	6.4^{b}
Root dry wt. (g/plant)	1.05^{d}	1.7^{c}	2.4^{b}	4.03a	2.7^{b}	0.9^{a}
No. of leaves /plant	98.9^{f}	103e	126.3^{d}	193a	149^{c}	64^{b}
Leaf area (cm^{2}/plant)	25.8^{f}	29.7^{e}	35.53^{d}	50.4^{a}	42.46^{c}	16.5^{b}

Values in each row followed by the same are not significantly different at at P ≤ 0.05 (Duncan's multiple range test).

Therefore, the aim of the present study is to improve growth and quality of tomato plants cultivated in a hydroponic soilless culture system by supplementation the system with yeast extract at different concentrations.

Materials and Methods

The experiment was carried out during summer of 2018 (1April) in the agriculture research Centre, Horticulture institute, Giza, to study the effect of application of yeast extract, on growth, yield and fruit quality of tomato (*Lycopersicon esculentum* L.) plants grown in a soilless agriculture system. Dry yeast was obtained from local market) Fares Alhaj *et al.,* 2017). Tomato seeds were surface sterilized by immersing it in 70% ethanol for 5 min, soaked in 5% aqueous sodium hypochlorite for one minute and carefully rinsed 3 times in sterile distilled water. Seeds were germinated on filter paper at growth chamber under 30 degree Celsius till seedlings14 days old were established. The 14th seedlings were immediately transplanted in pots filled with perlite in the wick system. Perlite is lightweight, easy to handle, clean and has no odor. It has a pH of 7.5. Two seedlings in each circled hole of the used pipes and incubated with led light. Root zone was periodic flooded with Hogland nutrient solution and this is followed by draining of the excess solution into a reservoir to let plants breathe in a Wick hydroponic system. This cycle happens throughout the day on a set timer. 6 pvc pipes were used, each one have 7 inch diameter. Each pipe was drilled 5 circled holes for culture pots. Pipes were suspended vertically on metal stands. The 6 Pipes were supplied with 6water reservoir and 2wicks/pipe, one for irrigation and the other for the drainage. Each water reservoir was supplied with air pump. Yeast extracts with different concentrations (0.0, 1, 2, 3, 4, 6 and 8g/L) were added to the nutrient solution every month, nutrients rise for the transplanted tomato by capillarity through wicks. After 75 days, harvesting and chemical analyses were carried out. Shoot height, Fresh and dry weights of shoots and roots, leaf number per plant were recorded at harvest. Leaf area was measured using a leaf area meter (Li-Cor, Lincoln, NE, USA). Fruit number, average weight of fruit's fresh and dry for each treatment were also recorded. Fruit masses in each treatment were recorded.

Chemical analyses were carried out in the genetic engineering institute, Agriculture research center in Giza.

Photosynthetic pigments were estimated according to Metzner *et al.,* (1965) in 85% acetone extracted leaves. Total carbohydrate content was determined using the enthrone method described by Umbriet et al (1959). The soluble protein content of leaf samples was determined using the method of Lowry *et al.,* (1959). Total acidity in fruits for each treatment was determined in the supernatant obtained by extracting 10 g of fruit with distilled water according to the method of Wills and Ku (2002) using citric acid as a reference. Fruit carotenoids were extracted from the fruit pericarp by acetone (85%) and determined according to Lichtenthaler and Weliburn (1983). Vitamin C in the fruit extract was estimated according to Pearson (1970). Lycopene content in the fruit extracts was assessed by RP-HPLC (Allteck, Milano, Italy) in the central laboratory of the genetic engineering institute of the agriculture research center where the pigment was separated using a C18 luna column equipped with a luna C18 guard column, utilizing a solution of Methyl hydroxide/THF as mobile phase. The flow rate was set at 2 ml/min and the elution of the compounds was obtained at isocratic conditions. Detection was performed at 450 nm and the peaks were tentatively identified by comparing their retention times to those of the lycopene standard. ANOVA program was used to analyze the results. A complete randomized block design at the 5% significance level and Duncan test were performed in the statistical analysis.

