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EFFECT OF COMPOST AND NPK WITH BIOFERTILIZERS ON GROWTH AND ESSENTIAL OIL PRODUCTION OF LEMONGRASS (*CYMBOPOGON CITRATUS*)

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ABSTRACT: A field experiment was carried out at the Nursery of Fac. Agric., Minia Univ. during the two successive seasons of 2011/2012 and 2012/2013 to explore the effect of three compost levels (0, 4 and 8 ton/fed) and four mineral NPK/biofertilization treatments on vegetative growth and essential oil of lemongrass plants.

Obtained results proved that vegetative growth characters (plant height, number of tillers/plant, fresh and dry weights of leaves/fed and essential oil percent and yield per fed were considerably augmented due to the use of both low and high compost levels, with the high one (8 ton/fed) being much more effective. Concerning mineral/biofertilization treatments, both 100% NPK and 75% NPK + E.M. + yeast treatments out grew the other two treatments (75% NPK + E.M. and 75% NPK + yeast) in producing higher values of growth and essential oil parameters. The best overall results were obtained when lemongrass plants were supplied with compost at the level of 8 ton/fed and fertilized with 75% NPK combined with E.M. and yeast.

Key words: Lemongrass, *Cymbopogon citratus*, compost, NPK, biofertilizer, E.M., yeast, vegetative growth, essential oil.

INTRODUCTION

Lemongrass (*Cymbopogon citratus*, Stapf), which belongs to Fam. Gramineae, is one of the essential oil crops. It is grown in many tropical countries in South America, as well as, Asia and Africa (Bagaturiya, 1990). It is turfied perennial grass with numerous stiff stems arising from a short, rhizomatous rootstock. The leaves are 100 cm long and 3 cm wide and used as a source of cellulose and paper production (Ciaramello, 1973). Essential oil content of the stems and leaves average 0.25-0.35% with citral being the main component (80-86%).

Among the most important agricultural practices and organic and mineral NPK fertilization, as well as, biofertilization treatments like effective microorganisms. and yeast. The role of organic fertilization on augmenting vegetative growth and essential oil was demonstrated by different authors on various medicinal and aromatic plants like lemongrass (Maheshwari *et al*., 1991; Naguib, 2002 and Adholeya and Prakash, 2004), basil (Baeck and Park, 2001 and Carlen *et al.,* 2004), rosemary (Khalil, 2002), mint (Abdou *et al.*, 2012) and marjoram (Abdou *et al.*, 2014). The efficiency of mineral NPK, however, was reported by Agina *et al.* (2001) on lemongrass, Sakr (2001) and El-Shora (2009) on mint, Singh *et al.* (2004), Golez *et al.* (2006) and Rao *et al.* (2007) on basil, Singh (2004) on rosemary and Rajab (2014) on marjoram. The positive influence of biofertilizers,

represented by Effective microorganisms and yeast was clarified by Harridy *et al.* (2001) and Mazrou (2008) on lemongrass, Hussein *et al.* (2008) on marjoram, Abd El-Raaof (2009) on borage, Abdou *et al.* (2009) on guar and Ali (2013) on African marigold for E.M. and by Badran *et al.* (2002) and El-Hindi and El-Boraie (2005) on marjoram, Naguib (2002) on lemongrass, Salman (2006) and Abd El-Salam (2014) on basil and Shalan (2013) on mint concerning yeast.

MATERIALS AND METHODS

This experiment was conducted in the Nursery of Fac. Agric., Minia Univ. during 2011/2012 and 2012/2013 seasons. This paper was aimed to study the effect of three compost levels and four NPK/biofertilization treatments and their interaction on vegetative growth characters and essential oil parameters of lemongrass (*Cymbopogon citratus*) plants.

