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EFFECT OF PLANT DENSITY AND SOME VITAMINS, AS WELL AS, ACTIVE YEAST ON SWEET BASIL (*OCIMUM BASILICUM*) PLANT B- ESSENTIAL OIL PRODUCTION AND CHEMICAL CONSTITUENTS

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ABSTRACT: The main object of this study was to determine the effect of plant density and some vitamins and active yeast on essential oil production and some chemical constituents of sweet basil. The experiment was conducted during two successive seasons of 2014 and 2015 at the ornamental laboratory and nursery, Fac. Agric., Minia Univ. Results showed that by increasing plant densities. The oil production decreased/plant and increased/fed. Also, the lower density increased pigments and NPK % elements.

All used vitamins and active yeast treatments increased essential oil production (oil % and yield). The collection of vitamins increased essential oil % and pigments content, while active yeast treatment increased essential oil yield and the percentages of N, P and K %.

The best interaction treatments for essential oil production/plant were two higher plant distance (80 and 65 plants/14.5 m^2) in combination with active yeast or 65 plants/14.5 m^2 × vit. B_1 + vit. C + vit. E. While, the highest yield of essential oil/fed were obtained with higher plant density (145 plants/14.5 m^2) in combination with active yeast or vit. B_1 + vit. C + vit. E.

Key words: *Ocimum basilicum*, plant density, vitamins, active yeast, essential oil, chemical constituents.

INTRODUCTION

Among various medicinal and culinary herbs, sweet basil is interested. Sweet basil (*Ocimum basilicum*, L.) from Lamiaceae family is one of the most common herbs. Essential oil of basil is known to posses antimicrobial, insecticidal activities and recently it has found to have vivo anti malaria activity (Bowes and Zheljazkov, 2004).

Khafi (2003) and Dadvand *et al.* (2009) found that density had significant effect on dry matter and essential oil yield of basil. Moreover, Arabasi and Bayran (2004) reported that the highest essential oil ratio obtained under non-nitrogen fertilizer condition with 20×20 cm plant spacing.

MATERIALS AND METHODS

The experiment was carried out during the two seasons of 2014 and 2015 at the floriculture nursery and in the laboratory of floriculture, Fac. Agric., Minia Univ. to investigate the effect of plant density and active yeast, as well as, some vitamins and their interaction on essential oil and chemical composition of *Ocimim basilicum*, L. plants.

Layout of the experiment:

The experiment was arranged in a complete randomized block design in a split plot design with three replicates. The main

plots (A) include four plant densities, which six treatments of active yeast and vitamins, as well as, control occupied the sub plots (B). Therefore, the interaction treatments (A×B) were 24 treatments. The experimental unit (plot) was 7.25 × 2.0 m and containing 5 rows. The seedlings (at the stages of 4.5 leaves and 11-12 cm height) were cultivated in hills, therefore each plot contained 145, 105, 80 and 65 plants/14.5 m^2 and distance between rows 40 cm. The physical and chemical analysis of the used soil in both seasons are determined according to Jackson (1973) and shown in Table (a).

Treatments:

Main plots (A)

The main plots (A) included the following four plant densities:

1. 145 plants/14.5 m^2=40000 plants/fed (25 cm distance) and 29 plants/row.
2. 105 plants/14.5 m^2 = 28966 plants/fed (35 cm distance) and 21 plants/row.
3. 80 plants/14.5 m^2 = 22069 plants/fed (45 cm distance) and 16 plants/row.
4. 65 plants/14.5 m^2 = 17931 plants/fed (55 cm distance) and 13 plants/row.

Sub plots (B)

The sub plots (B) were devoted to six treatments as follows:

1. Control (spray with tap water).
2. Thiamine, vit. B_1 at 50 ppm.
3. Ascorbic acid, vit. C at 50 ppm.
4. Alpha tocopherol, vit. E at 10 ppm.
5. Vit. B_1 + vit. C + vit. E at 50, 50 and 10 ppm, respectively.
6. Active dry yeast (ADY) at 5 g/l.

Each of suspension of yeast and vitamins were applied by hand sprayer, 3 times. The first one was after 6 weeks from transplanting date (April 14th), the second one was added after two weeks from the first cut (May 28th) and the third one was added after two week from the second cut (middle of July). The plants were sprayed till run off. All agricultural practices were performed as usual, in the region for the production of sweet basil plants.

Harvesting times:

During each experimental season, the plants were harvested three times at approximately 50 % flowering. In each harvest, the plants were cut leaving about 10 cm above the soil surface. The first cut was done on 14th of May, the second cut was done on 1st of July. Meanwhile, the third cut was done on 28th of August in the two growing seasons.

Table a. Physical and chemical properties of the used soil.

Soil Character	Value	Soil Character		Value
Sand %	29.00	**Available P %**		14.98
Silt %	30.00	**Exch. K^+ (mg/100 g soil)**		2.16
Clay %	41.00	**Exch. Ca^{++} (mg/100 g soil)**		31.55
Texture grade	Clay loam	**Exch. Na^+ (mg/100 g soil)**		2.39
Organic matter %	1.68	**DTPA Ext. ppm**	**Fe**	7.55
$CaCO_3$ %	2.08		**Cu**	2.16
E.C. (mmhos/cm)	7.85		**Zn**	2.64
pH (1:2.5)	1.04		**Mn**	7.35
Total N %	0.09			

Data recorded:

The following data were recorded:

Oil production

Essential oil % determination in random samples obtained from the air-dried herb of each treatment was carried out in each cut during the two experimental seasons according to the method described by British Pharmacopoeia (1963) by distilling 60 g of herb for 3 hours, in order to extract the essential oil and calculated essential oil yield/plant/cut and essential oil yield/plant and /fed.

