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Influence of Biofertilizers and Micronutrients on Growth, Seed Yield and Quality of Coriander (*Coriandrum sativum* L.) cv. Sadhana

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A B S T R A C T

A field experiment was conducted during *rabi* 2015-16 at Research Farm, College of Horticulture, Dr. Y.S.R. Horticultural University, Anantharajupet (Andhra Pradesh), India, to study the effect of biofertilizers and micronutrients on growth, seed yield and quality of coriander (*Coriandrum sativum* L.) cv. Sadhana. The experiment was evaluated in randomized block design with factorial concept consists two factors like biofertilizers and micronutrients. The first factor comprised of seed inoculation with Azospirillum, Phosphate solubilising bacteria, Azospirillum + Phosphate solubilising bacteria and control (without any biofertilizer) and the second factor consists foliar spray of Zinc sulphate, Copper sulphate, Ferrous sulphate each at @ 0.5% and control (without any micronutrient). Sixteen treatment combinations were replicated thrice. Among the treatments, seed inoculation with Azospirillum + Phosphate solubilising bacteria+ foliar spray of zinc sulphate @ 0.5% recorded maximum plant height, number of primary branches, number of secondary branches, days to maturity, number of umbels per plant, umbellets per umbel, seeds per umbel, 100 seed weight, seed yield g per plant, seed yield kg per hectare, Total carbohydrates, essential oils, oleoresins, moisture content. While, the lowest Days to germination was maximum with seed inoculation of Azospirillum + Phosphate solubilising bacteria + foliar spray of ferrous sulphate @ 0.5%.

Introduction

Coriander (*Coriandrum sativum L.*) is one of the major seed spices grown in India. India is the largest producer of coriander in the world and is mainly cultivated in Rajasthan, Gujarat, Andhra Pradesh, Madhya Pradesh, Tamil Nadu, Orissa, Karnataka, Uttar Pradesh and Bihar producing 52.4 million tonnes from 54.3 million hectares (NHB, 2013). Andhra Pradesh ranks second in production of coriander and ranks first in the Southern states of the country. The share of Andhra Pradesh is maximum i.e. 26,000 metric tonnes from 21,800 hectares (NHB, 2015). The coriander seeds are rich in carbohydrate and protein content. The aromatic nature of the plant is due to the presence of an essential oil (terpene tertiary alcohol i.e. linalool or coriandrol) present in seeds and leaves. The oil is used in perfumery, confectionery, cosmetics, for flavouring liquors and beverages.

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 is the major constraint in production of coriander in Andhra Pradesh (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 most wide spread biofertilizers significantly contributing N, P and K to plants and also providing resistance to drought situation (Maheshwari *et al.,* 1991).

(Kalidasu *et al.,* 2008) reported that foliar application of micronutrients on crop growth 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. Information regarding the use of biofertilizers and micronutrients suitable for rain fed vertisols in Andhra Pradesh is very meagre. Keeping this in view, the present field experiment was conducted to study the effect of biofertilizers and micronutrients on growth, seed yield and quality of coriander.

Materials and Methods

Present 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 randomized block design with factorial concept triplicate 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_4- 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_4 - 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_4-Seed inoculation with Azospirillum + PSB, B_4M_1- Foliar spray of $ZnSO_4$ @ 0.5%, B_4M_2- Foliar spray of $FeSO_4$ @ 0.5 %, B_4M_3 - Foliar spray of $CuSO_4$ @0.5%, B_4M_4 - Control. Seeds were sown in the plot of 2 m × 2m at 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 of 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 seed harvest. Five plant samples from each replication were selected at random to record data morphological, yield and quality attributing characters. The experimental data was analysed statistically by the method of analysis of variance as out lined by Panse and Sukhatme (1995).

Results and Discussion

Growth parameters

Morphological characters

Morphological characters such as plant height, number of primary branches per plant (Table 1), secondary branches per plant and days to maturity (Table 2) showed significant variation with different biofertilizers and micronutrients.

Height of plant

Among the biofertilizers, seed inoculation with Azospirillum + Phosphate solubilising bacteria recorded highest plant height at harvest (70.78 cm), number of primary branches at harvest (6.72), secondary branches per plant (15.51) and lowest days to maturity (96.75). Days to germination (Table 1) of coriander seed was significantly influenced by seed treatment with biofertilizers.

