Environment & Ecology 29 (3B) : 1502—1505, 2011
 ISSN 0970-0420

Effect of Zinc and Iron on Growth and Yield of Fennel Crop

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Abstract

A field experiment was conducted in an alkaline loamy sand soil to evaluate the effect of zinc and iron on growth and yield of fennel crop. The results indicated that plant height, number of branches, chlorophyll content, grain and straw yield of fennel crop increased significantly by the application of zinc, iron alone and in combination. Application of zinc and iron as soil + foliar application gave highest grain and straw yield. The nitrogen and potassium content in post harvest soil increased while phosphorus content decreased significantly with the application of zinc and iron.
Key words : Zinc, Iron, Growth, Yield, Fennel.

Fennel is widely accepted as a native of southern Europe and mediterranean region and is mainly cultivated in Russia, Germany, France, Italy, India, Japan and USA. In India, it is mainly cultivated in the states of Gujarat, Rajasthan, Uttar Pradesh, Punjab and Madhya Pradesh. It covers a total area of about 17,743 ha with an annual production of approximately 20042 tonnes. In Rajasthan, it occupied an area of approximately 2637 ha with an annual production of 1,423 tonnes. It is mainly cultivated in Tonk, Sirohi, and Jodhpur and to a limited extent in Bharatpur, Ajmer, Jaipur and Kota districts. The importance of micronutrient in Indian Agriculture has been realized only in the late sixties. Micronutrients are required in relatively small amount for the optimum growth of plant ; still they are as essential as the macronutrients which are needed in large amount, therefore, judicious and efficient use of micronutrients along with macronutrients is necessary to increase food-grain production per unit are to meet out the requirement of growing population of the country. Adoption of high yielding varieties, intensive cultivation, use of high grade analysis fertilizers, limited recovery of plant residue and the gap between the removal and application of micronutrients resulted into a wide spread deficiency of micronutrients in our soils ; especially that of zinc with the isolated report on the deficiency of other micronutrients. Use of zinc in enhancing the crop production has increased remarkably during last three decades, the use of iron, manganese and boron fertilizers are also picking up as areas of deficiencies are being identified. Deficiency of micronutrients may also reduce the fertilizer use efficiency of NPK and other agricultural inputs besides threatening the ecological sustainability of intensive agriculture. Zinc being an essential micronutrient takes active part in the metabolic activities of the plant. It acts as an activator of dehydrogenase, proteolases enzymes, directly or indirectly involved in the synthesis of carbohydrates and proteins. Similarly, iron is a constituent of ferrodoxin and cytochrome, which are involved in photosynthesis and respiration in plants. Available zinc in Indian soils ranges between 0.25 to 2.58 ppm but it varies with in soils belonging to different orders with an average of 0.38 to 0.46 in aridisol and entisols, respectively. DTPA extractable zinc in arid soils of Rajasthan varied from 0.27 to 2.36 ppm (1). Similarly iron content in Rajasthan soils varies between 0.5 to 5.6 ppm. Since, most of the light textured soils having low fertility status ; micronutrients are becoming the limiting factor for optimum crop production. Various crop exhibit deficiency symptoms of zinc and iron, therefore, an attempt has been made to study the response of Zn and Fe individually and in combination with respect to growth and yield of fennel crop with the soil and foliar application.

Table 1. Symbols of treatment combination with details.

Symbols	Details
T_0	Foliar spray as water (control)
T_1	Zinc through zinc sulfate as soil application at 5 kg Zn/ha
T_2	Zinc through zinc sulfate as follar application at 0.5% $ZnSO_4$. $7H_2O$ solution at 700 l/ha
T_3	Zinc through zinc sulfate as soil (T_1) + foliar application (T_2)
T_4	Iron through ferrous sulfate as soil application at 10 kg/ha
T_5	Iron through ferrous sulfate as foliar application at 0.25% $FeSO_4$..$7H_2O$ solution (700 l/ha)
T_6	Iron through ferrous sulfate as soil application (T_4) + foliar application (T_5).
T_7	Zinc through zinc sulfate and iron through ferrous sulfate as soil application at 5 kg/ha and 10 kg/ha respectively.
T_8	Zinc through zinc sulfate and iron through ferrous sulfate as foliar application at 0.5% $ZnSO_4$. $7H_2O$ solution and 0.25% $FeSO_4$.H_2O solution respectively.
T_9	Zinc through zinc sulfate and iron through ferrous sulfate as soil application (T_7) and foliar application (T_8).

