MORPHOLOGICAL AND ANATOMICAL STUDIES ON FENNEL PLANTS AS AFFECTED BY SOME GROWTH SUBSTANCES

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ABSTRACT

This study aimed to investigate the effect of some growth substances on morphological and anatomical structure of fennel plants as a source of aromatic drug and volatile oil. Spraying fennel plants with GA3 and kinetin increased plant height , while ethrel decreased it. All growth substances increased fresh and dry weights of fennel shoots.

Ethrel and kinetin increased stem and peduncle diameters, number of glandular canals. dimensions of schizocarp, endosperm and vitta as well as number of vitta in fennel fruits. It is interesting to state that, GA3 decreased most of these characters.

INTRODUCTION

Recently. cultivation of aromatic and medicinal plants has been given much attention in order to cover the increasing demands of the local industries, as well as export purposes. Several pharmaceutical studies revealed the important role of medicinal plants as a natural source for drugs. Fennel is a herbaceous perennial or biennial plant, reach heights of four or five feet, it is topped with umbels of yellow flowers that produce a warm, sweet, slightly anise flavored seed. It is considered as a condiment and agreeable aromatic as well as preservative against certain species of bacteria and fungi in food industries (Svab, 1978 and Ibrahim, 1985). In addition, fennel is a suitable crop for reclaimed soils with very low humus content (Svab, 1978). Besides, it represents an easily mechanizable crop and a well marketable product for its mericarp, drug and volatile oil purposes.

Numerous studies have been made on medicinal plants to increase their productivity using different methods. The growth substances are considered important to control the vegetative and generative growth, beside their effects on plant components (Sobti *et al.*, 1978; Helaly *et al.*, 1984; Ahmed, 1990; Abd El-Kader, 1992; Khafagy & Salama, 1996 and Gamal El-Din *et al.*. 1998). The present investigation aimed at evaluation the effect of different growth substances, *i.e.*, ethrel, gibberellin (GA_3) and kinetin on growth and internal structure in fennel plants.

MATERIALS AND METHODS

Two pot experiments were conducted at the Experimental Station of Plant Pathology Department, Faculty of Agriculture, Mansoura University, Mansoura, Egypt. during the two growing seasons of 1996/1997 and

1997/1998, to study the effect of ethrel (100 and 200 ppm), gibberellin (GA3) (100 and 200 ppm) and kinetin (10 and 20 ppm) on growth and anatomical structure of certain parts of fennel (*Foeniculum vulgare* var. vulgare, Mill). Family: Apiaceae. Complete randomized block design was used with three replicates.

Plastic pots, 40 cm diameter were filled with 20 kg clean air-dry soil. The physical and chemical analysis of the soil was done according to Black (1965) and recorded in Table (1).

Table 1. Mechanical and chemical analysis of experimental soil.

Soil Properties	1996/1997	1997/1998
Coarse sand	2.20	1.78
Fine sand	25.81	26.12
Silt	33.90	35.29
Clay	37.99	35.91
$CaCO_3$	2.11	2.29
Organic matter	1.80	2.40
Total nitrogen	0.18	0.20
Available phosphorus (ppm)	7.19	7.95
Exchangeable potassium (ppm)	220	229
PH	7.90	7.60

Ten fruits of fennel (*Foeniculum vulgare* var. *vulgare*, Mill) having similar size and color were sown in each pot on 21st October in the two growing seasons. After four weeks the seedlings were thinned to three similar plants per pot. Phosphorus fertilizer (calcium super phosphate 15.5% P2O5) was mixed with soil prior sowing at the rate of 100 kg/fed, while N (ammonium nitrate 33.5%) and K (potassium sulphate 48%) were added individually in two equal doses at the rate of 150 Kg/fed and 100 Kg/fed, respectively. The first dose was added after thinning and the second half at the beginning of flowering stage. Irrigation was conducted whenever required throughout the experimental period.

Plants were sprayed twice after 45 and 60 day from sowing with previously mentioned growth substances in addition to the top water as a control treatment. A hand atomizer was used for spraying plants after adding tween 20 (0.5%) as surfactant. Two samples were taken at 75 days and 90 days from sowing. The following parameters were detected: plant height (cm), number of leaves/plant, number of lateral branches / plant as well as shoot fresh and dry weight (g).

Specimens from the middle of the 3rd internode below the shoot tip of main stem samples from ripe fruits as well as peduncle of the main umbel were taken for anatomical structure. Specimens were killed and fixed in formalin acetic alcohol, dehydrated, embedded in paraffin wax (52-54°C m.p.), sectioned, stained by crystal violet and erythrosin, cleared, mounted and examined microscopically (Gerlach, 1977).

