Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.7686

ISSN: 2582 – 2845

Ind. J. Pure App. Biosci. (2019) *7*(4), 152-159

Research Article

Indian Journal of Pure & Applied Biosciences

Long Term Effect of Integrated Nutrient Management on Soil Micronutrient Status in Finger Millet Mono-Cropping System

Prashanth, D. V.[1*], R. Krishnamurthy[1], D. V. Naveen[2], Mudalagiriyappa[3] and B. Boraiah[4]

[1]Department of Soil Science and Agricultural Chemistry, College of Agriculture, GKVK, UAS, Bengaluru

[2]Department of soil science and Agricultural Chemistry, College of Sericulture, Chintamani

[3]Professor and Chief Scientist, AICRPDA, GKVK, UAS, Bengaluru

[4]Senor Farm Superintendent, ZARS, GKVK, UAS, Bengaluru

*Corresponding Author E-mail: prashanthmay10@gmail.com

Received: 4.07.2019 | Revised: 11.08.2019 | Accepted: 17.08.2019

ABSTRACT

Soil micronutrients were studied on Alfisols with a 40-years old experiment at All India Co-ordinated Research Project for Dry land Agriculture (AICRPDA), Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bengaluru, during kharif 2018. Results indicated that continuous application of chemical fertilizers and manures increased the micronutrient availability in soil and uptake by finger millet. Application of FYM @ 10 t ha^{-1} + 100% RDF over a period of 40 years significantly increased the micronutrient content in soil and uptake by finger millet as against 100% NPK treatment and control.

Keywords: *Inorganic and organic fertilizers, Soil micronutrient, Uptake, Nutrient content.*

INTRODUCTION

Micronutrients are essential for the growth of plants and animals. Micronutrient deficiencies in soil not only limit the crop production but also have negative effects on human nutrition and health (Govindaraj et al., 2011). Similarly, excessive agro-ecosystem inputs of micronutrients such as iron (Fe), manganese (Mn), copper (Cu), and zinc (Zn), which are heavy metals, can possibly lead to toxicity in plants and animals and consequently pose a threat to human health through the food chain (Westfall et al., 2005, Soriano-Disla et al., 2010). Micronutrient does not mean that they are less important to plants than other nutrients. Each essential element only when can perform its role in plant nutrition properly that other necessary elements are available in balanced ratios for plant. Plant growth and development may be retarded if any of these elements is lacking in the soil or is not adequately balanced with other nutrients. Inorganic micronutrients occur naturally in soil minerals. The availability of micronutrients in a given soil can also be strongly affected by fertilization practices.

Cite this article: Prashanth, D.V., Krishnamurthy, R., Naveen, D.V., Mudalagiriyappa, & Boraiah, B. (2019). Long Term Effect of Integrated Nutrient Management on Soil Micronutrient Status in Finger Millet Mono-Cropping System, *Ind. J. Pure App. Biosci.* *7*(4), 152-159. doi: http://dx.doi.org/10.18782/2320-7051.7686

However, Wei et al. (2006) found that available Zn and Fe were greater under treatments with nitrogen, phosphorus, and potassium (NPK) (at various rates) and organic fertilizer than under control treatments, while available copper (Cu) was not significantly influenced by fertilization under a monoculture system on calcareous soil in the Loess Plateau. Gao et al. (2000) found that manure is a better source of available Fe, Mn, and Zn than synthetic fertilizers, but manure applications accelerated the depletion of available Cu on a purple paddy soil in south western China after 9 years of fertilization. In contrast, in northern Italy, high liquid manure inputs reportedly increase risks of copper contamination on silty clay loam soils (Mantovi1 et al., 2003). Therefore, the study presented here evaluated effects of long-term applications of crop residue incorporation and organic manure on available micronutrients (Fe, Mn, Cu, and Zn) and uptake by micronutrients by finger millet were studied.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* 2018 at All India Co-ordinated Research Project for Dry land Agriculture (AICRPDA), Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bengaluru on an ongoing long term (40 years) experimental trail. The soil of the experimental site at Dry-land Agriculture Project is sandy clay loam in texture belongs to Vijayapura soil series. This is classified as fine, *kaolinitic*, *isohyperthermic*, *Typic Kandiustalf* as per USDA classification. The soil was sandy clay loam in texture, with a bulk density of 1.64 Mg m^{-3} and slightly acidic in reaction (pH of 5.00) with a electrical conductivity of 0.20 d Sm^{-1}, low in organic carbon content (0.40 %) and low in available N (200.00 kg ha^{-1}), low in available P_2O_5 (8.70 kg ha^{-1}) and low in available K_2O (132.80 kg ha^{-1}). The experiment consisted of 8 treatments which were arranged in a randomized block design with three replications general information of experiment is presented in Table 1 and treatment details were presented in Table 2. Soil available micronutrients were extracted by shaking the soil with 0.005 M DTPA (Diethylene –triamine penta acetic acid) solution and micronutrients in extract were estimated by atomic absorption spectrophotometer (Lindsay et al., 1978).

