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ORIGINAL ARTICLES

Effect of Naphthalene Acetic Acid and Yeast Extract on Growth and Productivity of Tomato (*Lycopersicon esculentum* Mill.) Plants

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ABSTRACT

The field experiment was conducted to study the effect of foliar application with 25 and 50 ppm naphthalene acetic acid and 2 and 4 g/L yeast extract and their combinations on some growth aspects, photosynthetic pigments, minerals, endogenous phytohormones, flowering, pollen grain fertility and fruit yield and quality of tomato cv. Super Strain B under summer conditions during 2009 and 2010 seasons. Plants were sprayed three times at 30, 45 and 60 days after transplanting. Results indicated that the different applied treatments significantly increased all studied growth parameters (number of branches and leaves, leaf area and leaf dry weight as well). Besides, the two concentrations of each applied yeast extract or naphthalene acetic acid 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 at 75 days after transplanting during 2010 season whereas abscisic acid was decreased. Furthermore, the highest fruit set, early and total yields were obtained with 4 g/L yeast extract plus 50 ppm naphthalene acetic acid. In addition, 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. Therefore, the present study strongly admit the use of naphthalene acetic acid and yeast extract as foliar application not only to increase early and total yields but also getting a good fruit quality as well, under summer conditions.

Key words: Yeast extract, naphthalene acetic acid, high temperature, endogenous phytohormones, flowering, fruit-set, yield, quality, tomato.

Introduction

Tomato (*Lycopersicon esculentum* Mill.) belongs to the family *Solanaceae* and is an important vegetable crop all over the world. It is used in various forms, such as fresh salad, cooked foods and in processed forms like ketchup, paste etc., it is known as a favorite vegetable crop, rich in antioxidants, vitamins and minerals for human. In Egypt, the late summer market tomato crop is yielded from transplants set up into the open field during April up to June. During this period, temperature can exceed 35°C under field condition resulting in either non-uniform growth and poor fruit yield or even completely failure of tomato cropping in a great part of the cultivated area (Pressman *et al.*, 2002; Adil *et al.*, 2004). With regard to the effect of temperature on growth and productivity of tomato plants, Saeed *et al.* (2007) whose found that high temperatures during the growing season have been reported to be detrimental to growth, reproductive development and yield of several crops. In tomato high temperature during reproductive development caused significant increment in flower drop and significant decrease in fruit set and consequently fruit yield was decreased to a great extent. At high temperature, the reproductive part of the flower is adversely affected. Stigma tube elongation, poor pollen germination, poor pollen tube growth and carbohydrate stress are the main reasons for poor fruit set at high temperature in tomato. Vollenweider and Gunthardt-Goerg (2005) and Sato *et al.* (2006) Also, reported that under high temperatures, fruit set in tomato plants failed due to disruption of sugar metabolism and transport during the narrow window of male reproductive development. Therefore, plant physiologists and breeders are studying insensitivity the problem of improvement of growth and flower set in tomato plant. Moreover, Heat

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stress is a major abiotic factor that limits tomato production during summer season in the Sudan. High temperature negatively affects plant growth and survival and hence crop yield (Abd El-Mageed and Gruda, 2009).

Fruit-set can also be induced by application of plant growth substances to unpollinated ovaries; the role of hormones on tomato fruit growth has been the subject of recent reviews (Serrani *et al*., 2007). With regard to the effect of plant hormones on growth and productivity, Tyburski *et al*. (2009) found that auxin induced reactions are often enhanced by oxidative stress. Many trails has been carried out for increasing flower set and fruit yield of tomato or other plants by the use of different factors including plant growth regulators and natural extracts as well (El- Desouky *et al*., 2000; Wanas, 2006). Also, much evidence suggests that auxin is involved in the regulation of fruit development. Auxin is produced in pollen and in the embryo of developing seeds and the initial stimulus for fruit set may result from pollination (Taiz and Zeiger, 2006). In this regard, the spray application of NAA at variable concentrations significantly increased the fruit yield of tomato and the nutrient contents were increased also in the majority of cases (Alam and Khan, 2002). Also, foliar application of NAA significantly increased fruit yield, number of fruits and average fruit weight of bell pepper. Total chlorophyll, ascorbic acid and nitrate reductase activity were also increased (Sridhar *et al.,* 2009). Recent studies indicated that the bioregulators IAA, IBA and NAA enhanced tomato growth in the field at the concentration of 100 $mg \cdot L^{-1}$ (Olaiya and Adigun, 2010). The effects of these bioregulators on tomato fruit yield and quality have also been reported (Olaiya, 2010a; Olaiya *et al.,* 2010).

