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EFFECT OF FOLIAR SPRAYING WITH ZINC AND/OR GAMMA RADIATION ON OIL CONTENT AND OIL COMPOSTION OF ANETHUM GRAVEOLENS DURING THREE DEVELOPING STAGES

Hussein ABDEL-BASIT HUSSEIN SAID-AL AHL[1], Atef MOHAMED SARHAN[2], Abou-dahab MOHAMED ABOU-DAHAB[2], El-shahat NASR ABOU-ZEID[1], Mohamed SAYED ALI[1], Nabila YAHYA NAGUIB[1]

[1]Department of Medicinal and Aromatic Plants National Research Center, Dokki, Giza, Egypt.
[2]Department of Ornamental Horticulture, Faculty of Agriculture, Cairo University, Cairo, Egypt

Corresponding author email: hussein_saidalahl@yahoo.com

Abstract

This study was to investigate the influence of pre-sowing treatment of Anethum graveolens L. seeds, consisted in irradiation with gamma radiation (0, 2, 4, 8, 16, 32 and 64 k-rd doses) with or without zinc (150 ppm), on the oil content and oil composition of plants during vegetative, flowering and fruiting stages. Spraying dill plants with zinc increased the oil content. Generally increasing gamma rays doses increased essential oil. However interaction treatment between zinc and gamma radiation at 8 k-rad dose recorded the highest values of essential oil in vegetative and fruiting stages, while interaction between zinc and gamma radiation at 2 k-rad dose recorded the highest essential oil in flowering stage. The major compounds were found to be α-phellandrene, limonene, β-phellandrene and p-cymene in the vegetative stage, p-cymene, carvone, dillether and dillapiole in the flowering stage, whereas, carvone, dillapiole and limonene in the fruiting stage.

Key words: *dill (Anethum graveolens L.) essential oil, gamma radiation, zinc*

INTRODUCTION

Anethum graveolens L. "Dill" is an annual herb from *Apiaceae* family used as a spice and medicine, It originates from the Mediterranean and West Asia. Herb and seed oil have also been widely investigated in respect of their antiseptic and exhibits anticarcinogenic, antimicrobial and antioxidant activity (Weiss, 2002).

Zinc acts as a metal component of various enzymes or as a functional, structural or regulatory cofactor (Marschner, 1995). Irradiated seeds with gamma rays induced biochemical, physiological and cytological changes (Korosi and Pal, 1989).

Therefore, this study aims to study the effect of zinc and gamma radiation treatment on essential oils content and composition of dill plants at different developing stages.

MATERIALS AND METHODS

The experiment was carried out at the Farm Station of National Research Centre, Egypt during the seasons of 2000/2001 and 2001/2002. Dill seeds were sown in 15 of October in both seasons. Dry seeds of dill were irradiated with gamma rays doses at 2, 4, 8, 16, 32 and 64 k-rad before sowing. The source of irradiation is installed at the Middle Eastern Radioisotope Centre for the Arab Countries, Dokki, Giza, Egypt. Zinc EDTA (150 ppm) was applied as foliar spray at interval times of 30 and 60 days after sowing. The essential oil of fresh herb at vegetative stage (90 days after sowing), flowering stage (180 days after sowing) and air dried seeds (fruiting stage, 210 days after sowing) was subjected to hydro-distillation for 3 hours using a modified Clevenger apparatus according to Guenther (1961). The resulted oil was dehydrated over anhydrous sodium sulphate and stored at freezer till used for gas liquid chromatographic (GLC) analysis.

RESULTS AND DISCUSSIONS

1-Essential oil ratio

The results presented in the Table 1 show that, volatile oil ratio in dill herb during vegetative stage in both seasons was significantly increased by zinc application and gamma radiation doses in most cases. In this concern,

the largest ratio of volatile oil in fresh herb was found by the irradiated seeds at 8 k-rad with zinc (0.0800 and 0.0866%) in the two seasons, respectively.

From the same table it can be noticed that all treatments caused a positive effect on the volatile oil ratio in herb during flowering stage in both seasons in comparison to control in most cases. Generally, volatile oil ratio in herb responded significantly to zinc application in the second season.