RESULTS AND DISCUSSION

Effect of long-term integrated nutrient management on micronutrient nutrient status of soil

The trend of available micronutrients like iron, zinc, copper and manganese in the soil remains same after the harvest of finger millet (Table 3). It is observed that the available status was low in imbalanced fertilizer compared to the balanced fertilizer and FYM applied plots.

Available zinc

The treatment T_5 (FYM @ 10 t ha^{-1} + 100% RDF) recorded available Zn of 1.35 and 1.38 mg kg^{-1} (before sowing and at harvest, respectively). Treatment T_4 (FYM @ 10 t ha^{-1} + 50% RDF) was on par with the treatments T_5 with values of 1.20 and 1.23 mg kg^{-1} (before sowing and at harvest,). The lowest zinc content of 0.43 and 0.45 mg kg^{-1} (before sowing and at harvest, respectively) was recorded in T_1, which was an absolute control. Rajinder & Mandeep (2007) reported statistical significant increase in DTPA extractable zinc content in organic manure treated plots over no manure which revealed the fact that buildup of organic matter under continuous manuring possibly resulted in higher DTPA extractable Zn content. Increase in Zn content in FYM treated plots may be attributed to the slow release of Zn from FYM after mineralization and its chelating effect, which maintains regular supply of Zn (Gupta et al., 2000). Kher & Minhas (1993) also reported that the total Zn content of soil increased with addition of FYM upon mineralization, which led to release of organic form of Zn present in FYM. The treatments receiving super optimal and optimal dose NPK fertilizers recorded higher Zn content over treatments receiving lower imbalanced dose of inorganic fertilizers.

Available iron

Among the long term fertilizer treatments, the treatment T_5 (FYM @ 10 t ha^{-1} + 100% RDF) numerically higher iron content of 18.43 and 19.46 mg kg^{-1} (before sowing and at harvest, respectively) and it was on par with the treatments T_4 (FYM @ 10 t ha^{-1} + 50% RDF) 17.20 mg kg^{-1} and 18.09 mg kg^{-1} (before sowing and at harvest, respectively). The lowest Iron content 7.83 mg kg^{-1} and 7.63 mg kg^{-1} (before sowing and at harvest,) was recorded in T_1, (absolute control). Under long-term fertilizer application the available iron content increased even though land was continuously cropped, indicated that considerable quantity of iron being added to the soil every year through application of fertilizer or due to increase the H^+ activity on fertilizer application (Anand & Ghosh, 1980, Sarkar, 1990). The available iron was significantly decreased in FYM applied plots compared to other treatments. This might be due to formation of insoluble hydroxides of iron at soil pH of near neutrality (Kavalappa, 1989). Chaudhary & Narwal (2005) reported that application of FYM significantly increased the DTPA extractable Fe at 0 to 15, 15 to 30 and 30 to 45 cm soil depths and among different depths surface layer (0 to 15 cm) recorded higher iron content.

Available copper

Numerically highest copper content1.09 mg kg^{-1} and 1.12 mg kg^{-1} (before sowing and at harvest,) was observed in the treatment T_5 (FYM @ 10 t ha^{-1} + 100% RDF) and T_4 (FYM @ 10 t ha^{-1} + 50% RDF) 0.98 mg kg^{-1} and 1.00 mg kg^{-1} (before sowing and at harvest, respectively) was on par with T_5. The lowest copper content of 0.20 and 0.22 mg kg^{-1} (before sowing and at harvest, respectively) was recorded in T_1, (absolute control). The treatments recorded the higher available copper in the soil, could be attributed to the application of sulphur free fertilizer DAP over the years which might have encouraged build up of DTPA available copper by lowering soil pH. The result revealed that decrease in available copper was influenced by cropping, fertilizer levels and their interaction effect.

