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Effect of biostimulant and growth regulators on herbage yield and quality in coriander var. CO (CR) 4

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Abstract
The experiment to study the effect of biostimulants and growth regulators on herbage and quality in coriander var CO (CR) 4 was conducted at College Orchard, Department of Spices and Plantation Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore (Tamil nadu), India during 2015- 2016. The objective of the this study is to find out the influence of bio-stimulants and growth regulators (Panchagavya @ 3 per cent, Vermiwash @ 3 per cent, Moringa leaf extract @ 3 per cent, PPFM @ 1 per cent, Cytozyme @ 1000 ppm, Tricontanol @ 5ppm, Humic acid @ 1000 ppm and Brassinosteroid @ 0.5 ppm) on plant growth, physiological parameters, yield, quality and cost economics of leafy coriander var CO (CR) 4. The experiment was laid out in a randomized block design with nine treatments replicated thrice and data was recorded during 2015 - 2016 and mean data presented Among the different treatments, foliar application of 1 per cent PPFM (T_4) recorded the maximum plant height of 46.26 cm while growth parameters like average number of primary branches (10.41) and number of leaves (41.90) were highest in foliar application of humic acid @ 1000 ppm (T_7). The physiological parameters *viz*., leaf area (41.79 cm^2), total chlorophyll (2.74 mg g^{-1}) and nitrate reductase activity (348.28 µg of No_2 g ha^{-1}) were found to be highest in 1000 ppm humic acid. Humic acid @ 1000 ppm enhanced the physiological and biochemical parameters and resulted in higher cumulative herbage yield of 4679.73kg ha^{-1} The quality parameters like leaf ascorbic acid (141.71 g 100 g^{-1}) and leaf protein (2.81 g 100 g^{-1}) were highest in the humic acid @ 1000 ppm. The higest benefit cost ratio (3.0) was registered in foliar application of humic acid @ 1000 ppm (T_7) compared to other treatments.

Keywords: biostimulants, growth regulators, herbage yield, quality and BC ratio

Introduction

Coriander (*Coriandrum sativum* L.) is an annual herb, which belongs to the family Apiaceae. It is a native of Mediterranean region and is considered as one of the most important vegetables, spices and medicinal plants. India is the largest producer, consumer and exporter of coriander with an area of 704,000 ha, production of 9,00,000 tonnes and productivity is 900 kg per ha (NHB, 2016) which accounts 80 % of world coriander production. In India, coriander is mainly cultivated in Rajasthan and Gujarat with a sizeable acreage in Madhya Pradesh, Haryana, Punjab, Uttar Pradesh, Andhra Pradesh, Tamil Nadu and Bihar. In Tamil Nadu, the area under coriander is 9,590 hectares with a production of 4,100 MT (NHB, 2016). The fresh green herb is also very popular all over the world for the usefulness in soups, salads, seasoning, and chutney. Besides, green herbs are rich in vitamin C, A and B2. In the recent years, the use of biostimulants and growth regulators has been increasing and their application is becoming a common practice in the sustainable agriculture. The main objective of using these products is to reduce chemical fertilizers and to accelerate the organic products for healthy life. Based on nutrient availability, biostimulants improve the nutrient use efficiency and plant productivity (Russo and Berlyn, 1992) [19]. Hence, the proposed work was planned in coriander crop with the objectives to study the effect of biostimulant and growth regulators on herbage yield, quality and cost economics in leafy coriander var. CO (CR) 4.

Materials and Methods

Experiments were conducted to study the effect of biostimulants and growth regulators on herbage yield and quality in coriander var. CO (CR) 4 at the Department of Spices and Plantation Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural

University, Coimbatore. The experiment was laid out in Randomized Block Design with nine treatments and was replicated thrice. Details of treatments are given below

T_0: Control
T_1: TNAU Panchagavya 3 %
T_2: Vermiwash @ 3 %
T_3: Moringa leaf extract 3 %
T_4: PPFM (Pink Pigmented Facultative Methylobacteria) @ 1 %
T_5: Cytozyme @ 1000 ppm
T_6: Triacontanol @ 5 ppm
T_7: Humic acid @ 1000 ppm
T_8: Brassinosteroid @ 0.5 ppm

