Research Article

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Effect of integrated nutrient supply on yield and uptake of cardamom (*Elettaria cardamomum* L. Maton.)

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Abstract

Field experiments were conducted for seven years (2000 to 2007) to assess the effect of integrated nutrient supply with *Azospirillum* and the combination of *Azospirillum,* FYM and graded levels of nitrogen on yield and uptake of cardamom. Results revealed that application of FYM @ 5 or 10 kg/plant with or without *Azospirillum* did not influence the yield components as well as yield levels appreciably. Application of FYM @ 5kg/ plant + 75 % recommended N + *Azospirillum* yielded 163.53 kg/ha similar to that of FYM @ 5 kg / plant + 100 % recommended N (175.42 kg/ha) and FYM @ 5 kg / plant + 50 % recommended N + *Azospirillum* yielded 141.20 kg/ha similar to that of FYM @ 5 kg / plant + 75 % recommended N (146.34 kg/ha), thereby providing 25 % saving in inorganic nitrogen. Further, FYM @ 5 kg / plant + 100% recommended N + *Azospirillum*, responded with 186.48 kg/ha but found on par to FYM @ 5 kg/ plant + 100 % recommended N (175.42 kg/ha). Integrated nutrient management treatments recorded higher nitrogen in plants compared to pure organic treatments. Influence of *Azospirillum* is not that conspicuous on nitrogen uptake by plants.

Keywords: Azospirilum, capsule yield, farm yard manure, nitrogen, organic

Introduction

In Karnataka, cardamom is cultivated in an area of around 0.30 lakh ha with annual production of about 1,600 tones. Among the several factors responsible for low yield in cardamom, inadequate application of fertilizers or manures and summer drought are the major ones. The crop growing soils experiences problems such as leaching of applied nutrients due to heavy rainfall, high P fixation, low nutrient content and low water holding capacity of the soil makes nutrient use efficiency to be poor. Fertilizer application plays a crucial role to maintain buoyancy in production. Korikanthimath (2000) emphasized that application of organic and inorganic is essential as a part of scientific management to help maintenance of soil health and production of the crop. As a component of Integrated Nutrient management (INM), use of organics not only assumes a safe supplementation of nutrients but also provides soil resilience. *Azospirillum,* an associative symbiotic bacterium known to fix a substantial amount of atmospheric nitrogen and supply to the crop, enhances the fertilizer use efficiency, soil fertility status and ensures the partial saving of the nutrient thereby help to reduce cost of cultivation. As the response study for *Azospirillum* in cardamom is limited, the present investigation was carried out to assess the efficacy of *Azospirillum*, FYM and graded levels of nitrogen fertilizer on growth and nutrient uptake of cardamom.

Materials and Methods

The experiment was conducted at Zonal Agricultural Research Station, Mudigere, (13^{0}7'N Latitude, 75^{0}37'E Longitude, 982m msl) Karnataka State, during 2000-2007. The rainfall of 1,875, 1,793, 1,524, 2,282, 3,326, 3,593 and 4,634 mm was recorded respectively for years 2001, 2002, 2003, 2004, 2005, 2006 and 2007 as against the normal rainfall of 2350 mm. The soil of the experimental site was a typical lateritic red loam, having medium organic carbon (1.2-1.5 per cent), low P_2O_5 (7.0-10.8 kg/ha) and medium K_2O (315-398 kg/ ha). The experiment was laid out in a randomized block

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design comprising nine treatments replicated thrice. Various combinations of recommended dose of N with farm yard manure (FYM) and *Azospirillum* were included as treatments.

