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EFFECT OF SOIL AND FOLIAR APPLICATION OF ZINC AND IRON ON YIELD, QUALITY AND ECONOMICS OF FENNEL

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ABSTRACT

A field experiment was conducted at Jobner (Jaipur) during rabi season of 2011-12 to study the effect of soil and foliar application of Zn and Fe on Fennel. The treatment comprising five levels of soil application (control, 15 kg zinc sulphate ha^{-1}, 30 kg zinc sulphate ha^{-1}, 50 kg ferrous sulphate ha^{-1}and 100 kg ferrous sulphate ha^{-1}) and four levels of foliar spray (control, zinc sulphate @ 0.5 %, ferrous sulphate @ 0.5 % and zinc sulphate @ 0.5 % + ferrous sulphate @ 0.5 %) were evaluated under factorial randomized block design with three replications. The results indicated that soil application of 30 kg zinc sulphate ha^{-1} being at par with 100 kg ferrous sulphate ha^{-1} recorded significantly higher plant height, umbels per plant, seeds per umbels, seed and stover yield of fennel over control. The significantly maximum protein content, essential oil contents in seed, net returns and B:C ratio were recorded with 30 kg zinc sulphate ha^{-1}. Significantly maximum increase in plant height, number of umbels per plant, number of seeds per umbels, seed yield, stover yield, protein content, essential oil content in seed, net returns and B:C ratio were recorded with combined foliar spray of 0.5 % zinc sulphate + 0.5 % ferrous sulphate over control.

Key words: Soil application, foliar spray, zinc, iron, yield, quality, fennel

INTRODUCATION

India is the largest producer, consumer and exporter of spices in the world. The seed spices account about 36% of total area and 17% of total production of spices in the country. Fennel generally known as Saunf (*Foeniculum vulgare* Mill.) belongs to *Apiacae* family. The aroma is due to presence of volatile oil viz., anethole and fenchane. The oil is widely used as flavoring agent in culinary preparations of confectionary, cordials and liquors. Fennel is rich in vitamin A and contains a fair amount of calcium, phosphorus and potassium. The area, production and productivity of fennel in India in 2010-11 were 41368 ha, 58,265 tones and 1408 kg ha^{-1}, respectively, whereas, the area, production and productivity of fennel in Rajasthan were 26973 ha, 26157 tonnes and 970 kg ha^{-1}, respectively (Anon, 2011). In the recent years, micronutrients are considered as one of the constraints in the optimum production of crops. Singh (2008) reported that 48, 12, 5, 4, 33, 13 and 41% soils of India are deficient in Zn, Fe, Mn, Cu, B, Mo and S, respectively. Zinc plays a significant role in various enzymatic and physiological activities of the plant body. Zinc catalyses the process of oxidation in plant cells and plays a vital role in transformation of carbohydrates, regulates the consumption of sugar, increases the source of energy for the production of chlorophyll, adds in the formation of auxins and promotes absorption of water. Zinc itself involves in the formation of IAA hormone. The Fe is a structural component of porphyrin molecules, cytochromes, heams, hematin, ferrichrome and leg-heamoglobin involved in oxidation reduction reactions in respiration. It is an important part of the enzyme nitrogenase which is essential for nitrogen fixation through nitrogen fixing bacteria. The ferrodoxins are Fe-S proteins and are the first stable redox compound of the photosynthetic electron transport chain (Havlin *et al.*, 1997). Therefore, it is very pertinent to assass the impact of soil and foliar application of iron and zinc on yield and quality of fennel. Therefore the present investigation was undertaken to study the effect of soil and foliar application of Zn and Fe on yield, quality and economics of fennel.

