Annals of Arid Zone 55(1&2): 41-45, 2016

Effect of Phosphorus and Zinc with and without Vermicompost on Yield and Nutrient uptake of Fennel Crop (*Foeniculum vulgare* Mill.)

Abha and Yogesh Sharma*

College of Agriculture, S.K. Rajasthan Agricultural University, Bikaner 334 06, India

Received: April 2016

Abstract: A two year experiment was conducted to find out the effect of vermicompost, phosphorus and zinc on yield and nutrient uptake of fennel. Application of 2 t vermicompost ha^{-1} significantly increased the seed, stover yields and phosphorus and zinc uptake of seed and stover. Application of 40 kg P_2O_5 ha^{-1} had 43.16 and 25.89% higher seed and stover yield, respectively over control. Phosphorus uptake in seed and stover and zinc uptake in seed and stover increased significantly up to 40 kg P_2O_5 ha^{-1}. Application of 6.0 kg Zn ha^{-1} significantly increased seed and stover yield and phosphorus uptake in seed. Zinc uptake by seed and stover increased significantly up to 9.0 kg Zn ha^{-1}. Combined application of 2 t vermicompost ha^{-1} and 40 kg P_2O_5 ha^{-1} resulted in the highest seed (1377 kg ha^{-1}) yield and was found significant for phosphorus and zinc uptake by seed. The interaction effect of treatment combination 2 t vermicompost + 6 kg Zn ha^{-1} was found significant for phosphorus uptake by seed. However, in zinc uptake by seed the treatment combination 2 t vermicompost + 9 kg Zn ha^{-1} was found significant. The treatment combination of $P_{40}Zn_6$ (40 kg P_2O_5 ha^{-1} + 6.0 kg Zn ha^{-1}) was found significant for seed and stover yield and phosphorus uptake by seed.

Key words: Fennel, phosphorus, zinc, vermicompost, nutrient uptake.

India as the world's largest producer of seed spices account for about 4014.9 thousand tons from 2463.7 thousand hectare of area (Anonymous, 2009-10). Fennel cultivation in India is about 53497 hectare area and produces 83576 tons with an averages productivity of 1562 kg ha^{-1} (Anonymous, 2009-10). Fennel is grown in an estimated area of 26973 hectares and produces 26157 tons with an average productivity of 970 kg ha^{-1} (Anonymous, 2010-11). The reason for low productivity is the lack of ideal agronomical practices, water and nutrient management and non-adoption of suitable high yielding varieties. The present study was undertaken to evaluate the effect of vermicompost, phosphorus and zinc on yield, content and uptake by fennel.

Materials and Methods

A field experiment was conducted at the Agronomy Farm, College of Agriculture, S.K. Rajasthan Agricultural University, Bikaner during rabi seasons of 2008-09 and 2009-10. The soil of the experimental field was loamy sand in texture, with low to medium fertility status (i.e. 120.6 kg N, 20.0 kg P_2O_5, 237.6 kg K_2O ha^{-1} and 0.17 mg kg^{-1} Zn) with pH 8.45. Thirty two treatment combinations i.e. two levels of vermicompost (0 and 2 t ha^{-1}), four levels of phosphorus (0, 20, 40 and 60 kg P_2O_5 ha^{-1}) as main plot treatment and four levels of zinc (0, 3.0, 6.0 and 9.0 kg Zn ha^{-1}) as sub-plot treatment was laid out in split plot design with four replications. The fennel variety RF-125 was sown maintaining 45 cm row to row and 25 cm plant to plant distance.

*E-mail: yogeshcoabikaner@gmail.com

Results and Discussion

Vermicompost

Application of vermicompost @ 2 t ha^{-1} significantly enhanced the seed and stover yield over control (Table 1). The significant improvement in seed yield with the addition of vermicompost might be due to its positive influence on maintaining balanced source and sink relationship. The seed and stover yields being functions of growth and yield attributes improved significantly due to the cumulative effect of these attributes. Further, vermicompost might have increased the efficiency of added chemical fertilizer in soil, activities of N fixing bacteria and increased rate of humification. Humic acid in vermicompost might have enhanced the availability of both native and added nutrients in soil and as a result improved

Table 1. Effect of vermicompost, phosphorus and zinc levels on seed, stover yield, phosphorus and zinc uptake (on pooled basis)