Available manganese

The treatment T_5 (FYM @ 10 t ha^{-1} + 100% RDF) recorded highest manganese content of 18.50 and 18.53 mg kg^{-1} (before sowing and at harvest, respectively) in soil and it was on par with the treatments T_4 (FYM @ 10 t ha^{-1} + 50% RDF) 17.39 and 17.39 mg kg^{-1} (before sowing and at harvest, respectively). The lowest manganese content of 5.48 and 5.53 mg kg^{-1} (before sowing and at harvest, respectively) was recorded in T_1, (absolute control). The DTPA-extractable Mn declined from their respective initial values as a result of continuous cropping and fertilizer application in control and also with imbalanced fertilization. These findings are in agreement with the results obtained by Nambiar (1994). This is ascribed to the continuous uptake by the crops over the years in addition to their non-replenishment in the form of fertilizers (Kumar et al., 2009). The increased availability of micronutrients in soil may be due to application of manures, which could be ascribed to mineralization of the manure and complexing properties of these manures with micronutrients. These results are in accord with the findings of Chaitanya Devi et al. (2003). Chaudhary & Narwa, (2005) reported that application of FYM significantly increased the DTPA extractable Zn, Mn, Fe and Cu. Swarup, (1984) reported that the incorporation of organic manures brought about a remarkable improvement in the availability of native and micronutrient cation in soil form stable complexes with organic ligands that decreased their susceptibility to adsorption, fixation or precipitation in the soil. The addition of organic manures which might have resulted in the formation of such metal organic complexes of higher availability (Gupta, et al., 2000). Significantly, higher available micronutrients values were recorded in the treatment receiving FYM along with balanced fertilizer compared to no FYM treatments (Hemalatha & Chellamuthu, 2012).

Effect of long-term integrated nutrient management on micro nutrients content and uptake by grain and straw of finger millet

The data pertaining to micronutrient content and uptake by finger millet crop as influenced by application of different levels of fertilizer are presented in Table 4 and 5.

Iron

Iron content in grain and straw differed significantly with different levels of fertilizer application. The higher Fe content in grain (117.63 mg kg^{-1}) and straw (65.47 mg kg^{-1}) recorded in T_5 treatment which received FYM @ 10 t ha^{-1} + 100% RDF and T_4(FYM @ 10 t ha^{-1} + 50% RDF) grain (115.49 mg kg^{-1}) and straw (63.45 mg kg^{-1}) was on par with T_5. The lower Fe concentration in grain (96.63mg kg^{-1}) and straw (48.32 mg kg^{-1}) was registered in T_1 absolute control. Iron uptake by grain and straw differed significantly with different levels of fertilizer applied. Significantly higher Fe uptake by grain (963.64 g ha^{-1}) and straw (654.12 g ha^{-1}) was recorded in T_5 treatment receiving FYM @ 10 t ha^{-1} + 100% RDF and it was on par with T_4 (FYM @ 10 t ha^{-1} + 50% RDF) grain (951.74 g ha^{-1}) and straw (680.02 g ha^{-1}). The lower Fe uptake by grain (36.81 g ha^{-1}) and straw (34.37 g ha^{-1}) was noticed in T_1 absolute control.

Zinc

Zinc content in grain and straw differed significantly with different levels of fertilizer application. The higher Zn content in grain (25.19 mg kg^{-1} and straw (33.30 mg kg^{-1}) was recorded in T_5 treatment which received FYM @ 10 t ha^{-1} + 100% RDF and T_4(FYM @ 10 t ha^{-1} + 50% RDF) grain (24.73 mg kg^{-1}) and straw (31.22 mg kg^{-1}) was found to be on par with T_5 .The lower Zn concentration in grain (20.51 mg kg^{-1}) and straw (24.28 mg kg^{-1}) was observed in T_1 which is absolute control. Uptake of zinc by grain and straw significantly varied among the treatments, Significantly higher Zn uptake by grain (52.80 g ha^{-1}), straw (83.21 g ha^{-1}) was recorded in T_5 treatment which received FYM @ 10 t ha^{-1} + 100% RDF and it was on par with T_4(FYM @ 10 t ha^{-1} + 50% RDF) grain (44.71 g ha^{-1}) and straw (67.84 g ha^{-1}). The lower Zn uptake by grain (1.92 g ha^{-1}) and straw (4.34 g ha^{-1}) was observed in T_1 absolute control.

