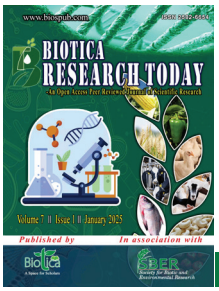
DOI: 10.54083/BRT/7.1.2025/10-15

Bio. Res. Today 2025, 7(1):10-15



Biotica Research Today

e-ISSN: 2582-6654

January, 2025

Article ID: RT1734 **Review Article**

Effect of Land Use Pattern on Soil Micronutrients Status: A Review

Dipta Som[1*], Amrit Tamang[1], Rajib Das[2] and Diptanu Datta[3]

[1]Dept. of Soil Science and Agricultural Chemistry, Uttarbanga Krishi ViswaVidyalaya, Pundibari, West Bengal (736 165), India

[2]Dept. of Agricultural Extension, Krishi Vigyan Kendra, Khowai, Tripura (799 207), India

[3]Dept. of Plant Pathology, Faculty of Agricultural Sciences, Siksha 'O' Anusandhan, Bhubaneswar, Orissa (751 003), India

Open Access

Corresponding Author

Dipta Som

: diptasom96@gmail.com

Conflict of interests: The author has declared that no conflict of interest exists.

How to cite this article?

Som, D., Tamang, A., Das, R., *et al*., 2025. Effect of Land Use Pattern on Soil Micronutrients Status: A Review. *Biotica Research Today* 7(1), 10-15. DOI: 10.54083/BRT/7.1.2025/10-15

Abstract

Soil health can be defined by the ability of soil to support ecosystem function and to sustain quality of the environment and biological productivity. Micronutrients in the soil play a major role to establish a healthy soil and it is very much needed for plant growth and development. It has been seen that different land uses has impacted the soil properties, such as micronutrients. The level of impact of different types of land use pattern on soil and environment varies and assessment of this is important with respect to a natural system in order to evolve long term management policies. Land use pattern plays a crucial role in controlling the soil nutrient recycling and soil quality. Long term cultivation or a specific type of system is one of the major factors that change the soil physical and chemical properties, it also changes the micronutrient concentration in soil and makes it available for plants for their growth. Micronutrients abundance in soil depends upon several things including pH, soil organic matter, clay surfaces and other chemical, biological and physical factors in the rhizosphere which is affected by land use. A major global concern is the changing land use as cultivated land is expanded to fulfil the demand of growing population which causes heavy application of fertilizers or intensive use of agriculture inputs that causes depletion in micronutrients, so proper management of land use system is necessary to establish a sustainable and eco-friendly agricultural environment.

Keywords: Land use pattern, Micronutrients, Soil quality, Sustainable agriculture

Introduction

Green revolution has taken the major part and showed self-sufficiency in production of required amount of food; in a time when the nation's population were increasing at a higher rate (Pingli, 2022). After green revolution, heavy uses of NPK and chemical suppressed the micronutrient addition. There might be a little addition or zero addition of micronutrients which reduces the bioavailability of micronutrients in the crop (Shukla *et al.*, 2019). In the post green revolution, the depletion in soil reserve of native micronutrients has not only limiting the crop productivity but also showing its result in human nutrition where people of India are suffering from several malnutrition deficiency problem (Bakker and van Doorn, 2009). Indian soils are known to be micronutrients deficient. Therefore, deterioration in fertility of soil system and productivity of crop due to decrease in micronutrients availability will become a threat to food security (Kaur *et al.*, 2021). Among the several micronutrients like Fe, Mn, Zn, Cu an B which can be categorised as cationic and anionic are to be discussed due to their importance in expressing gene, playing role in protein synthesis, chlorophyll and stress tolerance also most importantly in metabolism of carbohydrates and lipids, growth substances, secondary metabolites, *etc*. (Singh, 2004; Rengel, 2007; Gao *et al.*, 2008). Now all the micronutrients mentioned above have their certain constraints for availability and positive response towards plants growth. So when the world is thinking in a manner to take care of the up growing population by providing sufficient amount of food increasing the productivity of the food grains by any other possible way is the only way.

