

FAR WESTERN UNIVERSITY
Faculty of Agriculture
Undergraduate Program in Agriculture
Science



Second Semester Syllabus

B. Sc. Agriculture Science Second Semester Syllabus

S.N.	Name of the Course	Course Code	CH-Th	CH-Pr	CH-Total	Reference Page
1	Agro-Meteorology	AMT211	1	1	2	
2	Farm Management and Resource Economics	AEC221	2	1	3	
3	Field Crop Production - I	AGR221	2	1	3	
4	Fundamentals of Crop Physiology	CPH221	2	1	3	
5	Fundamentals of Genetics	PLB221	2	1	3	
6	Manure, Fertilizer and Nutrient Management	SSC221	2	1	3	
7	Ornamental Horticulture	HRT211	1	1	2	
8	Ruminant Production	ASC211	1	1	2	
Total			13	8	21	

FAR WESTERN UNIVERSITY
Faculty of Agriculture

Course Code	AMT211
Course Title	Agro-Meteorology
Credit Hours	2 (1+1)
Full Marks	50
Theory (Marks)	25
Practical (Marks)	25

Objective (s) of the Course
<p>Upon completing this course, the students will be able to:</p> <p>i. Understand the importance of weather and climate in agricultural production system and relate the growth, development and production of crops to prevailing weather and climate,</p> <p>ii. Understand the meaning of agro-climatic regionalization and make choices of crops and cropping system in the limits of weather and climate, and</p> <p>iii. Understand the importance of climate smart agriculture and means to climate proofing.</p>
Course Description
<p>Definition, role and importance of agro meteorology; Solar Radiation, temperature, humidity, wind movement, precipitation; Crop zonation, soil moisture and micro-climate modification; Basic understanding on elements of weather and climate, their variability and measurements, climatic requirements of different crops; Crop water requirements, agro-climatic regionalization; Weather forecast and agricultural advisory.</p>

Course Breakdown (Theory)		
SN	Course Outline	Lectures
1	Definition, role and importance of agro-meteorology; Scope of agro meteorology	1
2	Concepts of weather and climate; Classification of climate; Climate systems in Nepal; Sources of climatic variation and climate systems in Nepal	1
3	Solar Radiation: Diurnal and annual variations in solar radiation; Radiation balance and net radiation	1
4	Solar radiation and crop interaction: Crop productivity and solar radiation relationship.	1

5	Air and soil temperature: Diurnal and annual variation; Effects of air and soil temperature on crop physiology, growth, development and production	1
6	Atmospheric pressure and wind: Causes of wind movement; Wind speed and direction; Types of wind systems; Significance of wind movement in agriculture	1
7	Humidity: Processes of humidification and dehumidification of atmosphere; Saturation vapor pressure; Dew point; Significance of atmospheric humidity on agriculture	1
8	Precipitation: Forms and types of precipitation; Rainfall and agricultural decision making	1
9	Soil moisture: Soil water balance and ways of soil water loss in the field	1
10	Evaporation and transpiration; Factors affecting evaporation and transpiration	1
11	Agro-meteorological normal of cereals, pulses, oilseeds, horticultural and plantation crops	1
12	Components of automatic weather station; Sensors for measuring agro-meteorological variables and their working principles	1
13	Agro-meteorological Models	1
14	Types of weather forecast and their usefulness in agriculture; Agro-meteorological advisory system in Nepal	1
15	Climate change and its impact on agriculture; Impacts of climate change on crop and livestock production system in Nepal	1
	Total	15

Course Breakdown (Practical)		
SN	Course Outline	Lectures
1	Identification of various weather recording instruments in an agro-meteorological station	1
2	Study of the macro and micro-climate and ways to manage micro-climatic variability in the agriculture field	1
3	Introduction to Nepalese Agro-ecology and pocket zones of various agriculture crops	1
4	Measurement of solar radiation – intensity, duration, quality	1
5	Measurement of ambient, maximum and minimum air temperature	1
6	Measurement of soil temperature using various instruments	1
7	Measurement of atmospheric pressure and wind velocity for	1

	different height	
8	Measurement of atmospheric humidity using psychometric chart	1
9	Study and handling of rain gauge and computation of rainfall from recording type rain gauge	1
10	Estimation of missing precipitation data and computation of average precipitation of an area	1
11	Estimation and measurements of evaporation and transpiration	1
12	Visit to nearby Automatic weather station of the Agriculture Campus	1
13	Introduction to various weather related models	1
14	Introduction to various crop simulation models used in agriculture decision making	1
15	Agro-advisory service systems in Nepal and their implications in making agriculture production decisions	1

Recommended Reading Materials

1. Reddi S.R. and Reddi, D.S. (2014). *Agro-meteorology*. Kalyani Publishers, New Delhi.
2. Mote B.M. and Sahu, D. D. (2014). *Principle of Agricultural Meteorology*. Scientific Publishers, New Delhi.

