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Effect of Gibberellic Acidon Growth and Yield Parameters of Fennel (*Foeniculum vulgare* Mill.)

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ABSTRACT: The research work was conducted during winter season of 2012-13 at the research farm and laboratory of Department of Vegetable Science, CCS Haryana Agricultural University, Hisar. The experiment was laid out in Randomized Block Design (factorial) replicated thrice with four different gibberellic acid concentrations as main plot treatments i.e.Control or no spray (C_1),50 ppm (C_2), 75 ppm (C_3) and100 ppm (C_4) and three different application stages [Juvenile stage(S_1), Flowering stage (S_2), Initial seed setting stage(S_3)] as sub-plot treatments, thus making a total of twelve treatment combination.Gibberellic acid concentration andplant stage for its application showed significant improvement in all the growth and yield parameters over control.From the various parameters recorded plant height at harvest, number of branches per plant, minimum days to 50 per cent flowering, number of umbels per plant,biological yield, seed yield per plot and seed yield per hectare were favorable with the application of 100 ppm gibberellic acid (C_4) at juvenile stage of plant (S_1) i.e. C_4S_1. While, number of seeds per umbellate, number of seeds per umbel and harvest index (%) were maximum with application of 100 ppm gibberellic acid concentration (C_4) at flowering stage of plant (S_2) i.e. C_4S_2.

***Keywords**: randomized block design, gibberellic acid, juvenile stage, harvest index*

INTRODUCTION

India is the foremost country in production, consumption and export of spices hence known as Basket or land of spices. Among all spices, seed spices constitute a major portion. Fennel (*Foeniculum vulgare* Mill.) is a major seed spice, belonging to the family Apiacae. It is a stout, aromatic annual herb (biennial with potency of regeneration). It is one of the most important medicinal and aromatic plants due to its estrogenic activities and used as a carminative, diuretic, anti-inflammatory and antimicrobial drug. Fennel acts on smooth muscle and can be used internally for indigestion, wind, colic, bronchitis and coughs. Externally as a mouthwash or gargle for gum disease and sore throat. Fennel is widely cultivated throughout the temperate and sub-tropical regions of the world. In India, it is mainly cultivated in Gujarat, Rajasthan, Uttar Pradesh, Madhya Pradesh, Karnataka, Haryana and Punjab. Fennel is cultivated in about 25 thousand hectare with a production of about 30 thousand MT in our country (Anonymous, 2011). In spite of its various uses and demands within and outside the country, we are lacking behind in the expected level of fennel productivity and ultimately production.Agricultural research, until now, has been primarily concerned with increasing crop yields by the use of fertilizers, pesticides, irrigation, better management coupled with variety development and genetic improvements. Little attention has been given to regulation of the biological processes that limit crop productivity. It has been observed that synthesis and translocation of photosynthates into sink is very poor at later stages of the crop, besides poor vegetative growth and flowering. Growth hormones play an important role as the small quantities regulate the various physiological processes and balance the source and sink thereby increasing the productivity. Application of gibberellic acid during full bloom improves fruit set and helps in mobilization of food from leaves to the fruits for their development.Gibberellic acid is found to be one of the most important means to increase yield and seed quality in many of the seed spices like fenugreek, coriander and cumin. In spite

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of its great economic importance and export value, little research has been carried out on the application of growth regulators for obtaining higher productivity and good seed quality. Keeping in view the above facts, this experiment has been planned with the objective to find out appropriate concentration of gibberellic acid and perfect stage of plant for its applicationfor getting better growth and yield in fennel crop.

MATERIAL AND METHODS

The experiment was carried out at Vegetable Research Farm, Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during winter season of 2012-13. Hisar is situated at the latitude of 29°.10¢N, longitude of 75°.46¢E and at a mean altitude of 215.2 meters above sea level. This place is characterized by hot and dry summer (April to June) followed by a hot and humid monsoon period and cold winters during December-January.