Mekki and Ahmed (2005) reported that application of yeast increased yield and yield attributes of soybean plants. Further, yeast extract was suggested to participate a beneficial role during vegetative and reproductive growth through improving flower formation and their set of some plants due to its high auxin and cytokinin contents and enhancement of carbohydrate accumulation (Barnett *et al*., 1990). Moreover, khalil and Ismael (2010) indicated that the highest growth parameters were observed when *Lupinus termis* plants were treated with yeast by different ways resulting in an increase in yield and yield attributes. In addition, 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 (El- Desouky *et al.*, 1998; Wanas, 2002 and 2006). In addition, it contains protective agent, i.e. sugars, protein, amino acid and also several vitamins (Mahmoued, 2001). In addition, improving growth, flowering and fruit setting of some plants by using foliar application with yeast extract was reported by Fathy *et al*., (2000), Abou-Aly (2005) and Wanas (2006). Furthermore, many investigations indicated that yeast is natural source of cytokinins and has stimulatory effects on bean plants (Amer, 2004).

Therefore, the present study aimed to use foliar spray of different concentrations of naphthalene acetic acid (NAA) and yeast extract (YE) and their combination on tomato plants to improve growth and fruit set as well as to increase the final yield of this economic plant under the high temperature during summer seasons.

Material and methods

The field experiment was carried out at the Experimental Farm Station of the Faculty of Agriculture, Moshtohor, Banha University, Egypt, during 2009 and 2010 seasons to study the effect of foliar application with yeast extract, naphthalene acetic acid and their combinations on growth, flowering, yield and fruit quality as well as photosynthetic pigments, minerals, crude protein and carbohydrates of tomato (*Lycopersicon esculentu*m Mill.) cv. Super Strain B under summer conditions. Five-week old tomato transplants were set up into the field on 13th of April in the two seasons, the plot area was 17.5 m^2 (5 ridges each of 1 m width and 3.5 m length). Calcium super-phosphate (15.5 % P_2O_5) at 400 kg / fed. was banded on ridges at two times, the first (250 kg) was added during the soil preparation and the second one (150 kg) was carried out in the flowering period. Ammonium sulphate (20.5% N) as N-fertilizer was added at a rate of 400 kg/fed. in three equal doses, i.e., at 30, 45 and 60 days after transplanting, for all treatments. Potassium sulphate (48 % K_2O) was applied at a rate of 200 kg K_2O fed^{-1} at two times. The first portion took place before transplanting, whereas, the second part was added one month later. Cultural management, disease and pest control programs were followed according to the recommendations of the Egyptian Ministry of Agriculture.

The experimental design and treatments:

Naphthalene acetic acid (NAA, MW 186.21) of Sigma Aldrich was used with aqueous solutions (dissolve in a small amount of ethyl alcohol and then adjusted to the concentrations with water) at three levels, i.e., 0 (control, sprayed with distilled water), 25 and 50 ppm, applied as foliar application when 2-3 fully opened flowers were appeared on the first inflorescence of 50% of the plants, three sprays at 10 days intervals were performed also, yeast extract produced by Vi-cor$_{®}$ company, South Caroline Ave, Mason City, U.S.A., was

used aqueous solutions at three levels, i.e., 0 (control, sprayed with distilled water), 2 and 4 g/L, applied as foliar application at 30, 45 and 60 days after transplanting. Chemical analysis of yeast extract is presented in Table (A).

The treatments were arranged in a complete randomized block design with four replicates.

Table A: Chemical analysis of yeast extract used.

Amino acids %		Vitamins mg/100g dry weight		Growth regulators ppm	
Alanine	1.69	Vit.B1	23.33	Adenine	31
Arginine	1.49	Vit.B2	21.04	Betaines	56
Aspartic Acid	2.32	Vit.B6	20.67	Minerals	
Cystine	0.63	Vit B12	19.17	Nitrogen	6.88%
Glutamic Acid	3.76	Thimain	23.21	Phosphorous	0.66%
Glycine	1.45	Riboflavin	27.29	Potassium	0.95%
Histidine	0.71	Insitol	20.43	Magnesium	0.19%
Isoleucine	0.85	Biotin	20.04	Calcium	0.17%
Leucine	1.91	Nicotinic acid	73.92	Sulfur	0.48%
Lysine	1.13	Panthothenic acid	38.43	Iron	107 ppm
Phenylalanine	1.18	P amino benzoic acid	29.49	Zinc	77 ppm
Proline	1.29	Folic acid	26.22	Copper	5 ppm
Serine	1.98	Pyridoxine	22.09	Manganese	13 ppm
Threonine	1.54	Crude Protein		43.00%	
Tryptophan	0.25	Crude Fat		2.20%	
Tyrosine	0.99	Carbohydrates		33.21%	
Valine	1.4	Crude Fiber		7.20%	
Methionine	0.4	Ash		3.80%	

This Experiment Included the Following Treatments:

1. Control (distilled water).
2. Yeast extract at 2 g/L.
3. Yeast extract at 4 g/L.
4. NAA at 25 ppm.
5. NAA at 50 ppm.
6. Yeast extract at 2 g/L + NAA at 25 ppm.
7. Yeast extract at 2 g/L + NAA at 50 ppm.
8. Yeast extract at 4 g/L + NAA at 25 ppm.
9. Yeast extract at 4 g/L + NAA at 50 ppm.