The variety chosen for the study was 'M_1' and suckers were planted during July 2000 with a spacing of 1.8 X 1.8 m. In each treatment, fertilizers were applied in two split doses during last week of May and September. The recommended P and K (75:150 kg/ha) were common to all the treatments and applied along with N. The bio-fertilizer *Azospirillum brazilense* was obtained from the Department of Microbiology, UAS, GKVK, Bangalore. For each clump, bio-fertilizer @ 25 g was mixed well with FYM @ 5 kg and applied for the respective treatments. Chemical fertilizers were given 15 days after application of FYM. The harvest of capsule was done from August to November in each year. Soil samples for nitrogen analysis were drawn before application of any manures and fertilizers, 30 and 60 days after fertilization. Different plant samples were drawn during August first week for nitrogen analysis. Using standard laboratory techniques, nitrogen was determined both in soil and plant parts. Yield components were recorded before first harvest of the crop and subjected to statistical analysis (Panse and Sukhatme, 1989). The sustainable yield index was also computed using the formula of Singh *et al.* (1990).

SYI = Y- œ /Y max

Where, SYI – Sustainable yield index,

Y - Average yield over the years in response to a practice

œ - Standard deviation

Y max - Observed maximum yield in the plot

Results and Discussion

The effect of integrated nutrient management on yield parameters and cardamom capsule yield is presented in Tables 1 and 2, respectively. During 2002 and 2003, the plants started yielding and percentage of yielding plants was 12.5 and 23.8 per cent. In the subsequent years of study, application of *Azospirillum*, FYM and chemical N resulted in significant variation in yield of the crop. During 2003 and 2004 quantity and distribution of rainfall was well below the normal. The crop was affected during 2003 and the shock was not completely revoked in the succeeding years due to deficit rainfall in 2004. Because of this, the crop performance was low during 2004. While during 2005 to 2007, rainfall was normal favouring better growth and yield. During summer months of January to May, only life saving irrigation at 20 –25 days interval was given.

Effect of organic treatments

Pure organic treatments (T4, T5, T6 and T7) included in the study were FYM @ 5 or 10 kg/plant with or without *Azospirillum*. These treatments recorded lower capsule yield compared to INM treatments with inorganic. During 2004, capsule yield was ranging from 58.85 to 65.42 kg/ha, while during 2005, 2006 and 2007 it varied from 114.82 to 153.59 kg/ha. The lower yield obtained during 2004 was mainly due to the effect of stress experienced by the plants causing reduction in yield parameters (Table 2). The yield parameters improved during the subsequent years and resulted in better response in terms of yield. But, compared to INM treatments involving inorganic, these parameters were low only. However, over the years, steady increase in yield was noticed due to organic application. At the end of fifth year, the performance of application of FYM @ 5 kg/ha was found to be on par with that of application of 10 kg/plant. Mixing with *Azospirillum* had no positive effect on yield components or yield. The results are in line with that of Kadalli *et al.* (2008).

Effect of INM treatments

Cardamom responded positively for fertilizer application (Table 2). Yield levels obtained were lower during 2004 (79.40 - 101.78 kg/ha), while it was normal during 2005, 2006 and 2007 (159.44 - 220.76 kg/ha). The yield components recorded (Table 1) also showed lower values during 2004, while for other years it was better. It was noticed that application of 100 % recommended N + FYM @ 5 kg / plant with or without *Azospirillum* recorded significantly higher capsule yields than rest of the treatments. In normal years of rainfall, the yield levels of 198.74, 210.79 and 190.62 kg/ha was recorded in 100 % recommended N + FYM @ 5 kg / plant wherein, 100 % recommended N + FYM @ 5 kg / plant + *Azospirillum* recorded 213.24, 220.76 and 210.14 kg/ha, respectively for 2005, 2006 and 2007. It was followed by 75 % recommended N + FYM @ 5 kg / plant with *Azospirillum* (176.52, 208.58 and 189.62 kg/ha), respectively for 2005, 2006 and 2007 or without *Azospirillum* (159.44, 194.37 and 150.11 kg/ha), respectively for 2005, 2006 and 2007). Different yield parameters recorded was found to be significant for different INM treatments except that of panicle length during 2006. Among these different components, 100 % fertilization helped to realize maximum number of bearing suckers, flowering panicles and capsules/panicle. The positive growth of crop followed by better yield component is reflected in these treatments to get maximum yield. Reduction in nitrogen application had

