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Effects of plant growth regulators on seed yield and economics of coriander (*Coriandrum sativum* L.) cv. C.G. Dhaniya 1

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Abstract
Coriander is very popular in India due to its spiciness in the seeds and aroma in the leaves. D-linalool ($C_{10}H_{17}OH$), also known as Coriandrol is responsible for the aroma of coriander. India is renowned for being the "Home of Spices" or "Land of Spices". Coriander ranks first among the seed spices with respect to area, production and export. The field trial was carried out at a farm of KVK, Raipur, IGKV, Chhattisgarh in 2020–21 in nine treatments of three plant growth regulators and a control with three replications in a RBD i.e., GA_3 @ 15 ppm, 30 ppm and 45 ppm, NAA @ 20 ppm, 40 ppm and 60 ppm and 2,4-D @ 5 ppm, 10 ppm and 15 ppm used as foliar application at pre flowering stage and pre seed setting stage. According to the results, application of GA_3 at 45 ppm given the highest plant height (90.36), number of primary branches plant^{-1} (8.53), number of secondary branches plant^{-1} (14.33), number of nodes plant^{-1} (9.36), number of umbels (29.30) plant^{-1}, number of seeds umbel^{-1} (42.64), test weight of seed (12.90 g), seed yield plant^{-1} (8.43 g), seed yield ha^{-1} (13.01 q), net returns (Rs. 194180 ha^{-1}) and B: C ratio (1:2.94). However fresh weight (32.23 g) and dry weight (16.53 g) of plant was highest with NAA @ 60 ppm. Days to 50% flowering (50) and days to seed maturity (87) were obtained minimum with 15 ppm 2,4-D.

Keywords: *Coriandrum sativum* L., PGRs, seed yields, economics

Introduction
Coriander is an important annual spice, seed plant and is used in cooking. India is first in the world for spice production, consumption, and export. About 25 to 40% of seed coriander is used in the form of curry powder. The green plant is used in soups, salads and dressings and is used very often in chutneys in India and fruits are also used in the baking of pastries, biscuits, cakes and as a flavour for tobaccos products. The residue left over after extraction of volatile oil is used in cattle feed. The aldehyde content of the essential oil is responsible for the distinctive aroma of the green plant. Aroma of the green plant decreases with maturity and is no longer present in the fruits after ripening and drying. Coriander contains between 0.03 and 2.6% of essential oil and between 9.9 and 27.7% of fatty oil. High levels of vitamin C (160 mg per 100 g of ascorbic acid), vitamin A (12 mg per 100 g of carotene) and 60 mg per 100 g of vitamin B_2 are also present in coriander.

PGRs' effectiveness is determined by a variety of factors, including concentration, method of application and application time. Exogenous PGR application has been shown to increase growth and yield of various crops (Bharud *et al.*, 1988) [2]. Recent studies have focused on how plant growth regulators affect the growth and quality of coriander. Spraying PGRs on crop plants improves growth, yield, and quality attributes, according to some researchers (Varma and Sen, 2006 and Meena *et al.*, 2006 and Singh *et al.*, 2017) [16, 7, 15]. In coriander GA_3 was found to be helpful for boosting higher growth and seed yield with the highest Benefit: Cost ratio (Andrabi *et al.*, 2019 and Kurmi *et al*., 2019) [1, 6].

Material and Method
The field trial was carried out in *Rabi* season at farm of KVK, Raipur under department of Horticulture, Vegetable Science, IGKV, Chhattisgarh in 2020-21. Raipur district is part of Chhattisgarh lies in the tropical zone. In the trial field, the soil has a clay-like texture and a soil pH of 7.12, nitrogen availability is low (185 kg/ha), phosphorus status is medium (16.4 kg/ha), and potassium content is high (311.08 kg/ha). The field research was carried out in nine

treatments of three plant growth regulators and a control with three replications in a randomized block design i.e., GA_3 at 15 ppm, 30 ppm, 45 ppm, NAA at 20 ppm, 40 ppm, 60 ppm and 2,4-D at 5 ppm, 10 ppm, 15 ppm. Foliar applications of plant growth regulators are made at the pre-flowering and pre-seed-setting stage. Plot size was 6m×6m with 30cm×10cm spacing were used. In each replication five plant samples for each treatment were randomly selected to collect information on morphological traits that contribute to yield. According to Panse and Sukhatme (1978) [12], the analysis of variance method was used to statistically analyze the experimental results.

