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Influence of foliage cutting and foliar spray of plant growth regulators and biostimulants on plant growth and seed yield of coriander (*Coriandrum sativum* L.)

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Abstract
Globally coriander seed production holds significant importance extending beyond its culinary uses as a key spice in various cuisines. A field experiment was conducted at PG Research Block, Raichur, during *rabi* 2023-24 to study the effect of foliage cutting and foliar spray of plant growth regulators and biostimulants on coriander growth and seed yield. The experiment was laid out in a two-factorial RCBD design with three cuttings as a first factor (no cut, one cut at 45 DAS, one cut at 60 DAS) and five foliar sprays as a second factor (GA_3, NAA, CCC, microbial consortia and humic acid). The results showed that, one cut at 45 DAS with foliar spray of humic acid (2.5ml L^{-1}) at flowering and seed setting stage significantly increased the plant height (66.07 cm), umbels per plant (35.83), flowers per umbel (16.96), seeds per umbel (11.03), foliage yield per hectare (154.25 q ha^{-1}) and seed yield per hectare (19.08q ha^{-1}). The foliage cutting at 45 DAS with humic acid spray at 2.5ml $L^{-1}$was found to be effective in enhancing growth which in turn helps in getting higher foliage yield and seed yield that provides an extra income to farmers.

Keywords: Foliage cutting, foliar spray, plant growth regulators, biostimulants

Introduction

India is said to be the 'Land of Spices' since the time immemorial because of its rich history, diverse geography and favorable climate, which have collectively created a heaven for spice cultivation and trade. Among the seed spices, coriander seed holds significant importance due to its versatile uses, nutritional value and economic significance. As a key ingredient in various cuisines, particularly in Indian, Middle Eastern and African cooking, coriander seed adds flavor, aroma and texture to numerous dishes. Its medicinal properties, including anti-inflammatory and antioxidant effects, make it a valuable component in traditional medicine. Coriander seed is also a rich source of essential vitamins, minerals and fiber, contributing to its nutritional value.

Coriander (*Coriandrum sativum* L.) which is also called as Dhania, Chinese parsley or Cilantro, belongs to family *Apiaceae* (Umbelliferae) and is an annual herbaceous plant, native to the Eastern Europe and Asia, mainly cultivated for its seeds as well as for the tender green leaves. Its name has been derived from Greek word "Koris" meaning bad bug because of unpleasant, fetid bug like odour of the green unripened fruits (Jan *et al*., 2011) [3]. It has 2n = 22 chromosomes with cross-pollination as mode of reproduction. Coriander occupies the top place in terms of area, production and export among the seed spices. The major producing countries are Morocco, India, Russia, Bulgaria, Mexico, Argentina, China, Romania, Japan and Italy. Madhya Pradesh ranked highest by produced the largest volume of coriander seeds in fiscal year 2023 across India. This amounted to over 396 thousand metric tons, over an area of 292 thousand hectares. The country's annual production of coriander seeds that year was over 847 thousand metric tons (Anon., 2023) [1]. In Karnataka, the area under coriander seed production is 0.03 lakh hectares and production of 0.02 lakh tonnes with the productivity of 748 kgs per hectare (Anon., 2023) [1].

Coriander seed production is highly specialized job and it requires intimate knowledge of seed production particularly, the floral biology, mode of pollination, climatic and nutritional requirements, etc. As coriander is an annual herb and according to climatic conditions, it is cultivated as a summer or winter annual crop. Despite being an economically important plant, the crop has received little or no concerted efforts for its improvement. Since almost all the economic characters including growth and yield in nature are highly influenced by environment and has some major challenges. The plant's limited branching leads to a decrease in the number of inflorescences and subsequently, lower seed yield. Another significant issue affecting coriander seed production is its tendency to bolt, where it prematurely produces flowers and seeds, particularly in warm weather conditions. This phenomenon making it essential for farmers to adopt strategies to mitigate these challenges and optimize coriander seed production.

Foliage cutting and foliar spray of plant growth regulators and biostimulants can help in overcome the challenges. These are essential for the vegetative and reproductive growth of the plant, which in turn resulting in higher green leaf and seed yield.

Coriander's regenerative capacity allows for 2-3 foliage cuttings to boost yield. For green leafy vegetables i.e., coriander, harvested by clipping of the leaves and young shoots and repeated cutting influences the seed yield. (Datta *et al*., 2008) [2]. Early-stage cutting can provide an extra income and increase seed yield by promoting branch multiplication (Rema *et al*., 1997) [6]. Timely cutting balances foliage and seed production. Whereas delayed cutting reduces the plant growth and seed yield. So overall to take good foliage and seed yield, the crop should be left for seed production on time.

Plant growth regulators (PGRs) and biostimulants have been defined as one of the main factors influences plant growth, development of primary and secondary metabolites pool.