Soil analysis revealed that the soil of the experimental field was sandy loam in texture, slightly saline (pH=8.18), medium in organic carbon content (0.44%), low in available nitrogen (140 kg/ha), high in available phosphorus (21.0 kg/ha) and rich in potassium content (486.0 kg/ha).

The experiment was laid out in Randomized Block Design (factorial) replicated thrice with four different gibberellic acid concentrations as main plot treatments i.e. Control or no spray (C_1),50 ppm (C_2), 75 ppm (C_3) and 100 ppm (C_4) and three different application stages [Juvenile stage (S_1), Flowering stage (S_2), Initial seed setting stage (S_3)] as sub-plot treatments, thus making a total of twelve treatment combination (C_1S_1, C_2S_1, C_3S_1, C_4S_1, C_1S_2, C_2S_2, C_3S_2, C_4S_2, C_1S_3, C_2S_3, C_3S_3, C_4S_3)in a plot size of 3.0 m × 2.4 m = 7.2 m^2 for each replication. A spacing of 30cm × 20 cm was maintained between line-to-line and plant-to-plant.

The seed material used for the present investigation was a local genotype HF-33 (Hisar Swarup) which was procured from the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar, Haryana. For prepration of gibberelic acid solution, required amount of gibberellic acid (50 milligram for 50 ppm solution, 75 milligram for 75 ppm solution, 100 milligram for 100 ppm solution) was dissolved in one litre of water, but while preparing the solution, gibberellic acid was first dissolved in two to three drops of alcohol as gibberellic acid cannot be dissolved directly in water.

Ten plants were randomly selected in each replication of each treatment for recording various plant growth parameters. Mean values of different characters were used for statistical analysis. Various observations recorded wereplant height at harvest (cm), number of branches per plant, minimum days to 50 per cent flowering, number of umbels per plant, number of seeds per umbellate, number of seeds per umbel, biological yield (kg/plot), seed yield per plot (kg/plot), seed yield per hectare (q/ha) and harvest index (%).

Biological yield isthe total above ground biomass of all the plants, which were left in their respective plots after harvest for sun drying, was weighed and the values were expressed in kg/plot. The harvest index was calculated by dividing the economic yield (seed yield per plot) with total biological yield and expressed as percentage.

$$\text{Harvest index (\%)} = \frac{\text{Economical yield}}{\text{Biological yield}} \times 100$$

The data to be recorded for various parameters during the course of investigation will be subjected to statistical analysis by using the techniques of analysis of variance (ANOVA) as suggested by Panse and Sukhatme (1961). The significance of treatment effects will be judged using F test.

RESULTS

Data presented in Table-1, 2 & 3 indicates thatplant height at harvest, number of branches per plant, minimum days to 50 per cent flowering, number of umbels per plant, number of seeds per umbellate, number of seeds per umbel, biological yield, seed yield per plot, seed yield per hectare and harvest index (%) were significantly influenced by bothvarious concentration of gibberelic acidand stage of plant for its application.

It is revealed from the data recorded for various observations thatplant height at harvest, number of branches per plant, minimum days to 50 per cent flowering, number of umbels per plant, biological yield, seed yield per plot and seed yield per hectare were favorable with the application of 100 ppm gibberellic acid (C_4) at juvenile stage of plant (S_1) i.e. C_4S_1. While, number of seeds per umbellate, number of seeds per umbel and harvest index (%) were maximum with application of 100 ppm gibberellic acid concentration (C_4) at flowering stage of plant (S_2) i.e. C_4S_2.