Methods

Jobner is located at 75.28 East longitude and 26.26 North latitude at 427 m MSL. Jobner falls under semi-arid region. It is characterized by aridity of atmosphere and salinity of rhizosphere with extremity of temperature both in summer (30—46^{0}C) and in winters (0 to—5C). The average annual rainfall ranges between 400 to 500 mm, which is mostly received during the monsoon season from July to September. The experimental soil was loamy sand in texture having pH 8.2, EC (1 : 2.5 soil water suspension) 1.30 dS m^{-1}, organic carbon 0.28%, available N 120.00, P_2O_5 15.46, K_2O 160.50 kg/ha, available zinc (ammonium acetate—dithizone carbon tetra chloride extractable) 0.59 and available iron (N ammonium acetate extractable at pH 4.8) 1.65 ppm. The experiment was laid out according to the randomized block design. Treatment combinations were ten including one control and were replicated three times. The treatments were allocated randomly to different plots by using the random numbers from the table of Fisher and Yates. The details of the treatments and their combinations are given in Table 1. Required quantity of finely powder zinc sulfate and iron sulfate were thoroughtly mixed with soil and applied in each plot separately before sowing. N, P_2O_5 and K_2O were applied at the rate of 120, 60 and 80 kg/ha through urea ; diammonium phosphate and muriate of potash, respectively. Half dose of N and full dose of P_2O_5 and K_2O were applied as a basal dose and remaining N was applied as top dressing in two equal splits at the time of branching and flowering.

Table 2. Effect of zinc and iron on growth and yield of fennel crop.

Treatments	Average plant height (cm)	Number of branches per plant	Chlorophyll content (mg/l)	Grain yield (q/ha)	Straw yield (q/ha)
T_0	70.76	4.28	4.93	2.58	10.12
T_1	81.74	5.12	9.17	3.27	13.09
T_2	84.18	5.21	10.95	3.39	13.46
T_3	86.09	5.30	12.08	3.51	14.88
T_4	77.41	4.54	5.71	2.85	11.84
T_5	78.95	4.82	6.06	2.90	12.25
T_6	79.66	5.01	7.88	3.04	12.81
T_7	90.52	5.39	14.26	3.60	15.97
T_8	93.17	5.63	15.89	3.91	16.57
T_9	97.80	5.87	17.34	4.02	17.23
SE ±	0.11	0.018	0.25	0.036	0.09
CD at 5%	0.326	0.053	0.742	0.106	0.26

Foliar Spray of Zinc and Iron

Zinc sulfate 0.5% solution and 0.25% solution of iron sulfate were prepared in polythene carboy by

Table 3. Effect of zinc and iron applications on NPK, Fe and Zn content in soil after harvest the crop.

Treatments	N (kg/ha)	P (kg/ha)	K (kg/ha)	Zn (ppm)	Fe (ppm)
T_0	120.00	15.46	160.50	0.59	1.65
T_1	130.11	10.15	165.75	0.71	1.67
T_2	120.42	15.00	160.32	0.60	1.64
T_3	124.66	12.50	162.30	0.65	1.66
T_4	123.21	13.47	150.14	0.57	1.78
T_5	120.10	15.11	160.46	0.59	1.65
T_6	122.72	14.17	154.17	0.58	1.72
T_7	128.12	13.55	161.35	0.67	1.70
T_8	120.70	14.40	160.50	0.60	1.66
T_9	125.63	14.50	163.10	0.64	1.68
SE ±	0.28	0.01	0.24	0.004	0.03
CD at 5%	0.856	0.12	0.72	0.012	0.09