FAR WESTERN UNIVERSITY
Faculty of Agriculture

Course Code	AEC221
Course Title	Farm Management and Resource Economics
Credit Hours	3 (2+1)
Full Marks	75
Theory (Marks)	50
Practical (Marks)	25

Objective (s) of the Course
Upon the completion of this course, the students will be able to understand the various aspects of farm management, different principles of production economics and the effective ways of managing available agricultural resources to obtain the optimum income from the farm businesses.
Course Description
Farm management: definition, scope and importance, relationship of farm management with other sciences; Farm management functions; Farm management decisions; Factors to be considered in selecting a farm; Terminologies: Definition and types of resources, cost and its types, product and its types, break-even point (BEP), benefit-cost ratio (BCR), factors of production, short-run and long-run production decisions, comparative advantage and competitive advantage; Production economics: concept of agricultural production economics, production function, classical production function and stages of production; Production relationships: factor-product relationship, factor-factor relationship, product-product relationship; Basic principles in farm management decisions; Farm resource management: land management, labor management, capital equipment management; Economies of scale: internal and external economies of scale; Farm planning and farm budgeting; Farm records and accounts; Farm inventory; Net worth statement (balance sheet); Depreciation of farm assets; Farm efficiency measures; Linear programming; Risk and uncertainty in agriculture; Project cycle: Assessment/ Analysis of a project (Payback period, Benefit-Cost Ratio, Net present Value, Internal Rate of Return, sensitivity analysis); Resources-Definition, types; Relationship between human and farm resources-different components of Nepalese farming system; Resources depletion and mitigation approaches; Economic valuation of natural resources: their use in policy development and evaluation; Climate change and land use regulation; Environmental plans and policies in Nepal and Institutions involved; EIA– Definition, importance and process.

Course Breakdown (Theory)		
SN	Course Outline	Lectures
1	Farm management: definition, scope and importance; Relationship of farm management with other sciences	1
2	Farm management functions: planning, organizing, staffing, directing and controlling functions; Basic skills and role of a farm manager	1
3	Farm management decisions: production and organizational decisions, administrative decisions and marketing decisions	1
4	Factors to be considered in selecting a farm: natural factors, artificial factors, other factors affecting farm selection	1
5	Resources and its types (fixed and variable; flow and stock); Product and its types	1
6	Short-run and long-run production decisions	1
7	Comparative and competitive advantage	1
8	Concept of agricultural production economics; Production function and production schedule; Continuous and discrete production function; Transformation period	1
9	Classical production function and analysis of the three stages of production	1
10	Production relationships: factor-product (input-output) relationship; Equilibrium point in case of input-output relationship (Maximization of net revenue)	1
11	Production relationships: factor-factor (input-input) relationship; Least cost combination	1
12	Production relationships: product-product relationship; Production Possibility Curve	1
13	Principles involved in farm management decisions: Principle of variable proportions	1
14	Principles involved in farm management decisions: Principle of factor substitution and Principle of product substitution (Law of equi-marginal returns)	1
15	Principles involved in farm management decisions: Cost principle and Opportunity cost principle (Principle of opportunity cost)	1
16	Principles involved in farm management decisions: Time comparison principle (Principle of time value of money)	1
17	Economies of scale: internal and external economies of scale	1
18	Farm planning: concept and importance; Characteristics of a good	1

	farm plan	
19	Farm budgeting: concept, importance, and types of farm budgeting (partial and enterprise budgeting); Complete budgeting concept	1
20	Farm records and accounts: concept and importance; Types of farm records - physical farm records and financial farm records	1
21	Concept of farm inventory; Purpose and process of making farm inventory; Valuation of farm inventory (cost minus depreciation, cost or market price, net selling price, replacement cost minus depreciation, income capitalization) ; Selection of methods for valuation of farm assets	1
22	Concept of depreciation; Methods of computing depreciation (annual revaluation; straight line; diminishing balance; sum-of-the-year-digits / reducing fraction); Selection of methods for computing depreciation	1
23	Concept of Net Worth Statement / Balance sheet; Income Statement; Cash-flow Statement	1
24	Farm efficiency measures: profitability analysis, net worth analysis, liquidity analysis, solvency analysis	1
25	Farm resource management: land and labor management (only Economic/Financial aspect)	1
26	Farm resource management: machinery and farm building management (only Economic/Financial aspect)	1
27	Linear programming – concept, assumptions, and basic elements; application in agriculture with the help of graphical method	1
28	Linear programming – application in agriculture with the help of Simplex Method with two variables	1
29	Concept of risk and uncertainties in agriculture; Types of risk and uncertainties in agriculture	1
30	Risk management strategies in agriculture; Planning for managing risks	1
Total		30

