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Seed Yield and Essential Oil Composition of Fennel Plant as Affected by Ethrel and B-9 Application

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ABSTRACT

The important results of this experiment can be summarized as follows:Both growth regulators increased significantly the total seed yield per plant and B-9 proved to be more effective in this respect.Both growth regulators increased significantly the essential oil yield per plant and no significant difference between the two regulators was found in this respect.Ethrel had no effect on the content of anethole but decreased significantly the contact of fenchone in the essential oil comparing with the untreated plants.B-9 increased the content of anethole and decreased considerably the content of fenchone. Generally, B-9 is superior and the most suitable compound for improving the essential oil quality since it increased the anethole and decreased the fenchone content of the oil.

INTRODUCTION

Fennel (*Foeniculum vulgare* Mill. var. *vulgare* is a very suitable crop for our poor soils, which are of very low humus content. Besides, fennel represents an easily mechanizable crop and a well marketable product for seed, drug and volatile oil purposes (Svab, 1978). Numerous studies have been made on many essential oil plants to increase their productivity by treatment with some growth substances.

In this connection, Abou-Zied (1974) recorded that spraying the growth retardant B-9 at a range of 500 to 4000 ppm, on to caraway and fennel plants reduced the stem height, whereas it increased the umbel number per plant. A slight increase in seed yield as well as weight of 1000 seeds of the two Apiaceous plants was induced by B-9. The largest values of volatile oil, crude fat and carbohydrates in the seeds of the two plant species resulted from 4000 ppm B-9. The crude protein was not affected by the B-9 treatment in both species.

However, information about the effect of these substances on fennel plants generally is laking. Therefore, this investigations were aimed at comparing two growth substances i.e., Ethrel and B-9 to evaluate the best conditions for growth and development of the plant as well as for its essential oil production and composition.

MATERIALS AND METHODS

Fruits of *Foeniculum vulgare* Mill. var. *vulgare* were secured from the Experimental Station, Schloss Rauischholzhauser, Ebsdorfergrund – 4, Germany.

The two growth regulators used in this investigation were Ethrel and B-9. Ethrel (ethephon; CEPA; Florel; Flordimex) was obtained from planzenschutz URANIA GmbH, Alsterufer 20, Hamburg, Germany. It was 474 g/l, a.i. ethephon, aqueous solution. The four concentrations, 0 (control), 150, 300 and 600 mg/l were used as spray application and prepared at the rate of 248 litre per feddan, using distilled water, i.e., 0.78.5, 157.0 and 313.9 ml Ethrel per feddan, respectively.

Alar (daminozide; B-9, B-995; Alar 85; SADH; N-dimethyl amino succinamic acid) was obtained from Feinbiochemica Serva, Heidelberg, Germany. It was a 100% pure B-9 and had also the composition, 100% pure commercial Alar formulation. The four concentrations 0 , 2000 , 4000 and 8000 mg/l were used as spray application and prepared at the rate of 248 liter per feddan, using distilled water, i.e., 0 , 0.496 , 0.992 and 1.984 kg Alar per feddan, respectively.

The pot experiment was conducted in the greenhouse. Seeds were sown on 8 March then transplanted into pots (2 kg soil weight) after 22 days, one plant per pot. A number of 8 pots presented each treatment.

Fertilization:

NPK were supplied as follows:

142.8 mg NH_4 NO_3/Kg soil corresponding to 150 Kg N/ha.

271.2 mg Ca (H_2 PO_4)2. H_2O/Kg soil corresponding to 200 Kg P/ha.

111.4 mg K_2 SO_4/Kg soil corresponding to 150 Kg/ha.

After grinding in a mortar, the fertilizers were mixed into the dry soil with the help of a soil mixer.

The conditions of the experiment were as follows:

Average daily temperature: maximum 32° C.
minimum 21° C.

Relative air humidity: maximum 84%
minimum 39%

All plants were sprayed with the growth regulators until they were thoroughly wet, during the development of the flower buds (112 days after sowing).

