Effect of NPK and Bio-Fertilizers Rates on the Vegetative Growth and Oil Yield of *Ocimum basillicum* L. Plants

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ABSTRACT

The present study was designed to investigate the response of *Ocimum basilicum* L. plants to four rates of NPK (0, 50, 75 and 100% of recommended) and four treatments of active dry yeast (ADY) as biofertilizer (0, 2, 4, and 6 g l^{-1}) and their combinations. The recommended dose of NPK (100%) was 11.11, 7.41 and 3.70 g $plant^{-1}$ of ammonium sulphate (20.5% N), calcium super phosphate (15.5 P_2O_5) and potassium sulphate (48.5% K_2O), respectively.

The experiment was carried out during the growing seasons of 2012 and 2013 at Agric. Research Station, Alex. Univ., Egypt. The result showed that 100% of NPK combined with ADY at 4 and/ or 6 g l^{-1} gave the highest value of vegetative growth characters (plant height, number of branches, number of leaves, leaf area and leaves dry weight) in the two cuts of the two seasons as well as the greatest content of total chlorophyll, oil percentage and linalool, eucalyptol percentage in the oil of basil leaves. The highest significant increase in the Estragol and trans-4-methoxycinamaldehyde percentage in the oil of basil leaves were obtained by using 50 or 75% dose of NPK in combination with 4g l^{-1} of ADY.

Keywords: sweet basil, *Ocimum basilicum,* vegetative growth, NPK fertilizer, active dry yeast, oil yield, estragole.

INTRODUCTION

The genus *Ocimum*, (Lamiaceae), collectively called basil has long been recognized as a diverse and rich source of essential oils. *Ocimum* contains between 50 to 150 species of herbs and shrubs from the tropical regions of Asia, Africa, and Central and South America (Gill and Randhawa, 1997). Among all the species, *O. basilicum* is the most economic important species, cultivated, and utilized throughout the world (Bravo *et al*., 2008).

Traditionally basil has been used as a medicinal plant for various ailments, such as headaches, coughs, diarrhea, constipation, warts, worms and kidney malfunction, antispasmodic, stomachicum, carminative, expectorant, antimalarial, febrifuge and stimulant (Wome, 1982; Giron *et al*., 1991). Fresh and dry leaves of plant are used in food and spice industries, perfumery, dental and oral products (Vieira and Simon, 2000).

The chemical composition of basil is a great interest to various industries that are using basil essential oil and yield that are more important than herbage (shoot) biomass (Zheljazkov *et al.,* 2008a and 2008b). The most component of basil is essential oil and its yield varies from 0.1 to 0.45% based on ecological and agronomical conditions (Arabaci and Bayram, 2004). Pripdeevech *et al.* (2010) reported that the dominant components of essential oil were methyl chavicol (81.82 %), β-(E)-Ocimene (2.93%), α-(*E*)-bergamotene (2.45%), α-epi-cadinol (2.08%), 1,8-cineole (1.62%), methyl eugenol (1.10%), and camphor (1.09%). In the field experiment that was conducted to assess yield, oil content, and composition of 38 genotypes of *O. basilicum*, the availability of various chemotypes or individual compounds such as linalool, eugenol, methyl chavicol (estragole), methyl cinnamate, or methyl eugenol offers the opportunity for production of basil to meet the market requirements of specific basil oils (Zheljazkov *et al.,* 2008a).

Previous studies reported that there were a significant effect of plant nutrition such as N fertilization on sweet basil productivity and oil composition (Golcz *et al.,* 2006; Sifola and Barbieri, 2006). Nitrogen is a constituent part of protein and component of protoplasm, which increases the chlorophyll contents in leaves. All this factors led to cell multiplication, cell enlargement and cell differentiation, which have resulted in increasing of number and length of leaves (Parmer, 2007a and b). On the other hand, NPK fertilizers provide plants with macro-elements necessary for growth and yield. Nitrogen promotes vegetative growth, phosphorus is a main constituent of energy compounds, nucleic acids, phospholipids and co-enzymes and potassium increases plant resistance to diseases and prevent excessive water loss (Ezz El-Din and Hendawy, 2010b).

Active dry yeast (ADY) is a natural safety biofertilizer causes various promoted effects on plants and it is a natural source of cytokinins which simulates cell division and enlargement as well as the synthesis of protein, nucleic acid and B-vitamin (Ezz El-Din and

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Hendawy, 2010a). Also, active dry yeast releases CO_2 which reflected in improving net photosynthesis (Kurtzman and Fell, 2005).

The objective of this work was to investigate the effect of NPK fertilizers and ADY as biofertilizer on the growth and oil yield of *Ocimum basilicum* L.

MATERIALS AND METHODS

The present work was carried out during 2012 and 2013 seasons at Agriculture Research Station, Faculty of Agriculture, Alexandria University, Egypt.

Soil analysis:

The physical analysis of the used soil in both season revealed that it was containing 25, 13 and 62% clay, silt and sand, respectively. The chemical analysis cleared that the available N, P and K were 427, 46.6 and 610 ppm, respectively and the electric conductivity (EC) was 9.6 (dsm-1) with pH of 7.82.

Preparation of *Ocimum basilicum* plants

Seeds of *Ocimum basilicum* L. were sown on the 12th March of 2012 and 2013 seasons, respectively, in sandy clay soil in seed pans. Seedling transplanted after one month from sowing to 30 cm clay pots filled with sandy clay soil, when the seedling reached 8-10 cm height with 6:8 leaves and 4 branches. Herb harvest was took place twice; the first cut when inflorescence shoots occurred in July (50% flowering) and after two months the second cut harvest was done (in September), in both seasons (Taie *et al.,* 2010). In each harvest, all the plant parts were cut at the height 6–7 cm above the ground (Biesiada and Kuś, 2010).

Experimental treatments:

The fertilizers used:

a- NPK fertilizers: four rates of NPK were used in this study; 0, 25, 50 and 100 % of recommended. The recommended dose of NPK (100%) was 11.11, 7.41 and 3.70 g plant^{-1} of ammonium sulphate (20.5% N), calcium super phosphate (15.5 P_2O_5) and potassium sulphate (48.5% K_2O), respectively. Calcium super-phosphate fertilizer was added to the soil during the preparation at one dose for each rate. The amount fertilizers of ammonium sulphate and potassium sulphate were mixed and divided into equal two doses. The first dose was added after 15 days from the final transplanting and the second dose added 10 days after the first cut (Sleem, 1973).

b- Biofertilizer treatments: four rates of ADY were applied as a foliar application (0, 2, 4 and 6 g l^{-1} ADY) at three times, the first application after one month from transplanting, the second one after two weeks from the first one and the third one after one month from the first cut (Shalaby and El-Nady, 2008).

Experimental design:

The experimental layout was split plot design, for arrangement of pots, with three replicates. Each replicate contained 16 treatments (4NPK × 4ADY) and five plants were used as an experimental unit (5 pots and each pot contained 1 plant) (Snedecor and Cochran, 1974). Therefore, the number of plants used in each experiment was 240 plants (4NPK×4ADY×3Reps. ×5 Pots).

NPK fertilizer treatments were arranged in the main plot, while, the biofertilizer levels were randomly distributed in the sub-plot.

Growth characteristics:

At harvesting herb, the vegetative growth parameters were measured; plant height (cm), number of branches, leaves numbers, leaf area (cm^2) and leaves dry weight (g), of all plants in each experimental unit.

Chemical composition:

1- Total Chlorophyll: at harvesting herb, the total chlorophyll of leaves was measured according to the method suggested by Yadava (1986) using Minolta SPAD Chlorophyll Meter model-502.

2- The essential oil was extracted by water distillation method according to Novak *et al.* (2002). The amount of oil obtained from five plants was measured and oil percentage (%) was calculated according to Charles and Simon (1990).

3- Chemical constituents of essential oil of leaves were analyzed using the Trace GC Ultra/Mass Spectrophotometer ISQ (Thermo Scientific) (GC/MS) apparatus. The main chemical components of the oil were estragole, linalool, eucalyptol, and trans-4-methoxycinnamaldehyde.

Statistical analysis:

The data were statistically analyzed according to methods described by Snedecor and Cochran (1974).

