Mysore J. Agric. Sci., 60 (2) : 11-23 (2026)

Fertility Status of Soils in Different Land Use Systems of Northern Transect of Bengaluru

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Received : October 2025
Accepted : December 2025

Abstract

A research was conducted to study the fertility status of soils in different land use systems of northern transect of Bengaluru, Karnataka. The land use systems selected for the study were agriculture, horticulture, forest, sericulture, organic farming and fallow. From each land use system, twenty surface (0-15 cm depth) soil samples were collected randomly and analyzed for different fertility parameters by using standard analytical procedures. The results revealed that soil texture under different land use systems varied from sandy clay loam to sandy clay. Significantly lower soil pH was recorded in forest land use (5.38) followed by agriculture land use (5.56). Electrical conductivity (EC) was recorded significantly lower in forest land use (0.15 dS m^{-1}) and higher in horticulture land use (0.48 dS m^{-1}). Forest land use has recorded significantly higher organic carbon (OC) content (19.60 g kg^{-1}) followed by organic farming (12.40 g kg^{-1}) while significantly lower values were recorded for fallow land use (2.70 g kg^{-1}). The available nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) content was recorded significantly higher in horticulture land use (400.54, 113.30 and 282.91 kg ha^{-1}) which was on par with agriculture land use (384.35,108.65 and 257.58 kg ha^{-1}). Organic farming land use has recorded significantly higher exchangeable calcium (Ca) content (5.89 cmol (p+) kg^{-1}) while exchangeable magnesium (Mg) content was found to be significantly higher in sericulture land use (2.67 cmol (p+) kg^{-1}) and significantly higher available sulphur (S) content was observed in horticulture land use (19.34 mg kg^{-1}). Diethylene triamine penta acetic acid (DTPA) extractable iron (Fe) and zinc (Zn) contents were recorded significantly higher in forest land use (28.15 and 0.72 mg kg^{-1}, respectively), whereas, DTPA extractable manganese (Mn) and copper (Cu) contents were recorded significantly higher in organic farming (19.78 and 0.28 mg kg^{-1}, respectively) land use. Forest land use has recorded significantly higher values of microbial biomass carbon (MBC) and microbial biomass phosphorus (MBP) with mean values of 447.12 and 25.45 mg kg^{-1}, respectively.

Keywords : Land use systems, Soil fertility, Organic carbon, Micronutrients, Microbial biomass

Bengaluru is a rapidly growing metropolitan city which relies extensively on the adjacent rural areas for a steady supply of food grains, vegetables and fruits *etc*. Increasing demand has resulted in the widespread transformation of traditional, diverse dryland farming systems into intensive cropping systems both on the urban periphery and within the city limits (Shreshma and Subbarayappa, 2023). Such transitions have driven a significant shift in agricultural land use towards a high-input, irrigated, multi-cropping systems that depend heavily on chemical fertilizers. The impact of these changes on soil properties-particularly organic matter, nutrient cycling with an emphasis on nutrient dynamics and overall soil productivity remain largely unquantified. The intensification of agriculture through increased use of fertilizers such as DAP, SSP, NPK complexes as well as urban compost and partial irrigation with wastewater, influences the physical, chemical and biological propertiesof soils. These changes in turn affect the ability of soils to match nutrient supply with crop demand efficiently. As the application of chemical fertilizers have increased, which can boost the yield and quality of crops, the contemporary agricultural challenge lies in managing chemical fertilizers effectively to maximize their efficiency while minimizing environmental pollution. Successful agriculture depends on sustainable management of soil resources, as soils can quickly degrade in quality due to various factors. Agricultural practices, therefore, necessitate a fundamental understanding of sustainable land use. Practices related to land use and soil management, impact soil nutrients and processes such as erosion, oxidation, mineralization and leaching. Consequently, these practices can alter the transportation and redistribution of nutrients in soil (Celik, 2005). Soil fertility is crucial for both agricultural productivity and sustainability. Grasping the connection between land use systems and the levels of available soil nutrients is crucial for crafting effective nutrient management strategies and enhancing overall soil health (Guo *et al*., 2016). Soil quality mainly depends on the management practices undertaken in different land use systems, which may modify the soil properties and hence the soil productivity. Such information is meager particularly in the soils of northern transect of Bengaluru and therefore the present study is a step in that direction. The selected land use systems (agriculture, horticulture, forest, sericulture, organic farming and fallow) are ecologically and agronomically significant for the northern transect of Bengaluru because these systems represent the major land uses and farming practices that directly influence soil health and resource sustainability in this region. Agriculture and horticulture dominate due to food supply needs for the rapidly urbanizing Bengaluru, while forests contribute to biodiversity and soil conservation, making their inclusion vital for assessing land use impacts on soil properties. Sericulture and organic farming represent livelihood diversification and sustainable practices that mitigate chemical input pressures seen in high-input systems. The fallow land use system serves as a baseline for evaluating soil nutrient dynamics in the absence of cropping or management, providing comparative insight into land use effects. The current study aims to investigate how the changes in land use systems affect associated soil nutrient status. The findingsfrom this research would contribute to the broader understanding of soil nutrient management and provide practical recommendations for maintaining soil health and productivity in diverse land use systems.

