

**FAR WESTERN UNIVERSITY**  
**Faculty of Agriculture**  
**Undergraduate Program in Agriculture**  
**Science**



**Fourth Semester Syllabus**

## B. Sc. Agriculture Science Fourth Semester Syllabus

S.N.	Name of the Course	Course Code	CH-Th	CH-Pr	CH-Total	Reference Page
1	Agri-Business Management	AEC420	2	0	2	
2	Agricultural Extension	AEX421	2	1	3	
3	Diseases of Agronomical Crops and their Management	PPA421	2	1	3	
4	Fundamentals of Aquaculture	AQU421	2	1	3	
5	Fundamentals of Plant Breeding	PLB421	2	1	3	
6	Medicinal and Aromatic Plants	AGF411	1	1	2	
7	Principles and Practices of Insect Pest Management	ENT421	2	1	3	
8	Principles and Practices of Seed Production and Technology	AGR421	2	1	3	
9	Soil Physics, Genesis and Classification	SSC411	1	1	2	
<b>Total</b>			<b>16</b>	<b>8</b>	<b>24</b>	

**FAR WESTERN UNIVERSITY**  
**Faculty of Agriculture**

<b>Course Code</b>	<b>AEC420</b>
<b>Course Title</b>	<b>Agri-Business Management</b>
<b>Credit Hours</b>	<b>2+0</b>
<b>Full Marks</b>	<b>50</b>
<b>Theory (Marks)</b>	<b>50</b>
<b>Practical (Marks)</b>	<b>0</b>

<b>Objective (s) of the Course</b>
Upon completion of this course, students will be able to understand how agriculture could be turned into a profitable business and how it could be optimally managed to provide ample economic opportunities to the adopting farmers.
<b>Course Description</b>
Definition, concept, scope and importance of agribusiness; Concept of agribusiness firm, plant, industry and their interrelationship; Agribusiness environment and management system; Supply chain and value chain management; Strategic production planning and planning tools in agribusiness management; Agribusiness plan; Organizational, business, and human resource management in agribusiness organization; Consumer demand analysis and forecasting; Financial and economic analysis of agribusiness; Agribusiness financing; Capital acquisition, agribusiness control and evaluation; Risk management in agribusiness; Marketing management in agribusiness; International trade, treaties and its impact in Nepalese agribusiness; Problem and prospect of Nepalese agribusiness; Comparative and competitive advantage of major commercial crops; Business ethics and social responsibility.

<b>Course Breakdown (Theory)</b>		
<b>SN</b>	<b>Course Outline</b>	<b>Lectures</b>
1	Definition and concept of Agribusiness; Differences between Agribusiness and Business	1
2	Scope and importance of Agribusiness management in Nepal	1
3	Basic concept and definition of Firm, Plant, Industry and their interrelationships with respect to agricultural production	1
4	Agribusiness enabling environments	1
5	Competition and globalization in the context of Agribusiness	1
6	Business ethics and social responsibility	1
7	Factors of production and Input-Output management in	1

	Agribusiness	
8	Strategic planning and management in Agribusiness	1
9	Planning tools in Agribusiness management	1
10	Managerial roles and skills: Organizational and business management function and managerial decisions	1
11	Human resource management in Agribusiness organization	1
12	Leadership, motivation, and effective communication	1
13	Managing quality, operations, technology and information systems	1
14	Understanding consumer demand, consumption trend, and forecasting future Supply-Demand scenario of major Agribusiness products of Nepal	1
15	Demand forecasting of major Agribusiness products of Nepal	1
16	Preparation and analysis of Financial statements	1
17	Economic/ financial appraisal of Agribusiness firm	1
18	Agribusiness financing: Concept and importance	1
19	Economic principles involved in capital acquisition	1
20	Agribusiness plan: Concepts and elements	1
21	Preparation and analysis of Agribusiness plan	1
22	Risk management in Agribusiness	1
23	Concept of supply chain and value chain analysis	1
24	Value chain analysis and mapping of major commercial crops	1
25	Marketing management for Agribusiness firm: Strategic market planning, marketing mix, marketing decision tools	1
26	Implication of international trade and treaties in Nepalese agriculture sector and Agribusinesses	1
27	Study of major national and international Agribusiness	1
28	Impact of government policies on Nepalese Agribusiness Enterprises	1
29	Problem and prospect of Agribusiness in Nepal	1
30	Comparative and competitive advantage of some commercial crops (Cardamom and Coffee)	1
	<b>Total</b>	<b>30</b>

### Recommended Reading Materials

1. Baker, G. A., Grunewald, O. and Gorman, W. D. (2001). *Introduction to Food and Agribusiness Management (First Edition)*. Prentice Hall, New Jersey, USA.
2. Barnard, F. L., Akridge, J. T., Dooley, F. J., Foltz J. C. and Yeager, E. A. (2016). *Agribusiness Management (Fifth Edition)*. Routledge (Taylor and Francis Group), New York, USA.

3. Beierlein, J. G., Schneeberger, K. C. and Osburn, D. D. (2014). *Principles of Agribusiness Management (Fifth Edition)*. Waveland Press Inc., Illinois, USA.
4. Downey, W. D. and Erickson, S. P. (1987). *Agribusiness Management (Second Edition)*. McGraw Hill, Pennsylvania, USA.
5. Ricketts, C. and Ricketts, K. G. (2008). *Agribusiness Fundamentals and Applications (Second Edition)*. Cengage Learning Inc., New York, USA.  
Van-Fleet, D. Van-Fleet, E. and Seperich, G.J. (2014). *Agribusiness: Principles of Management*. Cengage Learning Inc., New York, USA.