RESULTS AND DISCUSSION

Vegetative growth

Plant height (cm)

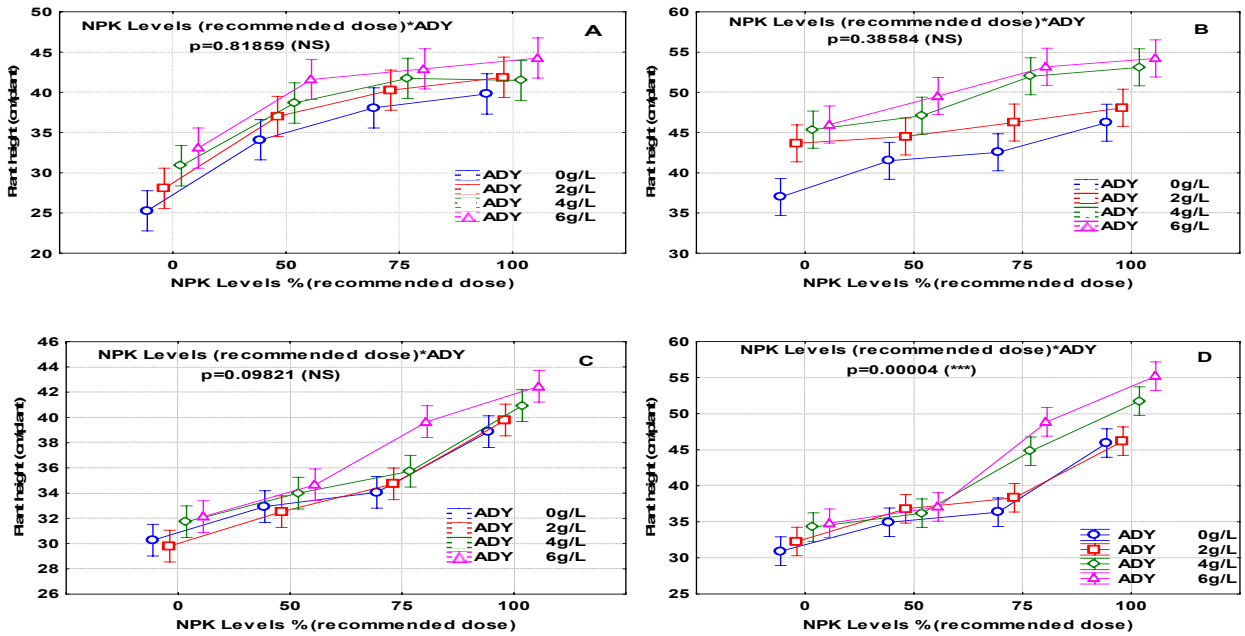
There was significant effect of all NPK rates on the plant height of *O. basilicum* (Table 1), where the highest value was obtained with treating *O. basillicum* plants by 100% of recommended NPK rate, in the two cuts of the two seasons (41.85 and 50.41 cm for the 1st season, 40.51 and 49.76 cm for the 2nd season, respectively).

Table 1. Means of plant height (cm) of *O. basilicum* plants as influenced by rates of NPK and active dry yeast (ADY) fertilizers and their combinations in the two seasons of 2012 and 2013

First season (2012)										
	First cut					Second cut				
NPK(A)	Active Dry Yeast (ADY) gl^{-1} (B)									
%	0	2	4	6	mean	0	2	4	6	mean
0	25.26	28.06	30.86	33.06	29.31	36.98	43.66	45.36	46.00	43.00
50	34.10	37.00	38.66	41.60	37.84	41.50	44.51	47.10	49.55	45.66
75	38.06	40.26	41.73	42.91	40.74	42.55	46.25	52.00	53.18	48.49
100*	39.80	41.86	41.46	44.26	41.85	46.23	48.0	53.11	54.22	50.41
mean	34.30	36.80	38.18	40.46		41.81	45.62	49.39	50.73	
$LSD_{0.05}$	A=2.23		B=1.71	A×B= NS**		A=2.22		B=1.52	A×B= NS**	
Second season (2013)										
	First cut					Second cut				
NPK (A)	Active Dry Yeast (ADY) gl^{-1} (B)									
%	0	2	4	6	mean	0	2	4	6	mean
0	30.26	29.80	31.73	32.13	30.98	30.93	32.26	34.26	34.80	33.06
50	32.93	32.53	34.00	34.66	33.53	34.93	36.80	36.20	37.06	36.25
75	34.06	34.73	35.73	39.66	36.05	36.33	38.33	44.80	48.86	42.08
100*	38.86	39.80	40.93	42.46	40.51	45.93	46.20	51.73	55.20	49.76
mean	34.03	34.21	35.60	37.23		37.03	38.40	41.75	43.98	
$LSD_{0.05}$	A=0.91		B=0.93	A×B= NS**		A=1.83		B=1.33	A×B=2.79	

* Recommended dose of NPK= 11.11, 7.41 and 3.70 g $plant^{-1}$ of ammonium sulphate (20.5% N), calcium super phosphate (15.5 P_2O_5) and potassium sulphate (48.5% K_2O).

** NS= Not significant at the level of probability of 0.05.



A: first season first cut; B: first season second cut; C: Second season first cut, D: Second season second cut

Figure 1. Effect of NPK and active dry yeast treatments on the height (cm) of *Ocimum basillicum* plants.

The results may be due to the role of NPK in forming important molecules of phospholipids, nucleotides, nucleic acid and certain co-enzymes, which play an important role in plant metabolism and thus growth that was confirmed by Kadu *et al.* (2009). Moreover, the results appeared that foliar application of ADY up to 6 g l^{-1} lead to increase significant of plant height, in the two cuts of both seasons. Data in (Table 1 and Figure 1) showed that the interaction between the effects of NPK and ADY treatments did not show significant effect on the plant height of *O. basilicum* plants, except in the second cut of the second season which achieved the best result with 100% NPK + 6 g l^{-1} ADY (55.20 cm).

Number of branches plant $^{-1}$

Number of branches per plant of *O. basilicum* plants (Table 2) was affected by NPK fertilizers rates and foliar application of ADY. The highest number of branches was achieved by soil application of NPK up to 100% rate of recommended, in the two cuts of the two seasons (46.23, 81.94, 59.75 and 86.60 branches $plant^{-1}$, respectively). Moreover, the highest number of branches was obtained by the concentration of 6 g l^{-1} ADY for both cuts of the two seasons (41.25, 65.26, 51.88 and 67.08 branch $plant^{-1}$, respectively). According to the interaction, there was a significant effect of the interaction between NPK and ADY in the two seasons except of the first cut of the first season, where the most effective interaction was 100% NPK with 4 or 6 g l^{-1}. Similar results were reported by Ahmed (2001) on *Calendula officinalis* plants and Abd EL-Gawad (2001) on coriander plants and Badran and Safwat (2004) on *Calendula officinalis* plants. Muller and Leopold (1966) demonstrated that the enhancing effects of yeast application might be due to yeast cytokinins that improving the accumulation of soluble metabolites. In addition, cytokinins stimulate cell proliferation and differentiation, controlling shoot and root morphogenesis and chloroplast maturation (Amer, 2004).

Number of leaves plant^{-1}

There were significant increases in the number of leaves by increasing NPK and ADY levels in the two cuts of the two seasons compared with control plants (Table 3). The best results were achieved by treating plants with 100% of recommended NPK in the two cuts of both seasons (441.63, 766.59 for the 1st season as well as 585.47 and 826.04 leaf $plant^{-1}$ for the 2nd season, respectively). The highest number of leaves $plant^{-1}$ was obtained by using 6 g l^{-1} ADY (438.23, 671.61, 491.03 and 712.30 leaf $plant^{-1}$, respectively).

Table 2. Means of number of branches of *O. basilicum* plants as influenced by rates of NPK and active dry yeast (ADY) fertilizers and their combinations in the two seasons of 2012 and 2013

First season (2012)										
	First cut					Second cut				
NPK	Active Dry Yeast (ADY) (B) gl^{-1}									
(A) %	0	2	4	6	mean	0	2	4	6	mean
0	24.53	28.33	27.66	28.60	27.28	31.31	34.60	40.98	44.35	37.81
50	30.31	36.26	39.73	41.73	37.01	45.18	52.45	52.86	53.90	51.10
75	37.10	44.73	46.53	44.48	43.21	44.82	54.63	65.00	68.25	58.17
100*	41.06	44.60	49.06	50.20	46.23	63.31	77.58	92.33	94.55	81.94
mean	33.25	38.48	40.75	41.25		46.16	54.81	62.79	65.26	
$LSD_{0.05}$	A=4.156		B=2.52	A×B=NS**		A=3.29		B=3.428	A×B=6.54	
Second season (2013)										
	First cut					Second cut				
NPK	Active Dry Yeast (ADY) (B) gl^{-1}									
(A) %	0	2	4	6	mean	0	2	4	6	mean
0	28.33	30.60	34.20	36.86	32.50	37.13	35.46	41.86	40.00	38.61
50	39.86	41.93	46.26	47.00	43.76	40.26	42.60	44.80	49.06	44.18
75	46.73	49.06	49.40	56.26	50.36	40.20	53.00	68.40	78.86	60.11
100*	56.80	51.40	63.40	67.40	59.75	65.60	89.66	90.73	100.40	86.60
Mean	42.93	43.25	48.31	51.88		45.80	55.18	61.45	67.08	
$LSD_{0.05}$	A=3.36		B=2.35	A×B= 5.003		A=3.49		B=3.69	A×B=7.03	

* Recommended dose of NPK= 11.11, 7.41 and 3.70 g $plant^{-1}$ of ammonium sulphate (20.5% N), calcium super phosphate (15.5 P_2O_5) and potassium sulphate (48.5% K_2O)..

