International J. Seed Spices 9(2), July 2019:21-28

Impact of FYM enriched with iron and zinc on nutrient uptake, yield, quality and economics of fennel cultivation

***S.M. Patel, A.U. Amin, H.B. Patel and J.A. Patel**

Associate Professor, Seed Spices Research Station, SDAU, Jagudan, India

Abstract

To study the impact of FYM enriched iron and zinc on yield, quality, economics and nutrient uptake of fennel, an experiment was conducted during *rabi* season of 2013-14 to 2015-16 at Seed Spices Research Station, S. D. Agricultural University, Jagudan. Eight treatments *viz*.,T_1: RDF (90 kg N + 30 kg P_2O_5 ha^{-1}), T_2: T_1 + 3.0 t FYM ha^{-1}, T_3: T_1 + 6.0 kg Fe ha^{-1}, T_4: T_1 + 3.0 kg Zn ha^{-1}, T_5: T_1 + 6.0 kg Fe ha^{-1} + 3.0 kg Zn ha^{-1}, T_6: T_1 + 200 kg FYM enriched with 3.0 kg Fe ha^{-1}, T_7 : T_1 + 200 kg FYM enriched with 1.5 kg Zn ha^{-1} and T_8: T_1 + 200 kg FYM enriched with 3.0 kg Fe ha^{-1} + 1.5 kg Zn ha^{-1} were laid out in RBD with three replication. In general, all the growth and yield attributes were the maximum under application of 200 kg FYM enriched with Fe and Zn alongwith RDF. Effect of different FYM enriched with iron and zinc treatments were found positive w.r.t. seed yield in fennel during the study period and on pooled basis. Application of RDF along with 200 Kg FYM enriched with 3.0 kg Fe ha^{-1} + 1.5 kg Zn ha^{-1} were found significantly superior with respect to yield on pooled basis. The treatment receiving RDF along with 200 kg FYM ha^{-1} enriched with 3.0 kg Fe and 1.5 kg Zn ha^{-1} (T_8) recorded significantly the highest uptake of Fe and Zn through seed and stover over rest of the treatments. The maximum net realization (₹ 87150/-) and BCR (2.11) values were achieved when crop was fertilized with RDF (90 kg N + 30 kg P_2O_5 ha^{-1}) + 200 Kg FYM enriched with 3.0 kg Fe h^{-1}a + 1.5 kg Zn ha^{-1}.

Key words : Cumin, farm yard manure, iron, recommended those of fertilizers, zinc.

Introduction

Extensive cultivation of seed spices under arid and semiarid regions, increasing in national and international demand due to more profitability as compared to other *rabi* crops, seed spices are known as low volume but high value crops in Gujarat and Rajasthan. Fennel (*Foeniculum vulgare* Mill) is one of the four most important seed spice cultivated throughout the temperate and sub-tropical regions of the world and exported. In intensive agriculture, uses of high analyze inorganic fertilizers, little or scarce use of FYM and considerable reduction in recycling of crop residues resulted in deficiencies of micronutrients in soil. Now a days the deficiencies of micronutrients in soil have become major constraints for maintaining soil productivity. In recent days excessive use of non micro nutrient fertilizers and less or no use of organic manure is leading to micronutrients disorder in crop plants particularly in arid and semi arid regions of India where, soils are poor structured and low in native nutrient status. The soils of semi arid regions are low in micro-nutrients such as iron and zinc (Harisha *et al*., 2017) Poor soil structure, salinity and less use of methods of application of micro-nutrients pose a server problems to achieve the targeted yield. Fennel is a long duration crop with huge biomass, thus removes higher amount of nutrients from the soil. For the optimal growth and development of plants, balanced application of nutrients is highly essential. If essential element is lacking in the soil or not adequately balanced with other nutrients, growth suppression or even complete inhibition may result (Mengel *et al*., 2001). Deficiency of micronutrient may be responsible for reducing the yield and quality of fennel seed. Fertilization of these micronutrients plays the vital role not only improving yield and quality of fennel, but sustain the soil productivity also. Harisha *et al*., (2017) reported in fennel crop that crop response to micronutrients when there is deficiency in soil or crop demands more nutrients. Micronutrients enriched with FYM may increase the availability of nutrients. Wide spread of these micronutrients deficiencies was observed particularly for Fe and Zn in light textured soil of North Gujarat. Lower levels of organic carbon, S, Ca, Mg, Mn, Fe, Cu, Zn *etc*, are the limiting factors in spice growing fields contributing to the lower productivity and quality. Therefore, the investigation was planned on “Impact of FYM enriched iron and zinc on yield, quality, economics and nutrient uptake of fennel” at SSRS, Jagudan.