Material and Methods

General Description and Location of Study Area

The study area falls under Eastern Dry Zone of Karnataka (Zone 5). This zone consists of an area of 1.81 M ha. The annual rainfall ranges from 679.1 to 888.9 mm and the main cropping season is *kharif* (Tejashvini and Subbarayappa, 2022). The elevation ranges from 800 to 900 m above MSL and the soils are red sandy loam in majority of areas and lateritic in the remaining areas (Fig. 1 and 2).

Selection of Land use Systems

From the northern transect of Bengaluru, six major land use systems were identified *viz.*, agriculture, horticulture, forest, sericulture, organic farming and fallow land use systems.

Soil Sampling and Analysis

From each land use system, twenty surface soil samples were collected at a depth of 0 to 15 cm (Kader & Perera, 2018). One hundred and twenty representative surface soil samples were collected which were geo-referenced and placed in polythene

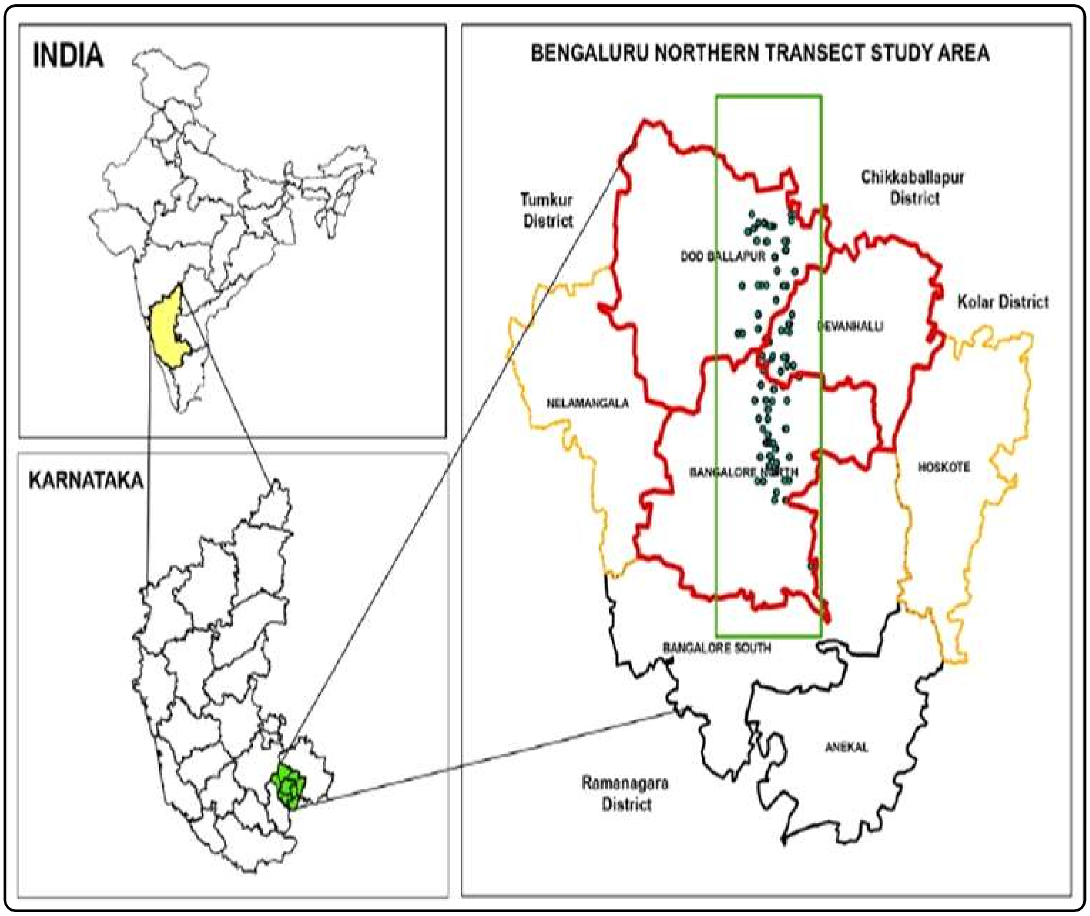

Fig. 1 : Northern transect of Bengaluru

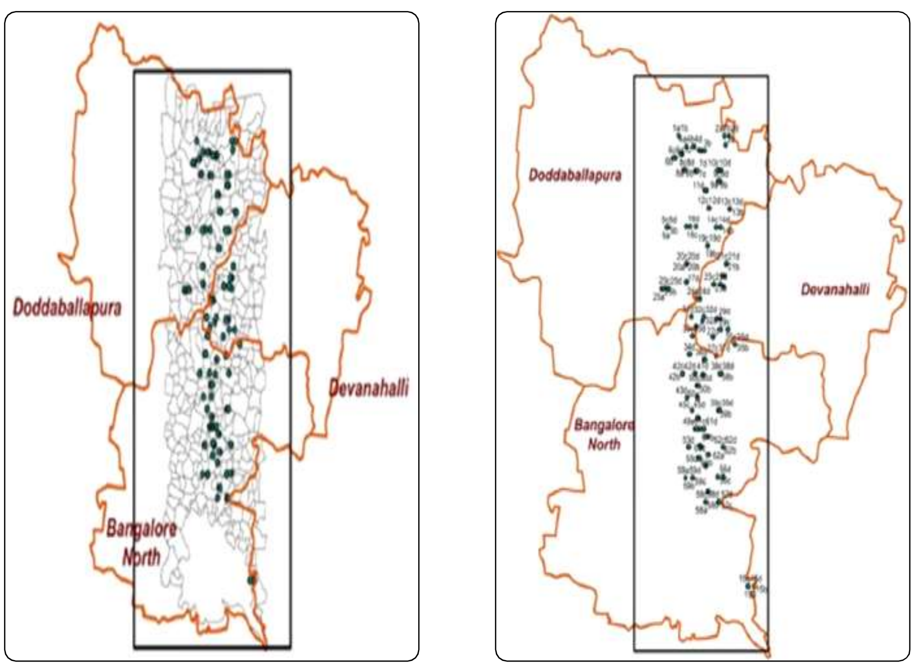

Fig. 2 : Location of grid points in study area, northern transect of Bengaluru

TABLE 1

Standard analytical methods followed for analysis of soil fertility parameters

Soil fertility parameters	Standard analytical methods
Soil texture	International pipette method (Jackson, 1973)
pH (1:2.5)	Potentiometry (Jackson, 1973)
EC (1:2.5) (dS m^{-1})	Conductometry (Jackson, 1973)
OC (g kg^{-1})	Wet oxidation method (Walkley and Black, 1965)
Available N (kg ha^{-1})	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	Brays No. 1 method for acidic soils (Jackson, 1973)
	Olesen's method for neutral and alkaline soils (Jackson, 1973)
Available K_2O (kg ha^{-1})	Flame photometry (Jackson, 1973)
Exchangeable Ca and Mg [cmol (p+) kg^{-1}]	Versenate titration method (Jackson,1973)
Available S (mg kg^{-1})	Turbidometry method (Black, 1965)
