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Original Research Paper

Effect of biofertilizers and micronutrients on growth, leaf yield and quality of coriander (*Coriandrum sativum* L.) cv. Sadhana

Y. Mounika, G. Thanuja Sivaram*, P. Syam Sundar Reddy and M. Ramaiah
College of Horticulture, Dr. YSR Horticultural University, Anantharajupeta 516 105, YSR Dist. (A.P.), India
*E-mail: th_09@rediffmail.com

ABSTRACT

A field experiment was conducted during *rabi* 2015-16 at Research Farm, College of Horticulture, Dr.Y.S.R. Horticultural University, Anantharajupeta (Andhra Pradesh), India, to study the effect of different biofertilizers and micronutrients on growth, leaf yield and quality of coriander (*Coriandrum sativum* L.) cv. Sadhana. The experiment was conducted in a factorial randomized block design with biofertilizers and micronutrients. The biofertilizer treatments were seed inoculation with *Azospirillum*, Phosphate Solubilising Bacteria (PSB), *Azospirillum* + Phosphate Solubilising Bacteria (PSB) and control (without any biofertilizer), while the micronutrient treatments comprised of foliar sprays of Zinc sulphate, Copper sulphate, Ferrous sulphate each at @ 0.5% and control (without any micronutrient). The sixteen treatment combinations were replicated thrice. Among the treatments, seed inoculation with *Azospirillum* + PSB+ foliar spray of zinc sulphate @ 0.5% recorded maximum plant height, number of primary branches, leaf area, fresh leaf yield per plant, leaf yield per plot, leaf yield per hectare, dry matter production, protein content, ascorbic acid content and moisture content. While, the lowest days to germination and leaf chlorophyll contents were recorded with the seed inoculation of *Azospirillum* + PSB + foliar spray of ferrous sulphate @ 0.5%.

Key words: Coriander, growth, biofertilizers, micronutrients, quality, yield.

INTRODUCTION

Coriander (*Coriandrum sativum L.*) is a major seed spice of India, and is mainly cultivated in the states of Rajasthan, Gujarat, Andhra Pradesh, Madhya Pradesh, Tamil Nadu, Orissa, Karnataka, Uttar Pradesh and Bihar, with a production of 52.4 million tonnes from 54.3 million hectares (NHB, 2013). Andhra Pradesh ranks second in production of coriander and ranks first among the Southern states of the country. The share of Andhra Pradesh is highest i.e. 26,000 metric tonnes from 21,800 hectares (NHB, 2015). Coriander is globally referred to as Cilantro or Chinese parsley, and is very popular around the world for the use in soups, salads, dressing of vegetables and seasoning purposes .Under Andhra Pradesh conditions, the crop has to survive under residual soil moisture throughout the cropping period and generally experiences terminal moisture stress which results in poor yields, which has been identified as a major constraint in coriander production (Sarada *et al*., 2008). In recent years, biofertilizers have emerged as an important component of integrated nutrient supply system and have shown promise to improve crop yields and nutrient supplies. *Azotobacter*, PSB and *Azospirillum* are the widely used biofertilizers, that significantly contribute N and P to plants besides providing tolerance to water stressed situations (Maheshwari *et al.* 1991). Kalidasu *et al.* 2008., reported that the beneficial effect of foliar application of micronutrients on crops may be due to the improved ability of the crop to absorb nutrients, photosynthesis and better sink source relationship as these play vital role in various biochemical processes. Since information regarding the use of biofertilizers and micronutrients suitable for rainfed vertisols of Andhra Pradesh is very meagre, the present field experiment was conducted to study the effect of biofertilizers and micronutrients on growth, leaf yield and quality of coriander.

