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Influence of integrated supply of AM, PSB, *Azotobacter* and inorganic fertilizer on growth, yield and quality in coriander (*Coriandrum sativum*) and micro-flora population in the soil

LALIT PATIDAR[1], J K RANJAN[2], BALRAJ SINGH[3], B K MISHRA[4], O P AISWATH[5], KRISNA KANT[6], BHUPENDRA SHARMA[7] and RAVI KANT RAI[8]

ICAR–National Research Centre on Seed Spices, Ajmer, Rajasthan 305 206

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ABSTRACT

A field experiment was conducted at the Horticulture Unit of NRC on Seed Spices, Ajmer to find out the response of coriander (*Coriandrum sativum* L.) to the application of biofertilizers in combinations with different doses of chemical fertilizers. The treatment included various combinations of *Azotobacter*, Arbuscular Mycorrhizal Fungi (AMF), phospahte solublizing bacteria (PSB) in combination with 80 and 100% Recommended Dose of Fertilizer (RDF). The effects of these treatments were evaluated for various growth, yield and quality traits. Plant height, number of primary and secondary branches, number of umbel per plant, number of umbellet per umbel, number of seeds per umbellet, total seed yield per plot, chlorophyll 'a', 'b' and total chlorophyll were found maximum in treatment *Azotobacter*+AM+PSB+100% RDF which was *at par* with *Azotobacter*+AM+PSB+80% RDF while it was found minimum in treatment having only biofertilizer . Thus the treatment *Azotobacter*+AM+PSB+80% RDF was found superior for better growth, yield, and quality of the plants while taking into consideration of long term beneficial effects of organic sources of plant nutrition.

Key words: Biofertilizers, Coriander, *Coriandrum sativum*, Integrated nutrient management, Micro-flora

Farmers generally rely on by chemical means of fertilizers for growing coriander (*Coriandrum sativum* L.) as it gives a more greenish appearance of the crop. The use of chemical fertilizer help in achieving maximum yield but keeping present scenario of sustainability and soil health in view, there is a need to enhance the productivity through supplementation of nutrient requirement through biofertilizers. There has been serious concern regarding the use of chemical fertilizers like they pose health hazards,reduce microbial population in the soil, and they are quite expensive thereby making the cost of production high. Under these circumstances, biofertilizers may play a major role (Tiwary *et al*. 1998). Such eco-friendly integrated approach has great potential particularly to those areas where approaches such as the use of biofertilizers have not yet gained popularity among farmers. The biofertilizers such as *Azotobacter,* Arbuscular Mycorrhizae (AM) and phosphate solubilizing bacteria (PSB) increase the availability of nutrient and thereby reduce the fertilizer requirements which ultimately results inreduction of cost of production. Application of biofertilizer showed an increase in yield and quality by various researchers, but the effect of these biofertilizers on crop plants is enormously influenced by the agroclimatic conditions. The information on these aspects is meagre for coriander. Hence, the present study was undertaken to explore the effect of different biofertilizers and reduced dose of fertilizer (RDF) on growth, yield, and quality of coriander and soil microbial population of the field.

MATERIALS AND METHODS

The present investigation was conducted during the *rabi* season in 2011-2012 at Experimental Farm of ICAR-National Research Centre on Seed Spices, Ajmer. The centre lies on 740º 35' 39" E to 740º 36' 01" longitude and 260º 22' 12" to 260º 22' 31" N latitude at an altitude of 460.17 m above mean sea level.The soil of research farm was sandy loam, poor in fertility and water holding capacity, having pH 8 to 8.3, EC 0.07 to 0.12 and 0.15 to 0.23% organic carbon, available N, 178.5 kg/ha (low), P2O5 12 kg/ha (medium), K_2O 85 kg/ha (low), Ca 214.7 kg/ha (high), Mg 258 kg/ha(medium), S 27 kg/ha (high). Three biofertilizer along with two nitrogen and two phosphorus doses were applied in 10 different combinations (Table 1). The crop was raised as per standard recommended cultural practices.

The coriander variety ACr-1, developed by ICAR-National Research Centre on Seed Spices, Ajmer, India,

[2]e mail: jkranjan2001@yahoo.com.in, Present address: Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh.

