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RESEARCH ARTICLE

EFFECT OF GROWTH REGULATORS AT DIFFERENT STAGES ON GROWTH AND YIELD OF FENNEL (*Foeniculum Vulgare* MILL.)

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ABSTRACT

A field experiment was conducted at experimental block of the Department of Plantation, Spices, Medicinal and Aromatic Crops, Kittur Rani Channamma College of Horticulture, Arabhavi, Belagavi district, Karnataka during *Rabi*-2015-16 and 2016-17 to study the effect of growth regulators at different stages on growth and yield of fennel (*Foeniculum vulgare* Mill.). The experiment was laid out in split plot design with three replications. The experiment consisted of two main plots - stages of application [S_1: Vegetative stage (45 DAS) and S_2: Reproductive stage (Flowering stage)] and seven subplots-growth regulators [G_1- GA_3 -50 ppm, G_2- NAA -25 ppm, G_3- Ethrel-50 ppm, G_4- Benzyl Adenine (BA)- 10 ppm, G_5- Ascorbic acid- 50 ppm, G_6- Salicylic acid- 0.5 ppm and G_7- Cycocel (CCC)- 50 ppm]. Plants received GA_3 50 ppm at vegetative stage recorded significantly higher seed yield (32.12 g plant^{-1} and 2.38 t ha^{-1}), number of umbels (27.73), number of umbellets per umbel (21.20) and dry matter production (187.34 g plant^{-1} and pooled data of 2 years) over other treatment combination. Among the growth regulators plants treated with GA_3 50 ppm at vegetative stage registered maximum plant height (220.14 cm) compared to other treatments and it was on par with NAA 25 ppm at vegetative stage (217.11 cm). The minimum plant height (192.43 cm) was found with Cycocel 50 ppm at flowering stage.

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INTRODUCTION

Among the spices, seed spices are the group which denotes all those annuals whose dried fruit or seeds are used as spices. The seed spices are aromatic vegetable products of tropical origin and are commonly used in pulverized form, primarily for seasoning or garnishing the foods and beverages. They are also used in preparation of various value added products *viz*., spice oils, oleoresins and spice powders. Seed spices also have industrial importance and are used in various pharmaceutical preparations and medicines. Seed spices contribute about 50 per cent of total area and 20 per cent of production of spices in the country. Presently, 17.40 lakh hectares of area is under seed spices cultivation with a production of 14.54 lakh tonnes annually. Among seed spices, fennel is one of the important spice crops which believed to be native of Southern Europe and Mediterranean region. It is widely cultivated throughout the temperate and subtropical region of the world. In India, fennel is mainly grown in Gujarat and Rajasthan and to some extent in Uttar Pradesh, Karnataka, Andhra Pradesh, Punjab, Madhya Pradesh, Bihar, Haryana and Jammu and Kashmir as a winter crop covering a total cultivated area. Among these seed spices, fennel is cultivated in an area of 0.75 lakh hectares with a production of 1.25 lakh tonnes with an average productivity of 1.66 tonnes per hectare (Anon., 2018). Plant growth regulators (PGR's) have great potential in increasing agricultural production and helps in removing many of the barriers imposed by genetics and environment. These are considered as new generation agro-chemicals after fertilizers, pesticides and herbicides to augment growth, yield and quality. PGR's play an important role in mitigating the stress and increasing the flower set. Exogenous application of PGR's has been reported to improve the growth and yield of various crops (Bharud *et al*., 1988). The plant growth regulators are known to enhance the source sink relationship and stimulate the translocation of photo-assimilates thereby helping in better retention of flowers and fruits. Besides this, the growth regulators have the ability to cause accelerated growth in plants. The growth regulators or promoters like GA_3 and NAA stimulate vegetative growth and are involved in the initiation of cell division in the cambium. These plant growth regulators cause osmotic uptake of water which maintain a swelling force against the softening of cell wall (Arora *et al.,* 1985). Hence,

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the present investigation was conducted to study the effect of growth regulators at different stages on growth and yield of fennel (*Foeniculum vulgare* Mill.).