Available Zn, Fe, Mn and Cu (mg kg^{-1})	DTPA extraction and AAS method (Lindsay and Norvel, 1978)
Available B (mg kg^{-1})	Hot water extraction method (Page *et al.,*1982)
Soil microbial biomass carbon and phosphorus	Chloroform fumigation method (Jenkinson and Powlson, (1976)

cover with proper labelling. Collected soil samples were air-dried, ground using a wooden pestle and mortar and sieved using 2 mm sieve. Processed soil samples were analyzed for different fertility parameters by using standard analytical procedures as detailed in Table 1.

Statistical Analysis and Data Interpretation

One-way statistical analysis was used (Gopinath *et al.,* 2020) for comparing soil fertility characteristics among different land use systems in the northern transect of Bengaluru. The level of significance used for determining the significant difference was 5 per cent. Duncan's Multiple Range Test (DMRT) was used to identify significant differences between treatment means after a significant ANOVA has been performed.

RESULTS AND DISCUSSION

Soil Texture

Soil texture in different land use systems is presented in Table 2. There was a significant difference between different land use systems with respect to sand, silt and clay content. Soil texture under different land use systems varied from sandy clay loam (Agriculture and fallow land use systems) to sandy clay (Horticulture, Forest, Sericulture and Organic farming land use systems). Agriculture and fallow land use systems have recorded significantly higher values of sand content (56.46 and 53.92%, respectively) which were on par with each other

TABLE 2

Texture of the surface soils in different land use systems of northern transect of Bengaluru

Land use system	Sand	Silt	Clay
	(%)		
Agriculture	56.46 a	13.18 b	30.36 c
Horticulture	49.95 c	10.77 ef	39.28 a
Forest	47.59 c	11.34 e	41.07 a
Sericulture	49.97 c	14.82 a	35.21 b
Organic farming	51.18 bc	12.49 bc	36.33 b
Fallow	53.92 ab	12.23 cd	33.85 b