Results and Discussion

Effect of yeast extract on growth of hydroponic tomato plants grown in a soilless culture system

In comparison of the control plants of hydroponic tomatoes (75 days) with treated ones by yeast extract at different concentrations, it is clear that shoot height, shoot fresh and dry weights, root fresh and dry weights, number of leaves and leaf area of the treated plants were significantly increased till 4g/L yeast extract. 3g/L was the best applied dose, while 8 g/L which is the higher used concentration recorded a retarding effect on vegetative growth compared with untreated plants. These findings are in agreement with the El-Tohamy *et al.,* (2008) whose indicated that the application of yeast increased eggplant growth.The improvement of growth in response to yeast application on tomato may be due to its contents of different nutrients, higher amino acid percentage, higher values of vitamins, especially B and growth regulators like adenine and betaines which may play an important role in improving growth (Abou El-Yazied and Mady 2011). Also they reported significant increases in photosynthetic pigments, N, P, K, Fe, Zn and Mn in tomato leaves and endogenous phytohormones. Shehata *et al.,* (2000); Sridhar *et al.,* (2009) attributed the stimulatory effect of yeast extract on the growth parameters of tomato to the endogenous phytohormones specially the growth promoters, *i.e.* Auxins, gibberellins and cytokinins. Also, Attia and Jadoa (1999) reported that yeast extract affect cytokinesis process and play a role in induction of cell expansion of maize because of its content of proteins, vitamin B, thiamine, riboflavin, auxin and gibberellin. The leaf area increase may be resulted from the rapid rate of movement of nutrients and hormones transported through the transpiration stream from roots which can accelerate the rate of leaf expansion in the developing leaves (Aldesuquy and Ibrahim 2000). The higher yeast extract concentration 8g/L may led to an increase of abscisic (ABA) acid production in hydroponic tomatoes, which is often referred to as an inhibitory rather than stimulatory hormone, to which the retarding effect may be attributed. ABA is also known to inhibit other hormonal actions. Also, it may cause increases of the growth hormones; auxins, gibberellins and cytokinins to their maximum concentrations which exert a retarding effect (Abou El-Yazied and Mady 2011).

Effect of yeast extract on photosynthetic pigments of hydroponic tomato plants grown in a soilless culture system.

Data represented in Fig. 1 indicate that, 3g/L yeast extract had the superior positive effect on chlorophyll a, chlorophyll b, carotenoids and total pigments content of hydroponic tomato plants (75 days) cultivated in a soilless culture system enriched with different concentrations of yeast extract relative to controls, while higher applied yeast extract concentration (8g/L) had a drastic effect on them. The present results are in agreement with those of El-Tohamy and EL-Greadly (2007), they found that application of yeast extract at 4 g/L increased chlorophyll a and b as well as caroteinods in snap bean plants. The improvement of photosynthetic pigments in response to the yeast extract may be due to its effect on bioregulators which affect the balance between photosynthesis and photorespiration in plants (Olaiya, 2010b and El-Yazied and Mady 2011). Also Shalaby and El-Nady (2008) reported that yeast cytokinins delay the aging of leaves by reducing the degradation of chlorophyll and enhancing the protein and RNA synthesis. The negative effect of the higher applied dose of yeast extract 8g/L on photosynthetic pigments might be attributed to an its effect on vegetative growth, number of leaves and leaf area.

Effect of yeast extract on fruit yield of hydroponic tomato plants grown in a soilless culture system