Mother plants were divided on Nov. 11th and Nov. 17th for the first and second seasons, respectively. Uniform and healthy divisions were planted in 15 cm clay pots, then transplanted on March 15th of both seasons to the open field. Field experimental units were 2.0 × 1.2 m included 5 rows 65 cm apart with 3 plants in the row spaced at 40 cm between each plot contains 9 plants. Physical and chemical soil properties are shown in Table (a).

A split plot design in complete randomized block arrangement, with three replicates was followed in this experiment. The main plot consisted of three compost levels, 0, 4 and 8 ton/fed, while the sub plot contained four mineral NPK/biofertilization treatments, namely, 100% NPK, 75% NPK + E.M., 75% NPK + yeast and 75% NPK + E.M. + yeast. Mineral NPK was used at the rate of 400 kg ammonium sulphate (20.6% N), 300 kg calcium superphosphate (15.5% P_2O_5) and 150 kg potassium sulphate (48.5% K_2O) for the treatment of 100% NPK. While 75% NPK was represented by 300, 225 and 112.5 kg/fed. These fertilizer amounts were divided into three equal batches and added 3 weeks from planting date and 21 days after the first and second cuts for each season. Concerning E.M., it was applied three times to the soil around the plants (50 cm^3/hill where 1 ml=10^7 cells of bacteria), while yeast was foliar sprayed at the concentration of 5 g/l three times. The first application of E.M. and yeast was added after 2 weeks from planting date and repeated 2 weeks after the first and second cuts. Other agricultural practices were performed as usual.

For each cut, data were recorded for plant height (cm), number of tillers/plant, leaves fresh and dry weights/fed, essential oil % and essential oil yield/fed. Essential oil in the fresh leaves was determined according to British Pharmacopoeia (1963). Obtained date were statistically analyzed according to MSTAT-C (1986) and differences between the means were tested using the L.S.D. at 5%.

Table a. Physical and chemical properties of the soil.

Soil Character	Value	Soil Character		Value
Sand %	28.30	**Available P %**		15.13
Silt %	29.95	**Exch. K^+ mg/100 g**		2.32
Clay %	41.75	**Exch. Ca^{++} mg/100 g**		31.77
Soil type	Clay loam	**Exch. Na^+ mg/100 g**		2.46
Organic matter %	1.54	**DTPA Ext. ppm**	**Fe**	8.50
Ca CO_3 %	1.58		**Cu**	2.07
pH (1:2.5)	7.86		**Zn**	2.74
E.C. (m mhos/cm)	1.08		**Mn**	8.24
Total N %	0.07			

RESULTS AND DISCUSSION

1- Vegetative growth characters:

The four studied vegetative growth characters, plant height, number of tillers/plant and leaves fresh and dry weights/fed, in the two seasons, were gradually and consistently increased along the three cuts as shown in Tables (1, 2, 3 and 4). Such four characters recorded, for the first, second and third cut, 65.3, 76.1 and 94.2 cm for plant height; 11.3, 21.1 and 31.6 for number of tillers/plant; 1.80, 3.39 and 5.25 ton/fed for leaves fresh weight and 181.1, 338.6 and 526.9 ton/fed for leaves dry weight, respectively, in the first season. Similar trend was in the second season.

Concerning compost levels, all of the four characters, in both seasons and along the three successive cuts, were gradually increased parallel to the increase in compost level with significant differences between each two compost levels as clearly indicated in Tables (1, 2, 3 and 4). In agreement with these results were the results revealed by Baeck and Park (2001), Khalil (2002), Adholeya and Prakash (2004), Abdou *et al.* (2012) and Abdou *et al.* (2014) on basil, rosemary, lemongrass, mint and marjoram, respectively.

