THE ASIAN JOURNAL OF HORTICULTURE
Volume 7 | Issue 2 | December, 2012 | 561-564

Research Paper

Article history :
Received : 11.07.2012
Revised : 21.11.2012
Accepted : 11.12.2012

Response of bio-fertilizer *Azospirillum* on growth and yield of fennel cv. RAJENDRA SAURABH

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ABSTRACT : The Experiment was conducted during 2007-2008 to 2009-2010 at experimental field of the Department of Horticulture, Tirhut College of Agriculture, Dholi, Muzaffarpur (Bihar). Combination of bio-fertilizer *Azospirillum* + inorganic nitrogen + FYM gave the better performance in comparison to alone application of bio-fertilizer *Azospirillum*, inorganic nitrogen, FYM and other combination. The combination treatment as soil application of inorganic N (100%) of RDF + *Azospirillum* @ 15 kg ha^{-1} + FYM – @ 5 t ha^{-1} (T_1) produced the maximum plant height (169.32 cm), number of branches per plant (9.36), number of umbels per plant (65.65), number of umbellets per umbel (49.42), number of grains per umbellets (46.14) and yield per plot (1.18 kg 7.2 m^{-2}) or per hectare (1.63 t ha^{-1}) and increased the yield 96.38 per cent over control followed by treatment (T_2) as soil application of inorganic N (75%) of RDF + *Azospirillum* @ 15 kg ha^{-1} + FYM – 5 t ha^{-1} *i.e.* plant height (156.00 cm), number of branches per plant (8.05), number of umbels (61.71), number of umbellets per umbel (43.72), number of grains per umbel (40.54) and yield per plot (1.04 kg 7.2 m^{-2}) or per hectare (1.45t ha^{-1}) and increased yield (74.69%) over control. The lowest yield (0.83t ha^{-1}) was recorded with control. The maximum net profit Rs.58, 200 ha^{-1} or benefit: cost (Rs.2.50) were calculated with treatment (T_1) inorganic N (100%) RDF + Azospirillum @ 15 kg ha^{-1} + FYM-5 t ha^{-1}.

KEY WORDS : *Azospirillum*, Organic (FYM), Inorganic nitrogen, Fennel, Economics

HOW TO CITE THIS ARTICLE : Singh, S.P. (2012). Response of bio-fertilizer *Azospirillum* on growth and yield of fennel cv. RAJENDRA SAURABH, *Asian J. Hort.*, **7**(2) : 561-564.

Fennel *(Foeniculum Valgare* Mill) is a minor seed spices which belong to family Apiaceae. Fennel is a stout, tap rooted, aromatic herbaceous plant which usually grows to a height of 100-180 cm. The stem is glabrous slender and hollow at maturity with prominent parallel vein. The leaves are pinnately compound with sheathed petiole, partile leaf blade and alternate phyllotaxy. The inflorescence is a compound umbel with substended involucre of bracts and appears terminally on the plant. The plant is diploid and it has chromosome number 22 (2n = 2 x 11). The fennel fruit have peculiar aromatic and pleasant test. The aroma is due to the volatile oil content in seed. The volatile oil contains anethole, fenchone and manute quantity of pinene, comphene, diphentene etc. Fennel can be grown on a variety of soil, however, proper nutritional management is essential, as application of different nutrients was found to influence the growth, yield and quality of garlic (Wange, 1995). Use of organic manure along with inorganic fertilizers has been advocated by several workers. In view of the escalating cost of chemical fertilizers and due to their hazardous effect on soil, soil resources and human health, it is imperative to explore the possibility of supplementing chemical fertilizers with ecofriendly low cost input of microbial orgin like *Azospirillum*, *Azotobactor* and phospho bacteria. The microbial inoculants improve nutrient availability resulting in enhanced growth, yield and quality of vegetable crops, besides reducing the quantum of nitrogen and phosphatic fertilizers as reported by Gaur (1985), Musmade and Konde (1986), Gurubatham *et al.* (1989), Wange (1995), Chattoo *et al.* (1997), Thiiakavathy and Rammaswamy (1999) and Karuthamani *et al.* (1995). Keeping in view their significance present investigation was undertaken to assess the effect of bio-fertilizers *Azospirillum*, organic, and inorganic fertilizer alone and combination with bio-fertilizer *Azospirillum*, organic and inorganic under different level of organic manure and inorganic nitrogen on fennel regarding growth and yield in region of Bihar.