DISCUSSION

In view of the literature information available, the result presented in the Table-1, 2 & 3 is discussed

Table 1
Effect of Gibberellic Acid on Growth and Yield Parameters of Fennel

GA_3 Concentration	Recorded Observations and Stages of GA_3 application (S_1, S_2, S_3)															
	Plant height at harvest (cm)				*Number of branches per plant*				*Days to 50 % flowering*				*Number of umbels per plant*			
	S_1	S_2	S_3	*Mean*	S_1	S_2	S_3	*Mean*	S_1	S_2	S_3	*Mean*	S_1	S_2	S_3	*Mean*
C_1 Control (no spray)	157.63	153.56	153.00	154.73	8.00	7.83	7.10	7.64	120.83	121.50	120.80	121.04	19.93	19.90	19.03	19.62
C_2 50 ppm	163.66	159.13	162.26	161.68	8.90	8.26	8.26	8.47	118.20	118.83	119.26	118.90	22.60	20.63	20.70	21.31
C_3 75 ppm	166.73	160.53	161.80	163.02	9.16	8.70	8.30	8.72	116.60	120.00	119.80	118.80	24.83	22.83	20.96	22.87
C_4 100 ppm	174.60	161.53	163.33	166.02	11.16	8.60	8.36	9.37	116.13	120.76	116.63	117.84	26.96	24.56	20.80	24.11
Mean	165.65	158.69	160.10		9.30	8.35	8.00		117.89	120.27	119.12		23.58	21.98	20.37	
C.D. (P=0.05)	GA_3 Concentrations: 1.17 Application stages: 1.02 GA_3 Concen. × Application stages: 2.04				GA_3 Concentrations: 0.44 Planting methods: 0.38 GA_3 Concen. × Application stages: 0.76				GA_3 Concentrations:0.65 Planting methods: 0.56 GA_3 Concen. × Application stages:1.12				GA_3 Concentrations:0.72 Planting methods: 0.62 GA_3 Concen. × Application stages:1.25			

Table: 2

GA_3 Concentration		Recorded Observations and Stages of GA_3 application (S_1, S_2, S_3)											
		Number of seeds per umbellet				*Number of seeds per umbel*				*Harvest index (%)*			
		S_1	S_2	S_3	*Mean*	S_1	S_2	S_3	*Mean*	S_1	S_2	S_3	*Mean*
C_1	Control (no spray)	17.33	17.46	17.73	17.51	503.36	503.70	498.23	501.76	24.50	28.50	26.40	26.80
C_2	50 ppm	18.13	19.33	17.93	18.46	527.56	537.06	524.63	529.75	26.50	26.50	24.60	25.80
C_3	75 ppm	19.43	21.10	17.73	19.42	563.56	612.26	547.20	574.34	26.80	29.80	24.50	27.00
C_4	100 ppm	21.53	21.53	18.20	20.42	647.50	654.10	581.10	600.41	37.30	41.80	20.90	33.33
	Mean	19.10	19.85	17.90		547.95	568.95	537.80		28.80	31.90	24.10	
C.D. (P=0.05)		GA_3 Concentrations: 0.66 Application stages: 0.57 GA_3 Concen. × Application stages: 1.14				GA_3 Concentrations: 5.08 Application stages: 5.05 GA_3 Concen. × Application stages: 10.09				GA_3 Concentrations: 3.75 Application stages: 3.24 GA_3 Concen. × Application stages: 6.49			

Table: 3

GA_3 Concentration		Recorded Observations and Stages of GA_3 application (S_1, S_2, S_3)											
		Biological yield (kg/plot)				*Seed yield per plot (kg/plot)*				*Seed yield per hectare (q/ha)*			
		S_1	S_2	S_3	*Mean*	S_1	S_2	S_3	*Mean*	S_1	S_2	S_3	*Mean*
C_1	Control (no spray)	3.90	4.10	4.20	4.00	1.08	1.09	1.08	1.09	15.17	15.23	15.07	15.16
C_2	50 ppm	4.30	4.60	5.00	4.60	1.13	1.12	1.07	1.11	15.59	15.66	14.95	15.40
C_3	75 ppm	6.10	4.30	4.90	5.10	1.26	1.17	1.07	1.16	16.48	16.27	14.96	15.90
C_4	100 ppm	7.00	6.00	6.20	6.40	1.28	1.18	1.18	1.21	17.84	17.52	16.39	17.25
	Mean	5.30	4.70	5.10		1.20	1.14	1.10		16.27	16.17	15.34	
C.D. (P=0.05)		GA_3 Concentrations: 0.30 Application stages: 0.26 GA_3 Concen. × Application stages: 0.52				GA_3 Concentrations: 0.01 Application stages: 0.04 GA_3 Concen. × Application stages: 0.02				GA_3 Concentrations: 0.24 Application stages: 0.21 GA_3 Concen. × Application stages: 0.43			