Chemical constituents

The chlorophylls a, b and carotenoids were extracted by N-N dimethyl-formamnide according to Moran (1982), using the spectrophotometer at wave length of 656, 665 and 452.5 µm, respectively.

Nitrogen % was determined by using the modified micro-kjeldahl method as described by Wilde *et al.* (1985).

Phosphorus % was determined by the spectrophotometer at wave length of 650 µm according to the method of Chapman and Pratt (1975).

Potassium % was estimated using Flame-Photometry method according to Cottenie *et al*. (1982).

Statistical analysis:

The obtained data were tabulated and statistically analyzed according to MSTAT-C (1986) and the L.S.D. test at 5 % was followed to compare between the means.

RESULTS AND DISCUSSION

A- Essential oil production:

1- Essential oil %:

Data presented in Tables (1 and 2) indicated that the influence of density on essential oil % become significant (at level of 5 %) increasing density decrease essential oil % significantly during the three cuts in both seasons. Therefore, the lowest density (65 plants/14.5 m^2) results the highest percentage. It was observed that by increasing density, the essential oil % decreased, which is in agreement with El-Gendy *et al.* (2001) and Atghaei *et al.* (2015) on *Ociminm basilicum*.

All used treatments of vitamins (vit. B_1, vit. C, vit. E and vit. B_1 + vit. C + vit. E) and active yeast significantly increased essential oil % during three cuts on both seasons comparing with control, except, vit. B_1 in the second and third cuts in the second season. Among such five used treatments

The treatment of vit. B_1 + vit. C + vit. E resulted the significant highest essential oil % comparing with other treatments and control. Similar results were obtained by Abd El-Salam (2014) on basil plants and Helmy (2016) on cumin plants.

The interaction between main and sub plots (A×B) was significant for essential oil % during the three cuts in both seasons (Tables, 1 and 2). The highest values were obtained with the treatment of lowest density (65 plants/14.5 m^2) in combination with vit. B_1+ vit. C + vit. E or vit. E or the interaction treatment of 80 plants/14.5 m^2 × vit. B_1 + vit. C + vit. E.

2- Essential oil yield/plant/cut:

Plant density had significant effect on essential oil yield/plant/cut in both seasons as clearly shown in Tables (3 and 4). Essential oil yield/plant/cut were increased by decreasing plant density. So, the treatment of 65 plants/14.5 m^2 gave the highest essential oil yield/plant/cut in both seasons. Similar results were obtained by Khafi (2003) and Dadvand *et al.* (2009) on basil plants.

Data presented in Tables (2 and 3) indicated that all used five treatments of vitamins and active yeast significantly increased essential oil yield/plant/cut comparing with control in both seasons .

The treatment of active yeast had significantly the highest yield of essential oil

Table 1. Effect of plant densities and some vitamins (vit. B_1, vit. C and vit. E) and yeast treatments on essential oil percentage of sweet basil (*Ocimum basilicum*, L.) plants during the first season.

Treatments (B)	Plant densities /14.5 m^2 (A)				
	145	105	80	65	Mean (B)
1st Cut					
Control	0.671	0.680	0.691	0.698	0.685
Vit. B_1	0.677	0.686	0.697	0.704	0.691
Vit. C	0.688	0.697	0.708	0.715	0.702
Vit. E	0.693	0.702	0.713	0.720	0.707
Vit. B_1+Vit. C +Vit. E	0.701	0.710	0.721	0.727	0.715
Yeast	0.685	0.694	0.705	0.712	0.699
Mean (A)	0.686	0.695	0.706	0.713	0.700
L.S.D. at 5 %	A : 0.003		B : 0.004		AB : 0.008
2nd Cut					
Control	0.686	0.693	0.701	0.707	0.697
Vit. B_1	0.693	0.700	0.708	0.714	0.704
Vit. C	0.708	0.716	0.724	0.730	0.720
Vit. E	0.713	0.721	0.729	0.735	0.725
Vit. B_1+Vit. C+Vit. E	0.722	0.730	0.738	0.744	0.734
Yeast	0.701	0.708	0.716	0.722	0.712
Mean (A)	0.704	0.711	0.719	0.725	0.715
L.S.D. at 5 %	A : 0.004		B : 0.005		AB : 0.010
3rd Cut					
Control	0.679	0.689	0.699	0.705	0.693
Vit. B_1	0.687	0.697	0.707	0.713	0.701
Vit. C	0.698	0.708	0.718	0.724	0.712
Vit. E	0.703	0.713	0.723	0.729	0.717
Vit. B_1+Vit. C+Vit. E	0.710	0.722	0.730	0.736	0.725
Yeast	0.694	0.704	0.714	0.720	0.708
Mean (A)	0.695	0.706	0.715	0.721	0.710
L.S.D. at 5 %	A : 0.003		B : 0.004		AB : 0.008

Table 2. Effect of plant densities and some vitamins (vit. B_1, vit. C and vit. E) and yeast treatments on essential oil percentage of sweet basil (*Ocimum basilicum*, L.) plants during the second season.