MATERIAL AND METHODS

A field experiment was conducted at research block of the Department of Plantation, Spices, Medicinal and Aromatic Crops, Kittur Rani Channamma College of Horticulture, Arabhavi, Belagavi district which is situated in Northern Dry Zone of Karnataka at a latitude of 16°15' N latitude and 94°45' E longitude and at an altitude of 612 m above Mean Sea Level (MSL). The experiment was conducted to study the effect of growth regulators on growth and yield of fennel (*Foeniculum vulgare* Mill.) *cv*. Gujarat Fennel 1 during *rabi* – 2015-16 and 2016-17 with irrigated condition. The experiment was laid out in split plot design and treatments were replicated thrice. The net plot size was 1.8 m × 1.8 m (3.24 m²). Recommended dose of nutrients for fennel is 90:60:30 N:P_2O_5:K_2O kg ha^{-1}. The experiment consisted of two main plots - stages of application [S_1: Vegetative stage (45 DAS) and S_2: Reproductive stage (Flowering stage)] and seven subplots-growth regulators [**G_1**- GA_3 -50 ppm, **G_2**- NAA -25 ppm, **G_3**- Ethrel-50 ppm, **G_4**- Benzyl Adenine (BA)- 10 ppm, **G_5**- Ascorbic acid- 50 ppm, **G_6**- Salicylic acid- 0.5 ppm and **G_7**- Cycocel (CCC)- 50 ppm]. Treatments were imposed as per the treatment combinations. Soil of the experimental site was red sandy loam with a pH of 7.56**,** EC (0.22 dSm^{-1}), low in organic carbon (0.52 %) and low in available nitrogen (160.54 kg ha^{-1}), medium in P_2O_5 (27.57 kg ha^{-1}) and low in K_2O (196 kg ha^{-1}). Experimental data collected was subjected to statistical analysis by adopting Fisher's method of analysis of variance (ANOVA) as outlined in Gomez and Gomez (1984). Critical difference (CD) values were calculated whenever the "F" test was significant at 5 per cent level.

RESULTS AND DISCUSSION

Increase in growth and yield of any crop is greatly influenced by different agro- techniques adopted besides the variety. Among different agro- techniques, use of growth regulators and their stage of application play an vital role in promotion or inhibition of growth by which better yield could be achieved.

Effect of growth regulators at different stages on growth and yield of fennel: In the present investigation, application of different growth regulators and its stage has great impact on fennel growth and yield. Growth regulators, their stages of application and their interaction had a significant influence on seed yield per plant and hectare of fennel during two consecutive years [Table 1]. Plants received GA_3 50 ppm at vegetative stage recorded maximum seed yield (32.12 g $plant^{-1}$ and 2.38 t ha^{-1}). It could be attributed to improved vegetative growth due to gibberellic acid application coupled with increased photosynthesis and greater mobilization of photosynthates towards reproductive sites might have increased the yield. Thus, the cumulative effect of seed yield per plant recorded was maximum, which leads to increased yield per plot and per hectare. This could also be related to the interaction of growth regulating substances with the sink efficiency might be involved in influencing the yield potential. The similar results were reported by Bagde *et al*. (1993), Shah *et al*. (2006), Shah and Samiullah (2006), Panda *et al*. (2007) in coriander, Pariari *et al*. (2012) in black cumin, who noticed maximum seed yield with the application of gibberellic acid.

Harvest index (%) of fennel was significantly influenced by growth regulators, their stages of application and their interaction during two consecutive years. The treatment GA_3 50 ppm spray at flowering stage showed the maximum harvest index of (18.42 %) and GA_3 50 ppm (18.34 %) compared to other growth regulators. The increase in harvest index might be attributed to increased seed yield. The lower harvest index with gibberellic acid application at flowering stage and vegetative stage might be due to increased vegetative growth resulting in more dry matter production. Yield is the manifestation of growth and yield parameters. Number of umbels per plant of fennel showed non-significant differences between the spray at vegetative and flowering stages. Plants sprayed with of GA_3 at 50 ppm vegetative stage significantly increased the number of umbels per plant (27.32) and also number of umbellets per umbel (19.98). The interaction of spray at vegetative stage with GA_3 at 50 ppm recorded significantly maximum number of umbels (27.73) and number of umbellets per umbel (21.20) pooled data of 2 years (Table 2). Improved vegetative growth due to GA_3 at 50 ppm application coupled with increased photosynthesis and greater mobilization of photosynthates towards reproductive sites. This might have increased the number of umbels and umbellates per plant. Similar observations were recorded by Panda *et al.* (2007) in coriander, Meena *et al*. (2006) in coriander, Prajapat (2013) in fennel and Yugandhar *et al*. (2014) in coriander.