Manganese

The manganese content in grain and straw varied significantly with different levels of fertilizer applied, significantly higher Mn content in grain (117.47 mg kg^{-1}), straw (128.24 mg kg^{-1}) was recorded in T_5 treatment which received FYM @ 10 t ha^{-1} + 100% RDF and it was on par with T_4 (FYM @ 10 t ha^{-1} + 50% RDF) grain (115.68 mg kg^{-1}) and straw (125.31 mg kg^{-1}). The lower Mn concentration in grain (95.04 mg kg^{-1}) and straw (94.57 mg kg^{-1}) was observed in T_1 which is absolute control. Manganese uptake by grain and straw differed significantly with different treatments. Significantly higher Mn uptake by grain (246.21 g ha^{-1}), straw (321.42 g ha^{-1}) was recorded in T_5 treatment which received FYM @ 10 t ha^{-1} + 100% RDF and it was on par with T_4 (FYM @ 10 t ha^{-1} + 50% RDF) grain (209.22 g ha^{-1}) and straw (272.29 g ha^{-1}). The lower Mn uptake by grain (8.90 g ha^{-1}) and straw (16.91 g ha^{-1}) was observed in T_1 absolute control.

Copper

Copper content in grain and straw differed significantly with different levels of fertilizer nutrients applied. Significantly higher Cu content in grain (12.29 mg kg^{-1}), straw (7.35 mg kg^{-1}) was recorded in T_5 treatment which received FYM @ 10 t ha^{-1} + 100% RDF and it was on par with T_4 (FYM @ 10 t ha^{-1} + 50% RDF) grain (12.25 mg kg^{-1}) and straw (7.14 mg kg^{-1}) The lower Cu concentration of grain (10.23 mg kg^{-1}) and straw (5.45 mg kg^{-1}) was observed in T_1 which is absolute control. Copper uptake by grain and straw differed significantly with different levels of fertilizer nutrients applied, significantly higher Cu uptake by grain (25.72 g ha^{-1}), straw (18.41g ha^{-1}) was recorded in T_5 treatment which received FYM @ 10 t ha^{-1} + 100% RDF and it was on par with T_4 (FYM @ 10 t ha^{-1} + 50% RDF) grain (22.12 g ha^{-1}) and straw (15.52 g ha^{-1}). The lower Cu uptake by grain (0.99 g ha^{-1}) and straw (0.97 g ha^{-1}) was observed in T_1 absolute control. In accordance with the yield levels, the content and uptake of micronutrients (Zn, Cu, Fe and Mn) by finger millet differed significantly. The highest micronutrients content and uptake was recorded with the combined application of organic and inorganic sources of nutrients. This would suggest that the application of FYM encouraged the uptake of micronutrients by formation of soluble complexes. Addition of organic manures to soil, besides increasing the availability of micronutrients in soil, the complexing properties of manure (FYM and maize residues) with micronutrients might have prevented precipitation, fixation, leaching and kept them in soluble form by microbial activity and higher uptake of these micronutrients by crop and the inorganic fertilizers in the absence of organic matter might reduce the availability of micronutrients due to precipitation. Kumar et al. (1994) and Gupta et al. (2000). Ghosh et al. (2001) and Sharma et al. (2014), (Shashi, 2003, Manasa, 2013). Atheefamunawery, (2007), (Sushma, 2005). The values recorded in control may be due to continuous cropping and removal of micronutrients over the years in long-term fertilizer experiments Manna et al. (1978).

