(iii) Ph.D. (Forestry) Silviculture & Agroforestry
Major courses

Course code	Course Title	Credit hrs.
	Semester-I	
SAF-611	Quantitative Silviculture	2+1
SAF-612	Forest Stand Dynamics	1+0
SAF-613	Forest Stand Management Techniques	1+1
SAF-614	Plantation Forest Productivity	1+1
SAF-615	Regeneration Silviculture	2+1
SAF-616	Agroforestry for Sustainable Agriculture	1+0
	Semester-II	
SAF-621	Agroforestry Research and Management	2+0
SAF-622	Productivity and Evaluation of Agroforestry Systems	2+1
SAF-623	Agroforestry for Ecosystem Services and Environmental Benefits	2+0
SAF-624	Restoration Forestry	1+0
SAF-625	Forest Soil Management	1+1
	Semester-III	
SAF-691	Doctoral Seminar I	1+0
	Semester-IV	
SAF-692	Doctoral Seminar II	1+0
	Semester-V & VI	
SAF-699	Doctoral Research	0+75

***Core and compulsory courses**

Syllabus of Major courses of Ph.D. (Forestry) Silviculture and Agroforestry

SAF 611 QUANTITATIVE SILVICULTURE 2+1

Theory

UNIT I

Principles of tree and stand growth and yield. Habitat types; site quality; site index.

Growth functions - empirical, exponential, allometry and Backman's growth functions. Growth pattern and growth increment curve. Growth cycle and phases.

Quantifying site quality: Methods - tree and stand height data, periodic height growth. Techniques - guide curves, difference equations, parameter prediction.

UNIT II

Stand density and stocking, measures of density: –3/2 power rule of self-thinning, point density, competition indices. Control of growing stock to achieve specific management objectives - growth-growing stock relations, Full site occupancy, Onset of competitive interactions. Langsaeter's hypothesis, stand density index and techniques for translating this understanding into rational density management regimes.

UNIT III

Techniques: stand density management diagrams and stocking charts. Construction and use of stand density management diagrams. Designing density management regimes to suit specific management objectives.

UNIT IV

Predicting growth and yield: normal and empirical yield tables, stand growth and yield equations, stand table projections. Simulation models: whole-stand models, size-class distribution models, single-tree/ distance-independent and distance-dependent models, process models, linkage of models at different

levels. Evaluation, calibration, verification, and validation of forest growth and yield prediction systems. Introduction to existing forest growth and yield simulators.

Practical

Assessment of growth characteristics. Preparation of growth and increment curves. Site quality assessment, Stand density diagrams. Growth prediction models. Yield simulation techniques.

Suggested Readings

Clutter JL, Fortson JC, Pienaar LV, Brister GH and Bailey RL. 1992. *Timber Management: A Quantitative Approach.* Krieger Publishing Company.

Davis LS and Johnson KN. 1987. *Forest Management.* 3rd Ed. McGraw-Hill.

Evans J. 1982. *Plantation Forestry in the Tropics*. Clarendon Press.

Johnson PS, Shifley SR and R. Rogers. 2009. *Self-thinning and Stand Density. The Ecology and Silviculture of Oaks*. CABI, Cambridge, MA.

Luna RK. 1989. *Plantation Forestry in India*. International Book distributors.

Vanclay JK. 1994. *Modeling Forest Growth and Yield: Application to Mixed Tropical Forests.* CAB International.

SAF 612 FOREST STAND DYNAMICS 1+0

Theory

UNIT I

Introduction-plant interactions and limitations of growth - mutualism and competition – the niche - limitations of growth - concept of growing space.

UNIT II

Tree architecture and growth- general growth patterns - shoot development patterns, crown shapes, height growth, root growth, and tree development.

UNIT III

Disturbances and stand development – impact of disturbances - major and minor- classification of disturbances - characteristics of disturbance agents. Stand structure and fire behaviour. Building resilience to disturbances.

UNIT IV

Overview of stand development patterns - temporal and spatial patterns of tree invasion - stand initiation stage - stem exclusion stage – understorey reinitiation stage - old growth stage - multicohort stands – behaviour of component cohorts- development of multicohort stands - quantification of stand development - forest patterns over long times and large areas. Gap dynamics.

Suggested Readings

Dagar JC, Tewari JC, Vindhya Prasad. 2018. *Agroforestry Anecdotal to Modern Science*. Springer.

