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Effects of Zinc and Gamma Radiation on Some Chemical Compositions of Dill Herb

Hussein A. H. Said Al Ahl[1, *], Atef M. Z. Sarhan[2], Abou Dahab M. Abou Dahab[2], El-Shahat N. Abou-Zeid[1], Mohamed S. Ali[1], Nabila Y. Naguib[1]

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

Abstract

This investigation was initiated to study the effect of foliar spray with zinc, different gamma radiation doses and their interaction treatments on chemical composition of dill. The results can be summarized as follows; pre-sowing seeds were irradiated with gamma radiation doses (0, 2, 4, 8, 16, 32 and 64 k rd) with or without zinc (150 ppm). The treatments of zinc and in most doses of gamma radiation increased the contents of chlorophyll a, b and total chlorophyll (a+b), the interaction treatments between zinc and 2, 4 and 8 k-rad of gamma radiation was superior in increasing these values. The treatments of zinc or gamma radiation up to 32 k-rad increased total carbohydrate content, the treatment of zinc combined 2 k-rad gave the highest value in this concern.

Keywords

Anethum graveolens L., Zinc, Carbohydrate, Gamma Radiation, Chlorophyll

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1. Introduction

Zinc is an essential micronutrient that acts either as a metal component of various enzymes or as a functional, structural or regulatory cofactor, and is thus associated with saccharide metabolism, photosynthesis, and protein synthesis, the synthesis of auxin, cell division, the maintenance of membrane structure and function and sexual fertilization (Marschner, 1995). Zinc deficiency has been reported to be associated with high pH soils, low extractable zinc content, calcareous soils, soils with very low organic matter and those with high available phosphorus concentrations. Zn deficiency reduces plant growth, flowering and seed production in a wide variety of plants, and in practice zinc deficiency is easy to correct by spraying or by soil application with zinc fertilizers (Takkar and Walker, 1993).Radiation processing is well established as a physical, non-thermal method to preserve various food products that involves the exposure of food products (raw or processed) to ionizing or non-ionizing radiation (Antonio et al., 2012). Irradiation of food products causes a minimal modification in the flavor, color, nutrients, taste, and other quality attributes of food (Diehl, 2002). It has been reported that under certain favorable conditions, the concentration of plant phytochemicals might be increased. These conditions contain exposure to irradiation sources, wounding, storage at low temperatures, and/or exposure to extreme temperatures (Zobel, 1996). Therefore, this study aims to study the effect of zinc and gamma radiation treatment on content of dill plant parts at vegetative and flowering developing stages.

2. Materials and Methods

2.1. Plant Material and Experimental Procedure

The experiments of this study were carried out at the Farm

* Corresponding author
E-mail address:hussein_saidalahl@yahoo.com (H. A. H. S. Ahl)

Station of National Research Centre, at Shalakan, Kalubia Governorate during the two successive seasons of 2000/2001 and 2001/2002. Seeds of dill (*Anethum graveolens* L.) were obtained from Medicinal and Aromatic Research Dep., Ministry of Agriculture, Egypt. 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 dill seeds were sown in 15th October in the two seasons. The experimental design of the three experiments was factorial and planned in a complete randomized block design. The concentrations of chlorophyll a, b were determined by using spectrophotometer and calculated by using Wettstein formula (Wettstein, 1957). The percentage of total carbohydrates was determined using the method described by Dubois et al. (1956).

2.2. Statical Analysis

The data of the three experiments were statistically analyzed and the differences between the means of the treatments were considered significant when they were more than least significant differences (L.S.D) at 5% level according to Steel and Torrie (1980).