*Corresponding author email: shileshp1967@gmail.com

Materials and methods

To find out the effect of FYM enriched with Fe and Zn on growth, yield and economics of fennel crop, an investigation was carried out at Seed Spices Resarch Station, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, during *rabi* 2013-14 to 2015-16. Soil texture was loamy sand with low organic carbon (0.18 %) and low nitrogen (135 kg ha^{-1}) as well as medium available phosphorus (36 Kg P_2O_5 ha^{-1}) and potassium (285 kg K_2O ha^{-1}). Eight treatments *viz*., T_1: RDF (90 kg N + 30 kg P_2O_5 ha^{-1}),T_2: T_1 + 3.0 t FYM ha^{-1}, T_3: T_1 + 6.0 kg Fe ha^{-1}, T_4: T_1 + 3.0 kg Zn ha^{-1}, T_5: T_1 + 6.0 kg Fe ha^{-1} + 3.0 kg Zn ha^{-1}, T_6: T_1 + 200 kg FYM enriched with 3.0 kg Fe ha^{-1}, T_7: T_1 + 200 kg FYM enriched with 1.5 kg Zn ha^{-1} and T_8: T_1 + 200 kg FYM enriched with 3.0 kg Fe ha^{-1} + 1.5 kg Zn ha^{-1} were laid out in Randomized Block Design with three replications. The fennel seeds of variety GF 12 were sown manually 2-3 cm deep at 45 cm apart in furrow . The entire quantity of phosphorus and half of nitrogen in the form of DAP and Urea were manually applied as basal dose in the furrows. 1000 kg FYM was thoroughly mixed before 45 days with the $ZnSO_4.7H_2O$ or $FeSO_4.7H_2O$ as per the enrichment treatments *viz*., 0.75 and 1.5 kg Zn and 1.5 and 3.0 kg Fe $hectare^{-1}$. It was filled in the pre-dug polythene lined pits of 1.5 × 1.5 × 1.5 m size. The moisture percentage of FYM was kept at about 75 per cent after mixing with $ZnSO_4.7H_2O$ or $FeSO_4.7H_2O$ and cow dung slurry of 1 per cent. The pit was covered with polythene sheet and the mixture was allowed to decompose. The mixture was turned over periodically (weekly) and moisture loss was maintained. The enrichment process was completed after 5 to 6 weeks. This process helps to convert inorganic Fe and Zn in to organically bound and naturally chelated form of Fe and Zn. The content of different micronutrient in FYM before and after enrichment with iron and zinc is mentioned below.

Content of micronutrients in FYM (Before and after enrichment)

Treat. No.	Treatment	Year	Micronutrient content (ppm)			
			Fe	Mn	Zn	Cu
A.	Before enrichment					
	FYM	2013-14	2231	91.2	45.6	7.0
		2014-15	2352	85.7	42.2	10.0
		2015-16	2468	95.3	47.4	11.4
B.	After enrichment					
T_6	200 kg FYM enriched with 3.0 kg Fe/ha	2013-14	5270	99.2	62.5	13.5
		2014-15	5160	98.2	68.7	11.2
		2015-16	5403	102.8	65.4	10.2
T_7	200 kg FYM enriched with 1.5 kg Zn/ha	2013-14	2724	97.3	2320	15.7
		2014-15	2616	102.4	2114	13.4
		2015-16	2581	106.2	2428	12.2
T_8	200 kg FYM enriched with 3.0 kg Fe/ha + 1.5 kg Zn/ha	2013-14	5450	100.5	2545	19.8
		2014-15	5208	97.8	2236	14.8
		2015-16	5522	110.3	2512	13.6

The estimation of organic carbon was determine by Walkely and Black rapid titration method (Jackson,1978). Seed and straw samples were collected at harvest from each treatment for drying at 70°C and powdered in a grinder having stainless steel blade and digested in di-acid mixture (HNO_3 and $HClO_4$ in ratio of 3:1). The extract was used for the determination of Fe and Zn by atomic absorption spectrophotometer (ELICO SL-194). The uptake of Fe and Zn was calculated by multiplying dry weight of seed and straw with their respective content. The post harvest soil samples were collected, processed and analyzed for DTPA-Fe and Zn by extraction with 0.005 M DTPA (Lindsay and Norvell, 1978) on atomic absorption spectrophotometer.