Daniel TW, Helms JA and Baker FS. 1979. *Principles of Silviculture*, 2nd edition, McGraw-Hill, 2nd ed.

Kimmins JP. 1997. *Forest Ecology*, Macmillan Publishing Company, New York Upper Saddle River, Prentice Hall.

Koop H. 1989. *Forest Dynamics Silvi-star: A Comprehensive Monitoring System*. Springer-verlag. New York.

Oliver CD and Larson BC. 1996. *Forest Stand Dynamics*. John Wiley & Sons, Inc. New York New York: John Wiley & Sons, Inc.

Smith DM. 1986. *The Practice of Silviculture*, 8th ed, Wiley, New York.

Waring RH and Schlesinger WH. 1985. *Forest ecosystems: Concepts and management*, Academic. Press, San Diego.

SAF 613 FOREST STAND MANAGEMENT TECHNIQUES 1+1

Theory

UNIT I

Philosophy of silviculture – advance reproduction methods and their role in silviculture – Judging successful establishment; Analysis of active and passive site preparation – Silviculture with an ecosystem approach.

UNIT II

Advances in silvicultural practices; tropical forest, sub-tropical forest and temperate forest.

UNIT III

Analysis of different techniques of silviculture in forest stand management, Technique for early stand development; Analysis of thinning methods and its impact on wood yield and quality; Stand protection and health management. Silvicultural use of prescribed fire. Mechanization and role in silviculture.

UNIT IV

Advance silviculture techniques for plantation forestry; Case studies of advance silviculture in India and abroad; mixed plantation forestry, Precision silviculture, silviculture of intensively managed plantations, silviculture for climate change mitigation. Sewage silviculture. Silviculture management for watershed and catchment areas. Silviculture for wildlife habitat improvement.

UNIT V

Adjusting silviculture to meet industrial demands – silviculture in perspective – Problem solving procedure for silviculture – silviculture in retrospect.

Practical

Study of components of silvicultural system for sustained yield; Management strategies for even aged and uneven aged stands; Choice of site preparation methods, Plantation map, Quality planting stock, Planning for tree planting, Release cutting operation, Selection of thinning methods, Intensity of thinning, Analysis of site quality and biomass production for timber, pulp wood and fuel wood species, Problems in silviculture in tropical, subtropical plantation and their solutions.

Suggested Readings

Brang P, Spathelf P, Larsen JB, Bauhus J, Bončina A and Chauvin C. 2014. *Suitability of Close-To-Nature Silviculture for Adapting Temperate European Forests to Climate Change*. Forestry.

Colak AH, Rotherham ID and Calikoglu M. 2003. *Combining 'Naturalness Concepts' with Close-to-Nature Silviculture*. Forstwiss. Centralbl. 122, 421–431.

Cole DN and Yung L. (eds) 2010. *Beyond Naturalness: Rethinking Park and Wilderness Stewardship in an Era of Rapid Change* . Island Press.

Daniel TW, Helms JA and Baker FS. 1979. *Principles of Silviculture*, 2nd edition, McGraw-Hill, 2nd ed.

Fettig CJ, Reid ML, Bentz BJ, Sevanto S, Spittlehouse DL and Wang T. 2013. *Changing climates, changing forests: A western North American perspective*.

Franklin JF. 1989. *Towards a New Forestry*. Am. For.

Holm-Nielsen LB, Nielsen IC and Balsev H. (eds.) 1989. *Tropical Forests*, Academic Press, London.

Pukkala T and Gadow KV. 2012. *Continuous Cover Forestry*. 2nd Edition Springer.

Sairll PS, Evans J, Auclair D and Flack J. 1997. *Plantation Silviculture in Europe*. Oxford University Press.

Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. *The Practices of Silviculture*: Applied Forest Ecology. John Wiley & Sons.

SAF 614 PLANTATION FOREST PRODUCTIVITY 1+1

Theory:

UNIT I

Plantation forests - scope and perspectives, international and national scenario.

UNIT II

Dynamics of plantation growth – site quality, stand density, dynamics of nutrient cycling, thinning, spacing and crown efficiency, nutrient pools and dynamics, biological factors in nutrient supply.

UNIT III

Advances in site preparation techniques. Recent trends in fertilization and irrigation of plantations. Tending and cultural operations and plantation productivity - prospects of mechanization in tropical plantations. Reduced impact logging. Clonal forests, their management and productivity comparisons.