3. Results and Discussion

3.1. Chlorophyll (A) Content

Data in Table(1) clearly show that leaf content of chlorophyll (a) was increased by gamma radiation, spraying zinc and their combination at vegetative stage in the two seasons in comparison to control ones. With regard to vegetative stage, it is clear that combined treatment of 64 k-rad + zinc gave the highest value (0.0838mg/100mg leaf fresh weight) in the first season, with 64 k-rad alone giving the highest value (0.0842 mg/100mg leaf fresh weight) in the second season. Spraying plants with Zn alone produced the highest values of chlorophyll (a) (0.5898 and 0.6082 mg/100mg leaf fresh weight) at flowering stage in the two seasons, respectively. Also, leaf content of chlorophyll (a) was decreased by using gamma radiation at flowering stage in both seasons. There was a significant effect on leaf content of chlorophyll (a) between the interaction treatments at flowering stage in the second season. Application of zinc treatment to dill plants significantly increased leaf content of chlorophyll (a) at both stages in the two seasons, exception those of vegetative stage in the second season; whereas, this increment was not significant. It is known that the changes in chlorophyll content are associated with the changes in chloroplasts (Preil, 1985). The important factors which control chloroplast differentiation are: (1) genetic information present in plastids which contain the chloroplast DNA (Bidwell, 1979), (2) cytokinins which have been shown to control chloroplast differentiation independently of their action on cell division (Laloue, 1978) and (3) inorganic salts (magnesium, iron, copper, potassium and ammonium salts) which play important roles in the chlorophyll synthesis or metabolism (Bidwell, 1979). Accordingly, the effect of gamma rays doses which resulted in high amount of the leaf chlorophyll pigments in the present work can be attributed to enhancement of chloroplast differentiation and stimulation of the plastid division. Also, gamma-rays may increase endogenous cytokinins and nutrient components utilization which reflected on an increase in the leaf chlorophyll content. In this respect, Preill (1985) stated that changes in leaf chlorophyll were caused by genetic changes in chloroplast DNA and gene and/or plastid changes. Similar results were recorded by (El-Shafie et al., 1987; Eid et al., 1991; Zaharia et al., 1991; Misra, 1992; El-Esawy, 1995; Hussein et al., 1995; 1998; Ahmed, 2002; Attia, 2002; Kassem, 2002; Khalil et al., 2002; Hassanein et al., 2003).

3.2. Chlorophyll (B) Content

From the Table (2) it can be noticed that the treatments caused a positive effect on chlorophyll (b) content at both stages in the two seasons compared to control in most cases. Zinc fertilizer significantly increased chlorophyll (b) at both stages in the two seasons. In this concern, the highest content of chlorophyll (b) in the leaves was obtained by irradiated at 2 k-rad (0.0788 mg/100 mg leaf fresh weight) at vegetative stage in the first season, and (0.0767 mg/100 mg leaf fresh weight) in the second season when plants treated at 2 k-rad + zinc. In addition, spraying plants with zinc gave the highest values of chlorophyll (b) content (0.5260 and 0.5333 mg/100mg leaf fresh weight) in the flowering stage and in both seasons, respectively. Similar results were recorded by (El-Shafie et al., 1987; Eid et al., 1991; Zaharia et al., 1991; Misra, 1992; El-Esawy, 1995; Hussein et al., 1995; Mohamed, 1998; Ahmed, 2002; Attia, 2002; Kassem, 2002; Khalil et al., 2002; Hassanein et al., 2003).

3.3. Total Chlorophyll (a+b) Content

From the given data in Table (3) it can be seen that leaf content of chlorophyll (a+b) as influenced by gamma radiation, spraying plants with zinc and their interaction, behaved partly the same tendency of chlorophyll (a) or (b) as shown in Tables (1 and 2). In briefly, it can be noticed that the highest content of total chlorophyll (a+b) in vegetative stage was shown by 2 k-rad + zinc (0.1571 and 0.1565 mg/100mg leaf fresh weight) in the first and second seasons, respectively. Application of zinc significantly increased total chlorophyll (a+b) content at both stages in the two seasons. In addition, zinc application alone, gave the highest values of chlorophyll (a+b) (1.1159 and 1.1416 mg/100 mg leaf fresh weight) in the flowering stage and in the two seasons, respectively. The above mentioned results agreed with those obtained by (El-Shafie et al., 1987; Misra, 1992; Hussein et al., 1995; Yan and Wen, 1996; Mostafa et al., 1997; Nakhlla, 1998; Ahmed, 2002; Attia, 2002; Khalil et al., 2002;Badr et al., 2005).

Table 1. Effect of foliar spray with zinc, gamma radiation and their interaction treatments on the chlorophyll (a) content (mg/100mg fresh leaves) of dill plants during the two seasons (2000/2001 and 2001/2002).