As far as NPK/fertilization treatments are concerned, both 100% NPK and 75% NPK + E.M. + yeast treatments were significantly equal, for the four growth traits, in the two seasons along the three cuts, in giving taller plants, more tillers number/plant and heavier leaves fresh and dry weight/fed than the other two examined treatments (75% NPK + E.M. and 75% NPK + yeast as indicated in Tables (1, 2, 3 and 4). The role of NPK in augmenting various vegetative characters was reported by Sakr (2001) and El-Shora (2009) on mint, Singh *et al*. (2004) and Rao *et al.* (2007) on basil, Singh (2004) on rosemary and Rajab (2014) on marjoram. While that of E.M. was revealed by Mazrou (2008), Hussein *et al.* (2008), Abd El-Raaof (2009), Abdou *et al.* (2009) and Ali (2013) on lemongrass, marjoram, borage, guar and African marigold, respectively, meanwhile, the effectiveness of yeast was observed on lemongrass (Naguib, 2002), marjoram (Badran *et al*., 2002 and El-Hindi and El-Boraie, 2005) and basil (Salman, 2006 and Abd-El-Salam, 2014).

In regard to the interactions between compost levels and NPK/biofertilization treatments, they proved to be significant in both seasons and along the three cuts for plant height, number of tillers/plant and fresh and dry weights of the leaves/fed. The highest values were obtained due to the interaction between the high compost level (8 ton/fed) and either 100% NPK or 75% NPK + E.M. + yeast. Each one of these two superior combined treatments gave significantly, in the two seasons and for the three cuts, higher values than the traditional treatment (zero compost plus 100% NPK) as illustrated in Tables (1, 2, 3 and 4).

2- Essential oil parameters:

Tables (5 and 6) show that essential oil % and essential oil yield/fed, in the two seasons, were increased upward from the first cut and up to the third one. In other words, essential oil % recorded 0.222, 0.237 and 0.253% for three cuts in the first season; and 0.227, 0.244 and 0.270% in the second season, respectively. While, essential oil yield/fed were 4.00, 7.92 and 13.39 liter/fed in the first season and 4.99, 7.36 and 11.54 liter/fed in the second season, respectively for the three successive cuts.

In regard to compost levels, both low and high levels caused significant augmentation in essential oil percent and yield per fed in both seasons along the three cuts of control treatment. However, the high level (8 ton/fed) was much more effective than the low one (4 ton/fed) in this concern as shown in Tables (5 and 6). Numerically, essential oil yield/fed was increased by 29.9, 37.8 and 33.2% in the first season and 39.2, 34.1 and 25.3% in the second season, respectively due to the use of the high compost level in comparison with the control treatment. In agreement with these results

Table 1. Effect of compost and mineral NPK/biofertilizers treatments on plant height (cm) of lemongrass plants at 2011/2012 and 2012/2013.

NPK/biofertilizer treatments (B)	Compost levels (ton/fed) (A) 1st Season				2nd Season			
	0	4	8	Mean (B)	0	4	8	Mean (B)
				1st Cut				
100 % NPK	63.3	66.2	69.0	66.2	62.4	66.3	70.1	66.3
75 % NPK + E.M.	62.5	64.6	67.8	65.0	59.9	64.5	66.7	63.7
75 % NPK + Y	60.8	62.2	65.6	62.9	57.7	62.0	65.6	61.8
75 % NPK + E.M. + Y	65.0	66.4	69.8	67.1	61.6	65.3	69.2	65.4
Mean (A)	62.9	64.9	68.1	65.3	60.4	64.5	67.9	64.3
L.S.D. at 5%	A: 1.9	B: 2.2		AB: 3.8	A: 2.7	B: 2.3		AB: 4.0
				2nd Cut				
100 % NPK	73.0	77.3	85.6	78.6	68.1	70.9	74.9	71.3
75 % NPK + E.M.	69.4	74.2	80.9	74.8	66.4	68.5	72.0	69.0
75 % NPK + Y	66.4	70.8	76.6	71.3	64.0	66.2	71.0	67.1
75 % NPK + E.M. + Y	73.9	78.3	86.2	79.5	67.5	70.4	74.5	70.8
Mean (A)	70.7	75.2	82.3	76.1	66.5	69.0	73.1	69.5
L.S.D. at 5%	A: 2.6	B: 2.5		AB: 4.3	A: 2.3	B: 2.1		AB: 3.6
				3rd Cut				
100 % NPK	91.7	96.7	101.2	96.5	75.3	79.1	84.6	79.7
75 % NPK + E.M.	90.4	93.3	96.2	93.3	72.3	76.1	81.9	76.8
75 % NPK + Y	89.0	89.4	93.4	90.6	70.5	74.3	80.3	75.0
75 % NPK + E.M. + Y	92.6	96.2	100.6	96.5	74.4	79.7	83.6	79.2
Mean (A)	90.9	93.9	97.9	94.2	73.1	77.3	82.6	77.7
L.S.D. at 5%	A: 2.9	B: 3.2		AB: 5.5	A: 3.2	B: 2.8		AB: 4.8