Results and discussion

Growth and yield attributes

Different FYM enriched with Fe and Zn treatments emerged significant effect on plant height, numbers of umbels $plant^{-1}$ and test weight whereas, number of branches $plant^{-1}$, numbers of umbellates $umbel^{-1}$ and numbers of seeds $umbellate^{-1}$ remained non significant (Table 1). In general, all the growth and yield attributes were the maximum under application of 200 kg FYM enriched with Fe and Zn along with RDF. The plant height of 154.4 cm was attained when crop was fertilized with RDF (90 kg N + 30 kg P_2O_5 ha^{-1}) + 200 Kg FYM enriched with 3.0 kg Fe ha^{-1} + 1.5 kg Zn ha^{-1} over rest of the

Table 1. Growth and yield attributes of fennel as influenced by different FYM enriched Fe and Zn treatments (Pooled data of three years)

Treatments	Plant height (cm)	No. of branches plant^{-1}	No. of umbels plant^{-1}	No. of umbellates umbel^{-1}	No. of seeds umbellate^{-1}	Test weight (g)
T_1:RDF (90 kg N + 30 kg P_2O_5 /ha)	118.7	5.6	12.6	32.6	35.9	4.4
T_2:T_1 + 3.0 t FYM / ha	119.7	5.8	12.9	32.5	36.5	4.3
T_3:T_1 + 6.0 kg Fe / ha	145.7	5.8	14.9	32.9	36.1	4.5
T_4:T_1 + 3.0 kg Zn / ha	141.5	5.8	14.7	32.9	36.3	4.5
T_5:T_1 + 6.0 kg Fe / ha + 3.0 kg Zn / ha	143.8	6.0	14.9	33.1	36.4	4.4
T_6:T_1+ 200 Kg FYM enriched with 3.0 kg Fe/ ha	146.2	5.9	15.1	32.4	36.3	5.0
T_7:T_1 + 200 Kg FYM enriched with 1.5 kg Zn/ ha	147.4	6.2	15.2	34.0	36.5	5.1
T_8:T_1 + 200 Kg FYM enriched with 3.0 kg Fe / ha + 1.5 kg Zn / ha	154.4	6.6	16.9	35.4	37.7	5.3
S. Em. ±	4.4	0.25	0.45	1.16	1.53	0.11
C.D. at 5 %	12.6	NS	1.3	NS	NS	0.3
C.V. %	9.5	12.80	9.22	10.5	12.61	7.48
Y x T	NS	NS	NS	NS	NS	NS

treatments and remained at par with the treatments T_7, T_6, T_5 and T_3 on pooled basis. Significantly highest numbers of umbels plant^{-1} (16.9) was recorded with treatment T_8: T_1 + 200 Kg FYM enriched with 3.0 kg Fe ha^{-1} + 1.5 kg Zn ha^{-1}, whereas test weight (5.3 g) was significantly maximum under the treatment recorded by T_8: T_1 + 200 Kg FYM enriched with 3.0 kg Fe ha^{-1} + 1.5 kg Zn ha^{-1} over rest of the treatments except the treatments T_6 and T_7. This might be due to increase in microbial activity leading to ease availability of nutrients to the crop in available form. These observations are similar to that reported by Sinta *et al*., (2014) in coriander and Harisha *et al.,* (2017) in fennel. Patel *et al.,* (2016) also reported the similar results for growth and yield attributes of cumin crop when application of 200 kg FYM enriched with Fe and Zn with RDF was made. Increase in seed weight might be due to better mineral utilization by plants accompanied with enhancement in photosynthesis, other metabolic activities and greater diversion of food material to seeds (Naga *et al*., 2013). The positive influence of micronutrients application on fennel crop growth might be due to the improved ability of the crop to absorb nutrients to photosynthesize and better sink source relationship. The crop fertilized with only RDF recorded the minimum growth and yield attributes.