Data (average of the two seasons) were statistical analysis according to Snedcor and Cochran (1968).

RESULTS AND DISCUSSION

Growth parameters:

Plant height:

Data in Table (2) show that both GA_3 and kinetin increased significantly plant height. The promotive effect of GA_3 on plant height may be a result of both larger number of cells formed and elongation of the individual cells (Sacks, 1961). Moreover, Runkova (1977) found that GA_3 increased plant height by increasing the leaf content of active indolic compounds and accelerated the synthesis of IAA. Sherif (1981) reported that the high content of IAA auxin inhibited lateral bud formation and induced apical dominance in vascular plants. Moreover, cytokinins affect on both cell division and enlargement (Arteca, 1996). In addition, he added that exogenous applications of cytokinins promote cell expansion and enlargement due to water uptake caused by a decrease in the osmotic potential.

Table 2. Effects of growth substances on morphological characters of fennel plants.

Treatments	Plant height (cm)		Number of leaves		Lateral branches		Weight of plant			
							Fresh weight		Dry weight	
	75 days	90 days	75 days	90 days	75 days	90 days	75 days	90 days	75 days	90 days
Control	51.00	70.07	8.00	9.67	5.00	6.33	39.00	45.67	4.07	4.91
Eth. 100 ppm	47.40	67.93	11.00	12.67	6.33	7.00	42.74	73.67	4.33	7.32
Eth. 200 ppm	45.40	65.63	13.33	15.00	8.00	10.67	65.45	95.61	6.67	9.90
GA_3 100 ppm	83.00	102.53	8.33	10.00	5.00	6.00	48.08	64.90	4.23	6.68
GA_3 100 ppm	85.53	113.13	9.33	10.67	4.33	5.67	50.30	67.91	5.07	7.44
Kin. 10 ppm	54.30	73.83	10.33	11.33	6.67	8.00	42.08	56.65	4.50	6.13
Kin. 20 ppm	57.67	76.40	11.33	12.33	7.67	9.33	52.04	70.51	5.60	7.84
F-test	**	**	**	**	**	**	**	**	**	**
L.S.D. 1%	2.28	2.95	1.89	1.55	1.11	1.11	2.66	6.67	0.67	1.06
5%	1.63	2.11	1.35	1.11	0.79	0.79	1.90	4.77	0.48	0.75

In this investigation, it has been found that ethrel decreased significantly plant height. The retarding effect of ethrel on plant height may be due to its effects on plant growth through the liberation of ethylene

(Anderson. 1971). Ethylene is a natural growth regulator, which causes many of the biological effects such as inhibition of terminal bud growth and stimulation of basal shoot growth (Khosla and Singh, 1977) on *Ammi visnaga*. Hradilik (1976) reported that ethrel may act through the production of IAA oxidase and peroxidase which cause a decrease in IAA level. The low level of IAA decreased ABA production (Lovell, 1977). Both processes increased cytokinin/ABA ratio which induced lateral bud growth (Turker and Mansfield. 1973).

Number of leaves/plant:

Data in the same Table indicate that ethrel, GA3 and kinetin increased significantly number of leaves/plant in both seasons. The enhancing effect of GA_3 on number of leaves/plant could be attributed to an increase in internodes of stems (Helaly et al., 1985) on coriander. However, the promotive effect of ethrel on the previous parameter may be due to the fact that ethrel liberates ethylene which affects plant growth (Anderson, 1971). Ethylene causes inhibition of terminal bud growth and stimulation of lateral shoot growth as well as leaf number (Miller et al. (1969); Khosla and Singh (1977); Helaly et al. (1984) and El-Hadidi et al. (1986).

Number of lateral branches/plant:

Data in Table (2) reveal that both ethrel and kinetin caused significantly an increase in the number of lateral branches/plant. The enhancing effect of ethrel may be due to the role of ethrel on inhibition of terminal bud growth and stimulation of lateral shoot growth (Arteca, 1996). Kinetin may be reducing apical dominance and induced growth of lateral buds of intact plants (Bidwell, 1974). In contrast, GA_3 decreased number of branches/plant. This decrease may be a result of increasing IAA content which in turn. inhibits lateral shoot formation, therefore, decreasing branching (Helaly et al., 1984).

