



Plant Archives

Journal homepage: <http://www.plantarchives.org>

DOI Url : <https://doi.org/10.51470/PLANTARCHIVES.2026.v26.no.2.075>

SOIL PROPERTIES AND NUTRIENT DYNAMICS UNDER DIFFERENT BAMBOO SPECIES IN SUB-MONTANE ZONE OF MAHARASHTRA INDIA

Rashmi Jakhar*, Gajbhiye P.N. and Krishan Kumar Sharma

Department of Soil Science and Agricultural Chemistry, RSCM Govt. College of Agriculture, Kolhapur, Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahilyanagar, Maharashtra-413 772, India

*Corresponding author E-mail: rashmijakhar2001@gmail.com

(Date of Receiving-27-05-2026; Date of Revision-28-07-2026; Date of Acceptance-19-08-2026)

ABSTRACT

Bamboo plantations play a significant role in improving soil quality through litter decomposition, root turnover, and efficient nutrient cycling. The present investigation was conducted to evaluate the influence of different bamboo species on soil physical properties and the available and total nutrient status of rhizosphere soil under the sub-montane conditions of Maharashtra after 15 years of plantation establishment. Rhizosphere soil samples (0–15 cm depth) were collected from six bamboo species, namely *Bambusa tulda*, *Bambusa balcooa*, *Bambusa bambos*, *Dendrocalamus asper*, *Dendrocalamus strictus*, and *Melocanna baccifera*, laid out in a randomized block design (RBD) with four replications. The results revealed a marked improvement in soil properties and nutrient status under all bamboo species compared with the baseline soil. Although soil bulk density did not differ significantly among the species, *Dendrocalamus strictus* recorded the lowest numerical bulk density (1.32 Mg m^{-3}) and a significantly higher maximum water-holding capacity (38.48%). Soil pH, electrical conductivity (EC), and calcium carbonate content were not significantly influenced by bamboo species; however, soil organic carbon increased substantially under all bamboo plantations relative to the baseline soil. Among the species, *Dendrocalamus strictus* recorded the highest soil organic carbon content (13.0 g kg^{-1}), followed by *Bambusa tulda*. The highest available nitrogen (348 kg ha^{-1}), phosphorus (15.90 kg ha^{-1}), potassium ($150.40 \text{ kg ha}^{-1}$), sulphur (28.92 mg kg^{-1}), and zinc (1.22 mg kg^{-1}) were also observed under *Dendrocalamus strictus*. Furthermore, this species exhibited comparatively higher total major and micronutrient contents, indicating enhanced nutrient cycling and greater nutrient accumulation in the rhizosphere. Overall, the findings demonstrate that bamboo species exert a significant influence on soil physico-chemical properties and nutrient dynamics. Among the species evaluated, *Dendrocalamus strictus*, followed by *Bambusa tulda*, showed the greatest potential for improving soil fertility and sustaining soil health under the sub-montane conditions of Maharashtra.

Key words: Available nutrients, Bamboo species, soil properties, total nutrient,

Introduction

Bamboo, a fast-growing perennial woody grass of the family Poaceae and subfamily Bambusoideae, is among the most productive plant groups of the tropical and subtropical world. Its vigorous growth, extensive root-rhizome network, and continuous biomass production enable bamboo stands to modify soil physical conditions and drive nutrient cycling, making it a valuable species for ecosystem restoration and sustainable land management (Sujatha *et al.*, 2008; Dasog, 1995). Globally, bamboo occupies nearly 37 million hectares, accounting

for about 3.2 per cent of the forest area of bamboo-growing nations (Lobovikov *et al.*, 2007), while India, home to roughly 144 species across six subfamilies, ranks second only to China in bamboo genetic resources, with an estimated standing stock of 189 million tonnes (Tewari *et al.*, 2019; Sharma and Nirmala, 2015). The rhizosphere is among the most biologically dynamic zones of the soil profile, where root activity, litter decomposition, and microbial processes interact to govern nutrient release and retention. In bamboo systems, continuous litterfall, sheath shedding, root turnover, and rhizodeposition supply

organic residues that undergo mineralization, improving nutrient availability and soil structural conditions (Liese and Köhl, 2015; Kaushal *et al.*, 2022). Species-specific differences in litter quantity and quality, decomposition rate, and rooting behaviour, however, mean that not all bamboo species influence the rhizosphere equally- thick-walled, high-biomass species such as *Bambusa balcooa* and *Dendrocalamus strictus* contribute substantial litter loads, whereas fast-growing species such as *Melocanna baccifera* and *Bambusa tulda* favour rapid decomposition and quicker nutrient turnover (Liese and Köhl, 2015; Gogoi and Bhuyan, 2016).