Seed yield (kg ha^{-1})

Effect of different iron and zinc enriched FYM treatments were found positive on seed yield of fennel during course of investigation and on pooled basis (Table 2). Application of RDF along with 200 Kg FYM enriched with 3.0 kg Fe ha^{-1} + 1.5 kg Zn ha^{-1} (T_8) found significantly superior in respect to yield during all the years as well as on pooled basis, except it was remained at par with the treatments T_6: T_1 + 200 Kg FYM enriched with 3.0 kg Fe ha^{-1} and T_7: T_1 + 200 Kg FYM enriched with 1.5 kg Zn ha^{-1} in the year 2015-16. Minimum seed yield of fennel was recorded with the treatment T_1: RDF (90 kg N + 30 kg P_2O_5 ha^{-1}) during all the years and on pooled basis except in the year 2013-14, the minimum seed yield was recorded with T_2: T_1 +3.0 t FYM ha^{-1} and was remained at par with T_1. Sharma (1998) and Harisha *et al.,* (2016) in fennel crop, Meena and Chaudhary (1998) in cumin crop and Jakhar *et al.,* (2013) in fenugreek crop reported same trend as observed in this study. Similar response for cumin crop in respect to yield was observed by Patel *et al* (2016) at SSRS, Jagudan. Increase in yield might be attributed to increased plant height, maximum number of umbels and test weight, which were positively affected by the application of iron and zinc eniriched with FYM to soil for correcting its deficiency in soil.

Economics

The maximum net realization (₹ 87,150/-) and BCR (2.11) value were recorded when crop was fertilized with RDF (90 kg N + 30 kg P_2O_5 ha^{-1}) + 200 Kg FYM enriched with 3.0 kg Fe ha^{-1} + 1.5 kg Zn ha^{-1} (Table 3).

Table 2. Fennel seed yield (Kg ha^{-1}) as influenced by different FYM enriched Fe and Zn treatments

Treatments	Fennel seed yield (Kg ha^{-1})			
	2013-14	2014-15	2015-16	Pooled
T_1: RDF (90 kg N + 30 kg P_2O_5 ha^{-1})	791	992	1035	939
T_2: T_1 + 3.0 t FYM ha^{-1}	787	1057	1081	975
T_3: T_1 + 6.0 kg Fe ha^{-1}	926	1112	1109	1049
T_4: T_1 + 3.0 kg Zn ha^{-1}	936	1023	1143	1034
T_5: T_1 + 6.0 kg Fe ha^{-1} + 3.0 kg Zn ha^{-1}	989	1013	1174	1059
T_6: T_1 + 200 Kg FYM enriched with 3.0 kg Fe ha^{-1}	983	1145	1313	1147
T_7: T_1 + 200 Kg FYM enriched with 1.5 kg Zn ha^{-1}	1013	1211	1359	1195
T_8: T_1 + 200 Kg FYM enriched with 3.0 kg Fe ha^{-1} + 1.5 kg Zn / ha	1264	1471	1545	1427
SEm+	70	76	82	44
C.D. at 5 %	212	232	250	125
CV %	12.5	11.7	11.6	12

Table 3. Economics of the different treatments as influenced by different FYM enriched Fe and Zn treatments.

Treatments	Seed yield (kg ha^{-1})	Gross realization (₹ ha^{-1})	Gross expenditure (₹ ha^{-1})	Net return (₹ ha^{-1})	BCR
T_1: RDF (90 kg N + 30 kg P_2O_5 ha^{-1})	939	84510	40234	44276	1.10
T_2: T_1 + 3.0 t FYM ha^{-1}	975	87750	45894	41856	0.91
T_3: T_1 + 6.0 kg Fe ha^{-1}	1049	94410	40604	53806	1.33
T_4: T_1 + 3.0 kg Zn ha^{-1}	1034	93060	40569	52491	1.29
T_5: T_1 + 6.0 kg Fe ha^{-1} + 3.0 kg Zn ha^{-1}	1059	95310	40708	54602	1.34
T_6: T_1 + 200 Kg FYM enriched with 3.0 kg Fe ha^{-1}	1147	103230	41228	62002	1.50
T_7: T_1 + 200 Kg FYM enriched with 1.5 kg Zn ha^{-1}	1195	107550	41210	66340	1.61
T_8: T_1 + 200 Kg FYM enriched with 3.0 kg Fe ha^{-1} + 1.5 kg Zn / ha	1427	128430	41280	87150	2.11