The use of PGRs in the field of agriculture has become commercialized. PGRs have emerged as magic chemical that could increase agricultural production at an unprecedented rate and help in removing or circumventing many of the barrier imposed by genetics and environment (Nickell, 1982) [4]. Effectiveness of PGRs depend upon several factors *viz*., concentration, method and time of application etc.

Foliar application of growth regulators offers unique opportunities of scaling plants to any size and alter physiological processes in the plant to increase plant growth and yield. It is well known that, all the PGRs regulate the physiological functions of the plant and play an important role in mitigating the stress. Among different PGRs, gibberellic acid is found to induce the stem, internode elongation, flowering, fruit setting and growth. Application of naphthalic acetic acid (NAA) is also known to induce higher physiological efficiency including photosynthetic ability of plants. Cycocel (CCC) helps in reducing the height, stem elongation and apical dominance, thereby increases the seed yield parameters. Plant growth regulators also lead to better growth and yield without substantial increase in the cost of production.

Foliar spray of biostimulants like humic acid and microbial consortium can help to protect plants from stress factors such as drought, heat, cold and disease. Humic acid foliar spray can significantly increase chlorophyll production, stimulates root growth and improves photosynthesis and crop yields. Microbial consortium foliar spray can promote plant growth, increase nutrient use efficiency and enhance the nutritional content of the products when applied in small quantities. The main aim of this experiment is to study the effect of foliage cutting and foliar spray on plant growth and seed yield.

Materials and methods

Influence of foliage cutting and foliar spray of plant growth regulators and biostimulants on plant growth and seed yield of coriander was carried out at Post Graduate Research Block of University of Agricultural Sciences Raichur, during rabi 2023-24.

The seeds of coriander variety DCC-81 were obtained from University of Horticultural Sciences, Bagalkote, Karnataka. The experiment was laid out in two factorial RCBD (Randomized Complete Block Design). All the treatments were replicated thrice.

Preparation of solutions for foliar spray

GA_3 solution of 75 ppm, NAA solution of 50 ppm, CCC solution of 250 ppm, microbial consortium solution of 3 ml L^{-1} and humic acid solution of 2.5 ml L^{-1} was prepared by dissolving 75 mg of GA_3, 50 mg of NAA, 250 mg of CCC, 3 ml of microbial consortium and 3 ml of humic acid in 1 litre of water. Spraying was done by using knapsack sprayer at 35 and 70 days after sowing.

Foliage cutting

The foliage cutting at 45 days after sowing has been done by cutting the primary and secondary branches at a height of 10-12 cm (4-5 inches) from the soil surface, leaving the lower leaves intact to allow for continued photosynthesis. The foliage cutting at 60 days after sowing by cutting the primary and secondary branches at a height of 15-18 cm (6-7 inches) from the soil surface, leaving the lower leaves intact. Made clean cuts just above a node (where a leaf meets the stem) to promote healthy regrowth. The foliage cutting has been performed in the morning or late afternoon to minimize stress.

Observations were recorded for growth and yield parameters. The data obtained from the experiments were statistically analyzed by adopting appropriate statistical methods as outlined by Panse and Sukhatme (1985) [5].

Results and Discussion

The data pertaining to various plant growth and yield parameters (plant height, number of umbels per plant, number of flowers per umbel, number of seeds per umbel, foliage yield per hectare and seed yield per hectare) are presented in Table 1 and 2.

A perusal of the data revealed that the foliage cutting and foliar spray significantly affect the plant heightand maximum plant height (66.07 cm) was observed with foliage cutting at 45 DAS and foliar spray of humic acid @ 2.5 ml L^{-1} (C_1S_5) followed by one cut at 45 DAS with foliar spray of GA_3 @ 75 ppm (C_1S_1) (65.22 cm) and minimum plant height (54.35 cm) was recorded with the foliage cutting at 60 DAS along with the foliar spray of microbial consortium @ 3ml L^{-1} (C_2S_4).The maximum plant height of coriander was observed with the foliage cutting at 45 DAS along with the foliar spray of humic acid might be due to the optimal hormonal balance, enhanced nutrient uptake, increased cell division and expansion, reduced apical dominance and this synergistic effect increased the plant height.

The synergistic effect of cutting foliage and applying foliar spray on number of umbels per plantwas found to be significant. Among the interactions, significantly higher number of umbels per plant (35.83) was observed with the foliage cutting at 45 DAS along with the foliar spray of humic acid @ 2.5 ml L^{-1} (C_1S_5) and it was followed by one cut at 45 DAS with foliar spray of CCC @ 250 ppm (C_1S_3) (34.05). Significantly lower number of umbels per plant (19.93) was recorded with foliage cutting at 60 DAS along with the foliar spray of microbial consortium @ 3ml L^{-1}(C_2S_4). Foliage cutting at 45 DAS might promotes branching and encourages the plant to produce more umbels, while humic acid foliar spray might be provide essential nutrients that enhance umbel formation.