Studied Characteristics:

After 75 days from transplanting, the number of branches and leaves/plant as well as total leaf area (using the disk method according to Derieux *et al.*, 1973) was recorded. Leaves were dried in an oven at 70°C until the constant weight was obtained. Photosynthetic pigments, Chlorophyll a, b and carotenoids were determined in the fourth leaf, calorimetrically determined as described in A.O.A.C. (1990). Pollen grain fertility was estimated by the method described by Shahine (1961). Number of clusters per plant, number of flowers per cluster, number of flowers per plant and fruit set percentage (ten plants from each plot were labelled at random before flowering stage) was calculated as follows:

$$\text{Fruit set \%} = \frac{\text{Number of setting fruits}}{\text{Total number of flowers}} \times 100$$

Early yield (as the first two pickings), total yield per plant, plot and feddan were recorded. Total nitrogen, phosphorus and potassium were determined in tomato leaves at 75 days after transplanting and in fruits at harvest (red ripe stage) according the methods described by Horneck and Miller (1998), Sandell (1950) and Chapmen and Pratt (1961), respectively. Also, Fe, Zn and Mn were determined according to Evenhuis (1978). Crude protein was calculated according to the following equation: Crude protein = Total nitrogen x 6.25 (A.O.A.C., 1990). Total carbohydrates were determined according to Dubois *et al.*, (1956). Endogenous phytohormones were quantitatively determined in tomato shoots at 75 days after transplanting in the second season using High- Performance Liquid Chromatography (HPLC) according to Koshioka *et al*. (1983) for auxin (IAA), gibberellic acid (GA_3) and abscisic acid (ABA), while, cytokinins were determined according to Nicander *et al.* (1993). Total soluble solids were measured using a Carl Zeiss Refractometer Model RL3. Vitamin C and titratable acidity were determined according to the method described by the A.O.A.C. (1990).

Metreological Data:

Average metreological data for Kaliobia region, at Banha, during the growing seasons of tomato (2009 and 2010) were obtained from the central meteorological laboratory, Dokki, Giza, Ministry of Agriculture, A.R .E. (Table B).

Table B: Meteorological data of the two growing seasons, 2009 and 2010, at Banha, El kaliobia location.

Season	2009 season				2010 season			
Month	Temperature (c°)		R.H. %		Temperature (c°)		R.H. %	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
April	35.4	9.9	88.3	20.4	35.2	11.4	89.5	22.7
May	36	10.1	85.5	26.9	40.5	12.7	87.9	20.5
June	36.8	12.4	85.8	28.9	40.4	11.6	87.4	22.5
July	36.9	10.7	88.4	30.1	38	12.6	87.9	29.1
August	34.8	12.9	88.5	29.4	38.2	13.4	89.6	28.5
September	36.8	15.7	88.1	30.3	38.7	17.3	88.7	29.7
October	36.9	16.7	88.5	23.8	38.7	18.1	87.8	24.6

*Central meteorological laboratory, Dokki, Giza, Ministry of Agriculture, A.R.E.

Statistical Analysis:

Data obtained in this study were statistically analyzed using the least significant differences test (L.S.D) according to Snedecor and Cochran (1982).

Results and dessicusion

Vegetative Characteristics:

The number of branches and leaves, total leaf area, and dry weight of leaves per plant were significantly increased by all foliar applications with NAA or yeast extract at 75 days after transplanting during the two seasons as shown in Table (1). The interaction effect between naphthalene acetic acid and yeast extract foliar application with all concentrations gave the highest values of growth parameters at 75 days after transplanting during the two growing seasons compared with either individual foliar application or control treatments. The maximum stimulatory effect was induced in plants treated with 25 ppm and NAA 4 g/L yeast extract as foliar application during the two seasons. The results are in agreement with those of Wanas (2002) and Sharaf El-Deen and Manaf (2009) on faba been, El-Tohamy and El-Greadly (2007) on snap bean, El-Tohamy *et al.* (2008) on eggplant and Sridhar *et al.* (2009) on bell pepper, mentioned that yeast extract and naphthalene acetic acid increased plant height, number of branches and leaves per plant and dry weight as well. These results could be due to the fact that yeast extract contains growth factors and a relatively larger proportion of free amino acids and short peptides of two or three amino acids long than protein hydrolisates (Bevilacqua *et al.,* 2008).