E.M.: Effective microorganisms Y: Yeast

Table 2. Effect of compost and mineral NPK/biofertilizers treatments on no. of tillers/plant of lemongrass plants at 2011/2012 and 2012/2013.

NPK/biofertilizer treatments (B)	Compost levels (ton/fed) (A) 1st Season				2nd Season			
	0	4	8	Mean (B)	0	4	8	Mean (B)
				1st Cut				
100 % NPK	11.2	11.7	12.9	11.9	13.5	15.2	17.6	15.4
75 % NPK + E.M.	10.4	10.7	11.9	11.0	12.8	14.2	16.5	14.5
75 % NPK + Y	9.6	9.8	11.6	10.3	11.5	13.3	15.5	13.4
75 % NPK + E.M. + Y	10.9	11.5	13.4	11.9	13.3	15.0	17.3	15.2
Mean (A)	10.5	10.9	12.4	11.3	12.8	14.4	16.8	14.7
L.S.D. at 5%	A: 0.7	B: 0.5		AB: 0.9	A: 1.2	B: 1.0		AB: 1.7
				2nd Cut				
100 % NPK	20.4	22.5	24.7	22.5	18.7	21.4	24.5	21.5
75 % NPK + E.M.	18.2	20.6	22.1	20.3	17.3	20.5	22.7	20.2
75 % NPK + Y	17.5	19.1	21.3	19.3	15.5	18.4	22.1	18.7
75 % NPK + E.M. + Y	19.7	22.0	24.6	22.1	18.5	21.0	24.2	21.2
Mean (A)	19.0	21.1	23.2	21.1	17.5	20.3	23.4	20.4
L.S.D. at 5%	A: 1.3	B: 1.2		AB: 2.1	A: 1.6	B: 1.8		AB: 3.1
				3rd Cut				
100 % NPK	30.2	32.8	35.9	33.0	25.1	27.4	30.3	27.6
75 % NPK + E.M.	28.5	30.4	33.1	30.7	22.9	25.8	28.1	25.6
75 % NPK + Y	26.2	29.4	31.1	28.9	21.0	23.2	26.9	23.7
75 % NPK + E.M. + Y	31.3	33.3	36.3	33.6	24.6	26.0	30.1	26.9
Mean (A)	29.1	31.5	34.1	31.6	23.4	25.6	28.9	26.0
L.S.D. at 5%	A: 1.6	B: 1.6		AB: 2.8	A: 2.0	B: 2.2		AB: 3.8

E.M.: Effective microorganisms Y: Yeast

Table 3. Effect of compost and mineral NPK/biofertilizers treatments on leaves fresh weight (ton/fed) of lemongrass plants at 2011/2012 and 2012/2013.