Table 1 Treatment details for integrated supply of VAM, PSB, *Azoatobacter* and inorganic fertilizer in coriander crop

Treatment	Treatments detail
T_1	*Azotobacter* + PSB+80% RDF*
T_2	*Azotobacter* + PSB+100% RDF
T_3	*Azotobacter* +AM+ 80%RDF
T_4	*Azotobacter* +AM+ 100%RDF
T_5	AM+PSB+80% RDF
T_6	AM+PSB+100% RDF
T_7	*Azotobacter* + AM+PSB+80%RDF
T_8	*Azotobacter* + AM+PSB+100%RDF
T_9	Only Biofertilizers
T_{10}	100% RDF

*RDF: recommended dose of chemical fertilizers (N:P:K::60:30:10 kg/ha).

was used as experimental material. It is a dual purpose variety showing resistance to stem gall and tolerance to powdery mildew.

Biofertilizers namely *Azotobacter*, PSB (*Bacillus megatherium* var. Phosphoticum) and AM (Arbuscular Mycorrhizae) were procured from Division of Microbiology, Indian Agricultural Research Institute (IARI), Pusa Campus, New Delhi. For seed treatment 10 g jaggery was boiled in 100 ml of water for half an hour and then cooled. In cooled jiggery solution 20 g biofertilizer of each culture was poured separately and stirred well. The seeds of coriander were mixed thoroughly with the solution of culture and were allowed to dry in shade. The seeds were sown on the same day in bed size of 2.0×2.1 m^2. The AM was applied @ 250 g/m^2 of experimental plots inthe soil just before seed sowing of coriander crop.

The observations on all the phenological parameters, viz. plant height, number of primary and secondary branches/ plant and reproductive parameter, viz. days to 50% flowering, number of umbels/plant, number of seeds/umbellet, seed yield and test weight were recorded as per standard procedure. Chlorophyll (a, b and total) and carotenoid content in leaves were estimated according to the method of Hiscox *et al.* (1979) using Dimethyl Sulfoxide (DMSO). For this 100 mg of fresh leaf portion was kept in a test tube containing 5 ml of DMSO. The test tube was then placed in an oven at 60° C for about 2 hr or more (if required) to facilitate complete extraction of the pigments. After 2 hr and at attaining the room temperature, absorbance was recorded at 645, 663, 638 and 480 nm on a computer aided spectrophotometer (Spectrophotometer-119 Lab India UV 3000) running a multiple wavelengths programme. DMSO was used as blank. Calculations for different pigments were made according to Welburn (1994).

Chl 'a' (g/ml) = 12.19 A665-3.45 A645

Chl 'b' (g/ml) = 21.99 A645-5.32 A665

Quantity of all these pigments was calculated in mg/g tissue dry weight and expressed as moles/g tissue dry weight by using the following relationship:-

moles of chl 'a' = mg chl 'a' × 1.119

moles of chl 'b' = mg chl 'b' × 1.102

moles of carotenoides = mg carotenoids × 1.809

moles of total chlorophyll = chl 'a' (moles) + chl 'b' (moles)

Total viable counts of bacteria were estimated according to the method of Kaushik *et al*. (2004) using standard plate count nutrient agar growth media. Ten fold dilution was prepared by diluting the sample (rhizospheric soil) with a series of 9 ml water blanks. The number of dilutions may vary according to the requirement. Pre-sterilized nutried agar medium (Hi-media) was poured into plates and let them solidify. From the last three dilution, aliquot of 0.1 ml was taken and spread .Total viable counts of fungi were estimated by the standard plate count method using Rose Bengal agar medium supplemented with streptomycin. The composition of the media was, glucouse-10.0 g, peptone-5.0 g, KH_2PO_4-1.0g, $MgSO_4$.7H2O- 0.5 g, Rose Bangal-0.03 g, Agar 20.0 g and tap Water-1 000 ml. The sample was diluted, poured and counted in the same way as described above. The plates were incubated at optimum temperature (25±1°C) for 24 to 48 hr and the plate having 30-300 colonies was selected for counting.The viable bacterial and fungal population in terms of colony forming unit (cfu) per gramof rhizospheric soil sample from coriander crop was calculated.

All the experiments were laid out in of factorial randomized block design with three replications. Data were subjected to statistical analysis as per the procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Biofertilizers are the products which contain living cells of different types of microorganisms (Chen 2006) that have an ability to convert nutritionally important elements from unavailable to available form through biological processes and are known to help with the expansion of the root system and better seed germination. Biofertilzers are less expensive, eco-friendly and sustainable and are likely to assume greater significance as a compliment or supplement to inorganic fertilizers (Vessey 2003). Biofertilizers are presently attracting more attention in the context of sustainable agriculture. This is a consequence of the need to solve health and environmental problems caused by the excessive use of agrochemicals in traditional agriculture. In the present investigation, observations on various plant biometrical data were recorded to study the effect of various treatments (individual as well as combined) of AM, *Azotobacter* and PSB along with inorganic fertilizer on the growth and yield of coriander.