** NS= Not significant at the level of probability of 0.05.

Table 3. Means of number of leaves/ plant of *O. basilicum* plants as influenced by rates of NPK and active dry yeast (ADY) fertilizers and their combinations in the two seasons of 2012 and 2013

First season (2012)										
	First cut					Second cut				
NPK(A) %	Active Dry Yeast (ADY) (B) gl^{-1}									
	0	2	4	6	mean	0	2	4	6	mean
0	196.50	232.89	261.39	341.01	257.95	279.66	359.23	397.1	438.74	368.71
50	231.81	298.33	325.33	435.65	322.78	363.78	452.38	492.50	564.05	468.18
75	241.74	388.28	436.45	463.06	382.39	394.96	463.34	524.31	610.33	498.24
100*	324.56	457.93	470.82	513.19	441.63	433.75	644.70	914.57	1073.30	766.59
mean	248.65	344.36	373.50	438.23		368.04	479.92	582.14	671.61	
$LSD_{0.05}$	A=69.53		B=48.35	A×B=NS**		A=39.14		B=48.86	A×B=90.40	
Second season (2013)										
	First cut					Second cut				
NPK(A) %	Active Dry Yeast (ADY) (B) gl^{-1}									
	0	2	4	6	mean	0	2	4	6	mean
0	266.76	271.71	297.96	338.04	293.62	312.28	340.23	370.54	398.93	355.50
50	323.92	343.26	381.12	410.54	364.71	366.32	402.81	436.01	542.95	437.03
75	351.72	370.54	449.09	526.45	424.45	410.70	515.25	636.33	796.51	589.70
100*	492.00	542.86	617.91	689.08	585.47	489.47	690.35	1013.52	1110.80	826.04
Mean	358.61	382.10	436.53	491.03		394.70	487.16	614.11	712.30	
$LSD_{0.05}$	A=46.9		B=30.436	A×B=NS**		A=26.368		B=51.05	A×B=90.32	

* Recommended dose of NPK= 11.11, 7.41 and 3.70 g plant^{-1} of ammonium sulphate (20.5% N), calcium super phosphate (15.5 P_2O_5) and potassium sulphate (48.5% K_2O).

** NS= Not significant at the level of probability of 0.05.

The results showed that there was significant effect of interaction between NPK and ADY treatments in the second cut of the two seasons only. The best result was obtained by using 100% NPK of recommended with 6 g l^{-1} ADY (1073.30 and 1110.80 leaf plant^{-1}, respectively).

These results may be attributed to the influence of N at specific concentration on the growth of plant, which led to new cells formation, consequently, increased number of leaves plant^{-1} (Hewitt and Cutting, 1979; El-Naggar and El-Nasharty, 2009). In addition, the favorable effect of nitrogen in promoting number and length of leaves might be due to the fact that N is a constituent part of protein and component of protoplasm which increases the chlorophyll contents in leaves. All this factors led to cell multiplication, cell enlargement and cell differentiation that have resulted in increasing of number and length of leaves (Parmer, 2007a and b). On the other hand, NPK fertilizers provide plants with macro-elements necessary for growth and yield. Nitrogen promotes vegetative growth, phosphorus is a main constituent of energy compounds, nucleic acids, phospholipids and co-enzymes and potassium increases plant resistance to diseases and prevents excessive water loss (Ezz El-Din and Hendawy, 2010b). These results are in agreement with those reported by Abdou et al. (2013) on *Nigella sativa* plants, Mohsen (2002) on *Ocimum basilicum*, and Badran *et al.* (2007) on fennel plants.

Leaf area (cm^2 plant^{-1})

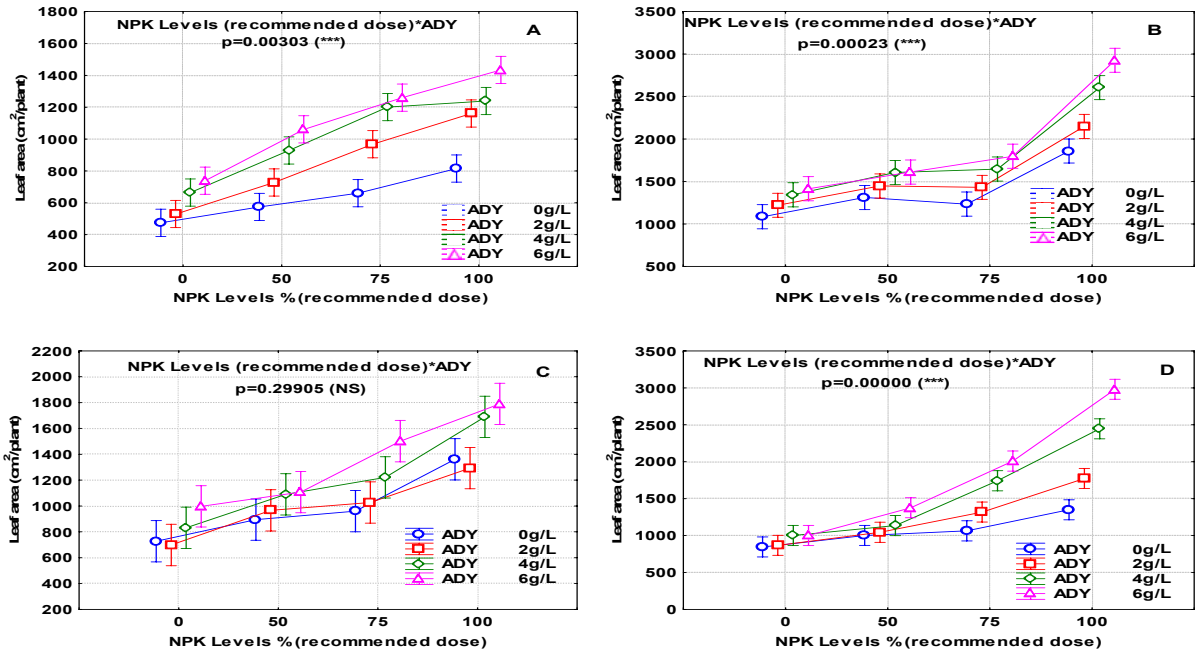
Data in Table 4 and fig. 2 illustrated that soil application of NPK had significant effect on leaf area compared with untreated plants in the two cuts of the both seasons. The largest leaf area plant^{-1} was obtained by full dose of NPK (1162.05, 2384.23, 1533.72 and 2136.94 cm^2, respectively). Moreover, among the ADY treatments, the largest leaf area was obtained at the level of 6 g l^{-1} ADY followed by 4 g l^{-1} ADY in the two cuts of both seasons. Concerning to the interaction between NPK and ADY treatments, there was significant effect on leaf area compared with control in the two seasons, except of the first cut in the second season. Nitrogen is the most important constituent of chlorophyll and is a component of amino acids and enzymes, thus it might have increased the meristematic activities, cell division, cell number and cell enlargement of the plant Gajbhiye *et al.* (2013). The obtained results were in agreement with Singh and Ramesh (2002), Kandeel (2004) on sweet basil and Salman (2006) on *Ocimum basilicum*.

Table 4. Means of leaf area/plant (cm^2) of *O. basilicum* plants as influenced by rates of NPK and active dry yeast (ADY) fertilizers and their combinations in the two seasons of 2012 and 2013

First season (2012)										
	First cut					Second cut				
NPK(A)	Active Dry Yeast (ADY) gl^{-1} (B)									
%	0	2	4	6	mean	0	2	4	6	mean
0	473.94	529.22	664.61	738.80	601.64	1084.74	1220.15	1343.43	1414.53	1265.72
50	574.24	727.66	928.26	1060.58	822.69	1311.60	1447.03	1605.78	1610.84	1493.81
75	660.08	967.82	1200.46	1259.93	1022.08	1233.40	1430.33	1646.06	1796.78	1526.65
100*	814.66	1160.88	1238.87	1433.78	1162.05	1858.36	2147.47	2604.57	2926.50	2384.23
mean	630.73	846.40	1008.05	1123.28		1372.03	1561.25	1799.96	1937.16	
$LSD_{0.05}$	A=61.0		B=63.28	A×B=120.85		A=121.29		B=99.39	A×B=200.87	
Second season (2013)										
	First cut					Second cut				
NPK(A)	Active Dry Yeast (ADY) gl^{-1} (B)									
%	0	2	4	6	mean	0	2	4	6	mean
0	727.02	698.53	831.95	997.62	813.78	846.12	867.60	1000.24	1000.38	928.59
50	894.57	967.03	1090.12	1107.70	1014.86	1001.89	1044.82	1134.82	1376.94	1139.62
75	960.31	1026.69	1221.12	1501.97	1177.53	1063.56	1318.46	1741.84	2008.92	1533.20
100*	1360.90	1293.93	1689.93	1790.09	1533.72	1348.63	1773.44	2445.31	2980.34	2136.94
mean	985.70	996.55	1208.29	1349.35		1065.05	1251.09	1580.56	1841.65	
$LSD_{0.05}$	A=191.08		B=87.93	A×B=NS**		A= 110.06		B= 97.15	A×B= 192.43	

- Recommended dose of NPK= 11.11, 7.41 and 3.70 g $plant^{-1}$ of ammonium sulphate (20.5% N), calcium super phosphate (15.5 P_2O_5) and potassium sulphate (48.5% K_2O).