Soil physical properties such as bulk density and water-holding capacity are fundamental determinants of root proliferation, aeration, and moisture availability, while the available and total status of macronutrients and micronutrients together define both immediate fertility and long-term nutrient reserves. Whereas, total-nutrient status reflects the soil's underlying capacity to sustain fertility over time; jointly, they offer a more complete picture of how vegetation shapes nutrient dynamics than either measure alone (Cai *et al.*, 2018; Kumar *et al.*, 2021). In Maharashtra, bamboo is distributed across diverse agro-climatic tracts such as the Western Ghats, the Konkan coastal belt, Vidarbha, and the sub-montane zones where variation in rainfall, temperature, and soil type produces marked differences in species growth and soil-modifying capacity (FSI, 2021). The soils of the Kolhapur region, representative of this sub-montane zone, are classified as Entisols on gently undulating terrain (slope 5.0–6.5%), conditions under which erosion and nutrient loss through runoff are recurring concerns. Bamboo cultivation on such sloping land has been proposed as an effective means of reducing runoff losses and stabilizing soil (Gaikwad *et al.*, 2022; Shinde *et al.*, 2023).

Although the general soil-improving role of bamboo is well established, comparative evidence on how individual bamboo species differentially influence rhizosphere physico-chemical properties and available/total nutrient pools under the specific edaphic and climatic conditions of sub-montane Maharashtra remains limited. Given that species selection can materially affect the degree of soil improvement achieved, such comparative data are essential for recommending suitable species for soil restoration and agroforestry planning in this zone.

The present investigation was therefore undertaken to evaluate the influence of six bamboo species viz. *Bambusa tulda*, *Bambusa balcooa*, *Bambusa bambos*, *Dendrocalamus asper*, *Dendrocalamus strictus*, and *Melocanna baccifera* on rhizosphere soil properties and

available and total major and micronutrients, under the sub-montane conditions of Maharashtra. The findings are expected to inform species selection for soil fertility improvement and sustainable bamboo-based land-use systems in the region.

Materials and Methods

Experimental site

The present investigation was conducted at the Zonal Agricultural Research Station (ZARS), Shenda Park, Kolhapur, Maharashtra. The experimental site is situated in the sub-montane zone of Maharashtra at an elevation of approximately 605 m above mean sea level, at 16°42' 17.24" N latitude and 74°14' 10.74" E longitude. The bamboo plantation was established in September 2010 and comprised six bamboo species grown under uniform management practices. The soil of the experimental field belongs to the *Entisol* order. The area has gently undulating topography with an approximately 5% slope. Laboratory analysis of the soil samples was carried out at the Department of Soil Science, Zonal Agricultural Research Station, Kolhapur.

Climate

The experimental site experiences a humid tropical climate. The average annual rainfall ranges from 900 to 1200 mm and is received mainly during the southwest monsoon from June to September. The mean maximum temperature ranges from 32 to 36°C during summer, whereas the mean minimum temperature ranges from 14 to 18°C during winter.

Experimental details

The field experiment was conducted in a Randomized Block Design with six bamboo species as treatments and four replications. The bamboo plantation was established in September 2010 at a spacing of 5.0 × 5.0 m under uniform management practices. The treatments consisted of *Bambusa tulda* (T₁), *Bambusa balcooa* (T₂), *Bambusa bambos* (T₃), *Dendrocalamus asper* (T₄), *Dendrocalamus strictus* (T₅) and *Melocanna baccifera* (T₆).