dissolving the required quantity of salt in water. In another polythene carboy 0.25% solution of lime was prepared. The observation was taken by pouring, the decant solution of lime in pipette and taking 100 ml. 0.5% zinc sulfate and 0.25% iron sulfate solution in conical flask that how much amount of decanted lime precipitated the 100 ml of 0.5% zinc sulfate and 0.25% iron sulfate solution was mixed in such a proportion that there was no precipitation but it reached to neutralization point. These two solutions were mixed just before spraying the solution. In those treatments where the volume of spray solution exceeded the requirement for complete wetting of plants of a plot, the remaining volumes was applied in the second spray on the same day but only after the plants were dried of the previous spray. The sprayer "Aspee Bolo" which consisted of plastic parts (those which come in contact of solution) was used. Plastic buckets were used for transferring the solution in the chest of the sprayers. After threading the weight of fennel grains per plot was recorded and expressed as q/ha. Straw yield was calculated after subtracting the weight of grain from the total dry matter of each plot. The statistical analysis of the data was done by standard statistical method of analysis of variance. In the analysis, the variance ratio for appropriate standard error for each factor was worked out. The treatment differences i.e. treatment means, the critical differences (CD) at 5% level of significance was calculated for comparison as per method described by Panse and Sukhatme (2), wherever *F* tests came out to be significant.

Results and Discussion

Table 2 shows that all the treatments increased plant height of fennel crop significantly. The highest plant height was obtained under zinc and iron as soil + foliar application (T_9) whereas, lowest under control (T_0). Iron as soil, foliar, soil + foliar (T_4,T_5,T_6) gave significantly lower plant height as compared to the similar treatments of the zinc (T_1,T_2,T_3). Further combined application of zinc and iron increased the plant height significantly as compared to zinc and iron separate application under all the three type of applications. Further the data reveal that all the treatments increased the number of branches of fennel crop significantly. The light textured soil under study was low in available zinc and iron and therefore, responded well to the application of zinc and iron and their combinations. Results obtained get support from the findings of Jain (3).

The chlorophyll content of fennel leaves has been increased significantly by all the treatments of zinc and iron application except between T_4 and T_5 treatments (iron as soil and iron as foliar) which were found at par. The maximum chlorophyll content was recorded under zinc and iron as soil + foliar application (T_9) while the minimum was under control (T_0). Combined applications of zinc and iron increased the chlorophyll content significantly in comparison to their separate applications the soil foliar, soil + foliar. Increased chlorophyll content in leaves may be due to the application of zinc and iron because it has been well established that zinc helps in the synthesis of chlorophyll and also promotes the uptake of iron.

Thus all the treatments increased the grain yield of fennel significantly, however, the treatments T_4 with T_1 (zinc as soil + foliar with zinc and iron as soil) were found at par. The maximum grain yield (4.02 q/ha) was obtained under zinc and iron as soil + foliar application (T_9) whereas, it was minimum (2.58 q/ha) under control (T_0). The increase in grain yield in all the treatments over control is presumably due to balanced nutrition of fennel crop which responded well to the zinc and iron applications. Results obtained get support from the findings of Akbari (4) and Yadav et al. (5). Comparatively higher grain yield of fennel was obtained under soil + foliar treatment followed by foliar and then soil, may be attributed to the availability of zinc and iron under soil + foliar applications throughout the growth period i.e. initial stages by soil and at later stages by foliar application. Results are in close conformity with the findings of Singh et al. (6) and Bahl et al. (7).

All the treatments increased the straw yield of fennel significantly over control. The maximum straw yield (17.23 q/ha) has been obtained under zinc and iron as soil + foliar applications (T_9) whereas ; it was minimum 10.12 q/ha under control. The increasing trend of different applications was applications of zinc and iron separate as well as combined. The increase in straw yield in all the treatments over control may be due to balanced nutrition of fennel crop. Soil + foliar treatments gave higher straw yield in comparison to foliar then soil mainly due to higher availabil-

ity of zinc and iron throughout the growth period, whereas, less straw yield under soil application may be due to less availability of zinc and iron at pH 8.2 and later stages of growth. Zinc application gave higher straw yield in comparison to iron mainly due to better response of zinc which enhanced the yield parameters and further resulted into the higher uptake of N, K, Zn and Fe. Results are agreement with findings of Ghildyal et al. (8) and Mehta and Singh (9).

Table 3 reveals that the effect of zinc and iron applications on N, P, K, Zn and Fe content of soil was found to be significant. Zinc and iron increased available N and K, Fe, Zn content in soil. The increase in N content may be attributed to supply of Fe and Zn to the nitrogen transforming microbes whereas available P content in soil decreased by zinc applications. This increase in N, K, Fe, Zn content in soil may be due to the increasing availability of Zn and Fe in soil by their applications, whereas, P content decreased by zinc treatments due to antagonistic relationship between P and Zn. Iron application also decreased K content in soil due to their antagonistic relationship. Increasing levels of zinc and iron in soil leads higher content of Zn and Fe in soil.