** NS= Not significant at the level of probability of 0.05.



A: first season first cut; B: first season second cut; C: Second season first cut, D: Second season second cut

Figure 2. Effect of NPK and active dry yeast treatments on the total leaf area (cm^2) per plant of *Ocimum basillicum*

Leaves dry weight (LDW)

Table 5 and Fig. 3, show that soil application of NPK fertilizers and foliar application of ADY caused significant increases in LDW of basil plants in the cuts of the two seasons. The best results achieved with 100% rate of recommended NPK in the two cuts of the two seasons. The more effective concentration of ADY was 6g l^{-1}. The interaction effect between NPK fertilizers rates and ADY treatments appeared that there were significant differences among the mean values of the leaves dry matter weight of basil plants in the two cuts of the two seasons. The most effective treatment was 100% NPK + 6g l^{-1} of ADY in the four cuts (7.38, 15.00, 9.83 and 10.76 g $plant^{-1}$, respectively). The stimulatory effect of NPK fertilizers may be due to its role in enhancing metabolic processes such as photosynthesis, starch synthesis, glycolysis and synthesis of fats and proteins. Moreover, Phosphorus is also found in plants as a constituent of nucleic acids, phospholipids, coenzymes and the high emerge phosphate compounds, these aspects encourage dry matter accumulation and dry weight of leaves and stem $plant^{-1}$ (El Habbasha *et al.*, 2007). These results are in agreement with those reported by Abd El-Azeem (2003) on *Salvia officinalis*, AL-Sharief (2006) on caraway plant, and Abdou *et al.* (2013) on *Nigella sativa* plants.

Chemical constituents of *Ocimum basillicum* plants

1. Total Chlorophyll content (SPAD)

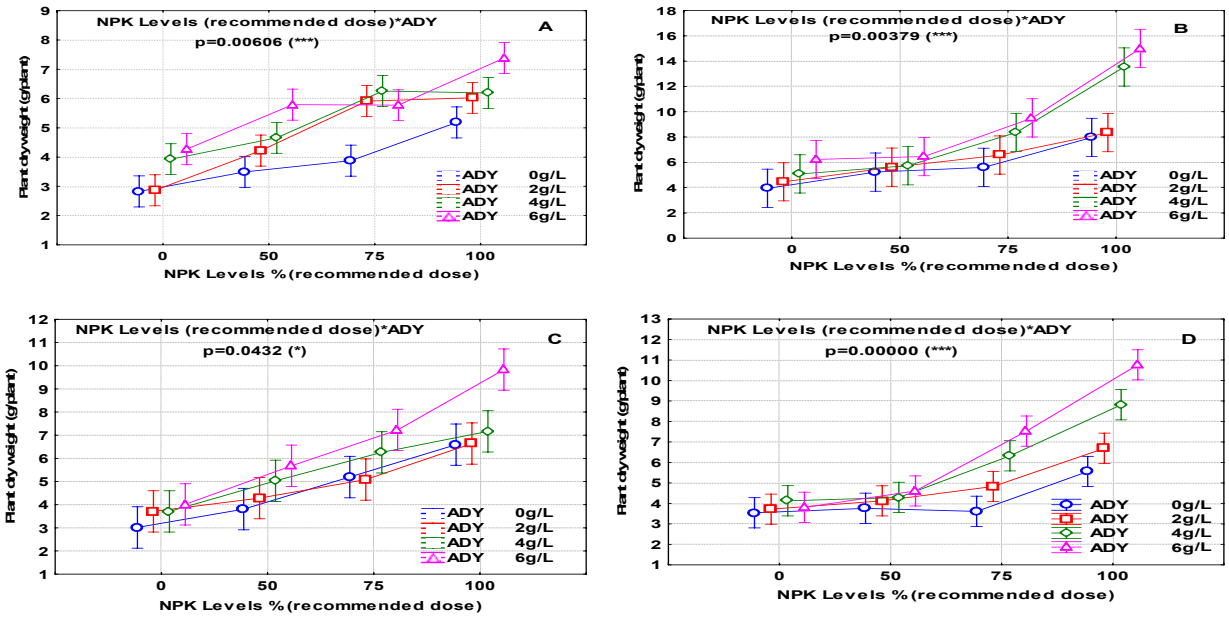
The results presented in (Table 6) showed that all NPK and ADY treatments had a significant effect on the total chlorophyll content of the two seasons compared with control. Concerning the interaction, it had no effect on total chlorophyll content, except the second cut of the second season. Such increase in photosynthetic pigment 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 (Castelfranco and Beale, 1983). These results were in agreement with Hellal *et al.* (2011) on dill plant, Poznan (2006) and Naguib *et al.* (2007) on *Ruta graveolens*.

Table 5. Means of leaves dry weight (g)/ plant of *O. basilicum* plants as influenced by rates of NPK and active dry yeast fertilizers and their combinations in the two seasons of 2012 and 2013

First season (2012)										
	First cut					Second cut				
NPK(A)	Active Dry Yeast (ADY) gl^{-1} (B)									
%	0	2	4	6	mean	0	2	4	6	mean
0	2.82	2.86	3.93	4.27	3.47	3.95	4.46	5.08	6.23	4.93
50	3.49	4.22	4.65	5.79	4.54	5.23	5.61	5.74	6.45	5.76
75	3.88	5.91	6.25	5.77	5.45	5.60	6.58	8.36	9.51	7.51
100*	5.18	6.02	6.19	7.38	6.19	7.97	8.35	13.54	15.00	11.21
mean	3.84	4.75	5.25	5.80		5.68	6.25	8.18	9.30	
$LSD_{0.05}$	A=0.29		B=0.41	A×B=0.75		A=1.68		B=0.89	A×B=2.13	
Second season (2013)										
	First cut					Second cut				
NPK(A)	Active Dry Yeast (ADY) gl^{-1} (B)									
%	0	2	4	6	mean	0	2	4	6	mean
0	3.01	3.71	3.71	4.01	3.61	3.54	3.72	4.12	3.80	3.79
50	3.81	4.28	5.03	5.68	4.70	3.76	4.12	4.29	4.61	4.19
75	5.19	5.08	6.26	7.22	5.94	3.61	4.82	6.32	7.52	5.57
100*	6.59	6.63	7.16	9.83	7.55	5.55	6.69	8.81	10.76	7.95
mean	4.65	4.92	5.54	6.68		4.11	4.84	5.88	6.67	
$LSD_{0.05}$	A=0.97		B=0.54	A×B=1.26		A=0.61		B=0.52	A×B=1.04	

* Recommended dose of NPK= 11.11, 7.41 and 3.70 g $plant^{-1}$ of ammonium sulphate (20.5% N), calcium super phosphate (15.5 P_2O_5) and potassium sulphate (48.5% K_2O).

** NS= Not significant at the level of probability of 0.05.



A: first season first cut; B: first season second cut; C: Second season first cut, D: Second season second cut

Figure 3. Effect of NPK and active dry yeast treatments on the dry weight (gm) of *Ocimum basillicum* plants

Table 6. Means of total chlorophyll of *O. basilicum* plants as influenced by rates of NPK and active dry yeast fertilizers (ADY) and their combinations in the two seasons of 2012 and 2013

First season (2012)										
	First cut					Second cut				
NPK(A) %	Active Dry Yeast (ADY) (B) gl^{-1}									
	0	2	4	6	mean	0	2	4	6	mean
0	37.21	40.73	38.94	40.86	39.43	34.55	38.21	39.10	42.16	38.51
50	38.17	41.47	40.88	43.06	40.90	42.01	45.01	47.65	48.24	45.73
75	39.56	45.10	45.32	48.31	44.57	43.02	50.22	49.39	50.23	48.21
100*	43.41	52.11	52.51	52.20	50.05	47.27	51.22	51.80	52.54	50.71
mean	39.59	44.41	44.85	46.11		41.71	46.16	46.98	48.29	
$LSD_{0.05}$	A=3.12	B=3.54	A×B=NS**			A=1.22	B=2.70	A×B=NS**		
Second season (2013)										
	First cut					Second cut				
NPK(A) %	Active Dry Yeast (ADY) (B) gl^{-1}									
	0	2	4	6	mean	0	2	4	6	mean
0	24.67	35.20	38.56	36.14	33.64	30.05	39.41	38.91	39.01	36.84
50	36.62	39.05	41.29	43.44	40.10	38.47	43.52	44.01	45.31	42.82
75	40.01	45.24	49.47	53.00	46.93	42.86	45.41	46.41	46.47	45.29
100*	41.01	48.74	48.34	51.53	47.40	48.30	46.80	46.41	47.46	47.24
mean	35.58	42.06	44.42	46.03		39.92	43.78	43.93	44.56	
$LSD_{0.05}$	A=4.17	B=2.32	A×B=NS**			A=3.40	B=2.14	A×B=4.74		

* Recommended dose of NPK= 11.11, 7.41 and 3.70 g $plant^{-1}$ of ammonium sulphate (20.5% N), calcium super phosphate (15.5 P_2O_5) and potassium sulphate (48.5% K_2O).

