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GROWTH, YIELD AND CHEMICAL COMPOSITION OF *Foeniculum vulgare*, MILL. AS AFFECTED BY NITROGEN, DRY YEAST AND TRYPTOPHAN APPLICATION

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Abstract: This study was conducted in the two successive seasons of 2005/2006 and 2006/2007 at the Experimental Farm of Floriculture, Faculty of Agriculture, Assiut University. The aim of this study was to investigate the effect of three rates of each of nitrogen (0, 50 and 100 kg/fed.), active dry yeast (0, 2 and 4 g/l) and tryptophan (0, 50 and 100 ppm) on the growth, fruit and oil yield and chemical composition of fennel plants. The obtained results revealed that the application of nitrogen, active dry yeast and/or tryptophan resulted in a significant increase in vegetative growth, fruit and oil yield as well as fruit content of total carbohydrates, N, P and K compared to the controls. It was interesting to observe that the application of active dry yeast at 4 g/l as biofertilizer with 100 ppm tryptophan as organic nitrogenous source gave nearly equal results to those obtained with the high level of mineral nitrogen fertilizer (100 kg N/fed.) alone. Also, the application of active dry yeast at 4 g/l or tryptophan at 100 ppm combined with 50 kg N/fed. resulted in a significant increase in all studied parameters compared to the high level of nitrogen alone. The maximum vegetative growth and flowering, fruit and oil yield as well as fruit nutrient content were obtained from the combined treatment of 50 kg N/fed. + 2 or 4 g/l active dry yeast + 50 ppm tryptophan.

Key words: Fennel, nitrogen fertilization, dry yeast, tryptophan, fruit and oil yield

Introduction

Fennel (*Foeniculum vulgare*, Mill.; Fam. Umbelliferae) is one of the most important medicinal and aromatic plants which grows well in middle Egypt. The economic value of this crop is related mainly to the fruits which contain volatile and fixed oil. Fennel is used in several purposes as a stimulant, carmine-ative, galactagogue, flavoring agent, diuretic, estrogenic activities, essence in cosmetics and perfumery, antioxidant, antimicrobial, anti-inflammatory (Evans, 1989; Singh *et al*., 2006; Mahfouz and Sharaf-Eldin, 2007).It is well known that chemical fertilization, particularly N, is used for increasing the productivity of medicinal and aromatic plants (Abdel-Kader, 1992; El-Keltawi *et al*., 2006). However, the intensive and/or excessive use of manufactured nitrogen fertilizers raises the major production cost, causes environmental pollution and reduces the acceptance of the crops for export as well as affects the soil fertility (Maticic *et al*., 1992; Sherif and El-Naggar, 2005). In addition, the application of large quantity of soluble fertilizers caused nutritional imbalances that lead to crop diseases and insect infestations, and it is believed to stimulate certain problems of weed species (Barber, 1982). For these reasons the use of organic and biofertilizers is recommended for sustainable agriculture. Many trials have been conducted in this concern for raising the productivity of many medicinal and aromatic plants. Among these trials the use of active dry yeast as biofertilizers and amino acids as organic nitrogenous compounds to reduce or replace the chemical nitrogen fertilizers (El-Sayed *et al*. 2002; Abou Dahab and Abd El-Aziz, 2006; Abd El-Aziz and Balbaa, 2007).

The various positive effects of applying active dry yeast as a newly used biofertilizer were attributed to its content of different nutrients, higher percentage of proteins, large amount of vitamin B and natural plant growth regulators such as cytokinins and auxin (Larson *et al*., 1962; Ferguson *et al*., 1987). Also, the application of active dry yeast is very effective in releasing CO_2 which improves net photosynthesis (Idso *et al*., 1995). The beneficial effects of active dry yeast in improving plant growth, quality, nutritional status and increasing yield of some medicinal and aromatic plants have been reported by El-Sayed *et al*. (2002) on *Coriandrum sativum,* Naguib and Khalil (2002) on *Nigella sativa* and Bishr *et al*. (2006) on *Silybum marianum* L.

Amino acids are used to regulate plant growth and biosynthesis of important economic chemical constituents. Davies (1982) reported that amino acids as organic nitrogenous compounds are the building blocks in the synthesis of proteins. The amino acid tryptophan has an indirect role on the growth via its influence on auxin synthesis. Phillips (1971) reported that alternative routes of IAA synthesis exist in plants, all starting from tryptophan. Moreover, there have been reports that foliar application of tryptophan enhanced the vegetative growth, yield and chemical constituents (Mohamed and Wahba, 1993 on *Rosmarinus officinalis*; Attoa *et al*., 2002 on *Iberis amara*; Abou Dahab and Abd El-Aziz, 2006 on *Philodendron erubescens*).

The aim of the present study was to investigate the effect of active dry yeast and tryptophan in the presence of different levels of N fertilizer on the growth, fruit and oil yield and chemical constituents of fennel (*Foeniculum vulgare*, Mill.) to reduce or replace the chemical nitrogen fertilizers.

Material and Methods

The present investigation was carried out at the Experimental Farm of Floriculture, Faculty of Agriculture, Assiut University, Assiut, Egypt for two successive seasons (2005/2006 and 2006/2007). The fruits of local cultivar of fennel (*Foeniculum vulgare* var. *vulgare*, Mill.) were sown in a clay soil at the beginning of November for both seasons. Some physical and chemical properties of the used soil in this study were done according to the methods described by Jackson (1973) and Black *et al*. (1982) as shown in Table (1).

Table(1): Physical and chemical characteristics of the field experimental soil.

Properties		Value	Properties		Value
Texture analysis:	Clay %	51.5	Soluble cations:	Ca^{++} (meq/100g)	3.38
	Silt %	26.2		Mg^{++} (meq/100g)	2.44
	Sand %	22.3		Na^{+} (meq/100g)	2.45
Texture grade		clay		K^{+} (meq/100g)	1.72
Total Ca CO_3 (%)		1.97	Soluble anions:	Cl^{-} (meq/100g)	0.78
EC (1:1, dS/m)		1.13		$CO_3^{=}$ +HCO^{-}_3 (meq/100g)	0.29
pH (1:1 water suspension)		7.6	Total nitrogen (%)		0.65
Organic matter (%)		1.27	Total phosphorus (%)		0.211
			Total potassium (%)		0.413

The experiment was arranged in a split-split-plot design, with three replicates. The three nitrogen levels (0, 50 and 100 kg N/fed.) represented the main plots, meanwhile concentrations of active dry yeast (0, 2 and 4 g/l) and tryptophan (0, 50 and 100 ppm) represented the sub-plots and sub-sub plots, respectively. Each sub-sub plot of 2.0 x 1.6 meters contained two rows. The planting distance was 30 cm between plants. After 45 days from planting, the plants were thinned to one plant per hill (12 plants/ plot) i. e. 15000 plants/fed.

