Indian Journal of Agricultural Sciences **86** (1): 31–6, January 2016/Article
https://doi.org/10.56093/ijas.v86i1.55183

Comprehensive evaluation of coriander (*Coriandrum sativum*) varieties under different organic modules

G LAL[1] and RAVINDRA SINGH[2]

National Research Centre on Seed Spices, Tabiji, Ajmer, Rajasthan 305 206

Received: 14 July 2015; Accepted: 22 September 2015

ABSTRACT

An experiment was conducted for the evaluation of coriander (*Coriandrum sativum* L.) varieties under different organic modules for sustainable production during *rabi* season of 2009-10 to 2012-13 (four years) at ICAR- National Research Center on Seed Spices, Tabiji, Ajmer, Rajasthan. The experiment was laid out in Factorial Randomized Block Design consisting of three organic modules (M_1, M_2 and M_3) and two varieties Ajmer Coriander-1 (ACr-1, V_1) and Rajasthan Coriander-41 (RCr-41, V_2) with four replications. Findings of this study showed significant differences among the performance of different organic modules tested for two coriander varieties. Organic module M_1 [comprising soil application of vermicompost (5 tonnes/ha), foliar spray of garlic extract (5% @ 2.0 kg/ha) + neem oil (2% @ 5 l/ ha, soil application of neem cake (150 kg/ha) and *Trichoderma* (2.5 kg/ha), seed treatment with *Rhizobium* (100 ml/kg seed), PSB (100 ml/kg seed) and *Trichoderma* (10 g/kg seed)] exhibited maximum number of primary branches (8.05/ plant), secondary branches (21.88/ plant), number of umbels (32.22/ plant), number of seeds (8.81/ umbellate) and highest seed yield (1323.90 kg/ha) in coriander crop. Similarly, significant differences were recorded in the performance of coriander varieties under different organic modules and the maximum number of primary branches (7.87/ plant), secondary branches (21.55/ plant), number of umbels (29.20/ plant), number of umbellates (5.81/ plant) and number of seeds (8.40/ umbellate) with earliest flowering (66.05 days after sowing-DAS), and highest seed yield (1296.31 kg/ ha) were recorded in coriander variety ACr-1 than that of variety RCr-41. Cultivation of coriander variety ACr-1 with the application of Module-1 exhibited maximum values for all the growth parameters, yield attributing characters with maximum seed yield. Hence, variety ACr-1 is suggested to grow organically with the application of Module-1 (M_1) under semi-arid environmental conditions.

Key words: Biofertilizers, Coriander, Garlic extract, Neem oil, Manures, *Trichoderma*,Seed yield, Vegetative growth

Organic agriculture considers the medium- and long-term effect of agricultural interventions on the agro-ecosystem. It aims to produce food while establishing an ecological balance to prevent soil fertility or pest problems. (FAO/WHO Codex Alimentarius Commission, 1999). Modern trends in present agriculture are concentrating on reducing the use of inorganic fertilizers by organic manures and biofertilizers (Gyaneshwar *et al.* 2002 and Darzi *et al.* 2011) and the soil fertility status is maintained over a longer period of time, which helps in enhancing availability of nutrients to plants. With high level of nitrogen application, the plants become succulent and attract sucking pests like aphids etc. With judicious use of manures, the pest and diseases are not attracted. Organic amendments like neem cake stimulate beneficial microorganisms (natural enemy) like *Trichoderma*, *Pseudomonas,* etc. which keep down diseases causing pathogens. The plant parasitic nematodes which damage roots of the crop plants are also suppressed/ reduced by organic amendments.

Today people are becoming more conscious about the health problems due to consumption of agricultural products contaminated with pesticide residue and of the adverse impact of the modern agriculture on the environment throughout the world. Increased dependence on agro-chemicals including fertilizers has led to several ill effects on the environment and health of flora and fauna including human beings. Besides improving soil health, organic manures supply the major nutrients and micronutrients (Palaniappan and Annadurai 1999) and could enhance the vegetative growth and yield of turmeric (Vadiraj *et al*. 1998a), basil (Anwer *et al*. 2005), garlic (Arguello *et al*. 2006) fennel (Darzi *et al*. 2008) and coriander (Godara *et al.* 2014).