MATERIAL AND METHODS

A field experiment was conducted during *rabi* 2015-16 at Research Farm, College of Horticulture, Dr. Y.S.R. Horticultural University, Anantharajupeta, Andhra Pradesh (India).The experiment was laid out in factorial randomized block design with sixteen treatments, *viz.*, B_1M_1-Seed inoculation with *Azospirillum*+ foliar spray of $ZnSO_4$ @ 0.5%, B_1M_2-Seed inoculation with *Azospirillum* + foliar spray of $FeSO_4$ @0.5%, B_1M_3-Seed inoculation with *Azospirillum*+ foliar spray of $CuSO_4$ @ 0.5%, B_1M_0-Seed inoculation with *Azospirillum*, B_2M_1- Seed inoculation with PSB + foliar spray of $ZnSO_4$@ 0.5%, B_2M_2-Seed inoculation with PSB +foliar spray of $FeSO_4$ @ 0.5%, B_2M_3-Seed inoculation with PSB +foliar spray of $CuSO_4$@ 0.5%, B_2M_0-Seed inoculation with PSB, B_3M_1-Seed inoculation with *Azospirillum* +PSB+foliar spray of $ZnSO_4$@ 0.5%, B_3M_2-Seed inoculation with *Azospirillum* + PSB +foliar spray of $FeSO_4$@ 0.5%,B_3M_3-Seed inoculation with *Azospirillum*+PSB+ foliar spray of $CuSO_4$ @ 0.5%,B_3M_0-Seed inoculation with *Azospirillum* +PSB, B_0M_1- Foliar spray of $ZnSO_4$ @ 0.5%, B_0M_2- Foliar spray of $FeSO_4$ @ 0.5 %, B_0M_3-Foliar spray of $CuSO_4$ @0.5%, B_0M_0-Control. Seeds were sown in 2 m × 2m plots with a spacing of 20 cm × 15 cm. The crop was fertilized with 10 t of FYM along with NPK @ 30: 40: 20 kg/ha as basal. Two third's of the nitrogen was applied as top dressing in two equal splits i.e. at 20 and 40 DAS. Need based cultural and plant protection operations were taken up to the leaf harvest. Five plant samples from each replication were selected at random to record data on morphological, yield and quality attributing characters. The experimental data was analysed statistically as outlined by Panse and Sukhatme (1995).

RESULTS AND DISCUSSION

Morphological characters

Morphological characters such as plant height, number of primary branches per plant **(Table 1)**, leaf area per plant **(Table 2)** showed significant variation with different biofertilizers and micronutrient treatments. Among the biofertilizers, seed inoculation with *Azospirillum* + PSB recorded highest plant height at harvest (29.03 cm), number of primary branches at harvest (4.30) and leaf area (67.95cm^2) at 45 days of leaf harvest. The days to germination **(Table 1)** of coriander seed was significantly influenced by seed treatment with biofertilizers. As the application of micronutrients was done post-emergence of the crop, the micronutrient effect and the interaction between biofertilizers and micronutrients application were found to be non-significant. The observed differences between the control and inoculated treatments could

Table 1. Effect of biofertilizers and micronutrients on the days to germination, plant height at harvest and number of primary branches at harvest of coriander cv. Sadhana.

	Days to germination					Plant height (cm) at harvest					Number of primary branches at harvest				
						Biofertilizers									
Micronutrients	B_0	B_1	B_2	B_3	Mean	B_0	B_1	B_2	B_3	Mean	B_0	B_1	B_2	B_3	Mean
M_0	8.1	7.2	7.4	7.8	7.6	20.2	24.2	24.8	26.0	23.8	2.8	3.5	2.2	4.2	3.2
M_1	7.2	6.6	7.5	7.4	7.2	23.0	27.3	26.4	36.3	30.8	3.0	4.2	3.4	4.4	3.8
M_2	7.1	7.6	7.2	6.4	7.1	22.4	27.8	28.0	32.6	26.2	3.1	3.9	3.9	4.2	3.7
M_3	8.3	7.4	7.1	7.4	7.6	23.1	26.0	27.6	31.2	26.0	3.0	3.6	3.2	4.3	3.5
Mean	7.7	7.2	7.3	7.3		22.2	27.5	28.0	29.0		3.0	3.8	3.2	4.3	
Source	B		M		B×M	B		M		B×M	B		M		B×M
S. E m ±	0.13		0.13		0.25	0.17		0.17		0.34	0.02		0.02		0.05
CD *(P=0.05)*	0.37		NS		NS	0.49		0.49		0.99	0.07		0.07		0.13

B_0 : Control
B_1 : Seed inoculation with *Azospirillum*
B_2 : Seed inoculation with PSB
B_3 : Seed inoculation with *Azospirillum* + PSB

M_0 : Control
M_1: Foliar spray of $ZnSO_4$ @ 0.5%
M_2: Foliar spray of $FeSO_4$ @ 0.5%
M_3: Foliar spray of $CuSO_4$ @ 0.5%

Table 2. Effect of biofertilizers and micronutrients on leaf area, dry matter production and moisture of coriander cv. Sadhana