Treatments (B)	Plant densities /14.5 m^2 (A)				
	145	**105**	**80**	**65**	**Mean (B)**
1st Cut					
Control	0.677	0.682	0.689	0.697	0.686
Vit. B_1	0.683	0.689	0.693	0.704	0.692
Vit. C	0.693	0.702	0.703	0.719	0.704
Vit. E	0.698	0.707	0.718	0.726	0.712
Vit. B_1+Vit. C +Vit. E	0.705	0.714	0.725	0.734	0.720
Yeast	0.688	0.698	0.698	0.716	0.700
Mean (A)	0.691	0.699	0.704	0.716	0.703
L.S.D. at 5 %	A : 0.003		B : 0.005		AB : 0.010
2nd Cut					
Control	0.696	0.701	0.708	0.715	0.705
Vit. B_1	0.697	0.705	0.714	0.720	0.709
Vit. C	0.712	0.721	0.729	0.734	0.724
Vit. E	0.718	0.725	0.734	0.741	0.730
Vit. B_1+Vit. C+Vit. E	0.777	0.733	0.742	0.750	0.738
Yeast	0.704	0.713	0.720	0.726	0.716
Mean (A)	0.709	0.716	0.725	0.731	0.720
L.S.D. at 5 %	A : 0.004		B : 0.006		AB : 0.012
3rd Cut					
Control	0.686	0.697	0.705	0.714	0.701
Vit. B_1	0.689	0.699	0.710	0.716	0.704
Vit. C	0.701	0.701	0.721	0.726	0.712
Vit. E	0.709	0.718	0.729	0.735	0.723
Vit. B_1+Vit. C+Vit. E	0.717	0.725	0.737	0.744	0.731
Yeast	0.697	0.708	0.717	0.722	0.711
Mean (A)	0.700	0.708	0.720	0.726	0.714
L.S.D. at 5 %	A : 0.005		B : 0.005		AB : 0.010

Table 3. Effect of plant densities and some vitamins (vit. B_1, vit. C and vit. E) and yeast treatments on essential oil yield/plant/cut (ml) of sweet basil (*Ocimum basilicum*, L.) plants during the first season.

Treatments (B)	Plant densities /14.5 m^2 (A)				
	145	105	80	65	Mean (B)
1st Cut					
Control	0.225	0.218	0.296	0.349	0.272
Vit. B_1	0.265	0.367	0.410	0.422	0.365
Vit. C	0.303	0.421	0.440	0.508	0.417
Vit. E	0.287	0.404	0.431	0.430	0.388
Vit. B_1+Vit. C +Vit. E	0.470	0.541	0.638	0.653	0.575
Yeast	0.499	0.569	0.678	0.726	0.617
Mean (A)	0.341	0.419	0.481	0.514	0.438
L.S.D. at 5 %	A : 0.081		B : 0.037		AB : 0.074
2nd Cut					
Control	0.250	0.244	0.314	0.517	0.330
Vit. B_1	0.321	0.432	0.518	0.674	0.485
Vit. C	0.352	0.433	0.533	0.756	0.517
Vit. E	0.344	0.452	0.507	0.807	0.526
Vit. B_1+Vit. C+Vit. E	0.491	0.824	0.856	0.954	0.780
Yeast	0.541	0.787	0.927	0.945	0.799
Mean (A)	0.382	0.526	0.607	0.773	0.571
L.S.D. at 5 %	A : 0.039		B : 0.040		AB : 0.080
3rd Cut					
Control	0.338	0.404	0.414	0.533	0.421
Vit. B_1	0.387	0.602	0.637	0.974	0.648
Vit. C	0.510	0.648	0.693	1.073	0.729
Vit. E	0.439	0.629	0.647	1.053	0.689
Vit. B_1+Vit. C+Vit. E	0.957	0.993	1.011	1.281	1.003
Yeast	0.949	0.872	1.271	1.440	1.130
Mean (A)	0.590	0.690	0.777	1.023	0.769
L.S.D. at 5 %	A : 0.080		B : 0.092		AB : 0.184

Table 4. Effect of plant densities and some vitamins (vit. B_1, vit. C and vit. E) and yeast treatments on essential oil yield/plant/cut (ml) of sweet basil (*Ocimum basilicum*, L.) plants during the second season.

Treatments (B)	Plant densities /14.5 m^2 (A)				
	145	105	80	65	Mean (B)
1st Cut					
Control	0.259	0.129	0.335	0.384	0.276
Vit. B_1	0.284	0.381	0.396	0.416	0.369
Vit. C	0.312	0.444	0.452	0.566	0.442
Vit. E	0.301	0.395	0.421	0.438	0.388
Vit. B_1+Vit. C +Vit. E	0.367	0.596	0.633	0.667	0.565
Yeast	0.430	0.616	0.669	0.740	0.612
Mean (A)	0.159	0.481	0.540	0.591	0.441
L.S.D. at 5 %	A : 0.096		B : 0.037		AB : 0.074
2nd Cut					
Control	0.381	0.336	0.393	0.459	0.392
Vit. B_1	0.447	0.631	0.656	0.707	0.609
Vit. C	0.489	0.679	0.724	0.761	0.662
Vit. E	0.470	0.661	0.672	0.759	0.640
Vit. B_1+Vit. C+Vit. E	0.810	0.986	1.027	1.043	0.953
Yeast	0.778	1.078	1.148	1.229	1.057
Mean (A)	0.383	0.783	0.827	0.883	0.717
L.S.D. at 5 %	A : 0.105		B : 0.041		AB : 0.082
3rd Cut					
Control	0.423	0.435	0.505	0.585	0.487
Vit. B_1	0.669	0.816	0.896	0.948	0.832
Vit. C	0.735	0.852	0.957	1.047	0.896
Vit. E	0.708	0.856	0.940	1.001	0.875
Vit. B_1+Vit. C+Vit. E	1.080	1.229	1.305	1.351	1.240
Yeast	1.004	1.446	1.499	1.574	1.378
Mean (A)	0.768	0.993	1.072	1.140	0.941
L.S.D. at 5 %	A : 0.098		B : 0.038		AB : 0.076

during the three cuts in both seasons, except the second cut during the first season. Salman (2006), Abdou *et al.* (2014) and Omar *et al.* (2016) found that active yeast treatment had positive effects on essential oil yield of basil plants.