**FAR WESTERN UNIVERSITY**  
**Faculty of Agriculture**

<b>Course Code</b>	<b>AEX421</b>
<b>Course Title</b>	<b>Agricultural Extension</b>
<b>Credit Hours</b>	<b>3 (2+1)</b>
<b>Full Marks</b>	<b>75</b>
<b>Theory (Marks)</b>	<b>50</b>
<b>Practical (Marks)</b>	<b>25</b>

<b>Objective (s) of the Course</b>		
<p>Upon the completion of this course, the students will be able to understand the basic concept of education and extension education, their principle, philosophy, objective, method, system and practices etc. This course will be helpful to develop student's understanding and ability to apply the agricultural extension knowledge to the farming community.</p>		
<b>Course Description</b>		
<p>Meaning, concept, definition and type of education and extension education, their objective, role in agricultural development; Principle, philosophy and method of extension education derived from psychology of education and their application to agricultural extension; Historical perspective of extension education and scope of agricultural extension, their system, organizational setup and method used in extension education; Extension teaching learning process, agricultural technology and transfer of technology; Program planning and their characteristics, type, level and principle of good program planning process; Identification, characteristics, selection of local leader and their roles in agricultural extension program; Role, function, organizational setup of Land Grant System model of Agricultural College and University in agriculture development; Monitoring and evaluation of extension program.</p>		
<b>Course Breakdown (Theory)</b>		
<b>SN</b>	<b>Course Outline</b>	<b>Lectures</b>
1	Objectives and role of non-formal education in agricultural development	1
2	Concept of pedagogy and andragogy; Adult learning characteristics and principle of adult learning	1
3	Meaning, concept, definition of extension and extension education	1
4	Scope, objectives and role of extension in agricultural development	1

5	Principle and philosophy of extension education	1
6	Historical events and different approaches of extension used worldwide	1
7	History of extension and extension education in Nepal	1
8	Extension approaches: Extension approaches used in Nepal (Conventional , IRDP, T and V, BPP, TUKI , F to F)	1
9	Contemporary extension approaches (Privatization, Projectization, Pluralistic Extension and Group approach, Farmers Field School)	1
10	Group concept, types, stage of formation and uses of group in agricultural development	1
11	Extension teaching method: Individual, group and mass method	1
12	ICT and social media as extension teaching methods	1
13	Concept of innovation diffusion process and stages of adoption process	1
14	Categories of farmers based on the technology adoption and factors affecting rate of adoption	1
15	Transfer of technology in agriculture: Concept of agricultural technology and sustainable technology and models of TOT (Conventional, feedback and Farmers participatory)	1
16	Role of extension agent in transfer of technology and emerging concept in TOT (FSRE, PTD, PRA, RRA)	1
17	Basic concept of leader and leadership development and their qualities	1
18	Types, selection, utilization, role of local leader in rural development program	1
19	Basic concept, meaning, scope, objective, principle of program planning in agricultural extension	1
20	Models and steps of program planning cycle in agriculture	1
21	Agricultural extension and advisory service delivery system in federal Nepal	1
22	Agricultural extension and advisory service system in Far Western Province	1
23	Concept of farmers training: Training phases (pre training, during training and post training) and steps in farmers training	1
24	Monitoring and evaluation: Concept, type and differences between monitoring and evaluation; Monitoring and evaluation indicators: input, process, output and impact indicators	1
25	Participatory monitoring and evaluation; Tools for participatory	1

	monitoring and evaluation	
26	Land Grant System (LGS) and role of Nepalese university (AFU, TU, PU, FWU and MWU) in agriculture development.	1
27	Research-Extension and Education system (REE) linkage in Nepal; Importance of REE linkage in agricultural development	1
28	Research in Agricultural Extension: Areas of research, models (qualitative and quantitative research), importance of research in agricultural extension	1
29	Updates in Agricultural Extension (Teacher's review)	2
	<b>Total</b>	<b>30</b>
<b>Course Breakdown (Practical)</b>		
<b>SN</b>	<b>Course Outline</b>	<b>Lectures</b>
1	A visit to individual farm (Agriculture/Crop) for experience sharing	1
2	A visit to individual farm (Livestock) for experience sharing	1
3	Interaction visit and meeting with AKC, DLS, NGOs, ADB/N, Zone/ Superzone and study their program planning process, plan of work, organizational setup and calendar of operation	3
4	Formation and planning for group farming in campus area	1
5	Visit and observation of agricultural and livestock section of local government at the grass root level study their program planning process, plan of work and implementation	2
6	Conduction of method demonstration (group work)	1
7	Conduction of result demonstration (group work)	1
8	Focus Group Discussion with farmers (Agriculture, livestock )	1
9	Interview schedule preparation and use of interview schedule in collection of data from the farmers	2
10	Visit/participate in FFS and/ or farmers training	1
11	Organize/participate in an agricultural fair/exhibition	1
	<b>Total</b>	<b>15</b>

### Recommended Reading Materials

1. Van Den Ban A. W. and Hawkins, H. S. (1988). *Agricultural Extension*. Longman Scientific and Technical Co-published with John Wiley and Sons Inc., New York, US.
2. Dongol, B. B. S. (2004). *Extension Education*. Prativa Singh Dongol Printers, Kathmandu, Nepal.
3. Dahama, O. P. and Bhatnagar. O.P. (1998). *Education and Communication for Development*. Oxford and IBH Publishing Co. Ltd., New Delhi, India.



**FAR WESTERN UNIVERSITY**  
**Faculty of Agriculture**

<b>Course Code</b>	<b>PPA421</b>
<b>Course Title</b>	<b>Diseases of Agronomical Crops and their Management</b>
<b>Credit Hours</b>	<b>3 (2+1)</b>
<b>Full Marks</b>	<b>75</b>
<b>Theory (Marks)</b>	<b>50</b>
<b>Practical (Marks)</b>	<b>25</b>

**Objective (s) of the Course**

After completion of this course, the students will be able to identify the major diseases of agronomical crops, their etiology, epidemiology, disease cycle and their management.

**Course Description**

Major diseases of rice, wheat, barley, maize, millet, pigeon pea, lentil, gram, mustard, groundnut, sesame, linseed, soybean, sugarcane, jute, cotton, tobacco, tea, coffee and rubber with special reference to Nepal; their symptoms, etiology, epidemiology disease cycle and management practices.