Course Breakdown (Practical)		
SN	Course Outline	Lectures
1	Visit to a nearby farm and collection of farm's/farmer's data for the preparation of different farm records and farm financial analysis	1
2	Preparation of farm inventory (along with valuation of farm assets using appropriate methods) and computation of their depreciation	1

	using different methods	
3	Preparation of different types of physical farm records	1
4	Preparation of Balance Sheet; Income Statement and Cash Flow Statement	1
5	Farm physical efficiency measures- Land use efficiency, labor use efficiency, machinery use efficiency, production efficiency	1
6	Farm financial efficiency measures- Profitability analysis, net worth analysis, liquidity analysis, solvency analysis	1
7	Analysis of Benefit-Cost Ratio, Net Present Value, Payback Period and Internal Rate of Return of the Firm	1
8	Sensitivity analysis: cost over-run and/or income depletion	1
9	Preparation of a farm budget: partial and enterprise budget	1
10	Comparison of different project based on time value of money	1
11	Determination of “least cost combination” of inputs of a farm	1
12	Determination of optimum input use (single input) and maximization of profit using input-output relationship	1
13	Determination of optimum product combination for revenue maximization using output-output relationship	1
14	Case Study (Group-wise/ choice of one among three broader topics as below): a. Agricultural risks and safeguarding measures b. Economic impact of climate change in agriculture c. Valuation of eco-system services	1
15	Estimation of suitable production level of any two commodities based on linear programming principle	1
Total		15

Recommended Reading Materials

1. Chopra, P.N. (2012). *Principles of Economics*. Kalyani Publishers, New Delhi.
2. Debertin, D. L. (2012). *Agricultural Production Economics*. Create space Independent Pub., USA.
3. Johl, S. S. and Kapur, T. R. (2015). *Fundamentals of Farm Business Management*. Kalyani Publishers, India.
4. Kay, R. and Edwards, W. (2011). *Farm Management*. McGraw-Hill Education/Asia.
5. Subba-Reddy, Raghu Ram, S., P., Sastry, T. V. N. and Devi, I. B. (2019). *Agricultural Economics*. Oxford and IBH Publishing Co. Pvt. Ltd., India.

FAR WESTERN UNIVERSITY
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Course Code	AGR221 / AGR321
Course Title	Field Crop Production - I / II
Credit Hours	3 (2+1)
Full Marks	75
Theory (Marks)	50
Practical (Marks)	25

Objective (s) of the Course

Upon completion of this course, students will gain scientific knowledge and skills for growing summer season field crops successfully (This course will be offered either in second or third semester depending on the nature of growing season of the crop).

Course Description

Introduction and importance, origin, area, production, productivity, distribution, soil and climatic requirement, constraints and opportunities of production, improved cultural practices: land preparation, nursery raising, seeds and sowing, nutrients, water and weed management, harvesting, threshing, cleaning, drying and storage, and recommended varieties of rice, maize, millet, cotton, sugarcane soybean, sunflower, groundnut, sesame, black gram, green gram, and pigeon pea.

Course Breakdown (Theory)

SN	Course outline	Lectures
1	Rice cultivation	
1.1	Introduction, importance, origin, area, production, productivity and distribution; Major constraint and opportunity of rice in Nepal	1
1.2	Morphology, growth stages of rice, sub species of sativa: <i>indica</i> , <i>japonica</i> and <i>javanica</i>	1
1.3	Soil and climatic requirements and their effects on rice production; Rice growing seasons in Nepal: Boro, Spring and Rainy season	1
1.4	System of rice culture: Upland (Ghaiya), Transplanted rice (TPR), Dry direct seeded rice (DSR), Wet direct seeded, System of rice intensification (SRI); Recommended rice varieties in Nepal	1
1.5	Methods of raising rice seedlings, land preparation and puddling for seed sowing and transplanting, seed rate, sowing and planting spacing	1
1.6	Nutrient management (green manuring, organic manures, chemical	1