Soil sampling

Composite rhizosphere soil samples were collected from each bamboo species during the active growing season in 2025 from a depth of 0–15 cm. The samples were air-dried, gently crushed using a wooden mortar and pestle, and passed through a 2-mm sieve before analysis. Soil samples collected from a nearby non-bamboo area having similar soil characteristics were used as baseline samples for comparison.

Table 1. Soil physical properties as influenced by different bamboo species.

Treatment/Bamboo species	BD (Mg m ⁻³)	MWHC (%)
<i>Bambusa tulda</i>	1.34	37.85
<i>Bambusa balcooa</i>	1.34	37.76
<i>Bambusa bambos</i>	1.33	38.05
<i>Dendrocalamus asper</i>	1.34	37.80
<i>Dendrocalamus strictus</i>	1.32	38.48
<i>Melocanna baccifera</i>	1.34	37.70
Baseline Samples	1.41	35.15
SEm _±	0.003	0.15
CD at 5 %	NS	0.43

Soil analysis

The soil samples were analysed using standard analytical procedures for the determination of soil physical properties, available nutrients and total nutrient contents.

Soil physical properties: Bulk density was determined by the core method (Piper, 1950). Maximum water holding capacity was estimated using the Keen's box method as described by Blake and Hartge (1986).

Available nutrients: Available nitrogen was determined by the alkaline permanganate method (Subbiah and Asija, 1956). Available phosphorus was extracted using 0.5 M sodium bicarbonate (pH 8.5) and determined calorimetrically by the method of Watanabe and Olsen (1965). Available potassium was extracted using 1 N neutral ammonium acetate at pH 7.0 and determined using a flame photometer (Jackson, 1973). Available sulphur was estimated by the turbidimetric method (Chesnin and Yien, 1950). Available micronutrients, namely iron, manganese, copper and zinc, were extracted using the DTPA extraction method and determined using an Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978).

Total nutrients: Total nitrogen was determined by the Kjeldahl digestion method (Bremner, 1996). Total phosphorus, potassium, sulphur and micronutrients were determined after hydrofluoric acid–perchloric acid digestion following the procedure described by Jackson (1958). Total phosphorus was measured calorimetrically using a spectrophotometer, total potassium using a flame photometer, total sulphur by the turbidimetric method, and total micronutrients using Atomic Absorption Spectrophotometry.

Statistical analysis

The experimental data were subjected to analysis of variance appropriate for a Randomized Block Design as described by Panse and Sukhatme (1985). The significance of treatment differences was tested at the

Table 2: Soil chemical properties as influenced different bamboo species.

Treatment/Bamboo species	pH (1:2.5)	EC (dSm ⁻¹)	CaCO ₃ (%)	Org. C (g kg ⁻¹)
<i>Bambusa tulda</i>	6.82	0.12	0.875	11.6
<i>Bambusa balcooa</i>	6.73	0.13	0.844	11.4
<i>Bambusa bambos</i>	6.76	0.13	0.937	10.2
<i>Dendrocalamus asper</i>	6.73	0.13	0.875	9.8
<i>Dendrocalamus strictus</i>	6.67	0.12	0.872	13.0
<i>Melocanna baccifera</i>	6.80	0.13	0.904	9.2
Baseline Samples	7.05	0.14	1.1	5.1
SEm _±	0.08	0.01	0.06	0.606
CD at 5 %	NS	NS	NS	1.825

5% probability level. The standard error of mean (SEm_±) and critical difference (CD) were calculated wherever treatment effects were significant.

Results and Discussion

Soil physical properties

Bulk density was not significantly affected by bamboo species and ranged from 1.32 to 1.34 Mg m⁻³ (Table 1). The lowest bulk density was recorded under *Dendrocalamus strictus* (1.32 Mg m⁻³), whereas the highest value (1.34 Mg m⁻³) was observed under *Bambusa tulda*, *Bambusa balcooa*, *Dendrocalamus asper*, and *Melocanna baccifera*. All bamboo species recorded lower bulk density than the baseline soil (1.41 Mg m⁻³), indicating an improvement in soil physical condition under bamboo plantations.