As the application of micronutrients was post-emergence of the crop, the micronutrient effect and the interaction between biofertilizers and micronutrients application were non- significant.

This might be due to Azospirillum and phosphate solubalizing bacteria that help to increase the nitrogen availability. Balanced or integrated nutrient management which enhances the synthesis of the carbohydrates, phytohormones and even biofertilizers also promote maximum growth of crop and build up organic status of the soil that also increases the availability of other nutrients.

The results are in conformity with those of Sahu *et al.,* (2014) in coriander.

Among different micronutrients, foliar application of zinc sulphate @0.5 % (M_1) recorded significantly highest plant height at harvest (70.45cm), number of primary branches at harvest (6.35), secondary branches per plant (15.29) and lowest days to maturity (97.29).

This might be due to the involvement of Zn in protein synthesis and in biosynthesis of plant hormones by activating tryptophan, which is a precursor of IAA (auxin), a growth harmone, involved in cell division and cell elongation which in turn promotes the vertical growth of the plant. The results are in conformity with those of Choudhary *et al.,* (2014) in garlic, Manna *et al.,* (2014) and Acharya *et al.,* (2015) in onion. Combination of biofertilizers and micronutrients on seed inoculation with Azospirillum + Phosphate solubilising bacteria+ foliar spray of zinc sulphate @0.5% B_3M_1 recorded significantly highest plant height at harvest (73.85cm), number of primary branches at harvest (6.99), secondary branches per plant (15.80) and lowest days to maturity (95.25).

Yield and yield attributes

The yield and yield attributing characters, such as Number of umbels per plant (Table 2), umbellets per umbel, seeds per umbel, 100 seed weight (Table 3), seed yield g per plant and seed yield kg per hectare (Table 4) were also showed significant variation among the different biofertilizers and micronutrients.

Among the biofertilizers, seed inoculation with Azospirillum + Phosphate solubilising bacteria recorded maximum Number of umbels per plant (26.83), umbellets per umbel (6.56), seeds per umbel (35.49), 100 seed weight (1.63), seed yield g per plant (5.00) and seed yield kg per hectare (1196.75 kg).

It is obvious that availability of P improved by PSB, N taped from atmosphere by Azospirillum and soil was already have sufficient amount of K leads to balance supply of major nutrients and ultimately contributed to higher yield and yield attributing characters.

These results are in agreement with those reported by Belimov *et al.,* (1995) in barley.

Among different micronutrients, foliar application of zinc sulphate @0.5 % (M_1) recorded significantly maximum Number of umbels per plant (24.77), umbellets per umbel (6.41), seeds per umbel (32.11), 100 seed weight (1.60), seed yield g per plant (4.91) and seed yield kg per hectare (1149.90 kg).

Table.1 Effect of biofertilizers and micronutrients on days to germination, Plant height (cm) at harvest and Number of primary branches at harvest of coriander cv. Sadhana

Micronutrients	Days to germination					Plant height (cm) at harvest					Number of primary branches at harvest				
	Biofertilizers														
	B_1	B_2	B_3	B_4	Mean	B_1	B_2	B_3	B_4	Mean	B_1	B_2	B_3	B_4	Mean
M_1	7.38	7.71	6.88	7.38	7.40	70.25	70.25	73.85	65.48	70.45	6.52	6.54	6.99	5.35	6.35
M_2	7.96	7.40	7.00	7.25	7.41	62.28	69.68	72.23	63.68	67.34	6.56	6.10	6.56	5.85	6.27
M_3	7.65	7.25	7.65	8.25	7.83	63.45	68.45	71.28	65.28	66.72	6.25	6.35	6.98	5.30	6.22
M_4	7.41	7.65	8.00	8.85	7.85	61.28	61.48	69.35	60.38	63.12	6.23	5.40	6.35	5.15	5.78
Mean	7.48	7.50	7.57	7.93		64.32	68.83	70.78	63.71		6.39	6.10	6.72	5.41	
Source	**B**		**M**		**B×M**	**B**		**M**		**B×M**	**B**		**M**		**B×M**
S. Em ±	0.05		0.05		0.10	0.43		0.43		0.86	0.04		0.04		0.08
CD (*P=0.05*)	0.29		NS		NS	1.24		1.24		2.48	0.12		0.12		0.23