Coriander (*Coriandrum sativum* L.) is one of the most commonly grown seed spices in India and extensively used in Indian cookery. India being largest country in spice production annually produces 4.96 lakh tonnes of coriander from 5.16 lakh ha area. Leaves, tender stem and seeds of coriander have pleasant aromatic flavor due the presence of essential oil and thus is indispensable food adjunction

[1]Principal Scientist, Horticulture (e mail: glal67@yahoo.co.in), [2]Principal Scientist, Agronomy (e mail: mahla_rs@yahoo.com)

in our kitchen. Its whole or ground seeds are used as condiment to flavor foods like curry, pickles and confectionery (Lal *et al*. 2010). Organically produced coriander is in great demand in domestic as well as in international markets. Fertilizer is one of the most important inputs for increasing production. But the continuous and liberal use of inorganic fertilizer alone affects soil health and thus resulting in lower yield with poor quality produce (Mamatha 2006). By using right and appropriated nutritional sources through manures and biofertilizers with organically pest and disease management practices, quantitative and qualitative yield of coriander can be maximized. Consequently, it is felt necessary to advocate the use of the organic sources of nutrients and plant protection for sustainable production of quality produce without any chemical residual toxicity so as the present study was carried out.

MATERIALS AND METHODS

An investigation on the "Comprehensive evaluation of coriander varieties (ACr-1and RCr-41) under different organic modules" was carried out at Research Farm, ICAR-National Research Centre on Seed Spices, Tabiji, Ajmer, Rajasthan, during '*rabi*' seasons of 2009-10 to 1012-13 (04 years). The centre lies on 740 35' 39" E to 740 36' 01" longitude and 260 22' 12" to 260 22' 31" N latitude at an attitude of 460.17 m above mean sea level. The soil of the research farm is 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), P_2O_5 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 (medium).

The experiment comprised three organic modules, viz. M_1 [Vermicompost (5 t/ha), foliar spray of garlic extract (5% @ 2.0 kg/ha) + neem oil (2% @ 5 litre/ha], M_2 [FYM (10 tonnes/ha), foliar spray of garlic extract (5% @ 2.0 kg/ha) alone] and M_3 [sheep manure (10 tonnes/ha), foliar spray of karanj oil (2% @ 5 l/ha)] and two varieties Ajmer Coriander-1 (ACr-1, V_1) and Rajasthan Coriander-41 (RCr-41, V_2) was laid out in factorial RBD with four replications keeping plot size of 3m × 4m (12 m^2). Neem cake (150 kg/ha) and *Trichoderma* (2.5 kg/ha) applied in soil were common in all the modules and seeds under all the modules were treated with *Rhizobium* (100 ml/kg seed), PSB (100 ml/kg seed) and *Trichoderma* (10 g/kg seed) and then sown in furrows opened at 30 cm row spacing and covered with soil properly. Recommended package of practices for the crop were followed with respect to irrigation and intercultural operations. Sowing of seed was done in first week of November and harvesting was done in the first fortnight of April each year. Observations on different growth and yield parameters like days to germination, plant height, number of branches per plant, days flowering, number of umbels per plant, numbers of umbellates per umbel, number of seeds per umbellate and grain yield per hectare were recorded. To work out the feasibility of organic coriander production, the common cost of cultivation for coriander were ₹ 12300 (average of 4 years). Whereas the treatment cost for module-1, module-2 and module-3 were ₹ 20963, 17363 and 21113, respectively which was incurred for application of different organic modules in addition to the common cost of cultivation. The average (2009-2013) sale price for organically produced coriander were ₹ 75.0/kg for calculating the gross and net returns, considering the 20% premium price (62.5 /kg) over chemically produced coriander.

Data obtained during the study were statistically analysis by adopting appropriate method of analysis of variance as suggested by Panse and Sukhatme (1985). Whereas the variance ratios (F-values) were found significant at 5% level of probability, the critical difference (CD) values were computed for making comparison among treatment means.