Results and Discussion

The data obtained on different coriander parameters including plant height at harvest, number of primary branches and secondary branches per plant at harvest, number of nodes at harvest, days to 50% flowering, days to seed maturity, fresh weight and dry weight of plant were presented in table 1 and yield and character that attribute yield, production cost, net profit and benefit cost ratio were shown in table 2.

The maximum plant height recorded with GA_3 @ 45 ppm is 90.36cm at harvest. The lowest plant height of 66.93 were obtained by using 2,4-D @ 10 ppm at harvest. GA application may have increased plant height due to the stimulation of cell elongation, increased cell wall plasticity and quick cell division in the growing part, resulting in longer internodes (Sargent, 1965 and Mohammed, 1975) [13, 8].

The lowest number of primary branches of 6.06 was obtained by using 2,4-D at 15 ppm at harvest. The maximum number of primary branches is 8.53 was found with the application of GA_3 @ 45 ppm at harvest. The numbers of secondary branches are 14.33 found maximum with the application of GA_3 @ 45 ppm at harvest. The numbers of secondary branches are 10.53 was obtained minimum with 2,4-D at 15 ppm at harvest. Application of GA increases the lateral buds, breaks apical bud dominance and physiological development may be the reason for the increased number of branches per plant (Kumar *et al.*, 2018) [5].

The number of nodes plant^{-1} considerably increased after the application of plant growth regulators. The number of nodes on main shoot plant^{-1} was recorded maximum of 9.36 with the application of GA_3 @ 45 ppm at harvest. The minimum number of nodes (7.93) on main shoot per plant obtained with the control at harvest.

The lowest days required for 50% flowering are 50 recorded with the treatment of 15 ppm 2,4-D. The maximum days required for 50% flowering (62.33) were found with the application of 45 ppm GA_3. The lowest days needed for seed maturity is 87 were recorded with the application of 15 ppm 2,4-D while the application of GA_3 at 30 ppm recorded highest number of days (94.06) for seed maturity. Fresh weight (32.23 g) and dry weight (16.53 g) of plant was observed maximum with the foliar application of 60 ppm NAA. The lowest plant fresh weight and plant dry weight were obtained (14.13 g) and (6.46 g) respectively with control. The findings of Haokip *et al.* (2016) [3], Singh *et al.* (2017) [15], and Andrabi *et al.* (2019) [1] in coriander are in accordance with the data reported above.

The foliar application of GA_3 @ 45 ppm, which was the best plant growth regulator for higher production of number of umbels, resulted in the highest number of umbels (29.30) plant^{-1} while 2,4-D at 15 ppm produced lowest number of umbels (16.20) plant^{-1}. Application of GA_3 produced per plant more primary and secondary branches, which may have contributed to the rise in umbels per plant.

The application of GA_3 @ 45 ppm resulted in the highest number of seeds umbel^{-1} (42.64) plant^{-1}, which was statistically most efficient plant growth regulators in terms of seeds umbel^{-1} while with the 2,4-D @ 15 ppm minimum quantity of seeds per umbel (28.28) per plant was noted. The seed yield were obtained maximum with the application of GA_3 wherein the plants physically more active to accumulate enough food stocks for producing flowers and fruits, which led to maximum fruit set and the plant was able to produce the greatest amount of seeds.

The use of PGRs has significantly higher on seed test weight. Maximum test weight of seed is 12.90 g was found with the GA_3 @ 45 ppm. The lowest test weight of seed (8.96 g) was found with control. Similar findings in coriander were recorded by Panda *et al.*, (2007) [10], Singh *et al.*, (2012) [14].

Among the plant growth regulators, GA_3 @ 45 ppm gives highest seed yield (8.43 g) plant^{-1}. The lowest seed yield (5.33 g) per plant was recorded with control. Among the plant growth regulator, the seed yield plant^{-1} was significantly increased by GA_3 @ 45 ppm which might be due to an increase in number of umbels per plant, number of seeds per umbel and which in turn due to increased number of branches.

