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Effect of iron and zinc enriched organics (FYM and Vermicompost) on quality and yield of *kharif* greengram (*Vigna radiata* L.) in loamy sand

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Abstract
An experiment was conducted to study the "Effect of iron and zinc enriched organics (FYM and Vermicompost) on quality and yield of *kharif* greengram (*Vigna radiata* L.) in loamy sand." at C. P. College of Agriculture, SDAU, Sardarkrushinagar during *kharif*, 2018. 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 1.5 kg Fe ha^{-1} produced significantly higher numbers of pods per plant (17.80), number of seeds per pod (7.99), 100-seed weight (4.83 g), seed yield (734 kg/ha) and stover yield (1431 kg/ha), but it was remained at par with all Fe or Zn enriched organics treatments. The total uptake of N, P and S in seed and stover by greengram 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 by greengram, while the uptake of Zn in seed and stover by greengram crop was significantly higher under RDF + 0.2 t vermicompost/ha enriched with 0.75 kg Zn/ha. The available 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, greengram

Introduction
Greengram (*Vigna radiata* L.) is one of the important *kharif* pulse crop. It ranks third among all pulses grown in India after chickpea & pigeonpea. It is short duration pulse crop which contains 25 percent protein of high digestibility and has appreciable amount of riboflavin and thiamine. The root nodule of moongbean contain aerobic bacteria rhizobia which fix atmospheric nitrogen in the root. It is also used as green manure crop which improves physical condition and fertility of soil.
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 [1, 4, 5] PG Scholar [2], Associate Research Scientist, Bio Science Research Center and [3] Associate Research Scientist, Livestock Research Station 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.

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 *kharif* 2018 to study the effect of iron and zinc enriched organics (FYM and Vermicompost) on quality and yield of *kharif* greengram. 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 0.26 per cent, respectively. The fertility status of the experimental field was found to be low in available nitrogen (160.62 kg ha^{-1}), medium in available phosphorus (37.40 kg ha^{-1}) and available potassium (245.30 kg ha^{-1}). The available iron and zinc status of the soil were 3.22 mg kg^{-1} and 0.42 mg kg^{-1} which is below their critical level. Total ten treatments *viz.*, $T_{1:}$ RDF (20 kg N + 40 kg P_2O_5 ha^{-1}) + 1.0 t FYM ha^{-1}, $T_{2:}$ RDF + 0.5 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.

Greengram (Guj. Moong 4) was sowed at a depth of 4-6 cm keeping inter row spacing of 45 cm and plant to plant spacing of 10 cm using recommended seed rate of 20 kg ha^{-1} and fertilizers were applied @ 20 kg N and 40 kg P_2O_5 ha^{-1}.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 45 days before their use in *kharif* season experiment on greengarm. 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 and branches per plant), yield attributing characters (pod length, number of pods per plant, number of seeds per pod and 100-seed weight) as well as seed and stover yield of greengram were recorded. Protein content in seed was computed by the multiplying the N percentage with 6.25 for each treatment. Seed and stover samples were collected at the harvest of greengram for determination uptake of N, P, S, 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 1973) [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 uptake of nutrients were calculated by multiplying dry weight of seed and stover with their respective content. Representative soil samples (0-15 cm depth) were collected to know the nutrient status of soil after harvest of greengram crop. The samples were air dried, ground and passed through 2 mm sieve and were analyzed for organic carbon by Walkley and Black titration method (Jackson 1973) [3], 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) [9] 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) [17].

Results and Discussion

Effect on growth parameters

The plant population per metre row length 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 (12.63) per metre row length. The non significant results indicated that at initial stage there was no effect of different treatments on germination of greengram seed as well as on survival of plants. The highest plant height (47.9 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 Yadav *et al.* (2011) [18] in wheat and Patel *et al.* (2016) [11] in cumin. The higher branches/plant (7.97) 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 branches/plant might be due to the increased supply of almost all plant essential nutrients which improved the overall growth and development of plant. These results are in accordance with those reported by Patel *et al.* (2016) [11] in cumin and Meena *et al.* (2017) [8] in mungbean.