Fresh and dry weight of shoots:

Data in the same Table reveal that all the growth substances increased significantly fresh and dry weights. Regarding the increasing effects of both ethrel and kinetin may be a result of enhancement of branching and number of leaves (Khafagy and Salama, (1996) on coriander and Helaly et al. (1984) on fennel. In addition, Gamal El-Din et al. (1998) recorded that ethrel and kinetin increased the shoot fresh and dry weights due to the remarkable increase in the number of lateral shoots (Table 2). Concerning the increasing effects which obtained by GA_3, these results may be attributed to the stimulating effect of GA_3 on plant height (Helaly et al., 1984) and enhanced number of leaves (Table 2).

Anatomical Characters

A. Stem structure

The transverse sections in the mature stems of fennel plants treated with the three growth substances are shown in Table (2) and Fig. (1).

Table (2): Effect of some growth substances on fennel stem structure (average of 5 readings).

Treatments	Diameter of cross section		Vascular bundle dimensions				Width of cortex		Width of pith		No of vascular bundle		No of vessels per vascular bundle	
			Length		Width									
	U	%	u	%	U	%	u	%	u	%		%		%
Control	3430	100	318	100	124.8	100	211.2	100	2244	100	20.8	100	6.2	100
Eth.100 ppm	3788.4	110	325.6	102	145.2	116	228.8	108	2459.6	110	23.2	112	7	113
Eth.200 ppm	4347.2	126	396	125	176	141	221.6	105	2917.2	130	22.6	109	6.8	110
GA_3 100 ppm	3348.4	97	277.2	87	113.2	91	126	60	2024	90	18.4	88	5.2	84
GA_3 200 ppm	2217.6	65	242	76	108.8	87	92.4	44	1337.6	60	18.6	89	4.4	71
Kin 10 ppm	3612.4	105	374	118	162.8	131	176	83	2376	106	22.2	107	6.8	110
Kin.20 ppm	4413.2	129	440	138	189.2	152	233.2	110	2776.4	124	23.2	112	8	129

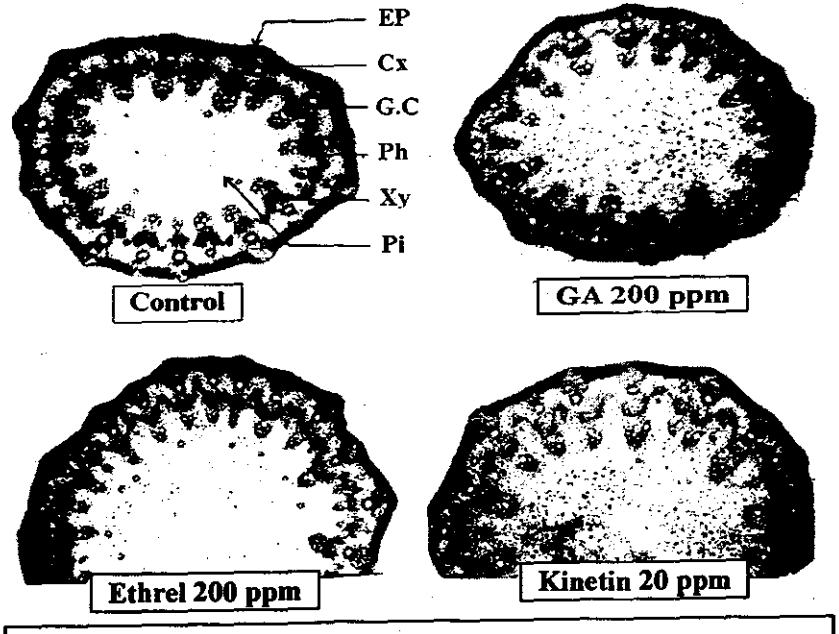

Fig. 1. Effect of some growth substances on fennel stem structure (40X)

The data in table (2) and fig.(1) reveal that the treatments of ethrel and kinetin led to an increase in the diameter of the stem due to corresponding increase in thickness of the cortical layers, width of pith,

vascular bundle dimensions as well as number of vessels/bundle. The increase in cortex may be attributed to the increase in both number of cortical layers and size of the individual cells. The data reveal that the high levels of ethrel (200 ppm) and kinetin (20 ppm) were more effective. In this respect, Boovaiah (1974) stated that ethrel stimulated lateral cell expansion in the vascular region in bean plants. Similar results were reported by El-Banna (1989) and Khafagy & Salama (1996). Regarding the effects of GA_3 on stem structure, data show that GA_3 at both levels (100 and 200 mg/L.) decreased stem diameter, which markedly occurred due to a decrease in thickness of cortex, pith, number of vascular bundles, and number of vessels per bundle. In addition there is a marked decrease in the dimension of the vascular bundle. The higher level of GA_3 (200 mg/L.) caused a pronounced effect in this respect (Fig. 1). Sakr (1977) attributed the tissue thinning to GA_3 as a result of decreasing the size of the individual cells, rather than the number of cell layers. According to Sakr & El-Kady (1981) GA_3 decreased stem diameter, due to a decrease in parenchyma cells, number of vessels and cell layers in the vascular cylinder. In addition GA_3 decreased the stem diameter of lupine due to the decrease in the thickness of the cortex and pith tissues (Ibrahim et al.. 1990).