The foliar application of GA_3 @ 45 ppm resulted in the highest seed yield hectare^{-1} (13.01 q.), after that NAA @ 60 ppm (10.88 q.) and GA_3 @ 30 ppm (10.61 q.). The control produced the minimum seed yield (6.74 q.). This rise in seed yield hectare^{-1} may be linked to increasing in yields related traits like number of umbels plant^{-1}, number of seeds umbel^{-1} as well as increasing in growth traits including plant height and numbers of both primary branches and secondary branches plant^{-1}.

The highest net return (Rs. 194180 ha^{-1}) and B: C ratios (2.94:1) were obtained with the application of GA_3 @ 45 ppm. It may be because there are more primary and secondary branches, umbels plant^{-1} and seeds umbel^{-1}, resulting in the maximum seed yield plant^{-1} when compared to other treatments.

The findings of Haokip *et al.*, (2016) [3], Singh *et al.*, (2017) [15] and Andrabi *et al.*, (2019) [1] in coriander, Krishnaveni *et al.*, (2016) [4] in fenugreek and Namdeo *et al.*, (2016) in ajwain were all confirmed by the data presented above."

According to the findings of the current field trial concluded that the highest dose of GA_3 @ 45 ppm and NAA @ 60 ppm substantially enhanced the coriander growth and seed yields.

Table 1: Effects of PGRs on growth parameter of coriander

Treatments	Plant height (cm)	Primary branches	Secondary branches	No. of nodes plant^{-1}	Days to 50% flowering	Days to seed maturity	Fresh weight (g)	Dry weight (g)
	At harvest	At harvest	At harvest					
Control	71.40	6.63	12.26	7.93	58.13	88.53	14.13	6.46
GA_3-15 ppm	89.10	7.16	13.60	8.06	57.46	89.70	17.16	11.13
GA_3-30 ppm	86.53	7.26	13.60	8.76	59.63	94.06	19.93	12.00
GA_3-45 ppm	90.36	8.53	14.33	9.36	62.33	86.00	28.33	9.33
NAA- 20 ppm	79.66	7.30	11.53	8.60	59.06	93.80	15.80	11.60
NAA-40 ppm	81.13	7.60	12.60	7.93	56.40	89.73	27.93	13.66
NAA-60 ppm	87.20	8.13	12.80	9.20	61.26	93.06	32.23	16.53
2,4-D-5 ppm	75.86	7.53	11.00	8.13	55.86	91.60	21.46	8.20
2,4-D-10 ppm	77.93	7.23	10.60	8.13	50.66	90.00	15.26	7.26
2,4-D-15 ppm	66.93	6.06	10.53	8.00	50.00	87.00	18.63	7.00
C.D. at 5%	8.38	0.60	1.39	0.74	5.08	N/A	3.47	2.13
SE(m)	2.80	0.20	0.46	0.24	1.69	2.58	1.16	0.71

Table 2: Effects of PGRs on yield attributing characters and economics of coriander

Treatments	No. of umbels per plant	No. of seeds per umbel	Test weight (g)	Seed yield/ plant (g)	Seed yield/ ha. (q/ha)	Cost of cultivation (RS. ha^{-1})	Net return (RS. ha^{-1})	Benefit cost ratio
Control	19.53	29.56	8.96	5.33	6.74	65,000	69800	1.07
GA_3-15 ppm	22.63	34.26	10.53	7.10	10.13	65,330	137270	2.10
GA_3-30 ppm	23.96	32.92	11.03	7.20	10.61	65,675	146525	2.23
GA_3-45 ppm	29.30	42.64	12.90	8.43	13.01	66,020	194180	2.94
NAA- 20 ppm	24.93	36.64	10.76	6.60	9.42	65,006	123394	1.89
NAA-40 ppm	25.16	36.48	10.40	6.80	9.86	65,010	132190	2.03
NAA-60 ppm	25.86	37.86	11.30	7.26	10.88	65,014	152586	2.34
2,4-D-5 ppm	20.40	34.78	10.23	6.60	8.09	65,002	96798	1.40
2,4-D-10 ppm	18.86	31.37	9.96	5.53	7.30	65,005	80995	1.24
2,4-D-15 ppm	16.20	28.28	9.83	5.60	7.62	65,007	87393	1.34
C.D. at 5%	3.17	3.74	1.52	1.20	1.81			
SE(m)	1.06	1.25	0.50	0.40	0.60			

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