Note : Values within a column followed by the same letter do not differ significantly (DMRT test, P ≤ 0.05) while significantly lower value of sand content was recorded in forest land use system (47.59%). Similar trend was observed by Shreshma and Subbarayappa (2023) in the soils of northern transect of Bengaluru. The silt content ranged from 10.77 to 14.82 per cent across different land use systems with significantly higher values observed in case of sericulture land use system (14.82%). Significantly higher values of clay content were recorded in forest and horticulture land use systems with mean values of 41.07 and 39.28 per cent, respectively, which were on par with each other, while significantly lower value of clay content was recorded in agriculture land use system (30.36%). Routine farming activities like ploughing and harrowing may contribute to lower clay content in the surface layer, likely by disrupting the top soil and facilitating clay particle migration to sub-surface layers. Mulugeta *et al.* (2019) documented the occurrence of preferential clay particle removal and its subsequent migration into the subsurface soil layer through the process of clay migration. Chemeda *et al.* (2017) observed that the clay content in cultivated soil progressively increased from the surface to the subsurface soil layer due to prolonged cultivation practices. Gebrelibanos and Assen (2013) reported that lower clay and higher sand content was noticed in the surface layer and higher clay content was observed in the subsurface layer of cultivated land than the adjacent natural forest, plantation forest and grazing lands. The variations in soil texture across different land use systems directly influence soil chemical properties by affecting water retention ability, soil pH buffering, organic carbon status and nutrient adsorption.

Chemical Properties

The chemical properties of the surface soils in different land use systems is detailed in Table 3.

TABLE 3

Chemical properties of the surface soils in different land use systems of northern transect of Bengaluru

Land use system	pH	EC ($dS\ m^{-1}$)	OC ($g\ kg^{-1}$)
		(%)	
Agriculture	5.56 [ab]	0.44 [ab]	6.0 [c]
Horticulture	5.97 [a]	0.48 [a]	6.80 [c]
Forest	5.38 [b]	0.15 [d]	19.60 [a]
Sericulture	5.84 [ab]	0.39 [b]	5.90 [c]
Organic farming	6.08 [a]	0.43 [bc]	12.40 [b]
Fallow	5.61 [ab]	0.21 [c]	2.70 [d]

Note : Values within a column followed by the same letter do not differ significantly (DMRT test, $P \leq 0.05$)

The study area was dominated by red soil (*Alfisols*) regardless of different land use systems. Soil pH of the study area was found to be varying from strongly acidic to slightly acidic. This trend of reduced pH levels might be due to the presence of red soil, a characteristic feature resulting from the presence of granite parent material along the northern transect of Bengaluru. Similar observations were reported by Shen *et al.* (2021). Significantly lower soil pH was recorded in forest land use system (5.38) dominated by Eucalyptus trees which was on par with agriculture land use system (5.56). Seyoum (2016) reported the lowest soil pH under Eucalyptus plantation as compared to other land use systems in the highlands of Ethiopia. The lowest soil pH in Eucalyptus plantations might be associated with more uptake of basic cations by the trees roots and poor litter return rate to the soil. Moreover, loss of base-forming cations downward the soil profile through leaching and continuous use of ammonium-based fertilizers such as di-ammonium phosphate ($(NH_4)_2HPO_4$) in the cultivated fields could have contributed to high acidity level. Organic farming and horticulture land use systems have recorded significantly higher soil pH values (6.08 and 5.97, respectively) when compared to forest land use system. Variation in soil pH under different land use systems observed in the present study might be regulated by turnover and the decomposition rate of residues and time as reported by Mishra *et al.* (2004) and Minhas *et al.* (2007).

The soils of the study area were non saline in nature irrespective of different land use systems. EC was recorded significantly lower in forest land use system (0.15 dS m^{-1}), while, significantly higher value was observed in horticulture land use system (0.48 dS m^{-1}). In horticulture land use systems, application of inorganic fertilizers might have increased the soluble salt content in the surface soils. Similar results were found by Sahrawat *et al.* (2014) who reported that soil EC was higher in inorganic nutrient management systems due to soluble salt build up in the soil. As there was no external input of inorganic fertilizers in forest and fallow land use systems, EC was recorded low. Rakshita *et al.* (2025) opined that lower EC in forest soils might be due to the downward movement of basic cations through leaching which is attributed to lower bulk density and high porosity of soils.

