International Journal of Advanced Biochemistry Research 2023; SP-7(2): 564-567

International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2023; SP-7(2): 564-567
www.biochemjournal.com
Received: 16-10-2023
Accepted: 22-11-2023

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Effect of iron and zinc enriched organics on available nutrient status of soil after harvest of potato in loamy sand

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DOI: https://doi.org/10.33545/26174693.2023.v7.i2Sh.267

Abstract
A field experiment was conducted at the Agronomy Instructional Farm, Department of Agronomy, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar to study the effect of Fe and Zn enriched organics on growth, yield attributes and yield of potato in loamy sand (Typic *Ustipsamments*) during the *Rabi* seasons of 2016-17 and 2017-18. The results revealed that an application of 5 t vermicompost ha^{-1} recorded significantly higher available P_2O_5 content, DTPA-Fe and DTPA-Zn as compared to 20 t FYM ha^{-1}. The organic carbon and available nitrogen content were recorded higher with 20 t FYM ha^{-1}. An application of organics 2 t ha^{-1} enriched with 6 kg Fe and 4 kg Zn (N_5) recorded significantly higher organic carbon, available nitrogen, available P_2O_5, available K_2O, DTPA-Fe and DTPA-Zn concentration compared to no application of Fe and Zn.

Keywords: FYM, micronutrient deficiencies, iron, zinc, vermicompost, potato

Introduction
Micronutrient deficiencies in Indian soils and crops have been on the increase since the adoption of modern agricultural technology with increased use of NPK fertilizers generally free from micronutrients, intensive cultivation with fertilizer responsive improved varieties of crops with more irrigation facilities, limited use of organic manure and restricted recycling of crop residues (Prasad, 1999) [8]. The reports in literature indicate that combination of organics with inorganic fertilizers is helped in decreasing the use of chemical fertilizers under integrated plant nutritional system (IPNS). Supplementation of deficient nutrients is necessary for higher crop yields. Potato is an important crop of North Gujarat particularly in Banaskantha district. The process of enrichment of organics with Fe and Zn not only increase crop yield but also helps in reducing the load of inorganic chemicals as well as quantity of organics to a considerable extent (Meena *et al.* 2006) [5]. The information on Fe and Zn enriched organics (FYM/Vermicompost) is lacking on Fe and Zn deficient soils of Banaskantha of North Gujarat where potato crop is grown. Present study was conducted to assess the Fe and Zn enriched organics on growth, yield attributes and yield of potato crop.

Materials and Methods
A field experiment was conducted at the Agronomy Instructional Farm, Department of Agronomy, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during the *Rabi* seasons of 2016-17 and 2017-18 to study the effect of Fe and Zn enriched organics on growth, yield attributed and yield of potato. Twelve treatment combinations comprising of two organics *viz.*, 20 t FYM ha^{-1} (M_1) and 5 t vermicompost ha^{-1} (M_2) and six treatments of Fe and Zn supplementation *viz.*, No Fe and Zn (N_1), 6 kg Fe and 4 kg Zn ha^{-1} (Inorganic) (N_2), organics 2 t ha^{-1} enriched with 3 kg Fe (N_3), organics 2 t ha^{-1} enriched with 2 kg Zn (N_4), organics 2 t ha^{-1} enriched with 6 kg Fe and 4 kg Zn (N_5) and organics 2 t ha^{-1} enriched with 3 kg Fe and 2 kg Zn (N_6) were laid out under factorial randomized block design with four replications. The enrichment process was started 45 days before their use in *Rabi* experiment on potato. The required quantities of organics (FYM and vermicompost) were filled in the pre-dug pit of 1.0 × 1.0 × 1.0 m^3 size.

The FYM and vermicompost were thoroughly mixed with the solution of $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$ having required concentration as per treatments *viz.*, 3 kg Fe, 2 kg Zn, 6 kg Fe and 4 kg Zn and 3 kg Fe and 2 kg Zn through 2 tonnes of organics (FYM and vermicompost) per hectare. The moisture percentage of FYM and vermicompost after mixing with $FeSO_4.7H_2O$ and $ZnSO_4$. $7H_2O$ were kept at about 75 to 80. The representative dry samples of potato tuber and haulm were analyzed for ascertaining the nutrient (N, P, K, Fe and Zn) content and uptake. The N, P, K, Fe and Zn contents were analyzed by micro-Kjeldahl, Vanadomolydo phosphoric acid yellow-colour, and flame Photometric method and DTPA extraction methods respectively. Available N, P_2O_5, K_2O, Fe and Zn content in soil were analyzed by alkaline permanganate, Olsen's method, Flame photometric method and DTPA extraction methods, respectively.