Gamma rays significantly increased volatile oil ratio of herb at flowering stage in both seasons. However, the highest volatile oil ratios was recorded by irradiated plants with 2 k-rad (1.1666 and 1.1183%) in the flowering stage during the two seasons.

The results given in Table 1 also show that, application of zinc insignificantly increased volatile oil ratio in dill fruits in the two seasons. In this regard, the irradiated seeds with gamma doses up to 32 k-rad led to significant increases in volatile oil percentages of fruits in the two seasons, excepting the dose of 64 k-rad with or without zinc which induced a reduction of volatile oil percent in the second season comparing to the control.

There was significant effect on volatile oil ratio for the interaction of zinc and gamma radiation in the two seasons. The largest ratio of volatile oil in dill fruits was resulted by the treatment of 8 k-rad (3.4166 and 3.2333%) in both seasons, respectively. This superiority might be the result of the cumulative effect of the zinc application on enzymes activity and metabolism improvements.

These results are in agreement with those found by Jeliazkova et al. (1997), Said-Al Ahl and Omer (2009) on *Coriandrum sativum* and Yadegari (2013) on *Borago officinalis.*

Table 1. Effect of foliar spray with zinc, gamma radiation and their interaction treatments on volatile oil content (%) of dill plants

Zinc (ppm) / Gamma radiation (k-rad)	First Season								
	Vegetative stage (90 days after sowing)			Flowering stage (180 days after sowing)			Fruiting stage (210 days after sowing)		
	Herb			Herb			Fruits		
	Zn (0 ppm)	Zn (150 ppm)	Mean	Zn (0 ppm)	Zn (150 ppm)	Mean	Zn (0 ppm)	Zn (150 ppm)	Mean
0	0.0600	0.0700	0.0650	0.7150	0.7666	0.7408	2.3666	2.7333	2.5499
2	0.0633	0.0733	0.0683	1.1666	0.9733	1.0699	2.9166	2.9500	2.9333
4	0.0633	0.0733	0.0683	0.9383	0.9650	0.9516	2.8333	2.8666	2.8499
8	0.0766	0.0800	0.0783	0.8550	0.8650	0.8600	3.4166	3.1500	3.2833
16	0.0733	0.0733	0.0733	0.8983	0.9316	0.9149	2.8833	2.9166	2.8999
32	0.0566	0.0600	0.0583	0.8350	0.8900	0.8625	2.8166	2.6833	2.7499
64	0.0600	0.0633	0.0616	0.8850	0.8916	0.8883	2.5833	2.5333	2.5583
Mean	0.0647	0.0704		0.8990	0.8975		2.8309	2.8333	
L.S.D. at 5%	Zinc = 0.0029 Radiation = 0.0055 Interaction = N.S			Zinc = N.S Radiation =0.0328 Interaction =0.0463			Zinc = N.S Radiation =0.0832 Interaction =0.1177		
	Second Season								
0	0.0633	0.0733	0.0683	0.7183	0.8400	0.7791	2.4833	2.5500	2.5166
2	0.0766	0.0833	0.0799	1.1183	1.0416	1.0799	2.8166	2.9500	2.8833
4	0.0766	0.0800	0.0783	0.8966	0.9033	0.8999	2.8500	2.9833	2.9166
8	0.0800	0.0866	0.0833	0.8866	0.8933	0.8899	3.2333	2.9333	3.0833
16	0.0733	0.0800	0.0766	0.8450	0.9100	0.8775	2.6500	2.6666	2.6583
32	0.0666	0.0700	0.0683	0.8150	0.8716	0.8433	2.9166	2.8000	2.8583
64	0.0733	0.0766	0.0749	0.8650	0.9150	0.8900	2.4666	2.4000	2.4333
Mean	0.0728	0.0785		0.8778	0.9106		2.7737	2.7547	
L.S.D. at 5%	Zinc = 0.0031 Radiation = 0.0059 Interaction = N.S			Zinc = 0.0147 Radiation = 0.0276 Interaction =0.0390			Zinc = N.S Radiation =0.0804 Interaction =0.1137		

