4. RESULTS AND DISCUSSION

EFFET OF GAMMA RADIATION AND / OR FOLIAR APPLICATION OF ATP, KINETIN AND TRYPTOPHAN ON FENNEL (*FOENICULUM VULGARE* MILL) AND CARAWAY (*CARUM CARVI*) PLANTS:

4.1. Vegetative Growth:

4.1.1. Shoot fresh weight:

4.1.1.1.Effect of gamma radiation and /or foliar application of ATP on fennel and caraway plants :

Data present in Table (1) demonstrate the impact of the imposed gamma radiation doses and/ or foliar application of ATP on fennel and caraway plants. The data revealed that gamma irradiation and /or foliar application of ATP significantly affected shoot fresh weights of fennel and caraway plants. Means of shoot fresh weight in the two plants were markedly and significantly increased by all gamma doses comparing to control plants. Also, spraying plants with 15, 30 and 45 p.p.m ATP increased significantly the means of shoot fresh weights of fennel and caraway plants.

Interaction between gamma doses and foliar application of ATP at all the applied concentrations had significant effect on shoot fresh weights of fennel and caraway plants. Single gamma irradiation at all doses (40, 80, 120 and 160 Gy) significantly increase shoot fresh weights, comparing to control plants of two plants. Other combined treatments markedly increased shoot fresh weights .

Table (1): Effect of gamma irradiation doses and / or foliar spray of ATP, kinetin and tryptophan on fresh weights (gm/ plant) of fennel and caraway shoots.(Data are means of two successive seasons)

Foliar Spray (p.p.m.) / Gamma ray (Gy)	ATP					Kinetin					Tryptophan				
	Fennel plants														
	0	15	30	45	Mean	0	20	40	60	Mean	0	40	60	80	Mean
0	305.42	329.70	354.31	370.33	339.94	332.32	349.11	362.37	369.60	353.35	322.70	340.85	362.62	350.55	344.18
40	346.50	436.29	485.95	517.41	446.53	369.43	500.10	554.64	592.83	504.25	331.24	460.08	506.35	537.77	458.86
80	386.63	511.10	554.37	573.62	506.43	403.13	591.07	612.93	671.11	569.56	378.85	552.30	580.20	612.57	530.98
120	365.63	488.82	510.50	541.98	476.74	382.37	538.60	586.07	622.32	532.34	354.84	508.31	527.63	582.44	493.31
160	331.98	411.37	475.23	505.13	430.93	341.43	451.73	520.15	579.50	473.20	325.70	436.17	495.95	514.97	443.20
Mean	347.23	435.47	476.07	501.69		365.74	486.12	527.23	567.07		342.67	459.54	494.55	519.66	
	Caraway plants														
	191.19	201.13	212.09	221.31	206.43	220.80	236.41	259.67	271.15	247.01	214.97	227.53	243.79	256.38	235.67
40	207.33	243.37	295.33	323.00	267.26	249.15	317.50	352.24	382.15	325.26	232.02	263.25	311.51	356.53	290.83
80	228.41	291.09	349.75	409.14	319.60	277.53	380.34	416.87	451.16	381.48	274.47	377.50	383.16	446.97	370.53
120	217.06	275.87	317.97	381.97	298.22	277.53	354.75	387.52	407.53	356.83	244.60	313.40	330.98	396.56	321.39
160	198.32	233.42	280.42	304.95	254.28	228.19	293.76	325.28	360.54	301.94	222.8	257.09	294.59	336.86	277.84
Mean	208.46	248.98	291.11	328.07		250.64	316.55	348.32	374.51		237.77	287.75	312.81	358.66	

L.S.D. at 5 %	ATP	Gamma radiation	Interaction	kinetin	Gamma radiation	Interaction	Tryptophan	Gamma radiation	Interaction
Fennel	7.271	8.129	16.26	8.000	8.944	17.890	6.710	7.502	15.00
Caraway	7.680	8.587	12.333	9.001	9.745	13.256	8.686	8.879	12.765

The maximum increase was at 80 Gy after which, 120 and 160 Gy the increase tended to decline.

In general the most effective treatments for increasing shoot fresh weights were gamma rays at dose of 80 Gy and / or ATP at concentration of 45 p.p.m for single treatments and 80 Gy x 45 p.p.m ATP. In this concern the magnitude of increase in shoot fresh weight for fennel plants were 31.36, 48.98, 40.24 and 26.77 % for gamma radiation treatment at doses of 40, 80, 120 and 160 Gy. Moreover, the percent of increase for foliar application of ATP at concentrations of 15, 30 and 45 p.p.m were 25.41, 37.11 and 44.48%, respectively as compared with the control. Thus, it could be deduced that the maximum stimulation effect was exerted by combined treatment of 80Gy x 45 p.p.m of ATP followed by that of 120 Gy x 45 p.p.m ATP, 40 Gy x 45 p.p.m ATP and 160 Gy x 45 p.p.m ATP.