**Course Breakdown (Theory)**

<b>SN</b>	<b>Course Outline</b>	<b>Lectures</b>
<b>1</b>	<b>Major Diseases of Rice and Finger millet</b>	
1.1	Rice blast, Brown spot, Sheath blight, False smut of rice	3
1.2	Bacterial leaf blight, Bacterial leaf streak of rice, Zinc deficiency in rice	2
1.3	Millet blast and leaf spot of millet	1
<b>2</b>	<b>Diseases of Wheat and Barley</b>	
2.1	Wheat rust: Brown, Black and Yellow rusts	1
2.2	Loose smut of wheat	1
2.3	Covered smut of barley, Foliar blight (Spot blotch and Tan spot)	1
2.4	Leaf spot, Powdery mildew of wheat	1
2.5	Ear cockle of wheat, Ergot of bajra	1
<b>3</b>	<b>Maize Diseases</b>	
3.1	Grey leaf spot of maize, Southern and Northern leaf blight of maize	2

3.2	Banded leaf and sheath blight of maize, Cob rot, stalk rots of maize	2
<b>4</b>	<b>Diseases of Legumes</b>	
4.1	Wilt of pigeon pea, lentil and chickpea	1
4.2	Stemphylium blight of lentil and Collar rot of lentil, Gray mold of chickpea	2
4.3	Pod blight of soybean, Soybean Mosaic, Rusts and Bacterial pustules of soybean, Bacterial Blight of soybean	2
4.4	Mosaic of blackgram, mungbean, cowpea	1
<b>5</b>	<b>Diseases of Oilseed Crops</b>	
5.1	Sclerotinia blight of mustard, white rust of crucifers	1
5.2	Tikka disease of ground nut, Rhizoctonia collar and root rot	2
5.3	Sesamum blight and linseed rust	1
<b>6</b>	<b>Diseases of Commercial Crops</b>	
6.1	Red rot of sugarcane, Smut of sugarcane	1
6.2	Collar and Root rot of jute	1
6.3	Cotton wilt, Root rot of cotton	1
6.4	Anthraxnose and angular leaf spot of cotton	1
6.5	Tobacco damping off and TMV	1
	<b>Total</b>	<b>30</b>

<b>Course Breakdown (Practical)</b>		
<b>SN</b>	<b>Course Outline</b>	<b>Lectures</b>
1	Collection and preservation of diseased samples	1
2	Preparation of PDA medium for isolation of fungi	1
3	Preparation of medium for bacterial isolation	1
4	Isolation of fungi from infected sample	1
5	Isolation of bacteria from infected sample	1
6	Pathogenicity tests	2
7	T. S. cutting for the study of host-parasite relationship of cereal disease	1
8	T. S. cutting for the study of host-parasite relationship of oilseed disease	1
9	T. S. cutting for the study of host-parasite relationship of pulse disease	1
10	Preparation of slide by teasing method and identification of pathogen	2
11	Seed treatment and spraying of chemicals	1
12	Field visit to identify the disease and learn disease scoring	1

	technique	
13	Calculation of disease incidence and intensity	1
	<b>Total</b>	<b>15</b>

### **Recommended Reading Materials**

1. Agrios, G. N. (2005). *Plant Pathology 5th Edition*: Elsevier Academic Press. Burlington, Ma. USA, 79-103.
2. Chaube, H. S., and Pundhir, V. S. (2005). *Crop Diseases and their Management*. PHI Learning Pvt. Ltd.
3. Pandey, P. (2021). *Laboratory Manual and Workbook on Plant Pathology*.
4. Rangaswami, G., and Mahadevan, A. (1998). *Diseases of Crop Plants in India*. PHI Learning Pvt. Ltd.
5. R S Mehrotra. and Aggarwal, A. (2017). *Plant Pathology*. McGraw Hill Education (India) Private Limited.
6. R.S. Singh (2005). *Plant Disease (8th edition)*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

**FAR WESTERN UNIVERSITY**  
**Faculty of Agriculture**

<b>Course Code</b>	<b>AQU421</b>
<b>Course Title</b>	<b>Fundamentals of Aquaculture</b>
<b>Credit Hours</b>	<b>3(2+1)</b>
<b>Full Marks</b>	<b>75</b>
<b>Theory (Marks)</b>	<b>50</b>
<b>Practical (Marks)</b>	<b>25</b>

<b>Objective (s) of the Course</b>
Upon the completion of the course, the students will be able to explain about cultivable and cultivated fish species, culture units and construction, principles and practices of culture systems, various management required, disease control and post-harvest handling of fish.
<b>Course Description</b>
Definitions and importance of aquaculture; History of aquaculture in Nepal; Site selection and pond construction, pond management; Food and feeding; Water quality; Various fish farming systems; Fish breeding, nursing and rearing; Common fish diseases and parasites; Post-harvest technology.

<b>Course Breakdown (Theory)</b>		
SN	Course Outline	Lectures
<b>1.</b>	<b>Introduction</b>	
1.1	Brief description on fisheries, aquaculture, capture fisheries, culture based fisheries and enhanced fisheries; Definition of terminologies used in aquaculture	1
1.2	Importance of aquaculture: Economic social, nutritional, environmental; Desirable characters of fish for culture	1
<b>2.</b>	<b>Pond Construction</b>	
2.1	Criteria for site selection , soil quality test	1
2.2	Brief description on different types of pond used in aquaculture: One the basis of construction, use, topography and enclosure	1
2.3	Pond layout and brief description on its parts	
2.4	Steps in pond construction, optimum depth and size of different types of pond	1
<b>3.</b>	<b>Pond Management</b>	
3.1	Techniques used for pond management; Pond liming: Lime cycle, advantages of liming, chemicals used for liming, Method and	1

	dose, timing for lime application, neutralizing value of lime	
3.2	Pond fertilization: Brief description, fertilizer dose, types of fertilizer with their advantages and disadvantages, and their application methods	1
3.3	Brief description of feed; Brief description on different types of natural and formulated feed; Brief description on feed formulation, rate, time and methods of feeding; Precaution during fish feeding	1
3.4	Aquatic weed: Brief description, classification of aquatic weed, control of aquatic weed; Brief description and methods for removal of predatory and weed fish; Commonly used piscicides; Recent concept on weed fish	1
<b>4</b>	<b>Water Quality Management</b>	
4.1	Physical parameters-Temperature: Thermal stratification; Diel fluctuation of temperature in fish pond; Effect of water temperature on fish growth; Temperature management on fish pond	1
4.2		
4.3	Physical parameters-Turbidity: Brief description; Types of turbidity; Effects of turbidity; Measurement of turbidity: Secchi disk visibility method; Measures to control pond turbidity	1
4.4	Chemical parameters- Dissolve Oxygen (DO): Brief description; Fluctuation of oxygen level in pond: Diel and seasonal fluctuation; Sign and symptoms of dissolve oxygen depletion; Preventive measure and solution for maintaining dissolve oxygen in pond; Measurement of dissolve oxygen in pond (Instrumental method) pH: Brief description; Diel fluctuation of pH in fish pond; Effect of pH on fish; Measurement of pH; pH management in fish pond	1
	Biological parameters- Planktons: Types of plankton in aquatic environment; Brief description on planktons present aquatic environment; Role of planktons in fish production	1
<b>5.</b>	<b>Fish Farming Systems (FFS)</b>	
5.1	Introduction; Classification of FFS: Description of fish farming system on the basis of intensity with their advantages and disadvantages; Extensive fish farming, semi intensive fish farming	1