Results and Discussion

Post-harvest availability of soil nutrients

Effect of organics

The data given in Table 1 showed that an application of 20 t FYM ha^{-1} (M_1) registered significantly higher organic carbon content and available nitrogen in soil at harvest than that of application of 5 t vermicompost ha^{-1} (M_2). The improvement in organic carbon status of soil at harvest due to 20 t FYM ha^{-1} (M_1) was to the extent of 2.43 per cent over 5 t vermicompost ha^{-1} (M_2) on pooled data basis. wherein treatment M_2 (5 t vermicompost ha^{-1}) registered significantly higher value of (Table 1) available P_2O_5, DTPA-Fe and DTPA-Zn content in soil as compared to M_1 treatment (20 t FYM ha^{-1}) during both the years of study and in pooled data. The available K content in soil after harvest of potato crop was found to be non-significant due to effect of organics during both the years of study as well as in pooled analysis.

An increase in available N content and organic carbon content in soil under FYM treatment was expected due to direct addition of nitrogen as well as indirect effect resulting from the better decomposition of organic matter which causes the mineralization of organically bound nitrogen and thereby improvement in available status of nitrogen. Another reason may be due to higher yield of tuber under vermicompost treatment which caused higher removal of nitrogen from the soil. The results are in closed conformity with the findings of Singh *et al.* (2014) [14] and Parmar (2016) [2].

The significant increase in available P_2O_5 content and DTPA-Fe in soil after harvest of potato crop may be ascribed to the beneficial role of vermicompost in mineralization of native as well as its own nutrient content by creating favourable conditions for microbial as well as chemical activities which enhanced the available nutrient pool of the soil. The biological properties of soil and also transformation of their solid phase form to soluble matalo-complexes may be due to mineralization of native as well as own nutrient content by creating favourable conditions for microbes. The results are in agreement with those of Sutaria *et al.* (2011) [11], Kumari *et al.* (2012) [3] and Sharma (2016) [9].

Effect of Fe and Zn supplementation

A perusal of data presented in Table 1 revealed that the organic carbon content in soil after harvest of potato crop was significantly the higher value was obtained with treatment of organics 2 t ha^{-1} enriched with 6 kg Fe and 4 kg Zn ha^{-1} (N_5) as compared to N_1 treatment (control) as well as straight application of 6 kg Fe and 4 kg Zn ha^{-1} (N_2), but was on par with treatments of N_3, N_4 and N_6 treatments during both the years as well as in pooled data. The results further revealed that the value of organic carbon content in soil under all the enriched treatments did not differed significantly. Supplementation of either Fe and Zn alone or its combination after enrichment with organics (N_3, N_4, N_5 and N_6) significantly improved organic carbon status over control as observed in present study could be due to fat that organics (FYM/vermicompost) add organic matter to the soil which in turn increases organic carbon content in soil. The results are in agreement with those reported by Gurjar (2012) [1], Patel *et al.* (2016) [7] and Parmar (2016) [2].

The highest value of available N content (Table 1) in soil was obtained with application of organics 2 t ha^{-1} enriched with 6 kg Fe and 4 kg Zn (N_5) as compared to other treatments, but proved significantly superior to control (N_1 treatment) and straight application of 6 kg Fe and 4 kg Zn ha^{-1} (N_2) during both the years as well as in pooled analysis.

The beneficial effect of various Zn-enriched organics to improve soil properties and thereby increase in N availability has been reported by Latha *et al.* (2001) [4]. These results are in close agreement with those reported by Singh *et al.* (2014) [10], Parmar (2016) [6] and Sharma (2016) [9]. Non-significant variation in available P_2O_5 content and available K content (Table 2) in soil were seen due to Fe and Zn supplementation during both years and in pooled analysis.