Production, change and maintenance that people undertake in a certain land cover type through arrangements, activities and input is called as land use (Ufot *et al.*, 2016). Sustainable

Article History

RECEIVED on 01st September 2024 RECEIVED in revised form 11th January 2025 ACCEPTED in final form 18th January 2025

use of soil resources is required to establish a successful agriculture, as because within a short period of time soil losses its quality and quantity very easily which might be for different reasons for *e.g.*, Intensive cultivation, soil erosion and leaching (Kiflu and Beyene, 2013). A worldwide issue which has drawn attention in the techniques and processes of crop production is the improper land use that even leads to soil quality reduction (Khan, 2022). The soil is a heterogeneous system, so the abundance of micronutrients depends upon several things including pH, soil organic matter and other chemical, physical and biological factors. The soil properties are been effected by the parameters such as altitude, depth and land use system particularly micronutrient concentration also gets effected (Takele *et al.*, 2014). It has been seen that different types of land uses has impacted the soil properties such as micronutrients. Different land use pattern have impact on soil and environment though it varies an assessment of this is important with respect to a natural system in order to evolve long term management policies. A crucial role is played by Land use pattern in controlling the nutrient recycling and soil quality (Venkatesh *et al.*, 2003). Long term cultivation practices or a specific type of system is one of the major factors that change the soil physical and chemical properties, it also changes soils micronutrient concentration that makes it accessible for plants and helps in their growth and development. Changes in the soil reaction and Organic matter at different land use influences the availability of micronutrients and its distribution (Doran and Gregorich, 2002). The nutrient concentration at different land uses can be different depending upon the soil properties of the particular land use. A major global concern is the changing land use as cultivated land is expanded to fulfil the demand of growing population (Turner *et al.*, 2007). The land-use form shift *i.e.*, forest become cultivable land varies the micronutrient cycling and their distribution in the soils (Han *et al.*, 2007).

The requirement to utilize the fertility of the available soils has arisen from the need to feed the world's growing population. Thus, in order to accomplish the objective of sustainable development, the necessity to understand the impact of land use pattern on different soil properties especially on soil micronutrients is important (Dhaliwal and Dhaliwal, 2019). Terms used to describe land-use patterns show how human activity interacts with the natural environment (forests, for example) and how man utilizes them throughout time and place. Scientists should take responsibility to support policy decisions about land uses, which should consider both human needs and ecological reaction (Pandey and Ranganathan, 2018). It helps to understand the impact of specific soil quality parameters that might affected by agricultural land use and the declination in critical soil quality parameter due to some agricultural practices or environmental factors, because declining soil fertility brought on by changes in land usage has disastrous effects.

Concept of Land Use Pattern in India

The land which is used for agriculture, grazing, construction, *etc*., the arrangement or layout of such lands are known as land use pattern and the factors that determines this are climate, relief, population density, soil and socio-economic factors (Shijitha, 2021). Lands in India are having the primary use in agricultural sector; out of country's total land area agriculture sector accounts nearly for 60%. Land has two dimensions like any other resources, *viz.*, quality and quantity and due to exhaustive use of land in agriculture and non agriculture sector both the crucial aspects of land are under serious threat (Ramasamy *et al.*, 2005). After independence, the growing economy and its pressure on land and other natural resources has increased also due to exponential increase in population the demand to convert farm land for non-agricultural uses has also increased (Bardhan and Tewari, 2010). A table has shown below (Table 1) of different land uses with the change in area in last four decades. Cultivation of various food and non-food crops comes around 42% out of total geographical area of 328.7 million hectares and this is one of the world's highest proportions (Pandey and Ranganathan, 2018). Through an analysis in 2010-11 it was found that forest occupied around 21% of the geographical area whereas 8% was utilized for non-agricultural purposes, 5% was unproductive or barren and uncultivable and 7.5% was fallow (Anonymous, 2015). In addition to needs and choices, the use of land is influenced by its usefulness and potential. Different factors such as topographical variations, soil type, pH levels, soil quality and moisture content play a significant role in determining how land is utilized (Dhaliwal *et al*., 2023). Table 1 below shows the structural change of land use pattern with time.