Treatments	Yield (kg ha^{-1})		Phosphorus uptake (kg ha^{-1})		Zinc uptake (kg ha^{-1})	
	Seed	Stover	Seed	Stover	Seed	Stover
Vermicompost levels (t ha^{-1})						
V_0	1021	2857	4.82	3.91	22.17	41.81
V_2	1249	3267	6.65	5.00	30.41	53.98
S.Em±	6.57	12.69	0.04	0.04	0.14	0.23
CD (P=0.05)	18.75	36.21	0.11	0.11	0.41	0.65
Phosphorus levels (kg P_2O_5 ha^{-1})						
P_0	880	2626	4.10	3.04	22.70	45.73
P_{20}	1130	2982	5.62	4.24	26.33	47.16
P_{40}	1260	3306	6.55	5.21	28.06	49.33
P_{60}	1270	3333	6.68	5.34	28.07	49.36
S.Em±	9.29	17.94	0.06	0.06	0.20	0.32
CD (P=0.05)	26.52	51.21	0.16	0.16	0.58	0.92
Zinc levels (kg ha^{-1})						
Zn_0	971	2513	5.30	3.86	19.96	35.09
Zn_3	1109	3018	5.63	4.44	25.35	46.43
Zn_6	1219	3339	5.99	4.77	29.55	54.54
Zn_9	1240	3377	6.04	4.77	30.29	55.53
S.Em±	8.53	15.99	0.05	0.05	0.21	0.31
CD (P=0.05)	23.84	44.70	0.13	0.14	0.59	0.87

growth and yield attributes and yield of the crop significantly (Sreenivas *et al.*, 2000).

The phosphorus and zinc uptake by seed and stover showed significant improvement due to application of 2 t vermicompost ha^{-1} during both the years of experimentation. The increased uptake of P and Zn by the crop due to vermicompost application could also be due to improvement in nutritional environment of root zone, which encouraged the proliferation of roots thereby facilitating more withdrawal of water and nutrients from larger area and greater depth (Sharma and Bali, 2001).

Phosphorus

Application of 40 kg P_2O_5 ha^{-1} significantly increased the seed yield and stover yield of fennel. The outside supply of phosphorus to the soil deficient in phosphorus might have accelerated various physiological processes in plants favoring increased seed and stover yields of fennel. The increase in seed yield due to phosphorus application might be attributed to better source and sink relationship in terms of greater translocation of food material to yield attributing parts. It appears that greater translocation of photosynthates from source to sink (seed) might have increased the seed yield.

Increasing levels of phosphorus upto 40 kg ha^{-1} increased the phosphorus and zinc uptake significantly on pooled basis. Nutrient uptake is primarily a combined function of nutrient contents in the plant parts and biomass production of the crop, uptake of P and Zn increased significantly with increasing levels of phosphorus application due to the cumulative effect of increased or slightly decreased (Zn) nutrient contents and considerably increased seed and stover yields.

Zinc

Application of zinc upto to 6.0 kg ha^{-1} to the soil with poor zinc status significantly increased the seed yield over control. This improvement in yield attributes could be ascribed to increased supply of available zinc to the plants by way of its addition to soil resulting in improvement in growth and development attributed to its role in activation of enzymes, increased photosynthetic activity and biosynthesis of indole acetic acid (IAA). Growth promotion due to zinc application as a consequence might have

Table 2. Combined effect between vermicompost and phosphorus levels on seed and stover yield, phosphorus and zinc uptake (in pooled over two seasons)

Vermicompost levels	Phosphorus levels			
	P_0	P_{20}	P_{40}	P_{60}
Seed yield (kg ha^{-1})				
V_0	746.00	1035.00	1144.00	1160.00
V_2	1014.00	1224.00	1377.00	1380.00
S.Em±	13.14			
CD (P=0.05)	37.50			
Phosphorus uptake in seed (kg ha^{-1})				
V_0	3.27	4.83	5.54	5.66
V_2	4.93	6.40	7.57	7.70
S.Em±	0.08			
CD (P=0.05)	0.23			
Zinc uptake in seed (g ha^{-1})				
V_0	18.57	22.69	23.62	23.79
V_2	26.83	29.97	32.49	32.35
S.Em±	0.29			
CD (P=0.05)	0.82			

helped in laying out primordia for reproductive parts and promoted more partitioning of photosynthates towards reproductive organs. The seed yield being a combined function of yield attributes, it increased significantly as a natural manifestation of increase in yield attributes due to application of zinc in a soil already with its poor availability.