The joint effect of cutting foliage and spraying foliar applications for number of flowers per umbel was found to be significant. Among the interactions, significantly higher number of flowers per umbel (16.96) was observed with the foliage cutting at 45 DAS along with the foliar spray of humic acid @ 2.5 ml L^{-1} (C_1S_5) and followed by one cut at 45 DAS with foliar spray of CCC @ 250 ppm (C_1S_3) (16.03). Significantly lower number of flowers per umbel was recorded (5.01) with the foliage cutting at 60 DAS along with the foliar spray of microbial consortium @ 3ml L^{-1} (C_2S_4). Humic acid enhances nutrient uptake, leading to regulate plant hormones that promote cell elongation and cell division, resulting in increased flower production. Additionally, foliage cutting at 45 DAS reduces stress, allowing plants to focus energy on reproductive growth and humic acid foliar spray further enhances this effect. This combination might create a synergistic effect, leading to a significant increase in the number of flowers per umbel.

The combined impact of foliage cutting and foliar spraying for number of seeds per umbel was found to be significant.

Among the interactions, significantly higher number of seeds per umbel (11.03) was observed with the foliage cutting at 45 DAS along with the foliar spray of humic acid @ 2.5 ml L^{-1} (C_1S_5) and followed by one cut at 45 DAS with foliar spray of CCC @ 250 ppm (C_1S_3) (10.75). Significantly lower number of seeds per umbel (3.73) was recorded with the foliage cutting at 60 DAS along with the foliar spray of microbial consortium @ 3ml L^{-1} (C_0S_4). Foliage cutting at 45 DAS reduces stress and promotes reproductive growth, while humic acid foliar spray enhances nutrient uptake and hormone regulation, leading to increased seed production. The combination of these two practices creates a synergistic effect, resulting in a higher number of seeds per umbel.

The concurrent effect of foliage cutting and foliar spray treatments for foliage yield per hectare were found to be significant. Among the interactions, significantly higher foliage yield per hectare (154.25 q ha^{-1}) was observed with the foliage cutting at 45 DAS along with foliar spray of humic acid @ 2.5 ml L^{-1} (C_1S_5) and followed by one cut at 45 DAS with foliar spray of CCC @ 250 ppm (C_1S_3) (152.69 q ha^{-1}). Significantly lower foliage yield per plant (0.0 q ha^{-1}) was recorded in no foliage cutting treatment with all the foliar spray treatments (C_0S_1), (C_0S_2), (C_0S_3), (C_0S_4) and (C_0S_5). Foliage cutting at 45 DAS might promotes lateral branching and increases leaf growth, while humic acid foliar spray enhances nutrient availability resulting in increased foliage yield.

Table 1: Effect of foliage cutting and foliar spray on plant height at maturity, number of umbels per plantand number of flowers per umbelin coriander

Treatments	Plant height (cm)						Number of umbels per plant						Number of flowers per umbel					
	S_1	S_2	S_3	S_4	S_5	Mean (C)	S_1	S_2	S_3	S_4	S_5	Mean (C)	S_1	S_2	S_3	S_4	S_5	Mean (C)
C_0	62.97	57.47	55.83	55.87	65.16	59.46	28.59	24.75	30.98	22.94	32.99	28.05	12.53	12.26	13.34	10.33	13.76	12.44
C_1	65.22	61.17	57.39	56.87	66.07	61.34	31.72	27.91	34.05	26.05	35.83	31.11	15.03	14.33	16.03	10.43	16.96	14.55
C_2	57.96	56.28	54.47	54.35	58.11	56.23	25.92	21.83	27.89	19.93	29.94	25.10	9.61	8.91	10.61	5.01	11.54	9.13
Mean (S)	62.05	58.31	55.90	55.70	63.12		28.74	24.83	30.97	22.97	32.92		12.39	11.83	13.32	8.59	14.08	
	S.Em. ±			CD @ 5%			S.Em. ±			CD @ 5%			S.Em. ±			CD @ 5%		
C	0.18			0.54			0.006			0.019			0.04			0.12		
S	0.24			0.72			0.008			0.024			0.05			0.15		
C × S	0.41			1.21			0.014			0.041			0.09			0.27		

Legend

Factor I – Foliage cut: C_0 - No cut, C_1 – One cut at 45 DAS, C_2 – One cut at 60 DAS

Factor II – Foliar spray: S_1 – GA_3 at 75ppm, S_2 – NAA at 50 ppm, S_3 – CCC at 250 ppm, S_4 – Microbial consortia at 3 ml L^{-1}, S_5 – Humic acid a 2.5 ml L^{-1}

Table 2: Effect of foliage cutting and foliar spray on number of seeds per umbel, foliage yield per hectare and seed yield per hectare in coriander