Forest land use system has recorded significantly higher SOC content (19.60 g kg^{-1}) followed by organic farming land use system (12.40 g kg^{-1}) (Fig. 3). Rakshita *et al.* (2025) observed higher SOC content in forest and coffee land use systems which was attributed to the significant litter biomass addition and reduced oxidation due to less soil disturbance. Similar findings were reported by Nagaraja (1997). Significantly lower SOC content was recorded in fallow land use system (2.70g kg^{-1}) which might be due to the non-application of organic matter (Gupta *et al.,* 2012). These chemical properties directly influence the availability and dynamics of plant nutrients by regulating their mineralization rates, solubility, fixation and leaching losses across different land use systems.

Available Primary Nutrients

The available primary nutrient status in different land use systems is detailed in Table 4 and Fig.4.

Significantly higher available N was recorded in horticulture land use system (400.54 kg ha^{-1}) which was on par with agriculture land use system (384.35 kg ha^{-1}). Direct and extensive use of inorganic fertilizers like urea and DAP might have increased the available N content in the agriculture and horticulture land use systems (Shivakumar *et al*., 2020).

Available N content in land use systems like sericulture, forest and organic farming were on par with each other (356.78, 323.71 and 314.15 kg ha^{-1},

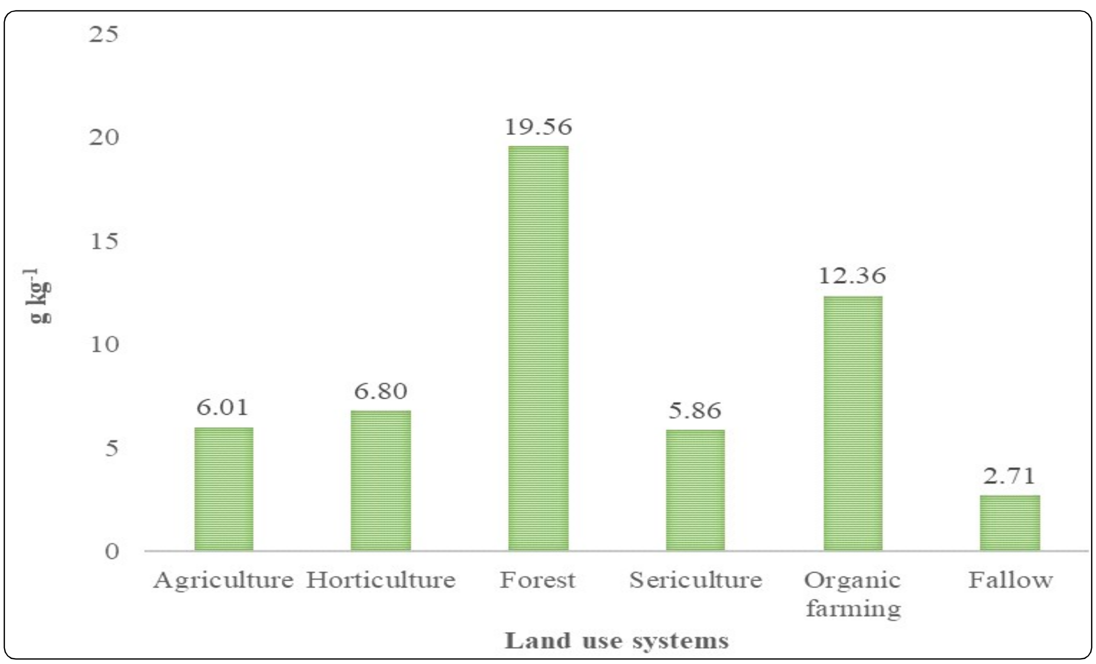

Fig. 3 : Soil organic carbon (OC) status under different land use systems of northern transect of Bengaluru

TABLE 4

Available primary nutrient status of the surface soils in different land use systems of northern transect of Bengaluru

Land use system	N	P_2O_5	K_2O
	(kg ha^{-1})		
Agriculture	384.35 a	108.65 a	257.58 ab
Horticulture	400.54 a	113.30 a	282.91 a
Forest	323.71 b	32.23 bc	247.99 ab
Sericulture	356.78 ab	36.18 b	234.53 bc
Organic farming	314.15 b	39.15 b	220.02 bc
Fallow	205.22 c	21.03 c	199.69 c

Note : Values within a column followed by the same letter do not differ significantly (DMRT test,$P \leq 0.05$)

respectively). Significantly lower value of available N was recorded in fallow land use system (205.22 kg ha^{-1}). This may be due to the non-application of N containing fertilizers and organic matter addition. Similar findings were reported by Mandal *et al.* (2018). Lower available N content recorded in fallow land use system might also be due to reduced litter inputs and SOC loss from previous cultivation. Livestock grazing and soil exposure can increase runoff, removing residues and thus depleting soil N (Rakshita *et al.,* 2025).