Data presented in Table 2 revealed that plant height was significantly influenced by various treatments of fertilizers. Maximum plant height (115.0 cm) was recorded with treatment T8 (*Azotobacter*+VAM+PSB+100% RDF) but it was statistically at par with treatment T3, T5, T7 and T10 while, minimum plant height (104.33 cm) was observed with T9 (only biofertilizer) treatment. Number of primary

Table 2 Effect of treatments on plant height, number of branches, days to 50% flowering and number of umbels

Treatment	Plant height (cm)	Number of primary branch	Number of secondary branch	Days to 50% flowering	Number of umbel/plant	Number of umbellets/umbel
T_1 - *Azotobacter*+PSB+80% RDF	105.00	10.33	35.67	94.33	50.00	7.00
T_2 - *Azotobacter*+PSB+100% RDF	105.67	11.00	49.17	95.00	51.67	7.33
T_3 - *Azotobacter*+VAM+80% RDF	109.33	11.17	45.33	95.00	43.33	8.33
T_4 - *Azotobacter*+VAM+100% RDF	106.00	10.00	36.67	95.00	40.00	6.67
T_5 - VAM+ PSB+80% RDF	113.00	10.33	43.33	94.67	38.33	8.67
T_6 - VAM+ PSB+100% RDF	106.33	11.83	38.50	93.00	48.00	7.67
T_7 - *Azotobacter*+VAM+PSB+80% RDF	109.00	12.33	49.33	94.33	47.67	7.33
T_8 - *Azotobacter*+VAM+PSB+100% RDF	115.00	12.50	50.00	95.33	57.00	9.00
T_9 - Only biofertilizer	104.33	9.33	34.33	92.00	36.67	6.33
T_{10} - 100% RDF	112.33	10.33	40.00	93.33	56.67	8.00
SEm±	1.30	0.36	2.06	0.51	2.52	0.27
CD (P=0.05)	7.09	1.96	11.28	NS	13.79	1.47

branch at harvest was also maximum (12.50) in T8 (*Azotobacter* + VAM+PSB+100% RDF) treatment, which was at par with treatment T2, T3, T6 and T7. Minimum number of primary branch (9.33) was observed with T9 (only biofertilizer). In the same way effect of biofertilizer and inorganic fertilizer on secondary branches at harvest was found significant. Maximum secondary branch at harvest (50.0) was recorded with T8 (*Azotobacter* + VAM + PSB + 100% RDF) which was statistically at par with treatment T2, T3, T5, T7 and T10.

Maximum number of umbels/plant (57.00) was recorded with treatment T8 (*Azotobacter*+VAM+PSB+100% RDF) and was at par with T1, T2, T3, T5, T6, T7 and T10, whereas, it was found minimum (36.67) with T9.

Significantly higher number of umbellets/umbel (9.0) was recorded with T8 (*Azotobacter*+VAM+PSB+100% RDF) which was significantly at par with T3, T5, T6 and T10. Whereas, minimum number of umbellet/umbel (6.33) was observed with T9. The nitrogen synthesized in amino acid, which are built into complex proteins and helps in promoting the luxurious growth of leaves and may be due to higher level of nitrogen. The present results are in close accordance with report of Rajaraman *et al.* (2011) and Das *et al.* (2013).

It is clearly seen from the data that major nutrient supplied by the biofertilizer with inorganic fertilizer utilized quickly by crops. The biofertilizer of these helped to supply the more nitrogen, which being the constituent of protein, protoplasm and vigorously inducing the vegetative development of the plants. The present results are in close accordance with reports of Ramchandra *et al*. (1983), Patil *et al*. (2008), Mujahid and Gupta (2010), Omolayo *et al*. (2011) and Kumar *et al*. (2010). Also the biofertilizer gives efficient microbial activity, better root proliferation, abundant supply of availability of nutrients from the soil. The present results are in close conformity with the report of Prajapati (2010).