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 1.5 kg Fe ha^{-1} (T_8) produced significantly higher numbers of pods per plant (17.80), number of seeds per pod (7.99) and 100-seed weight (4.83 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 results further revealed that irrespective of organic sources, application of Fe or Zn enriched organics increased both number of pods per plant and number of seeds per pod 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 Meena *et al.* (2017) [8] in mungbean and Kumar and Salakinkop (2018) [5] in maize. The increase in the 100-seed 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 (seed). The results are in accordance with those reported by Yadav *et al.* (2011) [18] in wheat and Meena *et al.* (2017) [8] in mungbean.

Seed yield and stover yield

Significantly higher seed yield (734 kg ha^{-1}) and stover yield (1431 kg ha^{-1}) of greengram was produced under the treatment $T_{8:}$ RDF +0.2 t vermicompost ha^{-1} enriched with 1.5 kg Fe 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_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 Zn ha^{-1} (Table 2). The lowest seed yield (537 kg ha^{-1}) and stover yield (1030 kg ha^{-1}) was obtained under treatment receiving RDF + 1.0 t FYM ha^{-1}. The increase in seed yield and stover yield due to RDF + 0.2 t vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1} was to the tune of 33.51 and 35.77 per cent over RDF + 0.5 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 seed and stover 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 *kharif* greengram

Treatments	Plant population (per meter row length)	Plant height (cm) at harvest	Branches plant^{-1}	Number of pods plant^{-1}	Number of seeds pod^{-1}	100-seed weight (g)
$T_{1:}$ RDF + 1.0 t FYM ha^{-1}	10.22	40.4	5.97	12.62	6.63	3.61
$T_{2:}$ RDF + 0.5 t Vermicompost ha^{-1}	10.46	40.9	6.10	12.72	6.96	3.74
$T_{3:}$ RDF + 0.5 t FYM ha^{-1} + 3. 0 kg Fe ha^{-1}	10.95	41.0	6.43	14.28	7.12	4.01
$T_{4:}$ RDF + 0.2 t Vermicompost ha^{-1} + 3. 0 kg Fe ha^{-1}	11.35	41.3	6.57	14.58	7.21	4.14
$T_{5:}$ RDF + 0.5 t FYM ha^{-1} + 1.5 kg Zn ha^{-1}	10.61	41.2	6.33	13.48	7.04	4.00
$T_{6:}$ RDF + 0.2 t Vermicompost ha^{-1} + 1.5 kg Zn ha^{-1}	11.25	41.3	6.63	14.31	7.23	4.35
$T_{7:}$ RDF + 0.5 t FYM ha^{-1} enriched with 1.5 kg Fe ha^{-1}	12.13	46.7	7.67	16.79	7.85	4.68
$T_{8:}$ RDF + 0.2 t Vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1}	12.63	47.8	7.80	17.80	7.99	4.83
$T_{9:}$ RDF + 0.5 t FYM ha^{-1} enriched with 0.75 kg Zn ha^{-1}	11.94	46.2	7.60	16.75	7.91	4.63
$T_{10:}$ RDF + 0.2 t Vermicompost ha^{-1} enriched with 0.75 kg Zn ha^{-1}	12.33	47.9	7.97	17.72	7.97	4.73
S.Em. ±	0.56	1.52	0.30	0.66	0.19	0.11
C.D. (P = 0.05)	NS	4.5	0.90	1.97	0.57	0.32
C.V. %	8.50	6.07	7.58	7.60	4.46	4.31

The results are in accordance with those reported by Chitdeshwari and Duraisami (2005) [1] in sunflower, Patel *et al.* (2016) [11] in cumin, Meena *et al.* (2017) [8] in mungbean and Kumar and Salakinkop (2018) [5] in maize.