RESEARCH METHODS

The experiment was conducted during 2007-2008 to 2009-2010 at experimental fields of the Department of Horticulture, Tirhut College of Agriculture, Dholi, Muzaffarpur (Rajendra Agricultural University, Bihar). The experiment was laidout in Randomized Block Design with three replications using variety Rajendra Saurabh. The seeds were sown in nursery in the 3rd weeks of September and transplanted in 3rd week of October every year. The experiment was allotted by ICAR under All India Coordinated Research Project on Spices. The plot size for each treatment was 3.0m x 2.4m with a spacing of 60cm x 60cm. Experimental plot soil was of sandy loam texture with PH-7.2, EC-0.36 dsm^{-1}, organic carbon 0.32 per cent and available N,P,K were 112.0, 13.5, 105.0 kg ha^{-1}, respectively. The treatment details are given below.

Table A : Treatment details

T_1	Inorganic N (100%) of RDF + *Azospirillum* @ 15 kg ha^{-1} + FYM – 5t ha^{-1}.
T_2	Inorganic N (75%) of RDF + *Azospirillum* @ 15 kg ha^{-1} + FYM – 5t ha^{-1}.
T_3	Inorganic N (50%) of RDF + *Azospirillum* @ 15 kg ha^{-1} + FYM – 5t ha^{-1}.
T_4	FYM 5 t ha^{-1} + *Azospirillum* @ 15 kg ha^{-1}
T_5	FYM – 5 t ha^{-1} alone.
T_6	FYM – 10 t ha^{-1} + *Azospirillum* @ 15 kg ha^{-1}
T_7	FYM – 10 t ha^{-1} alone.
T_8	100% inorganic nitrogen of RDF alone.
T_9	*Azospirillum* @ 15 kg ha^{-1} alone.
T_{10}	Control.

Observation on growth and yield were recorded from selected five random plants of each treatments and replication using standard procedures

RESEARCH FINDINGS AND DISCUSSION

The results obtained from the present investigation are summarized in the following sub heads :

Effects of growth attribute:

Combined effect of bio-fertilizer *Azospirillum*, FYM and inorganic nitrogen gave significant effect as compared to control regarding growth parameters (Table 1). Maximum plant height (169.32 cm) and number of branches per plant (9.36) were recorded with treatment (T_1) as soil application inorganic N (100%) of RDF + *Azospirillum* @ 15 kg ha^{-1} + FYM - 5t ha^{-1} followed by treatment (T_2) as soil application inorganic N (75%) of RDF + *Azosprillum* @ 15 kg ha^{-1} + FYM – 5t ha^{-1} *i.e.* plant height (156.00cm) and number of branches per plant (8.05). Minimum plant height (131.00cm) and number of branches per plant (5.39) were recorded with treatment (T_{10}) control (No application). Increase in growth related attributes due to bio-fertilizer application was reported by Karuthamani *et al.* (1995), Wange (1995), Thilakavathy and Ramaswamy (1999) and Chattoo *et al.* (2007) in other vegetable crops. The improvement in growth related attributes could be because of certain growth promoting substances, secreted by bio-fertilizer, besides increasing the availability of atmospheric nitrogen and soil phosphorus, which might have led to better root and shoot development, better uptake of water, nutrients and their transportation.

Effect of yield attributes:

Yield and yield related attributes of fennel were significantly influenced by combined effect of bio-fertilizer Azospirillum, FYM and inorganic nitrogen as compared to

Table 1 : Effect of bio-fertilizer *Azospirillum*, organic and inorganic nitrogen on growth and yield attributes of fennel