5.2	Description of fish farming system on the basis of enclosure: Cage culture and pen culture; Cage culture: Description, site selection, characteristics of fish for cage culture; Types of cage used with brief description; Species stocked and stocking densities; Advantages and disadvantages; Management practices of cage fish culture; Pen culture- Description; Advantages and Disadvantages; Difference between cage fish farming and pen fish farming	1
5.3		
5.4	Description of fish farming system on the basis of fish species with their advantages and disadvantages: Monoculture, Polyculture, and their differences	1
	Description of fish farming system on the basis of integration: Rice fish farming, horticulture fish farming and livestock fish farming; Basic principle of integrated fish farming system; Advantages of integrated fish farming system	1
5.5	Rice fish farming: Background; Site selection; Construction of refuge in rice fish farming; Characteristic of rice variety to be cultivated; Fish species and their stocking rate; Feed and fertilizer; Care and management; Harvesting; Advantage and disadvantages	1
6.	<b>Fish Breeding</b>	
6.1	Brood fish management- Selection of broodstock; Sex differentiation; Source of broodstock; Criteria of good broodstock pond; Segregation of broodstock; Stocking density; Feeding and Care of broodfish	1
6.2		
6.3	Brief description on different types of breeding methods: Natural breeding, semi-artificial breeding and induced breeding; Method of injecting hormone to broodfish; Description of hormones used for artificial spawning: Pituitary gland extract, Human chorionic gonadotropin hormone and Ovaprim	1
	Favorable environment required for successful egg development; Characteristics of good and bad egg; Breeding of common carp, Brief description on Natural breeding; Semi artificial breeding-brief description; Natural condition required to bring spawning; Kakaban; Hatching time and latency period; Brief description and steps involved in artificial breeding	1
6.4	Breeding of Chinese carp- Short notes and steps involved in natural semi artificial and artificial breeding of Chinese carp; Breeding of Indigenous major carps; Short notes and steps	1

	involved in natural, semi artificial and artificial breeding of Indian major carps	
<b>7.</b>	<b>Transportation of Fish Seed</b>	
7.1	Stage of fish for transportation; General guidelines for fish seed transportation; Cause of mortality during fish seed transportation	1
7.2	Conditioning of fish seed before transportation; Method of fish seed packing and transportation: Open and closed system of transportation; Chemical used in fish transportation	1
<b>8.</b>	<b>Common Fish Diseases and Parasites</b>	
8.1	Brief description on fish disease and parasite; Causes of fish disease; Common sign and symptoms	1
8.2	Diagnosis of fish disease: History taking, environmental study, body examination, postmortem examination and laboratory examination; Types of fish diseases: Brief description of Infectious and Non-infectious disease	1
8.3	Non-infectious disease: Cause, symptom, prevention and treatment of Asphixiation and Gas bubble disease	
8.4	Infectious disease: Causal organism, environment requirement, symptom and control measure of Fungal disease: Saprolegneasis/water mould disease Causal organism, environment requirement, symptom and control measure of Bacterial disease: Tail or fin rot disease	1
8.5	Causal organism, environment requirement, symptom and control measure of Parasitic disease: Protozoan disease (White spot disease); Disease caused by Monogenetic trematode (Gyrodactylosis and Dactylogyrosis); Crustaceans (fish lice)	1
<b>9.</b>	<b>Post-Harvest Technology</b>	
9.1	Introduction and importance of post-harvest technology; Practices for maintenance of quality of fish during post-harvest handling: initial handling, on board storage	1
9.2	Techniques for post-harvest storage: Low temperature storage (chilling, super chilling, and freezing); High temperature storage (smoking, drying, brine salting, curing, and canning)	1
	<b>Total</b>	<b>30</b>

<b>Course Breakdown (Practical)</b>		
<b>SN</b>	<b>Course Outline</b>	<b>Lectures</b>
1	Identification of different equipment's used in fish culture and	1

	breeding	
2	Observation of pond types and measurements of a typical pond with its parts	1
3	Pond liming and fertilization	1
4	Water quality measurements (temperature, transparency, Dissolve oxygen and pH)	2
5	Identification of different types feeds used for feeding fish	1
6	Identification of different types of net used in fishing	1
7	Common Carp breeding	1
8	Fry nursing and transportation	1
9	Identification of fresh and spoiled fish	1
10	Common drugs and chemicals used in fish disease treatment	1
11	Preparation of Kakaban for fish breeding	1
12	Preparation of fish feed	1
13	Fish farm visit and preparation of report	2
	<b>Total</b>	<b>15</b>

### **Recommended Reading Materials**

1. Biswas, K.P. (2014). *Fish Processing and Preservation*. Daya Publishing House, India
2. ICAR. (2006). *Handbook of Fisheries and Aquaculture*. New Delhi: Indian Council of Agricultural Research (ICAR).
3. Jhingran, V.G. and R.S.V. Pullin. (1985). *A Hatchery Manual for the common, Chinese and Indian Major Carps*. Manila, Philippines: Asian Development Bank, ICLARM.
4. NACA. (1989). *Integrated Fish Farming in China Technical Manual*. Bangkok, Thailand: A World Food Day Publication of the Network of Aquaculture Centre in Asia and the Pacific.
5. Shrestha M.K. and Jha, D.K (1993). *Introduction to Fish Culture*. Rampur, Chitwan, Nepal: Institute of Agriculture and Animal Science.
6. Shrestha, M.K. and Pandit, N.P. (2012). *A Text Book of Principles of Aquaculture* (2<sup>nd</sup> ed.). Rampur, Chitwan, Nepal: Aquaculture Department, Institute of Agriculture and Animal Science.
7. Woynarovich, E. (1975). *Elementary Guide to Fish Culture in Nepal*. Rome Italy: FAO.
8. Woynarovich, E. and Horvath, L. (1984). *The Artificial Propagation of Warm Water Finfishes: A Manual for Extension*. FAO fisheries technical paper. 20



**FAR WESTERN UNIVERSITY**  
**Faculty of Agriculture**

<b>Course Code</b>	<b>PLB421</b>
<b>Course Title</b>	<b>Fundamentals of Plant Breeding</b>
<b>Credit Hours</b>	<b>3 (2+1)</b>
<b>Full Marks</b>	<b>75</b>
<b>Theory (Marks)</b>	<b>50</b>
<b>Practical (Marks)</b>	<b>25</b>