RESULTS AND DISCUSSION

Vegetative growth parameters

Findings of this study reveals that seed germination and plant height of coriander crop was not influenced significantly with the application of different organic modules, though the height of the plants increased from germination to harvest irrespective of the treatments applied. Organic module M_1 exhibited maximum plant height of 6.86, 16.35, 79.97 and 93.11cm at 30, 60, 90 DAS and at harvest, respectively whereas it was lowest in module M_3. Similarly maximum number of basal leaves (6.14/plant) were recorded in M_1 module as compared to minimum number of basal leaves in M_3 module.

Results of this study exhibited that numbers of primary and secondary branches of coriander plants were significantly influenced with the application of different organic modules (Table 1). The maximum number of primary branches (8.05/plant) and secondary branches (21.88) were recorded in module M_1 as compared to minimum primary branches (7.25/plant) and secondary branches (19.92/plant) in module M_2.

Further, it is depicted from the data (Table 1) that germination initiation was affected significantly between the varieties and earliest germination initiation in 6.70 days after sowing was recorded in RCr-41 (V_2) variety as compared to slightly delayed germination in ACr-1 (V_1) variety but the completion of germination was not significantly differed between both the varieties of coriander in this study. Number of basal leaves and plant height at all the growth stages of the coriander varieties in this study were not differed with each other but contrary to this, the number of branches in the plants of coriander varieties differed significantly. Here, maximum number of primary branches (7.87/plant) and secondary branches (21.55) were recorded in the plants of variety ACr-1 as compared to minimum number of primary branches (7.07) and secondary branches (20.09/plant) in variety RCr-41.

Interaction effects of the present study showed that organic modules and varieties collectively did not influence

Table 1 Effect of organic modules and varieties on vegetative growth parameters of coriander (Pooled data of 2009-10 to 2012-13)

Treatment	Days to germination initiation	Days to germination completion	No. of basal leaves/ plant	Plant height at 30 DAS (cm)	Plant height at 60 DAS (cm)	Plant height at 90 DAS (cm)	Plant height at harvest (cm)	Number of primary branches/ plant	Number of secondary branches/ plant
Organic modules									
M_1	7.37	9.54	6.14	6.86	16.35	79.97	93.11	8.05	21.88
M_2	7.37	9.49	6.09	6.42	15.65	76.73	89.45	7.11	20.66
M_3	7.28	9.25	5.94	6.51	16.55	78.04	91.26	7.25	19.92
SEm±	0.12	0.12	0.11	0.10	0.25	1.41	1.24	0.21	0.40
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	0.61	1.14
Varieties									
V_1	7.98	9.67	5.98	6.36	15.48	78.65	93.36	7.87	21.55
V_2	6.70	9.18	6.13	6.83	16.88	78.00	88.93	7.07	20.09
SEm±	0.10	0.09	0.09	0.08	0.20	1.15	0.99	0.17	0.41
CD (P=0.05)	0.27	NS	NS	NS	NS	NS	NS	0.50	1.17
CV %	6.67	5.09	10.21	7.50	7.00	8.08	5.88	12.95	12.24
Interaction M × V	NS	NS	NS	NS	NS	NS	NS	NS	NS

significantly the seed germination, plant height and number of branches. However, the performance of variety ACr-1 grown under Module-1 (M_1V_1 treatment combination) was recorded better than that of variety RCr-1 grown under Module-2 (M_2V_2) with respect to all the vegetative growth parameters.