UNIT IV

Productivity decline in plantation forests – second rotation decline - harvest related resource export - Modern silvicultural interventions.

UNIT V

Project formulation, designing and appraisal of different kinds of plantations to meet specific objectives.

Practical

Plantation productivity analysis – growing stock and MAI assessment - stand density estimation, fertilizers and fertilizer application in plantation, response of plantation to irrigation, productivity of clonal forestry, modern tools in site preparation, weed management methods, management strategies for enhancing plantation productivity.

Suggested Readings

Evans J and Turnbull JW. 2004. *Plantation Forestry in the Tropics: The Role, Silviculture and Use of Planted Forests for Industrial, Social, Environmental and Agroforestry Purposes*. OUP Oxford.

Evans J. 1982. *Plantation Forestry in the Tropics*. Clarendon Press.

Ford ED. 1984. *Nutrition of Plantation Forests*. Academic Press.

Krishnapillay B. 2000. *Silviculture and Management of teak plantations*. *Unasy.* 201. 51:14-21p.

Nambiar EKS, Cossalter C and Tiarks A. 1998. *Site Management and Productivity in Tropical Plantation Forests.* Workshop Proceedings, South Africa.

Sairll PS, Evans J, Auclair D and Flack J. 1997. *Plantation Silviculture in Europe*. Oxford University Press.

Smith DM. 1980. *The Practice of Silviculture*. 8th ed., John Wiley & Sons.

Suzuki K, Ishii K, Sakurai S and Sasaki S. 2006. *Plantation Forestry in the Tropics*. Springer Tokyo.

Zobel BJ, Wyk G and Stahlper P. 1987. *Growing Exotic Forests*. John Wiley & Sons.

SAF 615 REGENERATION SILVICULTURE 2+1

Theory

UNIT I

Planning for regeneration, setting the objectives for regeneration, principles and methodologies of forest regeneration, ecological basis of natural regeneration techniques.

UNIT II

Basic Concepts in forest regeneration, importance of different combinations of light, moisture, soil in determining success or failure of regeneration. Factors affecting natural and artificial regeneration- kinds, extent and quality of sites.

UNIT III

Techniques of canopy manipulation and forest continuum in regular and irregular forests canopy, light pattern and regeneration establishment. Regeneration survey and methodology. Major silvicultural systems of tropical and temperate parts of the world. Continuous cover forestry. Advances in coppice silviculture. Silviculture in a changing world.

UNIT IV

Advances in artificial regeneration techniques, advances in vegetative propagation techniques like mini and micro-cutting techniques, production technology for quality planting stock, carbon enrichment techniques for production of quality planting stock. Integrated nutrient management in nursery production. Plant quality assessment tools.Nursery production system of important timber and Non-Timber Forest Products, NTFP's yielding species in the region.

UNIT V

Sustainable site establishment practices, Novel tree establishment techniques. Regeneration problems of important conifers and broad leaved species-case studies.

Practical

Factors affecting natural and artificial regeneration, Advances in vegetative propagation techniques like mini and micro-cutting techniques, Production technology for quality planting stock, Carbon enrichment techniques for production of quality planting stock, Integrated nutrient management in nursery production. Novel tree establishment techniques. Modern approaches in containerized seedling production.

Suggested Readings

Colak AH, Rotherham ID and Calikoglu M. 2003. *Combining 'naturalness concepts' with close-to-nature silviculture*. Forstwiss. Centralbl. 122, 421–431.

Sairll PS, Evans J, Auclair D and Flack J. 1997. *Plantation Silviculture in Europe*. Oxford University Press.

Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. *The Practices of Silviculture*: Applied Forest Ecology. John Wiley & Sons.

SAF 616 AGROFORESTRY FOR SUSTAINABLE AGRICULTURE 1+0

Theory

UNIT I

Current Agricultural scenario in India. Sustainable agriculture: issues and challenges. Land use changes-agroforestry: an opportunity for sustainability and rainfed agriculture.

UNIT II

Agroforestry options for sustainable agriculture: integration of perennial components in agriculture. Role of trees in enhancing the productivity of traditional agriculture. Strategies on integration of trees suitable for different cropping systems for important agro-ecological regions. Tree management for productivity optimization.

UNIT III

Agroforestry for different land holdings. Integrated farming systems. Agroforestry strategies for short term and long term returns.

UNIT IV

Processing, value addition and marketing of agroforestry products.