	Leaf area (cm^2)					Dry matter production (g/plant)					Moisture (%)				
	Biofertilizers														
Micronutrients	B_0	B_1	B_2	B_3	Mean	B_0	B_1	B_2	B_3	Mean	B_0	B_1	B_2	B_3	Mean
M_0	27.35	50.15	44.21	60.65	45.59	0.46	0.59	0.50	0.58	0.53	82.28	85.65	86.00	86.25	85.04
M_1	40.15	66.21	64.18	75.65	61.55	0.53	0.60	0.63	0.78	0.64	85.21	85.28	84.65	90.15	86.32
M_2	38.65	63.65	56.82	71.25	57.59	0.50	0.62	0.62	0.68	0.61	83.65	84.56	82.65	88.19	84.76
M_3	33.25	58.34	48.68	64.25	51.13	0.48	0.63	0.64	0.65	0.60	84.34	83.85	84.65	88.65	85.37
MEAN	34.85	59.59	53.47	67.95		0.49	0.61	0.60	0.67		83.87	84.84	84.48	88.31	
Source	B		M		B×M	B		M		B×M	B		M		B×M
S.E M ±	0.35		0.35		0.69	0.003		0.003		0.008	0.56		0.56		1.13
CD (*P=0.05*)	1.00		1.00		2.00	0.01		0.01		0.02	1.63		1.63		3.26

B_0 : Control
B_1 : Seed inoculation with *Azospirillum*
B_2 : Seed inoculation with PSB
B_3 : Seed inoculation with *Azospirillum* + PSB

M_0 : Control
M_1: Foliar spray of $ZnSO_4$ @ 0.5%
M_2: Foliar spray of $FeSO_4$ @ 0.5%
M_3: Foliar spray of $CuSO_4$ @ 0.5%

be attributed to the availability of atmospheric nitrogen and soil phosphorus as a result of microbial inoculation, have led to better root and shoot development, better uptake of water, nutrients and their transportation. The observed results were in accordance with Rahimi *et al*. (2009) in coriander and Mehta *et al*. (2012) in fenugreek.

Among the different micronutrients, the foliar application of zinc sulphate @ 0.5 % (M_1) recorded significantly higher plant height at harvest (30.81cm), number of primary branches at harvest (3.83) and leaf area (61.55 cm^2) at 45 days of leaf harvest. This could be attributed to fact that zinc is an activator of enzymes, and is involved in protein synthesis besides having a direct effect on the enzymatic regulation in plants. The synthesis of tryptophan, the precursor of Indole Acetic Acid (IAA) in the presence of zinc, could be attributed to the improved plant growth as previously described by Ingle *et al*. (1993) in chilli and Chhibba *et al*. (2007) in fenugreek.

The combination of *Azospirillum* + PSB + foliar spray of zinc sulphate @ 0.5% (B_3M_1), recorded significantly higher plant height at harvest (36.31cm), number of primary branches at harvest (4.40) and leaf area (75.65cm^2) at 45 days of leaf harvest.

Yield and yield attributes

The yield and yield attributing characters, such as fresh leaf yield per plant, leaf yield per plot, leaf yield per hectare **(Table 3)** and dry matter production **(Table 2)** also showed significant variation among the different biofertilizer and micronutrient treatments. Among the biofertilizers, seed inoculation with *Azospirillum* + PSB recorded maximum leaf yield per plant (3.74g), leaf yield per plot (0.48 kg), leaf yield per hectare (1.22t) and dry matter production (0.97g per plant). The application of biofertilizers might have enhanced the availability of nutrients and the production of growth hormones by bacteria could have contributed to the increase in the length and breadth of leaves leading to increased leaf yield. Similar results were obtained by Singh *et al*. (2012) and Sonali *et al*. (2012) in fenugreek.

Among different micronutrients, the foliar application of zinc sulphate @ 0.5 % (M_1) recorded significantly higher leaf yield per plant (3.60g), leaf yield per plot (0.46kg), leaf yield per hectare (1.18t) and dry matter production (0.64g per plant). Similar results were observed by Chhibba *et al*. (2007) in fenugreek.

Interaction effect of biofertilizers and micronutrients on seed inoculation with *Azospirillum* + PSB + foliar spray of zinc sulphate @ 0.5% B_3M_1 recorded significantly maximum leaf yield per plant (3.94g), leaf yield per plot (0.50 kg), leaf yield per hectare (1.30t) and dry matter production (0.78g per plant).

Table 3. Effect of biofertilizers and micronutrients on leaf yield per plant, leaf yield per plot and leaf yield per hectare of coriander cv. Sadhana.

	Leaf yield per plant (g)					Leaf yield per plot (kg)					Leaf yield per hectare (t/ha)				
	Biofertilizers														
Micronutrients	B_0	B_1	B_2	B_3	Mean	B_0	B_1	B_2	B_3	Mean	B_0	B_1	B_2	B_3	Mean
M_0	2.8	3.1	3.0	3.4	3.1	0.3	0.4	0.4	0.4	0.40	0.9	1.0	1.0	1.1	1.0
M_1	3.2	3.6	3.5	3.9	3.6	0.4	0.4	0.4	0.5	0.46	1.0	1.2	1.1	1.3	1.1
M_2	3.0	3.2	3.3	3.8	3.3	0.4	0.4	0.4	0.4	0.44	0.9	1.1	1.1	1.2	1.1
M_3	2.9	3.2	3.2	3.7	3.3	0.3	0.4	0.4	0.4	0.42	0.9	1.0	1.0	1.2	1.0
Mean	3.0	3.3	3.3	3.7		0.4	0.4	0.4	0.4		0.9	1.1	1.0	1.2	
Source	B		M		B×M	B		M		B×M	B		M		B×M
S. E m ±	0.02		0.02		0.04	0.01		0.01		0.02	0.01		0.01		0.02
CD (*P=0.05*)	0.06		0.06		0.12	0.03		0.03		0.09	0.02		0.02		0.04