From the above results of this study, it is clear that performance of organic module M_1 containing vermicompost (5 tonnes/ha), foliar spray of garlic extract (5% @ 2.0 kg/ha) + neem oil (2% @ 5 l/ha, soil application of neem cake (150 kg/ha) and *Trichoderma* (2.5 kg/ha), seed treatment with *Rhizobium* (100 ml/kg seed), PSB (100 ml/kg seed) and *Trichoderma* (10 g/kg seed) proved best with respect to vegetative growth parameters of coriander crop. Vermicompost an important organic source of plant nutrients, contains a higher amount of N, P and K, necessary for plant growth in readily available forms (Nagavallemma *et al*. 2004), it has a potential for improving plant growth and dry matter yield when added to soil (Atiyeh *et al*. 2000) and plays a major role in improving growth and yield of different field crops, including vegetables, flowers and fruit crops (Nagavallemma *et al*. 2004, Edwards 1998b). Vadiraj *et al.* (1998b) reported that application of vermicompost in coriander crop produced herbage yields that were comparable to those obtained with chemical fertilizers. Humic acids extracted from vermicompost stimulated to increase in the number of roots, giving the plant ability to scavenge nutrient from the growing environment for growth and development (Pritam *et al*. 2010). The application of PSB enhances root and shoot length, plant biomass and vigour, all leading to a better growth of the plant due to the production of metabolites such as phytohormone and antibiotics which finally promotes the plant growth and grain yield (Balachandran and Nagarajan 2002). The effect of seed inoculation with *Azotobacter* resulted in increased number of branches and plant height and N_2 fixed by *Azotobacter* translocated to plant system through xylem vessels, which enhanced the synthesis of carbohydrates and protein. This might have helped in improved growth parameters with *Azotobactor* inoculation. These findings are in corroboration with the results reported by Chatterjee and Thirumdasu (2014) in vegetables and Garg (2007) in fennel.

Seed yield and yield attributes

It is inferred from the results of the present investigation that, days to 50% flowering and number of umbellates per umbel in coriander crop were not affected significantly with the application of different organic modules. Contrary to this, the number of umbels per plant and number of seeds per umbellate and seed yield were influenced significantly with the application of various organic modules (Table 2). The highest number of umbels (32.22/plant) and seeds (8.81/umbellate) with maximum seed yield (1 323.90 kg/ha) with higher net returns (₹ 66 029.5/ ha) were recorded in the crop grown under organic module M_1 as compared to lowest number of umbels (24.37/plant) and seeds (7.35/umbellate) with minimum seed yield (1 168.21 kg/ha) obtained in the crop grown under organic module M_2. The study further revealed that the days to 50% flowering, number of umbels per plant, number of umbellates per umbel, number of seeds per umbellate and seed yield were significantly differed in both the varieties of coriander (Table 2). The earliest 50% flowering (66.05 DAS), highest number of umbels (29.20/plant), number of umbellates (5.81/umbel) and number of seeds (8.40/ umbellate) with maximum seed yield (1 296.31 kg/ha) with higher net returns (₹ 65 110.25) were recorded in ACr-1 (V_1) variety as compared to the latest 50% flowering (69.81 DAS), lowest number of umbels (26.90/ plant), number of umbellates (5.50/umbel) and number of seeds (7.38/ umbellate) with minimum seed yield (1 175.53 kg/ha) and lower net returns (₹ 56 051.75/ha) in RCr-41 (V_2) variety.

The M × V interaction effects of modules and varieties

Table 2 Effect of organic modules and varieties on grain yield and yield attributes of coriander (Pooled data of 2009-10 to 2012-13)

Treatment	Days to 50% flowering	Days to completion of flowering	Number of umbels/ plant	Number of umbellates/ umbel	No. of seeds/ umbellate	Seed yield (kg/ha)	Cost of cultivation (₹)	Gross returns (₹)*	Net returns (₹)	B:C ratio
Organic modules										
M_1	67.66	72.47	32.22	5.76	8.81	1323.90	33263.0	99292.50	66029.50	1.99
M_2	67.38	73.08	24.37	5.60	7.35	1168.21	29663.0	87615.75	57952.75	1.95
M_3	68.76	73.14	27.61	5.61	7.50	1191.06	33413.0	89329.50	55916.50	1.67
SEm±	0.59	0.79	0.82	0.12	0.21	28.99				
CD (P=0.05)	NS	NS	2.32	NS	0.61	82.06				
Varieties										
V_1	66.05	71.00	29.20	5.81	8.40	1296.31	32113.0	97223.25	65110.25	2.03
V_2	69.80	74.79	26.90	5.50	7.38	1175.53	32113.0	88164.75	56051.75	1.75
SEm±	0.49	0.42	0.67	0.10	0.18	23.77				
CD (P=0.05)	1.38	1.19	1.89	0.28	0.52	67.27				
CV %	2.73	2.17	9.75	10.74	10.06	12.32				
Interaction M × V	NS	NS	NS	NS	NS	NS				