Table 1: Land use pattern in India ("000 ha)

Land use category	1980-1981	1995-1996	2019-2020
Forest area	67,460	68,817	71,750.9
Uncultivable and barren lands	19,958	19,009	16,541.6
Land in non-agricultural uses	19,596	22,362	27,777.2
Permanent pastures and other grazing lands	11,989	11,064	10,479.8
Cultivable wastes	16,744	14,098	11,945.3
Miscellaneous tree crops and groves	3,578	3,481	3,133.9
Current fallows	14,826	13,831	13,769.5
Fallows other than current fallow	9,720	10,016	11,242.2
Net sown area	140,288	142,197	139,902.3
Total reported area	304,159	304,875	306,542.8

(Source: Anonymous, 2015)

Modern economic considerations involve assessing both the economic and social viability of land. The economy of a country is boosted by agriculture. Since 2005-06 the net sown area under agriculture is increasing and also there is an exponential growth rate (Table 2) in different sector which is a step in the right direction for the nation's limited land resources (Khan, 2022).

Table 2: Exponential growth rate of productivity in India at different sector

Period	Agriculture	Non-agriculture	Forest	Fishing
2005-06 to 2020-21	3.26%	5.59%	1.5%	6.65%

(Source: Khan, 2022)

Status and Importance of Micronutrients in India

To produce crop sustainably micronutrient plays a crucial role in Indian agriculture sector. The significance of micronutrients should be considered within the broader context of food systems, as incorporating them into a balanced fertilization plan can enhance their availability and supply throughout the complete food consumption process (Doran and Gregorich, 2002). Due to the long time cultivation practices and without addition of micronutrient fertilizer the Indian soils have become less fertile. Due to the high-yielding crop, intensive cropping techniques and the use of fertilizers with lower micronutrient content, the demand for micronutrients has increased (Ram *et al.*, 2022). On top of that nowadays use of crop residues and OM *i.e.*, organic manures has been decreased and crops are growing in soils that are low in reserve micronutrient. All this factors including several other natural and human induced factors are adversely affecting the availability of micronutrients and it provokes the situation (Takkar and Shukla, 2015). After analysing around 2 lakh samples all over the country an average of 12.8, 7.1, 36.5, 4.2 and 23.2% soils were found deficient (Figure 1) in Fe, Mn, Zn, Cu and B, respectively and this experiment was conducted in ICAR-Indian Institute of Soil Science, Bhopal.

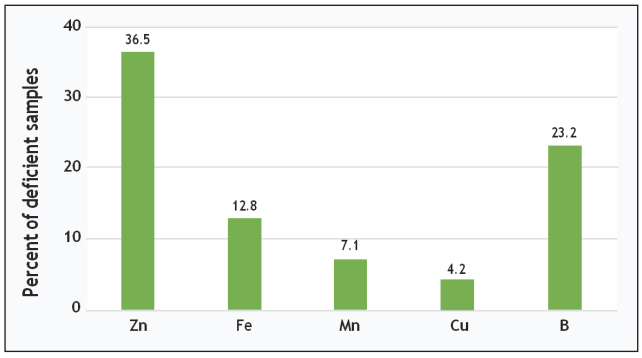


Figure 1: Micronutrient deficiency in Indian soil (Source: Shukla *et al*., 2019)

Micronutrients are essential for crop growth and production. They also contribute in the protein synthesis, chlorophyll, nucleic acids, lipids and carbohydrate metabolism and enhance stress tolerance (Barker and Pilbeam, 2015). Plant life cycle is incomplete without micronutrients. As a result, healthy nutrition and development of plant is mostly dependent on soil micronutrients. To provide balanced nutrition, increasing crop production and to increase the healthier growth of plants and soil quality micronutrients are required in small amounts (Lal, 2009). The food chain or the grain production gets a negative impact due to deficiency of micronutrient as it creates hindrance in the outcome of crops (Deckers and Steinnes, 2004).