Maximum water holding capacity (MWHC) was significantly influenced by bamboo species and varied from 37.70 to 38.48%. The highest value was recorded under *D. strictus* (38.48%), followed by *Bambusa bambos* (38.05%), while the lowest was recorded under *Melocanna baccifera* (37.70%). The improvement in soil physical properties may be attributed to continuous litter deposition, root biomass production, and enhanced soil aggregation under bamboo plantations, resulting in lower bulk density and improved moisture retention. The results are in accordance with those of Nath *et al.*, (2015), Kaushal *et al.*, (2020), Gaikwad *et al.*, (2022), and Shinde *et al.*, (2023).

Soil chemical properties

Soil pH and electrical conductivity (EC) were not significantly influenced by bamboo species. Soil pH ranged from 6.67 to 6.82, while EC varied from 0.12 to 0.13 dS m⁻¹ (Table 2). The lower pH values observed under bamboo plantations compared with the baseline soil may be attributed to decomposition of bamboo litter and release of organic acids during microbial activity. The consistently

Table 3: Soil available macronutrient status as influenced by different bamboo species.

Treatment/ Bamboo species	Soil available macro nutrients			
	N	P	K	S
	(kg ha ⁻¹)			(mg kg ⁻¹)
<i>Bambusa tulda</i>	335	15.7	144.8	28.03
<i>Bambusa balcooa</i>	329	15.2	146.4	26.65
<i>Bambusa bambos</i>	326	15.0	139.2	25.93
<i>Dendrocalamus asper</i>	314	15.4	138.0	22.71
<i>Dendrocalamus strictus</i>	348	15.9	150.4	28.92
<i>Melocanna baccifera</i>	322	14.8	135.2	21.21
Baseline samples	256	10.3	76.7	19.18
SEm±	5.2	0.49	3.15	1.42
CD at 5%	15.6	NS	9.48	4.27

low EC values indicated that bamboo plantations maintained favourable soil conditions without causing salt accumulation.

Organic carbon content was significantly influenced by bamboo species. The highest value was recorded under *D. strictus* (13.0 g kg⁻¹), followed by *B. tulda* (11.6 g kg⁻¹) and *B. balcooa* (11.4 g kg⁻¹), while the lowest was recorded under *M. baccifera* (9.2 g kg⁻¹). Calcium carbonate content did not differ significantly among treatments and ranged from 0.844 to 0.937%. All bamboo species recorded higher organic carbon and lower calcium carbonate content than the baseline soil. The increase in organic carbon may be attributed to continuous litter deposition, fine-root turnover, and decomposition of organic residues, while the reduction in calcium carbonate may be associated with enhanced biological activity and carbonate dissolution in the rhizosphere. The findings are in line with that of Majumdar *et al.*, (2005), Kaushal *et al.*, (2020), Kumar *et al.*, (2021), and Shinde *et al.*, (2023).

Available macronutrient status

Available nitrogen, potassium, and sulphur were significantly influenced by bamboo species, whereas available phosphorus showed non-significant variation (Table 3.). The highest available nitrogen was recorded under *D. strictus* (348 kg ha⁻¹), statistically at par with *B. tulda* (335 kg ha⁻¹), while the lowest was observed under *D. asper* (314 kg ha⁻¹). Available phosphorus ranged from 14.80 to 15.90 kg ha⁻¹ with no significant difference among species. The highest available potassium was recorded under *D. strictus* (150.40 kg ha⁻¹), followed by *B. balcooa* (146.40 kg ha⁻¹), while the lowest was under *D. asper*. Available sulphur also varied significantly, with the highest under *D. strictus* (28.92 mg kg⁻¹) and the lowest under *M. baccifera* (21.21 mg kg⁻¹).

Table 4: Soil available micronutrient status as influenced by different bamboo species.