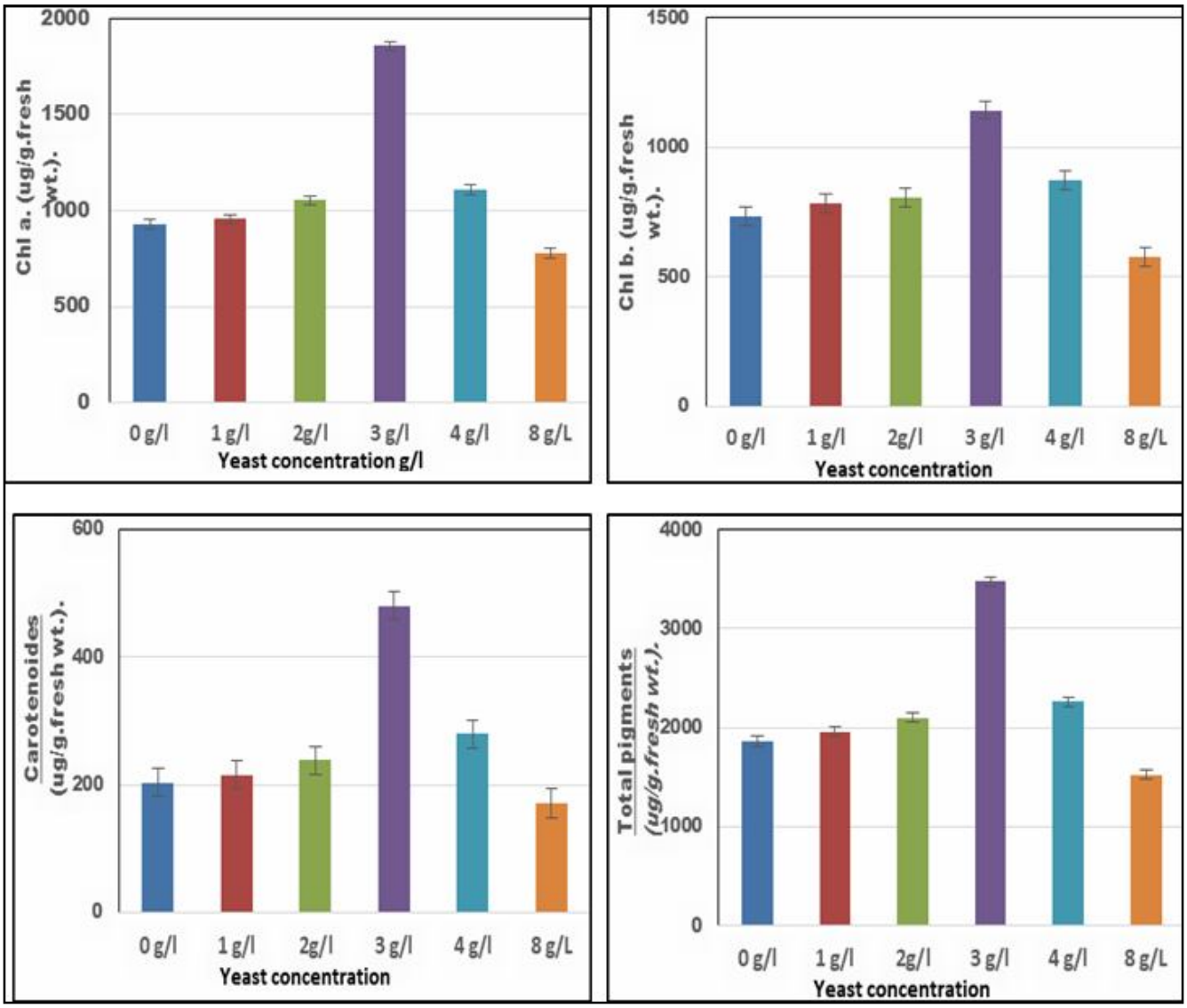

Fig. 1: Effect of yeast extracts on the photosynthetic pigments content of hydroponic tomato plants grown in a soilless culture system.

As shown in Fig. 3 all fruit criteria including fruit number, average fruit weight and fruit thickness of hydroponic tomatoes were considerably improved by supplementation of the soilless system with yeast extract till 4g/L concentration and 3g/L represents the superior. Whereas 8 g/L recorded a retarding effect on fruit yield and quality compared with control plants. The beneficial effects of yeast extract on fruit yield may be due to the translocation of more photoassimilation to fruits, thereby increasing fruit weight. Our findings are supported by the results of Abou El-Yazied and Mady 2011 who stated that the increases of early and total yields might be reflection to the increase of pollen grain fertility and hence fruit setting. Also, El-Tohamy *et al.,* (2008) on eggplant indicated that the application of yeast extract increased yields and their component. The increased yield of at certain doses can be attributed to higher dry matter in reproductive parts, higher fruit set as well as yield (Sridhar *et al.,* 2009).

Effect of yeast extract on fruit quality of hydroponic tomato plants grown in a soilless culture system

Analysis of the juice of the produced tomato fruits may be taken as an indicator of the quality of the resultant fruits. Data represented in Fig. 3 clears that, the application of yeast extract till 4g/L on hydroponic tomatoes grown in the soilless system significantly increased total acidity, vitamin C and carotenoids, total soluble sugar content, total carbohydrates and total protein of the juice of the fruits of hydroponic tomatoes compared with control untreated plants. Also, Lycopene, which is responsible for the red colour of tomatoes, is greatly affected by the application of yeast extract. Yeast extracts till 4g/L considerably improved lycopene content in hydroponic tomatoes. It has been shown that 8g/L yeast