Suggested Readings

Chin K Ong, Colin Black and Julia Wilson. 2015. *Tree-Crop Interactions*, 2nd Edition: Agroforestry in a Changing Climate. CAB International ICRAF.

Nair PKR, Rai MR and Buck LE. 2004. *New Vistas in Agroforestry*. Kluwer.

Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer, Netherlands.

Ong CK and Huxley PK. 1996. *Tree Crop Interactions – A Physiological Approach*.

Schroth G and Sinclair F. 2003. *Tree Crops and Soil Fertility: Concepts and Research Methods*. CABI, Wallingford, UK.

Snelder DJ and Lasco RD. 2008. *Smallholder Tree Growing for Rural Development and Environmental Services*. Springer Science, Amsterdam.

SAF 621 AGROFORESTRY RESEARCH AND MANAGEMENT 2+0

Theory

UNIT I

Recent trends in agroforestry research and development. Agroforestry land use systems and their salient features. Research designs and analysis in agroforestry. Multi-functionality of agroforestry systems-multiplicity of products and services, food and nutritional security, livelihood security, gender related aspects. Constraints in agroforestry research - research prioritization.

UNIT II

Study of systems specification, prioritizing potential interventions and technology specifications; space and time related considerations.

UNIT III

Introduction to on-farm and on-station research experiments. Biomass production and allocation patterns- changes thorough agroforestry interventions.

UNIT IV

Belowground dynamics- role of fine roots in agroforestry productivity. Tree husbandry practices in agroforestry for productivity optimization. Soil-site sustainability and environmental resource sharing.

Site-species compatibility. Competition, predation, mutualism, commensalisms. Simulation modeling of agroforestry systems.

UNIT V

Carbon and nutrient dynamics in agroforestry- carbon sequestration- carbon credits- mitigatory and adaptive roles of agroforestry in the context of climate change- climate negotiations and agroforestry.

UNIT VI

Management of multifunctional agroforestry – sustainability, links with UNFCCC, UNCCD and UNCBD. Carbon conservation, sequestration, and substitution functions of agroforestry trees. Domestication of useful species and crafting market regimes for the products derived from agroforestry and ethno-forestry systems. Contract fuel wood schemes, small-scale nursery enterprises, charcoal policy reform, novel market information systems, facilitating and capacity building of farmer and farm forest associations. Climate change and reforestation incentive policies.

UNIT VII

Market intelligence for agroforestry products. Agroforestry value chain models: consortia concepts. Successful case studies.

Suggested Readings

Chin K Ong, Colin Black, Julia Wilson. 2015. *Tree-Crop Interactions*, 2nd Edition: Agroforestry in a Changing Climate. CAB International.

Kumar BM and Nair PKR. 2011. *Carbon Sequestration Potential of Agroforestry Systems: Oportunities and Challenges.* Springer.

Nair PKR, Rai MR and Buck LE. 2004. *New Vistas in Agroforestry*. Kluwer.

Ong CK and Huxley PK. 1996. *Tree Crop Interactions – A Physiological Approach*. ICRAF.

Snelder DJ. and Lasco RD. 2008. *Smallholder Tree Growing for Rural Development and Environmental Services*. Springer Science, Amsterdam.

SAF 622 PRODUCTIVITY AND EVALUATION OF AGROFORESTRY SYSTEMS

2+1

Theory

UNIT I

Concept of crop productivity. Productivity potential in relation to light, water and nutrients.

UNIT II

System complementarity, supplementarity, competitiveness, sustainability and management techniques. Tree root architecture, re-allocation of resources within the plant system.

UNIT III

Biological yield and harvest index. Growth and yield functions. Land equivalent ratio. Water use efficiency, photosynthetic efficiency, radiation balance, canopy transmissivity, canopy management, plant geometry and crop yield.

UNIT IV

Allelopathic effects. Strategies to improve the efficiency and productivity of different land use systems.

UNIT V

Role of various financing agencies in agroforestry and critical evaluation of different credit systems with emphasis on agroforestry. Methodologies for evaluating agroforestry hedonic pricing, PES, LER and LEV.

UNIT VI

Financial, economic and social accounting of agroforestry projects. Advances in marketing management of agroforestry products. Evaluating combined productivity and profitability of different agroforestry systems *vis-a-vis* other competitive agro-based systems. Tree insurance schemes.