2-Essential oil constituents

a- In the vegetative stage

The main constituents of the essential oils distilled from fresh herb during vegetative stage as affected by spraying zinc and gamma radiation doses are shown in Table 2; the results revealed that in all treatments, α-phellandrene ranged from 33.9058 to 54.5671%, limonene ranged from 10.8714 to 13.7269%, β-phellanrene ranged from 6.4833 to 13.7149% and p-cymene ranged from 11.6728 to 27.0142%. The results within hand indicated differences in the volatile oil compositions due to the action of different treatments. Thus, zinc treatment was distinguished with high content of α-phellandrene (54.5671%), followed by the treatment of 16 k-rad, 8 k-rad and then 2 k-rad giving the contents of 54.3210, 53.6559 and 49.5163%, respectively, on the expense of limonene, β-phellandrene and p-cymene that reduced. On the other hand, all treatments decreased the content of limonene while control plants recorded the highest content of limonene (13.7269%). β-phellandrene content increased with the treatment of 32 and 64 k-rad giving the highest contents (13.7149) and 11.9062%), respectively, compared to the other treatments. All treatments except of 2 k-rad + zinc and 64 k-rad + zinc decreased p-cymene content and these doses resulted in the highest p-cymene content (27.0142 and 24.5739%), respectively, compared to the other treatments. However, Nagiub et al. (1998) on *Anethum graveolens* found that foliar application with zinc at 50 and 75 ppm led to increase linalool content and decreased the contents of limonene and carvone of herb essential oil. El-Sawi and Mohamed (2002) found differences in the oil constituents of cumin herb by application of zinc spray which increased the main constituents such as cumin aldehyde and decreased β-pinene, p-cymene, α-terpineol and thymol.

Table 2. Effect of foliar spray with zinc, gamma radiation and their interaction treatments on the constituents of dill volatile oil "herb" (90 days after sowing) in the second season (2001/2002)

Treatments / Identified compounds	Control	2K-rad	4K-rad	8K-rad	16K-rad	32K-rad	64K-rad	Zn(150ppm)	2K-rad +Zn	64K-rad +Zn
α-pinene	1.6383	1.7974	1.8901	1.9763	1.9059	1.7525	1.9106	1.9403	trace	trace
β-pinene	0.2781	0.2673	0.2881	0.3030	0.2980	0.2602	0.3333	0.2879	trace	trace
α-phellandrene	46.3320	49.5163	41.7208	53.6559	54.3210	33.9058	47.1898	54.5671	trace	trace
Limonene	13.7269	12.8234	11.7102	12.9282	13.1126	10.8714	12.9978	13.1349	trace	trace
β-phellandrene	11.0111	9.1626	10.9918	9.6725	9.4752	13.7149	11.9062	8.7047	6.6631	6.4833
γ-terpinene	0.3637	trace	trace	0.2759	0.2590	0.3384	0.2690	trace	trace	trace
P-cymene	17.8812	13.4692	15.6183	12.8502	12.0912	16.1557	11.6728	14.5944	27.0142	24.5739
Dillether	0.4540	0.3238	0.4013	0.2772	0.2914	0.4138	0.2669	0.3519	trace	trace
Dihydrocarvone	0.2261	0.2549	0.2345	0.2649	0.1923	0.7562	0.3387	trace	0.3129	trace
Sabinol	1.0462	0.9648	1.3265	1.1019	1.2430	2.5898	0.8829	0.9599	2.2044	trace
Carvone	2.1161	1.9052	2.8169	1.5604	1.3942	4.0910	2.0420	1.3117	3.2173	1.9718
Piperitone	0.2391	0.2070	0.5379	0.3164	0.1971	0.5233	0.1876	trace	5.2361	4.9990
Carveol	0.6624	0.8569	1.4896	0.8318	0.6479	2.1876	0.9592	0.5573	0.9825	7.2734
Nerolidol	0.7168	1.5388	1.0765	0.6572	0.6761	2.3750	2.4901	0.4743	4.4874	6.5424
Eugenol	0.7961	1.2686	1.0898	0.6958	1.1251	1.6109	1.1639	0.9984	6.6546	8.4158
Thymol	0.5909	0.6691	1.0498	0.4810	0.8397	1.1915	1.7360	0.3305	1.9846	4.5253
Carvacrol	0.2442	0.2911	0.6435	0.2303	0.1913	0.6637	0.3205	trace	3.8849	6.9117
Myristicin	1.0782	0.2451	0.2560	1.3051	0.1304	0.6478	0.3162	1.1032	1.8029	2.0332
Dillapiole	0.5977	0.2148	0.4870	0.6150	0.1518	0.5421	0.2644	0.6829	2.5156	2.6660
Total	99.9991	95.7763	93.6286	99.9990	98.5432	94.5916	97.2479	99.9994	66.9605	76.3958