Table.2 Effect of biofertilizers and micronutrients on Number of secondary branches at harvest, Days to maturity and Number of umbels per plant of coriander cv. Sadhana

Micronutrients	Number of secondary branches at harvest					Days to maturity					Number of umbels per plant				
	Biofertilizers														
	B_1	B_2	B_3	B_4	Mean	B_1	B_2	B_3	B_4	Mean	B_1	B_2	B_3	B_4	Mean
M_1	15.54	14.65	15.80	15.18	15.29	97.65	97.00	95.25	99.25	97.29	23.25	24.08	28.80	22.93	24.77
M_2	15.28	14.26	15.58	13.29	14.60	98.25	96.65	96.23	99.65	97.70	22.13	24.00	27.25	21.65	23.76
M_3	14.75	14.18	15.55	13.00	14.37	96.85	98.25	96.86	99.89	97.96	21.72	24.80	26.01	21.42	23.49
M_4	14.52	14.07	15.38	12.98	14.24	99.00	99.25	98.65	110.00	101.73	21.52	24.97	25.26	20.22	22.99
Mean	15.09	14.29	15.51	13.61		97.94	97.79	96.75	102.20		22.16	24.46	26.83	21.56	
Source	**B**		**M**		**B×M**	**B**		**M**		**B×M**	**B**		**M**		**B×M**
S. Em ±	0.09		0.09		0.18	0.65		0.65		1.30	0.15		0.15		0.30
CD (*P=0.05*)	0.27		0.27		0.54	1.88		1.88		3.77	0.44		0.44		0.88

Table.3 Effect of biofertilizers and micronutrients on Number of umbellets per umbel, seeds per umbel and 100 seed weight of coriander cv. Sadhana

Micronutrients	Number of umbellets per umbel					Number of seeds per umbel					100 seed weight				
	Biofertilizers														
	B_1	B_2	B_3	B_4	Mean	B_1	B_2	B_3	B_4	Mean	B_1	B_2	B_3	B_4	Mean
M_1	6.29	6.30	6.85	6.18	6.41	30.00	31.69	38.73	28.00	32.11	1.55	1.50	1.80	1.40	1.60
M_2	6.14	6.29	6.65	6.08	6.29	27.53	30.00	36.81	25.63	29.99	1.48	1.58	1.72	1.30	1.52
M_3	6.10	6.31	6.40	5.95	6.19	26.20	32.15	34.21	23.61	29.04	1.45	1.49	1.65	1.39	1.46
M_4	6.02	6.34	6.35	5.86	6.14	24.53	32.18	32.19	23.00	27.98	1.38	1.42	1.48	1.29	1.39
Mean	6.14	6.31	6.56	6.02		27.07	31.51	35.49	25.06		1.47	1.54	1.63	1.35	
Source	**B**		**M**		**B×M**	**B**		**M**		**B×M**	**B**		**M**		**B×M**
S. Em ±	0.12		0.12		0.24	0.19		0.19		0.38	0.01		0.01		0.02
CD (*P=0.05*)	0.04		0.04		0.08	0.54		0.54		1.09	0.03		0.03		0.06

Table.4 Effect of biofertilizers and micronutrients on seed yield g per plant, seed yield kg per hectare and carbohydrates content (%) of coriander cv. Sadhana