Practical

Techniques for leaf area index, photosynthetically active radiation, soil moisture and leaf water potential and canopy density measurements. Exercises on developing alternative optimal agroforestry plans under perfect and imperfect knowledge situations. Socio-economic and financial evaluation of agroforestry projects.

Suggested Readings

Alavalapati JRR and D Evan Mercer. 2004. *Valuing Agroforestry Systems: Methods and applications*, Kluwer Academic Publishers.

Kant Shashi and Janaki Alavalapati. 2014. *Handbook of Forest Resource Economics,* Publisher: Routledge.

Nair PKR, Rai MR and Buck LE. 2004. *New Vistas in Agroforestry*. Kluwer.

Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer.

Ong CK and Huxley PK. 1996. *Tree Crop Interactions – A Physiological Approach*. ICRAF.

Sullivan, Gregory M, Susan M Hoke and Jefferson M Fox (editors). 1992. *Financial and Economic Analyses of Agroforestry Systems. Proceedings of a workshop held in Honolulu. Hawaii. USA. July* 1991. Paia, Ill: Nitrogen Fixing Tree Association.

Tejwani KG 1994. *Agroforestry in India* Oxford and IBH publishing Co. Pvt.Ltd.

SAF-623 AGROFORESTRY FOR ECOSYSTEM SERVICES AND ENVIRONMENTAL BENEFITS 2+0

Theory

UNIT I

Multifunctionality of agroforestry. Major ecosystem services and environmental benefits and international conventions and charters on climate change (UNFCCC, UNCCD, agroforestry and climate change negotiations: CoP) and biodiversity conservation (CBD) – an overview.

UNIT II

Agroforestry for carbon conservation, sequestration, substitution – role and potentials of various agroforestry systems. Estimates of carbon sequestration potential – measurement - prospects and problems. Factors affecting above and belowground carbon sequestration potential.

UNIT III

Agroforestry for soil enrichment – mechanisms – litter and fine root dynamics, rhizo-deposition and other rhizosphere effects, symbiotic and free-living N_2 fixation, mycorrhizal associations. Soil and water conservation benefits.

UNIT IV

Agroforestry for biodiversity conservation. Synergy with climate change mitigation. Landscape connectivity for wildlife, supporting the pollinators of plant species. Agroforestry for improved air and water quality. Non-point source pollution in Indian agro-ecosystems. Riparian buffers for alleviating agricultural non-point source pollution.

UNIT V

Private profitability vs. social profitability - exclusion or inclusion of social benefits and costs and non-market values, or externalities. Theory of externalities, effect of environmental costs and benefits on the profitability of agroforestry practices. Valuing environmental services. Profitability of timber-based agroforestry systems. Costs and benefits in agroforestry- valuation of inputs and outputs- environmental outputs.

Suggested Readings

Alavalapati JRR, Shrestha RK, Stainback GA and Matta JR. 2004. *Agroforestry development: An environmental Economic Perspective. Agroforestry Systems.* 61: 299–310.

Huxley P. 1999. *Tropical Agroforestry*. Blackwell.

IPCC. 2007. Climate Change 2007. *Mitigation of Climate Change*. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

Jain SK and Singh P. 2000. *Economic Analysis of Industrial Agroforestry: Poplar (Populus deltoides) In Uttar Pradesh (India). Agroforestry Systems.* 49: 255–273.

Jeffers JNR. 1978. *An Introduction to System Analysis with Ecological Application*. Edward Arnold.

Jose S. 2009. *Agroforestry for Ecosystem Services and Environmental Benefits: An Overview*. *Agroforestry Systems.* 76: 1-10.

Lyngbaek AE, Muschler RG and Sinclair FL. 2001. *Productivity and Profitability ff Multistrata Organic Versus Conventional Coffee Farms in Costa Rica*. *Agroforest. Syst.* 53: 205–213.

Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer, Netherlands.

Schroth G and Sinclair F. 2003. *Tree Crops and Soil Fertility: Concepts and Research Methods*, CABI, Wallingford, UK.

Young A. 1997. *Agroforestry for Soil Management*. 2nd ed. CABI, Wallingofrd, UK.

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SAF-624 RESTORATION FORESTRY 1+0

Theory

UNIT I

Introduction to restoration forestry, scope and opportunities for forest restoration, Natural regeneration, forest and land degradation in the Asia-Pacific region. Forest restoration techniques, tools for prioritization, decision-making and monitoring to enhance restoration success, The Bonn Challenge, The Bonn Challenge in Asia, Africa and Latin America.