Table 1. Effect of integrated nutrient supply on yield parameters of cardamom

Treatment	2004				2005				2006			
	Bearing suckers	Capsule/ Panicle	Panicle length (cm)	Flowers/ Panicle	Bearing suckers	Capsule/ Panicle	Panicle length (cm)	Flowers/ Panicle	Bearing suckers	Capsule/ Panicle	Panicle length (cm)	Flowers/ Panicles
T1	22.72	11.00	30.56	37.97	24.80	22.44	61.67	37.40	23.87	23.60	65.71	41.00
T2	19.00	10.17	25.05	35.67	22.60	20.30	59.31	35.13	20.80	22.75	65.87	38.07
T3	19.40	9.33	25.15	33.93	20.53	19.29	58.32	31.60	19.33	21.49	64.20	34.73
T4	13.78	8.67	22.12	28.25	17.67	14.50	56.49	30.00	16.93	16.79	62.87	30.40
T5	12.67	8.17	22.10	29.13	18.47	14.97	51.62	30.73	19.67	17.79	63.29	31.47
T6	15.00	8.99	23.33	31.73	18.60	15.12	56.13	29.40	18.33	17.64	64.62	30.47
T7	16.07	9.10	22.73	31.80	20.53	15.83	55.22	32.53	17.60	17.32	63.87	29.53
T8	21.87	10.68	28.34	39.36	24.80	22.57	65.11	39.40	23.73	23.21	67.71	39.40
T9	17.00	10.11	25.42	32.80	21.27	18.97	59.33	32.00	20.00	22.89	66.20	38.87
CD (P = 0.05)	2.89	0.38	3.61	4.20	2.13	1.44	4.56	4.32	1.74	2.43	NS	1.38

NS = Not Significant

T_1: Recommended N (100 %) + FYM @ 5 kg/plant + *Azospirillum*

T_2: Recommended N (75 %) + FYM @ 5 kg/plant + *Azospirillum*

T_3: Recommended N (50 %) + FYM @ 5 kg/plant + *Azospirillum*

T_4: FYM @ 5 kg/plant

T_5: FYM @ 5 kg/plant + *Azospirillum*

T_6: FYM @10 kg/plant

T_7: FYM @ 10 kg/ plant + *Azospirillum*

T_8: Recommended N (100 %) + FYM @ 5 kg/plant

T_9: Recommended N (75 %) + FYM @ 5 kg/plant

Table 2. Effect of integrated nutrient supply on cardamom dry capsule yield (kg/ha)

Treatments	2004	2005	2006	2007	Mean	SYI
T1	101.78	213.24	220.76	210.14	186.48	0.60
T2	79.40	176.52	208.58	189.62	163.53	0.50
T3	77.74	161.58	169.16	156.30	141.20	0.40
T4	58.85	140.10	150.16	137.10	121.55	0.32
T5	59.50	130.54	152.36	136.52	119.73	0.31
T6	65.42	121.28	153.59	124.27	116.14	0.29
T7	58.91	114.82	145.29	116.00	108.76	0.26
T8	101.50	198.74	210.79	190.62	175.42	0.55
T9	81.44	159.44	194.37	150.11	146.34	0.43
CD (P=0.05)	4.32	2.63	14.93	31.98	11.82	

SYI = Sustainable yield index, standard Error = 49.01 Y max = 228.09

the direct reflection in growth as shown by reduction of yield components and yield, thereby the crop suffered to some extent. The result corroborates the findings of Subramanian *et al.* (2003). Application of *Azospirillum* and chemical fertilizers in addition to FYM resulted in the highest dry berry yield in pepper (Kanthaswamy *et al*., 1996). Results of three-year study in clove and nutmeg also gave similar results (Anonymous, 2000).