NPK/biofertilizer treatments (B)	Compost levels (ton/fed) (A) 1st Season				2nd Season			
	0	4	8	Mean (B)	0	4	8	Mean (B)
				1st Cut				
100 % NPK	1.80	1.86	1.92	1.86	2.05	2.36	2.59	2.33
75 % NPK + E.M.	1.72	1.77	1.84	1.78	1.80	2.22	2.45	2.16
75 % NPK + Y	1.65	1.68	1.73	1.69	1.67	2.07	2.17	1.97
75 % NPK + E.M. + Y	1.83	1.87	1.93	1.88	1.99	2.32	2.56	2.29
Mean (A)	1.75	1.80	1.86	1.80	1.88	2.24	2.44	2.19
L.S.D. at 5%	A: 0.06	B: 0.06		AB: 0.10	A: 0.16	B: 0.14		AB: 0.24
				2nd Cut				
100 % NPK	3.23	3.46	3.67	3.45	2.84	3.17	3.55	3.19
75 % NPK + E.M.	3.16	3.38	3.54	3.36	2.60	2.94	3.34	2.96
75 % NPK + Y	3.08	3.26	3.46	3.27	2.45	2.73	3.14	2.77
75 % NPK + E.M. + Y	3.28	3.48	3.69	3.48	2.81	3.09	3.49	3.13
Mean (A)	3.19	3.40	3.59	3.39	2.68	2.98	3.38	3.01
L.S.D. at 5%	A: 0.14	B: 0.12		AB: 0.21	A: 0.22	B: 0.16		AB: 0.28
				3rd Cut				
100 % NPK	5.17	5.42	5.76	5.45	4.11	4.41	4.75	4.42
75 % NPK + E.M.	4.94	5.19	5.51	5.21	3.89	4.28	4.55	4.24
75 % NPK + Y	4.60	4.83	5.23	4.88	3.57	4.04	4.38	4.00
75 % NPK + E.M. + Y	5.19	5.47	5.78	5.48	4.09	4.36	4.69	4.38
Mean (A)	4.98	5.23	5.57	5.26	3.91	4.28	4.59	4.26
L.S.D. at 5%	A: 0.18	B: 0.21		AB: 0.36	A: 0.25	B: 0.20		AB: 0.34

E.M.: Effective microorganisms Y: Yeast

Table 4. Effect of compost and mineral NPK/biofertilizers treatments on leaves dry weight (kg/fed) of lemongrass plants at 2011/2012 and 2012/2013.

NPK/biofertilizer treatments (B)	Compost levels (ton/fed) (A) 1st Season				2nd Season			
	0	4	8	Mean (B)	0	4	8	Mean (B)
				1st Cut				
100 % NPK	183.9	191.2	194.7	189.9	208.7	240.3	263.3	237.4
75 % NPK + E.M.	170.5	179.8	185.4	178.6	178.0	220.6	242.1	213.6
75 % NPK + Y	159.1	167.8	167.3	164.7	164.6	203.2	218.6	195.5
75 % NPK + E.M. + Y	185.7	191.4	197.2	191.4	206.1	236.7	260.8	234.5
Mean (A)	174.8	182.5	186.1	181.1	189.4	225.2	246.2	220.3
L.S.D. at 5%	A: 6.2	B: 8.5		AB: 14.7	A: 14.3	B: 17.4		AB: 30.1
				2nd Cut				
100 % NPK	327.1	351.9	372.8	350.6	288.0	320.2	360.7	323.0
75 % NPK + E.M.	312.3	300.4	348.8	320.5	256.6	292.1	327.2	292.0
75 % NPK + Y	299.8	319.1	339.7	319.5	243.3	272.6	311.3	275.7
75 % NPK + E.M. + Y	330.7	353.0	373.7	352.5	284.2	315.3	354.6	318.0
Mean (A)	317.5	339.5	358.8	338.6	268.0	300.0	338.6	302.2
L.S.D. at 5%	A: 15.0	B: 13.6		AB: 23.6	A: 20.8	B: 18.6		AB: 32.2
				3rd Cut				
100 % NPK	528.8	557.0	589.1	558.3	413.2	444.6	480.2	446.0
75 % NPK + E.M.	487.2	508.9	537.8	511.3	387.3	426.5	451.4	421.7
75 % NPK + Y	449.4	472.2	508.2	476.6	350.6	401.2	436.0	395.9
75 % NPK + E.M. + Y	529.3	560.1	594.2	561.2	414.8	442.1	476.1	444.3
Mean (A)	498.7	524.6	557.3	526.9	391.5	428.7	460.9	427.0
L.S.D. at 5%	A: 21.2	B: 25.9		AB: 44.9	A: 26.6	B: 22.0		AB: 38.1

E.M.: Effective microorganisms Y: Yeast

Table 5. Effect of compost and mineral NPK/biofertilizers treatments on essential oil % of lemongrass plants at 2011/2012 and 2012/2013.