Impact of Land Use Pattern

Case Study: 1

A research has been done on the collected soil samples of five different sites that lie under different agro-climatic zones of Punjab, India. All the land uses showed a significant increase for all the DTPA-extractable micronutrients. The order of increasing micronutrient content at different land uses was forest > horticulture > crop land > barren land use (Table 3). The micronutrient concentration also found in a considerable ranges in the land uses which ranged from 5.37-2.87 mg kg^{-1} (Mn), 1.44-0.96 mg kg^{-1} (Ni) 1.14 to 0.81 mg kg^{-1} (Zn) and 0.85-0.51 mg kg^{-1} (Cu), respectively. The reason behind getting higher concentration of micronutrients in forest soil compare to all other land uses has been explained as more amount of litter fall and root biomass which has elevated the soil aeration and increased the intensity of organic matter in forest soils. This helps in preventing oxidation and micronutrients precipitation in bound form (Saha *et al.*, 2019; Dhaliwal *et al.*, 2019). Again under crop land use system the DTPA-extractable micronutrients was found lower as agricultural and tillage practices was more which resulted in quick decomposition of organic matter and loss of soil nutrients so in spite of more nutritional demand also the use efficiency by plant is less (Gong *et al.*, 2005).

Table 3: Available micronutrients concentration

	Micronutrients (mg kg^{-1})				
Land use systems	Zinc	Iron	Manga-nese	Copper	Nickel
Horticulture	0.94	11.00	4.35	0.61	1.12
Cropland	0.88	9.73	3.39	0.56	1.00
Barren	0.81	8.93	2.87	0.51	0.96
Forest	1.14	11.78	5.37	0.85	1.44
LSD (P=0.05)	0.27	0.23	0.24	0.04	0.03

(Source: Dhaliwal *et al*., 2023)

Case Study: 2

An experiment was conducted in the tropical Humid Region of Kerala on different land uses namely banana, rubber, oil palm, pineapple, coconut and paddy. The purpose of this study was to see the impact of those land use systems on soil properties. The micronutrients concentration was recorded as Paddy soils (98.70 mg kg^{-1}) > Coconut (34.23 mg kg^{-1}) > Banana (33.13 mg kg^{-1}) in-case of Fe and the lowest (18.38 mg kg^{-1}) Fe content was observed in pineapple land use

(Table 4). Again for Mn rubber soils (6.92 mg kg^{-1}) > oil palm (5.50 mg kg^{-1}) the lowest (2.8 mg kg^{-1}) Mn was recorded in coconut soils (Table 4). Available Copper (Cu) was noticed with higher value (3.95 mg kg^{-1}) in Paddy soils followed by rubber soils (3.46 mg kg^{-1}) and Oil palm soils (0.83 mg kg^{-1}) with lower mean value of Cu (Table 4). Soil Cu has a strong negative correlation with pH and a positive correlation with organic carbon this has resulted in the presence of adequate amount of copper in soil. Among the land uses highest Zn content (1.26 mg kg^{-1}) was observed in banana growing soils. In case of Boron the trend was paddy growing soils (0.32 mg kg^{-1}) > rubber soils (0.31 mg kg^{-1}) > pineapple (0.27 mg kg^{-1}) (Table 4). The lower concentration of micronutrients from the critical limit in crop land or horticultural land or plantation crop is mostly because of the gradual nutrient mining and continuous soil disturbance through different practices adopted in cultivation, removing biomass and not substituting micronutrient deficiency problems through external input.

Table 4: Soil fertility status of different land uses

	Micronutrients (mg kg^{-1})				
Land use system	Fe	Mn	Cu	Zn	B
Banana	33.13	5.33	2.96	1.26	0.30
Coconut	34.23	2.80	2.82	0.80	0.30
Oil palm	20.50	5.50	0.83	0.70	0.27
Paddy	98.70	4.67	3.95	0.98	0.32
Pineapple	18.38	4.78	3.34	0.68	0.27
Rubber	26.32	6.92	3.46	1.20	0.31
SD	30.16	1.34	1.09	0.25	0.02

(Source: Chandrakala *et al*., 2018)