*The average price of coriander (2009-10 to 2012-13) was ₹ 62.5 and 20% premium price added, hence ₹ 75.0/kg were used for organic produce

did not influence significantly the days to 50% flowering, number of umbels per plant, number of seeds per umbellate and seed yield. However, the earliest flowering, maximum numbers of umbels per plant, number of umbellates per umbel and number of seeds per pod with highest seed yield were recorded in variety ACr-1 grown under Module-1 (M_1V_1 treatment combination) the latest flowering, minimum numbers of umbels per plant, number of umbellates per umbel and number of seeds per umbellate with lowest seed yield recorded in variety RCr-41 grown under Module-2 (M_2V_2 treatment combination).

It is evident from results of this study that application of organic module M_1 [comprising vermicompost (5 tonnes/ ha), foliar spray of garlic extract (5% @ 2.0 kg/ha) + neem oil (2% @ 5 litre/ha, soil application of neem cake (150 kg/ ha) and *Trichoderma* (2.5 kg/ha), seed treatment with *Azotobactor* (100 ml/kg seed), PSB (100 ml/kg seed) and *Trichoderma* (10 g/kg seed)] proved best among the different modules tested with respect to yield attributing characters, seed yield, gross and net reurns of coriander crop. Here it is clear that vermicompost at 5 tonnes/ha significantly increased the values of vegetative and reproductive characters and seed yield per hectare over FYM and sheep manure. Vermicompost improves the physical and biological properties of soil including supply of almost all the essential plant nutrients for the growth and development of plants. Thus balanced nutrients under favourable environment might have helped in production of new tissues and development of new shoots in coriander plants, which ultimately increased the yield attributes and seed yield. These results corroborate the findings of Mba (1996) in cowpea. Singh *et al*. (1997) and Karmegam *et al.* (1999) also observed significant improvement in growth and yield attributes influenced by vermicompost in chillies and green gram, respectively. Further, vermicompost and azotobacter increase the activities of N-fixing bacteria and rate of humification. Humic acid enhanced the availability of both native and added micro nutrients in soil and thus plant growth, yield attributes and yield increased. Similar results were also reported by Mathur (2000) in green gram. The gradual release and steady supply of nutrients from vermicompost throughout the growth and development of plants maintained the later on the translocation of photosynthates to various sinks resulting in to higher seed yield. Similar findings were also reported by Parihar (2002) and Singh and Yadav (2006) in wheat and Jawadagi (2012) in onion. Mehta *et al.* (2012) reported that application of 4.0 tonnes/ha of vermicompost exhibited significantly higher yield attributes and yield of cumin. The seed yield in organic modules (Fig 1) and varieties (Fig 2) was initially less in 2009-10 and then increased in consecutive years. It might be due to residual effects of organic manures applied in preceding years, which enhanced the fertility status of the experimental field.

The improvement in vegetative growth and yield of coriander with the application of vermicompost and biofertilizers might be due to higher availability of nitrogen, phosphorus, potash and micronutrients in soils due to increased decomposition of vermicompost affected the continuous and slow release of nutrients and *Azospirillum* and PSB also might have contributed by supplying growth promoters (Okan 1985). (Mamatha 2006) observed the highest bulb diameter with the application of FYM + vermicompost in onion. Similar effect was also observed in okra and bitter gourd (Samuvel 1984). *Azotobactor* and PSB play an important role in the development of meristematic tissues at growing points for promoting growth and also aid in formation of seeds in plant. Increase in seed yield due to inoculation by *Azotobactor* and PSB has also been recorded by Patra *et al.* (2013) in sunflower, Sajan *et al*.