Zinc (ppm) Gamma radiation (k-rad)	First Season					
	Vegetative stage (90 days after sowing)			Flowering stage (180 days after sowing)		
	Zn (0 ppm)	Zn (150 ppm)	Mean	Zn (0 ppm)	Zn (150 ppm)	Mean
0	0.0696	0.0727	0.0711	0.4920	0.5898	0.5409
2	0.0722	0.0808	0.0765	0.5050	0.5718	0.5384
4	0.0701	0.0739	0.0720	0.4715	0.5103	0.4909
8	0.0707	0.0783	0.0745	0.5076	0.5213	0.5144
16	0.0771	0.0778	0.0774	0.4739	0.4990	0.4864
32	0.0766	0.0795	0.0780	0.4969	0.4990	0.4979
64	0.0836	0.0838	0.0837	0.5073	0.5145	0.5109
Mean	0.0641	0.0781		0.4934	0.5293	
L.S.D. at 5%	Zinc = 0.0038 Radiation = 0.0071 Interaction = N.S			Zinc = 0.0211 Radiation = N.S Interaction =N.S		
	Second Season					
0	0.0701	0.0711	0.0706	0.4770	0.6082	0.5426
2	0.0731	0.0798	0.0764	0.5106	0.5655	0.5380
4	0.0752	0.0770	0.0761	0.4852	0.5180	0.5016
8	0.0720	0.0755	0.0737	0.4980	0.5109	0.5044
16	0.0795	0.0811	0.0803	0.4849	0.5002	0.4925
32	0.0784	0.0797	0.0790	0.4899	0.5016	0.4957
64	0.0842	0.0840	0.0841	0.5132	0.5073	0.5102
Mean	0.0760	0.0783		0.4941	0.5302	
L.S.D. at 5%	Zinc = N.S Radiation = N.S Interaction = N.S			Zinc = 0.0183 Radiation = 0.0342 Interaction =0.0484		

Table 2. Effect of foliar spray with zinc, gamma radiation and their interaction treatments on the chlorophyll (b) content (mg/100 mg fresh leaves) of dill plants during the two seasons (2000/2001 and 2001/2002).

Zinc(ppm) Gamma radiation (k-rad)	First Season					
	Vegetative stage (90 days after sowing)			Flowering stage (180 days after sowing)		
	Zn (0 ppm)	Zn (150 ppm)	Mean	Zn (0 ppm)	Zn (150 ppm)	Mean
0	0.0528	0.0698	0.0613	0.4001	0.5260	0.4630
2	0.0788	0.0763	0.0775	0.4515	0.5146	0.4830
4	0.0705	0.0705	0.0705	0.3911	0.4749	0.4330
8	0.0459	0.0751	0.0605	0.4306	0.5060	0.4683
16	0.0721	0.0556	0.0638	0.3901	0.4219	0.4060
32	0.0558	0.0741	0.0649	0.3531	0.4631	0.4081
64	0.0682	0.0709	0.0695	0.4497	0.4252	0.4374
Mean	0.0634	0.0703		0.4094	0.4759	
L.S.D. at 5%	Zinc = 00048 Radiation = N.S Interaction = 0.0127			Zinc = 0.0306 Radiation = N.S Interaction = N.S		
	Second Season					
0	0.0479	0.0697	0.0588	0.3614	0.5333	0.4473
2	0.0657	0.0767	0.0712	0.4657	0.5224	0.4940
4	0.0673	0.0705	0.0689	0.3161	0.4739	0.3950
8	0.0427	0.0741	0.0584	0.4638	0.4895	0.4766
16	0.0570	0.0603	0.0586	0.4051	0.4394	0.4222
32	0.0555	0.0751	0.0653	0.3806	0.5047	0.4426
64	0.0657	0.0713	0.0685	0.4607	0.3927	0.4267
Mean	0.0574	0.0711		0.4076	0.4794	
L.S.D. at 5%	Zinc = 0.0071 Radiation = N.S Interaction = N.S			Zinc = 0.0308 Radiation = 0.0576 Interaction = 0.0815		

Table 3. Effect of foliar spray with zinc, gamma radiation and their interaction treatments on the total chlorophyll (a+b) content (mg/100 mg fresh leaves) of dill plants during the two seasons (2000/2001 and 2001/2002).

Zinc(ppm) Gamma radiation (k-rad)	Vegetative stage (90 days after sowing)			Flowering stage (180 days after sowing)		
	Zn (0 ppm)	Zn (150 ppm)	Mean	Zn (0 ppm)	Zn (150 ppm)	Mean
First Season						
0	0.1225	0.1425	0.1325	0.8921	1.1159	1.0040
2	0.1511	0.1571	0.1541	0.9565	1.0864	1.0214
4	0.1406	0.1444	0.1425	0.8626	0.9852	0.9239
8	0.1166	0.1534	0.1350	0.9382	1.0273	0.9827
16	0.1493	0.1335	0.1414	0.8641	0.9209	0.8925
32	0.1324	0.1536	0.1430	0.8500	0.9621	0.9060
64	0.1518	0.1547	0.1532	0.9570	0.9397	0.9483
Mean	0.1377	0.1484		0.9029	1.0053	
L.S.D. at 5%	Zinc = 0.0072 Radiation = 0.0135 Interaction = 0.0192			Zinc = 0.0466 Radiation = 0.0871 Interaction = N.S		
Second Season						
0	0.1181	0.1408	0.1294	0.8385	1.1416	0.9900
2	0.1389	0.1565	0.1477	0.9763	1.0879	1.0321
4	0.1425	0.1475	0.1450	0.8013	0.9919	0.8966
8	0.1148	0.1496	0.1322	0.9619	1.0004	0.9811
16	0.1366	0.1414	0.1390	0.8900	0.9396	0.9148
32	0.1339	0.1549	0.1444	0.8705	1.0064	0.9384
64	0.1499	0.1553	0.1526	0.9739	0.9000	0.9369
Mean	0.1335	0.1494		0.9017	1.0096	
L.S.D. at 5%	Zinc = 0.0105 Radiation = N.S Interaction = N.S			Zinc = 0.0408 Radiation = 0.0764 Interaction = 0.1080		

