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Effect of Fe and Zn enriched organics on yield, quality and nutrient uptake by summer groundnut

Vishal C Damor, JM Patel and PP Chaudhary

Abstract
An experiment was conducted to study the “Effect of Fe and Zn enriched organics on yield, quality and nutrient uptake by summer groundnut [*Arachis hypogaea* (L.)].” at C. P. College of Agriculture, SDAU, Sardarkrushinagar during summer, 2017. Total ten treatments were tried in randomized block design with three replications. Treatment consists of an application of FYM and vermicompost alone, applying the iron and zinc as such with FYM and Vermicompost as well as enriched with organics (FYM & Vermicpmpost). An application of RDF + 0.2 t vermicompost ha^{-1} enriched with 0.75 kg Zn ha^{-1} produced significantly higher numbers of filled pods per plant (25.60), total pods per plant (28.33), pod weight per plant (15.26 g), 100 kernel weight (41.85 g), pod yield (2537 kg ha^{-1}) and haulm yield (3644 kg ha^{-1}) but it was remained at par with all Fe or Zn enriched organics treatments. The total uptake of N, P and S by groundnut crop were significantly higher under Fe or Zn enriched organics (FYM or vermicompost) treatments. The application of RDF + 0.2 vermicompost/ha enriched with 1.5 kg Fe/ha recorded significantly the highest uptake of Fe (3682 g/ha) by groundnut, while total uptake of Zn (188.8) by groundnut crop was significantly higher under RDF + 0.2 t vermicompost/ha enriched with 0.75 kg Zn/ha. The available N and P_2O_5 content in soil were significantly increased under Fe or Zn enriched organics (FYM or vermicompost) treatments. The significant improvement in available S status in all treatments which are received the Fe and Zn in the form of ferrous sulphate and zinc sulphate, respectively. The significant higher build-up of Fe and Zn content were found with their application through enrichment as well as through straight application of Fe and Zn.

Keywords: Iron, zinc, enriched organics, nutrient, groundnut

Introduction

Intensification of cropping system with high yielding varieties, greater use of high analysis fertilizers and considerable decrease in recalling of crop residues and scares use of bulk manures in present day agriculture resulted in greater depletion of micronutrients in soil led to decrease the productivity of crops. Micronutrient deficiencies in Indian soils and crops have been increased since the adoption of modern agricultural technology with increased use of NPK fertilizers generally free from micronutrients, intensive cultivation with high yielding varieties with more irrigation facilities, limited use of organic matter and restricted recycling of crop residues (Prasad, 1999) [12]. Adoption of new technologies to increase crop productivity would ultimately end up in rapid depletion of nutrients and the soil fertility. Addition of organic material had beneficial effect on crop growth, productivity by sustaining soil health. Mixing inorganic salts of micronutrients with different organic materials can enhance the efficacy of micronutrients. On decomposition of organic manures numerous compounds like humic acid and fulvic acid and biological substances like organic acid, amino acid and polyphenols are produced which act as chelating agents that form stable complexes with native micronutrients and also prevent added inorganic micronutrients from precipitation, fixation, oxidation and leaching resulted in improvement in efficiency of applied micronutrients. The enrichment of organics with micronutrients not only improve the quality of organics but also reduced the quantity of both inorganic chemicals and as well as quantity of organics. It is reported that addition of enriched organics in lower quantities had similar effects on soil properties to that of high quantity (without enrichment). The enriched organics are expected to provide beneficial effect on plant growth for longer time.

Zinc and iron deficiencies are the common micronutrient deficiencies in light textured soils of North Gujarat limiting both crop production and nutritional quality.

Now a days, areas under summer groundnut cultivation is increasing north Gujarat but yellowing of leaves in groundnut is common feature owing to deficiency of either Fe or Zn. Fe and Zn application in the enriched form may enhance the fertilizer use efficiency and increase the yield of groundnut. However, information on the response of groundnut to iron and zinc enriched organics is limited. Hence, the present study was conducted for assessing the effect of iron and zinc enriched organics on growth parameters, yield attributes and yield, quality and nutrient uptake by groundnut.

