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Influence of foliage cutting and foliar spray of plant growth regulators and biostimulants on seed quality 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 seed quality. 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 spray 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 (2.5 ml L^{-1}) at flowering and seed setting stage significantly increased the seed germination (92.3 %), root length (8.66 cm), shoot length (9.64 cm), seedling dry weight (28.20 mg), seedling vigour index I (1670) and seedling vigour index II (2604). The foliage cutting at 45 DAS with humic acid spray at 2.5ml L^{-1} was found to be effective in enhancing seed quality of coriander.

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].

Producing high-quality coriander seeds with good foliage and seed yield is crucial due to its spice and economic value. Seed production requires specialized technical knowledge and favorable climatic conditions. Effective management of key factors such as date of leaving foliage crop for seed production, spraying PGRs and biostimulants at flowering, seed maturity and harvest time is essential. This determines seed vigour and viability, making it vital to establish optimal seed production and harvest times. However, technological gaps remain and increasing coriander seed production is a pressing need.

Seed quality is highly influenced by environment and has some major challenges. Coriander seed, a scizocarp, poses a challenge for germination due to its hard-outer shell, hindering easy sprouting. 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 bolting phenomenon compromises seed quality, 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 high quality seeds.

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 and quality (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, seed yield and quality. So overall to take good quality seed, 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, developmentof 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 (Nickelxl, 1982). 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 seed yield and quality. 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 quality 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 seed quality.

Materials and methods

Influence of foliage cutting and foliar spray of plant growth regulators and biostimulants on seed quality of coriander was carried out at Post Graduate Research Block of University of Agricultural Sciences Raichur, during rabi 2023-24. Seed quality parameters were determined in the laboratory of Department of Seed Science and Technology, University of Agricultural Sciences Raichur, Karnataka.

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 seed quality 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 seed quality parameters (seed germination, root length, shoot length, seedling dry weight, seedling vigour index-I and seedling vigour index-II) are presented in Table 1 and 2.

A perusal of the data revealed that, the cross-effect of foliage cutting and foliar spray treatments for seed germination were found to be non-significant.

The reciprocal impact of foliage cutting and foliar spraying for root length were found to be significant. Among the interactions, significantly higher root length (9.20 cm) 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) which was on par

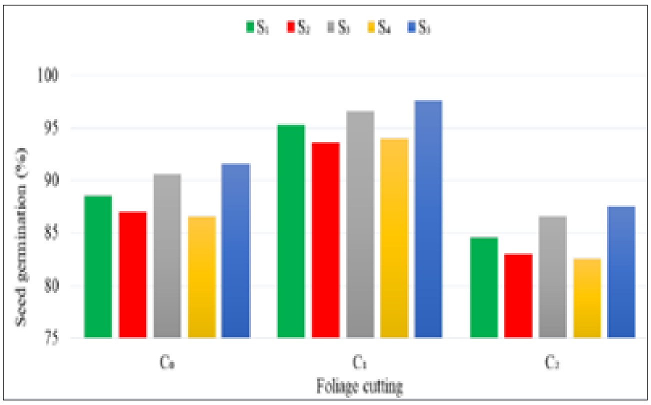

Fig. 1: Influence of foliage cutting and foliar spray on seed germination in resultant seeds of coriander

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}

with one cut at 45 DAS with foliar spray of CCC @ 250 ppm (C_1S_3) (8.99 cm). Significantly less root length (6.53 cm) was recorded with foliage cutting at 60 DAS along with the foliar spray of microbial consortium @ 3ml L^{-1} (C_2S_4). The maximum root length was observed with the foliage cutting at 45 DAS along with the foliar spray of humic acid can be attributed to the synergistic effect of these two practices. Foliage cutting at 45 DAS provides better seed quality that promotes root growth by increasing root hormones and nutrient uptake, while humic acid foliar spray enhances seed quality and induce plant growth regulators, resulting in improved root growth.

The correlated influence of foliage cutting and foliar spray applications for shoot length were found to be significant. Among the interactions, significantly higher shoot length (10.85 cm) 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) which was on par with one cut at 45 DAS with foliar spray of CCC @ 250 ppm (C_1S_3) (10.73 cm). Significantly less shoot length (7.36 cm) was recorded with foliage cutting at 60 DAS along with the foliar spray of microbial consortium @ 3 ml L^{-1} (C_2S_4). The synergistic effect of foliage cutting at 45 DAS provides better seed quality that promotes shoot growth by increasing growth hormones and nutrient uptake, while humic acid foliar spray enhances seed quality and induce plant growth regulators, resulting in improved shoot growth.

The associated effect of foliage cutting and foliar spray treatments for seedling dry weight was found to be significant. Among the interactions, significantly higher seedling dry weight (34.60 mg) 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) which was on par with one cut at 45 DAS with foliar spray of CCC @ 250 ppm (C_1S_3) (31.90 mg) and one cut at 45 DAS with foliar spray of GA_3 @ 75 ppm (C_1S_1) (30.23 mg). Significantly less seedling dry weight (14.90 mg) was recorded with the foliage cutting at 60 DAS along with the foliar spray of microbial consortium @ 3 ml L^{-1} (C_2S_4). Foliage cutting at 45 DAS provides better seed quality that promotes more root and shoot growth by increasing hormones and nutrient uptake, while humic acid foliar spray enhances seed quality and induce plant growth regulators, resulting in improved seedling dry weight.