Table 1: Effect of NAA and yeast extract on vegetative growth of tomato at 75 days after transplanting in 2009 and 2010 seasons.

Treatments	2009 Season				2010 Season			
	Number /plant		Leaf area (cm^2)/plant	Leaf dry weight (g/plant)	Number /plant		Leaf area (cm^2)/plant	Leaf dry weight (g/plant)
	Branches	Leaves			Branches	Leaves		
Control	8.13	31.68	1838.21	23.07	9.40	32.15	1810.15	24.10
YE_1	11.22	38.18	2215.37	28.59	12.10	39.80	2240.87	30.15
YE_2	12.17	42.80	2483.44	32.20	12.80	41.65	2345.03	33.17
NAA_1	10.04	41.10	2384.80	31.28	11.45	43.40	2443.56	33.29
NAA_2	10.90	39.60	2297.76	31.70	11.00	44.25	2491.42	33.74
$YE_1 + NAA_1$	11.75	40.70	2361.59	32.91	12.95	45.45	2558.98	33.92
$YE_1 + NAA_2$	13.80	44.45	2579.18	34.33	14.80	47.60	2680.06	38.16
$YE_2 + NAA_1$	15.35	49.60	2878.01	39.37	16.12	50.50	2843.31	40.67
$YE_2 + NAA_2$	12.70	43.71	2536.24	34.88	13.75	44.20	2488.60	34.92
L.S.D. at 5%	1.98	5.12	552.70	3.12	2.10	3.86	495.15	3.15

YE_1: yeast extract 2 g/L NAA_1: 25 ppm NAA
YE_2: yeast extract 4 g/L NAA_2: 50 ppm NAA

The stimulatory effect of yeast extract and NAA on the estimated characteristics of tomato growth could be attributed to the effect of these compounds upon photosynthetic pigments (Table 2), N, P, K, Fe, Zn and Mn in leaves (Table 3) and endogenous phytohormones (Table 4). It was also reported that these substances increased the endogenous phytohormones specially the growth promoters, i.e. Auxins, gibberellins and cytokinins (Shehata *et al*., 2000; Sridhar *et al.,* 2009). Also, these findings are in agreement with the results of El-Tohamy and El-Greadly (2007); El-Tohamy *et al.,* (2008) whose indicated that the application of yeast increased eggplant growth. Moreover, the improvement of plants growth in response to the foliar application of active dry yeast may be attributed to its contents of different nutrients, higher percentage of amino acids, higher values of vitamins, especially B and growth regulators like adenine and betaines (Table A) which may play an important role in improving growth.

Photosynthetic Pigments:

Data in Table (2) indicate that different photosynthetic pigments, i.e. chlorophyll a, b and carotenoids, positively responded to the different foliar applications with naphthalene acetic acid or yeast extract during the two assigned seasons. Also, the interaction between naphthalene acetic acid and yeast extract gave the highest value in this respect, comparing with the control plants. The increase of chlorophyll and carotenoid contents may enhance the photosynthetic efficiency and consequently increase plant growth (Table 1). In this respect, the improvement of photosynthetic pigments in response to the foliar application of yeast extract may be attributed to bioregulators (Table A) which affect the balance between photosynthesis and photorespiration in plants, (Olaiya, 2010b). Shalaby and El-Nady (2008) reported that the increase in photosynthetic pigments formation could be attributed to the role of yeast cytokinins in delaying the aging of leaves by reducing the degradation of chlorophyll and enhancing the protein and RNA synthesis. This stimulative effect of the combination of yeast extract and NAA might be due to its high auxin and cytokinin contents, protein, nucleic acid synthesis and chlorophyll formation (El- Desouky *et al*., 1998; Wanas, 1998 and 2006).

The present results are in agreement with those of El-Tohamy and EL-Greadly (2007), they found that application of yeast extract increased chlorophyll a and b as well as caroteinods in snap bean plants. Also, Fathy *et al.,* (2000) found that foliar application with yeast extract and other natural treatments increased photosynthetic pigments in tomato plants.

Table 2: Effect of NAA and yeast extract on photosynthetic pigment content (mg/g fresh weight) of tomato leaves at 75 days after transplanting in 2009 and 2010 seasons.