Nitrogen fertilizer was applied in the form of urea (46.5% N) at 0, 50 and 100 kg N/fed. as a basal dressing. The amount of each was divided into three equal doses.

A strain of dry yeast (*Saccharomyces cerevisiae*) was obtained from El Amal group for export and import, Egypt. Yeast dry matter was 95% and the live cells were 11.6 x 10^9/g. It was activated by dissolving the definite amount in warm water (38ºC), adding sugar at the same rate and kept over night for nearly 12 hours before application. Active dry yeast was added as a soil drench at 0, 2 and 4 g/l (one liter/plot of each concentration) just before irrigation.

Tryptophan was applied as foliar spray at 0, 50 and 100 ppm. Triton B as wetting agent at 0.1% concentration was added to all spraying solutions as well as tap water in the control. Spraying was done to cover whole plant leaves to the point of runoff.

All used treatments of nitrogen, yeast and tryptophan were applied at three times (immediately after thinning, one month later and at the beginning of flowering stage). All other agricultural practices were done as recommended.

The fruits were harvested before they were fully ripe, but sufficiently hard and greenish gray in colour. Data were recorded for plant height (cm), number of branches/plant, plant dry weight (g), number of umbels/plant, seed index (weight of 1000 fruits), fruit yield, fruits volatile oil percentage and oil yield per plant (ml). The volatile oil percentage of the dried fruits was extracted as described in the Egyptian Pharmacopoeia (1961). Distillation was continued for 3 hours as reported by Guenther (1961), then the oil yield per plant was calculated.

Total macronutrients (N, P and K) content in fennel fruits were determined after they were ground and wet ashing. Nitrogen was determined by using semi-micro Kjeldahl method, phosphorus was determined using Spectrophotometer and potassium using a flame photometer (Jackson, 1973). Total carbohydrates including poly-saccharides in fennel fruits were colorimetrically determined by the anthrone sulphuric acid method; Fales (1951).

Data obtained during the two seasons were statistically analyzed according to Steel and Torrie (1982) using the MSTAT computer software.

Results and Discussion

Vegetative growth characteristics:

Data presented in Tables (2 and 3) showed that vegetative growth measurements of fennel plants were markedly responded to various treatments of nitrogen, active dry yeast and amino acid tryptophan. Generally, the application of nitrogen at 50 or 100 kg N/fed. significantly increased plant height, number of branches per plant and plant dry weight compared to the control. The highest values of studied vegetative growth measurements were obtained by using the low level of nitrogen (50 kg N/fed.). These results are in agreement with those of several investigators working on fennel plants; Amin and Patel (2001), Rai *et al*. (2002) and El-Keltawi *et al*. (2006), who indicated that vegetative growth increased as a result of nitrogen application. The increase in vegetative growth measurements of fennel plants may be attributed to the role of nitrogen in initiation of merestemic activity and hence it resulted in an increase in cell number and cell size with an overall increase in plant growth.

Concerning the effect of active dry yeast application on vegetative growth (Tables 2 and 3), it was noticed that fennel plants treated with either 2 or 4 g/l showed a significant increase in plant height, number of branches per plant and plant dry weight compared to untreated plants. However, no significant differences in vegetative growth measurements were achieved among both concentrations of yeast (2 and 4 g/l) in both seasons. The obtained results are in accordance with those reported by Naguib and Khalil (2002) on *Nigella sativa*, Abdel-Kader (2005) on *Lawsonia alba* and Bishr *et al*. (2006) on *Silybum marianum*. This could be explained in the light of the various ingredients in yeast exudates as reported by Larson *et al*. (1962) and Freguson *et al*. (1987) like vitamin B and natural growth hormones. Also, the application of active dry yeast is very effective in releasing CO_2 which improves net photosynthesis (Idso *et al*., 1995).

Regarding the effect of amino acid tryptophan on the vegetative growth, it was observed that foliar application of tryptophan had a significant effect on plant height, number of branches/plant and plant dry weight compared to the control. The maximum values of vegetative growth measurements were obtained in plants treated by tryptophan at 50 ppm (Tables 2 and 3). These results coincided with the results obtained by Attoa *et al*. (2002), Wahba *et al*. (2002) and Abou Dahab and Abd El-Aziz (2006). They reported that foliar application of tryptophan

Table(2): Effect of nitrogen, active dry yeast and tryptophan on plant height and number of branches per plant of fennel during the 2005/2006 and 2006/2007 seasons.