Price : Fennel seed ₹ 90 kg^{-1}; Zn : ₹40 kg^{-1} (Zn SO_4.7 H_2O); Phosphorus : ₹46.25 kg^{-1} (SSP); Fe : ₹15 kg^{-1} (Fe SO_4 7 H_2O); Nitrogen : ₹13.26 kg^{-1} (Urea)

Uptake of Fe by seed and stover

The individual as well as pooled data revealed that the uptake of Fe by seed and stalk was influenced significantly due to different treatments of Fe and Zn enriched FYM (Table 4) during all the years of experimentation as well as on pooled basis. The treatment receiving RDF along with 200 kg FYM ha^{-1} enriched with 3.0 kg Fe and 1.5 kg Zn ha^{-1} (T_8) recorded significantly the highest uptake of Fe by seed and stalk over rest of the treatments. The lowest Fe uptake by seed was registered under control (T_1) but it was at par with treatments receiving RDF + 6.0 kg Fe ha^{-1} (T_3), RDF + 3.0 kg Zn ha^{-1} (T_4) and RDF + 3.0 t FYM ha^{-1} (T_2) in first and second year of experimentation, however it was at par with treatments T_4 and T_2 in third year and in pooled data. The minimum removal of Fe by stalk was recorded under treatment T_1, but it was at par with T_2 and T_4 treatments. Harisha *et al*., (2017) reported that content of iron in seed and straw was increased in fennel crop as compared to initial status, ultimately due to uptake by crop. The results are also in line with reported by Patel *et al.,* (2016) in cumin crop when iron was enriched with FYM.

Uptake of Zn by seed and stover

Uptake of Zn by seed and straw was affected significantly due to different treatments during all the years of experimentation as well as in pooled data (Table 5). Among different treatments tested, an application of RDF along with 200 kg FYM ha^{-1} enriched with 3.0 kg Fe and 1.5 kg Zn ha^{-1} (T_8) recorded significantly highest uptake of Zn by seed over rest of the treatments during all the years as well as in pooled data. The maximum removal of Zn by stalk was recorded with the application of RDF + 200 kg

Table 4. Iron uptake (g ha-1) by seed and stover of fennel as influenced by different treatments

Treatment	Fe uptake (g ha^{-1}) by seed				Fe uptake (g ha^{-1}) by stover			
	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled
T_1 : RDF (90 kg N + 30 kg P_2O_5/ ha)	54.5	52.1	67.7	58.1	112.0	114.2	156.8	127.7
T_2 : T1 + 3.0 t FYM/ha	58.8	57.9	75.2	64.0	133.4	135.6	170.5	146.5
T_3 : T1 + 6.0 kg Fe/ha	75.8	63.6	98.2	79.2	179.0	153.0	237.0	189.7
T_4 : T1 + 3.0 kg Zn/ha	71.1	61.2	77.0	69.8	132.6	128.7	193.3	151.6
T_5 : T1 + 6.0 kg Fe/ha + 3.0 kg Zn/ha	81.8	72.0	109.6	87.8	201.6	170.5	248.3	206.8
T_6 : T1 + 200 kg FYM enriched with 3.0 kg Fe/ha	89.3	79.2	129.5	99.3	212.4	207.3	292.8	237.5
T_7 : T1 + 200 kg FYM enriched with 1.5 kg Zn/ha	77.6	77.7	109.9	88.4	192.4	184.9	243.8	207.0
T_8 : T1 + 200 kg FYM enriched with 3.0 kg Fe/ha + 1.5 kg Zn/ha	120.0	111.9	160.0	130.6	294.2	297.0	408.1	333.1
SEm (±)	7.1	5.6	9.1	4.3	14.2	19.8	17.8	9.8
CD (P =0.05)	21.5	16.9	27.5	12.3	43.2	60.1	54.1	27.7
C V (%)	15.6	13.4	15.2	15.1	13.5	19.7	12.7	15.1
Y x T				NS				NS