here as under. In the present investigation among the various concentrations of gibberellic acid maximum plant hight at harvest was recorded when the crop was sprayed with 100 ppm solution of gibberellic acid (C_4). A continuous increase in gibberellic acid concentration showed an continuous increase in plant height at harvest.In case of stages of GA_3 application, maximum plant height was attained when foliar spray of GA_3 was done at juvenile stage (S_1). The results are in conformity with the findings of Singh *et al*. [1] in coriander, El-Keltawi *et al*. [2] in cumin and Meena and Malhotra [3] in coriander, who observed an increase in plant height with gibberellic acid application. The increase in plant height because of gibberellic acid application might be due to the stimulation of cell elongation

[Mohammed [4]]. Another possible explanation might be due to the increased osmotic uptake of water and nutrients under the influence of gibberellic acid and in turn improving nutrients metabolism in plant system [Pareek [5]].

There was a significant differencein the number of branches per plant at harvest. Maximum numbers of branches were observed when the crop was sprayed with 100 ppm solution of gibberellic acid (C_4).Among different stages of application, foliar spray of gibberellic acid at juvenile stage (S_1) resulted in maximum number of branches per plant. The results are in accordance with the findings ofVerma and Sen [6] in coriander, Shah and Samiullah [7] in black cumin, who observed the beneficial effect of gibberellic acid on number of branches per plant. These observations are quite in line with those of Panda *et al*. [8], who found that GA_3 100 ppm application as foliar spray at 45 and 60 days after sowing resulted in maximum number of branches per plant in coriander. The increase in number of branches per plant might be attributed to enhanced physiological activities like cell elongation, photosynthesis and translocation of nutrients and photosynthates [Saxena [9]].

Minimum days taken to fifty percent flowering were significantly influenced by the GA_3 concentrations and its application stage of plant. Minimum number of days taken to fifty percent flowering was observed when the crop was sprayed with 100 ppm solution of gibberellic acid (C_4).Among different stages of application, gibberellic acid spray at juvenile stage (S_1) showed the earliest flowering. Similar findings were observed by Gour *et al*. [10] and Panda *et al*. [8], who observed foliar spray of gibberellic acid 100 ppm at 45 and 60 days after sowing as the best with respect to days to 50 per cent flowering in coriander. These results also corroborate with the findings of Meena *et al*. [11]. The results of the present study indicate gibberellic acid involvement in transition of vegetative apices to floral apices in fennel. The early flowering in fennel might be attributed to enhanced mobility of carbohydrates in leaves.

Numbers of umbels per plant were significantly influenced by the GA_3 concentrations and its application stage of plant. Among various concentrations of applied gibberellic acid, 100 ppm concentration(C_4) gave the maximum number of umbels per plant. In case of stages of application, GA_3 applied at juvenile stage (S_1) showed the best result with respect to number of umbels per plant. The results are in conformation with the findings of Singh *et al*. [1] in coriander and Panda *et al*. [8], who reported the application of GA_3 100 ppm as the best with respect to number of umbels per plant in coriander. The findings of Meena *et al*. [11], Verma and Sen [6] also reported an increase in number of umbels per plant with gibberellic acid application in different crops. Improved vegetative growth due to gibberellic acid application coupled with increased photosynthesis on one hand and greater mobilization of photosynthates towards reproductive sites, on the other, might have increased the number of umbels per plant.