Significantly higher available P_2O_5 was recorded in horticulture land use system (113.30 kg ha^{-1}) which was on par with agriculture land use system (108.65 kg ha^{-1}). The available P_2O_5 content in case of organic farming, sericulture and forest land use systems were on par with each other (39.15, 36.18 and 32.23 kg ha^{-1}, respectively). Significantly lower P_2O_5 content (21.03 kg ha^{-1}) was recorded in fallow land use system.

Significantly higher available P_2O_5 content recorded in horticulture and agriculture land use systems might be due to the continuous application of phosphatic fertilizers (DAP, SSP, *etc.*) and manures. In cultivated lands, decomposition of organic matter will be more and release available phosphorusata fasterrate due to the lower C/P ratio than forest land system (Bolan *et al.,* 2012). Kaiser *et al.* (2012) and Liang *et al.* (2018) also reported a higher C/P ratio in forest land use system than in cultivated land use systems.

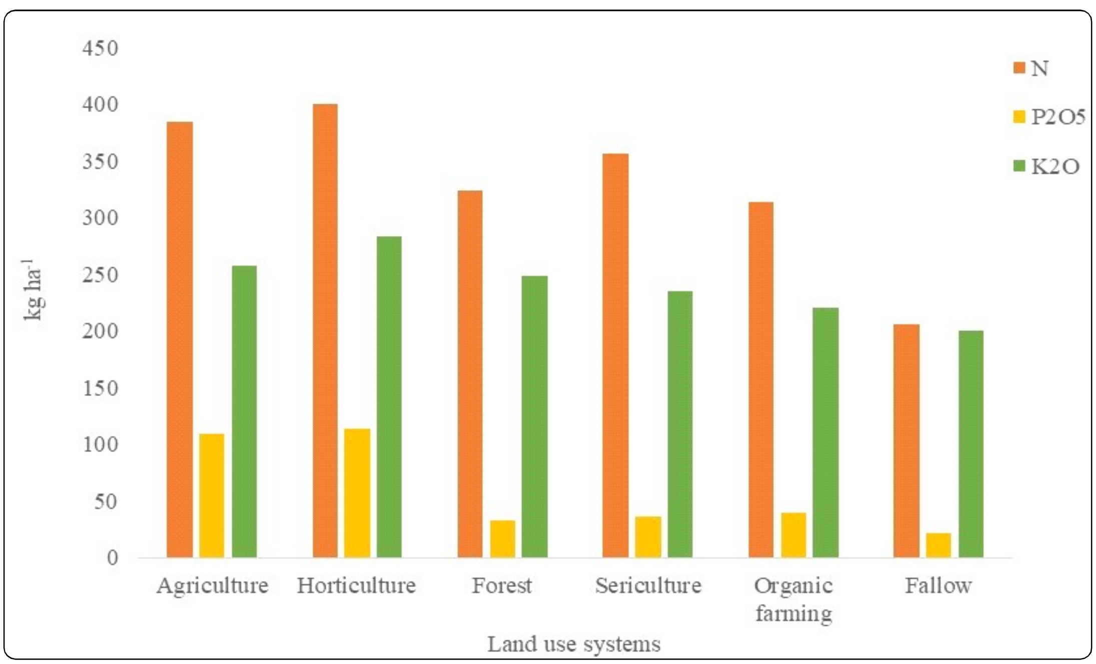

Fig. 4 : Available nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) status under different land use systems of northern transect of Bengaluru

Kaur and Bhat (2017) observed that available P was significantly higher in cropland compared with forestry and grassland.

Significantly higher K_2O content was recorded in horticulture land use system (282.91 kg ha^{-1}) which was on par with agriculture and forest land use systems (257.58 and 247.99 kg ha^{-1}) while significantly lower K_2O content was recorded in fallow land use system (199.69 kg ha^{-1}). Higher K_2O content in horticulture and agriculture land use systems might be due to continuous application of potassic fertilizers. Forest land use system could maintain available potassium levels similar to that of cultivated land use systems which may be due to the dominance of eucalyptus tree species in the forest land use systems that have a high affinity for potassium ions (Gazola e*t al.,* 2019). The study conducted by Pathakand Fagodiya (2022) revealed that Indian farmers usually do not apply the recommended dose of potassium fertilizer in cultivated fields which is also one of the reasons for non-significant level of potassium in cultivated and forest land use systems. Kaur and Bhat (2017) reported that significantly higher potassium content was recorded in cropland compared to agro-forestry and grassland. Studies by Anil kumar (2002) and Ananthkumar (2011) reported high potassium levels in horticulture systems due to excessive potassium fertilization. Forest systems have lower available K_2O compared to horticulture plantations, likely due to the absence of potassic fertilizers, crop removal and slower mineralization rate of SOM.

Available Secondary Nutrients

The available secondary nutrient status in different land use systems is detailed in Table 5.