NPK/biofertilizer treatments (B)	Compost levels (ton/fed) (A)							
	1st Season				2nd Season			
	0	4	8	Mean (B)	0	4	8	Mean (B)
	1st Cut							
100 % NPK	0.206	0.229	0.252	0.229	0.222	0.231	0.237	0.230
75 % NPK + E.M.	0.194	0.220	0.236	0.217	0.218	0.228	0.233	0.226
75 % NPK + Y	0.186	0.210	0.230	0.209	0.214	0.225	0.230	0.223
75 % NPK + E.M. + Y	0.209	0.231	0.252	0.231	0.220	0.229	0.236	0.228
Mean (A)	0.199	0.223	0.243	0.222	0.219	0.228	0.234	0.227
L.S.D. at 5%	A: 0.010	B: 0.008		AB: 0.014	A: 0.005	B: 0.004		AB: 0.007
	2nd Cut							
100 % NPK	0.221	0.238	0.273	0.244	0.239	0.247	0.255	0.247
75 % NPK + E.M.	0.214	0.227	0.259	0.233	0.237	0.241	0.251	0.243
75 % NPK + Y	0.207	0.218	0.252	0.226	0.232	0.240	0.245	0.239
75 % NPK + E.M. + Y	0.222	0.240	0.274	0.245	0.239	0.244	0.254	0.246
Mean (A)	0.216	0.231	0.265	0.237	0.237	0.243	0.251	0.244
L.S.D. at 5%	A: 0.014	B: 0.015		AB: 0.026	A: 0.008	B: 0.006		AB: 0.010
	3rd Cut							
100 % NPK	0.237	0.258	0.288	0.261	0.264	0.274	0.282	0.273
75 % NPK + E.M.	0.228	0.250	0.272	0.250	0.260	0.271	0.278	0.270
75 % NPK + Y	0.222	0.239	0.258	0.240	0.256	0.269	0.276	0.267
75 % NPK + E.M. + Y	0.239	0.261	0.287	0.262	0.263	0.271	0.280	0.271
Mean (A)	0.232	0.252	0.276	0.253	0.261	0.271	0.279	0.270
L.S.D. at 5%	A: 0.016	B: 0.012		AB: 0.021	A: 0.012	B: 0.004		AB: 0.007

E.M.: Effective microorganisms Y: Yeast

Table 6. Effect of compost and mineral NPK/biofertilizers treatments on essential oil yield (liter/fed.) of lemongrass plants at 2011/2012 and 2012/2013.