Table 3. Effect of foliar spray with zinc, gamma radiation and their interaction treatments on the constituents of dill volatile oil "herb" (180 days after sowing) in the second season (2001/2002)

Treatments / Identified compounds	Control	2K-rad	4K-rad	8K-rad	16K-rad	32K-rad	64K-rad	Zn(150ppm)	2K-rad +Zn	64K-rad +Zn
α-phellandrene	0.5948	0.4488	0.27375	0.1389	0.21505	0.1768	0.52785	1.13205	0.7287	5.7479
Limonene	0.4896	13.9558	13.09455	1.56535	0.2465	0.1850	0.65075	2.4146	1.2625	3.40155
β-Phellandrene	2.7002	3.84975	1.9140	1.6345	1.4729	0.99805	2.7177	7.67235	11.84175	3.51335
P-cymene	33.4236	30.13605	12.4088	15.6645	20.9028	10.93595	18.9239	14.1821	22.66095	19.80595
Linalool	0.3549	2.15815	3.19355	0.5088	0.08135	0.2745	0.2579	trace	1.8701	2.06605
Dillether	19.6369	7.4865	6.9993	23.4015	6.04855	25.32085	14.6603	26.53655	19.8128	13.2396
Dihydrocarvone	0.7368	0.7338	1.7367	1.23395	4.0528	1.7255	1.37045	1.2932	2.9191	2.9056
Sabinol	0.3132	1.09445	0.8439	trace	1.9289	0.41315	0.1487	1.4508	2.2814	0.23635
Carvone	13.1097	8.10495	14.98475	28.3321	16.2905	19.94225	15.42275	21.20685	9.0318	10.9535
Piperitone	4.60385	2.7639	2.9082	4.2495	4.01995	6.70485	4.5431	0.6625	2.85235	4.7520
Carveol	3.2440	4.28835	4.15145	1.6229	0.91125	3.0084	1.75465	0.7319	1.0365	6.8739
Nerolidol	1.48645	2.4969	3.8250	0.9874	0.63875	1.5302	1.18235	0.5108	0.95215	2.8895
Eugenol	1.55765	1.4469	1.3751	1.5779	1.24535	1.13135	1.4503	0.51765	0.75135	1.58405
Thymol	0.85815	1.33125	1.4006	0.4414	3.0775	0.8049	1.53185	2.96245	1.5438	1.11485
Carvacrol	1.6281	0.98895	1.1322	1.5123	1.79115	1.1125	1.3649	0.66955	1.12255	trace
Myristicin	0.6435	1.72055	1.44405	1.1224	2.06025	0.72205	1.00725	0.6748	0.81925	1.0386
Dillapiole	4.1622	8.40175	17.50245	11.7855	17.30025	19.1895	12.54755	10.34655	8.44505	13.88545
Total	89.5436	91.4068	89.18835	95.7789	82.2838	94.1758	80.06225	92.9647	89.9321	94.0082

Table 4. Effect of foliar spray with zinc, gamma radiation and their interaction treatments on the constituents of dill volatile oil "fruits" (210 days after sowing) in the second season (2001/2002)