Case Study: 3

To check the soil quality some physio-chemical parameters has been selected and an experiment was conducted in Kamrup District of Assam by selecting different land use systems. The land uses that were selected are shifting cultivation 1 & 2 (SC1 & SC 2), Orange Orchard (OO), Rubber plantation (RP), Tea plantation (TP) and Control site (C). The range of Mn was 15.79-16.84 mg kg^{-1} in surface soil and 13.50-16.57 mg kg^{-1} in Sub Surface soil. The available soil Fe content was 13.68-20.65 mg kg^{-1} in surface soil and 10.42-18.21 mg kg^{-1} in sub surface soil. Cu and Zn is ranging within 2.14-4.55 mg kg^{-1} and 1.13-3.64 mg kg^{-1} in the surface layer and in the sub surface layer the range was 1.12-2.82 mg kg^{-1} and 1.3-1.85 mg kg^{-1} for available Cu and Zn respectively. Tea garden is having the highest value (20.6 mg kg^{-1}) of iron (Table 5). Heavy litter fall, root exudates, above ground and root biomass are the primary reason of external carbon input and it has resulted in the increase of soil pH and redox potential which are the major reason for increasing the concentration of micronutrients under tree based system such as tea plantation (Mandal and Dhaliwal, 2018).

Table 5: Micronutrients content of soil at different land use system

Micro-nutrients (mg kg^{-1})	Land uses					
	SC 1	SC 2	RP	OO	TP	C1
Mn	16.65	15.8	16.5	16.3	15.7	16.8
Cu	4.32	2.82	3.47	2.14	2.62	4.55
Fe	19.45	17.81	17.5	18.8	20.6	13.6
Zn	3.13	2.01	1.97	3.52	3.40	3.64

(Source: Baishya and Sharma, 2017)

Conclusion

The soil properties and the dynamics of essential nutrients are influenced by different land use. Based on the studies and experiment that has been conducted throughout the world and those have discussed before it is clear that land use does alter the soil properties. The reason behind this can be different human practices at different land use such as tillage and many other inappropriate agricultural practices that affect the soil pH and organic matter at different land uses (Chandrakala *et al.*, 2018). Considering agricultural crop land regular practices, application of fertilizer can increase the pH to a moderate amount also some nutrient like P and K also can increase whereas micronutrients can fit better in the land uses with higher amount of organic carbon and CEC which might be due to higher litter fall and more biomass (Geetha *et al.*, 2021). It can also be concluded by saying that if we adopt the modern and intensive cropping practices high yielding crop and unbalanced fertilization it results into deficiency of micronutrients in soils and crop of India, so proper management of land use system is necessary to establish a sustainable and ecologically friendly agricultural environment (Govindaprasad and Manikandan, 2016).

References

Anonymous, 2015. *Agricultural Statistics at a Glance 2015*. Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India. p. 479.

Baishya, J., Sharma, S., 2017. Analysis of physico-chemicals properties of soil under different land use system with special reference to agro ecosystem in Dimoria Development Block of Assam, India. *International Journal of Scientific Research Education* 5(6), 6526-6532. DOI: http://dx.doi.org/10.18535/ijsre/v5i06.05.

Bakker, M.M., van Doorn, A.M., 2009. Farmer-specific relationships between land use change and landscape factors: Introducing agents in empirical land use modelling. *Land Use Policy* 26(3), 809-817. DOI: https://doi.org/10.1016/j.landusepol.2008.10.010.

Bardhan, D., Tewari, S.K., 2010. An investigation into land use dynamics in India and land under-utilisation. *Indian Journal of Agricultural Economics* 65(4), 658-676.

Barker, A.V., Pilbeam, D.J., 2015. *Handbook of Plant Nutrition*, Second Edition. CRC Press, Boca Raton. p. 773. DOI: https://doi.org/10.1201/b18458.

Chandrakala, M., Ramesh, M., Sujatha, K., Hegde, R., Singh, S.K., 2018. Soil fertility evaluation under different land use system in tropical humid region of Kerala, India. *International Journal of Plant & Soil Science* 24(4), 1-13. DOI: https://doi.org/10.9734/IJPSS/2018/40099.

Deckers, J., Steinnes, E., 2004. State of the art on soil-related geo-medical issues in the world. In: *Advances in Agronomy*, Volume 84. Elsevier Inc. pp. 1-35. DOI: https://doi.org/10.1016/S0065-2113(04)84001-X.