NPK/biofertilizer treatments (B)	Compost levels (ton/fed.) (A)							
	1st Season				2nd Season			
	0	4	8	Mean (B)	0	4	8	Mean (B)
	1st Cut							
100 % NPK	3.71	4.27	4.85	4.28	4.55	5.46	6.14	5.38
75 % NPK + E.M.	3.33	3.90	4.36	3.86	3.92	5.07	5.71	4.90
75 % NPK + Y	3.06	3.54	3.97	3.52	3.57	4.64	5.01	4.41
75 % NPK + E.M. + Y	3.82	4.32	4.88	4.34	4.39	5.32	6.03	5.25
Mean (A)	3.48	4.01	4.52	4.00	4.11	5.13	5.72	4.99
L.S.D. at 5%	A: 0.22	B: 0.18		AB: 0.31	A: 0.54	B: 0.31		AB: 0.54
	2nd Cut							
100 % NPK	7.12	8.23	10.02	8.46	6.80	7.81	9.05	7.89
75 % NPK + E.M.	6.77	7.70	9.18	7.88	6.16	7.09	8.40	7.22
75 % NPK + Y	6.40	7.12	8.73	7.42	5.69	6.53	7.70	6.64
75 % NPK + E.M. + Y	7.28	8.35	10.13	8.59	6.71	7.55	8.86	7.71
Mean (A)	6.90	7.35	9.51	7.92	6.34	7.25	8.50	7.36
L.S.D. at 5%	A: 0.31	B: 0.28		AB: 0.48	A: 0.72	B: 0.48		AB: 0.83
	3rd Cut							
100 % NPK	12.12	13.99	16.59	14.23	10.86	12.08	13.38	12.11
75 % NPK + E.M.	11.28	12.95	14.97	13.07	10.12	11.60	12.64	11.45
75 % NPK + Y	10.50	11.53	13.51	11.85	9.15	10.91	12.09	10.72
75 % NPK + E.M. + Y	12.40	14.28	16.58	14.42	10.75	11.83	13.12	11.90
Mean (A)	11.57	13.19	15.41	13.39	10.22	11.60	12.81	11.54
L.S.D. at 5%	A: 0.88	B: 0.92		AB: 1.59	A: 1.02	B: 0.43		AB: 0.74

E.M.: Effective microorganisms Y: Yeast

were the findings of Maheshwari *et al.* (1991), Naguib (2002) and Adholeya and Prakash (2004) on lemongrass; Khalil (2002) on rosemary, Carlen *et al.* (2004) on basil, Abdou *et al.* (2012) on mint and Abdou *et al.* (2014) on marjoram.

In connection with NPK/biofertilization treatments, significant differences were obtained for both essential oil % and yield/fed in both seasons as shown in Tables (5 and 6). The highest values were given, for both parameters, by the two treatments of 100% NPK and 75% NPK + E.M. + yeast with no significant differences between them. It was found that the use of both E.M. plus yeast in combination with 75% NPK was much more effective than either E.M. or yeast alone. Therefore, the triple treatment 75% NPK + E.M. + yeast increased the essential oil yield/fed, over 75% NPK + yeast and 75% NPK + E.M., respectively by 23.3 and 12.4% in the first cut; 15.8 and 9.0% in the second cut and 21.7 and 10.3% in the third cut for the first season. The corresponding values for the second season reached 19.0 and 7.1%, 16.1 and 6.8% and 11.0 and 3.9%. The role of NPK in augmenting essential oil % and yield was reported by Agina *et al.* (2001) on lemongrass, Sakr (2001) on mint, Singh (2004) on rosemary, Singh *et al.* (2004), Golez *et al.* (2006) and Rao *et al.* (2007) on basil and Rajab (2014) on marjoram. While that of E.M. was revealed by Harridy *et al.* (2001) and Mazrou (2008) on lemongrass and Hussein *et al.* (2008) on marjoram and that of yeast was given by Badran *et al.* (2002) and El-Hindi and El-Boraie (2005) on marjoram, Salman (2006) and Abd El-Salam (2014) on basil and Shalan (2013) on mint.

Obtained data show that the interactions between compost levels and NPK/biofertilization treatments were significant. The highest values of essential oil % and yield were obtained when lemongrass plants were supplied with the high level of compost (8 ton/fed) and fertilized with either 100% NPK or 75% NPK plus E.M. and yeast. Either one of these two combined treatments gave significantly higher essential oil % and essential oil yield/fed than the conventional NPK fertilization treatment (100% NPK).