** NS= Not significant at the level of probability of 0.05.

2. Oil percentage

Oil percentage of basil plants leaves was affected by rates of NPK fertilizers and foliar application of ADY in both cuts of the two seasons (Table 7 and fig. 4). The highest percentage was recorded by 100% NPK of recommended (0.47%, 0.38%, 0.38% and 0.39%, respectively). Furthermore, the comparisons among ADY treatments; indicated that the highest value of oil percentage was obtained by 6 g l^{-1} ADY (0.45%, 0.37%, 0.37% and 0.34%) for both cuts of the two seasons, respectively).

For the interaction among NPK and ADY treatments, there was no significant effect, except in the first cut in the first season. The best result was obtained with 75% or 100% NPK + 6 g l^{-1} ADY where the oil percentage reaches to 0.61% and 0.59%, respectively. This increase in oil percentage may be due to the increase in the number of oil glands or the enlargement in oil glands. These results are in agreement with those obtained by Singh and Ramesh (2002) on sweet basil, Sharafzadeh *et al.* (2011) on *O. basilicum*, Ahmed (2009) on *Melissa officinalis* and Khaled *et al.* (2014) on Majoram.

3. Chemical composition of the essential oil

According to GC/MS analysis of *Ocimum basillicum* leaves essential oil observed by different treatments, there were about 19 components identified in the oil for every treatment. Among them, there were four constituents considered as the major components (Estragole, Linalool, Eucalyptol and Trans-4-methoxycinnamaldehyde).

The results presented in Tables 8-11 and Figs 5, 6, showed that the percentages of estragole (second cut), Eucalyptol (first and second cuts) and trans-4-methoxycinnamaldehyde (first and second cuts) were not affected significantly by NPK treatments. Linalool component was affected significantly by NPK treatments. On the other hand, the main chemical components of the *Ocimum basillicum* leaves essential oil were affected significantly by the ADY and the interaction among the treatments of NPK and ADY in both two cuts in the first season (2012).

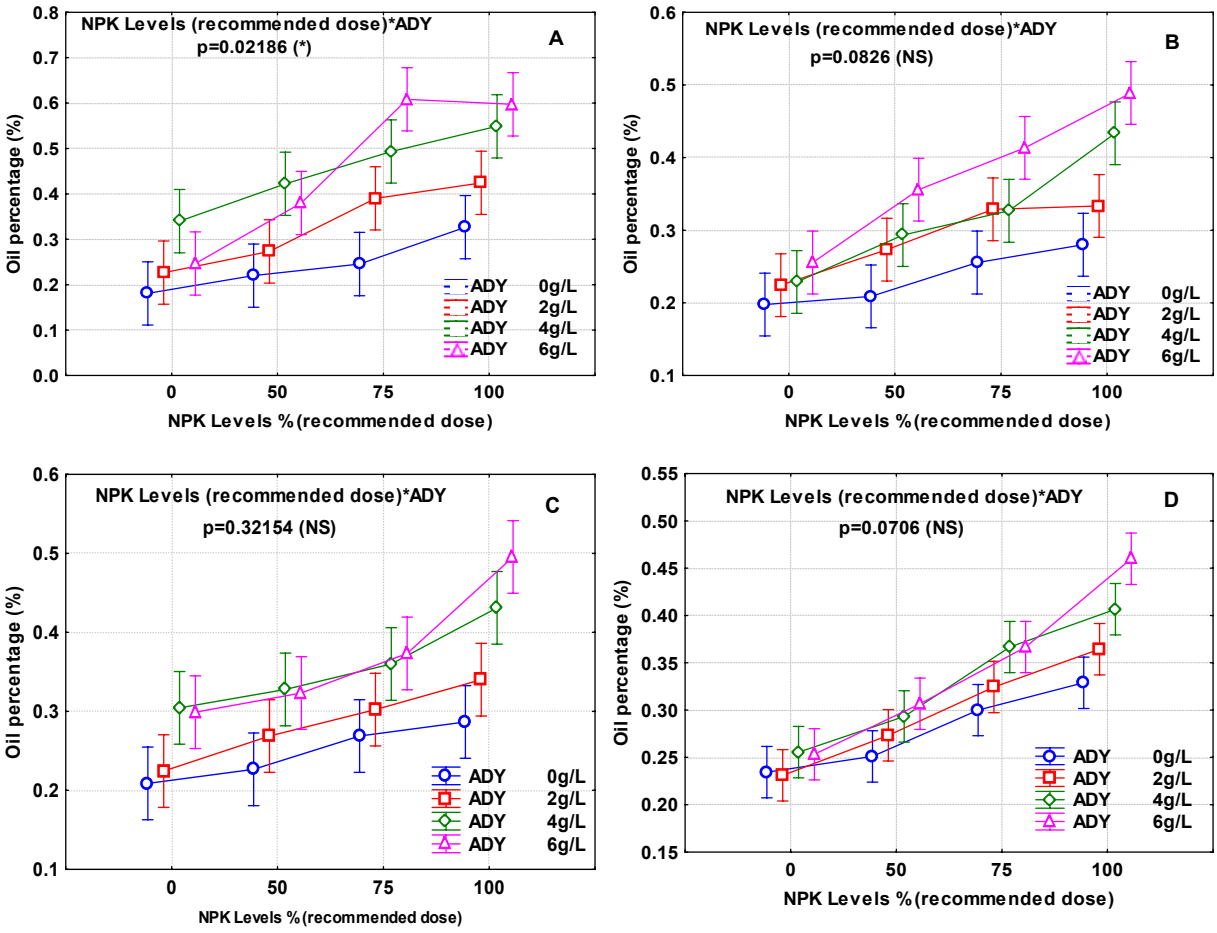
The highest values of estragole were observed by 75% of recommended NPK in the first and second cuts (69.47% and 70.91%, respectively), as well as foliar application of ADY at rate 4 g l^{-1} (70.31%) in the first cut and 2 g l^{-1} ADY (68.99%) in the second cut (Table 8). The best combinations of NPK and ADY treatments was found to be 75% of recommended NPK + 4 g l^{-1} ADY (73.58%) in the first cut, and 100% of recommended NPK + 2 g l^{-1} ADY (73.74*%).*

Table 7. Means of oil percentage (%) of *O. basilicum* plants as influenced by rates of NPK and active dry yeast (ADY) fertilizers and their combinations in the two seasons of 2012 and 2013

First season (2012)										
	First cut					Second cut				
NPK(A) %	Active Dry Yeast (ADY) (B) gl^{-1}									
	0	2	4	6	mean	0	2	4	6	mean
0	0.18	0.22	0.34	0.24	0.24	0.19	0.22	0.22	0.25	0.22
50	0.22	0.27	0.42	0.38	0.32	0.21	0.27	0.29	0.35	0.28
75	0.24	0.39	0.49	0.61	0.43	0.25	0.33	0.32	0.41	0.33
100*	0.32	0.42	0.55	0.59	0.47	0.28	0.33	0.43	0.49	0.38
mean	0.24	0.33	0.45	0.45		0.23	0.29	0.32	0.37	
$LSD_{0.05}$	A=0.07	B=0.04		A×B=0.09		A=0.027	B=0.033		A×B= NS**	
Second season (2013)										
	First cut					Second cut				
NPK(A) %	Active Dry Yeast (ADY) (B) gl^{-1}									
	0	2	4	6	mean	0	2	4	6	mean
0	0.21	0.22	0.30	0.30	0.26	0.234	0.231	0.255	0.253	0.24
50	0.22	0.27	0.32	0.32	0.28	0.251	0.27	0.29	0.30	0.28
75	0.27	0.30	0.36	0.37	0.32	0.30	0.32	0.36	0.36	0.34
100*	0.28	0.34	0.43	0.49	0.38	0.32	0.36	0.40	0.46	0.39
mean	0.24	0.28	0.35	0.37		0.27	0.29	0.33	0.34	
$LSD_{0.05}$	A=0.039	B=0.031		A×B=NS**		A=0.016	B=0.02		A×B=NS**	

* Recommended dose of NPK.

** NS= Not significant at the level of probability of 0.05.



A: first season first cut; B: first season second cut; C: Second season first cut, D: Second season second cut

Figure 4: Effect of NPK and active dry yeast treatments on the oil percentage of *Ocimum basillicum* plants.