Dhaliwal, M.K., Dhaliwal, S.S., 2019. Impact of manure and fertilizers on chemical fractions of Zn and Cu in soil under wheat-rice cropping system. *Journal of the Indian Society of Soil Science* 67(1), 85-91. DOI: https://doi.org/10.5958/0974-0228.2019.00009.4.

Dhaliwal, S.S., Naresh, R.K., Mandal, A., Walia, M.K., Gupta, R.K., Singh, R., Dhaliwal, M.K., 2019. Effect of manures and fertilizers on soil physical properties, build-up of macro and micronutrients and uptake in soil under different cropping systems: A review. *Journal of Plant Nutrition* 42(20), 2873-2900. DOI: https://doi.org/10.1080/01904167.2019.1659337.

Dhaliwal, S.S., Sharma, V., Shukla, A.K., Kaur, J., Gupta, R.K., Verma, V., Kaur, M., Singh, V.K., Singh, P., 2023. Interactive effect of land use systems on depth-wise soil properties and micronutrients minerals in North-Western, India. *Heliyon* 9(2), e13591. DOI: https://doi.org/10.1016/j.heliyon.2023.e13591.

Doran, J.W., Gregorich, E.G., 2002. Soil quality and sustainable agriculture. In: *Encyclopedia of Soil Science*. (Ed.) Lal, R. Marcel Dekker, New York. pp. 1088-1091.

Gao, S., Yan, R., Cao, M., Yang, W., Wang, S., Chen, F., 2008. Effects of copper on growth, antioxidant enzymes and phenylalanine ammonia-lyase activities in *Jatropha curcas* L. seedling. *Plant, Soil and Environment* 54(3), 117-122. DOI: https://doi.org/10.17221/2688-PSE.

Geetha, K., Chaitanya, T., Padmaja, G., Krishna, A., 2021. Effect of different land use systems on soil properties. *Pharma Innovation Journal* 10(8), 01-06.

Gong, J., Chen, L., Fu, B., Huang, Y., Huang, Z., Peng, H., 2005. Effect of land use on soil nutrients in the loess hilly area of the Loess Plateau, China. *Land Degradation & Development* 17(5), 453-465. DOI: https://doi.org/10.1002/ldr.701.

Govindaprasad, P.K., Manikandan, K., 2016. Farm land conversion and food security: Empirical evidences from three villages of Tamil Nadu. *Indian Journal of Agricultural Economics* 71(4), 493-503.

Han, F.X., Kingery, W.L., Hargreaves, J.E., Walker, T.W., 2007. Effects of land uses on solid-phase distribution of micronutrients in selected vertisols of the Mississippi River Delta. *Geoderma* 142(1-2), 96-103. DOI: https://doi.org/10.1016/j.geoderma.2007.08.006.

Kaur, T., Sehgal, S.K., Singh, S., Sharma, S., Dhaliwal, S.S., Sharma, V., 2021. Assessment of seasonal variability in soil nutrients and its impact on soil quality under different land use systems of lower shivalik foothills of Himalaya, India. *Sustainability* 13(3), 1398. DOI: https://doi.org/10.3390/su13031398.

Khan, F.M., 2022. Shifting land use patterns in India: A comprehensive analysis from 2004-05 to 2020-21. *Journal of Survey in Fisheries Sciences* 8(3), 209-217. DOI: https://doi.org/10.53555/sfs.v8i3.1556.

Kiflu, A., Beyene, S., 2013. Effects of different land use systems on selected soil properties in South Ethiopia. *Journal of Soil Science and Environment Management* 4(5), 100-107. DOI: https://doi.org/10.5897/JSSEM12.20.

Lal, R., 2009. Challenges and opportunities in soil organic matter research. *European Journal of Soil Science* 60(2), 158-169. DOI: https://doi.org/10.1111/j.1365-2389.2008.01114.x.

Mandal, A., Dhaliwal, S.S., 2018. Distribution of micronutrients in soils under different land-uses in south western plains of Punjab. In: *83rd Annual Convention of ISSS*, Anand Agricultural University, Anand, Gujarat, India. November, 2018. pp. 27-30. DOI: https://doi.org/10.13140/RG.2.2.20095.15527.