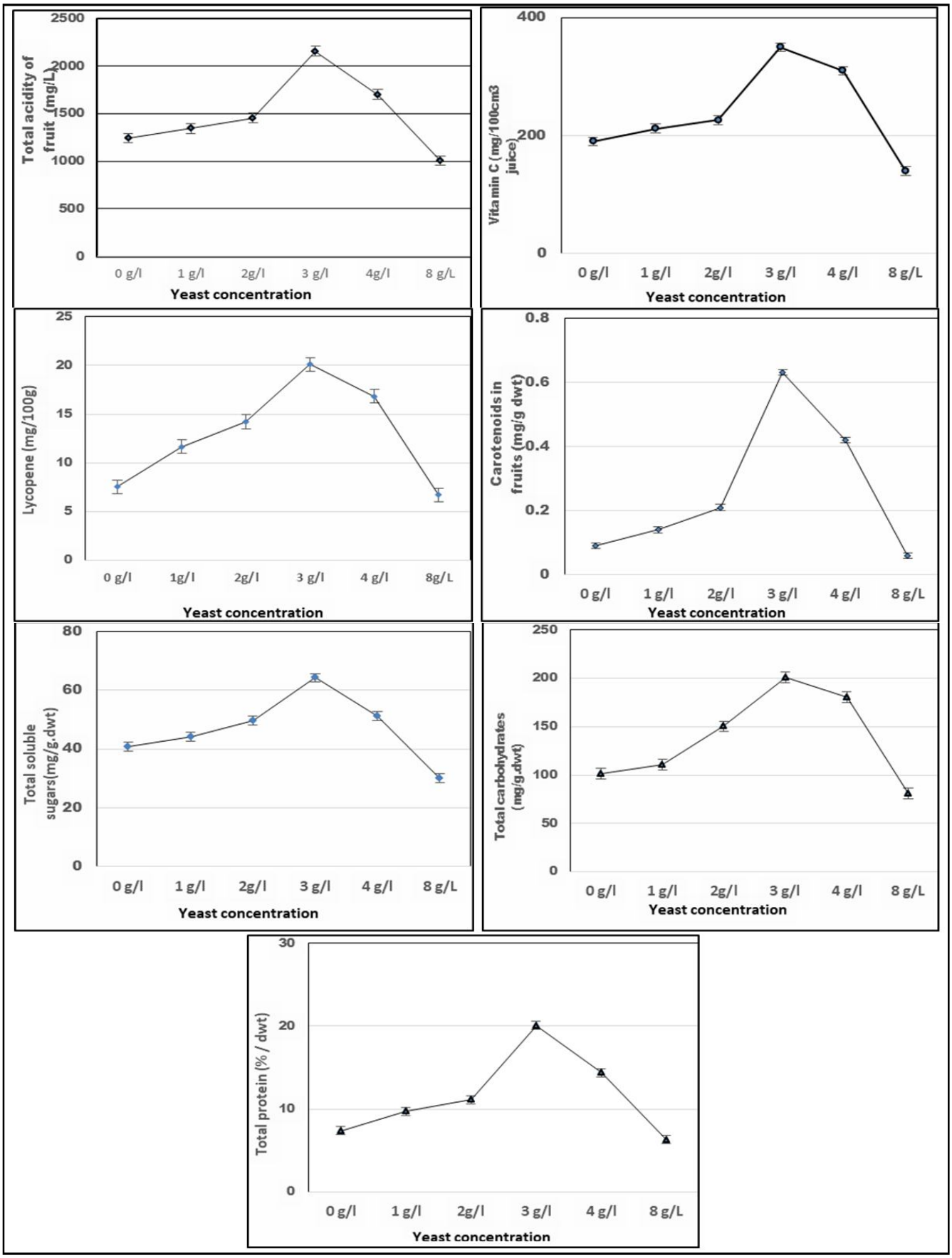

Fig. 2: Effect of yeast extracts on the fruit quality of hydroponic tomato plants grown in a soilless culture system.