MATERIALS AND METHODS

A field experiment was conducted during the rabi season of 2011-12 at Agronomy Farm, S.K.N. College of Agriculture, Jobner (Rajasthan) (26.05 N, 75.28 E and 427 m above mean sea level). The experimental soil was loamy sand in texture, alkaline in reaction (pH 8.3) with EC 0.90 dSm^{-1}, organic carbon l.8 g kg^{-1}, available N 128.1 kg ha^{-1}, P_2O_5 16 kg ha^{-1}, K_2O 161 kg ha^{-1}, Zn 0.40 mg kg^{-1} and Fe 4.26 mg kg^{-1}. The experiment was laid out in factorial randomized block design and replicated thrice with five levels of soil application (control, 15 kg $ZnSO_4$ ha^{-1} , 30 kg $ZnSO_4$ ha^{-1}, 50 kg $FeSO_4$ ha^{-1} and 100 kg $FeSO_4$ ha^{-1}) and four levels of foliar spray (control, 0.5 % $ZnSO_4$, 0.5 % $FeSO_4$ and 0.5 % $ZnSO_4$ + 0.5 % $FeSO_4$). A uniform dose of 90 kg N ha^{-1} and 50 kg P_2O_5 ha^{-1} was applied through urea and DAP. Half

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dose of nitrogen and full dose of phosphorus was applied as basal at the time of sowing, while, rest of nitrogen was applied in two equal splits at 30 days after sowing and at flowering stage as top dressing. Zinc sulphate and iron sulphate were applied through broadcasting at the time of sowing and foliar application of zinc sulphate and iron sulphate was done at 40 DAS. The fennel var. RF-101 was taken as test crop and sown in lines 45 cm apart manually by "Kera method" in open furrow. Usual crop husbandry operations were followed to raise a good crop. Yield from each plot was recorded as q ha^{-1}. Protein content in seed extraction is usually carried out with buffers used for the enzyme essay. 500 mg of the dried sample of the plant was ground in a steel grinder and mortar in 5 –10 ml of the buffer. Centrifuge and use the supernatant for protein estimation and essential (Volatile) oil content in fennel seed was determined by using standard method essential oil distillation assembly (AOAC, 1970). The economics of different treatments was worked out in terms of net returns and B: C ratio, on the basis of prevailing market prices for inputs and outputs.

RESULTS AND DISCUSSION

Yield attributes and yield

The plant height, number of umbels per plant, number of seeds per umbels, test weight, seed and stover yields of fennel were significantly increased with increasing level of both soil and foliar application of zinc sulphate and iron sulphate individually and in combination. The maximum values of these parameters *viz.*, plant height (105.92 cm and 106.44 cm), umbels per plant (27.78 and 28.08), seeds per umbels (196 and 195.13), test weight (3.92 g and 3.91 g), seed yield (12.50 q ha^{-1} and 12.61 q ha^{-1}) and stover yield (38.76 q ha^{-1} and 38.34 q ha^{-1}) were recorded due to soil application of 30 kg zinc sulphate ha^{-1} and foliar application of both 0.5% zinc sulphate + 0.5% iron sulphate, respectively (Table 1 and 2). The per cent increase in plant height, umbels per plant, seeds per umbels, seed yield and stover yield of fennel plant with the soil application of 30 kg $ZnSO_4$ ha^{-1} and 100 kg $FeSO_4$ ha^{-1} were 28.9 and 28.5, 26.9 and 26.0, 20.6 and 19.8, 49.7 and 44.8 and 40.3 and 38.3% over control, respectively. Similar, increase in plant height, umbels per plant, seeds per umbels, seed yield and stover yield with foliar application of 0.5% zinc sulphate + 0.5% iron sulphate was recorded as 24.3, 22.2, 15.1, 40.5 and 29.9 % over control, respectively.

Table 1: Effect of soil application and foliar spray of Zn and Fe on yield attributes of fennel

Treatment	Plant height (cm)	Umbels per plant	Seeds per umbels	Test weight (g)
Soil application				
Control	82.18	21.91	162.57	3.73
15 kg $ZnSO_4$ ha^{-1}	97.48	25.60	181.92	3.84
30 kg $ZnSO_4$ ha^{-1}	105.92	27.78	196.00	3.92
50 kg $FeSO_4$ ha^{-1}	96.28	25.48	179.33	3.81
100 kg $FeSO_4$ ha^{-1}	105.57	27.60	194.67	3.90
S.Em±	2.54	0.68	4.22	0.05
CD (P=0.05)	7.26	1.94	12.08	NS
Foliar spray				
Control	85.63	22.99	169.60	3.73
0.5 % $ZnSO_4$	99.06	25.87	184.25	3.87
0.5 % $FeSO_4$	98.82	25.77	182.60	3.84
0.5 % $ZnSO_4$ +0.5 % $FeSO_4$	106.44	28.08	195.13	3.91
S.Em±	2.27	0.61	3.78	0.05
CD (P=0.05)	6.49	1.74	10.81	NS