The data presented in Table 3 revealed that test weight (100 seed weight) of seed was influenced by integrated nutrient supply. Highest testweight (9.25 g) was

Table 3 Effect of biofertilizer and inorganic fertilizer on test weight of seed, number of seeds/umbellet and total coriander seed yield

Treatment	Test weight of seed (gm)	Number of seeds/umbellet	Total seed yield/bed (2.0×2.1 m^2)
T_1 - *Azotobacter*+PSB+80% RDF	7.97	9.67	529.33
T_2 - *Azotobacter*+PSB+100% RDF	6.76	10.00	496.00
T_3 - *Azotobacter*+VAM+80% RDF	7.48	9.87	450.00
T_4 - *Azotobacter*+VAM+100% RDF	8.03	10.33	484.33
T_5 - VAM+ PSB+80% RDF	7.71	11.67	483.00
T_6 - VAM+ PSB+100% RDF	8.82	9.93	500.67
T_7 - *Azotobacter*+VAM+PSB+80% RDF	9.25	9.87	468.00
T_8 - *Azotobacter*+VAM+PSB+100% RDF	9.12	12.80	546.33
T_9 - Only biofertilizer	6.45	9.33	402.67
T_{10} -100% RDF	9.08	12.67	536.67
SEm±	0.34	0.44	35.28
CD (P=0.05)	1.87	2.38	NS

recorded with treatment T7 (*Azotobacter*+VAM+PSB+80% RDF) and was statistically at par with treatment T1, T3, T4, T5, T6, T8 and T10, whereas it was found minimum (6.45 g) with T9. Maximum number of seeds/umbellate (12.80) was recorded with treatment T8 (*Azotobacter* + VAM + PSB + 100% RDF) and was at par with treatment T4, T5 and T10. However, it was found minimum (9.33) with T9. It might be due to the balanced nutrition of biofertilizer and urea resulting in development of proliferous root system and better absorption of water and nutrients with improved physical environment (Mujahid and Gupta 2010). Aishwath *et al.* (2012) observed that plant height at various stages and number of primary and secondary branches were higher with combine inoculation of PSB and *Azotobacter*. However, DAS to germination and DAS to 50% and complete flowering and number of umbels/plant were not influence with these inoculants. Numbers of umbellets/umbel, seed, straw and biological yields were highest with the combine use of biofertilizers, which was at par with individual inoculation. Per cent seed yield increased with the use of *Azotobacter*, PSB and their combinations of both was 8.8, 11.6 and 18.5, respectively, as compared to control. Carotenoid content at 60 DAS was more with PSB inoculation and protein content in straw was enhanced with individual and combine use of inoculants. There was non-significant difference among the treatment w.r.t seed yield (Table 3). Since statistically at par result was obtained by the treatment containing 80 reduce doze of chemical fertilizer as compare to control (100% recommended dose of fertilizer), it may be recommended to use reduced dose of chemical fertilizer along with *Azotobacter*, VAM and PSB keeping both quality of soil and produce in mind. Singh (2013) also observed that combination of biofertilizer *Azospirrilum* + inorganic nitrogen + FYM had better performance as compared to alone application of bio-fertilizer *Azospirrilum*, organic FYM, inorganic nitrogen and other combinations in coriander cultivar Pant Haritma.

The effect of integrated supply of organic and inorganic fertilizers on chlorophyll-a, chlorophyll-b and total chlorophyll content has been presented in Fig 1. No significant difference was observed among the treatment w.r.t. chlorophyll content, however, the maximum carotenoid content (0.26 mg/g FW) was recorded with treatment T8 (*Azotobacter*+VAM+PSB+100% RDF) which was statistically at par with treatment T7 and T10. However, the minimum carotenoid content (0.08 mg/g FW) was recorded with treatment T6 (VAM+ PSB+100% RDF). It is clear from the data that biofertlizer may help to increase or produce at par quality even at reduced doze of chemical fertilizer (T7).

Application of different biofertilizer and inorganic fertilizer has significantly influenced total viable count bacterial population in the soil. Maximum total viable count of bacteria (7.240 cfu/gm) was recorded with treatment T8 (*Azotobacter*+VAM+PSB+100% RDF), whereas it was found minimum (6.892 cfu/gm) with treatment T9. Similarly, highest total viable count of fungi (5.004 cfu/g) was recorded with treatment T8 (*Azotobacter*+VAM+PSB+100% RDF), but minimum (4.903 cfu/g) with treatment T5 (VAM+PSB+80% RDF) and T9 (only biofertilizer).