Table 1: General information of experimental details

Location	:	AICRPDA, Bengaluru, UASB, GKVK, Bengaluru 65
Season	:	*Kharif* 2018
Design	:	RCBD
Treatments	:	08
Replications	:	03
Crop	:	Finger millet
Variety	:	GPU 28
Seed rate (kg ha^{-1})	:	12.5
Spacing	:	30 cm x 10 cm
Gross plot size	:	13 x 3.3 sq. m
Net plot size	:	12.4 x 2.9 sq. m
RDF	:	50:50:25 (N: P_2O_5: K_2O) kg ha^{-1}
Organic source	:	FYM 10 tons ha^{-1}
	:	Maize residues 5 tons ha^{-1}
Duration	:	110-115 days

Table 2: Treatment details in long term effect of integrated nutrient management

T_1	Absolute control
T_2	100% RDF
T_3	FYM @ 10 t ha^{-1}
T_4	FYM @ 10 t ha^{-1} + 50% RDF
T_5	FYM @ 10 t ha^{-1} + 100% RDF
T_6	Maize residue @ 5 t/ha
T_7	Maize residue @ 5 t ha^{-1} + 50% RDF
T_8	Maize residue @ 5 t ha^{-1} + 100% RDF

Table 3: Effect of long-term integrated nutrient management on micro nutrients content of soil

Treatments	Zn (mg kg^{-1})		Fe (mg kg^{-1})		Cu (mg kg^{-1})		Mn (mg kg^{-1})	
	Before sowing	At harvest	Before sowing	At harvest	Before sowing	At harvest	Before sowing	At harvest
T_1: Absolute control	0.43	0.45	7.83	7.63	0.20	0.22	5.48	5.53
T_2: 100% RDF	0.53	0.55	11.83	10.50	0.43	0.45	7.33	7.37
T_3: FYM @ 10 t ha^{-1}	0.87	0.90	13.58	14.31	0.64	0.65	12.44	12.41
T_4: FYM @ 10 t ha^{-1} + 50% RDF	1.20	1.23	17.20	18.09	0.98	1.00	17.39	17.39
T_5: FYM @ 10 t ha^{-1} + 100% RDF.	1.35	1.38	18.43	19.46	1.09	1.12	18.50	18.53
T_6: Maize Residue @ 5 t ha^{-1}	0.55	0.56	13.07	12.22	0.52	0.54	9.55	9.58
T_7: Maize Residue @ 5 t ha^{-1} + 50% RDF	0.95	0.97	15.47	15.18	0.84	0.86	13.72	13.75
T_8: Maize Residue @ 5 t ha^{-1} + 100% RDF	1.02	1.05	16.45	17.16	0.93	0.94	15.67	15.70
S.Em ±	**0.05**	**0.05**	**0.94**	**0.85**	**0.03**	**0.03**	**0.93**	**0.91**
CD at 5%	**0.14**	**0.14**	**2.85**	**2.59**	**0.11**	**0.11**	**2.82**	**2.76**

Table 4: Effect of long-term integrated nutrient management on micro nutrients content in grain and straw of finger millet

Treatments	Iron (mg kg^{-1})		Copper (mg kg^{-1})		Zinc (mg kg^{-1})		Manganese (mg kg^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1: Absolute control	96.63	48.32	10.53	5.45	20.51	24.28	95.04	94.57
T_2: 100% RDF	102.47	56.41	11.23	6.18	22.27	25.99	106.20	109.48
T_3: FYM @ 10 t ha^{-1}	104.57	58.64	14.80	6.47	22.22	26.09	108.50	115.50
T_4: FYM @ 10 t ha^{-1} + 50% RDF	115.49	63.45	12.25	7.14	24.73	31.22	115.68	125.31
T_5: FYM @ 10 t ha^{-1} + 100% RDF.	117.63	65.47	12.29	7.35	25.19	33.30	117.47	128.24
T_6: Maize Residue @ 5 t ha^{-1}	100.77	52.33	11.00	5.85	21.40	25.86	101.62	102.31
T_7: Maize Residue @ 5 t ha^{-1} + 50% RDF	108.93	59.66	11.80	6.78	23.41	29.53	110.38	121.51
T_8: Maize Residue @ 5 t ha^{-1} + 100% RDF	112.35	61.66	12.03	6.85	24.26	30.70	112.85	123.97
S.Em ±	**5.19**	**4.10**	**0.64**	**0.32**	**1.40**	**1.86**	**5.60**	**5.54**
CD at 5%	**15.75**	**12.44**	**1.94**	**0.96**	**4.26**	**5.65**	**16.99**	**16.81**

Table 5: Effect of long-term integrated nutrient management on micro nutrient uptake by grain and straw of finger millet