Treatments	Number of seeds per umbel						Foliage yield per hectare (q ha^{-1})						Seed yield per hectare (q ha^{-1})					
	S_1	S_2	S_3	S_4	S_5	Mean (C)	S_1	S_2	S_3	S_4	S_5	Mean (C)	S_1	S_2	S_3	S_4	S_5	Mean (C)
C_0	8.77	7.11	9.66	5.99	10.20	8.63	0.00	0.00	0.00	0.00	0.00	0.00	11.84	8.00	14.23	6.19	16.24	11.3
C_1	9.92	8.80	10.75	7.93	11.03	9.88	151.58	149.92	152.74	148.58	154.25	151.41	14.97	11.16	17.31	9.30	19.08	14.36
C_2	7.82	5.39	8.88	3.73	9.59	7.49	75.45	72.30	79.07	66.79	82.80	75.28	9.17	5.08	11.14	3.18	13.19	8.35
Mean (S)	8.93	7.29	9.86	6.12	10.34		75.67	74.07	77.27	71.79	79.01		11.99	8.08	14.22	6.22	16.17	
	S.Em. ±			CD @ 5%			S.Em. ±			CD @ 5%			S.Em. ±			CD @ 5%		
C	0.002			0.006			0.30			0.89			0.012			0.034		
S	0.003			0.008			0.23			0.69			0.015			0.044		
C × S	0.005			0.013			0.53			1.54			0.026			0.076		

Legend

Factor I – Foliage cut: C_0 - No cut, C_1 – One cut at 45 DAS, C_2 – One cut at 60 DAS

Factor II – Foliar spray: S_1 – GA_3 at 75ppm, S_2 – NAA at 50 ppm, S_3 – CCC at 250 ppm, S_4 – Microbial consortia at 3 ml L^{-1}, S_5 – Humic acid a 2.5 ml L^{-1}

The integrated approach optimized plant growth and foliage production might leading to maximum foliage yield per hectare. The combined effect of foliage cutting and humic acid foliar spray resulted in significant increase in foliage yield and quality of coriander, attributed to enhanced nutrient uptake, reduced stress and ultimately leading to higher foliage yield per hectare.

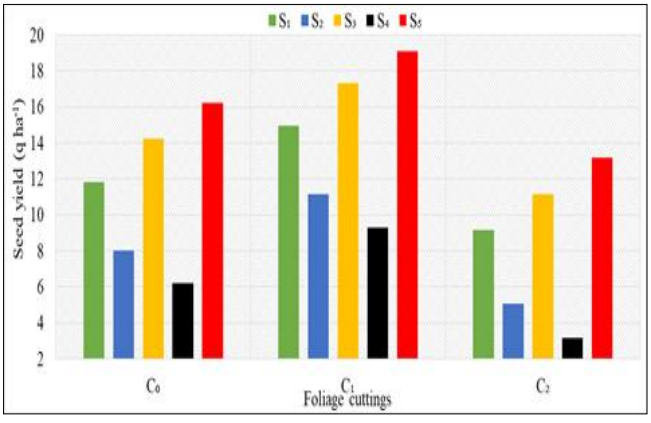

Fig 1: Influence of foliage cutting and foliar spray on seed yield of coriander

Legend

Factor I – Foliage cut: C_0 - No cut, C_1 – One cut at 45 DAS, C_2 – One cut at 60 DAS

Factor II – Foliar spray: S_1 – GA_3 at 75ppm, S_2 – NAA at 50 ppm, S_3 – CCC at 250 ppm, S_4 – Microbial consortia at 3 ml L^{-1}, S_5 – Humic acid a 2.5 ml L^{-1}

The combined influence of foliage cutting and foliar spray regimes for seed yield per hectare were found to be significant. Among the interactions, significantly higher seed yield per hectare (19.08 q ha^{-1}) was observed withthe foliage cutting at 45 DAS along with the foliar spray of humic acid @ 2.5 ml L^{-1} (C_1S_5) and followed by one cut at 45 DAS with foliar spray of CCC @ 250 ppm (C_1S_3) (17.31 q ha^{-1}). Significantly lowerseed yield per hectare (3.18 q ha^{-1}) was recorded with the foliage cutting at 60 DAS along with the foliar spray of microbial consortium @ 3ml L^{-1} (C_2S_4). In the synergistic effect of these two practices, foliage cutting at 45 DAS reduces apical dominance, promoting lateral branching and increasing seed-bearing umbels, while humic acid foliar spray enhances nutrient availability and resulting in increased seed yield.

Conclusion

In light of the results obtained from this investigation, it is concluded that, the combined impact of foliage cutting at 45 DAS and foliar spray of humic acid @ 2.5 ml L^{-1} was found to be superior for all the growth and yield parameters.

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