Table 5. Zinc uptake (g ha^{-1}) by seed and stover of fennel as influenced by different treatments

Treatment	Zn uptake (g ha^{-1}) by seed				Zn uptake (g ha^{-1}) by stover			
	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled
T_1: RDF (90 kg N + 30 kg P_2O_5/ ha)	14.0	18.1	30.5	20.8	12.9	16.9	27.3	19.0
T_2: T1 + 3.0 t FYM/ha	16.3	21.4	34.9	24.2	16.9	21.9	30.2	23.0
T_3: T1 + 6.0 kg Fe/ha	17.3	21.3	33.5	24.1	17.2	19.5	32.0	22.9
T_4: T1 + 3.0 kg Zn/ha	20.4	23.5	39.2	27.7	27.9	28.6	42.6	33.0
T_5: T1 + 6.0 kg Fe/ha + 3.0 kg Zn/ha	21.6	26.5	41.9	30.0	33.7	32.2	43.8	36.5
T_6: T1 + 200 kg FYM enriched with 3.0 kg Fe/ha	21.6	28.2	50.3	33.4	15.9	29.2	37.6	27.6
T_7: T1 + 200 kg FYM enriched with 1.5 kg Zn/ha	25.2	35.2	54.4	38.3	44.4	44.6	61.5	50.1
T_8: T1 + 200 kg FYM enriched with 3.0 kg Fe/ha + 1.5 kg Zn/ha	32.5	42.9	62.3	45.9	52.7	57.5	72.6	60.9
SEm (±)	1.6	2.1	2.8	1.4	2.8	4.5	4.6	2.2
CD (P =0.05)	4.9	6.3	8.7	4.1	8.422	13.7	14.0	6.2
C V (%)	13.3	13.2	11.5	12.8	17.4	25.0	18.4	20.6
Y x T				NS				NS

Table 6. Effect of different treatments on organic carbon and DTPA extractable Fe and Zn content in soil after harvest of crop

Treatment	DTPA - Fe (ppm)				DTPA-Zn (ppm)			
	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled
T_1 : RDF (90 kg N + 30 kg P_2O_5/ ha)	3.09	3.18	3.30	3.19	0.27	0.28	0.30	0.28
T_2 : T1 + 3.0 t FYM/ha	3.19	3.36	3.45	3.34	0.31	0.34	0.36	0.34
T_3 : T1 + 6.0 kg Fe/ha	3.37	3.40	3.56	3.44	0.29	0.29	0.32	0.30
T_4 : T1 + 3.0 kg Zn/ha	3.12	3.30	3.39	3.27	0.38	0.44	0.48	0.43
T_5 : T1 + 6.0 kg Fe/ha + 3.0 kg Zn/ha	3.38	3.43	3.52	3.44	0.40	0.45	0.50	0.45
T_6 : T1 + 200 kg FYM enriched with 3.0 kg Fe/ha	3.57	3.75	4.03	3.78	0.40	0.44	0.54	0.46
T_7 : T1 + 200 kg FYM enriched with 1.5 kg Zn/ha	3.50	3.55	3.77	3.60	0.49	0.51	0.60	0.53
T_8 : T1 + 200 kg FYM enriched with 3.0 kg Fe/ha + 1.5 kg Zn/ha	3.54	3.60	3.91	3.68	0.48	0.52	0.59	0.53
SEm (±)	0.036	0.034	0.044	0.035	0.033	0.031	0.038	0.018
CD (P =0.05)	0.109	0.104	0.134	0.12	0.100	0.094	0.116	0.05
C V (%)	1.86	1.72	2.12	1.92	15.08	13.23	14.40	14.25
Y x T				NS				NS

Initial status of soil (0 – 15 cm)

pH (1 : 2.5)	7.91	Available P_2O_5 (kg ha^{-1})	33.58	DTPA – Mn (ppm)	11.23
EC (dSm-1) (1 : 2.5)	0.14	Available K_2O (kg ha^{-1})	266.11	DTPA – Zn (ppm)	0.26
Organic carbon (%)	0.18	DTPA – Fe (ppm)	3.12	DTPA – Cu (ppm)	0.66

FYM enriched with 3.0 kg Fe and 1.5 kg Zn ha^{-1} (T_8) but it remained at par with RDF + 200 kg FYM ha^{-1} enriched with 1.5 kg Zn ha^{-1} (T_7) except in pooled data. The zinc uptake was increased due to higher seed yield achieved under this treatment and may be due to enrichment of zinc with FYM. In cumin crop at SSRS, Jagudan the same results were also reported by Patel *et al.,* (2016). The minimum removal of Zn by seed and stalk was noted under control (T_1).