Zinc application significantly increased its availability in soil while decreased significantly available phosphorus and iron. Patel (10) reported that zinc addition significantly decreased available phosphorus after harvest of wheat. Prasad and Ram (11) and Akbari (4) reported that available phosphorus and iron decreased with the increase in the doses of zinc application. Decrease in available P_2O_5 with zinc application after harvest of mustard was observed by Akbari (4). Takkar et al. (12) observed that application of zinc increase zinc status in loamy and soil of Faridkot (Punjab). A field experiment conducted by Patel (13) at Anand and reported that zinc availability increase with zinc application. Similar effects were also observed by Akbari (4). Singh (14) reported that zinc application decreased the available iron in soil after harvest of both mustard and wheat.

The result summarized above revealed that soil application of zinc + iron at 5 and 10 kg/ha with 0.50 and 0.25% foliar application (in the form of their sulfates) was found to be the best practice to obtain the optimum fennel grain (4.02 q/ha) and straw (17.23 q/ha) yield. Application of micronutrients as soil + foliar application were observed best amongst all the three applications.

References

1. Joshi D. C., R. P. Dhir and B. S. Gupta. 1982. Distribution of different forms of copper and zinc in some soils of arid Rajasthan. *J. Ind. Soc. Soil Sci.* 30 : 547—549.
2. Panse V. G. and P. V. Sukhatme. 1984. Statistical methods for agricultural workers. 4th edition. ICAR, New Delhi, India.
3. Jain G. L. 1971. Secondary and micronutrient in relation to crop in arid zone of India. *Ind. J. Agron.* 17 : 271—278.
4. Akbari K. K. 1990. *Crop response to micronutrients, sulfur and gypsum on red loam soil of Rajasthan*. Ph. D. thesis. Agric. Univ. Udaipur, India.
5. Yadav B. S., N. S. Patel and G. J. Hadvani. 1991. Effect of FYM, P, Zn, on groundnut in calcareous soil. *J. Ind. Soc. Soil Sci.* 39 : 391—393.
6. Singh S. P., P. N. Takkar and V. K. Nayyar. 1988. Effect of zinc on yield and uptake by wheat. *J. Ind. Soc. Soil Sci.* 36 : 383—385.
7. Bahl G. B., H. S. Baddesha, N. S. Pasricha and M. S. Aulakh. 1986. Sulfur and zinc nutrition of groundnut grown on Tolwal loamy sand soil. *Ind. J. Agric. Sci.* 56 : 429—433.
8. Ghildyal M. C., G. S. Sirohi and M. G. Pandey. 1981. Growth and nitrate reductase activity in mustard varieties as affected by zinc nutrition. *Ind. J. Pl. Physiol.* 24 : 113—122.
9. Mehta V. S. and V. Singh. 1988. Effect of sulfur and zinc on yield and uptake of nutrients by mustard. *J. Ind. Soc. Soil Sci.* 36 : 190—191.
10. Patel M. V. 1992. *Studies on phosphorus-zinc interaction and its effect on yield and nutrition of wheat (var Raj 3077) in sodic soil*. Ph. D. thesis. Rajasthan Agric. Univ., Jobner, India.
11. Prasad J. and H. Ram. 1986. Effect of zinc and copper and *Rhizobium* inoculation on P availability and uptake in moong bean. *J. Ind. Soc. Soil Sci.* 34 : 762—766.
12. Takker P. N., M. S. Mann and N. S. Randhawa. 1975. Effect of direct and residual available zinc on yield, concentration and its uptake by wheat and groundnut crops. *J. Ind. Soc. Soil Sci.* 23 : 91—95.
13. Patel M. K. 1988. *Response of mustard to P, S, Zn fertilization and their residual effect on bajra crop*. Ph. D. thesis, Gujarat Agric. Univ., Anand, India.
14. Singh M. V. 1990. Effect of phosphorus and zinc application on the growth, yield and chemical composition of mustard (*Brassica juncea* L.) in semi reclaimed alkali soil. *Nat. Sem. on Recent Development in Soil Research*. 22—25 Dec. 1990. Rajasthan College of Agriculture, Udaipur, India 119 pp.