The field was thoroughly prepared to a fine tilth. Seeds of coriander variety CO (CR) 4 were sown in lines adopting a spacing of 30 × 10 cm at the rate of 40 g per bed (2.0 m × 2.0 m). Plants were thinned at 30 days retaining 10 cm space between plants. The recommended packages of practices were followed uniformly in all the plots. The growth regulators and biostimulants were prepared according to the treatments and sprayed uniformly to the entire plot with the help of a hand sprayer during morning hours. The sprays were given at 35 DAS for leafy crop. Observations were taken five days after the application of biostimulants and growth regulators

Results and Discussion

Effect of biostimulants and growth regulators on plant height (cm)

Plant height is an important trait for growth, since increased plant height would allow greater biomass production and yield potential in crops. The plant height was significantly increased with all treatments compared to control (Table 1). Foliar application of 1 per cent PPFM recorded significantly higher plant height (46.26 cm) this was closely followed by humic acid @ 1000 ppm (43.06 cm). The plant height was less in control (28.95 cm). The highest plant height was recorded in PPFM 1 % (Fig.1) This might be due to the ability of PPFM to induce growth regulators including auxins and cytokinins in plants (Lee *et al.*, 2006 and Nadali *et al.*, 2010) [8, 14]. PPFM is necessary to improve the vegetative growth because malondialdehyde was concentrated in the meristematic cells and concomitant to cell division. PPFM can accelerate the rate of photosynthesis and decrease the rate of photorespiration (Lee *et al.*, 2006) [8], this is the possible reasons for obtaining maximum plant height in coriander in different stages.

Effect of biostimulants and growth regulators on number of primary branch and number of leaves per plant

The experimental results (Table 1) showed that increasing number of primary branches per plant (10.41) and number of leaves per plant (41.90) was observed in foliar application of humic acid @1000 ppm and the lowest number of primary branches (6.08) and number of leaves (21.75) was observed in control. The humic acid contains gibberllin like substances, which may lead to increased plant growth by producing more number of primary branches as reported by Vaughan *et al*. (1985) [22]. More number of side shoots obtained may also be owing to the presence of precursor of growth substance like IAA in humic acid, which could have increased the number of branches (Cossenove *et al*. 1990) [5]. Foliar spray of humic acid (1000 ppm) produced more number of leaves, this may be ascribed to the fact that humic acid has the optimum C: N ratio which on decomposition releases nitrogen in the form of usable nutrient ions such as ammonium and nitrate. This increase in the mineral constituents of soil might have exerted more number of leaves, since nitrogen is chief constituent of amino acids and coenzymes of biological importance. This is in concurrence with the findings of Maheswarappa *et al.* (2001) [10] in galangal and Adani *et al.* (1998) [1] in tomato.

Table 1: Effect of biostimulants and growth regulators on plant height, number of primary branches number of leaves per plant, leaf area, total chlorophyll and NRase activity in coriander var. CO (CR) 4 at 40 DAS

Treatments	Plant height (cm)	No. of primary branches per plant	No. of leaves per plant	Leaf area (cm^2)	Total chlorophyll mg g^{-1}
T_0 - Control	28.95	6.08	21.75	26.65	2.106
T_1 - TNAU Panchagavya (3%)	35.33	7.07	28.54	32.31	2.275
T_2 - Vermiwash (3%)	39.98	7.06	25.85	29.72	2.157
T_3 - Moringa leaf extract (3%)	33.84	6.52	24.76	29.36	2.182
T_4 - PPFM (1%)	46.26	7.98	31.67	39.42	2.458
T_5 - Cytozyme (1000 ppm)	34.73	7.40	27.58	30.34	2.258
T_6 - Triacontanol (5ppm)	38.23	9.85	39.18	40.61	2.691
T_7 - Humic acid (1000 ppm)	43.06	10.41	41.90	41.79	2.740
T_8 - Brassinosteroid (0.5 ppm)	38.96	7.97	29.62	33.73	2.408
SEd	1.38	0.28	1.12	1.22	0.085
CD @ 5%	2.78	0.57	2.27	2.47	0.172