Materials and methods

The experiment was conducted in iron and zinc deficient loamy sand soil at Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar during summer 2017 to study the effect of Fe and Zn enriched organics on growth, yield, quality and nutrient uptake by summer groundnut. The soil of experimental field was loamy sand soil having pH 7.62. The electrical conductivity and organic carbon content of soil were 0.11 dSm^{-1} and 0.310 per cent, respectively. The fertility status of the experimental field was found to be low in available nitrogen (156.5 kg ha^{-1}), medium in available phosphorus (43.41 kg ha^{-1}) and available potassium (253.0 kg ha^{-1}). The available iron and zinc status of the soil were 4.23 mg kg^{-1} and 0.41 mg kg^{-1} which is below the their critical level. Total ten treatments *viz.*, T_1 : RDF (25 kg N + 50 kg P_2O_5 ha^{-1}) + 0.5 t FYM ha^{-1}, T_2 : RDF + 0.2 t Vermicompost ha^{-1}, T_3 : RDF + 0.5 t FYM ha^{-1} + 3. 0 kg Fe ha^{-1}, T_4 : RDF + 0.2 t Vermicompost ha^{-1} + 3. 0 kg Fe ha^{-1}, T_5 : RDF + 0.5 t FYM ha^{-1} + 1.5 kg Zn ha^{-1}, T_6 : RDF + 0.2 t Vermicompost ha^{-1} + 1.5 kg Zn ha^{-1}, T_7 : RDF + 0.5 t FYM ha^{-1} enriched with 1.5 kg Fe ha^{-1}, T_8 : RDF + 0.2 t Vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1}, T_9 : RDF + 0.5 t FYM ha^{-1} enriched with 0.75 kg Zn ha^{-1} and T_{10} : RDF + 0.2 t Vermicompost ha^{-1} enriched with 0.75 kg $Znha^{-1}$ were tried in randomized block design with three replications.

Groundnut (GG 2) was sowed at a depth of 5 cm keeping inter row spacing of 30 cm and plant to plant spacing of 10 cm using recommended seed rate of 120 kg ha^{-1} and fertilizers were applied @ 25 kg N and 50 kg P_2O_5 ha^{-1}. Before sowing, seed was treated with *Rhizobium* and PSB. The full recommended nitrogen (20 kg ha^{-1}) and phosphorus (40 kg ha^{-1}) were applied through urea and DAP as basal application in each plot. Iron and Zinc enriched FYM and Vermicompost were prepared by thoroughly mixing the required quantity of FYM (500 kg ha^{-1}) and Vermicompost (200 kg ha^{-1}) with the required quantity of $FeSO_4$ $7H_2O$ and $ZnSO_4$ $7H_2O$ as per the enriched treatment. The enrichment process was started 50 days before their use in summer season experiment on groundnut. The mixture was filled in a pre-dug pit and the pit was covered with polythene for natural chelation during the process of composting. The mixture was turned over periodically (weekly) and moisture loss was compensated during the process of enrichment for seven weeks. The growth parameters (plant population, plant height), yield attributing characters (number of filled pods, total pods and pod weight per plant, 100 kernel weight) as well as pod and haulm yield of groundnut were recorded. Oil content in seed was determined by NMR method as suggested by Tiwari *et al.*, (1974) [16]. Protein content in kernel was computed by the multiplying the N percentage with 6.25 for each treatment. Pod and haulm samples were collected at the harvest of groundnut for determination uptake of N, P, Fe and Zn. The oven dried plant samples were finely ground in a stainless still willey mill and were digested with H_2SO_4 and H_2O_2 (Jackson 1967) [3] for estimation of nitrogen content and with HNO_3:$HClO_4$ (4:1) di-acid mixture for determination of P and S as per procedure given by Jackson (1973) [3]. The extract was used for the determination of Fe and Zn by Atomic Absorption Spectrophotometer. The uptakes of nutrients were calculated by multiplying dry weight of pod and haulm with their respective content. Representative soil samples (0-15 cm depth) were collected to know the nutrient status of soil after harvest of groundnut crop. The samples were air dried, ground and passed through 2 mm sieve and were analyzed for available N by Alkaline permanganate method (Subbaih and Asija, 1956) [15], available P_2O_5 by extraction of soil with 0.5 m $NaHCO_3$ (pH 8.5) and development of colour with $SnCl_2$ and measured the colour intensity spectrophotometrically (Olsen *et al.* 1954) [8] and available S by turbidimentric method (Williams and Steinberg, 1959) [17]. The available Fe and Zn in soil were analyzed in suitable aliquot of DTPA extract with the help of Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978) [5].