Nitrogen level "kg /fed." (A)	Active dry yeast con."g/l" (B)	1^{st} season (2005/2006)				2^{nd} season (2006/2007)			
		Tryptophan con. "ppm" (C)							
		Cont.	50	100	Mean	Cont.	50	100	Mean
		Plant height (cm)							
Control	Control	108.7	120.6	121.8	117.0	103.7	113.6	117.9	111.7
	2	120.8	125.5	127.8	124.7	113.9	121.8	122.5	119.4
	4	122.3	128.1	129.3	126.6	117.0	123.2	124.8	121.7
Mean		117.3	124.7	126.3	122.8	111.5	119.5	121.7	117.6
50	Control	123.0	127.4	130.1	126.8	118.8	123.6	127.5	123.3
	2	128.4	136.3	131.3	132.0	126.3	131.5	128.2	128.7
	4	135.2	135.2	130.8	133.7	131.3	130.2	127.8	129.8
Mean		128.8	133.0	130.7	130.8	125.5	128.4	127.8	127.2
100	Control	126.1	130.7	125.9	127.6	124.1	128.1	123.3	125.1
	2	134.5	126.0	124.7	128.4	130.3	121.8	119.5	123.8
	4	131.4	125.7	122.6	126.6	126.1	120.8	118.5	121.8
Mean		130.7	127.5	124.4	127.5	126.8	123.6	120.4	123.6
General mean		125.6	128.4	127.1		121.3	123.8	123.3	
General effects of active dry yeast concentrations:									
Control		119.3	126.2	125.9	123.8	115.5	121.8	122.9	120.1
2		127.9	129.3	127.9	128.4	123.5	125.0	123.4	124.0
4		129.6	129.7	127.6	129.0	124.8	124.7	123.7	124.4
L.S.D. at 5%		A: 1.8 B: 1.2 AB: 2.1 C: 1.0 AC: 1.8 BC: 1.8 ABC: 3.0				A: 2.0 B: 0.9 AB: 1.5 C: 1.2 AC: 2.1 BC: 2.1 ABC: 3.7			
		Number of branches/plant							
Control	Control	6.7	8.1	8.3	7.7	6.1	7.0	7.6	6.9
	2	8.0	8.5	8.7	8.4	7.1	8.1	8.3	7.8
	4	8.3	8.6	8.8	8.6	7.3	8.2	8.4	8.0
Mean		7.7	8.4	8.6	8.2	6.8	7.8	8.1	7.6
50	Control	8.4	8.8	9.0	8.8	7.7	8.3	8.6	8.2
	2	8.8	9.3	9.1	9.1	8.4	9.0	8.9	8.8
	4	9.2	9.2	9.0	9.1	8.9	9.0	8.6	8.8
Mean		8.8	9.1	9.0	9.0	8.3	8.8	8.7	8.6
100	Control	8.6	9.2	8.7	8.9	8.3	8.6	8.4	8.4
	2	9.2	8.7	8.6	8.8	8.8	8.4	8.2	8.5
	4	9.1	8.5	8.4	8.7	8.6	8.3	7.4	8.1
Mean		9.0	8.8	8.6	8.8	8.6	8.4	8.0	8.3
General mean		8.5	8.8	8.7		7.9	8.3	8.3	
General effects of active dry yeast concentrations:									
Control		7.9	8.7	8.7	8.4	7.4	8.0	8.2	7.8
2		8.7	8.8	8.8	8.8	8.1	8.5	8.5	8.4
4		8.9	8.8	8.7	8.8	8.3	8.5	8.1	8.3
L.S.D. at 5%		A: 0.4 B: 0.2 AB: 0.4 C: 0.1 AC: 0.2 BC: 0.2 ABC: 0.3				A: 0.2 B: 0.2 AB: 0.3 C: 0.1 AC: 0.2 BC: 0.2 ABC: 0.3			

Table(3): Effect of nitrogen, active dry yeast and tryptophan on plant dry weight and number of umbels per plant of fennel during the 2005/2006 and 2006/2007 seasons.

Nitrogen level "kg /fed." (A)	Active dry yeast con. "g/l"(B)	1st season (2005/2006)				2nd season (2006/2007)			
		Tryptophan con. "ppm" (C)							
		Cont.	50	100	Mean	Cont.	50	100	Mean
		Plant dry weight (g)							
Control	Control	198.1	237.2	253.9	229.7	181.3	229.2	236.1	215.5
	2	244.8	281.7	296.3	274.3	233.1	272.7	283.9	263.2
	4	260.2	300.7	307.2	289.4	242.3	281.8	287.7	270.6
Mean		234.4	273.2	285.8	264.5	218.9	261.2	269.2	249.8
50	Control	277.6	295.7	314.5	295.9	254.7	275.4	299.4	276.5
	2	307.1	338.7	324.5	323.4	297.9	328.3	308.3	311.5
	4	327.7	327.8	314.0	323.2	323.3	321.5	300.1	315.0
Mean		304.1	320.7	317.7	314.2	292.0	308.4	302.6	301.0
100	Control	291.3	315.9	292.2	299.8	283.1	303.8	282.6	289.8
	2	322.5	294.1	281.9	299.5	315.7	285.2	264.4	288.4
	4	316.4	284.3	267.1	289.3	298.0	272.3	256.4	275.6
Mean		310.1	298.1	280.4	296.2	298.9	287.1	267.8	284.6
General mean		282.9	297.3	294.6		269.9	285.6	279.9	
General effects of active dry yeast concentrations:									
Control		255.7	282.9	286.9	275.2	239.7	269.5	272.7	260.6
2		291.5	304.8	300.9	299.1	282.2	295.4	285.5	287.7
4		301.4	304.3	296.1	300.6	287.9	291.9	281.4	287.0
L.S.D. at 5%		A: 1.8 B: 1.9 AB: 3.3 C: 1.1 AC: 1.9 BC: 1.9 ABC: 3.3				A: 1.9 B: 1.3 AB: 2.2 C: 1.5 AC: 2.6 BC: 2.6 ABC: 4.6			
		Number of umbels/plant							
Control	Control	31.1	40.4	43.9	38.5	26.6	33.2	35.9	31.9
	2	39.2	46.7	48.9	44.9	31.9	38.2	40.1	36.7
	4	42.3	47.5	49.3	46.4	34.6	38.9	42.1	38.5
Mean		37.5	44.9	47.4	43.3	31.0	36.8	39.4	35.7
50	Control	45.6	51.8	54.3	50.6	37.7	42.4	45.7	41.9
	2	49.8	55.9	55.6	53.8	41.9	46.8	46.7	45.1
	4	53.6	55.8	50.3	53.2	45.7	46.9	42.1	44.9
Mean		49.7	54.5	53.4	52.5	41.8	45.4	44.8	44.0
100	Control	49.7	55.5	50.0	51.7	41.6	46.2	41.1	43.0
	2	52.1	49.8	46.1	49.3	44.8	41.2	37.9	41.3
	4	49.6	47.8	44.6	47.3	42.2	38.1	37.5	39.3
Mean		50.5	51.0	46.9	49.5	42.9	41.8	38.8	41.2
General mean		45.9	50.1	49.2		38.6	41.3	41.0	
General effects of active dry yeast concentrations:									
Control		42.1	49.2	49.4	46.9	35.3	40.6	40.9	38.9
2		47.0	50.8	50.2	49.3	39.5	42.1	41.6	41.1
4		48.5	50.4	48.1	49.0	40.8	41.3	40.6	40.9
L.S.D. at 5%		A: 01.0 B: 1.1 AB: 1.9 C: 0.9 AC: 1.6 BC: 1.6 ABC: 2.7				A: 1.1 B: 1.3 AB: 2.3 C: 1.1 AC: 1.9 BC: 1.9 ABC: 3.2			

significantly promoted plant growth. The increase in plant growth as a result of tryptophan application may be due to its conversion into IAA (Russell, 1982). The converted IAA plays an important role in activating plant growth, consequently the plant height, number of branches/plant and plant dry weight could be increased.