Soil microorganisms are responsible for recycling elements so they can be used over and over again. In microbiological profile of coriander field soils the total

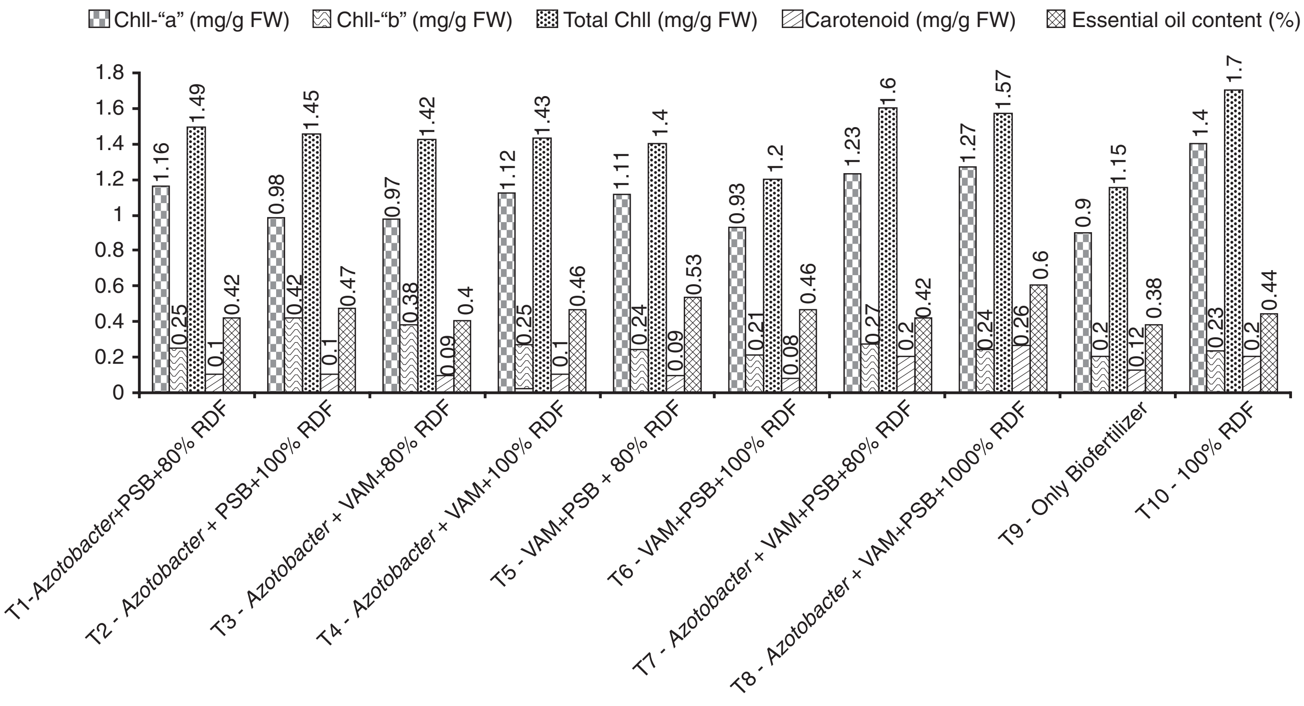

Fig 1 Effect of biofertilizer and inorganic fertilizer on chlorophylls, carotenoid contents and essential oil content in coriander

viable mesophilic bacterialcount of the ranged from 1.2×10^8 to 2.4×10^8 cfu/g soil while the mesophilic aerobic fungal population varied from 2.25×10^6 to 4.48×10^6 cfu/g of rhizosphere soil samples collected from major coriander growing areas of Rajasthan in India (Mishra *et al.* 2014).

Data presented in Fig 1 indicated that, effect of biofertilizer and inorganic fertilizer was found significant for essential oil content. Maximum essential oil content (0.60%) was observed with the treatment of T8 (*Azotobacter*+VAM+PSB+100% RDF) while, (0.38%) with T9 (only biofertilizer). Improvement in quality attributes of green coriander due to sole application of organic sources could be attributed to better and balanced nutrition and production of growth promoting substances by organics, which might have led to better quality. Improvement in quality of green coriander can also be attributed to the improvement in soil physical, chemical and biological properties leading to better root proliferation, improved nutrient uptake and better accumulation of photosynthesis. The present results are in close accordance with reports Bhore *et al.* (2006), Phadnis *et al.* (2007) and Mujahid and Gupta (2010).

In light of the results obtained from this investigation, it could be concluded that, treatment *Azotobacter* + AM + PSB + 80% RDF may be recommended for better growth, yieldand quality of coriander while taking into consideration of long term beneficial effects of organic sources of plant nutrition.

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