Treatments	Iron (g ha^{-1})		Copper (g ha^{-1})		Zinc (g ha^{-1})		Manganese (g ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1: Absolute control	36.81	34.37	0.99	0.97	1.92	4.34	8.90	16.91
T_2: 100% RDF	545.12	368.16	13.07	11.52	25.93	48.14	123.43	204.06
T_3: FYM @ 10 t ha^{-1}	523.73	594.98	14.43	14.98	28.37	60.49	136.49	267.70
T_4: FYM @ 10 t ha^{-1} + 50% RDF	951.74	680.02	22.12	15.52	44.71	67.84	209.22	272.29
T_5: FYM @ 10 t ha^{-1} + 100% RDF.	963.64	654.12	25.72	18.41	52.80	83.21	246.21	321.42
T_6: Maize Residue @ 5 t ha^{-1}	305.29	239.46	8.40	7.57	16.35	33.41	77.64	132.20
T_7: Maize Residue @ 5 t ha^{-1} + 50% RDF	822.28	515.12	18.23	14.68	36.13	63.94	170.76	263.06
T_8: Maize Residue @ 5 t ha^{-1} + 100% RDF	831.14	525.63	19.69	14.58	39.70	65.33	184.68	263.80
S.Em ±	**263.00**	**181.28**	**0.92**	**0.61**	**2.08**	**2.57**	**9.74**	**11.25**
CD at 5%	**797.80**	**549.92**	**2.78**	**1.84**	**6.30**	**7.78**	**29.53**	**34.13**

CONCLUSIONS

The DTPA extractable micronutrients available content was not influenced due to continuous cropping with different treatments. Micronutrient content in the soil was increased and more pronounced in FYM @ 10 t ha^{-1} + 100% RDF. Application of FYM @ 10 t ha^{-1} + 100% RDF over a period of 40 years significantly increased the micronutrient content in soil and uptake by finger millet as against 100% NPK treatment and control. For sustaining soil quality and crop productivity supplementing the inorganics with organics is the best strategy. This clearly indicated the complete supply of all the essential nutrients in sufficient amounts in balanced ratio during the crop growth period.

REFERENCES

Anand, S., & Ghosh, A. B. (1980). Changes in the status of water soluble sulphur and available micronutrient in soil as a result of intensive cropping and manuring. *J. Indian Soc. Soil Sci., 28,* 366-370.

Atheefamunawery, (2007). Influence of long term fertilizer application on availability of micronutrients under finger millet-maize cropping sequence. *M.Sc. Thesis,* UAS, Bangalore.

Chaitanya Devi, M., Ramavatharam, N., Naidu, M. V. S., & Reddy, K. S. (2003). Effect of inorganic fertilizers and organic manures on growth, yield and uptake of nutrients by groundnut (*Arachis hypogea*). *J. Oilseeds Res*., *20*(1), 126-128.

Chaudhary, M., & Narwal, R. P. (2005). Effect of long-term application of farmyard manure on soil micronutrients status. *Arch. Agron. Soil Sci*., *51*, 351-359.

Gao, M., F. C., Che, C. F., Wei, D. T., Xie, & Yang, J. H. (2000). Effect of long-term application of manures on forms of Fe, Mn, Cu, and Zn in purple paddy soil. *Plant Nutrition and Fertilizer Sciences 6*, 11–17.

Ghosh, B. N., Prakash, V., & Singh, R. D. (2001). Micronutrient status in soybean (*Glycine max*) - wheat (*Triticum aestivum*) cropping system in Kumaon region of Utttaranchal. *Indian J. Agric. Sci.*, *71*, 149-152.

Govindaraj, M., Kannan, P., & Arunachalam, P. (2011). Implication of micronutrients in agriculture and health with special reference to iron and zinc. *Int. J. Agricultural Management and Devel*, *1*, 207–210.

Gupta, R. K., Arora, B. R., Sharma, K. N., & Ahluwalia, S. K. (2000). Influence of biogas slurry and farmyard manure application on changes in soil fertility under rice-wheat sequence. *J. Indian Soc. Soil Sci.*, *48*, 500-505.

Hemalatha, S., & Chellamuthu, S. (2012). Impacts of long-term fertilization on soil nutritional quality under finger millet: maize cropping sequence. *J. Environ. Res. Develop., 7*(4), 1571-1576.