The magnitude of increase in shoot fresh weight for caraway plants were 29.47, 54.82, 44.47 and 23.18 % for gamma radiation treatment at doses of 40, 80, 120 and 160 Gy. The percent of increase for foliar application of ATP at concentrations of 15, 30 and 45 p.p.m were 19.44, 39.65 and 57.38 %, respectively as compared with the control. Thus, it could be deduced that the maximum stimulation effect was exerted by combined treatment of 80Gy x 45 p.p.m of ATP followed by that of 120 Gy x 45 p.p.m ATP, 40 Gy x 45 p.p.m ATP and 160 Gy x 45 p.p.m ATP.

4.1.1.2. Shoot dry weight:

Data concerning dry matter content of fennel and caraway plants shoots as influenced by pre-sowing gamma irradiation and

/or foliar spraying plants with foliar application of ATP shown in Table (2) .

Data clearly show that dry weights of fennel and caraway shoots were gradually increased as the dose of gamma rays raised from 0 up to 80 Gy, thereafter, 120 and160 Gy the increase tended to decline. In general gamma irradiation at all doses (40,80, 120 and 160 Gy) had significant increase in shoot dry weights. Also, shoot dry weights were significantly increased due to foliar application of ATP at concentrations of 15, 30 and 45 p.p.m. The highest increment was at 45 p.p.m comparing with control.

Regarding the interaction between gamma radiation doses and foliar application of ATP, the single dose of 80 Gy caused the maximum significant increase in fennel and caraway shoots dry weights . Also, the single foliar application of ATP at concentration of the control plants. Other combined treatments greatly increased dry matter yield of fennel and caraway shoots. Moreover, the highest value of shoots dry weight over all the experiment was obtained by the combination of the most effective treatment among of gamma doses and foliar application of ATP i.e. 80 Gy x 45 p.p.m ATP.

From the above-mentioned results it could be deduced that the maximum stimulation of plant growth as fresh and dry weights of fennel shoots were obtained by gamma rays treatments at 80 Gy and / or foliar application of ATP at 45 p.p.m for single treatments as well as their combination (80 Gy x 45 p.p.m ATP) .

Table (2): Effect of gamma irradiation doses and / or foliar spray of ATP, kinetin and tryptophan on dry weights (gm/ plant) of fennel and caraway shoots. (Data are means of two successive seasons)

Foliar Spray (p.p.m.) / Gamma ray (Gy)	ATP					Kinetin					Tryptophan				
	Fennel plants														
	0	15	30	45	Mean	0	20	40	60	Mean	0	40	60	80	Mean
0	74.26	77.93	79.92	81.02	78.28	80.42	85.72	87.54	90.92	86.15	77.47	80.02	83.83	87.67	82.87
40	77.59	94.81	103.22	111.64	96.82	85.09	116.37	124.83	127.12	113.35	82.93	103.38	110.01	114.97	109.26
80	81.48	103.56	122.23	128.03	108.83	94.36	131.06	135.63	139.58	124.41	90.74	121.58	127.65	131.93	117.23
120	80.35	99.76	117.33	123.07	105.13	90.71	126.97	130.22	133.65	120.14	87.06	115.88	122.33	126.22	116.44
160	75.62	87.51	94.52	105.80	90.86	82.47	112.18	117.85	120.85	106.84	79.65	96.35	102.30	111.72	97.51
Mean	77.86	92.71	103.44	109.91		86.61	114.46	119.21	122.42		83.57	103.44	109.22	114.50	
	Caraway plants														
0	41.45	43.36	46.10	49.19	45.03	52.24	55.02	57.17	59.96	56.10	44.67	48.94	53.70	55.61	50.73
40	47.30	63.17	70.01	74.59	63.77	56.06	75.93	80.49	85.42	74.48	50.12	71.94	74.11	77.69	68.47
80	53.83	74.81	79.90	89.68	74.56	62.26	87.39	91.83	97.90	84.85	59.10	83.34	88.17	92.20	80.70
120	52.71	69.64	74.83	85.99	70.79	60.44	80.19	88.51	90.65	79.95	57.50	78.20	82.64	85.50	75.96
160	45.96	60.67	66.33	70.23	60.80	54.53	70.33	76.04	80.26	70.29	48.87	69.34	69.34	72.40	64.99
Mean	48.25	62.33	67.43	73.94		57.11	73.77	78.81	82.84		52.05	70.35	73.59	76.68	

L.S.D. at 5 % :	ATP	Gamma radiation	Interaction	kinetin	Gamma radiation	Interaction	Tryptophan	Gamma radiation	Interaction
Fennel	1.916	2.142	4.285	2.100	2.348	4.695	2.265	2.533	5.065
Caraway	0.7381	0.8252	1.650	0.8332	0.9012	1.711	0.7880	0.8112	1.695