Table 8. Means of Estragole content (%) of *O. basilicum* plants as influenced by rates of NPK and active dry yeast (ADY) fertilizers and their combinations in the two seasons of 2012 and 2013

First season (2012)										
	First cut					Second cut				
NPK(A) %	Active Dry Yeast (ADY) (B) gl^{-1}									
	0	2	4	6	mean	0	2	4	6	mean
0	68.515	70.300	68.895	58.655	66.591	58.235	65.185	70.015	52.855	61.573
50	70.620	64.105	71.305	66.735	68.191	60.855	64.250	64.040	56.680	61.456
75	70.260	70.050	73.585	64.000	69.473	69.915	72.795	71.800	69.145	70.914
100*	71.640	69.330	67.450	58.640	66.767	63.425	73.745	65.780	54.765	64.429
mean	70.258	68.447	70.310	62.007		63.107	68.993	67.908	58.361	
$LSD_{0.05}$	A=1.515		B=1.822		A×B=3.390		A= NS**		B=1.352	A×B=5.962

* Recommended dose of NPK= 11.11, 7.41 and 3.70 g $plant^{-1}$ of ammonium sulphate (20.5% N), calcium super phosphate (15.5 P_2O_5) and potassium sulphate (48.5% K_2O).

** NS= Not significant at the level of probability of 0.05.

Table 9. Means of Linalool content (%) of *O. basilicum* plants as influenced by rates of NPK and active dry yeast fertilizers (ADY) and their combinations in the two seasons of 2012 and 2013

First season (2012)										
	First cut					Second cut				
NPK(A) %	Active Dry Yeast (ADY) (B) gl^{-1}									
	0	2	4	6	mean	0	2	4	6	mean
0	4.315	3.950	2.430	17.960	7.163	18.035	11.425	7.600	22.030	14.773
50	3.230	8.090	4.230	4.335	4.971	14.650	11.27	12.150	17.950	14.005
75	3.940	2.890	1.765	4.940	3.383	7.580	2.770	3.490	6.540	5.096
100	1.150	6.440	2.595	10.610	5.198	13.520	4.245	8.660	18.980	11.353
mean	3.158	5.342	2.755	9.461		13.446	7.428	7.975	16.376	
$LSD_{0.05}$	A=1.583		B=1.008	A×B =2.220		A=3.223		B=1.122	A×B =3.433	

* Recommended dose of NPK.
** NS= Not significant at the level of probability of 0.05.

Table 10. Means of Eucalyptol content (%) of *O. basilicum* plants as influenced by rates of NPK and active dry yeast (ADY) fertilizers and their combinations in the two seasons of 2012 and 2013

First season (2012)										
	First cut					Second cut				
NPK(A) %	Active Dry Yeast (ADY) (B) gl^{-1}									
	0	2	4	6	mean	0	2	4	6	mean
0	4.051	3.725	4.290	4.375	4.110	3.935	3.015	2.820	4.600	3.593
50	3.305	3.725	2.800	3.915	3.436	3.135	3.940	2.975	4.280	3.583
75	3.030	3.365	2.735	2.870	3.000	1.910	3.100	2.240	2.175	2.356
100*	1.615	3.400	3.275	3.200	2.873	2.080	1.925	3.190	4.605	2.950
mean	3.000	3.553	3.275	3.590		2.765	2.995	2.806	3.915	
$LSD_{0.05}$	A= NS**		B=0.327	A×B =1.445		A= NS**		B=0.175	A×B =1.43	

* Recommended dose of NPK= 11.11, 7.41 and 3.70 g $plant^{-1}$ of ammonium sulphate (20.5% N), calcium super phosphate (15.5 P_2O_5) and potassium sulphate (48.5% K_2O).
** NS= Not significant at the level of probability of 0.05.

Table 11. Means of Trans-4-methoxycinnamaldehyde content (%) of *O. basilicum* plants as influenced by rates of NPK and active dry yeast (ADY) fertilizers and their combinations in the two seasons of 2012 and 2013

First season (2012)										
	First cut					Second cut				
NPK(A) %	Active Dry Yeast (ADY) (B) gl^{-1}									
	0	2	4	6	mean	0	2	4	6	mean
0	5.540	4.715	4.915	3.100	4.568	3.225	2.850	3.545	2.635	3.064
50	4.660	4.165	3.920	4.565	4.328	2.625	2.195	2.755	2.655	2.558
75	4.960	4.570	4.610	5.145	4.821	3.500	3.250	3.460	3.385	3.399
100*	5.905	3.110	4.990	4.355	4.590	3.165	3.793	3.405	3.755	3.530
mean	5.266	4.140	4.608	4.291		3.128	3.022	3.291	3.107	
$LSD_{0.05}$	A= NS**		B=0.616	A×B =1.047		A= NS**		B=0.187	A×B =1.402	

* Recommended dose of NPK= 11.11, 7.41 and 3.70 g $plant^{-1}$ of ammonium sulphate (20.5% N), calcium super phosphate (15.5 P_2O_5) and potassium sulphate (48.5% K_2O).
** NS= Not significant at the level of probability of 0.05.

The control treatment of NPK (0%) showed the highest percent of linalool in the first cut (7.16%) and in the second cut (14.77%) but the percent was slightly decreased by adding NPK fertilizers up to 50% (14.005%) in the second cut. On the other hand, ADY treatments had a good effect on linalool content, where, the treatment of 6 g l^{-1} ADY gave 9.46% and 16.37% in first and second cuts, respectively. Furthermore, the best combinations were found to be 100% NPK + 6 g l^{-1} ADY (10.61%) and 0% NPK + 6 g l^{-1} ADY (22.03%), in the first and second cuts, respectively (Table 9).

The highest values of eucalyptol were observed by control treatments of NPK (4.11% and 3.59%, in the first and second cuts, respectively) and 6 g l^{-1} ADY (3.59% and 3.91%, in the first and second cuts, respectively). The best combination treatment was 50% NPK + 6 g l^{-1} ADY (3.91%) in the first cut and 100% NPK + 6 g l^{-1} ADY (4.605%) in the second cut (Table 10).

Data in Table 11 indicated that in the first cut, soil application of 75% of recommended NPK (4.82%) and control treatment of ADY (5.266%) as well as in the second cut, soil application of 100% NPK (3.53%) and 4 g l^{-1} ADY (3.29%) were achieved the highest values in the trans-4-methoxycinnamaldehyde. Moreover, the best combinations were 100%NPK + 0 g l^{-1} ADY (5.905%) and 100% NPK + 2 g l^{-1} ADY (3.793%), in the first and second cuts, respectively.

Methyl chavicol (estragole) was increased by increasing the NPK level up to 75% of recommended and linalool decreased, these results are in agreements with Rao *et al.* (2007), who found that nitrogen application increased methyl chavicol (by 4.1%) and decreased linalool (by 14.2%) contents in basil oil. Generally, the compositions of essential oil of several aromatic plants were reported to be not affected by application of fertilizers (Rao, 1992; Puttanna *et al.*, 2001), while in some short duration aromatic plants like *Tagetes minuta* L. (Rao *et al.,* 2000) and *Foeniculum vulgare* Mill. (Kahn *et al.,* 1999), changes in essential oil composition have been reported due to the fertilizer application. Additionally, methyl cinnamate was increased by about 4% in content in a chemotype of basil oil on application of 120 kg Nha^{-1} (Gulati *et al.* 1978). Zheljazkov *et al.* (2008a) and Zheljazkov *et al.* (2008b) reported that, N application rates had a significant effect on the yields of the major basil oil constituents were linalool, eugenol, bornyl acetate, and eucalyptol. Moreover, the results observed that the main 4 chemical components were affected significantly by applying ADY treatments. These results are in agreements with Ezz El-Din and Hendawy (2010a) on *Borago Officinalis* plants.

Heikal (2005) reported that ADY as foliar fertilizer enhanced growth, plant nutritional and essential oil yield of thyme plants. The effect of ADY is due to its capability in induction of endogenous hormones like GA3 and IAA (Khedr and Farid, 2000).

Note

This article was extracted from a Ph.D. thesis (in progress) by the author, M.E. A. Mohamed (Effect of mineral, organic and biofertilizers on vegetative growth and oil yield of *Ocimum basillicum* L. plants), for the Floriculture & Ornamental Horticulture and Landscape Gardening Program, Faculty of Agriculture, Alexandria University.