Table 3. Combined effect between vermicompost and zinc levels on seed and stover yield, phosphorus and zinc uptake (in pooled over two seasons)

Vermicompost levels	Zinc levels			
	Zn_0	Zn_3	Zn_6	Zn_9
Seed yield (kg ha^{-1})				
V_0	885	990	1096	1114
V_2	1058	1228	1343	1366
			S.Em±	CD (P=0.05)
Zn at the same level of V			12.06	33.71
V at the same level of Zn and at the different levels			12.34	34.70
Phosphorus uptake in seed (kg ha^{-1})				
V_0	4.59	4.70	4.99	5.03
V_2	6.02	6.55	6.98	7.06
			S.Em±	CD (P=0.05)
Zn at the same level of V			0.07	0.18
V at the same level of Zn and at the different levels			0.07	0.20
Zinc uptake in seed (g ha^{-1})				
V_0	17.13	21.03	25.05	25.46
V_2	22.80	29.67	34.05	35.12
			S.Em±	CD (P=0.05)
Zn at the same level of V			0.30	0.83
V at the same level of Zn and at the different levels			0.30	0.83

Table 4. Combined effect between phosphorus and zinc levels on seed and stover yield, phosphorus and zinc uptake (in pooled over two seasons)

Phosphorus levels	Zinc levels			
	Zn_0	Zn_3	Zn_6	Zn_9
Seed yield (kg ha^{-1})				
P_0	638	865	996	1019
P_{20}	1003	1103	1198	1215
P_{40}	1115	1228	1339	1359
P_{60}	1129	1241	1344	1366
			S.Em±	CD (P=0.05)
Zn at the same level of P			17.06	47.68
P at the same level of Zn and at the different levels			17.45	49.07
Phosphorus uptake in seed (kg ha^{-1})				
P_0	3.21	4.04	4.57	4.60
P_{20}	5.30	5.44	5.81	5.91
P_{40}	6.24	6.44	6.73	6.81
P_{60}	6.45	6.59	6.83	6.85
			S.Em±	CD (P=0.05)
Zn at the same level of V			0.09	0.26
V at the same level of Zn and at the different levels			0.10	0.28
Zinc uptake in seed (g ha^{-1})				
P_0	14.75	21.94	26.70	27.40
P_{20}	20.81	25.40	29.18	29.91
P_{40}	22.09	26.95	31.26	31.92
P_{60}	22.18	27.10	31.08	31.92
			S.Em±	CD (P=0.05)
Zn at the same level of P			0.42	1.18
P at the same level of Zn and at the different levels			0.42	1.17

Application of zinc upto 6.0 kg ha^{-1} significantly increased phosphorus uptake in seed and stover. The application of zinc @ 9.0 kg ha^{-1} significantly increased the zinc uptake in seed and stover on pooled basis. The increased uptake of P and Zn seem possibly due to their increased content in seed and stover and higher seed and stover yield.

Combined effects

Vermicompost x phosphorus: The interaction effect of vermicompost and phosphorus was found significant with 2 t vermicompost ha^{-1} + 40 kg P_2O_5 ha^{-1} for seed yield, phosphorus uptake by seed, zinc content and uptake by seed over rest of combinations of vermicompost and phosphorus. Phosphorus availability is at its highest when the reaction is between 6.5 and 7.5. The availability of P to plants for uptake and utilization is impaired in alkaline and calcareous soil due to the formation of poorly soluble calcium phosphate minerals. The solubility of these calcium phosphate mineral is lowest at about pH 8.0. The presence of lime in alkaline soil further exacerbates the P availability problem. There is substantial improvement in utilization efficiency of applied P fertilizer in the presence of organic acids produced during decomposition of applied FYM (Hue, 1992).

Vermicompost x zinc: The combined application of 2 t vermicompost ha^{-1} + 6 kg Zn ha^{-1} significantly augmented the seed yield, phosphorus uptake by seed, over rest of combinations of vermicompost and zinc. The zinc uptake by seed was significantly higher under combined application of 2 t vermicompost ha^{-1} + 9 kg Zn ha^{-1}. It might be due to the fact that zinc is an essential component of enzymes responsible for assimilation of nitrogen, help in formation of chlorophyll and plays an important role

in nitrogen metabolism. Thus it increases the absorption of nitrogen by plants. The combined application of zinc and vermicompost helped to improve the availability of nutrients on one side and their greater uptake by plant owing to increased cation exchange capacity of roots, physiological activities and vegetative growth of the plants on the other side. The higher uptake of nutrients from the soil and enhanced metabolic activities of plant might be resulted into higher seed and stover yields of fennel with higher nutrient content. Similar results were also reported by Kumar *et al.* (2001).