Treatments	2009 Season				2010 Season			
	Chlorophyll a	Chlorophyll b	Chlorophyll a+b	Carotenoids	Chlorophyll a	Chlorophyll b	Chlorophyll a+b	Carotenoids
Control	0.410	0.320	0.730	0.335	0.455	0.350	0.805	0.350
YE_1	0.490	0.376	0.866	0.370	0.510	0.385	0.895	0.384
YE_2	0.525	0.460	0.985	0.390	0.560	0.415	0.895	0.425
NAA_1	0.615	0.510	1.125	0.425	0.640	0.490	1.130	0.470
NAA_2	0.625	0.495	1.120	0.490	0.675	0.525	1.200	0.480
$YE_1 + NAA_1$	0.710	0.520	1.230	0.515	0.730	0.610	1.340	0.520
$YE_1 + NAA_2$	0.790	0.548	1.338	0.518	0.810	0.620	1.430	0.535
$YE_2 + NAA_1$	0.825	0.511	1.336	0.526	0.890	0.675	1.565	0.560
$YE_2 + NAA_2$	0.750	0.450	1.200	0.480	0.809	0.535	1.344	0.495
L.S.D. at 5%	0.05	0.08	0.13	0.11	0.07	0.14	0.15	0.12

YE_1: yeast extract 2 g/L NAA_1: 25 ppm NAA
YE_2: yeast extract 4 g/L NAA_2: 50 ppm NAA

Minerals and Some Bioconstituents:

Data in Table (3) clearly indicate that foliar application with naphthalene acetic acid and / or yeast extract increased N, P, K, Fe, Zn and Mn content in tomato leaves compared with those of control plants in both seasons. Also, it could be noticed that NAA at 25 ppm plus yeast extract at 4 g/L was the superior in this respect. On the other hand, foliar application with two the concentrations of NAA and yeast extract gave the best value of total carbohydrates and crude protein content in leaves of tomato plants at 75 days after transplanting during the two seasons. This might be attributed to the large photosynthetic area (Table 1) and high content of photosynthetic pigments (Table 2). These results are in harmony with the findings of Fathy *et al.* (2000) whose found that the application of yeast to tomato plants resulted in increases in nitrogen, potassium contents of leaves. Our data also confirmed the positive effect of yeast extract as reported by Bevilacqua *et al.*, (2008).

Table 3: Effect of NAA and yeast extract on minerals and bio-constituents in tomato leaves (D.W.) at 75 days after transplanting in 2009 and 2010 seasons.

Treatments	2009 Season								2010 Season							
	N %	P %	K %	Fe ppm	Znppm	Mnppm	Crude protein % (D.W.)	Total carbohydrates mg/g D.W.	N%	P%	K%	Feppm	Znppm	Mnppm	Crude protein % (D.W.)	Total carbohydrates mg/g D.W.
Control	3.35	0.314	2.87	113.05	62.35	53.64	20.94	366.86	3.40	0.318	3.04	102.18	67.54	55.60	21.25	370.24
YE_1	3.66	0.345	3.68	116.26	66.47	61.32	22.88	373.54	3.52	0.353	3.47	132.14	70.47	59.45	22.00	376.43
YE_2	3.70	0.356	3.71	135.18	69.33	63.25	23.13	378.33	3.74	0.366	3.52	124.36	74.23	62.28	23.38	382.64
NAA_1	3.85	0.411	3.76	142.65	75.80	65.67	24.06	384.63	3.80	0.423	3.64	154.82	77.80	68.34	23.75	388.15
NAA_2	3.92	0.447	4.45	150.16	76.24	66.95	24.50	418.27	3.86	0.431	3.87	163.45	69.98	67.56	24.13	432.41
$YE_1 + NAA_1$	3.94	0.468	3.88	15372	68.87	73.47	24.63	455.67	3.95	0.446	4.09	165.25	71.43	71.45	24.69	463.36
$YE_1 + NAA_2$	4.28	0.574	4.76	159.90	70.48	76.80	26.75	543.18	4.15	0.571	4.53	164.77	75.16	72.96	25.94	487.90
$YE_2 + NAA_1$	4.30	0.655	4.20	168.63	78.40	79.12	26.88	587.45	4.26	0.587	4.87	172.32	79.65	77.85	26.63	545.98
$YE_2 + NAA_2$	3.96	0.612	3.80	152.14	67.50	64.75	24.75	513.43	4.11	0.542	4.16	155.65	76.38	74.16	25.69	42362
L.S.D. at 5%	1.03	0.12	0.75	12.7	7.24	5.48	4.18	24.78	1.05	0.10	0.64	10.72	8.08	467	3.87	21.64

YE_1: yeast extract 2 g/L NAA_1: 25 ppm NAA
YE_2: yeast extract 4 g/L NAA_2: 50 ppm NAA

Endogenous Phytohormones:

As shown in Table (4) all promoters (auxins, gibberellins and cytokinins) were improved by spraying with naphthalene acetic acid and yeast extract, yet, abscisic acid was decreased. Foliar application with naphthalene acetic acid at 25 ppm combined with yeast extract at 4 g/L gave the maximum values in auxins, gibberellins and cytokinins while it gave the lowest values of abscisic acid in tomato leaves at 75 days after transplanting in 2010 season. This in turn might be reflected on the obtained growth characters (Table 1). Also, other studies reported similar results (Davis and Zhang, 1991; Saleh *et al.*, 2010; Nakhlla, 1998). Yeast extract has been reported to be a rich source of vitamins, phytohormones and many other growth factors (El-Desoukey *et al.*, 1998). Yeast is a natural source of cytokinins and has stimulatory effects on bean plants. This may explain the increase of cytokinins and other promoting hormones in response to yeast application (Amer, 2004).