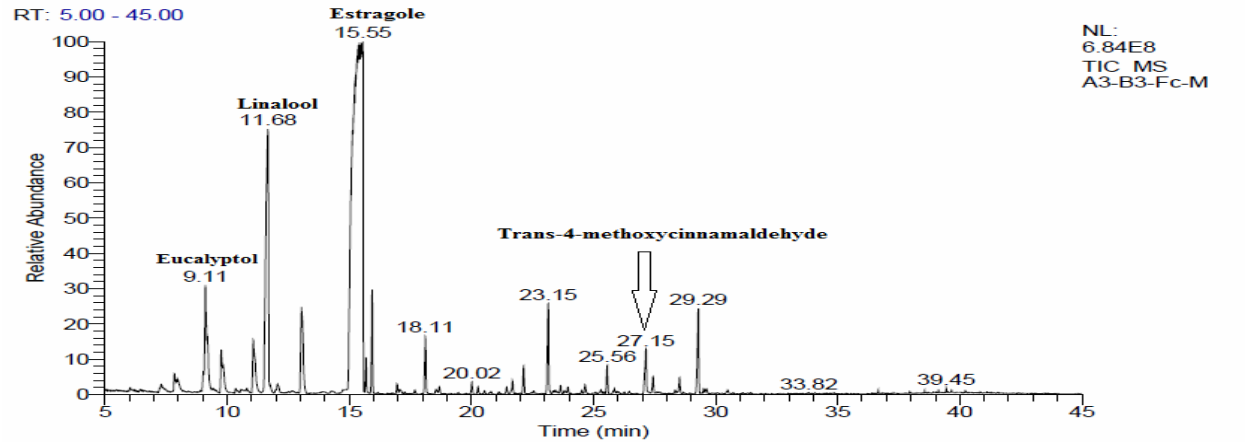


Figure 5. GC/MS chromatogram for the Effect of NPK and ADY treatments on the essential oil composition of *Ocimum basillicum* plants in the first cut first season

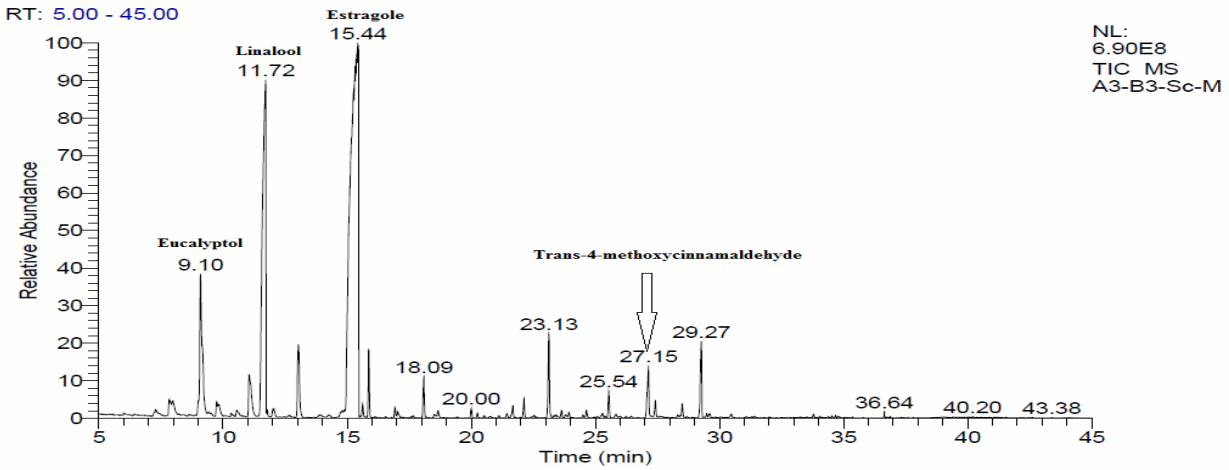


Figure 6. GC/MS chromatogram for the Effect of NPK and ADY treatments on the essential oil composition of *Ocimum basillicum* plants in the second cut first season

REFERENCES

Abd El-Azeem, W.M. (2003). Production of *Salvia officinalis* plant under Sinia conditions. Ph.D. thesis. Fac. of Agric., Minia Univ., Egypt

Abd El-Gawad, M.H. (2001). Response of coriander plants to some Fertilization treatments. M.Sc. Thesis, Fac. of Agric., Minia Univ.

Abdou, M.A.H., Taha, R.A., Salah EI-Deen, R.M. and Abd-EI-Raaof, R.M. (2013). Influence of Organic, NPK, bio-fertilization and natural substances treatments on Black Cumin plants. Annals of Agric. Sci., Moshtohor. 51(3): 243-252.

Ahmed, F.A. (2001). Response of pot marigold (*Calendula officinalis* L.) plants to some rock phosphate sources and yeast. 5th Arab Hort. Conf. Ismailia, Egypt, 31–41.

Ahmed, M.M.A. (2009). Effect of amino acids and yeast on growth, yield essential oil production and chemical constituent of common balm (*Melissa officinalis* L.) plant. Thesis(M.S.)- Cairo University.Faculty of Agriculture.

AL-Sharief, A.M. (2006). Response of caraway plants grown in sandy soil under drip irrigation system to some biofertilization and antioxidant treatments. M.Sc. Thesis. Fac. of Agric. Minia Univ. Egypt.

Amer, S.S.A. (2004). Growth, green pods yield and seeds yield of common bean (*Phaseolus vulgaris* L.) as affected by active dry yeast, salicylic acid and their interaction. J. Agric Sci. Mansoura univ., 29(3): 1407-1422.

Arabaci, O. and Bayram, E. (2004). The effect of nitrogen fertilization and different plant densities on some agronomic and technologic characteristics of *Ocimum basilicum* L. (Basil). J. Agron. 3:255–262.

Badran, F.S. and Safwat, M.S. (2004). Response of fennel plants to organic manure and bio-ferlilizers in replacement of chemical fertilization. Egypt J. Agric. Rrs. 82 (2). The second International. Conference in organic agriculture, March 2004.

Badran, F.S., Abdallah, N.M. and Ibrahim, S.M. (2007). Response of fennel to seedling rate and partial replacement of mineral NPK by biofertilization treatments. Proc. of the 8th African Crop Sci. Conf., Elminia, Egypt, 27-31 Vol. 8, Part I: 417- 422.

Biesiada, A. and Kuś, A. (2010). The effect of nitrogen fertilization and irrigation on yielding and nutritional status of sweet basil (*Ocimum basilicum* L.). Acta Sci. Pol., Hortorum Cultus. 9(2):3–12.

Bravo, E., Amrani, S., Aziz, M., Harnafi, H. and Napolitano, M. (2008). *Ocimum basilicum* ethanolic extract decreases cholesterol synthesis and lipid accumulation in human macrophages. Fitoterapia. 79 (7-8):515-523.

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

Charles, D.J. and Simon, J.E. (1990). Comparison of extraction methods for the rapid determination of essential oil content and composition of basil (*Ocimum* spp.). J. Amer. Soc. Hort. Sci. 115(3):458–462.

El-Habbasha, S.F., Hozayn, M., Khalafallah, M.A. (2007). Integration effect between phosphorus levels and bio-fertilizers on quality and quantity yield of Faba Bean (Vicia faba L.) in newly cultivated sandy soils. Research Journal of Agriculture and Biological Sciences. 3(6):966-971.

El-Naggar A.H. and El-Nasharty A.B. (2009).Effect of Growing Media and Mineral Fertilization on Growth, Flowering, Bulbs Productivity and Chemical Constituents of Hippeastrum vittatum, Herb. American-Eurasian J. Agric. & Environ. Sci., 6 (3): 360-371

Ezz EL-Din, A.A. and Hendawy, S.F. (2010a). Effect of dry yeast and compost tea on growth and oil content of *Borago Officinalis* plant. Research Journal of Agriculture and Biological Sciences. 6(4):424–430.

Ezz EL-Din, A.A. and Hendawy, S.F. (2010b). Comparative efficiency of organic and chemical fertilizers on herb production and essential oil of Lovage plants Grown in Egypt. American-Eurasian I. Agric. & Environ. Sci., 8 (I): 60-66.

Gajbhiye B.R., Vetal R.A., Puri A.N., Adsul P.B. (2013). Response of FYM, N, P and K levels on growth and flowering of gladiolus (Gladiolus gradiflorus) cv white prosperity The Journal of Rural and Agricultural Research 13 (2): 94-97.

Gill, B.S. and Randhawa, G.S. (1997). Effect of Different Transplanting Dates and Harvesting Stages on the Quality of French Basil Oil. Journal of Herbs, Spices & Medicinal Plants. 4(3): 35-42.

Giron, L.M., Freire, V., Alonzo, A. and Vaceres, A. (1991) Ethnobotanical survey of the medicinal flora used by the cribs of Guatemala. J. Ethnopharmacol., 34,173–187.

Golcz, A., Politycka, B. and Seidler-Lozykowska, B. (2006). The effect of nitrogen fertilization and stage of plant development on the mass and quality of sweet basil leaves (*Ocimum basilicum* L.). Herba Polonica. 52:22–30.

Gulati B.C., Duhan S. P. S. and Garg, S. N. (1978). Effect of nitrogen on the yield of herb, oil and quality of essential oil of *Ocimum basilicum* (methyl cinnamate type). Indian Perfumer 22: 53–54.

Heikal, A.E. (2005). Effect of organic and biofertilization on growth production and composition of (*Thymus vulgaris* L.) plants. M.Sc. Thesis, Fac. Agric. Cairo Univ.

Hellal, F.A., Mahfouz, S.A. and Hassan, F.A.S. (2011). Partial substitution of mineral nitrogen fertilizer by bio-fertilizer on (*Anethum graveolens* L.) plant. Agriculture and Biology Journal of North America. Agric. Biol. J. N. Am., 2011, 2(4):652-660.

Hewitt, J. and C. Cutting, 1979. Nitrogen Assimilation of Plants. Academic Press Inc. (London), LTD.24/28 Oval Road, London, NW1.