Effect on DTPA – Fe and Zn content in soil

DTPA extractable Fe

A perusal of data presented in Table 6 revealed that the difference in DTPA-Fe content in soil was found to be significant in all the years as well as in pooled data. The maximum build up of DTPA-Fe content in soil was noted due to application of RDF along with 200 kg FYM ha^{-1} enriched with 3.0 kg Fe ha^{-1} (T_6) but was at par with treatment receiving of RDF + 200 kg FYM ha^{-1} enriched with 3.0 kg Fe and 1.5 kg Zn ha^{-1} (T_8) in all the years as well as in pooled data. The minimum DTPA-Fe content in soil was recorded under control (T_1) which was at par with T_4 treatment.

DTPA extractable Zn

The year wise as well as pooled data (Table 6) revealed that the difference in DTPA-Zn content in soil due to different treatments was found significant. The pooled results showed that an application of RDF along with 200 kg FYM ha^{-1} enriched with 1.5 kg ha^{-1} (T_7) being at par with treatment T_8 registered significantly higher DTPA-Zn content in soil as compared to other treatments. The minimum DTPA-Zn content in soil was recorded under control (T_1) which was at par with T_3 treatment.

Conclusions

Based on the results of the study it may be concluded that application of FYM enriched with iron and zinc increases the availability of these nutrients. Soil application of FYM enriched iron and zinc along with RDF is best considering the growth and yield. It also correcting the deficiency of micronutrients in soil by increasing the availability, which ultimately increases the content and uptake of fennel. By achieving higher net realization and BCR value under this treatment reflect good economics.

References

Harisha, C. B, Singh, B., Diwakar, Y., Aishwath, O. P., Singh, R., Rothore, S. S. and Asangi, H. 2016. Impact of micronutrients application on growth and yield attributes of fennel (*Foeniculum vulgare* Mill.).*Int. J. Seed Spices* 6(1) :54-65.

Harisha, C. B., Diwakar Y., Aishwath, O. P., Singh, R., Asangi, H. 2017. Soil Fertility and Micronutrient Uptake by Fennel (*Foeniculum vulgare* Mill.) as Influenced by Micronutrients Fertilization. Environment and Ecology, 35 (1B): 514-518.

Jackson, M. L.1978. Soil chemical analysis. Printish Hole of India Private Limited, New Delhi.

Jakhar, R. K., Yadav, B. L. and Chaudhary, B. R. 2013. Irrigation water quality and zinc on growth and yield of fenugreek (*Trigonella Foenum graecum* L.). *Indian J. Spice and Aromatic Crops* 22(2): 170-173.

Lindsay, W. L. and Norvell, W. A. 1978. Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc. Am. J.* 42: 421-428.

Meena, N. L. and Chaudhary, G. R. 1998. First International Congress, New Delhi. November, 23-27.

Mengel, K., Kirkby, E. A., Kosergarten, H. and Appel, T. 2001. Principles of plant nutrition, Kluwer Academic: The Netherlands.

Naga, S. K., Swain, S. K., Sandeep, V. V. and Raju, B. 2013. Effect of foliar application of micronutrients on growth parameters in tomato (*Lycopersicon esculentum* mill.). *J.Agric. Food Sci.*1:146-151.

Patel, S. M., Amin, A. U., Patel, S. P. and Patel, B. T. 2016. Yield and quality of cumin as influenced by FYM enriched micronutrients. *Int. J. Seed Spices* 6(1)pp:17-24.

Sharma, R. 1998. Thesis, M.Sc.(Agri.) Departmrnt of Agronomy, SKN college of Agriculture, Jobner.

Sinta, I., Vijayakumar, A. and Srimathi, P. 2014. Effect of micronutrient application in coriander (*Coriandrum sativum* L.) cv.CO4. *African J. of Agric. Res.* 10(3): 84-88

Received : January 2019; Revised : March 2019; Accepted : June 2019.