Treatment/ Bamboo species	Soil available micronutrients content			
	Fe	Mn	Cu	Zn
	(mg kg ⁻¹)			
<i>Bambusa tulda</i>	22.18	11.98	3.59	1.18
<i>Bambusa balcooa</i>	21.55	11.83	3.29	1.16
<i>Bambusa bambos</i>	21.48	11.28	3.13	1.13
<i>Dendrocalamus asper</i>	21.38	11.21	3.14	1.09
<i>Dendrocalamus strictus</i>	22.56	12.21	3.72	1.22
<i>Melocanna baccifera</i>	21.36	11.32	3.13	1.08
Baseline Samples	20.83	11.40	2.80	0.97
SEm±	0.67	0.65	0.21	0.03
CD at 5 %	NS	NS	NS	0.10

The higher available nutrient status under bamboo plantations may be attributed to continuous litterfall, root turnover, decomposition of organic matter, and efficient nutrient recycling, which enhanced nutrient mineralization and availability. The superior performance of *D. strictus* may be associated with its higher biomass production and greater nutrient return through litter and root residues. Similar results were reported by Tariyal *et al.*, (2013), Kumari and Bhardwaj (2017), Kaushal *et al.*, (2020), Kumar *et al.*, (2021), and Pandey *et al.*, (2023).

Available micronutrient status

Data presented in Table 4 revealed that the availability of iron, manganese, copper, and zinc was higher under bamboo plantations compared with the baseline soil; however, significant variation among species was observed only for zinc, while iron, manganese, and copper showed non-significant differences. Among the species, *D. strictus* recorded the highest available iron (22.56 mg kg⁻¹), manganese (12.21 mg kg⁻¹), copper (3.72 mg kg⁻¹), and zinc (1.22 mg kg⁻¹); comparatively lower values were generally recorded under *M. baccifera*. The increase in available micronutrients under bamboo plantations may be attributed to continuous litter decomposition, enhanced organic matter accumulation, and increased biological activity in the rhizosphere, which improve micronutrient solubility and availability. The greater zinc availability under *D. strictus* suggests comparatively efficient nutrient recycling by this species. Similar findings were reported by Gogoi and Bhuyan (2016), Kaushal *et al.*, (2020), Kumar *et al.*, (2021), and Pandey *et al.*, (2023).

Total macronutrient status

Total nitrogen and sulphur were significantly influenced by bamboo species, whereas total phosphorus and potassium showed non-significant variation (Table 5). Among the species, *D. strictus* recorded the highest total nitrogen and sulphur, statistically at par with *B. tulda*,

Table 5: Soil total macronutrient status as influenced by different bamboo species.

Treatment/ Bamboo species	Total Macronutrient content			
	N	P	K	S
	(%)			
<i>Bambusa tulda</i>	0.246	0.164	0.379	0.955
<i>Bambusa balcooa</i>	0.236	0.161	0.372	0.952
<i>Bambusa bambos</i>	0.230	0.159	0.366	0.898
<i>Dendrocalamus asper</i>	0.225	0.157	0.349	0.768
<i>Dendrocalamus strictus</i>	0.251	0.167	0.379	0.975
<i>Melocanna baccifera</i>	0.223	0.156	0.336	0.756
Baseline samples	0.213	0.145	0.323	0.605
SEm ±	0.007	0.008	0.018	0.059
CD at 5%	0.020	NS	NS	0.177

while the lowest values were generally observed under *M. baccifera*. Total phosphorus and potassium showed only slight variation among species; nevertheless, bamboo plantations generally maintained higher nutrient status than the baseline soil. The improvement in total nutrient status under bamboo plantations may be attributed to continuous litter deposition, root biomass turnover, and efficient nutrient recycling, which enhanced nutrient accumulation in the soil over time. The comparatively better performance of *D. strictus* indicates its greater potential for improving long-term soil fertility under sub-montane conditions of Maharashtra. Similar findings were reported by Shanmughavel and Francis (2001), Kaushal *et al.*, (2020), Kumar *et al.*, (2021), and Zhou *et al.*, (2022).