<b>Objective (s) of the Course</b>
<p>This course is focused on the basic concept of plant breeding, its relationships with other disciplines, and application of the genetic principles for crop improvement. By the end of the course, the students will be able to:</p> <p>i) Discuss and understand the basic concepts of plant breeding and its role in crop improvement</p> <p>ii) Know about plant germplasm source, introductions, modes of reproduction and crossing methods in self- and cross-pollinated crops</p> <p>iii) Know about the hybridization techniques, heterosis and breeding methods in self- and cross- pollinated crops</p> <p>iv) Apply the breeding principles during maintenance breeding and seed certification</p> <p>v) Understand the principles of developing new varieties, release and intellectual property right</p>
<b>Course Description</b>
<p>Scope and history of plant breeding; Plant introduction and domestication; Modes of reproduction; Inheritance of qualitative and quantitative characters or traits; Biometrical techniques in plant breeding; Selection and hybridization in crops; Heterosis, mutation breeding, polyploidy; Release of new cultivars; Crop improvement in Nepal and plant breeding institutions.</p>

<b>Course Breakdown (Theory)</b>		
<b>SN</b>	<b>Course Outline</b>	<b>Lectures</b>
1	Introduction to plant breeding, history, objectives, activities	1
2	Achievements, constraints, opportunities, characteristics improved by plant breeders	1
3	Pattern of evolution in crop plants, center of origin of bio-diversity, germplasm and its conservation, plant introduction and acclimatization, significance of germplasm sources in plant	1

	breeding	
4	Modes of reproduction and pollination control methods, anthesis pollination, inbreeders and outbreeders	1
5	Mechanisms promoting self-pollination and cross pollination in crop plants and their significance in plant breeding	1
6	Qualitative and quantitative inheritance of characters or traits, experiments on qualitative and quantitative inheritance of traits in plants	1
7	Population genetics and Hardy Weinberg principle	1
8	Biometrical techniques and their applications in plant breeding (assessment of variability, aids to selection)	1
9	Choice of parents, crossing techniques, genotype by environment interactions	1
10	Breeding methods in self-pollinated crops: pure line theory, pure line selection, mass selection methods, line breeding	1
11	Pedigree selection, bulk selection, backcross method, single seed descent method, multiline method, di-allele selective mating and population breeding	1
12	Breeding methods in cross pollinated crops: selection, response to selection, mass selection, progeny testing, ear to row method	1
13	Progeny selection, recurrent selection schemes for intra and inter-population improvement, development of synthetic and composite varieties and population breeding	1
14	Hybrid breeding, genetical and physiological basis of heterosis and inbreeding	1
15	Production of inbred lines, breeding approaches for improvements of inbred lines, prediction of hybrid performance	1
16	Seed production of hybrid and their parent varieties/inbred lines.	1
17	Breeding methods in asexually/clonally propagated crops	1
18	Clonal selection and apomixis breeding	1
19	Self-incompatibility and male sterility in crop plants and their significance in plant breeding	1
20	Concept of plant ideotype and its role in crop improvement	1
21	Mutation breeding, breeding for abiotic stress	1
22	Breeding for pest resistance	1
23	Breeding for disease resistance	1
24	Cultivar development-testing, release and notification	1
25	Maintenance breeding, participatory plant breeding	1
26	Quality seed, production and maintenance	1

27	Crop improvement in Nepal (Wheat and Rice)	1
28	Crop improvement in Nepal (Maize and Legumes)	1
29	Crop improvement in Nepal (Oilseeds, Millets, Vegetables, Fruits, Spices, etc.)	1
30	Intellectual property rights in plant breeding and international agreements regarding plant varietal protection	1
	<b>Total</b>	<b>30</b>

<b>Course Breakdown (Practical)</b>		
<b>SN</b>	<b>Course Outline</b>	<b>Lectures</b>
1	Study the plant breeder's kit	1
2	Germplasm collection and conservation	1
3	Study of floral parts of field crops	1
4	Hybridization techniques in self-pollinated crops	2
5	Hybridization techniques in cross-pollinated crops	2
6	Plant breeding data recording and trial evaluation	1
7	Determining genetic purity of seed in the lab	1
8	Methods of maintaining genetic purity in the field	1
9	Scoring field data and determining resistance/susceptibility to disease and pest	1
10	Describing the traits for release of a new variety	1
11	Study plant breeding trials on research station and on farm trials	1
12	Analysis of variance (ANOVA) and its use in plant breeding	1
13	Estimation of heritability and genetic advance	1
	<b>Total</b>	<b>15</b>

### **Recommended Reading Materials**

1. Acquaah, G. (2009). *Principles of Plant Genetics and Breeding*. John Wiley and Sons.
2. Chopra, V. L. (Ed.). (1989). *Plant Breeding: Theory and Practice*. South Asia Books.
3. Gupta, S. K. (Ed.). (2000). *Plant Breeding: Theory and Techniques*. Agrobios.
4. Poehlman, J. M. and Sleper, D. A. (1995). *Breeding Field Crops*. 4<sup>th</sup> Iowa State University Press. Ames, USA P, 494.
5. Singh, B. D. and Singh, B. D. (1999). *Textbook of Plant Breeding*. Kalyani publishers.

**FAR WESTERN UNIVERSITY**  
**Faculty of Agriculture**

<b>Course Code</b>	<b>AGF411</b>
<b>Course Title</b>	<b>Medicinal and Aromatic Plants</b>
<b>Credit Hours</b>	<b>2 (1+1)</b>
<b>Full Marks</b>	<b>50</b>
<b>Theory (Marks)</b>	<b>25</b>
<b>Practical (Marks)</b>	<b>25</b>

<b>Objective (s) of the Course</b>
Upon the completion of this course, the students will be able to understand the importance of Medicinal and Aromatic Plants (MAPs), its traditional uses and research status of MAPs.
<b>Course Description</b>
Introduction, history, classification, importance, prospects and constraints of MAPs; Research status of MAPs in Nepal; Extraction and storage methods for MAPs; Impacts of environmental degradation; Climate change and over exploitation of MAPs, Phyto-medicine and uses of MAPs in different traditional health care system and description; Origin, distribution and chemical evaluation of Medicinal and Aromatic Plants.