Higher yield parameters might be due to higher total dry matter accumulation in the sink of the plant system. Total dry matter production of fennel differed significantly due to different growth regulators, their stages of application and their interaction during two consecutive years (Table 3). Plants received spray at vegetative stage GA_3 50 ppm (187.34 g $plant^{-1}$) and salicylic acid 0.5 ppm at vegetative stage (187.33 g $plant^{-1}$) at harvesting recorded maximum total dry matter production. Increased dry matter content might be due to the increased osmotic uptake of water and nutrients metabolism in plant system to better carbohydrates synthesis as it contain appreciable quantities of carbon which leads to increase in dry matter. This was also related to maximum fresh weight of plants from these treatments, since they recorded maximum plant height and more number of branches. These results are in conformity with the earlier findings of Pareek (1996) in coriander, Verma and Sen (2006) in coriander, Nikkhah and Soleymani (2012) in black cumin, Pariari *et al*. (2012) in black cumin, Mary Haokip *et al*. (2016) in coriander and Singh *et al*. (2017) in coriander. During vegetative stage, plants are in vegetative and active growth condition. Application of growth regulators to fennel at vegetative stage recorded maximum plant height (212.87 cm) than spray at flowering stage (211.30 cm) (Table 3). This could be attributed to higher cell division and cell elongation process and higher synthesis of photosynthates, during vegetative phase. Application of growth promoting substances supports and have synergistic effect on cell division and cell elongation resulted in maximum plant height compared to flowering stage where cell division and elongation are in recessive stage. The results are in conformity with the findings of Prajapat (2013) in fennel, Mary Haokip *et al*. (2016) and Singh *et al*. (2017) in coriander crop. Among the growth regulators plants treated with GA_3 at 50 ppm at vegetative stage registered maximum plant height (220.14 cm) compared to other treatments and it was on par with NAA 25 ppm at vegetative stage (217.11 cm).

Table 1. Seed yield and harvest index as influenced by growth regulators in fennel

Treatments		Seed yield (g/plant)			Seed yield (t/ha)			Harvest index (%)		
		2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Main plots: Sprays (S)										
S_1- Vegetative stage		24.93	28.97	26.95	1.85	2.15	2.00	14.91	15.19	15.05
S_2- Flowering stage		21.42	25.14	23.28	1.59	1.86	1.72	17.68	19.16	18.42
S.Em.±		0.28	0.15	0.14	0.02	0.01	0.01	0.19	0.16	0.11
CD at 5%		1.72	0.91	0.82	0.12	0.06	0.06	1.16	0.97	0.68
Sub: Growth regulators (G)										
G_1- GA_3 (50 ppm)		26.68	31.02	28.85	1.98	2.30	2.14	17.90	18.78	18.34
G_2- NAA (25 ppm)		25.83	29.22	27.52	1.91	2.16	2.04	17.59	18.13	17.86
G_3- Ethrel (50 ppm)		23.55	25.18	24.37	1.75	1.86	1.80	17.29	16.21	16.75
G_4- BA (10 ppm)		25.30	26.92	26.11	1.87	1.99	1.93	17.86	17.18	17.52
G_5- Ascorbic acid (50ppm)		20.89	24.57	22.73	1.55	1.82	1.68	15.33	16.13	15.73
G_6- Salicylic acid (0.5 ppm)		23.51	27.92	25.71	1.74	2.07	1.91	15.97	16.95	16.46
G_7- Cycocel (50 ppm)		16.46	24.56	20.51	1.22	1.82	1.52	12.16	16.85	14.51
S.Em.±		0.70	0.71	0.55	0.05	0.05	0.04	0.47	0.47	0.35
CD at 5%		2.03	2.07	1.59	0.15	0.15	0.11	1.36	1.36	1.02
Interactions (S×G)										
S_1G_1		30.30	33.93	32.12	2.24	2.51	2.38	17.35	16.97	17.16
S_1G_2		28.63	31.19	29.91	2.12	2.31	2.22	16.61	15.92	16.26
S_1G_3		24.23	28.67	26.45	1.80	2.12	1.96	15.08	15.23	15.16
S_1G_4		27.10	29.36	28.23	2.01	2.17	2.09	16.52	15.76	16.14
S_1G_5		21.12	25.87	23.50	1.57	1.92	1.74	13.09	14.22	13.65
S_1G_6		25.10	30.20	27.65	1.86	2.24	2.05	14.40	15.10	14.75
S_1G_7		18.05	23.59	20.82	1.34	1.75	1.54	11.34	13.12	12.23
S_2G_1		23.05	28.11	25.58	1.71	2.08	1.90	18.45	20.58	19.51
S_2G_2		23.04	27.24	25.14	1.71	2.02	1.86	18.57	20.33	19.45
S_2G_3		22.87	21.69	22.28	1.69	1.60	1.65	19.49	17.18	18.33
S_2G_4		23.49	24.49	23.99	1.74	1.81	1.78	19.20	18.60	18.90
S_2G_5		20.66	23.27	21.96	1.53	1.72	1.63	17.56	18.04	17.80
S_2G_6		21.92	25.64	23.78	1.62	1.90	1.76	17.54	18.81	18.17
S_2G_7		14.87	25.52	20.20	1.10	1.89	1.50	12.99	20.57	16.78
Main X Sub	S.Em±	0.99	1.01	0.77	0.07	0.07	0.06	0.66	0.66	0.49
	CD at 5%	2.88	2.93	2.25	0.21	0.21	0.16	NS	1.92	NS
Sub X main	S.Em±	0.52	0.38	0.32	0.14	0.10	0.09	0.42	0.37	0.28
	CD at 5%	1.52	1.12	0.93	0.41	0.30	0.25	1.22	1.09	0.81