UNIT II

Forest landscape restoration, environment for natural regeneration in forest and landscape restoration, economic and social aspects for successful integration of natural regeneration in forest landscape restoration, adaptive management for forested landscapes in transformation, measures to improve resilient and genetically diverse forests. Mangrove restoration.

UNIT III

Case studies on successful forest landscape restoration.

Suggested Readings

Beatty CR, Cox NA and Kuzee ME. 2018. *Biodiversity Guidelines for Forest Landscape Restoration Opportunities Assessments.* First edition. Gland, Switzerland: IUCN.

Blakesley D and Buckley P. 2016. *Grassland Management and Restoration.* Conservation handbooks. Pelagic Publishing. Food and Agriculture Organization of the United Nations.

Chokkalingam U, Shono K, Sarigumba MP, Durst PB and Leslie R. (eds). 2018. *Advancing the Role of Natural Regeneration in Large-Scale Forest and Landscape Restoration in the Asia-Pacific Region.* FAO and APFNet. Bangkok.

FAO. 2010. *Forests Beneath the Grass.* Proceedings Of The Regional Workshop On Advancing The Application Of Assisted Natural Regeneration For Effective Low-Cost Forest *Restoration.* Bangkok, FAO.

FAO/RECOFTC. 2016. *Forest Landscape Restoration in Asia-Pacific Forests*. by Appanah, S. (ed.). Bangkok, Thailand.198p

Prober SM, Byrne M, McLean EH, Steane DA, Potts BM, Vaillancourt RE and Stock WD. 2015. *Climate-Adjusted Provenancing: A Strategy for Climate-Resilient Ecological Restoration.* Frontiers in Ecology and Evolution, 23 June.

SAF-625 FOREST SOIL MANAGEMENT 1+1

Theory

UNIT I

Forest soils and vegetation development. Physical properties of forest soils. Forest soil classification. Soils of the major forest biomes – soils under different forest types - tropical rainforest soils – moist deciduous forests – dry deciduous. Soils and plant roots.

UNIT II

Soil chemistry and nutrient uptake. Soil organic matter - maintenance and build up. Biology of forest soils - role of microorganisms in ameliorating soils; N and C cycles. Forest biogeochemistry. Micorrhizae. Role of forests in conserving soils.

UNIT III

Nutrient transformation in soils. Nitrogen fixation in tropical forest plantations: N_2 fixation process, species, rates of N_2 fixation, factors influencing N_2 fixation; nutrient cycling - comparison of plantation productivity - case studies. Nutrition management: nutrient limitations, fertilization. Soil carbon sequestration - processes and mechanisms.

UNIT IV

Soil management for reforestation of salt affected soils, acid soils, coastal soils. Effects of fire on soils and their properties.

UNIT V

Management of long term soil productivity - soil compaction and erosion - harvest removal and nutrient budgeting - harvest effect on water quality - strategies for future management.

Practical

Nutrient budgeting for different plantation systems, quantification of physical and chemical soil constraints in plantation and agroforestry systems, evolving new strategies for soil and site development.

Suggested Readings

Binkley D and R. Fisher. 2012. *Ecology and Management of Forest Soils* (4th Edition), John Wiley & Sons Singapore Pte. Ltd., Singapore.

Fisher RF, Binkley D and Pritchett WL. 2000. *Ecology and Management of Forest Soils*. 3rd Ed.John Wiley & Sons Inc., New York.

Havlin *et al.* 2014. *Soil Fertility and Fertilizers: An Introduction to Nutrient Management* (8th Edition), PHI Learning Pvt. Ltd., Delh

Khan TO. 2013 *Forest Soils: Properties and Management*, Springer International Publishing, Switzerland.

Pritchett and Fisher RF 1987. *Properties and Management of Forest Soils*. John Wiley, New York.

Reddy MV. 2001. *Management of Tropical Plantation Forests and Their Soil Litter System-Litter, Biota and Soil Nutrient Dynamics.* Science Publishers, U. S.

Sadanandan Nambiar EK and Grown AG. (Eds.). 1997. *Management of Soil, Nutrients and Water in Tropical Plantation Forests*. ACIAR, CSIR and CIFOR, Australia.

Schulte A and Ruhiyat D. 1998. *Soils of Tropical Forest Ecosystems*: *Characteristics, Ecology, and Management*. Springer Verlag,Berlin, New York.