Table 4: Effect of NAA and yeast extract on endogenous phytohormones in shoots of tomato at 75 days after transplanting in 2010 season.

Treatments	Auxins(µg/10g FW)	Gibberellins(µg/10g FW)	Cytokinins(µg/10g FW)	Abscisic acid (µg/10g FW)
Control	86.49	44.72	81.65	1.021
YE_1	96.86	54.60	119.88	0.776
YE_2	103.75	53.11	122.74	0.754
NAA_1	115.24	62.32	109.53	0.713
NAA_2	123.16	57.45	111.24	0.614
$YE_1 + NAA_1$	98.60	74.80	118.78	0.642
$YE_1 + NAA_2$	101.55	81.60	124.43	0.598
$YE_2 + NAA_1$	99.34	84.32	143.12	0.578
$YE_2 + NAA_2$	94.45	68.94	114.66	0.674

YE_1: yeast extract 2 g/L NAA_1: 25 ppm NAA
YE_2: yeast extract 4 g/L NAA_2: 50 ppm NAA

Pollen Grain Fertility:

Data in Table (5) indicate that the different applied treatments increased the fertility and reduced the sterility of pollen grains in treated plants compared with control. Also, it could be noticed that 50 ppm NAA and 4 g/L yeast extract gave the highest fertility and the lowest sterility of the pollen grains. The above mentioned results could be directly reflected upon the high percentages of fruit setting (Table 6), early and total yields (Table 7).

Table 5: Effect of NAA and yeast extract on pollen grain fertility of tomato flowers in 2009 and 2010 seasons.

Treatments	2009 Season				2010 Season			
	Fertility%	Sterility		Total sterility%	Fertility%	Sterility		Total sterility%
		Normal%	Aborted%			Normal %	Aborted%	
Control	23.70	44.86	31.44	76.30	25.67	46.12	28.21	74.33
YE_1	34.26	36.42	29.22	65.64	33.85	44.70	21.45	66.15
YE_2	37.55	33.78	28.67	62.45	38.90	35.48	25.62	61.10
NAA_1	36.80	43.18	20.02	63.20	40.15	41.64	18.21	59.85
NAA_2	42.72	31.95	25.33	57.28	43.56	34.45	21.99	56.44
$YE_1 + NAA_1$	44.62	33.24	22.14	55.38	45.33	36.17	18.50	54.67
$YE_1 + NAA_2$	48.70	35.83	15.47	51.30	46.45	33.78	19.77	53.55
$YE_2 + NAA_1$	53.66	32.25	14.09	46.34	55.29	30.64	14.07	44.71
$YE_2 + NAA_2$	50.25	30.76	18.99	49.75	51.18	32.54	16.28	48.82
L.S.D. at 5%	3.75	2.65	2.05	3.84	3.21	2.78	1.94	3.70

YE_1: yeast extract 2 g/L NAA_1: 25 ppm NAA.
YE_2: yeast extract 4 g/L NAA_2: 50 ppm NAA.

Flowering and Fruit Setting:

Data in Table (6) presented the response of flowering characters, i.e., number of clusters per plant, number of flowers per cluster, number of flowers per plant, as well as fruit set percentage. The results of number of cluster per plant and number of flowers, it is obvious from the tabulated values that NAA at 50 ppm plus yeast extract at 4 g/L were superior and overcame the control plants, while, there were no significant differences among treatments in respect to number of flowers per cluster. On the other hand, the fruit set percentage, data in the same table show that application of the different substances with used concentrations had a clear and significant increase on the fruit set percentage. The combination treatments gave the highest values especially NAA at 50 ppm plus yeast extract at 4 g/L which ranked at the first in this respect. These results may be due to failure to obtain good fruit-set under experimental conditions which attributed to the adverse weather conditions during flowering stage (temperature, 34.8 °C - 36.9 °C in the first summer season and 35.2 °C - 40.5 °C in the second summer season, as well as relative humidity (RH%), 85.5 -88.5% and 87.4 – 89.6 in the first and second seasons, respectively, Table A). Moreover, Shehata *et al*. (1996) reported that limitation of pollen production, pollination, pollen germination, pollen tube growth, fertilization and/or the produced natural hormone. In such instances, certain synthetic growth regulators applied to the open flowers may supplement the deficiency of natural hormone. Therefore, the used growth regulators may stimulate the setting of tomato fruits which is considered an important parameter and prediction for the expected yield. In this respect, Adams *et al.* (2001) found that poor fruit, poor fruit set at high temperatures was due to the effect of temperature on pollen grain release and germination, as well as the number of pollen grains produced.