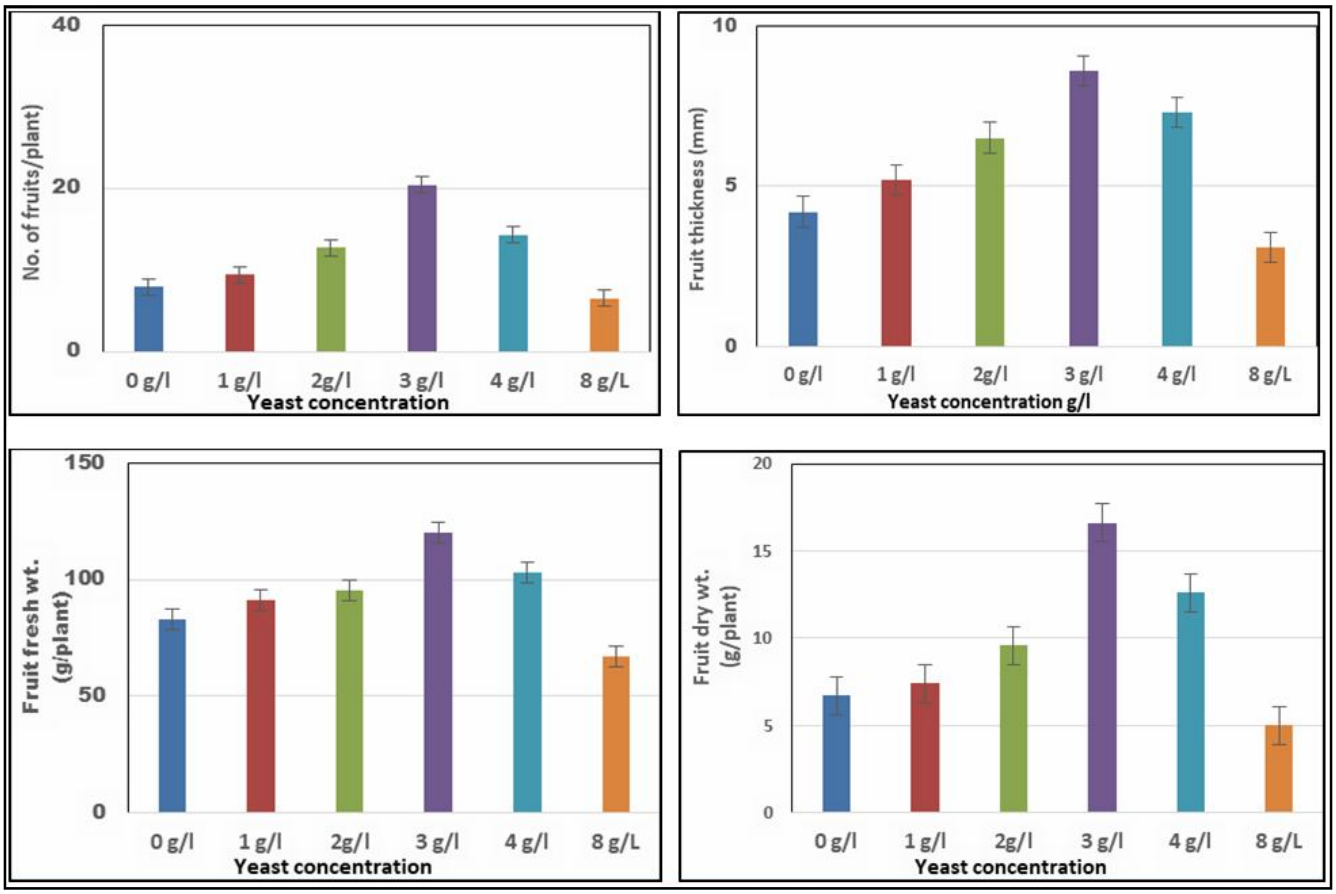

Fig. 3: Effect of yeast extract on the fruit yield of hydroponic tomato plants grown in a soilless culture system.

extract induced decreases effects on the ripened hydroponic tomatoes fruit content of the of sugars, carbohydrates, protein, carotene and lycopene The increasing effect of lower doses could be attributed to the stimulating effect of yeast extract on plant growth table 1, photosynthetic pigments Fig. 3. These results are in agreement with Abou El-Yazied and Mady (2011) who attributed these increases after yeast extract application to the improvement of growth, photosynthetic pigments and carbohydrates. They also reported maximum auxins, gibberellins and cytokinins values and minimum abscisic acid values in tomato leaves at 75 days as affected by foliar yeast treatment. The enhancing effect of yeast application might due to that yeast cytokinins enhance the accumulation of soluble metabolites, (Shalaby and El-Nady, 2008). Yeast is a natural source of cytokinins and has stimulatory effects on bean plants (Amer, 2004).

Conclusion

Application of yeast extract could be recommended in the present work to improve growth and fruit quality of hydroponic tomato plants grown in a soilless culture system by increasing photosynthetic pigments, enhancing vitamin C, lycopene, carotenoid contents, sugar contents, carbohydrates and proteins in fruits. 4 g/L yeast extract was the best applied dose for the achievement of better yield and better quality of tomatoes grown hydroponically.

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