Recording of data:

The procedure of recording the various data was carried out in the following manner:

Seed yield and yield components:

- Number of umbels per plant.
- Seed yield (g) per umbel ; taken from 10 random umbels per plant and four plants per replicate.
- Total dry weight yield of seeds (g) per plant ; determined on four plants per treatment.

Preparation of samples for distillation:

The essential oil was obtained from 10 g powedered fruits which were crushed in an electrical mixer for 2-3 min, and immediately transferred into the 1000 ml distillation flask with 300 ml water with a supplement of 2 ml xylol was distilled. The water – stream distillation lasted 2 hours.

Keeping the samples of essential oils:

Following dehydration with anhydrous sodium sulphate, distillation of the solvent and drying, the essential oil samples were kept in test tubes with polyacetylene stoppers at - 18° C under light protection. Later, the quantity as well as the quality of the important constituents were determined by means of gas chromatography after solving in petroleum ether.

For GLC – analysis only the concentration with achieved the maximal seed yield was selected from each growth regulator, i.e., Ethrel 300 and B-9 2000 mg/l.

The analyses were carried out with a gas chromatograph, type Perkin Elmer F_{30} with H_2 carrier gas at 40 ml/ min, on a column of 1.8 m/mm_2.

2% OV-7 , at a temperature programme from 60 to 135 °C with 5 °C/ min

The injector temperature was 250 °C, the detector temperature 300 °C.

The nutrient status of the soil is given in Table(1)

Table 1. Mineral analysis of the soil.

element	Exchangeable elements			Total content	
	K	Mg	P	N	Ca
mg/ 100g soil	9.71	29.30	0.75	24	4800

Statistical procedures:

Yield characters as well as the chemical part were subjected to appropriate analysis of variance as reported by Mudra (1958). The significance remained under S 5%. The proportion of the compounds in the essential oil was statistically evaluated after transforming the percentage values to angular degrees.

RESULTS AND DISCUSSION

Number of umbels per plant (Table 2):

Table 2. Number of umbels per plant of *Foeniculum vulgare* Mill. as affected by Ethrel and B-9.

Growth regulator mg/l									
Ethrel					B-9				
0	150	300	600	Ø	0	1000	2000	4000	Ø
19.4	20.5	23.8	23.7	21.8	19.2	20.5	26.3	26.3	23.1
L.S.D 5% : 1.77									

Ethrel increased significantly the number of umbels per plant at the two higher concentrations but was ineffective at the lowest compared with the untreated plants B-9 showed a similar effect increasing significantly the number of umbels per plant at both higher concentrations but not at the lowest. B-9 was more effective in increasing the number of umbels per plant than Ethrel.

The stimulating effects of Ethrel on the number of umbels per plant noticed in this study are in accordance with the results reported by Khosla and Singh (1977) on *Ammi visnaga* (L.) Lam and Sobti *et al.* (1978) on *Ammi majus* L.

The stimulative effects of B-9 was previously reported by Abou-Zied (1974) on fennel and caraway.

Seed yield per umbel (Table 3):

Table 3. Seed yield per umbel (g) of *Foeniculum vulgare* Mill. as affected by Ethrel and B-9.

Growth regulator mg/l									
Ethrel					B-9				
0	150	300	600	Ø	0	1000	2000	4000	Ø
0.6	0.7	0.9	0.9	0.8	0.6	0.9	1.1	0.9	0.9
L.S.D 5% : 0.10									

Ethrel increased significantly the seed yield per umbel when applied at the two higher concentrations while it showed no significant difference at the lowest.

B-9 increased significantly the seed yield per umbel at all concentrations and the middle concentration (2000 mg/l) showed the most beneficial effect compared with the untreated plants.

The increase in seed yield per umbel induced by Ethrel is thought to be due to increasing the ratio of bisexual to male flowers brought about by an increase in the number of bisexual flowers (Amruthavalli,1978 on coriander plants).

In the same connection, Miller *et al.* (1969) indicated that Ethrel encouraged the formation of pistillate flowers in some vegetable plants.