Table 2. Number of umbels per plant, number of umbellets per umbel and number of seeds per umbellet in fennel as influenced by growth regulators

Treatments		No. of umbels per plant			No. of umbellets per umbel			No. of seeds per umbellet		
		2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Main plots: Sprays (S)										
S_1- Vegetative stage		26.17	27.22	26.69	15.48	16.79	16.13	32.11	33.24	32.67
S_2- Flowering stage		26.16	27.04	26.60	18.04	17.31	17.68	34.72	35.78	35.25
S.Em.±		0.22	0.16	0.19	0.31	0.15	0.20	0.30	0.30	0.19
CD at 5%		NS	NS	NS	1.88	NS	1.20	1.81	1.84	1.17
Sub: Growth regulators (G)										
G_1- GA_3 (50 ppm)		26.75	27.67	27.21	19.42	20.53	19.98	34.25	35.21	34.73
G_2- NAA (25 ppm)		26.88	27.76	27.32	19.50	20.21	19.85	33.66	36.03	34.85
G_3- Ethrel (50 ppm)		25.06	27.08	26.07	12.28	13.23	12.76	29.56	30.08	29.82
G_4- BA (10 ppm)		26.79	27.45	27.12	18.52	17.69	18.10	36.17	37.23	36.70
G_5- Ascorbic acid (50ppm)		25.64	26.70	26.17	16.12	15.85	15.98	33.85	34.56	34.20
G_6- Salicylic acid (0.5 ppm)		26.18	26.64	26.41	18.36	16.57	17.46	35.12	35.30	35.21
G_7- Cycocel (50 ppm)		25.84	26.60	26.22	13.12	15.29	14.21	31.30	33.12	32.21
S.Em.±		0.20	0.23	0.17	0.54	0.55	0.46	0.39	0.30	0.20
CD at 5%		0.58	0.68	0.48	1.58	1.59	1.34	1.14	0.87	0.58
Interactions (S×G)										
S_1G_1		27.10	28.37	27.73	20.46	21.93	21.20	31.33	32.59	31.96
S_1G_2		27.41	27.94	27.67	18.33	19.12	18.73	30.77	34.47	32.62
S_1G_3		24.22	26.97	25.59	10.98	12.05	11.52	29.65	30.00	29.83
S_1G_4		26.68	27.65	27.16	17.99	18.07	18.03	35.84	37.07	36.45
S_1G_5		25.76	26.38	26.07	13.47	14.19	13.83	32.30	32.78	32.54
S_1G_6		26.43	27.08	26.76	14.80	16.77	15.79	34.27	34.27	34.27
S_1G_7		25.57	26.14	25.85	12.30	15.40	13.85	30.63	31.47	31.05
S_2G_1		26.40	26.97	26.69	18.38	19.13	18.76	37.16	37.84	37.50
S_2G_2		26.34	27.59	26.97	20.66	21.30	20.98	36.55	37.60	37.08
S_2G_3		25.90	27.19	26.55	13.58	14.41	14.00	29.47	30.17	29.82
S_2G_4		26.89	27.24	27.07	19.04	17.30	18.17	36.50	37.39	36.95
S_2G_5		25.52	27.03	26.27	18.78	17.50	18.14	35.39	36.33	35.86
S_2G_6		25.93	26.19	26.06	21.92	16.37	19.14	35.97	36.33	36.15
S_2G_7		26.10	27.05	26.58	13.95	15.18	14.56	31.97	34.77	33.37
Main X Sub	S.Em±	0.28	0.33	0.24	0.77	0.77	0.65	0.55	0.43	0.28
	CD at 5%	0.82	0.96	0.68	2.24	2.25	1.90	1.61	1.24	0.82
Sub X Main	S.Em±	0.30	0.23	0.25	0.59	0.40	0.42	0.37	0.36	0.23
	CD at 5%	0.87	0.67	0.74	1.72	1.18	1.21	1.09	1.04	0.67