Organic farming land use system has recorded significantly higher exchangeable calcium content (5.89 cmol (p+) kg^{-1}) which was on par with horticulture and sericulture land use systems (5.73 and 5.44 cmol (p+) kg^{-1}, respectively). Higher exchangeable Ca content inorganic farming land use system might be due to several interrelated management practices. Organic farming relies heavily on the addition of compost, manures and sometimes naturally derived mineral sources (such as lime or gypsum) that are rich in Ca. Farmers often apply Ca-rich liming materials more extensively in horticulture fields than in agriculture. This increased usage of liming materials contributes to the higher levels of exchangeable Ca in horticulture land use system (Martķn-Diana *et al.,* 2007). Similar trends of higher exchangeable Ca content in apple orchards as compared to wheat fields were reported by Gupta and Sharma (2010). Significantly lower exchangeable Cacontent was recorded in forest land use system (3.92 cmol (p+) kg^{-1}) which might be due to the leaching of Ca^{+2} ions from top soil layers to sub surface layers. The other reason is the fast-growing nature of eucalyptus trees which largely absorbs basic cations and hence reducing the Ca content in soils (Demessie *et al*., 2012). These values were on par with fallow and agriculture land use systems (4.32 and 4.03 cmol(p+) kg^{-1}). The absence of vegetation and inadequate soil cover in fallow lands can lead to increased erosion and the removal of Ca-rich topsoil through surface runoff (Luo *et al.,* 2023). Exchangeable Mg content was recorded significantly higher in sericulture land use system (2.67 cmol (p+) kg^{-1}) which was on par with organic farming and horticulture land use systems (2.58 and 2.41 cmol

TABLE 5

Available secondary nutrient status of the surface soils in different land use systems of northern transect of Bengaluru

Land use system	Exch. Ca (cmol (p+) kg^{-1})	Exch. Mg (cmol (p+) kg^{-1})	Available S (mg kg^{-1})
Agriculture	4.03 b	1.64 b	14.01 b
Horticulture	5.73 a	2.41 a	19.34 a
Forest	3.92 b	1.53 b	16.16 b
Sericulture	5.44 a	2.67 a	15.36 b
Organic farming	5.89 a	2.58 a	19.27 a
Fallow	4.32 b	1.86 b	9.23 c

Note : Values within a column followed by the same letter do not differ significantly (DMRT test, $P \leq 0.05$)

(p+) kg^{-1}), which might be due to specific management practices followed in these land use systems. Significantly lower Mg content was recorded in forest land use system (1.53 cmol (p+) kg^{-1}) which was on par with fallow and agriculture land use systems (1.86 and 1.64 cmol (p+) kg^{-1}), respectively). The lower Mg content in forest soils might be due to the sustained leaching, soil acidity, limited replenishment and competitive processes that limit Mg availability compared to more intensively managed land use systems. Significantly higher S content was observed in horticulture land use system (19.34 mg kg^{-1}) which was on par with organic farming land use system (19.27 mg kg^{-1}).

Higher available S recorded in horticulture land use system may be due to the application of sulfur-containing fertilizers, such as ammonium sulfate or elemental sulfur (Kaushik *et al.,* 2018). The available S content was on par with each other in land use systems like forest, sericulture and agriculture (16.16, 15.36 and 14.01 mgkg^{-1}, respectively). Pradeep and Krishnamurthy (2023) reported that when compared to agriculture land use system (finger millet) the available S level in soils under agroforestry was much higher followed by mango and natural forest which might be due to higher SOC content that reduces sulphate ion leaching. Available Scontent infallow land use system (9.23 mg kg^{-1}) recorded significantly low, which might be due to non-application of manures, S containing fertilizers and also possibly due to run off losses.

Available Micronutrients

The available micronutrient status in different land use systems is detailed in Table 6.

The DTPA extractable Fe content was recorded significantly higher in forest land use system (28.15 mg kg^{-1}) which was on par with organic farming land use system (25.54 mg kg^{-1}). The DTPA extractable Fe content of sericulture, agriculture, horticulture and fallow land use systems were on par with each other (20.73, 18.73,18.25 and 17.09 mg kg^{-1}, respectively).