<b>Course Breakdown (Theory)</b>		
<b>SN</b>	<b>Course Outline</b>	<b>Lectures</b>
1	Introduction, history and classification of Medicinal and Aromatic Plants	1
2	Importance, prospects and constraints of Medicinal and Aromatic Plants	1
3	Classification of Medicinal and Aromatic Plants	1
4	Extraction and storage methods for Medicinal Plants	1
5	Status of environmental degradation and climate change in Nepal	1
6	Effects of climate change and environmental degradation in MAPs	1
7	Ways to reduce effect of climate change and over exploitation of MAPs	1
8	Phyto-medicines and Medicinal crops; Uses of Medicinal Plants in Aurveda	1
9	Uses of Medicinal Plants in Siddha, Yoga, Unani, Naturopathy,	1

	Homeopathy, Chinese Medicine	
10	Uses of Medicinal plants in Folk-remedies and other traditional health care system	2
11	Description, origin, distribution and chemical evaluation of common MAPs	
11.1	Medicinal Plants: Aloe, Datura	1
11.2	Medicinal Plants: Rauwolfia, Neem	1
11.3	Aromatic Plants: Ginger Grass, Mint	1
11.4	Aromatic Plants : Rose, Tulsi	1
	<b>Total</b>	<b>15</b>

<b>Course Breakdown (Practical)</b>		
<b>SN</b>	<b>Course Outline</b>	<b>Lectures</b>
1	Preparation of questionnaire designed for recording traditional uses of locally available herbs/ MAPs	1
2	Pre-testing of questionnaire designed for recording traditional uses of locally available herbs/ MAPS	2
3	Documentation of local uses of important medicinal plants of local tribal community Tharu	1
4	Documentation of local uses of important medicinal plants of local tribal community Bote	1
5	Identification of important high value herbs and their products	1
6	Identification of important aromatic plants and their products	1
7	Nursery bed preparation of medicinal and aromatic plants	2
8	Planting of medicinal plants	1
9	Planting of aromatic plants	1
10	Field observation of herbal farms (medicinal plants)	1
11	Field observation of herbal farms (aromatic plants)	1
12	Field observation of processing plants (medicinal plants)	1
13	Field observation of processing plants (aromatic plants)	1
	<b>Total</b>	<b>15</b>

### **Recommended Reading Materials**

1. Atal, C.K. and. Kanpur, B.M. (1982). *Cultivation and Utilization of Medicinal and Aromatic Plants*. Regional Research Laboratory, CSIR, Jammu, Tawi, India.
2. Bhattacharjee, S.K. (2000). *Hand Book of Aromatic Plants*. Pointer Publisher, Jaipur, India.

3. Hussain, A. (1992). *A status report on Cultivation of Medicinal Plants in NAM countries*. Center of Science and Technology of the Non-aligned and other developing Countries, New Delhi.
4. IUCN. (2000). *National Register of Medicinal Plants*. IUCN - Nepal, Kathmandu.
5. Kaufman, P.B., Cseke, L.J., Warber, S., Duke, J.A. and Brielman, H.L. (1999). *Natural Products from Plants*. CRC Press, UAS. Journal of Medicinal and

**FAR WESTERN UNIVERSITY**  
**Faculty of Agriculture**

<b>Course Code</b>	<b>ENT421</b>
<b>Course Title</b>	<b>Principles and Practices of Insect Pest Management</b>
<b>Credit Hours</b>	<b>3 (2+1)</b>
<b>Full Marks</b>	<b>75</b>
<b>Theory (Marks)</b>	<b>50</b>
<b>Practical (Marks)</b>	<b>25</b>

<b>Objective (s) of the Course</b>
Upon the completion of this course, the students will be able to understand the different principles and practices of insect pest management, and will be able to manage the insect pests independently.
<b>Course Description</b>
Pest management concepts; Elements of insect-pest management, insecticides, cultural, mechanical, physical and legislative measures of insect-pest management; Host plant resistance, attractants, repellents and genetic control; Parasitoids and predators; Use of insect pathogens; Pest management strategies for insects affecting man and domestic animals; and integrated insect pest management.

<b>Course Breakdown (Theory)</b>		
SN	Course Outline	Lectures
<b>1</b>	<b>Agricultural Insect Pests and their Management</b>	
1.1	Concept of crop pest, insect pest management, significance and historical aspect of insect pest management	1
1.2	Factors responsible for increasing insect pests in crop fields	1
<b>2</b>	<b>Economics of Insect Pest Management</b>	
2.1	Concept of threshold level and its importance in decision making	1
2.2	Tools for decision making: sampling and monitoring	1
2.3	Tools for decision making: survey and surveillance	1
<b>3</b>	<b>Components of Insect Pest Management</b>	
3.1	Cultural methods: principle, methods and significance	1
3.2	Mechanical method: principle, methods and significance	1
3.3	Physical method: principle, methods and significance	1
3.4	Biological method	
3.4.1	Concept and significance of biological pest management	1
3.4.2	Parasitoids and predators	1
3.4.3	Insect pathogens	1

3.4.4	Bio-control techniques in pest management	1
3.5	Chemical method	
3.5.1	History of insecticides and their significance in insect pest management	1
3.5.2	Types, classification and hazardous level of insecticides	1
3.5.3	Formulation of insecticides	1
3.5.4	Pollution caused by insecticide, insecticide poisoning, first aid and antidotes	1
3.5.5	Insecticide misuse and precautionary measures in Nepal	1
3.6	Legislative and quarantine method	
3.6.1	Basic concept of legislative approaches through quarantine	1
3.6.2	Quarantine of Nepal and their role in pest management	1
3.7	Host Plant Resistance (HPR)	
3.7.1	Basic concept, history and significance in pest management	1
3.7.2	Mechanisms and measurement techniques for HPR	1
3.7.3	Genetic engineering techniques and their significance in insect pest management	1
3.8	Insect behavior manipulation	
3.8.1	Basic concept and significance in pest management	1
3.8.2	Types of attractants and repellents	1
<b>4</b>	<b>Integrated Pest Management (IPM)</b>	
4.1	Concept of IPM, and its significance in pest management	1
4.2	Historical aspect of Integrated Pest Management (IPM) in world and in Nepal	1
4.2	Components and available tools of IPM in Nepal	1
4.3	Concept of IPM extension model: Farmers Field School (FFS)	1
<b>5</b>	<b>Pesticide Residue Assessment Practices and Significance</b>	1
<b>6</b>	<b>Insect Pest Management in Precision Agriculture</b>	1
	<b>Total</b>	<b>30</b>