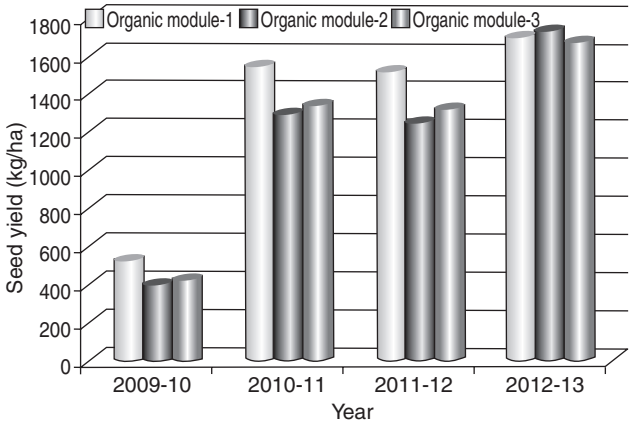

Fig 1 Effect of different organic modules on coriander yield during 2009-10 to 2012-13

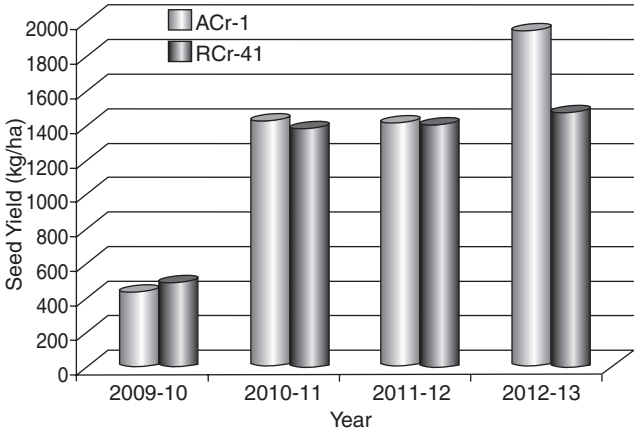

Fig 2 Performance of coriander varieties under organic cultivation during 2009-10 to 2012-13

(2002) in chilly and Mehta *et al*. (2010) in cumin. Also the use of neem oil and garlic extract as botanicals against aphid and *Trichoderma* used as soil and seed treatments proved positive with respect to control the pest population and soil born disease like wilt and saved the crop. Neem oil and garlic extract even protects crops from fungal infections such as blight and powdery mildew. Fruit yields from okra and eggplant were higher on botanically-treated plants than the control plants, probably due to the reduced fruit damage on the treated plants (Mochiah *et al*. 2011). Furthermore, for both okra and eggplant, the reduction in population of the foliage defoliators implied the availability of more undamaged foliage which through photosynthesis resulted in increased dry matter accumulation in the fruits (Mochiah *et al*. 2011).

A perusal of findings summarized in this study revealed that, the growth parameters, viz. plant height at various growth stages, number of branches/plant and yield attributes (number of umbels/plant, number of umbellates/umbel, number of seed/umbellate) and seed yield were significantly varied between the varieties of coriander. Coriander variety ACr-1 exhibited significantly higher plant growth parameters, yield attributes and grain yield. It is well recognized that the knowledge and understanding of the genetic basis of economic traits is important to enhance the progress in developing new varieties of the crop through breeding (Usman *et al*. 1991). The vertical analysis techniques have been found to be the useful tools to obtain precise information about the types of gene action involved in the expression of various traits and to predict the performance of the progenies in the latter segregating generation. Each variety has its own significant effect on yield and yield component and each variety has its own traits that are part and parcel as quality parameters of the crop (shape, size, colour, taste and pungency).The most important traits among others include, number of branches/plant (count), plant height, number of fruits/plant, days to maturity (count from date of sowing), dry fruit yield/plant, fruit length and single fruit weight (Marame *et al.* 2008). This might be attributed to the genetic makeup of varieties and/or the agro ecological factors including, soil type and its nutrient content, temperature, availability of irrigation or rain water in the growing area based on the study period.

From the above findings, it is concluded that coriander variety ACr-1 grown under Module-1 (M_1) [comprising of soil application of vermicompost (5 tonnes/ha), foliar spray of garlic extract (5% @ 2.0 kg/ha) + neem oil (2% @ 5 l/ha, soil application of neem cake (150 kg/ha) and *Trichoderma* (2.5 kg/ha), seed treatment with *Azotobacter* (100 ml/kg seed), PSB (100 ml/kg seed) and *Trichoderma* (10 g/kg seed)] exhibited maximum values for almost all the growth parameters, yield attributes, seed yield, gross returns, net reurns with higher B:C ratio. Hence, variety ACr-1 is recommended to grow organically with the application of Module-1 (M_1) under semi-arid environmental conditions.