Characters / Treatments	Height of the plant			Pooled mean	No. of branches per plant			Pooled mean
	2007-2008	2008-2009	2009-2010		2007-2008	2008-2009	2009-2010	
1	2	3	4	5	6	7	8	9
T_1	147.00	184.00	176.96	169.32	9.67	10.50	7.93	9.36
T_2	144.17	166.63	157.20	156.00	8.50	8.83	6.83	8.05
T_3	153.83	163.83	154.76	157.47	7.83	8.83	6.43	7.69
T_4	145.67	148.67	139.63	144.65	6.67	7.50	4.76	6.31
T_5	145.83	146.50	138.30	143.54	7.17	7.16	4.30	6.21
T_6	151.17	155.67	146.40	151.08	8.17	7.83	4.56	6.85
T_7	155.00	152.33	143.56	150.29	7.33	7.83	4.53	6.56
T_8	137.83	158.17	152.69	149.65	7.83	8.33	6.76	7.64
T_9	146.83	142.00	134.43	141.08	7.50	7.00	4.03	6.17
T_{10}	148.83	127.17	117.00	131.00	6.67	6.17	3.33	5.39
S.E. ±	9.57	6.77	6.08	5.63	0.56	0.25	0.25	0.28
C.D. (P=0.05) 20.12	NS	20.12	18.06	16.75	1.65	0.77	0.75	0.85
CV (%) 7.59	11.23	7.59	7.20	6.53	12.46	5.60	8.22	7.09

Table 1 contd...

Contd. Table 1

Characters / Treatments	No. of umbels per plant			Pooled mean	No. of umbellets per umbel			Pooled mean
	2007-2008	2008-2009	2009-2010		2007-2008	2008-2009	2009-2010	
	10	11	12	13	14	15	16	17
T_1	44.17	79.00	73.80	65.65	65.00	42.83	40.43	49.42
T_2	40.17	77.50	68.46	61.71	55.00	39.00	37.16	43.72
T_3	37.50	70.17	63.53	57.06	47.67	37.50	35.40	40.19
T_4	34.00	56.50	49.16	46.55	30.17	32.83	28.90	30.63
T_5	30.17	57.67	51.16	46.33	42.67	32.00	27.60	34.09
T_6	32.50	64.50	54.66	50.55	35.67	35.33	30.16	33.72
T_7	31.00	63.33	56.46	50.26	33.20	35.33	30.23	32.92
T_8	28.83	71.17	65.93	55.31	31.17	37.33	36.10	34.86
T_9	28.17	52.33	44.86	41.78	32.00	30.17	25.26	29.14
T_{10}	27.83	50.50	39.33	39.22	31.00	27.33	20.06	26.13
S.E.M ±	1.75	3.29	3.18	2.39	2.73	0.86	1.80	2.99
C.D. (P=0.05) 20.12	5.20	9.80	9.46	7.12	8.12	2.56	5.37	8.89
CV (%) 7.59.	9.07	8.89	9.72	8.07	11.74	4.27	10.05	14.61

Contd. Table 1

Characters / Treatments	No. of grains per umbellet			Pooled mean	Yield per plot (kg 7.2m^{-2})			Pooled mean
	2007-2008	2008-2009	2009-2010		2007-2008	2008-2009	2009-2010	
	18	19	20	21	22	23	24	25
T_1	41.00	52.17	45.27	46.14	1.18	1.38	0.97	1.18
T_2	37.33	45.00	39.30	40.54	0.93	1.28	0.91	1.04
T_3	36.50	43.33	36.06	38.63	0.86	1.12	0.85	0.94
T_4	32.17	34.83	28.73	31.91	0.83	0.86	0.73	0.80
T_5	35.83	32.67	26.23	31.57	0.72	0.77	0.70	0.73
T_6	32.17	36.33	28.63	32.37	0.68	0.95	0.73	0.78
T_7	29.67	34.67	27.30	30.54	0.78	0.99	0.73	0.83
T_8	29.33	39.83	36.63	35.26	0.72	1.04	0.81	0.85
T_9	29.33	31.67	23.60	28.20	0.70	0.67	0.70	0.69
T_{10}	29.67	27.17	20.00	25.61	0.68	0.47	0.63	0.59
S.E. ±	2.27	1.69	1.47	1.77	0.05	0.04	0.02	0.06
C.D. (P=0.05) 20.12	6.74	5.05	4.37	5.26	0.14	0.11	0.07	0.17
CV (%) 7.59.	11.80	7.78	8.17	9.00	10.27	6.93	4.74	12.35