The promotive effect of B-9 on seed yield noticed in this study was reported also by Abou-Zied (1974) in fennel and caraway plants.

Total seed yield per plant (Table 4):

Both growth regulators used in this investigation increased significantly the total seed yield per plant and B-9 proved to be more effective in this respect. The middle concentration of both growth regulators showed the most beneficial effect as compared to all other treated and untreated plants.

Table 4. Total dry seed yield (g/ plant) of *Foeniculum vulgare* Mill. as affected by Ethrel and B-9

Growth regulator mg/l									
Ethrel					B-9				
0	150	300	600	Ø	0	1000	2000	4000	Ø
7.6	10.5	13.9	9.9	10.5	7.7	10.1	16.1	12.0	11.5
L.S.D 5% : 0.97									

In all cases, the application of Ethrel and B-9 led to a considerable increase in the total seed yield per plant but B-9 proved to be more effective in this respect. This increase caused by both growth regulators can be attributed to an increase in the number of umbels as well as in the seed yield per umbel. These results are in accordance with those reported by Khosla and Singh (1977) in *Ammi Visnaga* (L.) Lam., and Sobti *et al.* (1978) in *Ammi Majus* L.

Moreover, Khafaga *et al.* (1996) indicated that some growth retardants application led to an increase in the seed yield of fennel plant.

Essential oil content (Table 5):

Ethrel did not affect significantly the essential oil content when applied at the lowest concentration but at the two higher increased significantly the oil content as compared to the untreated plants. The highest concentration showed the most beneficial effect in this respect.

Table 5. Essential oil content (µ/ g) in dried fruits of *Foeniculum vulgare* Mill. as affected by Ethrel and B-9.

Growth regulator mg/l									
Ethrel					B-9				
0	150	300	600	Ø	0	1000	2000	4000	Ø
22.8	22.8	26.9	28.0	25.1	22.8	21.5	23.1	24.8	23.0
L.S.D 5% : 2.08									

B-9 did not show any significant difference at all concentrations used compared with the untreated plants but tended to increase the essential oil content as the concentration was raised.

Accordingly, Ethrel was more effective in increasing the essential oil content than B-9.

In all cases, the application of Ethrel led to a significant increase in the essential oil content. Ethrel showed the most beneficial effect as compared to B-9 treated or untreated plants: This increase might be due to an increase in the number and / or the productivity of the glands in the pericarp which could have resulted from the ethylene production by Ethrel which may have interfered with the polar auxin transport and may have increased the membrane permeability. With regard to B-9, it was found that it tended to increase the essential oil content at low concentrations but at the higher had no effect in this respect.

This stimulating effect of B-9 on the essential oil content has been previously reported by Abou-Zied (1974) in fennel and Caraway plants. He added that it can be assumed that the biosynthesis of the essential oil in the seeds of fennel is quite responsive to B-9. El-Antably *et al*. (1975) working on *Origanum majorana* L. indicated that B-9 and other growth retardants were capable of preventing the hydrolytic breakdown of oil naturally occurring in the plants as a result of the presence of endogenous gibberellins and auxins, and thus could be the reason for the increased oil percentage.

Essential oil yield per plant (Table 6):

Table 6. Essential oil yield (µ/ plant) in dried fruits of *Foeniculum valgare* Mill. as affected by Ethrel and B-9.

Growth regulator mg/l									
Ethrel					B-9				
0	150	300	600	Ø	0	1000	2000	4000	Ø
173.9	238.4	373.5	277.6	265.9	172.2	217.4	372.4	296.0	264.5
L.S.D 5% : 27.71									

Compared with the untreated plants Ethrel increased significantly the essential oil yield per plant at all concentrations used and the middle (300 mg/ l) showed the most beneficial effect in this respect. B-9 also increased significantly the essential oil yield per plant at all concentrations used, and again the middle concentration was not effective as compared to the untreated plants. Between the two growth regulators no decisive difference was found in improving the total essential oil yield per plant.