B_0 : Control
B_1 : Seed inoculation with *Azospirillum*
B_2 : Seed inoculation with PSB
B_3 : Seed inoculation with *Azospirillum* + PSB

M_0 : Control
M_1: Foliar spray of $ZnSO_4$ @ 0.5%
M_2: Foliar spray of $FeSO_4$ @ 0.5%
M_3: Foliar spray of $CuSO_4$ @ 0.5%

Quality characters

With regards to quality characters, viz., moisture content **(Table 2)**, ascorbic acid content, protein content and chlorophyll content **(Table 4)** were significantly affected by different biofertilizers and micronutrients. Among the biofertilizers, seed inoculation with Azospirillum + PSB recorded maximum moisture content (88.31%), ascorbic acid content (140.47 $mg100g^{-1}$), protein (3.72%) and chlorophyll contents (1.33mg $100g^{-1}$). Similar results were observed by Singh (2015) in coriander.

Among the different micronutrients, foliar application of zinc sulphate @ 0.5 % (M_1) recorded significantly higher moisture content (86.32%), ascorbic acid content (137.32$mg100g^{-1}$) and protein content (3.63%).While, chlorophyll content in leaf was maximum (1.27 $mg100g^{-1}$) with foliar application of ferrous sulphate @ 0.5 % (M_2). These results are in

Table 4. Effect of biofertilizers and micronutrients on ascorbic acid, total chlorophyll and protein content of coriander cv. Sadhana

	Ascorbic acid (mg/100 g)					Total Chlorophyll (mg/100 g)					Proteins (%)				
	Biofertilizers														
Micronutrients	B_0	B_1	B_2	B_3	Mean	B_0	B_1	B_2	B_3	Mean	B_0	B_1	B_2	B_3	Mean
M_0	115.3	129.6	125.0	134.2	126.0	1.0	1.1	1.1	1.2	1.1	2.8	3.3	3.4	3.5	3.3
M_1	123.6	140.8	139.6	146.6	137.7	1.1	1.2	1.2	1.3	1.2	3.3	3.6	3.6	3.8	3.6
M_2	119.2	136.2	135.2	142.2	133.2	1.1	1.2	1.2	1.4	1.2	3.2	3.5	3.5	3.7	3.5
M_3	117.7	134.8	128.4	138.6	129.9	1.0	1.2	1.1	1.3	1.2	3.1	3.6	3.4	3.7	3.5
Mean	119.0	135.3	132.1	140.4		1.1	1.2	1.2	1.3		3.1	3.5	3.5	3.7	
Source	B		M		B×M	B		M		B×M	B		M		B×M
S. E m ±	0.85		0.85		1.70	0.01		0.01		0.02	0.02		0.02		0.04
CD (*P=0.05*)	2.45		2.45		4.90	0.02		0.02		0.05	0.06		0.06		0.13

B_0 : Control
B_1 : Seed inoculation with *Azospirillum*
B_2 : Seed inoculation with PSB
B_3 : Seed inoculation with *Azospirillum* + PSB

M_0 : Control
M_1: Foliar spray of $ZnSO_4$ @ 0.5%
M_2: Foliar spray of $FeSO_4$ @ 0.5%
M_3: Foliar spray of $CuSO_4$ @ 0.5%

line with the earlier findings of Rajamanickam *et al.* (2011) in mint.

The interaction effect of biofertilizers and micronutrients on seed inoculation with *Azospirillum* + PSB + foliar spray of zinc sulphate @ 0.5% B_3M_1 recorded significantly higher moisture content (90.15%), ascorbic acid content (146.68mg100g^{-1}) and protein content (3.80%).While, chlorophyll content in leaf was maximum (1.40 mg100g^{-1}) with seed inoculation of Azospirillum + PSB + foliar spray of ferrous sulphate @ 0.5%.

The results obtained from the present investigation inferred that the combination of seed inoculation with Azospirillum + PSB along with foliar application of $ZnSO_4$ @ 0.5 per cent showed significant influence on vegetative growth, leaf yield and quality parameters in coriander cv. Sadhana.

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