DTPA extractable Mn content was significantly higher in organic farming land use system (19.78 mg kg^{-1}) followed by forest, sericulture, horticulture, agriculture and fallow land use systems (17.79, 14.55,13.67,11.33 and 10.70 mg kg^{-1}, respectively). DTPA extractable Zn content of forest land use system (0.72 mg kg^{-1}) was recorded significantly higher followed by horticulture and organic farming (0.53 and 0.52 mg kg^{-1}, respectively) land use systems which were on par with each other. Sericulture and fallow land use systems (0.21 and 0.14 mg kg^{-1}, respectively) recorded significantly lower DTPA extractable Zn content among different land use systems. DTPA extractable Cu content was recorded

TABLE 6
Available micro nutrient status of the surface soils in different land use systems of northern transect of Bengaluru

Land use system	Fe	Mn	Zn	Cu	B
	(mg kg^{-1})				
Agriculture	18.73 ^{b}	11.33 ^{cd}	0.41 ^{c}	0.18 ^{c}	0.33 ^{c}
Horticulture	18.25 ^{b}	13.67 ^{bc}	0.53 ^{b}	0.15 ^{d}	0.47 ^{a}
Forest	28.15 ^{a}	17.79 ^{a}	0.72 ^{a}	0.25 ^{b}	0.27 ^{d}
Sericulture	20.73 ^{b}	14.55 ^{b}	0.21 ^{c}	0.12 ^{e}	0.41 ^{b}
Organic farming	25.54 ^{a}	19.78 ^{a}	0.52 ^{b}	0.28 ^{a}	0.31 ^{c}
Fallow	17.09 ^{b}	10.70 ^{d}	0.14 ^{d}	0.10 ^{f}	0.12 ^{e}

Note : Values within a column followed by the same letter do not differ significantly (DMRT test,P £ 0.05) significantly higher in organic farming land use system (0.28 mg kg^{-1}), followed by forest and agriculture land use system with mean values of 0.25 and 0.18 mg kg^{-1}, respectively. Fallow land use system recorded significantly lower values of DTPA extractable Cu content (0.10 mg kg^{-1}). Hot water soluble B content in horticulture land use system (0.47 mg kg^{-1}) was found to be significantly higher followed by sericulture land use system (0.41 mg kg^{-1}) whereas significantly lower B content was recorded in fallow land use system with mean value of 0.12 mg kg^{-1}. The micronutrient contents of the soil are generally influenced by various soil parameters, including pH, organic matter and soil moisture content, as mentioned by Komarek *et al.* (2010). These factors play a significant role in determining the availability and uptake of micronutrients by plants in the soil. Onwudike *et al.* (2017) reported that forest land use system has recorded the highest concentrations of available Mn, Zn and B in the sequence forest land > cassava dominated farm land > maize dominated farm land. Rakshita *et al.* (2025) opined that relatively high concentration of micronutrients in forest and pasture might be due to high organic matter and slightly acidic nature of forest soils. Pradeep and Krishnamurthy (2023) reported that DTPA extractable Fe, Mn, Cu and Zn availability depends on soil pH, organic matter content, adsorptive surfaces, other physical, chemical and biological conditions in the soil rhizosphere. They further stated that the difference in micronutrient status of soils under different land uses could be attributed to variation in micronutrient concentration and rate of decomposition of litter.

Soil Microbial Biomass Carbon (MBC) and Phosphorus (MBP) Content

The status of soil MBC and MBP in different land-use systems is presented in Table 7. There was a significant difference between different land use systems with respect to soil MBC and MBP content. Forest land use system has recorded significantly higher values of MBC and MBP with mean values of 447.12 and 25.45 mg kg^{-1}, respectively followed by organic farming land use system (383.45 mg kg^{-1} and 19.52 mg kg^{-1}, respectively). Significantly lower MBC and MBP contents were recorded in fallow land use system (133.87 and 3.78 mg kg^{-1}). This may be due to less microbial community accompanied by less substrate availability (organic matter) in fallow land use system. Similar trend was observed by Shreshma and Subbarayappa (2023) in soils of northern transect of Bengaluru. Decrease in SOC causes decrease in soil microbial biomass (Chen *et al*., 2005). This is evident from the positive relationship of MBC and MBP with SOC observed in current study, which is in agreement with the findings of Wang and Wang (2007).

TABLE 7

Soil microbial biomass carbon (MBC) and phosphorus (MBP) content of surface soils in different land use systems of northern transect of Bengaluru

Land use system	MBC	MBP
	(mg kg^{-1})	
Agriculture	276.50 d	10.89 d
Horticulture	311.36 c	13.94 c
Forest	447.12 a	25.45 a
Sericulture	260.79 d	8.33 e
Organic farming	383.45 b	19.52 b
Fallow	133.87 e	3.78 f

Note : Values within a column followed by the same letter do not differ significantly (DMRT test, P ≤ 0.05

The study demonstrates that both intensive agricultural management and natural land use systems have unique impacts on soil fertility characteristics, with fertilized horticultural and agricultural lands supporting higher nutrient availability, forests retaining greater organic carbon and micronutrients and organic farming benefiting secondary nutrient status through organic inputs while fallow lands showed nutrient depletion. These findings emphasize the need for site-specific soil management strategies to maintain long-term fertility and sustainable cropping across diverse land uses.

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