Results and Discussion

Effect on growth parameters

The plant population per net plot and plant height at harvest (Table 1) did not differ significantly due to different treatments. However, the treatment receiving recommended dose of fertilizer along with 0.2 t vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1} registered maximum plant population (159.77) per net plot. The non significant results indicated that at initial stage there was no effect of different treatments on germination of groundnut seed as well as on survival of plants. The highest plant height (45.71 cm) was noted under the treatment of RDF + 0.2 t vermicompost ha^{-1} enriched with 0.75 kg Zn ha-1 (T_{10}) over the other treatments. The increase in plant height under the treatments of Fe or Zn enriched organics in present study might be due to improvement in vegetative structure for nutrient absorption and photosynthesis. Similar results were observed by Gurjar (2012) [2] in mustard.

Effect on yield attributing character

An appraisal of data given in Table 1 revealed that an application of RDF + 0.2 t vermicompost ha^{-1} enriched with 0.75 kg Zn ha^{-1} (T_{10}) produced significantly higher numbers of filled pods per plant (25.60), total pods per plant (28.33), pod weight per plant (15.26 g) and 100 kernel weight (41.85 g) over straight or no application of Fe and Zn. This treatment was remained at par with all Fe or Zn enriched organics (FYM and Vermicompost) treatments. The magnitude of increased in filled pods per plant and total pods per plant under treatment of RDF + 0.2 t vermicompost ha^{-1} enriched with 0.75 kg Zn ha^{-1} over T_2 (RDF + 0.2 t vermicompost ha^{-1}) were to the tune of 37.12 and 27.21 per cent, respectively. Similar results were also found with all FYM enrichment treatments. The results further revealed that irrespective of organic sources, application of Fe or Zn enriched organics increased both filled and total pods per plant as compared to direct or no application of Fe or Zn. The beneficial effect of enriched organics (FYM and vermicompost) either Fe or Zn along with RDF on yield attributes character could be attributed to fact that enrichment techniques caused mobilization of the native nutrients to increase their availability to growing crops. These results are in agreement with the findings of Gurjar (2012) [2] in mustard and Rahevar *et al.* (2015) [13] in groundnut. The enriched organics treatment T_7, T_8, T_9 and T_{10} recorded 23.48, 26.69, 25.96 and 28.66 per cent higher pod weight as compared to non enrichment treatments T_3, T_4, T_5 and T_6, respectively. The increase in the pod weight and 100 kernel weight could be due to continuous supply of organically cheated micronutrients (Zn or Fe) to the crop. Zn and Fe are part of the photosynthesis, assimilation and translocation of photosynthesis from source (leaves) to sink (pod). The results are in accordance with those reported by Gurjar (2012) [2] in mustard.