The dependent influence of foliage cutting and foliar spraying for seedling vigour index-I were found to be significant. Among the interactions, significantly higher seedling vigour index-I (1436) 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) which was on par with one cut at 45 DAS with foliar spray of CCC @ 250 ppm (C_1S_3) (1369). Significantly less seedling vigour index-I (1148) was recorded with the foliage cutting at 60 DAS along with the foliar spray of microbial consortium @ 3 ml L^{-1} (C_2S_4). The timely cutting stimulates the production of growth

Table 1: Influence of foliage cutting and foliar spray on seed germination, root and shoot length in resultant seeds of coriander

Treatments	Seed germination (%)						Root length (cm)						Shoot length (cm)					
	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	88.6 (70.5)*	87.0 (68.9)	90.6 (72.3)	86.6 (68.6)	91.6 (73.3)	88.9 (70.7)	7.88	7.70	8.69	6.94	8.90	8.02	9.34	9.10	9.53	8.57	9.60	9.23
C_1	95.3 (78.3)	93.6 (75.6)	96.6 (79.6)	94.0 (75.9)	97.6 (81.5)	95.4 (78.2)	8.46	8.24	8.99	7.83	9.20	8.54	10.55	10.15	10.73	9.19	10.85	10.29
C_2	84.6 (67.0)	83.0 (65.6)	86.6 (68.6)	82.6 (65.4)	87.6 (69.5)	84.9 (67.2)	7.16	6.94	7.69	6.53	7.90	7.24	8.27	7.53	8.11	7.36	8.48	7.95
Mean (S)	89.5 (71.9)	87.8 (70.0)	91.3 (73.5)	87.7 (70.0)	92.3 (74.7)		7.83	7.62	8.45	7.10	8.66		9.39	8.92	9.46	8.37	9.64	
	S.Em. ±			CD @ 1%			S.Em. ±			CD @ 1%			S.Em. ±			CD @ 1%		
C	0.7			2.2			0.04			0.12			0.03			0.09		
S	0.9			2.9			0.05			0.16			0.04			0.12		
C × S	1.7			NS			0.09			0.27			0.07			0.22		

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}

NS – Non-significant

*Figures in the parenthesis indicate the arcsine transformed values

Table 2: Influence of foliage cutting and foliar spray on seedling dry weight, seedling vigour index-I and seedling vigour index-II in resultant seeds of coriander

Treatments	Seedling dry weight (mg)						Seedling vigour index-I						Seedling vigour index-II					
	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	22.96	18.50	21.70	19.10	26.10	21.67	1526	1462	1652	1344	1696	1534	2035	1609	1967	1655	2392	1927
C_1	30.23	27.50	31.90	25.33	34.60	29.91	1812	1723	1906	1599	1958	1798	2881	2576	3083	2381	3379	2855
C_2	22.40	15.30	23.60	14.9	23.90	20.02	1306	1201	1369	1148	1436	1290	1896	1269	2045	1231	2095	1701
Mean (S)	25.20	20.43	25.73	19.77	28.20		1542	1454	1636	1358	1670		2257	1795	2349	1735	2604	
	S.Em. ±			CD @ 1%			S.Em. ±			CD @ 1%			S.Em. ±			CD @ 1%		
C	1.02			2.98			12			35			95			279		
S	1.32			3.85			15			46			123			360		
C × S	2.29			6.84			27			82			214			640		

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}

hormones, leading to increased seedling vigour and robustness, resulting in a higher seedling vigour index-I. Humic acid's ability to reduce oxidative stress and improve membrane integrity contributes to its positive effect on seedling vigour. The synergistic effect of foliage cutting and foliar spray might enhance seed germination and seedling length that results in increase in seedling vigour index-I.

The combined impact of foliage cutting and foliar spraying for seedling vigour index-II was found to be significant. Among the interactions, significantly higher seedling vigour index-II (3379) 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) which was on par with one cut at 45 DAS with foliar spray of CCC @ 250 ppm (C_1S_3) (3083) and one cut at 45 DAS with foliar spray of GA_3 @ 75 ppm (C_1S_1) (2881). Significantly less seedling vigour index-II (2381) with the foliage cutting at 60 DAS along with the foliar spray of microbial consortium @ 3ml L^{-1} (C_2S_4). The timely cutting stimulates the production of growth hormones, leading to increased seedling vigour and robustness, resulting in a higher seedling vigour index-II. Humic acid's ability to reduce oxidative stress and improve membrane integrity contributes to its positive effect on seedling vigour. The synergistic effect of foliage cutting and foliar spray might enhance seed germination and seedling dry weight that results in increase in seedling vigour index-II.

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 seed quality parameters.

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