Peduncle structure:

The anatomical structure of the peduncle is similar to that of the main stem, including the distribution and the structure of the glandular canals. Secondary secretory canals also occur at the periphery of the pith. Table (4) and Fig. (2) show that ethrel and kinetin increased diameter of peduncle. This increase may be attributed to increase in thickness of cortex, width of xylem, number and dimensions of glandular canals as well as diameter of pith. Moreover, ethrel treatments increased the number of glandular canals than other treatments. The same data reveal that GA_3 at 200 mg/L. caused a significant decrease the diameter of peduncle, number of glandular canals width of xylem as well as diameter of cortex and pith.

Schizocarp structure:

Data in table (5) and Fig. (3) show that ethrel (100 and 200 mg/L.) and kinetin (10 and 20 mg/L.) caused an increase in the fruit and endosperm dimensions of fennel. In addition, ethrel produced the largest fruit. On the other hand, ethrel at 100 mg/L and kinetin at 10 mg/L caused an increase in the number of vitta. While, ethrel (200 mg/L) and kinetin (20 mg/L) caused insignificant increase in this respect. In addition, maximum dimensions of vittae were clearly increased by using ethrel at 100 mg/L (Fig. 3). The results of Arafa (1982) on fennel and El-Hadidi et al. (1986) on khella support our results.

Table 4: Effect of some growth substances on fennel peduncle structure (average of 5 readings).

Treatments	Diameter Of Peduncle		Width of cortex		Width of xylem area		No of glandular canals		Dimensions of glandular canals			
									Length		Width	
	U	%	U	%	U	%		%	U	%	U	%
Control	1764.4	100	118.8	100	105.6	100	20	100	62.7	100	54.15	100
Eth.100 ppm	2169.2	123	162.8	137	118.8	113	24.6	123	72.96	116	62.13	115
Eth.200 ppm	2257.2	128	171.6	144	110	104	23.8	119	73.53	117	62.7	116
GA_3 100 ppm	1993.2	113	149.6	126	105.6	100	20.8	104	76.38	122	56.43	104
GA_3 200 ppm	1465.2	83	101.2	85	83.6	79	18.4	92	58.71	94	49.59	92
Kin.10 ppm	2138.4	121	158.4	133	114.4	108	17.2	86	80.94	129	69.54	128
Kin.20 ppm	2367.2	134	145.2	122	114.4	108	21.6	108	65.55	105	51.30	95

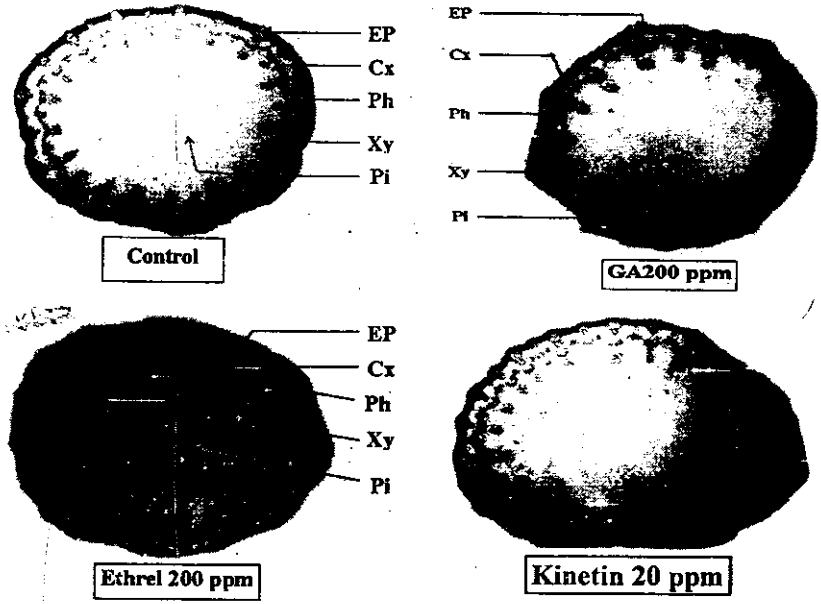

Fig. 2. Effect of some growth substances on fennel peduncle structure (40X)

Table 5: Effect of some growth substances on fennel schizocarp structure (average of 5 readings).