Table 3. Growth parameters as influenced by stages of application and growth regulators at harvest stages in fennel

Treatments		Plant height (cm)			Number of primary branches			Number of secondary branches			Dry matter production (t ha^{-1})		
		2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Main plots: Sprays (S)													
S_1- Vegetative stage		214.95	210.78	212.87	17.55	18.68	18.11	7.15	7.23	7.19	12.35	14.10	13.22
S_2- Flowering stage		219.36	203.24	211.30	16.66	17.23	16.94	6.30	6.73	6.52	8.95	9.71	9.33
S.Em.±		0.70	0.67	0.20	0.02	0.08	0.04	0.08	0.06	0.06	0.06	0.02	0.04
CD at 5%		4.28	4.06	1.22	0.14	0.49	0.25	0.50	0.36	0.37	0.375	0.134	0.254
Sub: Growth regulators G)													
G_1- GA_3 (50 ppm)		229.06	213.70	221.38	17.22	17.88	17.55	6.79	7.07	6.93	11.10	12.47	11.78
G_2- NAA (25 ppm)		224.39	209.59	216.99	16.73	17.23	16.98	6.75	7.06	6.90	10.98	12.22	11.60
G_3- Ethrel (50 ppm)		202.33	201.89	202.11	16.78	17.20	16.99	6.73	6.97	6.85	10.30	11.65	10.97
G_4- BA (10 ppm)		223.38	220.83	222.10	17.52	19.23	18.38	6.92	7.29	7.10	10.61	11.78	11.19
G_5- Ascorbic acid (50ppm)		218.97	208.43	213.70	17.03	17.06	17.05	6.32	6.43	6.37	10.33	11.52	10.93
G_6- Salicylic acid (0.5 ppm)		227.44	208.10	217.77	16.83	17.77	17.30	6.30	6.55	6.43	11.10	12.45	11.78
G_7- Cycocel (50 ppm)		194.49	186.56	190.52	17.60	19.32	18.46	7.30	7.48	7.39	10.14	11.25	10.69
S.Em.±		1.06	1.23	0.68	0.05	0.15	0.07	0.12	0.13	0.08	0.07	0.05	0.05
CD at 5%		3.09	3.58	1.99	0.15	0.43	0.21	0.35	0.36	0.23	0.215	0.136	0.144
Interactions (S×G)													
S_1G_1		224.61	215.66	220.14	17.80	19.00	18.40	7.25	7.73	7.49	12.94	14.81	13.87
S_1G_2		221.58	212.63	217.11	17.20	17.80	17.50	7.17	7.58	7.38	12.76	14.52	13.64
S_1G_3		204.38	208.06	206.22	17.30	17.86	17.58	7.00	7.25	7.12	11.90	13.95	12.93
S_1G_4		220.05	227.15	223.60	17.95	20.00	18.97	7.77	7.33	7.55	12.15	13.80	12.98
S_1G_5		218.35	214.43	216.39	17.22	17.52	17.37	6.50	6.47	6.48	11.95	13.48	12.72
S_1G_6		223.53	212.46	218.00	17.30	18.08	17.69	6.33	6.53	6.43	12.94	14.81	13.87
S_1G_7		192.13	185.10	188.62	18.08	20.50	19.29	8.07	7.70	7.88	11.80	13.31	12.56
S_2G_1		233.50	211.73	222.62	16.63	16.75	16.69	6.33	6.40	6.37	9.26	10.12	9.69
S_2G_2		227.21	206.55	216.88	16.27	16.65	16.46	6.33	6.53	6.43	9.19	9.93	9.56
S_2G_3		200.28	195.72	198.00	16.27	16.53	16.40	6.47	6.70	6.58	8.69	9.36	9.02
S_2G_4		226.70	214.50	220.60	17.10	18.47	17.78	6.07	7.25	6.66	9.06	9.75	9.41
S_2G_5		219.60	202.42	211.01	16.85	16.60	16.73	6.13	6.38	6.26	8.71	9.56	9.14
S_2G_6		231.35	203.74	217.55	16.37	17.47	16.92	6.27	6.57	6.42	9.26	10.10	9.68
S_2G_7		196.85	188.01	192.43	17.13	18.15	17.64	6.53	7.27	6.90	8.47	9.18	8.83
Main X Sub	S.Em±	1.50	1.74	0.97	0.07	0.21	0.10	0.17	0.18	0.12	0.10	0.07	0.07
	CD at 5%	4.37	5.06	2.82	0.22	0.60	0.29	0.50	0.51	0.33	0.305	0.193	0.203
Sub X main	S.Em±	0.36	0.37	0.15	0.05	0.15	0.08	0.24	0.19	0.17	0.13	0.05	0.09
	CD at 5%	1.04	1.07	0.42	0.14	0.44	0.22	0.69	0.54	0.50	0.39	0.15	0.26