<b>Course Breakdown (Practical)</b>		
<b>SN</b>	<b>Course Outline</b>	<b>Lectures</b>
1	Field visit and interaction with farmers on insect pest problems	1
2	Identification and proper handling of pesticides in laboratory condition	1
3	Pesticide dilution and dose calculation for field application	1
4	Study on the use and handling of pesticide appliances	1
5	Scouting techniques to common insect pests at nearby farm	1
6	Identification and uses of microbial pesticides	1



7	Preparation of food bait for insect pest management	1
8	Preparation of poison bait and use for rodent control	1
9	Collection, preparation and use of botanical materials for insect pest management	1
10	Monitoring of insect pests by different traps (pheromone/pit fall/sticky traps)	1
11	Monitoring of insect pests in light trap	1
12	Bio-assay techniques of pesticide and bio-pesticide against common pest	1
13	Pesticide survey in market and their classification: a case study	1
14	Insect zoo and cup study and its significance	1
15	Isolation of entomopathogenic fungi from soil and lab study of bio-pesticide focused on Metarhizium	1
	<b>Total</b>	<b>15</b>

### Recommended Reading Materials

1. Dhaliwal, G. S. and Arora, R. (2003). *Principles of Insect-pest Management*. Kalyani Publishers, New Delhi, India.
2. Flint, M. L. (2012). *IPM in Practice: Principles and Methods of Integrated Pest Management*. University of California Agriculture and Natural Resources, USA.
3. Koul, O., Dhaliwal, G.S. and Cuperus, G.W. (2004). *Integrated Pest Management: Potential, Constraints and Challenges*. CABI.
4. Manandhar, D. N. (2006). *Pesticides in Nepal*. The Rising Sun Printers, Teku, Kathmandu.
5. Neupane, F. P. (2002). *Tarkari Balima Lagne Kiraharuko Ekikrit Byabasthapan (in Nepali version)*. Jagadamba Press, Lalitpur, Nepal.
6. Norris, R.F., Caswell-Chen, E.P. and Kogan, M. (2002). *Concepts in Integrated Pest Management*. Prentice Hall of India Pvt. Ltd., New Delhi, India.

**FAR WESTERN UNIVERSITY**  
**Faculty of Agriculture**

<b>Course Code</b>	<b>AGR421</b>
<b>Course Title</b>	<b>Principles and Practices of Seed Production and Technology</b>
<b>Credit Hours</b>	<b>3 (2+1)</b>
<b>Full Marks</b>	<b>75</b>
<b>Theory (Marks)</b>	<b>50</b>
<b>Practical (Marks)</b>	<b>25</b>

<b>Objective (s) of the Course</b>
Upon the completion of this course, the students will understand the principles for successful production of seed of major crops and gain basic skills for producing quality seed.
<b>Course Description</b>
Seed, fruit, grain, propagating materials; Seed development process and factor affecting it, seed dormancy, germination and quality seed and factor affecting it, seed longevity; Types of seed and their multiplication techniques; Certification and distribution; National and International organization involved in seed, seed law, farmer's seed and intellectual property right (IPR).

<b>Course Breakdown (Theory)</b>		
<b>SN</b>	<b>Course Outline</b>	<b>Lectures</b>
<b>1</b>	<b>Basics of Seed Production</b>	
1.1	Seed and grains; Seed materials; Seed technology; Quality seed; Seed Production history and scope in Nepal	1
1.2	Seed system in Nepal and National Seed Vision (2013-2025)	1
1.3	Different categories of seed; Classes of seed (Nucleus, Breeder, Foundation, Certified, Improved, Truthful labelled Seeds) in Nepal	1
<b>2</b>	<b>Seed Policies and Provisions</b>	
2.1	Seed Act 2045, National Seed Policy 2056, Seed Regulation Act 2069, Seed Certification Directives 2074	1
2.2	Role of Seed Quality Control Centre (SQCC); Central Agriculture Laboratory; Provincial Seed Laboratory; International Seed Testing Association (ISTA)	1
2.3	Varieties release and registration processes in Nepal	1

<b>3</b>	<b>Seed Formation and Development</b>	
3.1	Factors affecting seed growth and development	1
3.2	Floral induction and flower structure, sexual and asexual reproduction	1
3.3	Post fertilization changes in flower, embryo, endosperm and seed-coat development	1
<b>4</b>	<b>Seed Germination and Dormancy</b>	
4.1	Seed germination: types, process, and factors affecting seed germination	1
4.2	Seed dormancy: causes, types and methods of breaking seed dormancy	1
<b>5</b>	<b>Genetic Principles of Quality Seed Production</b>	
5.1	Varietal deterioration, developmental variation, natural crossing	1
5.2	Effect of disease and pests, maintaining varietal purity	1
5.3	Hybrid seed production technologies and GM crops	1
<b>6</b>	<b>Agronomic Principles of Quality Seed Production</b>	
6.1	Recommended domain, variety and land selection, land preparation and fertilizer management	1
6.2	Sources of seed, seed rate and class; Isolation distance and time isolation	1
6.3	Supplementary pollination, rouging, weed management, water management	1
6.4	Disease and pest management	1
<b>7</b>	<b>Field Inspection and Seed Sampling</b>	
7.1	Objectives, general principles and methods of field inspection	1
7.2	Field inspection stages and time in various crops; Lot number and its arrangement in seed store	1
7.3	General principles of seed sampling, types of seed samples; Procedure of seed sampling; Precautions while doing seed sampling	1
<b>8</b>	<b>Seed Certification</b>	
8.1	Objectives, concepts and general principles	1
8.2	Seed certification process in Nepal	1
8.3	Minimum field and seed (lab) standard for seed certification in Nepal	1
<b>9</b>	<b>Seed Testing and Treatment</b>	

9.1	Principles of seed germination; Purity and Moisture test; Methods of seed germination, purity and moisture test; Seed rate calculation based on germination and purity results	1
9.2	Definition of seed vigor, principles of seed viability and moisture test; Seed priming, Inoculation, Disinfestation and Disinfection; Seed treatment: objective, concepts, process and precautions	1
<b>10</b>	<b>Seed Processing, Storage and Marketing</b>	
10.1	Seed crop harvesting, threshing, cleaning, drying	1
10.2	Seed grading principles and procedures	1
10.3	Principles and objectives of seed storage; Seed storage devices/ materials/ houses with their merits and demerits	1
10.4	Post-harvest management of seeds	1
	<b>Total</b>	<b>30</b>