Table (3): Effect of gamma irradiation doses and / or foliar spray of ATP, kinetin and tryptophan on volatile oil percentage (cc / 100 dried Fruits) of fennel and caraway plants.(Data are means of two successive seasons)

Magnitude of increase in fennel dry shoot weight were 23.68, 39.03, 38.13 and 16.08 % for gamma radiation at doses of 40, 80, 120 and 160 Gy . over the control, respectively. In addition , 19.07, 32.85 and 41.16 % for ATP at concentrations of 15, 30 and 45 p.p.m as compared with the control.

As for caraway plants the percent of increase in dry shoot weight were 41.62, 65.58, 57.21 and 35.02 % for gamma radiation at doses of 40, 80, 120 and 160 Gy over the control, respectively. In addition , 29.18, 39.85 and 53.24 % for ATP at concentrations of 15, 30 and 45 p.p.m as compared with the control.

In general, low doses of gamma rays, in particular at 80 Gy and /or foliar spraying with ATP, particularly at 45 p.p.m markedly stimulated plant growth which increased fresh and dry weights of fennel and caraway shoots. Moreover, response of plant growth was more pronounced to gamma irradiation than to spraying with ATP.

All combinations of gamma doses and foliar application of ATP at all the applied concentrations stimulated the growth of fennel and caraway plants comparing to the control . Moreover , the stimulation effect of most combined treatments was more pronounced than single treatments of both factors , the maximum increase in the growth parameters of fennel and caraway plants was due to combined treatment of (80 Gy x 45 p.p.m ATP).

Some investigators studied the role of ATP in increasing fresh and dry weights .**Salisbury and Ross (1978)** mentioned that ATP consider the energy source for many of the processes going on in cells as well as ion uptake in roots. **Robison and**

Gibbs (1982) reported that ATP compound plays an important role in the electron transport system. **Taylor *et al.*, (1982)** found that ATP has some enzyme activities. **Nofal (1987)** stated that ATP encourage the photosynthesis processes.

4.1.2. Effect of gamma radiation and/or foliar application of kinetin on fennel and caraway plants:

4.1.2.1. Shoot fresh weight:

With respect to the effect of gamma radiation and / or foliar application of kinetin on shoot fresh weight of fennel and caraway plants, data in Table (1) show that means of shoot fresh weight of fennel and caraway plants were significantly increased by all used gamma doses i.e., 40, 80, 120 and 160 Gy. In addition , foliar application of kinetin at concentrations of 20, 40 and 60 p.p.m resulted in significant increase of shoot fresh weight of fennel and caraway plants.

Regarding the interaction between gamma doses and foliar application of kinetin, single doses of 40, 80, 120 and 160 Gy increased significantly shoot fresh weight of fennel and caraway plants, comparing to the control. For single treatments of foliar application of kinetin, plants sprayed with all concentrations i.e., 20, 40 and 60 p.p.m produced higher shoot fresh weight of fennel and caraway plants than the control plants (not sprayed). Combinations markedly and significantly increased shoot fresh weight of both plants .

Generally, the highest value of shoot fresh weight was produced by irradiation dose of 80 Gy or by foliar application of kinetin at concentration of 60 p.p.m for single treatments and by their

combination (80 Gy x 60 p.p.m kinetin) for combined treatments.

The corresponding increase in fennel shoot fresh weight were 42.71, 61.19, 50.66 and 33.92 with regard to gamma radiation at doses of 40, 80, 120 and 160 Gy . Also, the percent of increase for kinetin were 26.30, 38.97 and 49.42 at concentrations of 20, 40 and 60 p.p.m as compared with the control.

Regarding the caraway shoot fresh weight, the percent of increases were 31.68, 54.44, 50.66 , 44.46 and 22.24 % with regard to gamma radiation at doses of 40, 80, 120 and 160 Gy . Moreover , the percent of increase for kinetin were 26.30, 38.97 and 49.42 % at concentrations of 40 and 60 p.p.m as compared with the control.

4.1.2.2. Shoot dry weight ;

Effect of gamma radiation and / or foliar application of kinetin on the shoot dry weight of fennel and caraway plants could be concluded from data presents in Table (2). Data indicate that the various gamma irradiation and kinetin treatments had a significant stimulation effect on growth behavior of fennel and caraway plants such as shoot dry weights.

As for the combined effect of gamma irradiation and / or foliar application of kinetin at different concentrations on fennel and caraway shoot dry weights there was gradual increase in the shoot dry weight due to combined effect between gamma radiation at all doses and foliar application of kinetin. In this regard, single treatments of gamma rays i.e., 40, 80, 120 and 160 Gy significantly increased shoot dry weigh of the two plants .