Number of seeds per umbel also differed among various treatments for both *i.e.* stages of application and gibberellic acid concentrations. The number of seeds per umbel increased with the increase in gibberellic acid concentration from zero to 100 ppm and the maximum number of seeds per umbel was obtained with the application of GA_3 at 100 ppm concentration (C_4). Among different stages of application, foliar spray of gibberellic acid at flowering stage (S_2) showed the best result with respect to number of seeds per umbel. The results are in accordance with the findings of Singh *et al*. [1] in coriander and Pariari *et al*. [12] in fenugreek. Panda *et al*. [8] observed GA_3 100 ppm as the best concentration in coriander and fenugreek to increase number of seeds per umbel. The application of growth regulators like gibberellic acid caused increased uptake of nutrients particularly of nitrogen from the soil and its further assimilation led to the synthesis of protein. Gibberellic acid is known to promote the metabolism of assimilates by enhancing various enzymatic activities leading to the production or conversion into mobile amino acids or amides [Akazawa and Miyata[13]].

An increase in number of seeds per umbellet observed with the application of gibberellic acid. Among different concentrations used, GA_3 at 100 ppm concentration (C_4) gave the best results. Gibberellic acid application at flowering stage (S_2) showed significantly better result over other stages of application. The increase in number of seeds per umbellet might be attributed to enhanced physiological activities like photosynthesis and translocation of nutrients and photosynthates [Mohammed [4]]. Another possible explanation for this might be due to the increased osmotic uptake of water and nutrients under the influence of gibberellic acid and in turn improving nutrients metabolism in plant system [Pareek [5]].

The biological yield was significantly influenced by various gibberellic acid concentrations applied at different stages. It is evident from the results that biological yield improved significantly with the increase in gibberellic acid concentration and the best result was noticed with the application of GA_3 at 100 ppm concentration (C_4). Among different stages of application, foliar spray at juvenile stage (S_1) gave the maximum biological yield. The results of the present investigation are in accordance with the findings of Singh *et al*. [1] in coriander, Verma and Sen [6], who reported increased biological yield with the application of gibberellic acid in coriander. The reason for the increase in biological yield might be improvement in vegetative growth, which was due to the stimulation of cell elongation and increase in plasticity of cell wall [Mohammed[4]]. This might also be due to increased osmotic uptake of water and nutrients under the influence of gibberellic acid and in turn improving nutrients metabolism in plant system [Pareek[5]].

Seed yield per plot and seed yield per hectare increased significantly with the increase in gibberellic acid concentration from zero to 100 ppm. Therefore, the application of GA_3 at 100 ppm concentration(C_4) gave the best result with respect to seed yield. Foliar spray of gibberellic acid at juvenile stage (S_1) gave the best result among different stages of gibberellic acid application. The results reported by Vasudevan *et al*. [14] in fenugreek and Panda *et al*. [8] in coriander also noticed maximum seed yield with the application of gibberellic acid at 100 ppm concentration. The results also support the findings of Pariari *et al*. [12], Verma and Sen [6], Shah and Samiullah [7]and Fisher and Pyshtaleva [15], who observed the beneficial effect of gibberellic acid with respect to seed yield in different crops. Improved vegetative growth due to gibberellic acid application coupled with increased photosynthesis on one hand and greater mobilization of photosynthates towards reproductive sites on the other hand might have been found to increase the yield attributes. Thus, the cumulative effect of all yield attributes resulted in significant increase in seed yield. Evans *et al*. [16] mooted that the interaction of growth regulating substances with the sink efficiency might be involved in influencing the yield potential.

The present findings revealed an improvement in harvest index with the use of gibberellic acid at different concentrations applied at various stages. The results indicate an increase in harvest index with the increase in gibberellic acid concentration and the maximum harvest index was observed with treatment GA_3 at 100 ppm concentration(C_4). Among different stages of application, the treatment GA_3 spray at flowering stage (S_2) showed the maximum harvest index. The beneficial effect of gibberellic acid application on fennel with respect to harvest index is in accordance with the findings of Singh *et al*. [1] in coriander. The increased harvest index might be attributed to increased seed yield in comparison to vegetative growth.