The interaction effects of nitrogen, active dry yeast and tryptophan on the plant height, number of branches per plant and plant dry weight were significant in the two seasons. The tallest plants, higher number of branches per plant and heavier dry weight of plant resulted from plants fertilized with 50 kg N/fed., drenched with active dry yeast at 2 g/l and sprayed with tryptophan at 50 ppm. Also, the obtained data in this study cleared that the application of active dry yeast at 4 g/l with 50 or 100 ppm tryptophan gave nearly equal results to those obtained with the highest level of nitrogen (100 kg/fed.) alone.

Flowering and fruiting characteristics:

Data in Tables (3 and 4) show clearly that supplying fennel plants with nitrogen at 50 or 100 kg/fed. resulted in a significant increase in number of umbels/plant, weight of 1000 fruits and fruit yield/plant compared to the control in the two seasons. Generally, the application of nitrogen at 50 kg/fed. was more effective than 100 kg/fed. in increasing flowering and fruiting characters. The increases were 22.3% in number of umbels/plant and 38.4% in fruit yield/plant over the control as average mean of both seasons as illustrated in Fig. (1). The increase in flowering and fruiting characteristics may be due to the stimulating effect of nitrogen on the vigor of vegetative growth and accumulation of photosynthates and their assimilation which stimulate fennel plants to produce high fruit yield. These results are in agreement with several investigators; Amin and Patel (2001) and El-Keltawi *et al.* (2006) on fennel plants.

Apparently, yeast application at varied concentrations significantly increased flowering and fruiting characters under investigation compared to the control. These increments were 5.4 and 4.9% in number of umbels/plant, 6.6 and 5.0% in fruit yield/plant for 2 and 4 g/l yeast, respectively over the control (Fig. 1). The enhancing effect of active dry yeast on the flowering and fruiting characters obtained in the present investigation was also found by Naguib and Khalil (2002) on *Nigella sativa*, Abdel-Kader (2005) on *Lawsonia alba* and Bishr *et al*. (2006) on *Silybum marianum* plants.

Table(4): Effect of nitrogen, active dry yeast and tryptophan on weight of 1000 fruits and fruit yield per plant of fennel during the 2005/2006 and 2006/2007 seasons.

Nitrogen level "kg /fed." (A)	Active dry yeast con. "g/l" (B)	1st season (2005/2006)				2nd season (2006/2007)			
		Tryptophan con. "ppm" (C)							
		Cont.	50	100	Mean	Cont.	50	100	Mean
		Weight of 1000 fruits (g)							
Control	Control	6.17	6.68	7.00	6.62	6.07	6.40	6.70	6.39
	2	6.66	7.25	7.30	7.07	6.43	6.97	7.16	6.85
	4	6.93	7.30	7.32	7.18	6.67	7.19	7.24	7.03
Mean		6.59	7.08	7.21	6.96	6.39	6.85	7.03	6.76
50	Control	7.17	7.51	7.76	7.48	6.87	7.32	7.58	7.25
	2	7.43	7.85	7.85	7.71	7.25	7.81	7.78	7.61
	4	7.80	7.84	7.49	7.71	7.67	7.81	7.28	7.59
Mean		7.47	7.73	7.70	7.63	7.26	7.65	7.55	7.49
100	Control	7.33	7.83	7.43	7.53	7.27	7.61	7.27	7.38
	2	7.70	7.40	7.27	7.46	7.47	7.26	7.16	7.30
	4	7.50	7.28	6.98	7.25	7.27	7.20	6.78	7.08
Mean		7.51	7.50	7.23	7.41	7.34	7.36	7.07	7.25
General mean		7.19	7.44	7.38		7.00	7.29	7.22	
General effects of active dry yeast concentrations :									
Control		6.89	7.34	7.40	7.21	6.73	7.11	7.18	7.01
2		7.26	7.50	7.47	7.41	7.05	7.35	7.37	7.26
4		7.41	7.47	7.26	7.38	7.20	7.40	7.10	7.23
L.S.D. at 5%		A: 0.06 B: 0.08 AB: 0.14 C: 0.10 AC: 0.17 BC: 0.17 ABC: 0.30				A: 0.12 B: 0.09 AB: 0.15 C: 0.07 AC: 0.13 BC: 0.13 ABC: 0.22			
		Fruit yield/plant (g)							
Control	Control	48.9	63.1	69.2	60.4	46.5	58.9	65.7	57.0
	2	60.8	74.3	78.7	71.3	55.9	66.2	72.2	64.8
	4	64.1	76.2	79.1	73.1	62.6	69.5	74.4	68.8
Mean		57.9	71.2	75.7	68.3	55.0	64.9	70.8	63.5
50	Control	73.6	91.8	100.2	88.6	66.3	79.5	90.2	78.7
	2	86.3	106.5	104.8	99.2	77.0	98.0	98.0	91.3
	4	98.0	106.1	90.6	98.2	90.4	100.0	83.1	91.2
Mean		86.0	101.5	98.5	95.3	77.9	92.8	90.4	87.0
100	Control	83.8	103.4	91.9	93.0	78.7	95.3	80.8	84.9
	2	94.0	90.0	73.9	86.0	88.7	79.2	66.0	78.0
	4	91.1	74.1	70.4	78.5	81.0	71.9	65.2	72.7
Mean		89.6	89.2	78.7	85.8	82.8	82.1	70.7	78.5
General mean		77.8	87.3	84.3		71.9	79.9	77.3	
General effects of active dry yeast concentrations:									
Control		68.8	86.1	87.1	80.7	63.8	77.9	78.9	73.5
2		80.4	90.3	85.8	85.5	73.9	81.4	78.7	78.0
4		84.4	85.4	80.0	83.3	78.0	80.5	74.2	77.6
L.S.D. at 5%		A: 1.3 B: 1.5 AB: 3.1 C: 1.4 AC: 2.5 BC: 2.5 ABC: 4.3				A: 1.2 B: 1.7 AB: 3.0 C: 1.9 AC: 3.3 BC: 3.3 ABC: 5.8			

It is evident from the present data that spraying tryptophan on fennel plants at 50 ppm resulted in the highest values of flowering and fruiting measurements (Tables 3, 4). The maximum values of increments were observed for number of umbels/plant by 8% and fruit yield/plant by 11.6% over the control (Fig. 1). The positive effect of amino acids on yield due to the vital effect of these amino acids stimulation on the growth of plant cell. Our results are comparable with those obtained by Mohamed and Wahba (1993) on *Rosmarinus officinalis* and Attoa *et al*. (2002) on *Iberis amara* plants.