Treatments / Identified compounds	Control	2K-rad	4K-rad	8K-rad	16K-rad	32K-rad	64K-rad	Zn(150ppm)	2K-rad +Zn	64K-rad +Zn
Limonene	14.6156	15.2200	21.1883	22.1267	21.7131	17.8006	7.2642	17.4400	9.2528	trace
P-cymene	0.3043	0.4831	0.2931	0.2633	0.3151	0.2167	trace	0.3474	trace	trace
Linalool	0.0173	0.0467	0.0191	0.0375	0.0168	0.0147	trace	0.0431	trace	trace
Dillether	1.6490	2.1049	1.6696	2.0552	2.3632	1.6495	1.8385	2.1059	20.3966	trace
Dihydrocarvone	0.0740	0.0668	0.0620	0.0656	0.0518	0.0488	trace	0.0636	trace	trace
Sabinol	0.0301	0.0496	0.0250	0.0225	0.0180	0.0033	trace	0.0321	1.9877	trace
Carvone	62.4883	57.2566	57.2408	51.5096	57.5308	59.5012	65.6520	60.1803	1.8758	26.6766
Piperitone	0.2106	0.1693	0.1688	0.1676	trace	0.0066	trace	0.2455	5.2112	2.3167
Carveol	0.0072	trace	0.0079	trace	0.0146	0.0107	trace	trace	trace	trace
Nerolidol	0.0165	0.0229	0.0042	0.0165	0.0049	0.0013	trace	trace	trace	5.4549
Eugenol	0.0053	0.0094	0.0042	0.0086	0.0084	0.0064	trace	trace	3.9766	3.8817
Thymol	0.0144	0.0194	0.0215	0.0323	0.0225	0.0196	trace	0.0202	0.7513	trace
Carvacrol	0.0299	0.0461	0.0329	0.0323	0.0246	0.0303	0.0322	0.0367	5.5313	trace
Myristicin	0.0555	0.0756	0.0722	0.0354	0.0339	0.0891	0.0812	0.0934	2.5200	0.8192
Dillapiole	19.5113	23.4544	18.3871	22.8572	17.1895	19.7647	22.4265	18.4222	5.1628	13.9000
Total	99.0293	99.0248	99.1967	99.2303	99.3072	99.1635	97.2946	99.0304	56.6661	53.0491

b- In the flowering stage

The influence of zinc and gamma radiation singly or collectively on the compounds of volatile oil distilled from fresh herb during flowering stage are recorded in Table 3. It is obvious that four main compounds were identified such as p-cymene ranging from 10.93595% (under 32 k-rad treatment) to 33.4236% (control plants), carvone ranging from 8.10495% (under 2 k-rad treatment) to 28.3321% (under 8 k-rad treatment), dillether ranging from 6.9993% (under 4 k-rad treatment) to 26.53655% (zinc treatment) and dillapiole ranging from 4.1622% (control plants) to 19.1895% (under 32 k-rad treatment). Zinc treatment increased dillether, dillapiole and β-phellandrene. All treatments caused an increase in dillapiole content. On the other hand, all treatments caused a decrease in p-cymene content. Gamma ray doses from 4 to 64 k-rad increased carvone content. Gamma ray at 32 k-rad resulted in the highest piperitone content (6.70485%), whereas, 2 k-rad+zinc and 64 k-rad+zinc gave the highest compound of β-phellandrene (11.84175%) and carveol (6.8739%), respectively, when compared with the other treatments.

c- In the fruiting stage

Data presented in Table 4 pointed out that pre-sowing gamma radiation and spraying zinc application alone or together caused variable changes in the ratios of different ingredients which represented the constituents of volatile oil distilled from dill seeds under investigation. It can be remarked that 15 compounds were identified. All treatments showed as main compounds carvone, dillapiole and limonene. Carvone ranged from 1.8758% (under 2 k-rad + zinc treatment) to 65.6520% (under 64 k-rad treatment), dillapiole ranged from 5.1628% (under 2 k-rad + zinc treatment) to 23.4544%% (under 2 k-rad treatment) and limonene ranged from 7.2642% (under 64 k-rad treatment) to 22.1267 (under 8 k-rad treatment). As general trend, limonene percent was considerably increased by spraying zinc alone and pre-sowing seeds with gamma radiation from 4 to 32 k-rad. Gamma rays at 2, 8, 32 and 64 k-rad increased dillapiole, whereas 64 k-rad treatments increased carvone and 2 k-rad + zinc treatment gave the highest content of dillether (20.3966%) at the expense of carvone (1.8758%).

CONCLUSIONS

Our two-year experiment involving several treatments showed the great differentiation in dill volatile oil content extracted from fresh herb at vegetative stage, fresh herb at flowering stage and seeds at fruiting stage as well as major components of essential oils during vegetative, flowering and fruiting stages.

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