Total micronutrient status

Total iron, manganese, copper, and zinc contents were not significantly influenced by bamboo species, although numerical variations were observed among treatments (Table 6). *D. asper* recorded the highest total iron (41,258 mg kg⁻¹), manganese (3,031 mg kg⁻¹), and copper (332 mg kg⁻¹), while *M. baccifera* recorded the highest total zinc (206 mg kg⁻¹). The baseline soil recorded higher total iron, manganese, and copper contents than all bamboo treatments, whereas total zinc was higher under *M. baccifera* and *B. tulda* than under several other species. Unlike available micronutrients, total micronutrient concentrations did not show a consistent superiority of *D. strictus*. The numerical variation observed may be associated with differences in the initial soil nutrient pool, nutrient uptake, litter return, root turnover, and redistribution of elements within the rhizosphere. Since treatment effects were non-significant, differences among bamboo species should be interpreted as numerical rather than statistically confirmed effects. Similar observations regarding species-related variation in soil nutrient status under bamboo plantations were

Table 6: Soil total micronutrient status as influenced by different bamboo species.

Treatment/ Bamboo species	Total micronutrients content			
	Fe	Mn	Cu	Zn
	(mg kg ⁻¹)			
<i>Bambusa tulda</i>	40900	2855	250	205
<i>Bambusa balcooa</i>	41048	2881	264	191
<i>Bambusa bambos</i>	41141	2903	281	197
<i>Dendrocalamus asper</i>	41258	3031	332	204
<i>Dendrocalamus strictus</i>	40533	2857	247	174
<i>Melocanna baccifera</i>	41398	2891	331	206
Baseline Samples	41700	3612	342	216
SEm ±	585.1	504.2	31.0	12.71
CD at 5 %	NS	NS	NS	NS

reported by Kaushal *et al.*, (2020), Kumar *et al.*, (2021), and Pandey *et al.*, (2023).

Conclusion

The present investigation demonstrated that bamboo species significantly influenced several soil physico-chemical properties and nutrient availability under the sub-montane conditions of Maharashtra. *Dendrocalamus strictus* showed the most favourable overall performance, recording the lowest bulk density, highest maximum water holding capacity, highest organic carbon content and superior available nitrogen, potassium, sulphur and micronutrient status. *Bambusa tulda* also performed comparatively well for several soil fertility parameters. It is therefore, concluded that, *Dendrocalamus strictus* and *Bambusa tulda* may be considered promising bamboo species for improving soil fertility and supporting sustainable soil management under the sub-montane conditions of Maharashtra.

Acknowledgement

The authors are thankful to Mahatma Phule Krishi Vidyapeeth, Rahuri for providing the facilities and support required for conducting the present investigation.

Conflict of Interest: The authors declare no conflict of interest.

References

- Blake, G.R. and Hartge K.H. (1986). Bulk density. In: Klute, A. (Ed.), Methods of Soil Analysis, Part I, 2nd ed. American Society of Agronomy and Soil Science Society of America, Madison, USA, 363–375.
- Bremner, J.M. (1996). Nitrogen—total. In: Sparks, D.L. (Ed.), Methods of Soil Analysis, Part 3: Chemical Methods. SSSA Book Series No. 5. Soil Science Society of America, Madison, Wisconsin, 1085–1122.
- Cai, X., Lin Z., Penttinen P., Li Y., Li Y., Luo Y., Yue T., Jiang P., and Fu W. (2018). Effects of conversion from a natural evergreen broadleaf forest to a Moso bamboo plantation