Table 6: Effect of NAA and yeast extract on flowering and fruit set percentage of tomato plants in 2009 and 2010 seasons.

Treatments	2009 Season				2010 Season			
	No. of clusters/plant	No. of flowers/cluster	No. of flowers/plant	Fruit setting%	No. of clusters/plant	No. of flowers/cluster	No. of flowers/plant	Fruit setting%
Control	16.20	6.41	103.8	18.35	16.43	6.47	106.3	19.65
YE_1	17.61	6.71	118.2	19.89	16.01	6.81	109.0	21.28
YE_2	17.54	6.43	112.8	20.27	17.74	6.67	118.3	21.47
NAA_1	15.78	6.11	94.8	22.16	16.85	6.68	95.7	23.22
NAA_2	16.71	6.50	108.6	25.04	16.78	6.20	104.0	24.93
$YE_1 + NAA_1$	18.10	6.74	122.0	25.94	18.32	6.15	110.8	25.31
$YE_1 + NAA_2$	15.96	6.30	100.5	26.53	17.54	6.99	122.6	27.23
$YE_2 + NAA_1$	17.64	6.23	109.9	26.10	17.64	6.65	117.3	27.61
$YE_2 + NAA_2$	18.47	6.92	127.8	27.28	18.28	6.84	125.0	29.01
L.S.D. at 5%	0.84	0.95	5.2	1.22	0.63	0.89	4.8	1.18

YE_1: yeast extract 2 g/L NAA_1: 25 ppm NAA
YE_2: yeast extract 4 G/L NAA_2: 50 ppm NAA

Fruit Yield:

Data in Table (7) indicate that there were significant increases in early and total yields with different foliar application treatments compared to control treatment during the two assigned seasons. The combination treatments gave the highest values especially NAA at 50 ppm plus yeast extract at 4 g/L which ranked at the first in this respect. The increases of early and total yields might be reflection to the increase of pollen grain fertility (Table 5) and hence fruit setting (Table 6). The increased yield can be attributed to higher dry matter in reproductive parts, higher fruit set as well as yield (Sridhar *et al.,* 2009). Similar results were obtained by yeast extract on soybean and broad bean (Awasthi *et al.,* 1997) and by NAA on tomato (Fathy *et al.,* 2000). These findings are also in agreement with the results of El-Tohamy and El-Greadly (2007) on snap bean and El-Tohamy *et al.* (2008) on eggplant indicated that the application of yeast extract increased yields and their component

Fruit Quality:

Data presented in Table (8) indicate that the different spray treatments increased N, P, K, crude protein and total carbohydrate concentrations in the marketable tomato fruits. Also, it could be noticed that NAA at 50 ppm plus yeast extract at 4 g/L gave the highest concentration of total carbohydrates in ripened tomato fruits followed by NAA at 50 ppm plus yeast extract at 2 g/L. The enhancing effect of yeast application might be due to that yeast cytokinins enhance the accumulation of soluble metabolites, (Shalaby and El-Nady, 2008). On the other hand, Kataoka *et al.* (2009) found that the addition of auxin solutions for fruit setting at anthesis increased the amount of sugar content per fruit at maturity in tomato cultivar ‘Louis 60’.

Table 7: Effect of NAA and yeast extract on fruit yield of tomato plants in 2009 and 2010 seasons.

Treatments	2009 Season				2010 Season			
	Early yield (kg/plant)	Total yield (kg/plant)	Total yield (kg/plot)	Total yield (ton/fed.)	Early yield (kg/plant)	Total yield (kg/plant)	Total yield (kg/plot)	Total yield (ton/fed.)
Control	0.30	1.40	81.67	17.73	0.33	1.47	85.75	18.62
YE_1	0.34	1.47	85.75	18.62	0.36	1.50	87.50	19.00
YE_2	0.37	1.53	89.25	19.38	0.38	1.56	91.00	19.76
NAA_1	0.31	1.60	93.33	20.27	0.34	1.76	102.90	22.34
NAA_2	0.29	1.84	107.33	23.31	0.33	1.89	110.25	23.94
$YE_1 + NAA_1$	0.35	1.87	109.08	23.69	0.40	1.86	108.50	23.56
$YE_1 + NAA_2$	0.39	1.95	113.75	24.70	0.40	1.93	112.58	24.45
$YE_2 + NAA_1$	0.38	1.98	115.50	25.08	0.45	2.02	117.83	25.59
$YE_2 + NAA_2$	0.41	2.06	120.17	26.09	0.44	2.09	121.92	26.47
L.S.D. at 5%	0.03	0.04	4.13	0.8	0.31	0.03	3.70	0.7

YE_1: yeast extract 2 g/L NAA_1: 25 ppm NAA
YE_2: yeast extract 4 g/L NAA_2: 50 ppm NAA

Table 8: Effect of NAA and yeast extract on N, P, K and some bio-constituents of tomato fruits in 2009 and 2010 seasons.