The soil application of 30 kg zinc sulphate ha^{-1} and 100 kg ferrous sulphate ha^{-1} remained at par in respect of plant height, umbels per plant, seeds per umbels, seed yield and stover yield. The increase in the yield attributes might also be due to role of zinc in biosynthesis of indole acetic acid (IAA) and especially due to its role in initiation of primordia for reproductive parts and partitioning of photosynthates towards them, which might have been resulted in better flowering and fruiting. A positive correlation between grain yield and available soil Zn and Fe was also observed by Habib (2012).The addition of zinc and iron to the soil might have also caused higher activation of micronutrients mainly due to its beneficial effects in mobilizing the native nutrients to increase their availability besides addition of zinc and iron to the soil to provide better nutrition over longer time and synergistic effect of both nutrients on yield component (Gaffar *et al.*,2011) which improved crop growth and thereby higher yields (Meena *et al.*,2006).

The significant increase in yield and yield attributes due to foliar application of zinc sulphate and iron sulphate might be due to increased leaf area (Ali *et al.*, 2008), seed weight (Bybordi and Malakouti, 2003) and stem diameter (Malakouti and Tehrani, 2005).

Table 2: Effect of soil application and foliar spray of Zn and Fe on yield, quality and economics of fennel

Treatment	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Protein content (%)	Essential oil (%)	Net returns (Rs.ha^{-1})	B:C ratio
Soil application						
Control	8.35	27.62	23.31	1.32	24991	1.27
15 kg $ZnSO_4$ ha^{-1}	10.81	33.94	24.94	1.44	36944	1.80
30 kg $ZnSO_4$ ha^{-1}	12.50	38.76	25.88	1.51	45263	2.14
50 kg $FeSO_4$ ha^{-1}	10.47	33.09	24.00	1.37	33766	1.54
100 kg $FeSO_4$ ha^{-1}	12.09	38.19	25.69	1.43	40330	1.69
S.Em±	0.26	1.16	0.31	0.02	1177	0.05
CD (P=0.05)	0.75	3.32	0.88	0.05	3369	0.16
Foliar spray						
Control	8.97	29.74	23.49	1.34	27076	1.29
0.5 % $ZnSO_4$	11.29	34.91	25.11	1.42	38537	1.80
0.5 % $FeSO_4$	10.50	34.28	25.02	1.40	34544	1.61
0.5 % $ZnSO_4$ +0.5 % $FeSO_4$	12.61	38.34	25.44	1.51	44878	2.04
S.Em±	0.24	1.04	0.28	0.02	1316	0.06
CD (P=0.05)	0.67	2.97	0.79	0.05	3767	0.17

Quality

The protein content in seed and essential oil of fennel was significantly influenced with soil and foliar application of zinc sulphate and iron sulphate (Table 2). The maximum protein content in seed (25.88%) and essential oil (1.51%) was recorded with 30 kg zinc sulphate ha^{-1} with an increase of 11.0 and 14.4 % over control, respectively, whereas, foliar spray of both 0.5% zinc sulphate+ 0.5% iron sulphate, gave only 8.3 and 12.7% increase in protein and essential oil over control, respectively. The significant increase in protein may be ascribed due to role of zinc in nitrate conversion to ammonia in plants (Boorboori *et al.*, 2012) and zinc sulphate leads to activate indole acetic acid and acid makes amino acids to protein (Moussavi-Nik and Kiani, 2012). The increase in essential oil content of the crop with application zinc and iron may be due to higher assimilate supply in such condition (Khan *et al.*, 2009).