Pod yield and haulm yield

Significantly higher pod yield (2537 kg ha^{-1}) and haulm yield (3644 kg ha^{-1}) of groundnut was produced under the treatment T_{10} : RDF +0.2 t vermicompost ha^{-1} enriched with 0.75 kg Zn ha^{-1} as compared to rest of the treatments, but it was remained at par with the treatment T_7 : RDF + 0.5 t FYM ha^{-1} enriched with 1.5 kg Fe ha^{-1}, T_8 : RDF + 0.2 t vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1} and T_9 (RDF + 0.5 t FYM ha^{-1} enriched with 0.75 kg Zn ha^{-1} (Table 2). The lowest pod yield (2009 kg ha^{-1}) and haulm yield (3038 kg ha^{-1}) was obtained under treatment receiving RDF + 0.5 t FYM ha^{-1}. The increase in pod yield and haulm yield due to RDF + 0.2 t vermicompost ha^{-1} enriched with 0.75 kg Zn ha^{-1} was to the tune of 24.0 and 19.4 per cent over RDF + 0.2 t vermicompost ha^{-1}. The similar trend was found in case of enriched treatment of FYM. Remarkable response of Fe or Zn enriched organics (FYM or vermicompost) on pod and haulm yield in present study could be attributed to the fact that enrichment technique caused mobilization of the native nutrients to increase their availability, besides addition of Fe and Zn in naturally chelated form which are expected to become slowly available to growing crop over a longer time. This might helped to provide balance nutrition of Fe and Zn besides supplementing other essential elements and made available to the crop for longer time that causes better crop growth.

Table 1: Effect of Fe and Zn enriched organics on growth parameters and yield attributes of summer groundnut

Treatments	Plant population (Per net plot)	Plant height (cm) at harvest	Filled pods $plant^{-1}$	Total pods $plant^{-1}$	Pod weight (g $plant^{-1}$)	100-kernel weight (g)
T_1 : RDF + 0.5 t FYM ha^{-1}	154.38	42.41	18.33	22.07	10.63	36.54
T_2 : RDF + 0.2 t Vermicompost ha^{-1}	154.98	43.26	18.67	22.27	10.95	36.71
T_3 : RDF + 0.5 t FYM ha^{-1} + 3. 0 kg Fe ha^{-1}	155.96	43.33	19.33	22.60	11.67	37.58
T_4 : RDF + 0.2 t Vermicompost ha^{-1} + 3. 0 kg Fe ha^{-1}	157.22	43.78	20.07	23.47	11.95	38.60
T_5 : RDF + 0.5 t FYM ha^{-1} + 1.5 kg Zn ha^{-1}	155.43	42.49	19.20	22.80	11.71	38.89
T_6 : RDF + 0.2 t Vermicompost ha^{-1} + 1.5 kg Zn ha^{-1}	156.09	44.22	19.53	22.93	11.86	39.23
T_7 : RDF + 0.5 t FYM ha^{-1} enriched with 1.5 kg Fe ha^{-1}	157.71	44.75	22.73	26.13	14.41	40.85
T_8 : RDF + 0.2 t Vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1}	159.77	45.67	24.67	27.73	15.14	41.70
T_9 : RDF + 0.5 t FYM ha^{-1} enriched with 0.75 kg Zn ha^{-1}	157.48	44.91	22.73	26.00	14.75	40.74
T_{10} : RDF + 0.2 t Vermicompost ha^{-1} enriched with 0.75 kg Zn ha^{-1}	159.50	45.71	25.60	28.33	15.26	41.85
S.Em. ±	4.451	1.373	1.07	1.06	0.59	0.811
C.D. (P = 0.05)	NS	NS	3.19	3.14	1.77	2.41
C.V. %	4.92	5.40	8.82	7.49	8.03	3.58

The results are in accordance with those reported by Chitdeshwary and Duraisami (2005) [1] in sunflower, Meena *et al*. (2006) [6] in mustard crop, Yadav *et al*. (2011) [18] in wheat, Patel *et al.* (2016) [11] in cumin and Kumar and Salakinkop (2018) [4] in Maize.

Table 2: Effect of Fe and Zn enriched organics on yield and quality of summer groundnut