The interaction between main and sub plots was significant for essential oil yield/plant/cut in both seasons. Generally, the highest yield of essential oil/plant/cut were obtained by the treatments of 80 or 65 plannts/14.5 m^2 in combination with active yeast or cultivated plants at 65 plants/14.5 m^2 and sprayed with vit. B_1 + vit. C + vit. E (Tables, 3 and 4).

3- Essential oil yield/plant and /fed:

Essential oil yield per plant was significant increase (1.313. 1.635, 1.865 and 2.311 ml/plant) with decreasing plant density (145, 105, 80 and 65 plants/14.5 m^2) in the first season. The same trend was obtained in the second season. The opposite trend was obtained for essential oil yield/fed where by increasing the density, essential oil yield/fed increases. The highest yield of essential oil (52.86 and 66.29 liter/fed in both seasons, respectively) were obtained by the treatment of higher density (40000 plants/fed) as compared with other treatments (28966, 22069 and 17931 plants/fed) which were recorded 47.51, 41.53 and 41.28 liter/fed in the first season and 60.67, 50.23 and 48.36 liter/fed in the second season, respectively.

It could be said that by increasing the distance between plants the growth of a single plant increases because of decreasing the competition for absorbing light, water and nutrition. But increasing growth due to that, could not compensate for increase in growth tissue resulting from the number of plants in unit, as a result of higher density the yield of dry matter increases, that reflected in essential oil yield/fed Similar results were obtained by Ram *et al.* (2002) and Arabasi and Bayran (2004) on *Ocimum* spp. and Katar and Gurbuz (2008) on *Melissa officinalis*.

Concerning the effect of vitamins and active yeast treatments, data in Tables (5 and 6) showed that the best treatments which gave the highest essential oil yield/plant and /fed was active yeast followed by vit. B_1 + vit. C + vit. E which significant differences between such two superior treatments. Active yeast had positive effect on essential oil yield because its contain many components which enhance and stimulate essential oil production. Similar results were obtained by Salman (2006), Abdou *et al.* (2014), Nassar *et al.* (2015) and Omar *et al.* (2016) on *Ocimum* sp.

The interaction between main and sub plots was significant for essential oil yield/plant and /fed in both seasons. The best interaction treatments for essential oil yield /plant were obtained by the two densities 65 and 80 plants/14.5 m^2 in combination with active yeast in both seasons and density in 65 plants /14.5 m^2 in combination with vit. B_1 + vit. C + vit. E as clearly shown in Table (5). The highest yield of essential oil/fed were obtained by cultivated plants in higher density 145 plants/14.5 m^2 in combination with active yeast or vit. B_1 + vit. C + vit. E in both seasons or plant density 105 plants/14.5 m^2 in combination with active yeast during the second season as clearly shown in Table (6).

B- Chemical constituents:

1- Photosynthetic pigments:

Data presented in Tables (7 to 12) showed that the effect of plant densities on photosynthetic pigments (chl. a, b and carotenoids) was significant during the three cuts in both seasons. The significantly highest contents of chl. a, b and carotenoids were obtained with the lowest density treatment (65 plants/14.5 m^2). Similar results were obtained by Badran and Hafez (2002) on *Nigella sativa* and Badran *et al*. (2003 and 2007) on *Pimpinella anisum* and fennel plants, respectively.

Regarding the effect of some vitamins and active yeast treatments, data in Tables (7 to 12) showed that all five used treatments

Table 5. Effect of plant densities and some vitamins (vit. B_1, vit. C and vit. E) and yeast treatments on essential oil yield/plant/season (ml/plant) of sweet basil (*Ocimum basilicum*, L.) plants during two seasons.

Treatments (B)	Plant densities /14.5 m^2 (A)				
	145	105	80	65	Mean (B)
First season					
Control	0.813	0.867	1.024	1.399	1.023
Vit. B_1	0.974	1.401	1.565	2.071	1.498
Vit. C	1.166	1.502	1.666	2.337	1.663
Vit. E	1.070	1.486	1.585	2.290	1.603
Vit. B_1+Vit. C+Vit. E	1.917	2.357	2.506	2.687	2.358
Yeast	1.989	2.228	2.876	3.112	2.546
Mean (A)	1.313	1.635	1.865	2.311	
L.S.D. at 5 %	A : 0.131		B : 0.121		AB : 0.242
Second season					
Control	1.062	0.901	1.234	1.429	1.155
Vit. B_1	1.400	1.828	1.948	2.072	1.810
Vit. C	1.536	1.975	2.133	2.374	2.000
Vit. E	1.479	1.912	2.033	2.198	1.903
Vit. B_1+Vit. C+Vit. E	2.256	2.811	2.965	3.061	2.758
Yeast	2.211	3.141	3.316	3.543	3.047
Mean (A)	1.310	2.258	2.439	2.615	
L.S.D. at 5 %	A : 0.142		B : 0.135		AB :0.270

Table 6. Effect of plant densities and some vitamins (vit. B_1, vit. C and vit. E) and yeast treatments on essential oil yield/fed/season (liter/fed) of sweet basil (*Ocimum basilicum*, L.) plants during two seasons.