\Effect of biostimulants and growth regulators on leaf area

The results (Table 1) revealed that superiority of foliar application of humic acid @1000 ppm showed more leaf area at 40 DAS (41.79 cm^2). However this was on par (40.61 cm^2) with of 5 ppm Triacontanol.Whereas control recorded the minimum leaf area (26.65 cm^2). Results of increasing leaf area suggested that uses of humic acid in coriander leaf cultivation have significant effect on biologic yield of coriander. According to Yildirim (2007), this improvement in biomass Yield may be related to the stimulation in the metabolism of micronutrients and macronutrients, activation of enzymes, changes in membrane permeability and protein synthesis. Further, Turkmen *et al.* (2005) [20] reported that application of humic acid increased the nitrogen content of shoot and root and which may lead to increases biomass of the crops. Bohme *et al.* (2001) [4], who reported an average of 105 per cent leaf area of cucumber was achieved by humic acid application. Similar observation of increase in leaf area was studied by Medeiros *et al*. (2001) [12] in lettuce.

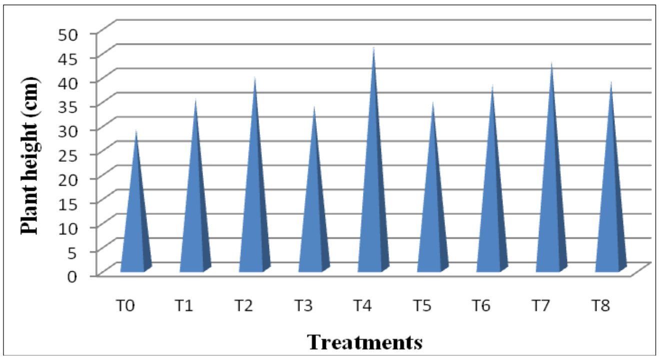

Fig 1: plant height cm

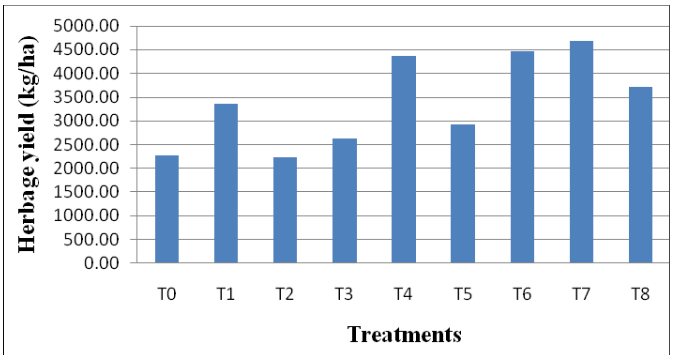

Fig 2: herbage yield kg ha^{-1}

Table 2: Effect of biostimulants and growth regulators on herbage yield, ascorbic acid, leaf protein, and B:C ratio in coriander var. CO (CR) 4 at 40 DAS

Treatments	NRase activity (µg NO_2 g^{-1} h^{-1})	Herbage yield per ha (kg)	Ascorbic acid (mg 100 g^{-1})	Leaf protein (g 100 g^{-1})	B : C ratio
T_0 - Control	322.90	2275.08	97.19	2.49	1.68
T_1 - TNAU Panchagavya (3%)	335.14	3360.91	119.11	2.59	2.18
T_2 - Vermiwash (3%)	331.84	2223.37	117.45	2.54	1.83
T_3 - Moringa leaf extract (3%)	327.73	2626.68	115.53	2.52	1.76
T_4 - PPFM (1%)	342.83	4374.35	129.62	2.66	2.51
T_5 - Cytozyme (1000 ppm)	333.61	2916.23	120.19	2.56	1.92
T_6 - Triacontanol (5ppm)	347.47	4467.42	134.95	2.69	2.64
T_7 - Humic acid (1000 ppm)	348.28	4679.73	141.71	2.81	3.00
T_8 - Brassinosteroid (0.5 ppm)	337.59	3705.61	125.02	2.60	2.36
SEd	12.22	125.46	4.54	0.09	
CD @ 5%	24.58	252.19	9.13	0.19	

