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Effect of plant growth regulators on yield and yield attributing characters in coriander (*Coriandrum sativum* L.)

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Abstract
In India, Coriander is very popular because of its spicy seeds and aromatic leaves. India is well known as 'Home of Spices' or 'Land of spices'. The field investigation was conducted during *Rabi* season 2020-21 at farm of Krishi Vigyan Kendra, Raipur under department of vegetable science, Indira Gandhi Krishi Vishwavidyalaya, Raipur, and Chhattisgarh. The results showed that the application of GA_3 @ 45 ppm gave maximum plant height (90.36 cm) and maximum number of branches {primary branches (8.53) and secondary branches (14.33)} plant^{-1}. However minimum days taken for complete seed maturity (87) was recorded with 2, 4-D @ 15 ppm. Among the yield and yield attributing characters such as number of umbels (29.30) plant^{-1}, number of umbellate umbel^{-1} (8.11), number of seeds umbel^{-1} (42.64) and seed yield ha^{-1} (13.01 q) was maximum with GA_3 @ 45 ppm.

Keywords: Umbel, umbellate, GA_3, NAA, 2, 4-D, plant growth regulators, yield

Introduction
Coriander (*Coriandrum sativum* L.) is an annual cross pollinated herb. India is the largest producer, consumer and exporter of spices in the world. The aroma of coriander is due to the integral ingredient i.e. d-linalool or Coriandrol ($C_{10}H_{17}OH$) which is a terpene tertiary alcohol. Coriander is one of the most significant aromatic spice seed crops. Both the fresh herb and seeds of coriander are mainly used for culinary purposes. Fruits are also commonly used in India as a condiment in the preparation of pickles, sausages and seasonings, pastry, cookies, buns and cakes, and flavoring for tobacco products. The essential oil content of coriander varies between 0.03 and 2.6%, and the fatty oil varies between 9.9 and 27.7%. Coriander is also rich in high vitamin C (ascorbic acid, up to 160 mg/100 g), vitamin A (carotene, up to 12 mg/100 g) (Girenko, 1982) [2] and vitamin B_2 (up to 60 mg/100 g) (Prakash, 1990) [10] which is noteworthy.
Plant growth regulators play a vital role in the growth and development of the plant which has a significant effect on the yield of the plant. Recently research is focusing on the effect of plant growth regulators on the growth and quality of coriander. Among different PGRs, GA_3 and NAA have reported to boost the growth, yield and quality attributes in coriander (Haokip *et al.*, 2016 and Singh *et al.*, 2017) [3, 12]. GA_3 found effective for increasing higher growth and yield with the maximum B: C ratio of coriander (Parmar *et. al*., 2018, Andrabi *et al.*, 2019 and Kurmi *et al*., 2019) [9, 1, 6].

Material and Methods
The field investigation was conducted during *Rabi* season 2020-21 at farm of Krishi Vigyan Kendra, Raipur under department of vegetable science, Indira Gandhi Krishi Vishwavidyalaya, Raipur, and Chhattisgarh. Raipur district falls under tropical zone of Chhattisgarh located at 21.25° N, latitude and 81.62° E longitude at an altitude of 289 meters above mean sea level. The soil of experimental field is clayey in texture, with soil ph 7.12, low in availability of nitrogen (185 kg/ha), medium in Phosphorus (16.4 kg/ha) and high in potassium status (311.08 kg/ha). The field experiment was conducted in randomized block design with three replications, consisting a control and nine treatments of three plant growth regulators i.e., GA_3 @ 15,30 and 45 ppm, NAA @ 20,40 and 60ppm and 2,4-D @ 5,10 and 15 ppm. Time of plant growth regulator application

1. Foliar application at pre flowering stage
2. Foliar application at pre seed setting stage

Plot size was 6m×6m and spacing of 30×10cm. five plant sample from each replication in each treatment were selected at random to record data on morphological and yield attributing characters. The experimental data was analyzed statistically by the method of analysis of variance as out lined by Panse and Sukhatme (1995) [14].

Results and Discussion

Growth and Morphological parameters

The data obtained on various growth and morphological parameters of coriander *viz*., plant height at harvest, number of branches (Primary and secondary branches) plant^{-1} at harvest and days taken for complete seed maturity were presented in Table 1.

Maximum plant height recorded with GA_3 @ 45ppm (90.36 cm) at harvest. Minimum plant height was observed with 2, 4-D @ 15ppm (66.93 cm) at harvest. The increase in plant height may be due to increase in cell wall plasticity and elongation in cell wall (Yugandhar *et al.,* 2014) [13]. These results are in conformity with the findings of Yugandhar *et al.,* (2014) [13], Haokip *et al.,* (2016) [3], Singh *et al.,* (2017) [12] and Andrabi *et al*., (2019) [1] in coriander.

Maximum number of primary branches (8.53) at harvest was recorded with the application of GA_3 @ 45 ppm. Minimum number of primary branches (6.06) at harvest were recorded with 2, 4-D @ 15 ppm. The number of secondary branches found maximum of 14.33 at harvest with the application of GA_3 @ 45 ppm while the number of secondary branches found minimum of 10.53 at harvest with 2, 4-D @ 15 ppm. The increase in number of branches per plant might be due to application of gibberellic acid which enhances the lateral buds, breaking apical dominance and vegetative growth' (Kumar *et al*., 2018). The results are in conformation with Haokip *et al.,* (2016) [3], Singh *et al.,* (2017) [12] and Andrabi *et al*., (2019) [1] in coriander.