Regarding the effect of foliar application of kinetin of shoot dry weight , kinetin at all the applied concentrations (20, 40 and 60 p.p.m) induced significant increase in shoot dry weight of fennel and caraway plants. There were gradual increase in the shoot dry weight due to the combined effect between gamma radiation at all doses and foliar application of kinetin comparing to control plants.

However, the highest value of shoot dry weight was recorded when fennel and caraway plants were subjected to irradiation dose of 80 Gy and foliar application of kinetin at concentrations of 60 p.p.m for single treatments and by (80 Gy x 60 p.p.m kinetin) for combined treatments.

These finding prove that the efficacy of various gamma irradiation and kinetin treatments on shoot dry weight of fennel and caraway plants were more superior than control plants. The percentage of increases in dry weight were 31.57, 45.28, 39.74 and 25.76 for fennel plants and 32.76, 51.25, 42.51 and 25.29 % for caraway plants when treated with gamma radiation at doses of 40, 80, 120 and 160 Gy over the control plants respectively. Moreover, the percent of increase in dry weights of fennel and caraway shoots as affected by kinetin at concentrations of 20, 40 and 60 p.p.m were 32.16, 37.64 and 41.35 and 29.17, 38.00 and 45.05 % for fennel and caraway plants respectively .

It is well known that kinetin has promoting effect on shoot fresh and dry weights which may be attributed to stimulating role of kinetin in either increasing the cell division **(letham 1967)** or elevating the levels of protein, DNA and RNA in cell **(Hall *et al.*, 1973)**.

These results are in harmony with those obtained by **Eraki *et al.*, (1993)** on *Salvia officinals* plants, **Abd-El-Fatah (1995)** on *Mercedes rosa* leaves; **Dessouky (1995)** on *Aloe vera*; **Farooqi *et al.*, (1996)** on *Artemisia annua*, **Gamal El-Din *et al.*, (1997)**; **Youssef and Talaat (1998)** on *Lavandula officinalis* plants; **Ibrahim and Tarraf (2000)** on tagetes plants; **Balbaa (2002)** on tagetes plants; **Youssef *et al.*, (2004 a)** on *Salvia officinalis* plants and **Youssef *et al.*, (2004 b)** on *Ocimum basilicum* plants, they found that kinetin resulted in the maximum plant fresh and dry weight.

4.1.3. Effect of gamma radiation and /or foliar application of tryptophan on fennel and caraway plants :

4.1.3.1 Shoot fresh weight :

Results concerning shoot fresh weight of fennel and caraway plants as affected by different doses of gamma radiation and / or foliar spraying with tryptophan treatments are shown in Table (1). The results indicate that shoot fresh weights of fennel and caraway plants were significantly increased according to various gamma radiation and / or tryptophan treatments.

Furthermore, interaction between gamma radiation and/ or foliar application of tryptophan had significant effect on shoot fresh weights of fennel and caraway plants. In this concern, single treatments of all gamma doses, i.e.40, 80, 120 and 160 Gy resulted in significant increase of shoot fresh weights of the two plants specially at the dose of 80 Gy. Spraying the plants with tryptophan at concentrations of 40, 60 and 80 p.p.m significantly increased shoot fresh weights with maximum increase at 80 p.p.m as compared with control plants. The rest of combination

treatments highly increased fresh weights comparing to plants of control.

The maximum increase in fresh weights of fennel and caraway plants was obtained by 80 Gy and 80 p.p.m tryptophan for single treatments as well as their combination (80 Gy x 80 p.p.m tryptophan).

In this connection, the magnitudes of increase for shoot fresh weight of fennel plants were 33.32, 54.27, 43.33 and 28.77 % with regard to gamma radiation at doses of 40, 80, 120 and 160 Gy. While, the percent of increase for tryptophan were 34.11, 44.32 and 51.65 % as compared with the control.

As for caraway plants the magnitudes of increase in shoot fresh weight were 23.41, 57.22, 36.37 and 17.89 % with regard to gamma radiation at doses of 40, 80, 120 and 160 Gy. The percent of increase due to foliar application of tryptophan were 21.02, 31.56 and 50.84 % as compared with the control.

4.1.3.2. Shoot dry weight :

Data presented in Table (2) proved that shoot dry weights of fennel and caraway plants were significantly increased according to various gamma radiation and / or tryptophan treatments.

Furthermore, interaction between gamma radiation and foliar application of tryptophan had significant effect on shoot fresh weights of fennel and caraway plants. In this concern, single treatments of all gamma doses, i.e. 40, 80, 120 and 160 Gy resulted in significant increase of shoot fresh weights of the two plants and the highest increase was at 80 Gy. Spraying plants with tryptophan at concentrations of 40, 60 and 80 p.p.m