The minimum plant height (192.43 cm) was found with Cycocel 50 ppm at flowering stage (Table 3). Increase in plant height could be attributed to increased plasticity of the cell wall followed by hydrolysis of starch to sugars which lowers the water potential of cell thereby resulting in the entry of water into the cell causing elongation. These osmotic driven responses under the influence of gibberellins might have attributed to increase in photosynthetic activity, accelerated translocation and efficiency of utilizing photosynthetic products. Thus, resulting in increased cell elongation and rapid cell division in the growing portion leading to increased length of internodes (Sargent, 1965). Spray taken at vegetative stage gave maximum plant height as the plants were in active stage during initial days to give more effect than spray taken at flowering stage. These results are in conformity with the findings of Shah and Pillai (1969) in cumin, Ahmed and Eid (1975) in umbelliferous plants, Mishriky (1990) in celery, Bagde *et al*. (1993) in fenugreek, El- Keltawi *et al*. (2000) in cumin, Purbey and Sen, (2005) in fenugreek, Meena *et al*. (2006) in coriander, Panda *et al.* (2007) in coriander, Vasudevan *et al*. (2008) in fenugreek, Verma and Sen (2008) in coriander, Gour *et al*. (2010) in fenugreek, Bairwa *et al*. (2012) in fenugreek, Pariari *et al*. (2012) in black cumin, Singh *et al.* (2012) in coriander, Pariari *et al*., 2012 in black cumin, Abbas (2013) in dill, Prajapat (2013) in fennel, Rohamare *et al*. (2013) in cumin, Mary Haokip *et al*. (2016) in coriander and Singh *et al*. (2017) in coriander. The reduction in plant height by growth regulators and chemicals are effective in moderating the vegetative growth by mobilizing the photosynthates from other parts. In the present study, the lowest plant height (190.52 cm) was registered in cycocel (CCC) sprayed plants. This could be attributed to the reduction in inter-nodal length and the inhibition of cell division. This is in conformity with the findings of Pareek (1996) and Maruthi *et al*. (2003) in Ginger crop. From this study it can be concluded that application of GA_3 50 ppm at vegetative stage are beneficial in improving yield of fennel due to better availability of growth promoting substances.

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