Table 2: Effect of Fe and Zn enriched organics on yield and quality of *kharif* greengram

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Protein content (%)
$T_{1:}$ RDF + 1.0 t FYM ha^{-1}	537	1030	19.63
$T_{2:}$ RDF + 0.5 t Vermicompost ha^{-1}	546	1054	19.79
$T_{3:}$ RDF + 0.5 t FYM ha^{-1} + 3. 0 kg Fe ha^{-1}	595	1197	20.25
$T_{4:}$ RDF + 0.2 t Vermicompost ha^{-1} + 3. 0 kg Fe ha^{-1}	608	1284	20.38
$T_{5:}$ RDF + 0.5 t FYM ha^{-1} + 1.5 kg Zn ha^{-1}	602	1201	20.29
$T_{6:}$ RDF + 0.2 t Vermicompost ha^{-1} + 1.5 kg Zn ha^{-1}	610	1273	20.35
$T_{7:}$ RDF + 0.5 t FYM ha^{-1} enriched with 1.5 kg Fe ha^{-1}	717	1387	21.75
$T_{8:}$ RDF + 0.2 t Vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1}	734	1431	21.90
$T_{9:}$ RDF + 0.5 t FYM ha^{-1} enriched with 0.75 kg Zn ha^{-1}	709	1391	21.71
$T_{10:}$ RDF + 0.2 t Vermicompost ha^{-1} enriched with 0.75 kg Zn ha^{-1}	732	1417	21.85
S.Em. ±	22.42	33.84	0.43
C.D. (P = 0.05)	67	101	1.27
C.V. %	6.08	4.63	3.55

Quality parameters

The data presented in Table 2 exhibited that the highest protein content in seed (21.90%) was recorded under the treatment of RDF + 0.2 t vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1} (T_8) over all other treatments. An application of RDF along with Fe or Zn enriched organics (FYM and vermicompost) treatments increased protein content in seed over rest of the treatments. The beneficial effect of Fe or Zn enriched organics (FYM and vermicompost) on protein content in seed 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 in soil and their by increased N content in seed that resulted in increase protein content in seed as N is basic constituent of amino acid which are building block molecules of proteins. The increased in protein content have also been reported by Patel *et al.* (2010) [10] in grain amaranth and Gurjar (2012) [2] in mustard crop.

Nutrient uptake

The data pertaining to nitrogen, phosphorus, sulphur, iron and zinc uptake by seed and stover of greengram crop as influenced by different treatments are given in Table 3. The significantly highest N uptake by seed (25.77 kg ha^{-1}) and stover (11.60 kg ha^{-1}) and highest phosphorus uptake by seed (4.29 kg ha^{-1}) and stover (2.56 kg ha^{-1}) were obtained under treatment receiving RDF + 0.2 t vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1} treatment (T_8), but it was at par with T_7: RDF + 0.5 t FYM 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 Zn ha^{-1}. Among different treatments, the application of RDF + 0.2 t vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1} (T_8) registered significantly the highest sulphur uptake by seed (1.49 kg ha^{-1}) and stover (1.34 kg ha^{-1}) by greengram crop over rest of the treatments except T_7, T_9 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 increase the seed yield and stover yield of greengram. The positive effect of Fe and Zn enriched FYM or vermicompost on N, P and S uptake has also been reported by Premkumar *et al.* (2002) [13] in cowpea and Kuniya (2014) [6] in clusterbean.

The treatment receiving RDF + 0.2 t vermicompost/ha enriched with 1.5 kg Fe ha^{-1} (T_8) recorded significantly highest Fe uptake by seed (92.91 g ha^{-1}) and stover (156.4 g ha^{-1}) by greengram crop over rest of treatments (Table 3). The data further revealed that highest zinc uptake by seed (11.50 g ha^{-1}) and stover (12.67 g ha^{-1}) were obtained under the treatment of RDF + 0.2 t vermicompost ha^{-1} enriched with 0.75 kg Zn ha^{-1} 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 greengram 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 seed and stover and also higher seed and stover yields under Fe or Zn enriched organics (FYM and vermicompost) along with RDF application might have contributed towards higher uptake of Fe and Zn by greengram. 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 wouldhave facilitated the higher nutrient uptake. The results are in accordance with those reported by Patel *et al.* (2016) [11] in cumin, Yadav *et al.* (2011) [18] in wheat and Meena *et al.* (2017) [8] in mungbean.