Contd… Table 1

Characters / Treatments	Yield (t ha^{-1})			Pooled mean	Increase in yield over check	
	2007-2008	2008-2009	2009-2010		t ha^{-1}	%
	26	27	28	29	30	31
T_1	1.64	1.92	1.34	1.63	0.80	96.38
T_2	1.29	1.79	1.27	1.45	0.62	74.69
T_3	1.20	1.56	1.18	1.31	0.48	57.83
T_4	1.16	1.20	1.02	1.12	0.29	34.93
T_5	0.99	1.07	0.97	1.01	0.18	21.68
T_6	0.96	1.32	1.02	1.10	0.27	32.53
T_7	1.08	1.36	1.02	1.15	0.32	38.55
T_8	0.99	1.45	1.13	1.19	0.36	43.37
T_9	0.97	0.93	0.97	0.95	0.12	14.45
T_{10}	0.96	0.66	0.87	0.83	-	-
S.E.M ±	0.06	0.05	0.02	0.08	-	-
C.D. (P=0.05) 20.12	0.19	0.15	0.10	0.26	-	-
CV (%) 7.59.	10.34	6.79	4.78	12.84	-	-

NS=Non-significant

Table 2 : Economics of the experiment (Fennel)

Treatments	Gross income (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net profit (Rs. ha^{-1})	Cost: benefit ratio
T_1	97,000	38,800	58,200	1:2.50
T_2	87,000	38,650	48,350	1:2.25
T_3	78,600	38,500	40,100	1:2.04
T_4	67,200	38,200	29,000	1:1.76
T_5	60,600	37,000	23,600	1:1.64
T_6	66,000	40,200	25,800	1:1.64
T_7	69,000	39,000	30,000	1:1.77
T_8	71,400	35,600	35,800	1:2.00
T_9	57,000	36,200	20,800	1:1.57
T_{10}	49,800	35,000	14,800	1:1.42

control (Table 1). Maximum number of umbels (65.65), number of umbellets per umbel (49.42), number of grains per umbellet (46.14) and yield per plot (1.18 kg 7.2 m^{-2}) or yield per hectare (1.63 t ha^{-1}) were observed with treatment (T_1) as soil application of inorganic N (100%) of RDF + *Azospirillum* @ 15 kg ha^{-1} + FYM - 5t ha^{-1} which increased the yield (96.38%) over control followed by treatment (T_2) as soil application inorganic N (75%) of RDF + *Azospirillum* @ 15 kg ha^{-1} + FYM – 5t ha^{-1} *i.e.* number of umbels per plant (61.71), number of umbellets per umbel (43.72), number of grains per umbellet (40.54) and yield per plot (1.04 kg 7.2 m^{-2}) or per hectare (1.45 t ha^{-1}) which increased the yield (74.69%) over control. The minimum number of umbels per plant (39.22), number of umbellets per umbel (26.13), number of grains per umbellet (25.61) and yield per plot (0.59 kg 7.2m^{-2}) or per hectare (0.83t ha^{-1}) were noticed with treatment (T_{10}) control (No application). Similar observations were also made by Gaur (1985), Karuthamani *et al.* (1995), Wange (1995) and Chatto *et al.* (1997), Thilakavathy and Ramaswamy (1999) and Chattoo *et al.* (2007) in other vegetable crops. The increase in yield attributes may be due to better root proliferation, uptake of nutrients and water, high leaf area, more photosynthesis and enhanced food accumulation, increasing availability of atmospheric nitrogen and phosphorus by microbial inoculants might have played a vital role in increasing the yield and yield related attributes of fennel.

Economics:

The economics of the experiment is presented in Table 2. The maximum gross income (Rs.97,000.00 ha^{-1}), net income (Rs.58,200 ha^{-1}) and benefit: cost ratio (2.50) were calculated with treatment (T_1) inorganic N (100%) of RDF + *Azospirillum* @ 15 kg ha^{-1} + FYM- 5t ha^{-1} followed by treatment (T_2) inorganic N (75%) of RDF + *Azospirillum* @ 15 kg ha^{-1} + FYM - 5t ha^{-1} *i.e.* gross income (Rs.87,000 ha^{-1}), net profit (Rs.48,350 ha^{-1}) and benefit : cost ratio (Rs.2.25). The total cost of cultivation was highest (Rs.40,200 ha^{-1}) with treatment (T_6) FYM – 10t ha^{-1} + Azospirillum @ 15 kg ha^{-1} and lowest cost in control (Rs.35,000.00 ha^{-1}).

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