Treatments	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Protein content (%)	Oil content (%)
T_1: RDF + 0.5 t FYM ha^{-1}	2009	3038	21.27	45.09
T_2: RDF + 0.2 t Vermicompost ha^{-1}	2046	3052	21.35	45.42
T_3: RDF + 0.5 t FYM ha^{-1} + 3. 0 kg Fe ha^{-1}	2129	3154	21.90	45.58
T_4: RDF + 0.2 t Vermicompost ha^{-1} + 3. 0 kg Fe ha^{-1}	2163	3194	22.83	46.21
T_5: RDF + 0.5 t FYM ha^{-1} + 1.5 kg Zn ha^{-1}	2140	3198	22.06	45.14
T_6: RDF + 0.2 t Vermicompost ha^{-1} + 1.5 kg Zn ha^{-1}	2158	3230	23.21	46.35
T_7: RDF + 0.5 t FYM ha^{-1} enriched with 1.5 kg Fe ha^{-1}	2457	3526	23.52	46.39
T_8: RDF + 0.2 t Vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1}	2523	3627	23.63	47.28
T_9: RDF + 0.5 t FYM ha^{-1} enriched with 0.75 kg Zn ha^{-1}	2472	3563	23.08	46.18
T_{10}: RDF + 0.2 t Vermicompost ha^{-1} enriched with 0.75 kg Zn ha^{-1}	2537	3644	23.38	46.95
S.Em. ±	93.02	89.75	1.165	0.63
C.D. (P = 0.05)	276.37	266.68	NS	NS
C.V. %	7.12	4.68	8.92	2.35

Quality parameters

The data presented in Table 2 exhibited that the protein and oil content did not differed significantly due to different treatments. However, the highest protein and oil content were recorded under the treatment of RDF + 0.2 t vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1} (T_{10}). An application of RDF alongwith Fe or Zn enriched organics (FYM and vermicompost) treatments slightly increased the oil and protein content in kernel over rest of the treatments. The beneficial effect of Fe or Zn enriched organics (FYM and vermicompost) on protein and oil content in kernel as observed in present study could be attributed to the fact that application of Fe or Zn enriched organics (FYM and vermicompost) increase the availability of N and S in soil their by increased uptake of N and S by crop that resulted in increase oil and protein content in seed. The increased in oil and protein content have also been reported by Patel *et al.*, (2010) [9] in grain amaranth and Gurjar (2012) [2] in mustard crop, respectively.

Nutrient uptake

The data pertaining to total nitrogen, phosphorus, sulphur, iron and zinc uptake by groundnut crop as influenced by different treatments are given in Table 3. The significantly highest N uptake (116.93 kg ha^{-1}) and phosphorus uptake (18.21 kg ha^{-1}) by groundnut crop was obtained under treatment receiving RDF + 0.2 t vermicompost ha^{-1} enriched with 0.75 kg Zn ha-1treatment (T_{10}), but it was at par with T_7 : RDF + 0.5 t FYM ha^{-1} enriched with 1.5 kg Fe ha^{-1}, T8 :RDF + 0.2 t vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1} and T_9 : RDF + 0.5 t FYM ha^{-1} enriched with 0.75 kg Zn ha^{-1}. Among different treatments, the application of RDF + 0.5 t FYM ha-1 enriched with 0.75 kg Zn ha-1 (T_9) registered significantly the highest total sulphur uptake (15.39 kg ha^{-1}) by groundnut crop over rest of the treatments except T_7, T_8 and T_{10}.

In present investigation, the Fe or Zn enriched organics (FYM or vermicompost) might have favored the better utilization of all other nutrients besides supplementation of Fe and Zn. The higher uptake of these nutrients (N, P and S) might be the outcome of increases the pod yield and haulm yield of groundnut. The positive effect of Fe and Zn enriched FYM on N, P and S uptake has also been reported by Patel *et al.*, (2010) [9] in grain amaranth and Gurjar (2012) [2] in mustard crop.

Table 3: Effect of Fe and Zn enriched organics on total uptake of nutrients by summer groundnut