Among different treatments, an application of organics 2 t ha^{-1} enriched with 6 kg Fe and 4 kg Zn (N_5) being on par with organics 2 t ha^{-1} enriched with 3 kg Fe and 2 kg Zn (N_6) registered significantly higher DTPA-Fe content (Table 2) in soil after harvest of crop as compared to other treatments during 2016-17. DTPA-Zn content (Table 2) in soil after harvest of potato crop significantly the highest recorded under application of organics 2 t ha^{-1} enriched with 6 kg Fe and 4 kg Zn (N_5) in 2016-17, 2017-18 and pooled analysis, respectively. The DTPA-Fe and Zn content of soil was significantly improved due to application of organics 2 t ha^{-1} enriched with 6 kg Fe and 4 kg Zn (N_5) might be due to enrichment of organics with Fe and Zn regulates its supply to the crop through mineralization and prevent them from leaching and other loses besides mobilizing and supplying native Fe and Zn. Another reason is fact that Fe and Zn availability in soil expected to be enhanced through complexation or chelation and thereby prevented fixation in soil which provided better nutrition of Fe and Zn in soil. The positive influence of Fe and Zn enriched organics on soil DTPA-Fe and Zn have also reported by Gurjar (2012) [1] in mustard, Patel *et al.* (2016) [7] in cumin and Parmar (2016) [6] in fenugreek.

Interaction effect

Interaction effect of M×N (organics × Fe and Zn supplementation) was found non-significant during 2016-17, 2017-18 and pooled results in respect to organic carbon, available N content, available P_2O_5 content and available K_2O content in soil after harvest of potato.

The treatment combination M_2N_5 (5 t vermicompost ha^{-1} + vermicompost 2 t ha^{-1} enriched with 6 kg Fe and 4 kg Zn) registered significantly the highest DTPA-Fe content (Table 3) in soil over rest of treatment combinations in individual year as well as in pooled analysis. Among all treatment combination, M_2N_5 treatment combination registered significantly the highest available Zn content (Table 4) in soil over rest of treatment combinations in 2016-17, 2017-18 and in pooled analysis. The combined application of 5 t vermicompost ha^{-1} and vermicompost 2 t ha^{-1} enriched with 6 kg Fe and 4 kg Zn (M_2N_5) increased the availability of Fe and Zn in soil might be due to addition of vermicompost to the soil which have initial higher contents of Fe and Zn in it and also it produced the organic acid which make it more available Fe and Zn in soil. Addition of Fe and Zn enriched vermicompost to the soil increased the availability of Fe and Zn in soil due to itself contains appreciable quantities of Fe and Zn after enrichment. Another reason is that Fe and Zn availability in soil expected to be enhanced through complexation or chelation and thereby prevented fixation in soil which provided better nutrition of Fe and Zn in soil. The synergistic effect of vermicompost and Fe and Zn enriched vermicompost influence on DTPA-Fe and Zn in soil.

Table 1: Organic carbon, available nitrogen content and available P_2O_5 content in soil after harvest of potato as influenced by organics and Fe and Zn supplementation

Treatments	Organic carbon (%)			Available Nitrogen (kg ha^{-1})			Available P_2O_5		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Organics (M)									
M_1	0.410	0.429	0.420	221.5	228.0	224.8	52.58	54.90	53.74
M_2	0.402	0.417	0.410	214.1	218.2	216.2	55.07	57.13	56.10
S.EM.±	0.002	0.002	0.001	1.65	1.22	1.03	0.51	0.64	0.41
C.D. (P=0.05)	0.005	0.006	0.004	4.8	3.5	2.9	1.47	1.84	1.15
Fe and Zn supplementation (N)									
N_1	0.384	0.403	0.393	203.1	214.3	208.7	52.50	54.71	53.61
N_2	0.390	0.409	0.400	209.9	217.0	213.4	52.89	55.33	54.11
N_3	0.412	0.429	0.420	220.0	224.7	222.4	53.95	55.83	54.89
N_4	0.414	0.431	0.422	222.1	226.8	224.4	54.34	56.45	55.39
N_5	0.420	0.434	0.427	226.2	228.5	227.4	54.83	57.21	56.02
N_6	0.418	0.433	0.425	225.5	227.3	226.4	54.43	56.57	55.50
S.EM.±	0.003	0.004	0.002	2.86	2.11	1.78	0.88	1.11	0.71
C.D. (P=0.05)	0.009	0.011	0.007	8.2	6.1	5.0	NS	NS	NS
Interaction (M×N)									
S.EM.±	0.005	0.005	0.003	4.05	2.98	2.51	1.25	1.56	1.00
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	2.28	2.45	2.37	3.72	2.67	3.22	4.64	5.59	5.16

Table 2: Available K_2O content and DTPA-extractable Fe and Zn in soil after harvest of potato as influenced by organics and Fe and Zn supplementation