Economics

The soil application of different levels of zinc sulphate and iron sulphate and foliar spray of zinc sulphate and iron sulphate either alone or in combination significantly increased the net returns and B: C ratios over control. The highest net returns Rs. 45263 was recorded with the soil application of 30 kg zinc sulphate ha^{-1} with B: C ratio of 2.14 whereas, foliar application of 0.5% zinc sulphate + 0.5 % iron sulphate obtained maximum net returns of Rs. 44878 with B: C ratio 2.04 (Table 2). It might be due to significant increase in yield with increased supply of available zinc in the soil and correction in hidden deficiency of zinc and iron in plants or better nutrition of the crop with foliar application of these micronutrients. The similar findings were also observed with zinc by Gupta (2012) in fennel and by iron application Sharma (2006) in fenugreek.

On the basis of findings, it is concluded that the soil application of 30 kg $ZnSO_4$ ha^{-1} or combined foliar spray of zinc sulphate @ 0.5% and ferrous sulphate @ 0.5% can be recommended for fennel cultivation in the Entisols for higher and yield, quality, net returns.

REFERENCES

A.O.A.C. (1970) Official Methods of Analysis. Assoc. of Agric. Chem. 11th Ed., Washington, D.C.

Ali, S. A., Khan, A., Marija, G., Arif, M., Fida, M. and Bipis, S. (2008) Assessment of different crop nutrient management practices for yield improvement. *Australian Journal of Crop Science*, 2(3):150-159.

Anonymous, (2011) Rajasthan Agricultural Statistics at a Glance. Commissioner of Agriculture, Rajasthan, Jaipur (Statistical Cell), pp.106

Boorboori, M. R., Asli, D. R. and Tehrani,M. (2012) The effect of dose and different methods of

iron, zinc, manganese and copper application on yield components, morphological traits and grain protein percentage of barley (*Hordeum vulgare* L.) in green house conditions. *Advances in Environmental Biology* 6:740-746.

Bybordi, A. and Malakouti, M.J. (2003) Effect of iron, manganese and copper on qualitative and quantitative traits of wheat under salinity conditions. *Journal of Soil and Water Science* 17:140-149.

Gaffar, A., Ehsanullah, Nadeem, E. and Sultan, H.K. (2011) Influence of zinc and iron on yield and quality of sugarcane planted under various trench spacing. *Pakistan Journal of Agriculture Science* 192:181-189.

Gupta, K. (2012) Role of phosphorus and zinc in enhancing growth, yield and quality of fennel crop (*Foeniculum vulgare* Mill.) in irrigated condition of North West Rajasthan. *Ph.D.Thesis*, Swami Keshwanand Rajasthan Agricultural University, Bikaner.

Habib, M. (2012) Effect of supplementary nutrition with Fe and Zn chelates and urea on wheat quality and quantity. *African Journal of Biotechnology* 11(11):2661-2665.

Havlin, L. John. Beaton, D. James, Tisdde, L. Samuel and Nelson, L. Werner (1997) Soil fertility and fertilizers. An introduction to nutrient management. Sixth edition. Practice Hall Upper Saddle River, New Jersey.

Khan, M. A., Din, J., Nasreen, S., Khan, M.Y., Khan, S. U. and Gurmani, A.R. (2009) Response of sunflower to different levels of zinc and iron under irrigated conditions. *Sarhad Journal of Agriculture* 25:159-163.

Malakouti, M. J. and Tehrani, M. (2005) The role of micronutrients in increasing yield and improving the quality of crops. IIIrd *ed*., *Tarbiat Modarres University Publications.*

Meena, M.C., Patel, K.P. and Rathod, D.D. (2006) Effect of zinc, iron and sulphur on mustard in loamy sand soil. *Indian Journal of Fertilizer* 2(5):55-58.

Moussavi-Nik, M.S. and Kiani, Z. (2012) Considering interaction effects of micro nutrition's elements (Fe, Zn, Mn) on qualitative yield of wheat varieties. *Annals of Biological Research* 2:1467-1472.

Sharma, P. (2006) Effect of vermicompost, potassium and iron on the performance of fenugreek (*Trigonella foenum-graecum* L.) under Typic Ustipsamment. *Ph.D. Thesis*, Rajasthan Agricultural University, Bikaner.

Singh, M.V. (2008) Micronutrient deficiencies in Indian Soils and Crops. *In: Micronutrient deficiencies in global crop production*. (Ed.B.J.Alloway). Springer Science+Business Media B.V.