Treatments	Nutrient Uptake				
	N	P	S	Fe	Zn
	Kg/ha			g/ha	
T_1 : RDF + 0.5 t FYM ha^{-1}	86.63	13.73	10.56	2048	118.1
T_2 : RDF + 0.2 t Vermicompost ha^{-1}	90.44	14.57	11.24	2230	129.3
T_3 : RDF + 0.5 t FYM ha^{-1} + 3. 0 kg Fe ha^{-1}	92.54	15.21	12.90	3017	131.2
T_4 : RDF + 0.2 t Vermicompost ha^{-1} + 3. 0 kg Fe ha^{-1}	99.31	15.26	13.05	3091	129.6
T_5 : RDF + 0.5 t FYM ha^{-1} + 1.5 kg Zn ha^{-1}	96.27	15.31	13.19	2390	155.5
T_6 : RDF + 0.2 t Vermicompost ha^{-1} + 1.5 kg Zn ha^{-1}	101.35	15.40	13.34	2278	162.9
T_7 : RDF + 0.5 t FYM ha^{-1} enriched with 1.5 kg Fe ha^{-1}	112.52	17.59	14.64	3305	156.7
T_8 : RDF + 0.2 t Vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1}	116.56	18.13	14.51	3682	156.8
T_9 : RDF + 0.5 t FYM ha^{-1} enriched with 0.75 kg Zn ha^{-1}	111.89	18.00	15.39	2651	186.7
T_{10} : RDF + 0.2 t Vermicompost ha^{-1} enriched with 0.75 kg Zn ha^{-1}	116.93	18.21	15.14	2682	188.8
S.Em. ±	3.97	0.62	0.46	130.02	7.26
C.D. (P = 0.05)	11.81	1.86	1.38	386.31	21.57
C.V. %	6.72	6.73	6.02	8.23	8.30

The treatment receiving RDF + 0.2 t vermicompost/ha enriched with 1.5 kg Fe ha^{-1} (T_8) recorded significantly highest Fe uptake (3682 g ha^{-1}) by groundnut crop over rest of treatments except T_3, T_4 and T_7 (Table 3). The data further revealed that highest zinc uptake (188.8 g ha^{-1}) was obtained under the treatment of RDF + 0.2 t vermicompost ha^{-1} enriched with 0.75 kg Zn/ha treatment (T_{10}), but it was at par with T_9 : RDF + 0.5 t FYM ha^{-1} enriched with 0.75 kg Zn ha^{-1}. The Fe or Zn enriched organics (FYM and vermicompost) caused higher utilization of Fe or Zn mainly due to its beneficial effects in mobilizing the native nutrients to increase their availability besides addition of Fe or Zn to soil in naturally cheated form. The higher removal of Fe and Zn by groundnut crop also be attributed to the priming effect of externally added Fe or Zn to improve crop growth and yield hence higher content of the Fe and Zn in pod and haulm and also higher pod and haulm yields under Fe or Zn enriched organics (FYM and vermicompost) alongwith RDF application might have contributed towards higher uptake of Fe and Zn by groundnut. The enrichments of organics with Fe or Zn which regulates its supply to the crop by slowly releasing of the nutrients in to soil solution would have facilitated the higher nutrient uptake. The results are in accordance with those reported by Patel *et al.* (2016) [11] in cumin, Yadav *et al.* (2016) [18] in wheat and Meena *et al.* (2017) [7] in mungbean.

Effect on soil available nutrient

The data presented in Table 4 revealed that the available nitrogen, phosphorus, sulphur, iron and zinc content in soil after harvest of groundnut crop was influenced significantly by different treatments. The significantly higher available nitrogen content in soil (184.7 kg ha^{-1}) was recorded with application of RDF + 0.2 t vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1} over rest of treatments except treatment T_7, T_9 and T_{10}. An application of RDF + 0.2 t vermicompost ha-1 enriched with 0.75 kg Zn ha^{-1} (T_{10}) registered significantly higher available phosphorus content in soil (48.13 kg ha^{-1}) as compared to other treatments except T_7, T_8 and T_9. The increased in available N under Fe or Zn enriched (FYM or vermicompost) treatments was expected due to direct addition of N and P_2O_5 as well as indirect effects resulting from the better decomposition of organic matter which causes the mineralization of organically bound nitrogen and thereby improvement in available status. The results are in agreement with those reported by Gurjar (2012) [2].