Treatments	2009 Season					2010 Season				
	N%	P%	K%	Crude protein %	Total carbohydrates mg/g D.W.	N%	P%	K%	Crude protein %	Total carbohydrates mg/g D.W.
Control	1.21	0.21	1.37	7.56	632.20	1.23	0.23	1.46	7.69	641.14
$Y E_1$	1.25	0.26	1.53	7.81	640.12	1.26	0.25	1.50	7.88	645.36
$Y E_2$	1.30	0.35	1.58	8.13	667.35	1.29	0.36	1.55	8.06	661.50
NAA_1	1.28	0.39	1.64	8.00	660.55	1.31	0.41	1.62	8.19	668.33
NAA_2	1.32	0.41	1.67	8.25	672.40	1.33	0.45	1.69	8.31	670.45
$YE_1 + NAA_1$	1.35	0.44	2.11	8.44	675.17	1.37	0.48	1.84	8.56	674.12
$YE_1 + NAA_2$	1.38	0.46	2.23	8.63	677.34	1.39	0.37	2.26	8.69	6679.42
$Y E_2 + NAA_1$	1.36	0.36	2.17	8.50	683.92	1.41	0.42	2.12	8.81	680.67
$Y E_2 + NAA_2$	1.40	0.49	2.28	8.75	689.24	1.42	0.48	2.36	8.88	684.75
L.S.D. at 5%	0.42	0.07	0.15	1.16	25.66	0.36	0.13	0.17	1.18	29.23

YE_1: yeast extract 2 g/L NAA_1: 25 ppm NAA.
YE_2: yeast extract 4 g/L NAA_2: 50 ppm NAA.

In addition, all treatments increased the amount of vitamin C, total soluble solids and titratable acidity in tomato fruits during the two seasons. Also, it could be noticed that the highest increases were obtained with NAA at 50 ppm plus yeast extract at 4 g/L (Table 9). These data are being important concerning the fruit quality, since this could prolong shelf time with different applied treatments specially with NAA at 50 ppm plus yeast extract at 4 g/L one. Similar results were obtained using yeast extract on tomato (Fathy *et al.*, 2000). The previously obtained results on yield and fruit quality (Tables 7, 8 and 9) could be attributed to the stimulation effect of NAA and yeast extract on plant growth (Table 1), photosynthetic pigments (Table 2), mineral and carbohydrates (Table 3), endogenous phytohormones (Table 4) in leaves, pollen grain fertility (Table 5) and fruit set percentage (Table 6).

It could be concluded that spraying with 50 ppm NAA combined with 4 g/L yeast extract increased the yield and quality of tomato fruits under the high temperature during the summer season under the experiment conditions.

Table 9: Effect of NAA and yeast extract on chemical constituents of tomato fruits in 2009 and 2010 seasons.

Treatments	2009 Season			2010 Season		
	Vitamin C (mg/100g F.W)	Total soluble solids (%)	Titratable acidity (%)	Vitamin C (mg/100g F.W)	Total soluble solids (%)	Titratable acidity (%)
Control	87.18	3.44	0.324	91.32	3.36	0.332
YE_1	96.42	3.53	0.328	98.11	3.42	0.341
$Y E_2$	103.70	3.64	0.343	106.65	3.50	0.338
NAA_1	109.89	3.76	0.349	111.72	3.67	0.345
NAA_2	115.54	3.78	0.354	113.22	3.83	0.362
$Y E_1 + NAA_1$	118.45	4.17	0.370	119.64	4.13	0.368
$Y E_1 + NAA_2$	121.66	4.77	0.378	120.75	4.48	0.374
$YE_2 + NAA_1$	119.17	4.65	0.373	118.62	4.37	0.369
$Y E_2 + NAA_2$	122.25	4.89	0.383	123.29	4.55	0.389
L.S.D. at 5%	3.70	0.98	0.070	5.25	1.02	0.090

YE_1: yeast extract 2 g/L NAA_1: 25 ppm NAA
YE_2: yeast extract 4 g/L NAA_2: 50 ppm NAA

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