The present results clearly indicated that the application of active dry yeast at 4 g/l plus 100 ppm tryptophan gave nearly equal results to those obtained from the high level of nitrogen (100 kg/fed.) alone. On the other hand, the application of yeast at 4 g/l or tryptophan at 100 ppm with the low level of nitrogen (50 kg/fed.) resulted in a significant increase in all studied flowering and fruiting characters compared to the high level of nitrogen alone.

The interactions between nitrogen, active dry yeast and tryptophan on number of umbels/plant, weight of 1000 fruits and fruit yield/plant were significant. The maximum increments of flowering and fruiting measurements were obtained by using nitrogen at 50 g/fed. ombined with 2 or 4 g/l active dry yeast and 50 ppm tryptophan.The increments were 77.9% in number of umbels/plant and 114.5% in fruit yield/plant over the control (Fig. 2). It is evident from the present data that spraying tryptophan on fennel plants at 50 ppm resulted in the highest values of flowering and fruiting measurements (Tables 3, 4). The maximum values of increments were observed for number of umbels/plant by 8% and fruit yield/plant by 11.6% over the control (Fig. 1). The positive effect of amino acids on yield due to the vital effect of these amino acids stimulation on the growth of plant cell. Our results are comparable with those obtained by Mohamed and Wahba (1993) on *Rosmarinus officinalis* and Attoa *et al*. (2002) on *Iberis amara* plants.

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The interactions between nitrogen, active dry yeast and tryptophan on number of umbels/plant, weight of 1000 fruits and fruit yield/plant were significant. The maximum increments of flowering and fruiting measurements were obtained by using nitrogen at 50 g/fed. ombined with 2 or 4 g/l active dry yeast and 50 ppm tryptophan.The increments were

77.9% in number of umbels/plant and 114.5% in fruit yield/plant over the control (Fig. 2).

Volatile oil percentage and yield:

Data presented in Table (5) show that treatment of fennel plants with nitrogen, active dry yeast and/or tryptophan significantly increased volatile oil percentage and yield in the fruits compared to the controls. However, the application of nitrogen was more effective on increasing oil production than that of yeast and/or tryptophan as illustrated in Fig. (1).

Generally, The highest volatile oil percentage and yield in fennel fruits were obtained by using nitrogen at 50 kg/fed.; which caused an increase of 14.7% and 57.1% over the control, respectively. These results are in agreement with those of several investigators working on fennel; Hussein and Abou El-Magd (1991), Amin and Patel (2001), Rai *et al*. (2002) and El-Keltawi *et al*. (2006).

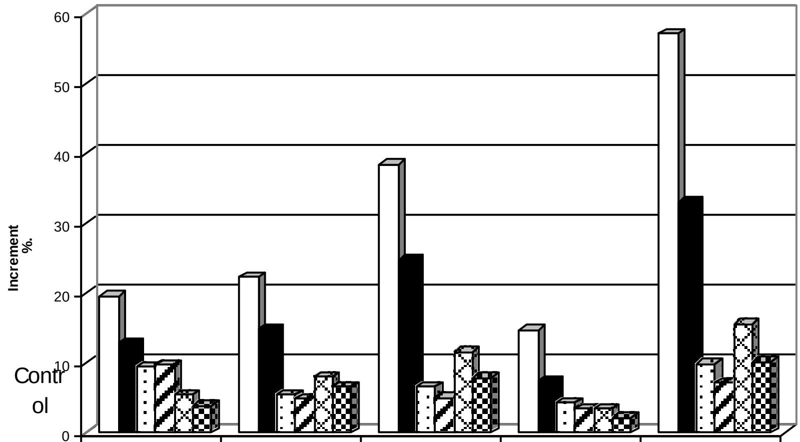
As for the effect of active dry yeast data presented in Table (5) indicated that both tested concentrations significantly increased volatile oil percentage and yield in fennel fruits in both seasons as compared to control. Generally, application of active dry yeast at 2 g/l was more effective on increasing volatile oil percentage and yield. The increases were 4.2% in volatile oil percentage and 9.8% in oil yield/plant over the control (Fig. 1). In accordance with the beneficial effect of active dry yeast were those reported by Naguib and Khalil (2002), El-Sayed *et al*. (2002) and Bishr *et al*. (2006). These results may be due to the stimulatory effect of yeast, which act as coenzymes of photosynthesis and metabolism of carbohydrates and other metabolites in seeds (Subba Rao, 1984 and Dewick, 2000).

Concerning the effect of tryptophan data in Table (5) show that the two tested concentrations succeeded in increasing volatile oil percentage and yield in fennel fruits compared to the controls in both seasons. The highest values of volatile oil percentage and yield were obtained from 50 ppm tryptophan, (3.5 and 15.6% over the control, respectively). These results are in harmony with those obtained by Mohamed and Wahba (1993) and Gomaa (2003), who reported that amino acids increased the oil percentage of *Crinum asiaticum* plant.

Regarding the interaction effects among nitrogen, yeast and tryptophan, data in Table (5) indicate that volatile oil percentage and yield in fennel fruits were significant. It also clears from the obtained data that application of nitrogen at 50 kg/fed. combined with active dry yeast at 2 or 4 g/l and 50 ppm tryptophan resulted in the highest pronounced effects on volatile oil percentage and yield. The increments were 31.5% in volatile oil percentage and 185% in oil yield/plant over the general control (Fig. 2). The increases in the volatile oil yield per plant as a result of nitrogen, yeast and tryptophan applications could be attributed to the increase in the production of fruit yield and oil percentage.