The lowest number days taken for seed maturity (87) was found with the application of 2,4-D @ 15 ppm while the highest number days taken for seed maturity (94.06) were found with the application of GA_3 @ 30 ppm.

Yield and yield attributing character

The data on yield and yield attributing characters were presented in Table 2.

Maximum number of umbel (29.30) per plant was recorded with the application of GA_3 @ 45 ppm, which was superior among all plant growth regulators in terms of increase of umbel per plant while the minimum number of umbel (16.20) per plant was recorded with 2,4-D @ 15ppm. The increase in number of umbels per plant could be attributed to the increase in the number of both primary and secondary branches per plant with GA_3.

Maximum number of umbellate (8.11) per umbel was recorded with GA_3 @ 45 ppm followed by NAA @ 60 ppm (6.91) and GA_3 @ 30 ppm (6.73). Minimum number of umbellate (4.64) per umbel was recorded with the 2, 4-D @ 15ppm. The increase in number of umbellate per umbel due to GA_3 might be due to accumulated metabolites which get translocated towards the reproductive sinks and these in turn resulted in stimulation of umbellate.

Maximum number of seeds per umbel (42.64) per plant was recorded with the application of GA_3 @ 45 ppm, which was statistically superior among all the plant growth regulators in terms of seeds per umbel. Minimum number of seeds per umbel per plant was recorded with 2, 4-D @ 15ppm (28.28). Maximum seed yield was produced may be due to GA_3 application by which the plant remained physiologically more active to build up sufficient food stocks for developing flowers, fruit and resulted in increased fruit set, which ultimately lead to higher seed yields.

Seed yield per hectare (13.01 q ha^{-1}) was significantly recorded maximum with the foliar application of GA_3 @ 45 ppm followed by NAA @ 60 ppm (10.88 q ha^{-1}) and GA_3 @ 30 ppm (10.61 q ha^{-1}). However both NAA @ 60 ppm and GA_3 @ 30 ppm were statistically at par with each other. Lowest seed yield (6.74 q ha^{-1}) was recorded with the control. This increase in seed yield per hectare could be attributed to increase in yield attributing characters such as number of umbels per plant, number of umbellate per umbel, number of seeds per umbel and increase in growth parameters like number of branches (primary and secondary) per plant.

The above results were in conformity with the findings of Singh *et al.* (2012) [12], Haokip *et al.,* (2016) [3], Singh *et al.,* (2017) [12] and Andrabi *et al*., (2019) [1] in coriander, Krishnaveni *et al.,* (2016) [4] in fenugreek and Namdeo *et al.,* (2016) [7] in ajwain."

Conclusion

The result from the present field experiment reveals that the higher concentrations of GA_3 @ 45 and NAA @ 60 ppm significantly increased the growth and seed yield of coriander. However, the above results are of one season experiment, it may be repeated with variable concentration of PGR's and with different variety too.

Table 1: Effect of plant growth regulators on growth and morphological parameters of coriander

Treatment	Plant height (cm)	Primary branches	Secondary branches	Days to seed maturity
	At harvest	At harvest	At harvest	
Control	71.40	6.63	12.26	88.53
GA_3-15 ppm	89.10	7.16	13.60	89.70
GA_3-30ppm	86.53	7.26	13.60	94.06
GA_3-45 ppm	90.36	8.53	14.33	86.00
NAA- 20ppm	79.66	7.30	11.53	93.80
NAA-40ppm	81.13	7.60	12.60	89.73
NAA-60ppm	87.20	8.13	12.80	93.06
2,4-D-5ppm	75.86	7.53	11.00	91.60
2,4-D-10ppm	77.93	7.23	10.60	90.00
2,4-D-15ppm	66.93	6.06	10.53	87.00
C.D. at 5%	8.38	0.60	1.39	N/A

SE(m)	2.80	0.20	0.46	2.58

Table 2: Effect of plant growth regulators on yield and yield attributing characters of coriander

Treatment	No. of umbels per plant	No. of umbellate per umbel	No. of seeds per umbel	Seed yield/ ha. (q/ha)
Control	19.53	5.07	29.56	6.74
GA_3-15 ppm	22.63	5.52	34.26	10.13
GA_3-30ppm	23.96	6.73	32.92	10.61
GA_3-45 ppm	29.30	8.11	42.64	13.01
NAA- 20ppm	24.93	5.91	36.64	9.42
NAA-40ppm	25.16	6.64	36.48	9.86
NAA-60ppm	25.86	6.91	37.86	10.88
2,4-D-5ppm	20.40	6.06	34.78	8.09
2,4-D-10ppm	18.86	4.84	31.37	7.30
2,4-D-15ppm	16.20	4.64	28.28	7.62
C.D. at 5%	3.17	0.98	3.74	1.81
SE(m)	1.06	0.32	1.25	0.60

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