CONCLUSION

Based on the experimental results, it can be concluded that application of gibberellic acid improved the growth and yield attributes of fennel crop. 100 ppm was the optimum concentration and juvenile stage was the right stage for gibberellic acid application to improve the growth and yield of fennel.

REFERENCES

Singh, D., Singh, P. P., Naruka, I. S. and Shaktawat, R. P. S. (2012), Effect of plant growth regulators on growth and yield of coriander. *Indian Journal of Horticulture* 69: 91-93.

El-Keltawi, N.K., Barham, I.H., El-Naggar, A.I. and Rekeby, A.F. (2000), Investigations on the responses of cumin plants to certain horticultural agrochemicals. *Egyptian Journal of Horticulture* 27(4): 439-458.

Meena, S.S. and Malhotra, S.K. (2006), Effect of sowing time, nitrogen and plant growth regulators on green leaf yield of coriander. *Haryana Journal of Horticultural Sciences* 35(3&4): 310-311.

Mohammed, H.M. (1975), Effect of GA_3, calcium, kinetin and ethylene on growth and cell wall composition of pea epicotyls. *Plant Physiology* 56: 622-625.

Pareek, N.K. (1996), Response of coriander (*Coriandrum sativum* L.) to nitrogen and plant growth regulators. M.Sc. Thesis, Rajasthan Agricultural University, Bikaner, India.

Verma, P. and Sen, N.L. (2006), Effect of plant growth regulators on vegetative growth and seed yield of coriander cv. RCr-435. *Journal of Spices and Aromatic Crops* 15(2): 118-122.

Shah, S.H. and Samiullah (2006), Effect of phytohormones on growth and yield of black cumin (*Nigella sativa* L.). *Indian Journal of Plant Physiology* 11: 217-221.

Panda, M.R., Chatterjee, R., Pariari, A., Chattopadhyay, P.K., Sharangi, A.B. and Alam, K. (2007), Effect of growth regulators on growth, yield and quality of coriander. *Indian Journal of Horticulture* 64(3): 369-371.

Saxena, O.P. (1989), Role of plant growth regulators in plant productivity studies. In: *Proceedings of National Seminar*

on Strategies in Physiological Regulation of Plant Productivity. December 1989, Bombay, India, pp. 13-17.

Gour, R., Naruka, I.S., Singh,P.P. and Rathore, S.S. (2009), Effect of phosphours and plant growth regulators on growth and yield of fenugreek (*Trigonella foenum-graecum* L.). *Journal of Spices and Aromatic Crops* 18 (1): 33-36.

Meena, S.S., Sen, N.L. and Malhotra, S.K. (2006), Influence of sowing date, nitrogen and plant growth regulators on growth and yield of coriander. *Journal of Spices and Aromatic Crops* 15(2): 88-92.

Pariari, A., Imam, M.N., Das, R., Choudhary, S.M. and Chatterjee, R. (2007), Growth and yield of fenugreek as influenced by growth regulators. *Journal of Interacademicia* 11(1): 24-27.

Akazawa, T. and Miyata, Y. (1982), Enzymatic and hormonal metabolism of starch synthesis in cereals. *Plant Physiology* 39: 371-378.

Vasudevan, S. N., Sudarshan, J. S. and Kurdikeri, M. B. (2008), Influence of Pinching of Apical bud and Chemical Sprays on Seed Yield and Quality of Fenugreek. *Karnataka Journal of Agriculture Science* 21(1): 26-29.

Fisher, A.M. and Pyshtaleva, O.T. (1974), Gibberellin as a mean of improving the nutritional value of green vegetables. *Trudy NII Kraev. Patol. Kazssr*. 26: 180-182.

Evans, L.T., Bingham, J. and Roskames, M.A. (1972), The pattern of grain set within ears of wheat. *Australian Journal of Biological Sciences* 25: 1-8.