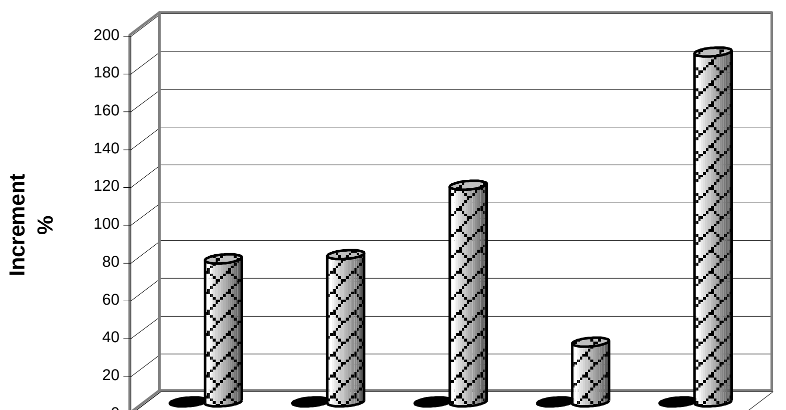
Table(5): Effect of nitrogen, active dry yeast and tryptophan on oil percentage and yield in fennel fruits during the 2005/2006 and 2006/2007 seasons.

Nitrogen level "kg /fed." (A)	Active dry yeast con. "g/l" (B)	1st season (2005/2006)				2nd season (2006/2007)			
		Tryptophan con. "ppm" (C)							
		Cont.	50	100	Mean	Cont.	50	100	Mean
		Oil percentage							
Control	Control	1.28	1.35	1.40	1.34	1.25	1.29	1.33	1.29
	2	1.35	1.41	1.45	1.40	1.30	1.38	1.41	1.36
	4	1.38	1.44	1.49	1.44	1.32	1.40	1.43	1.38
Mean		1.34	1.40	1.45	1.39	1.29	1.36	1.39	1.35
50	Control	1.40	1.56	1.59	1.52	1.37	1.45	1.47	1.43
	2	1.48	1.69	1.69	1.62	1.46	1.65	1.64	1.58
	4	1.60	1.68	1.58	1.62	1.57	1.65	1.50	1.57
Mean		1.49	1.64	1.62	1.59	1.47	1.58	1.54	1.53
100	Control	1.49	1.60	1.51	1.53	1.43	1.48	1.44	1.45
	2	1.55	1.50	1.42	1.49	1.57	1.45	1.36	1.46
	4	1.50	1.41	1.39	1.43	1.47	1.36	1.33	1.38
Mean		1.51	1.50	1.44	1.49	1.49	1.43	1.38	1.43
General mean		1.45	1.52	1.50		1.42	1.46	1.43	
General effects of active dry yeast concentrations:									
Control		1.39	1.50	1.50	1.46	1.35	1.41	1.41	1.39
2		1.46	1.53	1.52	1.50	1.44	1.49	1.47	1.47
4		1.49	1.51	1.49	1.50	1.45	1.47	1.42	1.45
L.S.D. at 5%		A: 0.02 B: 0.03 AB: 0.05 C: 0.02 AC: 0.04 BC: 0.04 ABC: 0.06				A: 0.02 B: 0.01 AB: 0.02 C: 0.01 AC: 0.02 BC: 0.02 ABC: 0.03			
		Oil yield/plant (ml)							
Control	Control	0.63	0.85	0.97	0.82	0.57	0.76	0.87	0.73
	2	0.82	1.05	1.14	1.00	0.73	0.91	1.02	0.89
	4	0.88	1.10	1.18	1.05	0.83	0.97	1.06	0.95
Mean		0.78	1.00	1.10	0.96	0.71	0.88	0.98	0.86
50	Control	1.03	1.43	1.59	1.35	0.91	1.15	1.33	1.13
	2	1.28	1.80	1.77	1.62	1.12	1.61	1.59	1.44
	4	1.57	1.78	1.43	1.59	1.42	1.65	1.25	1.44
Mean		1.29	1.67	1.60	1.52	1.15	1.47	1.39	1.34
100	Control	1.25	1.65	1.39	1.43	1.13	1.41	1.17	1.24
	2	1.46	1.35	1.05	1.29	1.40	1.15	0.90	1.15
	4	1.37	1.04	0.98	1.13	1.19	0.98	0.87	1.01
Mean		1.36	1.35	1.14	1.28	1.24	1.18	0.98	1.13
General mean		1.14	1.34	1.28		1.03	1.18	1.12	
General effects of active dry yeast concentrations:									
Control		0.97	1.31	1.32	1.20	0.87	1.11	1.12	1.03
2		1.19	1.40	1.32	1.30	1.08	1.22	1.17	1.16
4		1.27	1.31	1.21	1.26	1.15	1.20	1.06	1.14
L.S.D. at 5%		A: 0.03 B: 0.02 AB: 0.04 C: 0.02 AC: 0.03 BC: 0.03 ABC: 0.05				A: 0.03 B: 0.02 AB: 0.03 C: 0.02 AC: 0.03 BC: 0.03 ABC: 0.05			



	Dry weight	No.of umbels/plant	Fruit yield/plant	Oil %	Oil yield/plant
50kg N/fed.	19.6	22.3	38.4	14.7	57.1
100kg N/fed.	12.9	14.9	24.7	7.4	33
2 g/l yeast	9.5	5.4	6.6	4.2	9.8
4 g/l yeast	9.7	4.9	5	3.5	7.1
50ppm tryptophan	5.5	8	11.6	3.5	15.6
100ppm tryptophan	3.9	6.6	7.9	2.1	10.1

Fig.(1): General means of increment percentages of fennel growth and yield over the control as affected by nitrogen, active dry yeast and tryptophan applications.



	Dry weight	No.of umbels/plant	Fruit yield/plant	Oil %	Oil yield/plant
0 (control)	0	0	0	0	0
50kg N/fed.+2 g/l yeast+50 ppm tryptophan	75.6	77.9	114.5	31.5	185

Fig.(2): General means of increment percentages over the control for fennel growth and yield as affected by combined treatment of 50 kg N/fed. + 2 g/l yeast + 50 ppm tryptophan.