3.4. Total Carbohydrate Percentage

3.4.1. In the Aerial Parts

Data in Table (4) clearly revealed that, spraying plants with zinc alone induced significant increase of total carbohydrate percent in dill over control in both stages and seasons. Gamma radiation led to a considerable simulative effect on total carbohydrate percent in the flowering stage of both seasons comparison to that of control plants. On the other hand, gamma rays (32 and 64 k-rad) tended to a decrease in total carbohydrate percent of dill herb in the vegetative stage during the two seasons in comparison to control. Differences between interaction treatments were not significant at flowering stage in both seasons, while, there were significant differences between the interaction treatments of zinc and gamma radiation at vegetative stage in the two seasons. The largest percent of total carbohydrate was found by combined treatment of 8 k-rad + zinc (30.12 and 29.84%) at vegetative stage in both seasons, respectively. In the flowering stage, plants irradiated at 2 k-rad + zinc gave the highest values as follows: herb (23.18, 22.70%), umbels (23.52, 23.01%) and leaves + stems (22.84, 22.40%) in the first and second seasons, respectively. the effects of different radiation doses on enzyme activity of α-amylase. Increased amaylase activity which precedes differentiation may be necessary for increased mobilization of carbohydrate reserves concomitant with high synthetic activities which occur during organogensis (Thrope and Meier, 1972).The stimulatory effect of zinc on carbohydrate content would be attributed to its role in activation of the enzymes responsible for photosynthesis, biosynthesis and transformation of carbohydrates, regulation of sugars and starch formation, (Marschner, 1995). Similar results were recorded by (El-Sherbeny and Abou-Zied, 1986; Hussein et al., 1990; El-Shafie et al., 1990; Abou-Leila et al., 1994; Cai and Han, 1994; Abou-Zied et al., 1996; Mohamed, 1998; Khalil et al., 2001; Attia, 2002; Khalil et al., 2002).

3.4.2. In the Roots

Results in Table (5) indicate that all treatments were affected on total carbohydrate percent in dill roots during both stages in both seasons. Increasing gamma doses up to 16 and 32 k-rad increased total carbohydrates percent at both stages in the first and second seasons, respectively, with significant increases during both stages and the two seasons with gamma ray at 2 k-rad in comparison to unirradiated plants. The highest values of total carbohydrate percent (25.73 and 25.34% in the vegetative stage and 20.87, 20.35% in the flowering stage at both seasons, respectively) were found by plants irradiated at 2 k-rad + zinc.Regarding the effect of zinc on total carbohydrate percent, data in Table (5) show that, application of zinc significantly increased total carbohydrate percent at vegetative stage in both seasons, whereas, these increments were significant at flowering stage in second season. with 64 k-rad alone giving lower values of total carbohydrate percent in dill roots at both stages in the two seasons. Similar results were recorded by Ahmed (2002) on garlic.

Table 4. Effect of foliar spray with zinc, gamma radiation and their interaction treatments on the total carbohydrate content (%) of dill plants during the two seasons (2000/2001 and 2001/2002).