- on the soil nutrient pools, microbial biomass and enzyme activities in a subtropical area. *Forest Ecology and Management*, **422**, 161–171.
- Chesnin, L. and Yien C.H. (1950). Turbidimetric determination of available sulphates. *Proceedings of the Soil Science Society of America*, **15**, 149–151.
- Dasog, G.S. and Hosur G.C. (1995) Effect of tree species on soil properties. *Journal Indian Society of Soil Science*, **43**, 259–261.
- Forest Survey of India (FSI). (2021). *India State of Forest Report 2021*. Forest Survey of India, Ministry of Environment, Forest and Climate Change, Government of India, Dehradun, India.
- Gaikwad, A.S., Kale S.D. and Ghadge S.T. (2022). Effect of different bamboo species on soil properties grown on Entisol of semi-arid climate. *The Pharma Innovation Journal*, **11(1S)**, 829–835.
- Gogoi, B.H.A.B.E.S.H. and Bhuyan T.C. (2016). Physico-chemical properties and microbial biomass carbon of bamboo growing soils: A comparative study. *Indian Forester*, **142(8)**: 739–744.
- INBAR (2019). Global Assessment of Bamboo and Rattan (GABAR 2019). International Bamboo and Rattan Organisation, Beijing, China.
- Jackson, M.L. (1958). Soil Chemical Analysis. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, USA, 498.
- Jackson, M.L. (1973). Soil Chemical Analysis. Prentice-Hall of India Pvt. Ltd., New Delhi.
- Kaushal, R., Tewari S., Banik R.L., Chaturvedi O.P., Mandal D., Tomar J.M.S. and Chaturvedi S. (2020). Bamboo-based agroforestry systems: Soil health, carbon sequestration and ecosystem services. *Current Science*, **119(1)**, 48–57.
- Kumar, V., Singh L. and Chaturvedi O.P. (2021). Influence of bamboo plantations on soil organic carbon fractions in degraded lands of Central India. *Agroforestry Systems*, **95**, 1149–1162.
- Kumari, Y. and Bhardwaj D.R. (2017). Effect of various bamboo species on soil nutrients and growth parameters in mid hills of Himachal Pradesh, India. *International Journal of Chemical Studies*, **5(4)**, 19–24.
- Liese, W. and Köhl M. (Eds.). (2015). *Bamboo: The Plant and Its Uses*. Springer International Publishing. <https://doi.org/10.1007/978-3-319-14133-6>
- Lindsay, W.L. and Norvell W.A. (1978). Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal*, **42(3)**, 421–428.
- Majumdar, B., Venkatesh M., Bhatt B.P. and Singh K. (2005). Soil properties influenced by some important edible bamboo species in the North Eastern Himalayan region, India. *Journal of Bamboo and Rattan*, **4(3)**, 221–230.
- Nath, A.J., Lal R. and Das A.K. (2015). Ethnopedology and soil properties in bamboo (*Bambusa* sp.) based agroforestry system in North East India. *Catena*, **135**, 92–99.
- Olsen, S.R. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular No. 939. United States Department of Agriculture, Washington, D.C.
- Pandey, P., Parajuli M., KC A. and Bhattarai A. (2023). Effect of various bamboo species on soil properties in Pani Kholsi Micro-Watershed, Nepal. *Forestry: Journal of Institute of Forestry Nepal*, **20(1)**, 36–48.
- Pansee, V.G. and Sukhatme P.V. (1985). Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi.
- Piper, C.S. (1950). Soil and Plant Analysis: A Laboratory Manual of Methods for the Examination of Soils and the Determination of the Inorganic Constituents of Plants. University of Adelaide, Adelaide, Australia, 368.
- Shanmughavel, P. and Francis K. (2001). Bioproductivity and nutrient cycling in bamboo and acacia plantation forests. *Bioresource Technology*, **80(1)**, 45–48.
- Shinde, K.M., Gajbhiye P.N., Kamble B.M., Jadhav A.S. and Dhenge A.R. (2023). Soil physicochemical and enzymatic properties in bamboo plantation Entisol soil of sub-montane zone of Maharashtra. *International Journal of Statistics and Applied Mathematics*, **8(6S)**, 1193–1200.
- Subbiah, B.V. and Asija G.L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Science*, **25**, 259–260.
- Sujatha, M.P., Thomas T.P. and Sankar S. (2008). Influence of Reed Bamboo (*Ochlandra Travancorica*) on Soils of the Western Ghats in Kerala-a Comparative Study with Adjacent NonReed Bamboo Areas. *Indian Forester*, **134(3)**, 403–416.
- Tariyal, K., Upadhyay A., Tewari S. and Melkania U. (2013). Plant and soil carbon stock and carbon sequestration potential in four major bamboo species of North India. *Advances in Bioscience*, **4(2)**, 120–128.
- Zhou, X., Guan F., Zhang X., Li C. and Zhou Y. (2022). Response of Moso bamboo growth and soil nutrient content to strip cutting. *Forests*, **13**, 1293.