Chemical analysis:

The recorded data in Tables (6 and 7) revealed that total carbohydrates, N, P and K contents in fennel fruits were markedly increased as a result of nitrogen, active dry yeast or tryptophan applications compared to the controls. Generally, the low rate of each of nitrogen, yeast and tryptophan was more effective on accumulation of total carbohydrates, N, P and K than their controls and/or the highest one of them. These results are in agreement with those found by Naguib and Khalil (2002), Attoa *et al*. (2002), Gomaa (2003), Abdel-Kader (2005), Abou Dahab and Abd El-Aziz (2006) and El-Keltawi *et al*. (2006).

Respecting the interaction effects among nitrogen, active dry yeast and tryptophan, it was observed that the most effective combination in increasing fruit nutrient contents were 50 kg N/fed. + 2 or 4 g/l yeast + 50 ppm tryptophan. The accumulation of carbohydrates as a result of nitrogen application may be due to the important role of nitrogen in the biosynthesis of chlorophyll molecules (Meyer *et al*., 1968). Nitrogen enables the absorption of other nutrients that led to balance the growth of plant. This in turn improves photosynthesis and dry matter accumulation leading to higher yield (Aly *et al*., 1996). The increment in nutrient contents might be also due to the enhancement effect of yeast on some metabolic activities in the plants which lead to good accumulation of nutrient in seeds (Fruton and Simmonds, 1959). In addition, the increases in the content of total carbohydrates, N, P and K as a result of the tryptophan treatments may be attributed to its conversion of to IAA (Phillips, 1971).

Conclosion

From the aforementioned results and discussion, it may be concluded that:

- To replace the mineral nitrogen fertilizer, it is recommend to apply active dry yeast at 4 g/l plus 50 or 100 ppm tryptophan, since it gave nearly equal results to those obtained by the high level of nitrogen (100 kg/fed.) alone.
- The application of active dry yeast at 4 g/l or tryptophan at 100 ppm with 50 kg N/fed. resulted in a significant increase in vegetative growth, flowering and fruiting characteristics as well as oil production in fennel fruits compared to the high level of nitrogen (100 kg/ fed.) alone.
- To obtain the maximum vegetative growth, flowering fruit and oil yield of fennel plants and to reduce the chemical nitrogen fertilizer to the half dose, it could be recommend to use 50 kg N/fed. + 2 or 4 g/l active dry yeast + 50 ppm tryptophan.

Table(6): Effect of nitrogen, active dry yeast and tryptophan on the contents of total carbohydrates and N in fennel fruits during the 2005/2006 and 2006/2007 seasons.

Nitrogen level "kg /fed." (A)	Active dry yeast con. "g/l" (B)	1st season (2005/2006)				2nd season (2006/2007)			
		Tryptophan con. "ppm" (C)							
		Cont.	50	100	Mean	Cont.	50	100	Mean
		Total carbohydrates %							
Control	Control	11.4	12.6	13.3	12.4	11.1	12.5	13.0	12.2
	2	12.7	13.9	14.2	13.6	12.3	13.1	13.5	13.0
	4	13.2	13.9	14.3	13.8	13.0	13.4	13.7	13.4
Mean		12.4	13.5	13.9	13.3	12.1	13.0	13.4	12.8
50	Control	13.8	14.5	14.9	14.4	13.2	14.0	14.4	13.9
	2	14.2	15.4	15.2	14.9	14.1	14.9	14.8	14.6
	4	15.3	15.3	14.4	15.0	14.5	14.9	14.0	14.5
Mean		14.4	15.1	14.8	14.8	13.9	14.6	14.4	14.3
100	Control	14.0	15.1	14.1	14.4	13.6	14.5	13.9	14.0
	2	15.1	14.5	13.7	14.4	14.3	13.9	13.0	13.7
	4	14.4	13.6	13.3	13.8	13.9	13.0	12.9	13.3
Mean		14.5	14.4	13.7	14.2	13.9	13.8	13.3	13.7
General mean		13.8	14.3	14.2		13.3	13.8	13.7	
General effects of active dry yeast concentrations:									
Control		13.1	14.0	14.1	13.7	12.6	13.7	13.8	13.4
2		14.0	14.6	14.4	14.3	13.6	14.0	13.8	13.8
4		14.3	14.3	14.0	14.2	13.8	13.8	13.5	13.7
L.S.D. at 5%		A: 0.14 B: 0.20 AB: 0.34 C: 0.18 AC: 0.32 BC: 0.32 ABC: 0.55				A: 0.17 B: 0.13 AB: 0.23 C: 0.15 AC: 0.26 BC: 0.26 ABC: 0.45			
		Nitrogen %							
Control	Control	1.78	1.87	1.92	1.86	1.75	1.85	1.88	1.83
	2	1.87	2.11	2.14	2.04	1.85	1.92	1.93	1.90
	4	2.01	2.17	2.19	2.12	1.90	1.94	1.95	1.93
Mean		1.89	2.05	2.08	2.01	1.83	1.90	1.92	1.89
50	Control	2.10	2.21	2.35	2.22	1.92	2.14	2.20	2.09
	2	2.15	2.35	2.35	2.28	1.96	2.21	2.20	2.12
	4	2.31	2.34	2.20	2.28	2.17	2.22	2.18	2.19
Mean		2.19	2.30	2.30	2.26	2.02	2.19	2.19	2.13
100	Control	2.19	2.34	2.18	2.24	2.05	2.21	2.00	2.09
	2	2.28	2.20	2.12	2.20	2.15	1.95	1.92	2.01
	4	2.21	2.11	1.95	2.09	2.17	1.92	1.80	1.96
Mean		2.23	2.22	2.08	2.18	2.12	2.03	1.91	2.02
General mean		2.10	2.19	2.16		1.99	2.04	2.01	
General effects of active dry yeast concentrations:									
Control		2.02	2.14	2.15	2.10	1.91	2.07	2.03	2.00
2		2.10	2.22	2.20	2.17	1.99	2.03	2.02	2.01
4		2.18	2.21	2.11	2.17	2.08	2.03	1.98	2.03
L.S.D. at 5%		A: 0.09 B: 0.05 AB: 0.08 C: 0.04 AC: 0.08 BC: 0.08 ABC: 0.13				A: 0.06 B: N.S. AB: 0.09 C: 0.04 AC: 0.06 BC: 0.06 ABC: 0.11			

Table(7): Effect of nitrogen, active dry yeast and tryptophan on the contents of P and K in fennel fruits during the 2005/2006 and 2006/2007 seasons.