Phosphorus x zinc: The interactive effect of P and Zn on seed yield indicated that the response of Zn varied with the dose of P. The significant increase in seed yield was obtained with P_{40} Zn_6 combination. The favorable effect of optimum level of P-Zn combination might be because of i) phosphorous fertilization is likely to make the crop more responsive to Zn by increasing the growth (Millikan, 1940), ii) addition of zinc with P might have maintained a favourable balance between the applied nutrients in the plant for its optimum growth (Millikan, 1963; Brown and Leggett, 1964; Watanabe *et al.*, 1965) and iii) Zn enhanced the utilization of P by its effect on metabolism (Rossel and Ulrich, 1964; Watanabe *et al.*, 1965). Similar results were also reported by Yadav *et al.* (1985); Pusta and Jana (1995); Sharma and Abrol (2007).

Conclusion

On the basis of two years of experimental findings, it is concluded that application of 2 t vermicompost, 40 kg P_2O_5 ha^{-1} and 6.0 kg Zn ha^{-1} can be recommended for fennel under irrigated condition. Application of 2 t vermicompost and phosphorus upto 40 kg P_2O_5 ha^{-1} significantly increased the phosphorus and zinc uptake of seed and stover. Application of 6.0 kg Zn ha^{-1} significantly increased phosphorus uptake in seed. Zinc uptake by seed and stover increased significantly upto 9.0 kg Zn ha^{-1}.

References

Anonymous. 2009-10. Commissionrate of Agriculture, Rajasthan, Jaipur pp. 103.

Anonymous. 2010-11. *Directorate of Economics and Statistics*, Govt. of Rajasthan, Yojana Bhawan, Jaipur (Raj.).

Brown, L.C. and Leggette, C.E. 1964. Phosphorus and zinc concentration in Russet Burbank Potato tissue in relation to development of zinc deficiency symptoms. *Proceedings Soil Science Society of America* 28: 229-232.

Hue, N.V. 1992. Correcting soil acidity of a highly weathered vertisol with chicken manure and sewage sludge. *Communications in Soil Science and Plant Analysis* 23: 241-64.

Kumar, N., Verma, L.P., Singh, R. and Prasad, K. 2001. Soil properties, nutrient uptake and productivity of rice under integrated nutrient management system. *Annals of Plant and Soil Research* 31: 54-57.

Millikan, C.R. 1940. Zinc requirement of wheat. Effect of superphhosphate. *Journal of the Department of Agriculture, Victoria 38*: 135-136.

Millikan, C.R. 1963. Effect of different levels of zinc and phosphorus on growth of subterramean clover. *Australian Journal of Agriculture Research* 14: 180-205.

Pusta, A.M. and Jana, P.K. 1995. Effect of phosphorus and zinc on yield attributes and yield of pigeonpea varieties grown during winter season. *Madras Agricultural Journal* 82(5): 348-351.

Rossel, R.A. and Ulrich, A. 1964. Critical zinc contentration and leaf minerals of sugarbeet plant. *Soil Science* 97: 152-167.

Sharma, M.P. and Bali, S.V. 2001. Effect of row spacing and farm yard manure with increasing levels of nitrogen, phosphorus and potassium on yield and nutrients uptake in rice (*Oryza sativa*)-wheat (*Tritcum aestivum*) cropping sequence. *Indian Journal of Agricultural Sciences* 71(10): 661-663.

Sharma, V. and Abrol, V. 2007. Effect of phosphorus and zinc application on yield and uptake of P and Zn by chickpea under rainfed condition. *Journal of Food Legumes* 20(1): 49-51.

Sreenivash, C.H., Muralidhar, S. and Rao, M.S. 2000. Vermicompost : A viable component of IPNS in nitrogen nutrition of ridge gourd. *Annals of Agricultural Research* 21: 108-113.

Watanabe, F.S., Lindsay, W.L. and Olsen, S.R. 1965. Nutrient balance involving phosphorus, iron and zinc. *Proceedings of Soil Science Society of America* 29: 532-565.

Yadav, D.S., Antil, R.S., Kumar, V. and Singh, M. 1985. Effect of P and Zn application on dry matter yield and uptake of nutrient in cowpea (*Vigna unguiculata*). *Zeitschriff fiir P Flanzenernahruvg, Bodenkhde* 148(3): 233-240.

Printed in June 2016