An explanation to the physiological roles of compost and mineral fertilizers, as well as, E.M. and yeast additions in augmenting vegetative growth and essential oil parameters of lemongrass plants could be summarized in the following paragraphs. Concerning compost, Cooke (1972) demonstrated that organic fertilizer from plant sources contain a lot of N and P % and have a little or no soluble salts and added that microorganisms have the ability to supply the plants with fixed N, P and phytohormones that they have to be augmented the growth and N, P and K contents. Schachtschable (1979) proved that organic manure hold moisture and maintains sufficient pore spaces to permit good air circulation and drainage. Follet *et al.* (1981) proved the positive roles of organic fertilizers such as enhancement of soil properties, organic matter, humus and total nitrogen of soil. They added that microbial decomposition caused faster release of necessary nutrients and most micronutrients have to be more readily available at a wide range of pH.

The role of mineral N, P and K nutrients in augmenting vegetative growth characters and essential oil parameters of lemongrass plants is clearly realized throughout their fundamental roles in plant growth and development. Nitrogen, for instance, is a constituent of amino acids, enzymes and energy transfer materials such as chlorophyll, ADP and ATP, (Bidwell, 1974). Phosphorus is essential for cell division, development of meristematic tissues, carbohydrate transformation, photosynthesis and biological oxidation, (Lambers *et al.,* 2000). While, potassium functions as an osmoticum, reacts synergistically with IAA and carbohydrates translocation, (Mengel and Kirkby, 1987).

Obtained results declared the role of E.M. (Effective microorganisms) in

improving different growth aspects and essential oil parameters of lemongrass plants. It contains useful microorganisms including photosynthetic bacteria, lactic acid bacteria, yeasts and others. It is used now in many countries to reduce the amounts of agro-chemicals. It is reported by Ho and Hwan (2000) that E.M. is effective in enhancing soil properties, promoting crops yield and augmenting tolerance.

In regard to yeast, Nagodawithana (1991) reported that yeast is a source of many plant growth substances (cytokinins), large amount of vitamin B and nutritional elements (P, K, S. Na, Ca and Mg), as well as, organic compounds (protein, carbohydrates, nucleic acid and lipids). Moreover, Mady (2009) proved that yeast increased endogenous phytohormones like auxins and cytokinins and decreased abscisic acid, while, Khalil and Ismael (2010) mentioned that yeast can play a very good role in making nutrient elements more readily available to plant.

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تأثير الكمبوست و NPK مع التسميد الحيوي على النمو وإنتاج الزيت الطيار في نباتات حشيشة الليمون

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في تجربة حقلية تمت بمشتل كلية الزراعة جامعة المنيا خلال موسمين متتاليين ٢٠١١/٢٠١٢ و ٢٠١٢/٢٠١٣ بهدف دراسة تأثير ثلاثة مستويات من السماد العضوي (كمبوست) هي صفر ، ٤ ، ٨ طن للفدان وأربعة معاملات من التسميد المعدني NPK والحيوي على صفات النمو الخضري والزيت الطيار لنباتات حشيشة الليمون.

أظهرت النتائج أن صفات النمو الخضري وتشمل طول النبات وعدد الخلفات للنبات ومحصول الأوراق الطازج والجاف للفدان ونسبة الزيت الطيار بالعشب الأخضر ومحصول الزيت الطيار للفدان قد زادت زيادة كبيرة نتيجة إضافة سماد الكمبوست بالمستويين المنخفض والعالي ولكن كان المستوى العالي هو ٨ طن للفدان أكثر فاعلية من المستوى المنخفض. وبالنسبة لمعاملات التسميد المعدني/الحيوي تفوقت معاملة ١٠٠% معدني وكذلك ٧٥% معدني + E.M. + الخميرة على المعاملتين الأخيرتين (٧٥% معدني + E.M. ، ٧٥% معدني + الخميرة) بالنسبة لصفات النمو الخضري ونسبة محصول الزيت الطيار للفدان. وقد كانت أحسن المعاملات التي يوصى بها ناتجة عن إمداد نباتات حشيشة الليمون بالمعدل العالي من الكمبوست (٨ طن/فدان) مع التسميد بمقدار ٧٥% من السماد المعدني مقترناً بال E.M. + الخميرة.