Treatments	Schizocarp dimensions				Endosperm dimensions				Number of vittae		Vittae dimensions			
	Length		Width		Length		Width				Length		Width	
	u	%	u	%	u	%		%	U	%	U	%	u	%
Control	1606	100	2398	100	836	100	765.6	100	12	100	121.62	100	76.64	100
Eth.100 ppm	1914	119	2983.2	124	1114	137	1034	135	14.6	122	139.44	115	80.94	105.6
Eth.200 ppm	2032.8	127	3150.4	131	1254	150	1060.4	139	12.4	103	109.44	90	76.95	100
GA_3 100 ppm	1262.8	79	2644.4	110	589.6	71	893.2	117	12.4	103	103.17	85	74.67	97
GA_3 200 ppm	1130.8	70	2177.2	91	585.2	70	866.8	113	12	100	98.78	81	80.89	106
Kin.10 ppm	1631.2	102	2439	102	893	107	844.8	110	12.6	105	105.45	87	88.89	116
Kin.20 ppm	2151.6	134	2877.6	120	1333.2	159	998.8	131	12	100	129.39	106	104.88	137

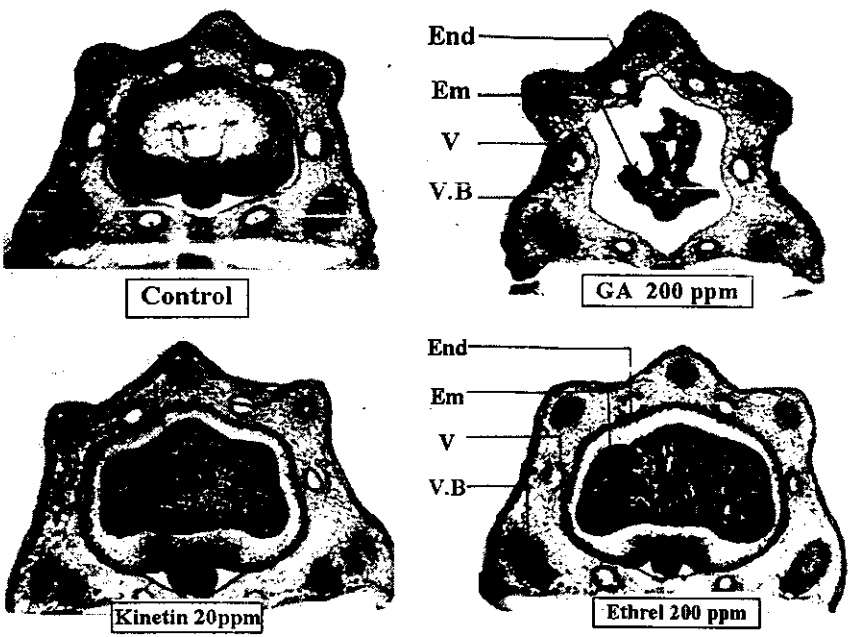

Fig. 3. Effect of some growth substances on fennel schizocarp structure (40X)

Regarding the effects of GA_3, the data reveal that GA_3 leads to a significant decrease in the fruit and endosperm dimensions. Such results confirm those reported by Arafa (1982) on fennel and El-Banna (1989) on coriander.

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الملخص العربى

دراسات مورفولوجيه وتشريحيه على نبات الشمر تحت تأثير بعض مواد النمو

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قسم النبات الزراعى ، كلية الزراعة ، جامعة المنصورة ، المنصورة ، مصر .

يهـدف البحث إلى دراسة تأثير بعض مواد النمو على الصفات المورفولوحيه والتركيب التشريحى لنبات الشمر الذى يعتبر أحد المصادر الهامة للمواد العطرية والزيوت الطيارة .

ولقـد وجـد أن رش النبات بالجبريللين والكينيتين يؤدى إلى زيادة طول النباتات ، بينما يؤدى الإيثيريل إلى نقص ذلك ، ولقد أدت مواد النمو المستخدمة إلى زيادة الوزن الغض والجاف للمجموع الخضرى للنبات .

تـؤدى معاملـة النباتات بالإيثريل والكينيتين إلى زيادة سمك كل من الساق وعنق النورة وكذلك عدد القنوات الغدية بها . كما أنها تؤدى إلى زيادة حجم الثميرة وكمية الإندوسبرم وكذلك عدد القنوات الزيتية بالثمرة . وتؤدى المعاملة بالجبريللين إلى نقص معظم هذه الصفات .