Kadu, A. P., Kadu, P. R. and Sable, A.S. (2009). Effect of nitrogen, phosphorus and potassium on growth, flowering and bulb production in tuberose cv. single. J. Soil and Crops, 19(2), 367-370.

Kahn, M.M.A., Azam, Z.M. and Samiullah, S.H.A. (1999). Changes in the essential oil constituents of fennel (*Foeniculum vulgare*) as influenced by soil and foliar levels of N and P. Canadian J. Plant Sci. 587–591.

Kandeel, Y.M. (2004). Effects of bioorganic and chemical fertilization on growth, essential oil productivity and chemical composition of *Ocimum basilicum* L. plant. J. of Agric. Sci. Moshtohor. 24(3): 1253- 1270.

Khaled, S.A., Abdella, E.M. and Mohamcd, C.F. (2014). Response of growth, chemical composition, anatomical structure, antioxidant and antimicrobial activity of marjoram to yeast and methionine. International journal of academic research. 6(1): 18-30.

Khedr, Z.M. and Farid, S. (2000). Response of naturally virus infected-tomato plants to yeast extract and phosphoric acid application. Ann. Sci. Moshtohor, Egypt, 38: 927-939.

Kurtzman, C.P. and Fell, J.W. (2005). Biodiversity and Ecophysiology of Yeasts (In: The Yeast Handbook, Gabor P, de la Rosa CL, eds) Berlin, Springer, 11-30.

Mohsen, M.M. (2002). Sweet basil herb oil production as affected by chemical and organic fertilization. M. Sc. Thesis Fac. Of Agric., CairoUniv., Egypt.

Muller, K. and Leopold, A.C. (1966). Mechanism of kinetin induced transport in corn leaves. planta, 68: 185- 205.

Naguib, Y. N., Hussein, M.S. El-Sherbeny, S.E. Khalil M.Y. and Lazari, D. (2007). Response of *Ruta graveolens* L. to Sowing Dates and Foliar Micronutrients. Journal of Applied Sciences Research, 3(11): 1534-1543.

Novak, J., Jan, L., Friedrich, P. and Chlodwig, M.F. (2002). Essential oil compounds in a historical sample of marjoram (*Origanum majorana* L., Lamiaceae). Flavour and Fragrance Journal. 17: 175–180.

Parmer, Y. S. (2007a). Effect of nitrogen, phosphorus and biofertilizer application on plant growth and bulb production in tuberose. Haryana J . Hortic. Sci, 36(1&2), 82-85.

Parmer, Y. S. (2007b). Influence of biofertilizers, nitrogen and phosphorus application on flower quality in tuberose (Polianthes tuberosa L.) cv. Double. Haryana J. Hortic. Sci, 36(3&4), 273-276.

Poznan, G.A. (2006). Effect of nitrogen fertilization and stage of plant development on the mass and quality of sweet basil leaves (*Ocimum basilicum* L.) Herba Polonica. 52(1/2): 22-30.

Pripdeevech, P., Chumpolsri, W., Suttiarporn, P. and Wongpornchai, S. (2010). The chemical composition and antioxidant activities of basil from Thailand using retention indices and comprehensive two-dimensional gas chromatography. J. Serb. Chem. Soc. 75 (11) 1503–1513.

Puttanna, K., Nanje Gowda, N.M. and Rao, E.V.S.P. (2001). Effects of applications of N fertilizers and nitrification inhibitors on dry matter and essential oil yields of Java citronella (*Cymbopogon winterianus* Jowitt). J. Agric. Sci. (UK) 136: 427– 431.

Rao, E.V.S.P. (1992). Fertilizer management in medicinal and aromatic crops. In: Tandon H L S (Ed.) Fertilizer use in Non Traditional Crops (pp. 73-93). Fertilizer Development and Consultation Organization, New Delhi.

Rao, E.V.S.P., Puttanna K. and Ramesh S. (2000). Effect of Nitrogen and harvest stage on the yield and oil quality of *Tagetes minuta* L. in tropical India. J. Herbs Spices Med. Plants 7: 19–24.

Salman, A.S. (2006). Effect of biofertilizationon *Ocimum basilicum* L. plant. Egypt. J. Agric. Res. 79(2):587-606.

Sifola, M.I. and G. Barbieri. (2006). Growth, yield and essential oil content of three cultivars of basil grown under different levels of nitrogen in the field. Sci. Hort. 108:408–413.

Singh, M. and Ramesh, S. (2002). Response of sweet basil (*Ocimum basilicum*) to organic and inorganic fertilizers in

semi-arid tropical conditions. Journal of Medicinal and Aromatic Plant Sciences, 24: 947-950.

Shalaby, M.E., El-Nady, M.F. (2008). Application of Saccharomyces cerevisiae as a biocontrol agent against Fusarium infection of sugar beet plants. Acta Biologica Szegediensis. 52(2):271-275.

Sharafzadeh, S., Esmaeili, M. and Mohammadi A.M. (2011). Interaction Effects of nitrogen, phosphorus and potassium on growth, essential oil and total phenolic content of Sweet Basil. Advances in Environmental Biology. 5(6):1285–1289.

Sleem, A.H.A. (1973). Effect of some growth regulators on growth and essential oil quantitiy and quality of *Majorana hortensis* Mnch. M.Sc. Thesis, Faculty of Agriculture, Alexandria University.

Snedecor, G. and Cochran, W. (1974). Statistical Methods. Sixth Edition. Iowa State University Press. Ames. Iowa. USA.

Taie, H.A.A., Salama, Z.A.R. and Radwan, S. (2010). Potential activity of basil plants as a source of antioxidant and anticancer agents as affected by organic and bio-organic fertilization. Notulae Botanicae Horti AgrobotaniciCluj-Napoca. 38(1):119-127.

Vieira, R.F. and Simon, J.E. (2000). Chemical characterization of basil (*Ocimum* spp.) found in the markets and used in traditional medicine in Brazil. Econ. Bot. 54:207–216.

Wome, B. (1982). Febrifuge and antimalarial plants from Kisangani, upper Zaire. Bulletin de la Societe Royale de botanique de Belgique, 115: 243–250.

Yadava, U.L. (1986). A raped and non-destructive method to determined chlorophyll in intact leaves. Hort. Science. 21(6):1449–1450.

Zheljazkov, V.D., Callahan, A. and Cantrell, C.L. (2008a). Yield and Oil Composition of 38 Basil (*Ocimum basilicum* L.) accessions grown in Mississippi. J. Agric. Food Chem. 56(1):241–245.

Zheljazkov, V. D., Cantrell, C.L., Ebelhar, M.W., Rowe, D. E. and Coker, C. (2008b). Productivity, Oil Content, and Oil Composition of Sweet Basil as a Function of Nitrogen and Sulfur Fertilization. Hortscience 43(5):1415–1422.

الملخص العربي

تأثير معدلات أسمدة NPK والسماد الحيوى على النمو الخضري وإنتاج الزيت في نباتات الريحان

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صممت هذه التجربة لدراسة استجابة نباتات الريحان لمعدلات أسمدة NPK(صفر، ٢٥، ٥٠، ١٠٠% من الموصي به، والمكونة من أسمدة: سلفات الأمونيوم (٢٠,٥% ن) بمعدل ١١,١١ جم نبات$^{-١}$، وسوبر فوسفات الكالسيوم(١٥,٥% فو**٢** أ**ي**) بمعدل ٧,٤١ جم نبات$^{-١}$، وسلفات البوتاسيوم (٤٨,٥% بو**٢أ**) بمعدل ٣,٧٠ جم نبات$^{-١}$. وكذلك الرش الورقي بالسماد الحيوي (الخميرة الجافة النشطة) بمعدل صفر، ٢، ٤، ٦ جم لتر$^{-١}$، بالإضافة إلي تأثير التداخل بين هذه العوامل علي صفات النمو الخضري، ومحتوى الأوراق من الكلوروفيل والزيت العطري.

وقد اجريت التجربة خلال موسمي ٢٠١٢ و٢٠١٣ فى محطة البحوث الزراعية التابعة لكلية الزراعة– جامعة الاسكندرية. وقد اشارت النتائج الى ان اضافة ١٠٠ % من أسمدة NPK مع اضافة السماد الحيوي ٤ ،٦ جم لتر$^{-١}$ قد أعطت أعلى القيم لصفات النمو الخضر (ارتفاع النبات، عدد الافرع، عدد الاوراق، المساحة الورقية والوزن الجاف) وأكبر محتوى للأوراق من الكلوروفيل الكلى، وكذلك أعلى نسبة زيت فى الأوراق، وأعلى نسبة من اللينالول، والايوكليبتول فى زيت أوراق الريحان. بينما تحققت أعلى زيادة معنوية للزيت من الاستراجول، والترانس-٤-ميثوكسى سناماالدهيد عند اضافة ٥٠%، و٧٥% من جرعة أسمدة NPK فى وجود الإضافة الورقية للسماد الحيوي بمعدل ٢، ٤ جم لتر$^{-١}$.