Table 3: Effect of Fe and Zn enriched organics on uptake of nutrients by *kharif* greengram

Treatments	N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		S uptake (kg ha^{-1})		Fe uptake (g ha^{-1})		Zn uptake (g ha^{-1})	
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
T_1: RDF + 1.0 t FYM ha^{-1}	16.85	7.82	2.76	1.67	0.98	0.88	61.95	105.2	6.92	7.54
T_2: RDF + 0.5 t Vermicompost ha^{-1}	17.27	8.05	2.80	1.71	0.99	0.91	63.36	108.0	7.44	7.87
T_3: RDF + 0.5 t FYM ha^{-1} + 3.0 kg Fe ha^{-1}	19.27	9.13	3.22	1.99	1.22	1.16	74.68	131.0	8.09	9.20
T_4: RDF + 0.2 t Vermicompost ha^{-1} + 3.0 kg Fe ha^{-1}	19.82	9.78	3.35	2.17	1.26	1.24	77.42	142.3	8.33	10.14
T_5: RDF + 0.5 t FYM ha^{-1} + 1.5 kg Zn ha^{-1}	19.59	9.11	3.15	1.96	1.20	1.12	70.35	124.6	9.02	10.21
T_6: RDF + 0.2 t Vermicompost ha^{-1} + 1.5 kg Zn ha^{-1}	19.89	9.75	3.32	2.14	1.20	1.21	72.15	133.4	9.46	10.92
T_7: RDF + 0.5 t FYM ha^{-1} enriched with 1.5 kg Fe ha^{-1}	24.94	11.16	4.05	2.43	1.42	1.27	89.44	151.0	9.60	10.73
T_8: RDF + 0.2 t Vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1}	25.77	11.60	4.29	2.56	1.49	1.34	92.91	156.4	9.95	11.41
T_9: RDF + 0.5 t FYM ha^{-1} enriched with 0.75 kg Zn ha^{-1}	24.58	11.23	3.95	2.40	1.41	1.28	83.28	145.2	10.80	12.07
T_{10}: RDF + 0.2 t Vermicompost ha^{-1} enriched with 0.75 kg Zn ha^{-1}	25.62	11.57	4.18	2.51	1.45	1.30	86.64	146.8	11.50	12.67
S.Em.±	0.81	0.27	0.18	0.08	0.05	0.03	2.89	4.10	0.35	0.42
C.D. (P = 0.05)	2.41	0.81	0.52	0.24	0.16	0.10	8.58	12.2	1.03	1.26
C.V. (%)	6.56	4.77	8.69	6.40	7.30	4.94	6.48	5.27	6.57	7.13

Nutrient status of soil after harvest

The data presented in Table 4 revealed that the organic carbon, available phosphorus, sulphur, iron and zinc content in soil after harvest of groundnut crop was influenced significantly by different treatments. The significantly higher organic carbon content in soil (0.347%) was recorded with application of RDF + 0.5 t vermicompost ha^{-1} over rest of treatments except treatment T_1, T_8 and T_{10}. Application of higher dose of organics or enriched organics significantly improved organic carbon status over treatment receiving non enriched organics observed in present study could be due to fact that addition of organics (FYM or Vermicompost) increased organic matter to the soil which in turn increases organic carbon content in soil. The results are in agreement with those reported by Rajkhowa *et al.* (2003) [14] in mungbean, Gurjar (2012) [2] in mustard and Kanwar *et al.* (2017) [4] in cowpea.