ACKNOWLEDGEMENT

Authors wish to express their sincere thanks to Indian Council of Agricultural Research (ICAR) and World Bank for financial support and facilities provided through National Agricultural Innovation Project (Componant-2) on "Value chain in major seed spices for domestic and export promotion".

REFERENCES

Anwer M, Patra D D, Chand S, Alpesh K, Naqvi A A and Khanuja S P S. 2005. Effect of organic manures and inorganic fertilizers on growth, herb and oil yield, nutrient accumulation and oil quality of French basil. *Comm. Soil Sci. Plant Analysis* **36** (13-14): 1 737–46.

Arguello J A, Ledesma A, Nunez S B, Rodriguez C H and Goldfarb M D D. 2006. Vermicompost effects on bulbing dynamics, non-structural carbohydrates content, yield and quality of Rosado Paraguayo garlic bulbs. *Hort. Sci*. **41**(3): 589–92.

Atiyeh R M, Arancon N Q, Edwards C A and Metzger J D. 2000. Influence of earthworm-processed pig manure on the growth and yield of greenhouse tomatoes. *Bioresource Technol*ogy **75**: 175–80.

Balachandran D and Nagarajan P. 2002. Dual inoculation of Rhizobium and phosphobacteria with phosphorus on black gram cv. Vamban1. *Madras Agricultural Journal* **89**(10-12): 691–3.

Chatterjee R and Thirumdasu R K. 2014. Nutrient management in organic vegetable production. *International Journal of Food*

Agricultural Veterinary Science **4**(3): 156–70.

Darzi M T, Ghalavand A and Rejali F. 2008. Effect of mycorrhiza, vermicompost and phosphate biofertilizers application on flowering, biological yield and root colonization in fennel (*Foeniculum vulgare* L). *Iranian Journal of Crop Science* **10**(1): 88–109.

Darzi M T, Haj S, Hadi M R and Rejali F. 2011. Effect of vermicompost and phosphate biofertilizerapplication on yield and yield componenets in Anise (*Pimpinella anisum* L.) *Iranian Journal of Medicina and Aromatics Plants* **4**(50): 452–65.

Garg V K. 2007. Effect of non-symbiotic microbial inoculants on growth, yield and quality of fennel (*Foeniculum vulgare* Mill.) grown in sodic soil. *Journal of Spices and Aromatic Crops* **16**(2): 93–8.

Godara A S, Gupta U S, Lal G and Singh R. 2014. Influence of organic and inorganic source of fertilizers on growth, yield and economics of coriander (*Coriandrum sativum* L.). *International Journal of Seed Spices* **4**(2): 77–80.

Gyaneshwar P, Kumar N G, Parekh L J and Poole P S. 2002. Role of soil microorganisms in improving P nutrition of plants. *Plant Soil* **245**: 83–93.

Jawadagi R S, Basavaraj N, Patil B N, Hemlanaik B, and Channappagoudar B B. 2012. Effect of different sources of nutrients on growth, yield and quality of onion (*Allium cepa* L.) cv. Bellary red. *Karnataka Journal of Agricultural Sciences* **25**(2): 232–5.

Karmegam N, Alyumalai K and Daniel T. 1999. Effect of vermicompost on the growth and yield of green gram. *Tropical Agricultural* **76**(2): 143–6.

Lal G, Meena S S, Anwer M M, Mehta R S and Maheria S P. 2010. *Advanced production technology of coriander*. A technical bulletin, National Research Centre on Seed Spices, Tabiji, Ajmer, Rajasthan, 36 p.

Mamatha H N. 2006. 'Effect of organic and inorganic sources of nitrogen on yield and quality of onion (*Allium cepa* L.) and soil properties in Alfisol.' M Sc (Agri.) thesis, University of Agricultural Science Dharwad.

Marame F, Desalegne L, Singh H, Fininsa C And Sigvald R. 2008. Genetic Components and Heritability of Yield and Yield Related Traits in Hot Pepper. *Research Journal of Agricultural and Biological Science* **4**(6): 803–9.