Treatments (B)	Plant densities /14.5 m^2 (A)				
	145	105	80	65	Mean (B)
First season					
Control	32.52	25.11	22.60	25.09	26.33
Vit. B_1	38.96	40.58	34.54	37.14	37.81
Vit. C	46.64	43.51	36.77	41.90	42.21
Vit. E	42.80	43.04	34.98	41.06	40.47
Vit. B_1+Vit. C+Vit. E	76.68	68.27	55.30	48.18	62.11
Yeast	79.56	64.54	63.47	55.80	65.84
Mean (A)	52.86	47.51	41.53	41.28	
L.S.D. at 5 %	A : 2.47		B : 2.23		AB : 4.46
Second season					
Control	42.48	26.10	27.23	25.62	30.36
Vit. B_1	56.00	52.95	42.99	37.15	47.27
Vit. C	61.44	57.21	47.07	42.57	52.07
Vit. E	59.16	55.38	44.87	39.41	49.71
Vit. B_1+Vit. C+Vit. E	90.24	81.42	65.43	54.89	72.99
Yeast	88.44	90.98	73.18	63.53	79.03
Mean (A)	66.29	60.67	50.23	48.36	
L.S.D. at 5 %	A : 2.68		B : 2.57		AB : 5.14

Table 7. Effect of plant densities and some vitamins (vit. B_1, vit. C and vit. E) and yeast treatments on chlorophyll a of sweet basil (*Ocimum basilicum*, L.) plants during the first season.

Treatments (B)	Plant densities /14.5 m^2 (A)				
	145	105	80	65	Mean (B)
1st Cut					
Control	2.220	2.255	2.280	2.299	2.264
Vit. B_1	2.250	2.280	2.303	2.329	2.291
Vit. C	2.287	2.320	2.345	2.370	2.331
Vit. E	2.300	2.336	2.360	2.390	2.347
Vit. B_1+Vit. C +Vit. E	2.315	2.351	2.375	2.406	2.362
Yeast	2.270	2.301	2.322	2.348	2.310
Mean (A)	2.274	2.307	2.331	2.357	2.317
L.S.D. at 5 %	A : 0.010		B : 0.008		AB : 0.016
2nd Cut					
Control	0.270	0.290	2.315	2.340	2.304
Vit. B_1	2.285	2.325	2.348	2.371	2.332
Vit. C	2.322	2.360	2.375	2.401	2.365
Vit. E	2.339	2.375	2.390	2.409	2.378
Vit. B_1+Vit. C+Vit. E	2.355	2.399	2.410	2.430	2.399
Yeast	2.301	2.346	2.360	2.385	2.348
Mean (A)	2.312	2.349	2.366	2.389	2.354
L.S.D. at 5 %	A : 0.015		B : 0.011		AB : 0.022
3rd Cut					
Control	2.240	2.278	2.300	2.324	2.286
Vit. B_1	2.270	2.301	2.321	2.349	2.310
Vit. C	2.301	2.336	2.350	2.380	2.342
Vit. E	2.321	2.353	2.370	2.400	2.361
Vit. B_1+Vit. C+Vit. E	2.340	2.375	2.399	2.412	2.382
Yeast	2.285	2.318	2.336	2.365	2.326
Mean (A)	2.293	2.327	2.346	3.372	2.335
L.S.D. at 5 %	A : 0.012		B : 0.007		AB : 0.014

Table 8. Effect of plant densities and some vitamins (vit. B_1, vit. C and vit. E) and yeast treatments on chlorophyll a of sweet basil (*Ocimum basilicum*, L.) plants during the second season.

Treatments (B)	Plant densities /14.5 m^2 (A)				
	145	105	80	65	Mean (B)
1st Cut					
Control	2.287	2.323	2.348	2.368	2.332
Vit. B_1	2.318	2.348	2.372	2.399	2.360
Vit. C	2.356	2.390	2.415	2.441	2.401
Vit. E	2.369	2.406	2.431	2.462	2.417
Vit. B_1+Vit. C +Vit. E	2.384	2.422	2.446	2.478	2.433
Yeast	2.338	2.370	2.392	2.418	2.379
Mean (A)	2.342	2.376	2.401	2.428	2.387
L.S.D. at 5 %	A :0.013		B : 0.009		AB : 0.018
2nd Cut					
Control	0.278	0.299	2.384	2.410	2.373
Vit. B_1	2.354	2.395	2.418	2.442	2.402
Vit. C	2.392	2.431	2.446	2.473	2.436
Vit. E	2.409	2.446	2.462	2.481	2.449
Vit. B_1+Vit. C+Vit. E	2.426	2.471	2.482	2.503	2.471
Yeast	2.370	2.416	2.431	2.457	2.418
Mean (A)	2.381	2.419	2.437	2.461	2.425
L.S.D. at 5 %	A : 0.017		B : 0.012		AB : 0.024
3rd Cut					
Control	2.307	2.346	2.369	2.394	2.355
Vit. B_1	2.338	2.370	2.391	2.419	2.379
Vit. C	2.370	2.406	2.421	2.451	2.412
Vit. E	2.391	2.424	2.441	2.472	2.432
Vit. B_1+Vit. C+Vit. E	2.410	2.446	2.471	2.484	2.453
Yeast	2.354	2.388	2.406	2.436	2.396
Mean (A)	2.362	2.397	2.416	3.473	2.405
L.S.D. at 5 %	A : 0.014		B : 0.007		AB : 0.014

Table 9. Effect of plant densities and some vitamins (vit. B_1, vit. C and vit. E) and yeast treatments on chlorophyll b of sweet basil (*Ocimum basilicum*, L.) plants during the first season.