Effect of biostimulants and growth regulators on total chlorophyll

The foliar application of biostimulants and growth regulators significantly improved the photosynthetic pigments in coriander leaves over control (Table1). The highest total chlorophyll (2.740 mg g^{-1}) content was observed in Humic acid @1000 ppm followed by foliar spraying of Triacontanol @ 5 ppm and minimum total chlorophyll (2.106 mg g^{-1}) was observed in the treatment T_0 (control). The increased chlorophyll content may be due to increased intake of iron by tomato grown in the presence of humic substances (Guminski *et al.*, 1965) [7]. Fernandez (1968) [6] added that the enhanced uptake of Mg^{2+} and Fe^{2+} in the presence of humic acid resulted in enhanced chlorophyll synthesis. These findings are in accordance with the reports of Peng Zheng Ping *et al*, (2001) [18] in brassica.

Effect of biostimulants and growth regulators on NRase activity

The treatment T_7 (Humic acid @ 1000 ppm) registered (Table 2) the maximum nitrate reductase activity (348.28 µg of NO_2 g^{-1} h^{-1}) which was on par with T_6 (Triacontanol @ 5 ppm) (347.47 µg of NO_2 g^{-1} h^{-1}) at 40 DAS. The minimum nitrate reductase activity was found in treatment T_0 (control) with 322.90 µg of NO_2 g^{-1} h^{-1}. The possible reason could be that humic acid enhances nitrate reductase activity in plants. This enzyme regulates nitrogen availability to plants. Improved nitrogen metabolism particularly through nitrase reductase activity might enhance the yield. The present findings are in consonance with earlier findings of Vadiraj *et al.* (1998) [21], Maheswarappa *et al.* (2001) [10] in galangal and Mridhula and Jayachandran (2001) [13] in turmeric.

Effect of biostimulants and growth regulators on herbage yield per hectare

The experiment (Table 2) revealed foliar spraying of Humic acid @ 1000 ppm had the higher herbage yield per hectare of 4679.73 kg which was on par with T_6 (Triacontanol @ 5 ppm) (4467.42 kg) and the treatment T_0 (control) had the lowest herbage yield per hectare (2275.08 kg). The maximum yield may be due to humus substances present in humic acid (Fig.2) could have mobilized the reserve food materials to the sink through increased activity of hydrolyzing and oxidizing enzymes. This would help the better availability and utilization of nutrients. All these scavenging effects might have made quick mobilizing. Availability of nutrients, which would have aided in increased the number of leaves, leaf area, leaf area index, photosynthetic rate. This in turn could have assisted for greater fresh weight of leaves. All these factors ultimately resulted in higher leaf yield in this particular treatment. This is in confirmation with findings of Mato and Mendez (1970) [11].

Effect of biostimulants and growth regulators on ascorbic acid and leaf protein

The experimental result (Table 2) showed that quality characters, such as ascorbic acid and soluble protein were also significantly influenced by the treatments The higher leaf ascorbic acid (141.71 mg 100 g^{-1}) and leaf protein content (2.81 g 100 g^{-1}) was observed from treatment T_7 (Humic acid @ 1000 ppm) the lowest ascorbic acid (97.19 mg 100 g^{-1}) and leaf protein content (2.49 g 100 g^{-1}) was recorded in control (T_0). Application of humic acid Increased the IAA activity which enhanced the sucrose synthetase activity and there by promotes the ascorbic acid content. The foliar Spraying of humic acid enhances nitrogen metabolism particularly through nitrate reductase activity might have resulted to increase the protein content in coriander leaves. The present findings are in consonance with earlier findings of Vadiraj *et al.* (1998) [21], Maheswarappa *et al.* (2001) [10] in galangal, Mridhula and Jayachandran (2001) [13] in turmeric.

Effect of biostimulants and growth regulators on economics of cultivation

The economics for different treatments was worked out (Table 2) and the results indicated that highest benefit – cost ratio 3.0 was observed in T_7 followed by treatment T_6 (2.64) the lowest benefit cost ratio (1.68) was recorded in T_0 (control).

Conclusion

The present study indicated that foliar application of humic acid 1000 ppm at 35 DAS after sowing was economical and significantly increase the herbage yield of coriander.

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