<b>Course Breakdown (Practical)</b>		
<b>SN</b>	<b>Course Outline</b>	<b>Lectures</b>
1	Identification of seeds along with the characteristics of various field crops	1
2	Practice on seed germination test in field and in lab	1
3	Practice on seed vigor and viability test	1
4	Practice on seed purity test and seed moisture test	1
5	Seed sampling from the seed store house	1
6	Visit to seed production farm nearby college	1
7	Method of field inspection of the seed crops and practices on filling forms	1
8	Practice of seed cleaning, drying and grading	1
9	Visit to seed processing plant, seed co-operative and seed production farm	1
10	Visit to seed laboratory Sundarpur, Kanchanpur/ Khajura, Banke	1
11	Seed production of a field crop	1
12	Practice on seed treatment, packaging and grading	1
13	Breaking dormancy of different crop seeds	1
14	Identification of seed borne diseases and pathogens	1
15	Practice on roguing of off types and diseased plants in the field	1
	<b>Total</b>	<b>15</b>

## **Recommended Reading Materials**

1. Agrawal, R.L. (2005). *Seed Technology*. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
2. Bhattachan, B.K. (2010). *Manual on Principles and Practices of Seed Technology*. Institute of Agriculture and Animal Science, Rampur, Chitwan.
3. Bhattachan, B.K. (2011). *Research Manual of Seed Technology*. Institute of Agriculture and Animal Science, Rampur, Chitwan.
4. Copeland, L.O. and McDonald, M.B. (1985). *Principles of Seed Science and Technology*. Burgess publishing Company, Minneapolis, Minnesota USA.
5. Justice, O.L and Louis, N.B. (1978). *Principles and Practices of Seed Storage*. Agric. Hand Book No 506.
6. LI-BIRD and The Development Fund. (2017). *Farmers' Seed Systems in Nepal: Review of National Legislations*. Pokhara, Nepal.
7. Mirja Hasanuzzaman. (2020). *Agronomic Crops*. Volume 1 Production Technologies. Springer Publication.
8. MoAD. (2014). *National Seed Vision 2013-2025*. Ministry of Agricultural Development. Nepal.
9. Paudel, M.N., Pokhrel, S., Gadal, N., Ferrara, G-Ortiz., KC D., Joshi, P., and Humagain, R. (2013). *An overview of different seed production initiatives in Nepal*. Agronomy Journal of Nepal. Vol 3.

**FAR WESTERN UNIVERSITY**  
**Faculty of Agriculture**

<b>Course Code</b>	<b>SSC411</b>
<b>Course Title</b>	<b>Soil Physics, Genesis and Classification</b>
<b>Credit Hours</b>	<b>2 (1+1)</b>
<b>Full Marks</b>	<b>50</b>
<b>Theory (Marks)</b>	<b>25</b>
<b>Practical (Marks)</b>	<b>25</b>

<b>Objective (s) of the Course</b>
To impart basic knowledge about soil physical properties and processes in relation to plant growth especially soil water, soil formation factors and processes, and use of diagnostic soil characteristics to develop classification of soils.
<b>Course Description</b>
Scope of soil physics and its relation with other branches of soil science; Soil as a three phase system; Quantitative concept of soil physics; Soil water: Soil-water constants, energy state of soil water, soil water potential, soil moisture characteristic curve; Water flow in saturated and unsaturated soils, Darcy's law; Hydraulic conductivity; Infiltration mechanism in soil; Soil forming factors and processes, soil moisture and temperature regimes, macro and micro morphological properties of soils; USDA and FAO soil classification system, Kinds and distribution of soils in Nepal and potential uses.

<b>Course Breakdown (Theory)</b>		
<b>SN</b>	<b>Course Outline</b>	<b>Lectures</b>
1	Introduction: Definition, scope of soil physics and its relation with other branches of soil science; Soil as a three phase system	1
2	Properties of soil water, importance of soil water	1
3	Energy concept of water; Soil water potential: Gravitational, Matric and Osmotic potential	1
4	Soil moisture characteristics curve, hysteresis and air entry suction, soil water constants	1
5	Hydraulic gradient, water flow in saturated and unsaturated soils	1
6	Infiltration mechanism in soil, mechanisms of surface sealing and crusting, and their management	1
7	Thermal properties of soil, heat movement in soils, soil temperature in relation to plant growth; Soil temperature management	1

8	Soil forming factors and processes and master horizons	1
9	Characteristics of diagnostic surface horizons	1
10	Characteristics of diagnostic sub-surface horizons	1
11	Soil moisture and temperature regimes: Definition, classification, significance	1
12	Basis for classification of soils according to USDA system; Features of Alfisols, Andisols, Aridisols, Entisols, Gelisols, Histosols	1
13	Features of Inceptisols, Mollisols, Oxisols, Spodosols, Ultisols, Vertisols	1
14	Soil Classification according to FAO system	1
15	Kinds and distribution of soils in Nepal and potential uses	1
	<b>Total</b>	<b>15</b>

<b>Course Breakdown (Practical)</b>		
<b>SN</b>	<b>Course Outline</b>	<b>Lectures</b>
1	Volume and mass relation of soil constituents	1
2	Determination of soil wetness by gravimetric method and soil depth	1
3	Determination of water content of soil by resistance	1
4	Measurement of soil water potential by Tensiometer	1
5	Observation of capillary process of soil	1
6	Study of the hysteresis effect	2
7	Determination of field capacity in field and by pot method	1
8	Identification of diagnostic horizons of soil	1
9	Soil profile observation and naming of soil horizons: Lowland	2
10	Soil profile observation and naming of soil horizons: Upland	2
11	Classification of soil and report presentation	2
	<b>Total</b>	<b>15</b>

### **Recommended Reading Materials**

1. Baver, L. D., Gardner, W.H. and Gardner, W.R. (1972). *Soil Physics*. John Wiley and Sons.
2. Brady, N. C. and Weil, N.R. (2012). *Nature and Properties of Soils (14th Edition)*. Macmillan Publishing Co. Inc., New York.
3. Buol, E. W., Hole, E. D., MacCracken, R. J. and Southard, R. J. (1997). *Soil Genesis and Classification (4th Edition)*. Iowa State University Publication/Ames.

4. Hillel, D. (1980). *Fundamentals of Soil Physics*. Academic Press, Inc. New York.
5. Shegal, J. (1996). *Concept and Application of Pedology*. Kalyani Publishers. New Delhi.
6. Lal, R. and Shukla, M. K. (2004). *Principles of Soil Physics*. Marcel Dekker and Sons.