Treatments (B)	Plant densities /14.5 m^2 (A)				
	145	105	80	65	Mean (B)
1st Cut					
Control	0.730	0.742	0.750	0.756	0.745
Vit. B_1	0.741	0.750	0.756	0.766	0.753
Vit. C	0.752	0.763	0.771	0.780	0.797
Vit. E	0.756	0.768	0.786	0.796	0.772
Vit. B_1+Vit. C +Vit. E	0.761	0.773	0.792	0.797	0.781
Yeast	0.746	0.757	0.762	0.773	0.760
Mean (A)	0.748	0.759	0.769	0.776	0.763
L.S.D. at 5 %	A : 0.005		B : 0.004		AB : 0.008
2nd Cut					
Control	0.746	0.753	0.761	0.770	0.758
Vit. B_1	0.751	0.765	0.772	0.780	0.767
Vit. C	0.764	0.776	0.782	0.790	0.778
Vit. E	0.769	0.781	0.786	0.793	0.782
Vit. B_1+Vit. C+Vit. E	0.775	0.789	0.793	0.800	0.789
Yeast	0.757	0.772	0.776	0.785	0.773
Mean (A)	0.760	0.773	0.778	0.786	0.774
L.S.D. at 5 %	A : 0.003		B : 0.004		AB : 0.008
3rd Cut					
Control	0.736	0.749	0.757	0.764	0.752
Vit. B_1	0.746	0.757	0.762	0.773	0.760
Vit. C	0.757	0.768	0.773	0.783	0.770
Vit. E	0.763	0.774	0.780	0.791	0.777
Vit. B_1+Vit. C+Vit. E	0.770	0.781	0.789	0.794	0.784
Yeast	0.751	0.762	0.768	0.778	0.765
Mean (A)	0.754	0.765	0.772	0.781	0.768
L.S.D. at 5 %	A : 0.003		B : 0.003		AB : 0.006

Table 10. Effect of plant densities and some vitamins (vit. B_1, vit. C and vit. E) and yeast treatments on chlorophyll b of sweet basil (*Ocimum basilicum*, L.) plants during the second season.

Treatments (B)	Plant densities /14.5 m^2 (A)				
	145	105	80	65	Mean (B)
1st Cut					
Control	0.752	0.764	0.773	0.779	0.767
Vit. B_1	0.763	0.773	0.779	0.789	0.776
Vit. C	0.775	0.786	0.794	0.803	0.821
Vit. E	0.779	0.791	0.810	0.820	0.795
Vit. B_1+Vit. C +Vit. E	0.784	0.796	0.816	0.821	0.804
Yeast	0.768	0.780	0.785	0.796	0.783
Mean (A)	0.770	0.782	0.792	0.799	0.786
L.S.D. at 5 %	A : 0.006		B : 0.005		AB : 0.010
2nd Cut					
Control	0.768	0.776	0.784	0.793	0.781
Vit. B_1	0.774	0.788	0.795	0.803	0.790
Vit. C	0.787	0.799	0.805	0.814	0.801
Vit. E	0.792	0.804	0.810	0.817	0.805
Vit. B_1+Vit. C+Vit. E	0.798	0.813	0.817	0.824	0.813
Yeast	0.780	0.795	0.799	0.809	0.796
Mean (A)	0.783	0.796	0.801	0.810	0.797
L.S.D. at 5 %	A : 0.004		B : 0.004		AB : 0.008
3rd Cut					
Control	0.758	0.771	0.780	0.787	0.775
Vit. B_1	0.768	0.780	0.785	0.796	0.783
Vit. C	0.780	0.791	0.796	0.806	0.793
Vit. E	0.786	0.797	0.803	0.815	0.800
Vit. B_1+Vit. C+Vit. E	0.793	0.804	0.813	0.818	0.808
Yeast	0.774	0.785	0.791	0.801	0.788
Mean (A)	0.777	0.788	0.795	0.804	0.791
L.S.D. at 5 %	A : 0.005		B : 0.003		AB : 0.006

Table 11. Effect of plant densities and some vitamins (vit. B_1, vit. C and vit. E) and yeast treatments on carotenoids of sweet basil (*Ocimum basilicum*, L.) plants during the first season.

Treatments (B)	Plant densities /14.5 m^2 (A)				
	145	105	80	65	Mean (B)
1st Cut					
Control	0.761	0.772	0.790	0.787	0.778
Vit. B_1	0.772	0.781	0.788	0.796	0.784
Vit. C	0.782	0.793	0.802	0.810	0.797
Vit. E	0.787	0.798	0.796	0.817	0.800
Vit. B_1+Vit. C +Vit. E	0.792	0.804	0.812	0.824	0.808
Yeast	0.778	0.787	0.793	0.803	0.790
Mean (A)	0.779	0.789	0.798	0.805	0.793
L.S.D. at 5 %	A : 0.003		B : 0.004		AB : 0.008
2nd Cut					
Control	0.777	0.783	0.792	0.800	0.788
Vit. B_1	0.782	0.795	0.803	0.810	0.798
Vit. C	0.794	0.807	0.812	0.820	0.808
Vit. E	0.799	0.811	0.819	0.823	0.813
Vit. B_1+Vit. C+Vit. E	0.805	0.820	0.824	0.830	0.820
Yeast	0.787	0.802	0.807	0.815	0.803
Mean (A)	0.791	0.803	0.810	0.816	0.805
L.S.D. at 5 %	A : 0.004		B : 0.005		AB : 0.010
3rd Cut					
Control	0.767	0.779	0.788	0.795	0.782
Vit. B_1	0.778	0.787	0.793	0.803	0.790
Vit. C	0.787	0.799	0.803	0.813	0.801
Vit. E	0.794	0.804	0.810	0.820	0.807
Vit. B_1+Vit. C+Vit. E	0.801	0.812	0.820	0.825	0.815
Yeast	0.782	0.793	0.799	0.808	0.796
Mean (A)	0.785	0.796	0.802	0.811	0.799
L.S.D. at 5 %	A : 0.005		B : 0.004		AB : 0.008

Table 12. Effect of plant densities and some vitamins (vit. B_1, vit. C and vit. E) and yeast treatments on carotenoids of sweet basil (*Ocimum basilicum*, L.) plants during the second season.