Pingli, P., 2022. Are the lessons from the green revolution relevant for agricultural growth and food security in the twenty-first century? In: *Agricultural Development in Asia and Africa*. Emerging-Economy State and International Policy Studies. (Eds.) Estudillo, J.P., Kijima, Y. and Sonobe, T. Springer, Singapore. pp. 21-32. DOI: https://doi.org/10.1007/978-981-19-5542-6_2.

Pandey, G., Ranganathan, T., 2018. Changing land-use pattern in India: has there been an expansion of fallow lands? *Agricultural Economics Research Review* 31(1), 113-122. DOI: DOI: https://doi.org/10.5958/0974-0279.2018.00011.3.

Ram, B., Singh, A.P., Singh, V.K., Shivran, M., Serawat, A., 2022. Effect of different land-uses systems on soil pH, electrical conductivity and micronutrients in Mollisols of Uttarakhand. *Biological Forum - An International Journal* 14(1), 712-716.

Ramasamy, C., Balasubramanian, R., Sivakumar, S.D., 2005. Dynamics of land use pattern with special reference to fallow lands - An empirical investigation in Tamil Nadu. *Indian Journal of Agricultural Economics* 60(4), 629-643. DOI: https://doi.org/10.22004/ag.econ.204427.

Rengel, Z., 2007. Cycling of micronutrients in terrestrial ecosystems. In: *Nutrient Cycling in Terrestrial Ecosystems*. (Eds.) Marschner, P. and Rengel, Z. Soil Biology, Volume 10. Springer, Berlin, Heidelberg. pp. 93-121. DOI: https://doi.org/10.1007/978-3-540-68027-7_4.

Saha, S., Saha, B., Seth, T., Dasgupta, S., Ray, M., Pal, B., Pati, S., Mukhopadhyay, S.K., Hazra, G., 2019. Micronutrients availability in soil-plant system in response to long-term integrated nutrient management under rice-wheat cropping system. *Journal of Soil Science and Plant Nutrition* 19, 712-724. DOI: https://doi.org/10.1007/s42729-019-00071-6.

Shijitha, M., 2021. Land use pattern in Kerala. *PhD (Agri) Thesis*, St. Thomas' College (Autonomous), Thrissur, Kerala, India. p. 72.

Shukla, A.K., Behera, S.K., Satyanarayana, T., Majumdar, K., 2019. Importance of micronutrients in Indian agriculture. *Better Crops South Asia* 11(1), 6-10.

Singh, M.V., 2004. Micronutrient deficiencies in Indian soils

and field usable practices for their correction. In: *IFA International Conference on Micronutrients*, New Delhi, February, 2004. pp. 23-24.

Takele, L., Chimdi, A., Abebaw, A., 2014. Dynamics of Soil fertility as influenced by different land use systems and soil depth in West Showa Zone, Gindeberet District, Ethiopia. *Agriculture*, *Forestry and Fisheries* 3(6), 489-494. DOI: https://doi.org/10.11648/j.aff.20140306.18.

Takkar, P.N., Shukla, A.K., 2015. Management of soil fertility: Micronutrients. In: *State of Indian Agriculture - Soil*. (Eds.) Pathak, H., Sanyal, S.K. and Takkar, P.N. NAAS, New Delhi, India. pp. 121-152.

Turner, B.L., Lambin, E.F., Reenberg, A., 2007. The emergence of land change science for global environmental change and sustainability. *Proceedings of the National Academy of Science USA* 104(52), 20666-20671. DOI: https://doi.org/10.1073/pnas.0704119104.

Ufot, U.O., Iren, O.B., Chikere Njoku, C.U., 2016. Effects of land use on soil physical and chemical properties in Akokwa area of Imo State, Nigeria. *International Journal of Life Sciences Scientific Research* 2(3), 273-278.

Venkatesh, M.S., Majumdar, B., Kumar, K., 2003. Status of micronutrient cations under various land use systems of Meghalaya. *Journal of the Indian Society of Soil Science* 51(1), 60-64.