Micronutrients	Seed yield g per plant					Seed yield kg per hectare					Carbohydrates (%)				
	Biofertilizers														
	B_1	B_2	B_3	B_4	Mean	B_1	B_2	B_3	B_4	Mean	B_1	B_2	B_3	B_4	Mean
M_1	4.80	4.96	5.82	4.08	4.91	1238.68	1100.25	1270.38	990.25	1149.90	22.67	23.01	25.45	17.29	22.13
M_2	4.24	4.68	5.00	3.98	4.47	1236.25	1060.35	1244.68	980.85	1130.53	21.21	21.69	24.20	16.25	20.84
M_3	4.36	4.20	4.80	3.70	4.26	1220.28	1050.48	1241.78	976.68	1126.30	20.20	22.00	23.09	18.06	20.82
M_4	4.28	4.15	4.37	3.25	4.01	1000.96	1020.21	1030.17	970.65	1005.50	20.68	19.65	20.00	14.02	18.59
Mean	4.42	4.50	5.00	3.75		1174.04	1057.82	1196.75	979.61		21.19	21.61	23.17	16.41	
Source	**B**		**M**		**B×M**	**B**		**M**		**B×M**	**B**		**M**		**B×M**
S. Em ±	0.03		0.03		0.06	7.00		7.00		14.00	0.13		0.13		0.26
CD (*P=0.05*)	0.08		0.08		0.17	20.22		20.22		40.44	0.38		0.38		0.76

Table.5 Effect of biofertilizers and micronutrients on essential oil (%), oleoresins (%) and moisture (%) of coriander cv. Sadhana

Micronutrients	Essential oil (%)					Oleoresins (%)					Moisture (%)				
	Biofertilizers														
	B_1	B_2	B_3	B_4	Mean	B_1	B_2	B_3	B_4	Mean	B_1	B_2	B_3	B_4	Mean
M_1	0.85	0.91	0.96	0.74	0.87	0.72	0.73	0.80	0.50	0.70	9.50	9.00	8.15	10.52	9.29
M_2	0.84	0.89	0.91	0.70	0.84	0.65	0.61	0.76	0.48	0.63	9.36	10.01	8.65	10.81	9.71
M_3	0.86	0.85	0.92	0.72	0.84	0.62	0.66	0.75	0.42	0.61	8.95	10.19	8.38	10.68	9.55
M_4	0.70	0.69	0.75	0.68	0.71	0.60	0.58	0.70	0.40	0.57	10.19	10.25	8.75	10.98	10.04
Mean	0.81	0.83	0.89	0.71		0.66	0.65	0.75	0.45		9.50	9.86	8.48	10.75	
Source	**B**		**M**		**B×M**	**B**		**M**		**B×M**	**B**		**M**		**B×M**
S. Em ±	0.01		0.01		0.02	0.004		0.004		0.008	0.07		0.07		0.13
CD (*P=0.05*)	0.02		0.02		0.04	0.011		0.011		0.02	0.19		NS		NS

Interaction effect of biofertilizers and micronutrients on seed inoculation with Azospirillum + Phosphate solubilising bacteria+ foliar spray of zinc sulphate @0.5% B_3M_1 recorded significantly maximum Number of umbels per plant (28.80), umbellets per umbel (6.85), seeds per umbel (38.73), 100 seed weight (1.80), seed yield g per plant (5.82) and seed yield kg per hectare (1270.38 kg).

Quality characters

With regards to quality characters, such as carbohydrate content (Table 4), essential oil content oleoresins content and moisture content (Table 5) were also showed significant variation among the different biofertilizers and micronutrients. Among the biofertilizers, seed inoculation with Azospirillum + Phosphate solubilising bacteria recorded maximum carbohydrate content (23.17%), essential oil content (0.89%), oleoresins content (0.75%) and lowest moisture content (8.48%). Similar observation was recorded by Rahimi *et al.*, (2009), Sahu *et al.*, (2012) in coriander crop.

Among different micronutrients, foliar application of zinc sulphate @0.5 % (M_1) recorded significantly maximum carbohydrate content (22.13%), essential oil content (0.87%), oleoresins content (0.70%) and lowest moisture content (9.29%).

The positive effect of zinc with respect to plant vegetative growth and yield with its attributes and quality is due to the fact that zinc favours the enzyme system, auxin and protein synthesis and seed production directly or indirectly. Zn improves photosynthesis and assimilates transportation to sinks and finally increased oleoresin contents.

Interaction effect of biofertilizers and micronutrients on seed inoculation with Azospirillum + Phosphate solubilising bacteria+ foliar spray of zinc sulphate @0.5% B_3M_1 recorded significantly maximum carbohydrate content (25.45%), essential oil content (0.96%), oleoresins content (0.80%) and lowest moisture content (8.15%).

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