Treatments (B)	Plant densities /14.5 m^2 (A)				
	145	105	80	65	Mean (B)
1st Cut					
Control	0.784	0.795	0.814	0.811	0.801
Vit. B_1	0.795	0.804	0.812	0.820	0.808
Vit. C	0.805	0.817	0.826	0.834	0.821
Vit. E	0.811	0.822	0.820	0.842	0.824
Vit. B_1+Vit. C +Vit. E	0.816	0.828	0.836	0.849	0.832
Yeast	0.801	0.811	0.817	0.827	0.814
Mean (A)	0.802	0.813	0.822	0.829	0.817
L.S.D. at 5 %	A : 0.004		B : 0.005		AB : 0.010
2nd Cut					
Control	0.800	0.806	0.816	0.824	0.812
Vit. B_1	0.805	0.819	0.827	0.834	0.822
Vit. C	0.818	0.831	0.836	0.845	0.832
Vit. E	0.823	0.835	0.844	0.848	0.837
Vit. B_1+Vit. C+Vit. E	0.829	0.845	0.849	0.855	0.845
Yeast	0.811	0.826	0.831	0.839	0.827
Mean (A)	0.815	0.827	0.834	0.840	0.829
L.S.D. at 5 %	A : 0.005		B : 0.005		AB : 0.010
3rd Cut					
Control	0.790	0.802	0.812	0.819	0.805
Vit. B_1	0.801	0.811	0.817	0.827	0.814
Vit. C	0.811	0.823	0.827	0.837	0.825
Vit. E	0.818	0.828	0.834	0.845	0.831
Vit. B_1+Vit. C+Vit. E	0.825	0.836	0.845	0.850	0.839
Yeast	0.805	0.817	0.823	0.832	0.820
Mean (A)	0.809	0.820	0.826	0.835	0.823
L.S.D. at 5 %	A : 0.005		B : 0.006		AB : 0.012

significantly increased the leaves contents of chlorophyll a, b and carotenoids during the three cuts in both seasons as compared with control treatments. Among these five treatments, the treatment of vit. B_1 + vit. C + vit. E resulted the highest contents of chlorophyll a, b and carotenoids. The positive effect of vitamins on contents of the pigments of sweet basil was found by Abd El-Salam (2014).

The interaction between plant densities, some vitamins and active yeast treatments was significant for chlorophyll a, b and carotenoids during the three cuts in both seasons. The highest contents of chlorophyll a and carotenoids were obtained with lower density (65 plants/14.5 m^2) plus vit. B_1 + vit. C + vit. E or vit. E during the three cuts in both seasons or plant density 80 plants/14.5 m^2 in combination with vit. B_1 + vit. C + vit. E during the second and third cuts in both seasons as clearly shown in Tables (7, 8, 11 and 12). The highest contents of chlorophyll b, during the three cuts in both seasons, were obtained with 65 and 80 plants/14.5 m^2 in combination with vit. B_1 + vit. C + vit. E or 65 plants/14.5 m^2 with vit. E as clearly shown in Tables (9 and 10).

2- N, P and K %:

Data presented in Tables (13, 14 and 15) cleared that sweet basil planted at 65 plants/14.5 m^2 recorded significantly highest percentages of nitrogen, phosphorus and potassium in the dry herb in both seasons comparing with other densities treatments. Similar results were obtained by El-Shaer (1986) on fennel and Badran *et al.* (2003) on anise plants who found that the elements % (NPK) in the dry herb was slightly increased by decreasing plant density.

Data in Tables (13, 14 and 15) mentioned that all used five treatments (vit. B_1, vit. C, vit. E, vit. B_1 + vit. C + vit. E and active yeast) significantly increased N. P and K % in both seasons comparing with control.

The treatment of active yeast significantly increased the percentages of N, P and K comparing with other treatments.

Active yeast had positive effect on percentages of N, P and K as mentioned by Abd-El-Salam (2014) on basil plants, El-Nady (2015) on lemongrass and Khaled *et al.* (2014) on marjoram plants.

The interaction between main and sub plots (A×B) treatments was significant for N, P and K % in both seasons (Tables, 13, 14 and 15). The best interaction treatments for N, P and K % were obtained with 65 plants/14.5 m^2 in combination with active yeast or vit. B_1 + vit. C + vit. E.

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Table 13. Effect of plant densities and some vitamins (vit. B_1, vit. C and vit. E) and yeast treatments on nitrogen percentage of sweet basil (*Ocimum basilicum*, L.) plants during two seasons.