It was found from the mean data of five years (Table 2) that application of 75 % recommended N + FYM @ 5 kg / plant + *Azospirillum* yielded 163.53 kg/ ha similar to that of 100 % recommended N + FYM @ 5 kg/plant (175.42 kg/ha). Similarly, 50 % recommended N + FYM @ 5 kg /plant + *Azospirillum* yielded 141.20 kg/ha similar to that of 75 % recommended N + FYM @ 5 kg /plant (146.34 kg/ha). These data clearly indicates that there is a saving of 25 % inorganic nitrogen. At the same level of nitrogen, addition of *Azospirillum* responded marginally. At 75 % recommended N, addition of *Azospirillum* helped to enhance yield level by 17 kg/ ha which is not statistically significant. Further, application of 100 % recommended N + FYM @ 5 kg / plant with or without *Azospirillum* recorded yields of 186.48 and 175.42 kg/ha, respectively but found significantly superior to that of the other treatments. These variations are mainly attributed to the yield components. *Azospirillum* might have increased yield components by production of growth promoting substances viz., IAA, GA and other phytohormones apart from nitrogen fixation (Govindan and Purushottaman, 1984; Govindarajan and Thangaraju, 2001 and Nandakumar and Veeraragavathatham, 2001). The sustainability yield index (Table 2) indicates that application of 100 % recommended N + FYM @ 5 kg / plant with or without application of *Azospirillum* and 75 % recommended N + FYM @ 5 kg/plant with *Azospirillum* reached the level of sustainability as the values were above the levels of 0.5 (Singh *et al.,* 1990). Hence, inorganic component plays a dominant role in enhancing and sustaining the yield levels of cardamom.

Plant uptake and soil nitrogen

The effect of *Azospirillum* in integrated nutrient management on plant uptake and soil nitrogen is presented in Tables 3 and 4, respectively. Three years of uptake study revealed that seed contains maximum nitrogen (> 2 per cent) followed by leaves on yield bearing pseudo stems (1.08-1.29 per cent) and husk (0.6-1.6 per cent). Yield bearing pseudo stems and panicles

had minimum content (0.7-1.2 per cent). Seed being the final sink do contained maximum nitrogen. Organic group of treatments found to contain relatively lower nitrogen in plant parts, which might be due to steady availability. Results of Mahfouz and Sharaf-Eldin (2008) also envisage lower nutrient content in fennel. Compared to initial status of N in different depths, steady increase in N level at 0-15 cm depth was noticed on 30th and 60th day. On the other hand, INM with inorganic group due to availability of nutrient after application showed a little higher content and supported for better growth and yield components. Soil available nitrogen status clearly indicates that after 30 days of application, the nitrogen content remained higher and the status was maintained even upto 60 days at 0-15 cm depth. With deeper depth (15-30 cm) wide fluctuations were recorded. With *Azospirillum* additions, a slight enhancement of nutrient level was recorded at 0-15 cm depth.

Conclusion

The study indicates that application of 75 % recommended N + FYM @ 5 kg /plant + *Azospirillum* yielded similar to that of 100 % recommended N + FYM @ 5 kg /plant and 50% recommended N + FYM @ 5 kg /plant + *Azospirillum* yielded similar to that of 75 % recommended N + FYM @ 5 kg /plant (146.34 kg/ha), thereby evidences for 25 % saving of inorganic nitrogen.