Treatments	Available K_2O			DTPA-Fe (mg kg^{-1})			DTPA-Zn (mg kg^{-1})		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Organics (M)									
M_1	245.5	250.4	248.0	4.34	4.44	4.39	0.409	0.437	0.423
M_2	250.7	254.5	252.6	4.46	4.57	4.51	0.437	0.449	0.443
S.EM.±	3.01	2.76	2.04	0.02	0.01	0.01	0.002	0.003	0.002
C.D. (P=0.05)	NS	NS	NS	0.05	0.03	0.03	0.005	0.007	0.005
Fe and Zn supplementation (N)									
N_1	242.4	247.1	244.8	4.21	4.32	4.26	0.384	0.402	0.393
N_2	247.5	251.5	249.5	4.37	4.44	4.44	0.429	0.447	0.438
N_3	251.1	254.6	252.9	4.42	4.51	4.46	0.399	0.419	0.409
N_4	254.2	257.2	255.7	4.33	4.39	4.36	0.434	0.452	0.443
N_5	246.6	251.3	249.0	4.57	4.71	4.64	0.454	0.480	0.467
N_6	247.0	252.9	249.9	4.49	4.65	4.57	0.436	0.455	0.446
S.EM.±	5.21	4.77	3.53	0.03	0.02	0.02	0.003	0.004	0.003
C.D. (P=0.05)	NS	NS	NS	0.08	0.05	0.05	0.010	0.013	0.008
Interaction (M×N)									
S.EM.±	7.37	6.75	5.00	0.04	0.02	0.02	0.005	0.006	0.004
C.D. (P=0.05)	NS	NS	NS	0.11	0.07	0.07	0.013	0.018	0.011
C.V.%	5.94	5.35	5.65	2.50	3.25	2.89	2.21	2.83	2.55

Table 3: Interaction effect of M×N on DTPA- extractable Fe (mg kg^{-1}) in soil after harvest of potato (2016-17, 2017-18 and Pooled)

Organics	Fe and Zn supplementation					
	N_1	N_2	N_3	N_4	N_5	N_6
	2016-17					
M_1	4.20	4.35	4.39	4.29	4.42	4.40
M_2	4.23	4.39	4.44	4.38	4.73	4.58
S.EM.±	0.04					
C.D.(P=0.05)	0.11					
	2017-18					
M_1	4.23	4.38	4.49	4.30	4.64	4.60
M_2	4.41	4.50	4.53	4.48	4.79	4.69
S.EM.±	0.02					
C.D.(P=0.05)	0.07					
	Pooled					
M_1	4.21	4.37	4.44	4.29	4.53	4.50
M_2	4.32	4.44	4.48	4.43	4.76	4.64
S.EM.±	0.02					
C.D.(P=0.05)	0.07					

Table 4: Interaction effect of M×N on DTPA- extractable Zn (mg kg^{-1}) in soil after harvest of potato (2016-17, 2017-18 and Pooled)

Organics	Fe and Zn supplementation					
	N_1	N_2	N_3	N_4	N_5	N_6
	2016-17					
M_1	0.378	0.417	0.387	0.418	0.432	0.419
M_2	0.390	0.440	0.410	0.451	0.475	0.453
S.EM.±	0.005					
C.D.(P=0.05)	0.013					
	2017-18					
M_1	0.399	0.446	0.420	0.447	0.460	0.450
M_2	0.406	0.447	0.419	0.458	0.501	0.460
S.EM.±	0.006					
C.D.(P=0.05)	0.018					
	Pooled					
M_1	0.388	0.432	0.404	0.432	0.446	0.435
M_2	0.398	0.444	0.414	0.454	0.488	0.457
S.EM.±	0.004					
C.D.(P=0.05)	0.011					

Conclusion

The field experiment demonstrated that the application of 5 t vermicompost ha^{-1} resulted in significantly higher levels of available P2O5, DTPA-Fe, and DTPA-Zn compared to 20 t FYM ha^{-1}. While 20 t FYM ha^{-1} led to higher organic carbon and available nitrogen content, the application of 2 t ha^{-1} organics enriched with 6 kg Fe and 4 kg Zn (N5) showed superior concentrations of various soil nutrients. This study highlights the potential of Fe and Zn enriched organics in enhancing soil nutrient status, providing valuable insights for sustainable agriculture practices, particularly in regions like Banaskantha, North Gujarat, where potato is a significant crop.

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