Treatments (B)	Plant densities /14.5 m^2 (A)				
	145	105	80	65	Mean (B)
First season					
Control	1.830	1.854	1.879	1.893	1.864
Vit. B_1	1.850	1.876	1.899	1.914	1.885
Vit. C	1.880	1.916	1.929	1.944	1.917
Vit. E	1.865	1.891	1.914	1.929	1.900
Vit. B_1+Vit. C+Vit. E	1.876	1.902	1.925	1.939	1.911
Yeast	1.887	1.912	1.936	1.949	1.921
Mean (A)	1.865	1.892	1.914	1.928	
L.S.D. at 5 %	A : 0.005		B : 0.006		AB : 0.012
Second season					
Control	1.834	1.866	1.890	1.903	1.873
Vit. B_1	1.856	1.889	1.914	1.926	1.896
Vit. C	1.890	1.924	1.947	1.958	1.930
Vit. E	1.875	1.908	1.932	1.943	1.915
Vit. B_1+Vit. C+Vit. E	1.891	1.936	1.956	1.968	1.938
Yeast	1.899	1.939	1.958	1.986	1.946
Mean (A)	1.874	1.910	1.933	1.986	
L.S.D. at 5 %	A : 0.004		B : 0.009		AB : 0.018

Table 14. Effect of plant densities and some vitamins (vit. B_1, vit. C and vit. E) and yeast treatments on phosphorus percentage of sweet basil (*Ocimum basilicum*, L.) plants during two seasons.

Treatments (B)	Plant densities /14.5 m^2 (A)				
	145	105	80	65	Mean (B)
First season					
Control	0.116	0.131	0.146	0.158	0.138
Vit. B_1	0.140	0.162	0.173	0.182	0.164
Vit. C	0.152	0.175	0.185	0.198	0.178
Vit. E	0.133	0.151	0.163	0.169	0.154
Vit. B_1+Vit. C+Vit. E	0.161	0.186	0.198	0.218	0.191
Yeast	0.171	0.201	0.210	0.218	0.200
Mean (A)	0.146	0.168	0.179	0.191	
L.S.D. at 5 %	A : 0.002		B : 0.003		AB : 0.006
Second season					
Control	0.125	0.140	0.151	0.162	0.145
Vit. B_1	0.141	0.165	0.177	0.185	0.167
Vit. C	0.155	0.180	0.186	0.201	0.181
Vit. E	0.135	0.155	0.166	0.171	0.157
Vit. B_1+Vit. C+Vit. E	0.168	0.189	0.211	0.225	0.198
Yeast	0.179	0.215	0.218	0.231	0.211
Mean (A)	0.151	0.174	0.185	0.196	
L.S.D. at 5 %	A : 0.001		B : 0.004		AB : 0.008

Table 15. Effect of plant densities and some vitamins (vit. B_1, vit. C and vit. E) and yeast treatments on potassium percentage of sweet basil (*Ocimum basilicum*, L.) plants during two seasons.

Treatments (B)	Plant densities /14.5 m^2 (A)				
	145	105	80	65	Mean (B)
First season					
Control	1.319	1.349	1.375	1.391	1.359
Vit. B_1	1.347	1.370	1.395	1.415	1.382
Vit. C	1.382	1.435	1.448	1.456	1.430
Vit. E	1.371	1.421	1.435	1.441	1.417
Vit. B_1+Vit. C+Vit. E	1.399	1.449	1.459	1.478	1.446
Yeast	1.419	1.469	1.472	1.487	1.462
Mean (A)	1.373	1.416	1.431	1.445	
L.S.D. at 5 %	A : 0.002		B : 0.006		AB : 0.012
Second season					
Control	1.323	1.354	1.381	1.398	1.364
Vit. B_1	1.350	1.374	1.400	1.421	1.386
Vit. C	1.385	1.439	1.453	1.462	1.435
Vit. E	1.374	1.425	1.441	1.448	1.422
Vit. B_1+Vit. C+Vit. E	1.403	1.454	1.465	1.484	1.452
Yeast	1.423	1.474	1.478	1.494	1.467
Mean (A)	1.376	1.420	1.436	1.451	
L.S.D. at 5 %	A : 0.001		B : 0.005		AB : 0.010

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تأثير الكثافة النباتية وبعض الفيتامينات والخميرة على نبات الريحان الحلو
ب – إنتاجية الزيت العطري والمكونات الكيماوية

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أجري هذا البحث لدراسة تأثير الكثافة النباتية (١٤٥ و ١٠٥ و ٨٠ و ٦٥ نبات/١٤.٥ م^{٢}) وبعض الفيتامينات (فيتامين ب$_{١}$ ، فيتامين ج ، فيتامين هـ و الخميرة النشطة والكنترول) على إنتاجية الزيت الطيار والتحليل الكيماوي لنبات الريحان.

أظهرت النتائج أن خفض الكثافة النباتية تؤدي إلى زيادة في النسب المئوية للزيت الطيار ومحصول الزيت للنبات ومحتوى صبغات البناء الضوئي والنسبة المئوية العناصر NPK ما عدا محصول الزيت للفدان.

كل المعاملات المستخدمة من الفيتامينات والخميرة النشطة تؤدي إلى زيادة معنوية في صفات إنتاجية الزيت الطيار والتحليل الكيماوي.

معاملة الخميرة يليها معاملة الفيتامينات معا (فيتامين ب١ + فيتامين ج + فيتامين هـ) سجلت أعلى القيم في هذا الشأن.

أفضل معاملات تفاعل لكل صفات انتاجية الزيت الطيار والتحليل الكيماوي للنبات كانت مع الكثافة القليلة والخميرة النشطة أو الفيتامينات (فيتامين ب١ + فيتامين ج + فيتامين هـ) بينما أعلى القيم للفدان نتجت عن الكثافة العالية مع الخميرة النشطة أو فيتامين ب١ + فيتامين ج + فيتامين هـ.