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Table 3. Effect of integrated nutrient supply on plant uptake of nitrogen (%) in cardamom

Treatment	2004					2005					2006				
	Yield bearing pseudo stem	Yield bearing leaves	Panicle	Husk	Seed	Bearing pseudo stem	Bearing leaves	Panicle	Husk	Seed	Bearing pseudo stem	Bearing leaves	Panicle	Husk	Seed
T1	0.88	1.24	0.78	1.58	2.51	0.92	1.28	0.76	1.06	2.41	0.81	1.23	0.75	1.00	2.21
T2	0.92	1.29	0.70	1.60	2.44	0.82	1.22	0.73	1.02	2.27	0.80	1. 21	0.63	1.00	2.17
T3	0.94	1.21	0.70	1.57	2.46	0.80	1.21	0.70	1.16	2.21	0.78	1.08	0.64	0.79	2.19
T4	0.90	1.16	0.68	1.34	2.10	0.80	1.04	0.68	1.15	2.18	0.66	1.15	0.70	0.79	2.16
T5	0.91	1.15	0.62	1.44	2.14	0.80	1.15	0.62	1.14	2.22	0.66	1.15	0.61	0.70	2.16
T6	0.85	1.12	0.63	1.42	2.18	0.73	1.14	0.63	1.04	2.17	0.66	1.10	0.61	0.71	2.18
T7	0.84	1.10	0.63	1.38	2.11	0.90	1.11	0.63	1.02	2.05	0.73	1.11	0.63	0.73	2.14
T8	0.92	1.26	0.89	1.53	2.57	0.90	1.22	0.92	1.06	2.44	0.76	1.16	0.66	0.61	2.37
T9	0.93	1.25	0.75	1.65	2.54	0.94	1.27	0.95	1.10	2.36	0.78	1.16	0.68	0.60	2.23
CD (P = 0.05)	0.049	0.046	0.111	0.082	0.161	0.048	0.067	0.066	0.044	0.057	0.09	NS	NS	0.148	NS

NS = Not Significant

Table 4. Effect of integrated nutrient supply on soil available nitrogen (kg/ha)

Treatment	2004						2005						2006					
	0-15 cm			15-30 cm			0-15 cm			15-30 cm			0-15 cm			15-30 cm		
	Initial	After 30 days	After 60 days	Initial	After 30 days	After 60 days	Initial	After 30 days	After 60 days	Initial	After 30 days	After 60 days	Initial	After 30 days	After 60 days	Initial	After 30 days	After 60 days
T1	266.56	219.52	282.24	282.24	250.88	282.84	213.4	268.9	242.8	244.6	25102	279.4	244.6	269.42	263.42	263.40	263.10	263.40
T2	250.18	297.92	297.92	266.56	229.52	250.88	244.6	250.1	245.3	250.4	258.5	276.4	267.8	263.12	255.88	243.80	253.42	251.10
T3	229.52	266.56	282.24	250.88	250.88	329.96	267.8	267.5	245.7	257.4	267.2	276.2	228.4	255.64	252.59	240.70	255.80	255.60
T4	250.88	266.56	266.56	250.88	282.24	313.60	229.4	234.3	221.4	257.4	242.8	267.8	229.4	261.62	249.62	233.80	247.10	244.10
T5	250.88	250.88	266.56	219.52	250.88	329.28	250.4	245.7	231.9	229.4	224.5	224.5	250.4	266.3	250.40	253.80	256.90	263.10
T6	282.24	266.56	282.92	219.52	250.88	329.28	257.4	257.4	247.1	267.8	254.1	265.6	244.6	240.9	251.50	261.30	265.60	264.80
T7	250.88	282.24	297.92	219.52	282.24	376.32	250.4	256.3	267.8	250.4	236.0	242.8	244.6	246.92	251.90	258.40	271.30	270.40
T8	250.88	250.88	282.24	282.24	297.92	313.60	244.6	256.3	264.4	261.8	276.3	265.1	250.4	259.10	254.40	243.30	265.90	254.90
T9	219.52	250.88	266.56	266.56	266.56	313.60	244.6	242.8	236.4	241.0	254.4	256.3	267.8	258.43	265.50	251.60	255.00	259.60
C.D. (P = 0.05)	15.98	10.56		14.37	NS			11.45	25.38		7.89	8.57		NS	NS		NS	NS

NS = Not Significant

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