In all cases, Ethrel and B-9 caused a considerable increase in the total essential oil yield per plant. The amount of increase was much more pronounced at the lower concentration. This increase in essential oil yield was clearly due to an increase in essential oil content as well as in the total seed yield per plant. In this regard Ethrel proved to be most effective in increasing the total essential oil yield per plant as compared to all other treated and untreated plants.

A promotive effect of B-9 on the essential oil yield was previously reported by Abou-Zied (1974) in fennel and caraway plants.

Essential oil composition (Table 7):

Ethrel had no effect on the content of anethole but decreased significantly the content of fenchone in the essential oil comparing with the untreated plants B-9 increased the content of anethole and decreased considerably the content of fenchone in the essential oil as compared to the untreated plants.

Table 7. Proportion of compounds in the essential oil of the fruits of *Foeniculum vulgare* Mill. as affected by Ethrel and B-9.

Treatments mg/ l	Compound			
	Trans-anethole	Estragole	Fenchone	Monoterpene hydrocarbons
Control 0	65.7 a	2.6 a	24.3 a	6.6 a
Ethrel 300	66.9 a	2.6 a	21.3 b	8.4 b
B-9 2000	74.1 b	3.1 a	14.4 c	7.7 b

Since both growth regulators improved the essential oil yield equally, the change in the quality of the oil is decisive for the choice of the most suitable compound.

In this respect B-9 is superior since it increased the anethole and decreased the fenchone content of the oil.

The obtained results showed that B-9 was able to change the relative percentage of some of the major constituents in the essential oil.

GLC analysis indicated reduction in monoterpene hydrocarbons but increases in anethole and estragole after B-9 treatment.

Hook *et al*. (1973) working with *Mentha piperita* recorded changes in the relative percentage of some of the major monoterpene volatile oil constituents as a result of growth retardants and suggested that an obvious reason for the different composition of oil from control and treated plants could be an alteration in their maturity at harvest resulting from the treatment.

However, the essential oil composition of fennel plant might be altered by using some growth substances (EL-Awadi and Esmat A. Hassan, 2010).

CONCLUSION

The obtained results showed that the seed and essential oil yield of fennel can be increased considerably by the application of the growth regulators Ethrel and B-9.

B-9 was the most effective compound for promoting the yield of seeds. Ethrel was slightly less efficient in increasing the seed yield but was superior to B-9 in improving the yield of essential oil.

None of the growth regulators had a detrimental effect on the composition of the essential oil ; on the contrary, Ethrel decreased the undesirable fenchone content, and B-9 not only decreased the fenchone content but increased the anethole content, and thus improved the quality of the essential oil more than Ethrel. Ethrel appears to be slightly superior if higher total oil yield is desired, B-9 appears pereferable if the aim is to increase seed yield and quality of the oil.

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محصول البذور وتركيب زيتها الطيار في نبات الشمر تحت تأثير المعاملة بالإيثريل والألار

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يمكن تلخيص أهم النتائج المتحصل عليها من هذه التجربة فيما يلي:أدت المعاملة بأي من منظمي النمو إلى زيادة معنوية في محصول البذور للنبات وكان الألار أكثر تأثير في هذا الصدد. أدت المعاملة بأي من منظمي النمو إلى زيادة معنوية في محصول الزيت الطيار للنبات ولم تسجل أية اختلافات معنوية بين المنظمين في هذا الشأن. لم يكن للمعاملة بالإيثريل أي تأثير على محتوى الأينثول في الزيت الطيار في حين أدت إلى نقص معنوي في محتوى الزيت من الفينشون مقارنة مع النباتات غير المعاملة. من جهة أخرى أدت المعاملة بالألار إلى زيادة محتوى الزيت الطيار من الأينثول في حين نقص محتوى الفينشون بشكل ملحوظ. بصفة عامة ، أظهرت النتائج تفوق الألار واعتباره الأكثر ملاءمة لتحسين نوعية الزيت الطيار نظرا لأنه أدى إلى زيادة محتوى الزيت الطيار من الأينثول مع نقص محتواه من الفينشون.