The significantly higher S (12.75 mg kg^{-1}) content in soil after harvest of crop was noticed with application of RDF + 0.2 t vermicompost ha^{-1} + 3. 0 kg Fe ha^{-1} (T_4) and it was statistically at par with all treatments except T_1 and T_2 treatments (Table 4). The significant improvement in available sulphur status of soil in all treatments which are received Fe and Zn in the form of $FeSO_4$ and $ZnSO_4$, respectively. This might be due to beneficial effect of organics on available S content in soil and S addition from $FeSO_4$ and $ZnSO_4$ to the soil. The results are in accordance with those reported by Gurjar (2012) [2].

The significantly higher Fe (4.28 mg kg^{-1}) content in soil after harvest of groundnut crop was estimated under the treatment receiving RDF + 0.2 t vermicompost ha^{-1} + 3. 0 kg Fe ha^{-1} (T_4) and it was significantly superior to rest of the treatments except T_3, T_7 and T_8 treatments. The overall increase in available Fe content in soil after harvest of groundnut crop under Fe application treatments was due to its addition to the soil either as inorganic source or through its enrichment with FYM or vermicompost. Similar observations were also made by Meena *et al.*, (2006) [6], Yadav *et al.*, (2011) [18] and Patel *et al.*, (2016) [11].

Table 4: Effect of Fe and Zn enriched organics on available nutrients in soil after harvest of summer groundnut

Treatments	Available Nutrients				
	N	P_2O_5	S	Fe	Zn
	(kg ha^{-1})		(mg kg^{-1})		
T_1 : RDF + 0.5 t FYM ha^{-1}	172.8	40.50	10.29	3.74	0.40
T_2 : RDF + 0.2 t Vermicompost ha^{-1}	174.1	42.35	10.42	3.78	0.42
T_3 : RDF + 0.5 t FYM ha^{-1} + 3. 0 kg Fe ha^{-1}	173.9	41.47	12.54	4.22	0.43
T_4 : RDF + 0.2 t Vermicompost ha^{-1} + 3. 0 kg Fe ha^{-1}	174.2	43.16	12.75	4.28	0.40
T_5 : RDF + 0.5 t FYM ha^{-1} + 1.5 kg Zn ha^{-1}	173.4	41.88	11.83	3.63	0.47
T_6 : RDF + 0.2 t Vermicompost ha^{-1} + 1.5 kg Zn ha^{-1}	174.0	43.37	12.01	3.81	0.49
T_7 : RDF + 0.5 t FYM ha^{-1} enriched with 1.5 kg Fe ha^{-1}	182.0	47.30	12.12	4.11	0.42
T_8 : RDF + 0.2 t Vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1}	184.7	47.78	12.27	4.13	0.43
T_9 : RDF + 0.5 t FYM ha^{-1} enriched with 0.75 kg Zn ha^{-1}	182.1	47.16	11.82	3.80	0.46
T_{10} : RDF + 0.2 t Vermicompost ha^{-1} enriched with 0.75 kg Zn ha^{-1}	184.4	48.13	12.47	3.78	0.47
S.Em. ±	2.46	1.22	0.33	0.09	0.01
C.D. (P = 0.05)	7.31	3.63	0.97	0.26	0.03
C.V. %	2.40	4.77	4.74	3.81	3.34

The significant higher buildup of available Zn content (0.49 mg kg^{-1}) in soil after harvest of groundnut crop was recorded with the application of RDF + 0.2 t vermicompost ha^{-1} + 1.5 kg Zn ha^{-1} (T_6) over rest of the treatments except T_5, T_9 and T_{10} treatments. This clearly shows that the available Zn status of soil was almost similar either its straight application as inorganic source with and without enrichment of FYM and vermicompost. The positive influence of Zn enriched organics on soil DTPA Zn has also been reported by Yadav *et al.* (2011) [18], Rathod *et al.* (2012) [14] and Patel *et al.* (2016) [11].

Conclusion

Based on the results of present study, it is concluded that iron and Zinc application in enriched form of FYM or vermicompost was beneficial in increasing the crop yield. An application of 0.2 t vermicompost/ha enriched with 0.75 kg Zn ha^{-1} along with RDF (25 kg N + 50 kg P_2O_5 ha^{-1}) to summer groundnut crop gave highest pod yield (2537 kg ha^{-1}) and haulm yield (3644 kg ha^{-1}) of summer groundnut. The practices of iron and zinc application through enrichment techniques also improved the available nutrients status in soil.