Nitrogen level "kg /fed." (A)	Active dry yeast con. "g/l"(B)	1st season (2005/2006)				2nd season (2006/2007)			
		Tryptophan con. "ppm" (C)							
		Cont.	50	100	Mean	Cont.	50	100	Mean
		Phosphorus %							
Control	Control	0.154	0.166	0.182	0.167	0.146	0.171	0.178	0.165
	2	0.172	0.186	0.191	0.183	0.164	0.181	0.174	0.173
	4	0.196	0.205	0.205	0.202	0.175	0.195	0.181	0.184
Mean		0.174	0.185	0.193	0.184	0.162	0.182	0.178	0.174
50	Control	0.187	0.216	0.198	0.200	0.182	0.193	0.184	0.186
	2	0.206	0.228	0.218	0.217	0.195	0.212	0.210	0.206
	4	0.218	0.218	0.192	0.209	0.197	0.208	0.185	0.197
Mean		0.204	0.221	0.203	0.209	0.191	0.204	0.193	0.196
100	Control	0.191	0.199	0.181	0.190	0.186	0.195	0.174	0.185
	2	0.195	0.184	0.178	0.186	0.188	0.172	0.170	0.177
	4	0.188	0.181	0.167	0.179	0.180	0.172	0.162	0.171
Mean		0.191	0.188	0.175	0.185	0.185	0.180	0.168	0.177
General mean		0.190	0.198	0.190		0.179	0.189	0.180	
General effects of active dry yeast concentrations:									
Control		0.177	0.194	0.187	0.186	0.171	0.186	0.179	0.179
2		0.191	0.199	0.196	0.195	0.182	0.188	0.185	0.185
4		0.201	0.201	0.188	0.197	0.184	0.192	0.175	0.184
L.S.D. at 5%		A: 0.003 B: 0.002 AB: 0.004 C: 0.002 AC: 0.004 BC: 0.004 ABC: 0.006				A:0.002 B:0.002 AB 0.003 C: 0.002 AC: 0.004 BC: 0.004 ABC: 0.006			
		Potassium %							
Control	Control	2.70	3.70	3.72	3.37	2.43	3.28	3.29	3.00
	2	3.61	3.72	3.74	3.69	3.27	3.30	3.31	3.29
	4	3.69	3.74	3.75	3.73	3.30	3.31	3.34	3.32
Mean		3.33	3.72	3.74	3.60	3.00	3.30	3.31	3.20
50	Control	3.60	3.83	3.96	3.80	3.29	3.52	3.60	3.47
	2	3.90	4.00	3.95	3.95	3.45	3.57	3.59	3.54
	4	3.99	4.10	3.86	3.98	3.61	3.58	3.44	3.54
Mean		3.83	3.98	3.92	3.91	3.45	3.56	3.54	3.52
100	Control	3.76	3.93	3.75	3.81	3.37	3.60	3.46	3.48
	2	4.10	3.75	3.63	3.83	3.57	3.43	3.25	3.42
	4	4.00	3.60	3.59	3.73	3.42	3.25	3.15	3.27
Mean		3.95	3.76	3.66	3.79	3.45	3.43	3.29	3.39
General mean		3.71	3.82	3.77		3.30	3.43	3.38	
General effects of active dry yeast concentrations:									
Control		3.35	3.82	3.81	3.66	3.03	3.47	3.45	3.32
2		3.87	3.82	3.77	3.82	3.43	3.43	3.38	3.42
4		3.89	3.81	3.73	3.81	3.44	3.38	3.31	3.38
L.S.D. at 5%		A: 0.10 B: 0.10 AB: 0.18 C: 0.08 AC: 0.15 BC: 0.15 ABC: 0.25				A: 0.09 B: 0.08 AB: 0.14 C: 0.06 AC: 0.10 BC: 0.10 ABC: 0.18			

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النمـو والمحصـول والمكونـات الكيميائيـة لنبات الشمـر متأثـرة بإضافـة النيتروجيـن والخميـرة والتربتوفـان

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أجرى هذا البحث بمزرعة أبحاث الزينة بكلية الزراعة – جامعة أسيوط خلال موسمي 2006/2005، 2007/2006 وذلك بهدف دراسة تأثير إضافة ثلاث معدلات من كل من النيتروجين (صفر، 50 ، 100 كجم ن/فدان) والخميره الجافة النشطة (صفر، 2 ، 4 جرام/لتر) والتربتوفان (صفر، 50 ، 100 جزء في المليون) على نمو ومحصول الثمار والزيت والمكونات الكيميائية لنبات الشمر.

وقد أوضحت النتائج المتحصل عليها ما يلي:-

- أدى إضافة أي من النيتروجين أو الخميره أو التربتوفان إلى حدوث زيادة معنوية في صفات النمو الخضري والزهري ومحصول الزيت والثمار وكذلك محتوى الأوراق من الكربوهيدرات الكلية والنيتروجين والفوسفور والبوتاسيوم مقارنة بالكنترول.
- كان جديرا بالملاحظة أن أعطت إضافة الخميرة بمعدل 4 جرام/لتر كسماد حيوي مع التربتوفان بمعدل 100 جزء في المليون كمصدر نيتروجينى عضوي نتائج مساوية تقريبا مع تلك المتحصل عليها باستعمال المستوى المرتفع من النيتروجين المعدني (100 كجم ن/فدان) بمفرده، ويوصى باستعمال ذلك في الزراعة الحيوية والعضوية لنبات الشمر.
- كما أدى إضافة أي من الخميرة الجافة النشطة بمعدل 4 جرام/لتر أو التربتوفان بمعدل 100 جزء في المليون مع استعمال المستوى المنخفض من النيتروجين (50 كجم ن/فدان) إلى زيادة معنوية في كل من الصفات المدروسة مقارنة بالمستوى المرتفع من النيتروجين بمفرده.
- لتقليل التلوث البيئي والاحتياجات السمادية من النيتروجين المعدني وكذلك للحصول على أعلى نمو خضري وزهري ومحصول ثمار وزيت، يوصى بتسميد نباتات الشمر بمعدل 50 كجم ن/فدان مع إضافة الخميرة الجافة النشطة للتربة بمعدل 2 أو 4 جرام/لتر والرش بالتربتوفان بمعدل 50 جزء في المليون.