Application of RDF + 0.2 t vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1} (T_8) registered significantly higher available phosphorus content in soil (46.63 kg ha^{-1}) as compared to other treatments except T_7, T_9 and T_{10}. Supplementation of either Fe or Zn after enrichment with FYM or vermicompost in conjunction with RDF (T_7, T_8, T_9 and T_{10}) significantly improved availability of P_2O_5 in soil over rest of the treatments. It might be due to better mineralization of organic P under the influence of organic acids. The production of organic acids which have a solubilizing effect on soil P and organic anions retards the fixation of P in soil that in turn enhances the P_2O_5 availability. Similar findings have been reported by Gurjar (2012) [2] in mustard crop.

The significantly higher S (16.96 mg kg^{-1}) content in soil after harvest of crop was noticed with application of RDF + 0.2 t vermicompost ha^{-1} enriched with 0.75 kg Zn ha^{-1}(T_8) 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] in mustard and Sharma *et al.* (2013) [15] in fenugreek.

The significantly higher Fe (4.24 mg kg^{-1}) content in soil after harvest of greengram 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 greengram 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 Yadav *et al*. (2011) [18] in wheat and Patel *et al*. (2016) [11] in cumin.

The significant higher buildup of available Zn content (0.49 mg kg^{-1}) in soil after harvest of greengram 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 available Zn has also been reported by Patel *et al.* (2010) [10] in grain amaranth Yadav *et al*. (2011) [18] in wheat and Patel *et al*. (2016) [11] in cumin.

Table 4: Effect of Fe and Zn enriched organics on nutrient status of soil after harvest of *kharif* greengram

Treatments	Organic carbon (%)	Available nutrients			
		P_2O_5 (kg ha^{-1})	S (mg kg^{-1})	Fe (mg kg^{-1})	Zn (mg kg^{-1})
T_1: RDF + 1.0 t FYM ha^{-1}	0.333	41.76	13.67	3.44	0.40
T_2: RDF + 0.5 t Vermicompost ha^{-1}	0.347	42.34	13.82	3.61	0.42
T_3: RDF + 0.5 t FYM ha^{-1} + 3.0 kg Fe ha^{-1}	0.283	41.95	16.12	4.19	0.41
T_4: RDF + 0.2 t Vermicompost ha^{-1} + 3.0 kg Fe ha^{-1}	0.290	42.39	16.39	4.24	0.42
T_5: RDF + 0.5 t FYM ha^{-1} + 1.5 kg Zn ha^{-1}	0.280	41.63	15.83	3.67	0.47
T_6: RDF + 0.2 t Vermicompost ha^{-1} + 1.5 kg Zn ha^{-1}	0.283	41.77	16.16	3.69	0.49
T_7: RDF + 0.5 t FYM ha^{-1} enriched with 1.5 kg Fe ha^{-1}	0.317	45.62	16.67	4.12	0.42
T_8: RDF + 0.2 t Vermicompost ha^{-1} enriched with 1.5 kg Fe ha^{-1}	0.333	46.63	16.83	4.11	0.42
T_9: RDF + 0.5 t FYM ha^{-1} enriched with 0.75 kg Zn ha^{-1}	0.313	45.94	16.81	3.76	0.46
T_{10}: RDF + 0.2 t Vermicompost ha^{-1} enriched with 0.75 kg Zn ha^{-1}	0.327	46.22	16.96	3.65	0.47
S.Em.±	0.008	1.05	0.51	0.11	0.01
C.D. (P = 0.05)	0.024	3.11	1.52	0.33	0.03
C.V. (%)	4.54	4.16	5.55	5.05	3.61
Initial	0.26	37.40	11.52	3.22	0.42

Conclusion

Based on the results of present study, it is concluded that the application of either 0.2 t vermicompost/ha or 0.5 t FYM/ha enriched with 1.5 kg Fe/ha or 0.75 kg Zn/ha along with RDF (20 kg N + 40 kg P_2O_5/ha) to *kharif* greengram gave higher yield and improved the fertility status of soil.

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