Kavalappa, B. N. (1989). Intensive manuring and cropping programme on soil properties, crop yield, nutrient uptake and nutritive quality of finger millet in an *Alfisols* of Bangalore. *Ph. D. Thesis*, University of Agricultural sciences Bangalore.

Kher, D., & Minhas, R. S. (1993). Long-term effect of liming, manuring and cropping on different hydrolysable 'N' forms in an acid *Alfisol*. *J. Indian Soc. Soil Sci.*, *40*, 840-842.

Kumar, A., Yadav, D. A., & Khanna, S. S. (1994). Integrated use of organic and inorganic in rice wheat cropping systems for higher production. *Proceedings of National seminar on development in soil science*. ISSS, IARI, New Delhi. pp 88-96.

Li, T. H., Li, C. W., Zhao, B. S., & Hua, T. M. (1994). Effects of organic manure on the diversification and balance of some trace elements. *Chinese Journal of Soil Science 25*(Suppl.), 26–29.

Lindsay, W. L., & Norvell, W. A. (1978). Development of a DTPA soil test for zinc, iron, manganese, and copper. *Soil Science Society of American Journal 42*, 421–428.

Manasa, V. (2013). Effect of water soluble fertilizers on the growth, yield and oil quality of groundnut (*Arachis hypogaea* L.) in a *Vertisol* of Northern transition zone of Karnataka. *M.Sc (Agri.) Thesis*, University of Agricultural Sciences, Dharwad.

Nambiar, K. K. M. (1994). Soil fertility and crop productivity under long-term fertilizer use in India. ICAR, New Delhi.

Manna, M. S., Takkar, P. N., Bansal, R. L., & Randhawa, N.S. (1978). Micronutrient status of soil and yield of maize and wheat as influenced by micronutrient and FYM application. *J. Indian Soc. Soil Sci.*, *26*, 208–214.

Mantovi1, P., Bonazzi1, G., Maestri, E., & Marmiroli, N. (2003). Accumulation of copper and zinc from liquid manure in agricultural soils and crop plants. *Plant and Soil 250*, 249–257.

Rajinder, S., A., & Singh, M. (2007). Effects of organic manures and fertilizers on organic matter and nutrients status of the soil. *Arch. Agron. Soil Sci.*, *53*(5), 519-528.

Sanjib Kumar, B., Singh, D., & Brahma Swaroop, D. (2009). Changes in fractions of iron, manganese, copper and zinc in soil under continuous cropping for more than three decades. *Commun. Soil Sci. Pl. Anal*., *40*, 1380-1407.

Sarkar, M. C. (1990). Long term effect of fertilizers on soil eco-system. *Fertilizer News*, *35*, 81-85.

Sharma, R. P., Kaushal, V., Gayatri, V., & Sharma, S. P. (2014). Effect of three-decade long application of chemical fertilizer and amendments on crop yield under maize - wheat cropping system in an acid *Alfisol. J. App. Nat. Sci.*, *6*(1), 106-109.

Shashi, (2003). Effect of FYM, fertilizers and agrochemicals on chemical properties and enzymes activity on soil, yield and nutrient composition of soybean. *M.Sc. (Agri.) Thesis,* University of Agricultural Sciences, Bangalore.

Soriano-Disla, J. M., Gómez, I., Navarro-Pedreño, J., & Lag-Brotons, A. (2010). Evaluation of single chemical extractants for the prediction of heavy metal uptake by barley in soils amended with polluted sewage sludge. *Plant and Soil 327*, 303–314.

Sushma, A. R. (2005). Residual effect of coir pith based compost with other organics and inorganics on ragi crop yield and soil properties. *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Bangalore.

Swarup, A. (1984). Effect of micronutrient and farmyard manure on the yield and micronutrient of rice and wheat grown on a sodic soil. *J. Indian Soc. Soil Sci*., *32*, 397-399.

Wei, X., Hao, M., Shao, M., & Gale, W. J. (2006). Changes in soil properties and the availability of soil micronutrients after 18 years of cropping and fertilization. *Soil and Tillage Research 91*, 120–130.

Westfall, D. G., Mortvedt, J. J., Peterson, G. A., & Gangloff, W. J. (2005). Efficient and environmentally safe use of micronutrients in agriculture. *Communications in Soil Science and Plant Analysis 36*, 169–82.