Zinc(ppm) Gamma radiation (K-rad)	First Season											
	Vegetative stage (90 days after sowing)			Flowering stage (180 days after sowing)								
	Herb			Umbels			Leaves + Stems			Herb		
	Zn (0 ppm)	Zn (150 ppm)	Mean	*Zn* (0 ppm)	Zn (150 ppm)	Mean	*Zn* (0 ppm)	Zn (150 ppm)	Mean	*Zn* (0 ppm)	Zn (150 ppm)	Mean
0	26.81	27.01	26.91	17.15	20.01	18.58	18.73	19.67	19.20	17.94	19.84	18.89
2	27.19	27.34	27.26	21.74	23.52	22.63	20.88	22.84	21.86	21.31	23.18	22.24
4	25.78	28.57	27.17	21.72	21.93	21.82	20.14	21.55	20.84	20.93	21.74	21.33
8	26.40	30.12	28.26	20.20	21.92	21.06	19.26	21.94	20.60	19.73	21.93	20.83
16	25.20	29.39	27.29	19.16	21.64	20.40	19.07	21.18	20.12	19.12	21.41	20.26
32	24.47	27.40	25.93	19.93	23.10	21.51	19.19	21.08	20.13	19.56	22.09	20.82
64	20.69	24.51	22.60	18.40	21.55	19.97	18.54	19.96	19.25	18.47	20.75	19.61
Mean	25.22	27.76		19.75	21.95		19.40	21.17		19.58	21.56	
L.S.D. at 5%	Zinc = 0.79 Radiation = 1.48 Interaction = 2.09			Zinc = 0.52 Radiation = 0.97 Interaction = 1.38			Zinc = 0.40 Radiation = 0.75 Interaction = N.S			Zinc = 0.43 Radiation = 0.81 Interaction = N.S		
	Second Season											
0	25.80	25.91	25.85	18.15	20.06	19.10	18.93	20.70	19.81	18.54	20.38	19.46
2	26.68	27.57	27.12	22.16	23.01	22.58	21.04	22.40	21.72	21.60	22.70	22.15
4	25.94	28.16	27.05	20.68	21.45	21.06	19.95	21.80	20.87	20.31	21.63	20.97
8	25.47	29.84	27.65	20.11	22.54	21.32	19.47	21.82	20.64	19.79	22.18	20.98
16	25.62	29.80	27.71	20.55	21.32	20.93	19.77	21.18	20.47	20.16	21.25	20.70
32	21.94	28.30	25.12	21.44	22.50	21.97	19.97	21.29	20.63	20.71	21.89	21.30
64	20.56	24.50	22.53	19.60	20.43	20.01	19.27	19.84	19.55	19.44	20.13	19.78
Mean	24.57	27.72		20.38	21.61		19.77	21.29		20.07	21.45	
L.S.D. at 5%	Zinc = 0.66 Radiation = 1.25 Interaction = 1.76			Zinc = 0.52 Radiation = 0.98 Interaction = N.S			Zinc = 0.33 Radiation = 0.63 Interaction = N.S			Zinc = 0.37 Radiation = 0.70 Interaction = N.S		

Table 5. Effect of foliar spray with zinc, gamma radiation and their interaction treatments on the total carbohydrate content (%) in the roots of dill plants during the two seasons (2000/2001 and 2001/2002).

Zinc(ppm) Gamma radiation (k-rad)	First Season					
	Vegetative stage (90 days after sowing)			Flowering stage (180 days after sowing)		
	Zn (0 ppm)	Zn (150 ppm)	Mean	Zn (0 ppm)	Zn (150 ppm)	Mean
0	22.29	23.48	22.88	18.99	20.00	19.49
2	23.66	25.73	24.69	19.92	20.87	20.39
4	22.46	24.04	23.25	18.53	19.24	18.88
8	22.60	24.65	23.62	20.22	18.78	19.50
16	22.96	24.65	23.80	19.75	19.85	19.80
32	22.38	22.40	22.39	17.68	18.55	18.11
64	19.53	20.37	19.95	17.92	17.60	17.76
Mean	22.26	23.61		19.00	19.27	
L.S.D. at 5%	Zinc = 0.66 Radiation = 1.25 Interaction = N.S			Zinc = N.S Radiation =0.80 Interaction =1.14		
	Second Season					
0	21.85	22.30	22.07	17.87	18.75	18.31
2	23.19	25.34	24.26	19.49	20.35	19.92
4	21.87	24.73	23.30	18.21	19.98	19.09
8	22.00	23.22	22.61	19.33	19.19	19.26
16	22.62	23.15	22.88	19.06	19.49	19.27
32	22.56	23.12	22.84	17.97	19.03	18.50
64	19.62	20.68	20.15	17.78	18.54	18.16
Mean	21.95	23.22		18.53	19.33	
L.S.D. at 5%	Zinc = 0.74 Radiation = 1.39 Interaction =N.S			Zinc = 0.49 Radiation = 0.92 Interaction =N.S		

4. Conclusion

The recorded results showed that in the two seasons, the interaction treatment between zinc and gamma radiation doses (2, 4 and 8 k-rad) recorded higher values for chlorophyll (a), (b), total chlorophyll (a+b). Also, the most effective treatment 2 k-rad + zinc was the best for total carbohydrate in different plant parts.

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