References

1. Chitdeshwari T, Duraisami VP. Impact of organic enriched micronutrient fertilization on sunflower yield, nutrient availability and uptake. Crop Research. 2005; 29(3):431-435.
2. Gurjar GL. Effect of iron and zinc enriched FYM on yield and quality of mustard (*Brassica juncea* Czern. and Coss.) in loamy sand. M.Sc. (Agri.) Thesis. Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, 2012.
3. Jackson ML. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, 1973, 183-192.
4. Kumar N, Salakinkop SR. Agronomic biofortification of maize with zinc and iron micronutrients. Modern Concepts and Development in Agronomy. 2018; 1(5):1-4. MCDA.000522. 2018.
5. Lindsay WL, Norvell WA. Development of a DTPA soil test for Zn, Fe, Mn, and Cu. Soil Science Society of America Journal. 1978; 42:421-428.
6. Meena MC, Patel KP, Rathod DD. Effect of zinc, iron and sulphur on mustard in loamy sand soil. Indian Fertilizer. 2006; 2(5):55-58.
7. Meena NR, Meena MK, Sahrma KK, Meena MD. Effect of zinc enriched farm yard manures on yield of mungbean and physico-chemical properties of soil. Legume Research. 2017. Print ISSN: 0250-5371/Online ISSN: 0976-0571.
8. Olsen SR, Cole CV, Watande FS, Dean LA. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. U. S. Department of Agriculture, Circular, 1954, 939.
9. Patel BT, Patel JJ, Patel AM, Patel MM, Patel JM. Effect of zinc enriched FYM on yield, content and uptake of Zn and quality of grain amaranth (*Amaranthus hypochondriacus* L.) grown in loamy sand (*Typic ustipsamments*) soils. GAU Research Journal. 2010; 35(1):18-22.
10. Patel BT, Patel JJ, Patel MM. Response of groundnut *Arachis hypogaea* L.) To FYM, sulphur and micronutrients and their residual effect on wheat (*Triticum aestivum*). Journal of Soils and Crops. 2007; 17(1):18-23.
11. Patel SM, Amin AU, Patel BT. Yield and quality of cumin as influenced by FYM enriched micronutrients. International Journal of Seed Spices. 2016; 6(1):17-24.
12. Prasad B. Conjoint use of fertilizers with organics, crop residues and green manuring for their efficient use in sustainable crop production. Fertilizer News. 1999; 44:67-73.

13. Rahevar HD, Patel PP, Patel BT, Josh SK, Vaghela SJ. Effect of FYM, iron and zinc on growth and yield of summer groundnut (*Arachis hypogaea*) under North Gujarat Agro-climatic conditions. Indian Journal of Agricultural Research. 2015; 49(3):294-296.
14. Rathod DD, Meena MC, Patel KP. Evaluation of different zinc enriched organics as source of zinc under wheat-maize cropping sequences on zinc-deficient *Typic haplustepts*. Indian Journal of Soil Science. 2012; 60(1):50-55.
15. Subbiah BV, Asija GL. A rapid processor for the estimation of available nitrogen in soils. Current Science. 1956; 25:259-260.
16. Tiwari PN, Gambhir PN, Rajan TS. Rapid and non destructive determination of seed oil by pulsed nuclear magnetic resonance technique. Journal of the American Oil Chemists Society. 1974; 51(3):104-109.
17. Williams CH, Steinberg A. Soil sulphur fractions as chemical indices of available sulphur in some Australian soils. Australian Journal of Agricultural Research. 1959; 10:340-352.
18. Yadav RS, Patel AM, Dodia IN, Agalodia AV, Patel GA, Augustine N. Agronomic Biofortification of wheat (*Triticum aestivum* L.) through iron and zinc enriched organics. Journal of Wheat Research. 2011; 3(1):46-51.