Mathur K. 2000. Effect of *Rhizobium* inoculation and various sources of nitrogen on growth and yield of summer green gram (*Vigna radiate* L.) M Sc thesis, CCSHAU, Hisar.

Mba C C. 1996. Treated-cassava peel vermicompost enhanced earthworm activities and cowpea growth in fields plots. *Resources Conservation and Recycling* **17**(3): 219–26.

Mehta R S, Anwer M M and Malhotra S K. 2012. Influence of sheep manure, vermi-compost and biofertilizer on growth, yield and profitability of cumin (*Cuminum cyminum* L.) production. *Journal of Spices and Aromatic Crops* **21**(1): 16–9.

Mehta R S, Patel B S, Meena S S and Meena R S. 2010**.** Influence of nitrogen, phosphorus and bio-fertilizers on growth characters and yield of fenugreek (*Trigonella foenum-graecum* L.). *Journal of Spices and Aromatic Crops* **19**(1 & 2): 23–8.

Mochiah M B, Banful B, Fening K N, Amoabeng B W, Offei Bonsu K, Ekyem S, Braimah H and Owusu-Akyaw M. 2011. Botanicals for the management of insect pests in organic vegetable production. *Journal of Entomology and Nematology* **3**(6): 85–97.

Nagavallemma K P, Wani S P, Lacroix S, Padmaja V V, Vineela C, Babu Rao M and Sahrawat K Lzz. 2004. Vermicomposting: Recycling wastes into valuable organic fertilizer. Global Theme on Agro ecosystems Report No. 8, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, p 20.

Okon. 1985. Azospirillum as potential inoculant for agriculture. *Tibtech,***3** : 223–8.

Palaniappan S P and Annadurai K. 1999. *Organic Farming: Theory and Practices.* Scientific Publishers, Jodhpur.

Panse V G and Sukhatme P V. 1985. *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi.

Parihar N S. 2002. Effect of sulphur, zink and organic manure on yield and nutrient uptake of wheat. Ph D thesis, *RAU,* Bikaner.

Patra P, Pati B K, Ghosh G K, Mura S S, Saha A. 2013. Effect of biofertilizers and sulphur on growth, yield, and oil content of hybrid sunflower (*Helianthus annuus*. L) in a Typical Lateritic soil. Scientific reports, p 603.

Pritam S, Garg V K, Kaushik C P. 2010. Growth and yield response of marigold to potting media containing vermicompost produced from different wastes. *Environmentalist* **30**: 123–30.

Rathore S S, Saxena S S and Singh Balraj. 2013. Potential health benefits of major seed spices. *International Journal of Seed Spices* **3**(2): 1–12.

Sajan M K, Govda K K, Niranjan Kumar and Sreeramu B S. 2002. Effect of biofertilizer on growth and yield of chilli (*Capsicum annum*) cv. Byadgi Daabba at different level of nitrogen and phosphorus. *Journal of Spices and Aromatic Crops* **11**: 58–61.

Samuvel G. 1984, Studies on the interaction between VAM and phosphobacterium in certain vegetable crop plants. *M Sc (Agri.)* thesis, Tamil Nadu Agricultural University, Coimbatore.

Singh D and Yadav B L. 2006. Effect of organic materials and zinc on growth and yield of wheat under irrigation with high RSC water. *Haryana Journal of Agronomy* **22**: 1 425–44.

Singh J, Bhat S J and Sadhasan M R. 1997. Performance of scotch bonnet chilli in Karanataka and its response to vermicompost. *Indian Coccoa Arecanut Spices Journal* **21**: 9–10.

Usman I S, J D, Olanrewaju and Ado S G. 1991. Effects of variety on the growth and yield of chilli pepper. Paper presented at the 12th Annual Conference of the Horticultural Society of Nigeria held at University of Nigeria, Nsukka, 3-6 November 1991, pp 6–9.

Vadiraj B A, Siddagangaiah A and Poti S N. 1998a. Effect of vermicompost on growth and yield of turmeric. *South Indian Horticulture* **46**: 176–9.

Vadiraj B A, Siddagangalah A and Potty S N. 1998b. Response of coriander cultivars to graded levels of vermin-compost. *Journal of Spices and Aromatic Crops* **7**(2): 141-3.