	fertilizer application, bio-fertilizers), irrigation management, weed management, mechanism of nitrogen loss from rice field and their prevention	
1.7	Maturity, harvesting, threshing, cleaning, storage and marketing of rice	1
2	Maize cultivation	
2.1	Introduction, importance, origin, area, production, productivity and distribution, major constraints and opportunities of maize production in Nepal	1
2.2	Soil and climatic requirements, production ecology in Nepal; Recommended or registered maize varieties in Nepal	1
2.3	Cultural Practices: Land preparation, sowing time, seed rate, seed treatments, sowing methods and spacing; importance of winter and spring maize in Nepal	1
2.4	Nutrient management; Water management; Weed management	1
2.5	Maturity, harvesting, threshing, cleaning, drying and storage; Importance of winter and spring maize in Nepal	1
3	Sugarcane cultivation	
3.1	Introduction, importance, origin, area, production, productivity, distribution, major constraints and opportunities of sugarcane production in Nepal	1
3.2	Growth stages of sugarcane, soil and climatic requirement; Characteristics different species of sugarcane	1
3.3	Planting time of sugarcane in Nepal, planting materials, sett selection, preparation and treatments; Planting methods: Flat, Furrow, Ridge and furrow, Trench, Space transplanting (Poly bag seedling transplant) and Ring or Pit method	1
3.4	Fertilizer and manure; Irrigation; Weed management, de-trashing, propping and tying and harvesting	1
3.5	Inter cropping Improved varieties and ratoon management in sugarcane	1
4	Cotton cultivation	
4.1	Introduction, importance, origin, area, production, productivity, distribution, major constraints and opportunities of cotton production in Nepal	1
4.2	Characteristics of cotton species; Soil and climatic requirements; Cotton fiber and its quality; Gossypol	1
4.3	Cultural practices: Seeds and sowing, sowing time, seed rate, spacing, thinning, fertilizer management, weed and irrigation	1

	management, topping, defoliation, desiccation, improved varieties and harvesting	
5	Jute cultivation	
5.1	Origin, history, distribution, production and importance of jute in Nepal; Morphology, growth and development of jute plant	1
5.2	Soil and climate requirement for cultivation; Varieties; Land preparation; Planting spacing; Seed rate; Nutrient management; Irrigation management; Weed management; Quality parameters	1
6	Summer grain legumes (Pigeonpea, Soybean, Blackgram, Greengram and Cowpea) cultivation	
6.1	Origin, history, distribution, production and importance of summer legumes in Nepal	1
6.2	Soil and climate requirement for cultivation of summer legumes	1
6.3	Land preparation; Planting spacing; Seed rate; Nutrient management; Irrigation management; Weed management of summer legumes	1
6.4	Varieties, maturity, harvesting, threshing, cleaning and storage of summer legumes	1
7	Summer oilseed crops (Groundnut, Sesame/ Sunflower) cultivation	
7.1	Origin, history, distribution, production and importance of summer oilseeds in Nepal; Soil and climate requirement for cultivation	1
7.2	Varieties; Land preparation; Planting spacing; Seed rate; Nutrient management; Irrigation management; Weed management; Maturity, harvesting, threshing, cleaning and storage	1
8	Finger millet cultivation	
8.1	Introduction, importance, origin, area, production, productivity and distribution, soil and climatic requirement, major constraints and opportunities of finger millet in Nepal	1
8.2	Cultural practices: Land preparation, seedling raising, sowing/transplanting time, seed rate, sowing methods, relay cropping with maize, fertilizer, weed and water management, recommended varieties, maturity judging, harvesting, threshing, cleaning and storage	1
	Total	30

Course Breakdown (Practical)

S.N	Course outline	Lectures
1.	Study of morphology and growth stages of rice	1

2.	Raising seedling in nursery: Wet bed, dry bed, Dapog and modified Dapog methods with their relative advantage and disadvantage	2
3.	Land preparation and transplanting of rice seedling	1
4.	Nitrogen application in rice through Leaf Color Chart (LCC)/ SPAD meter	1
5.	Study of morphology and growth stages of maize	1
6.	Practice on sowing of summer season crops	1
7.	Practice on weed management of summer season crops	1
8.	Study of morphology and growth stages of sugarcane	1
9.	Numerical problems in relation to seed (sett) requirement of sugarcane in various planting methods	1
10.	Land preparation and planting of cotton	1
11.	Study of morphological characteristics, branching and flowering of cotton	1
12.	Maturity judging and harvesting of summer crops	1
13.	Study of yield attributes and estimation of yield of summer crops	1
14.	Visit to farmers field to study grain-legumes in cropping system	1
15.	Yield and Commercial Cane Sugar (CCS) estimation in sugarcane	1
	Total	15

Recommended Reading Materials

1. Acquaaah, G. (2017). *Principles of Crop Production: Theory, Techniques and Technology*. Pearson Education Inc. India.
2. Jeyaraman, S. (2017). *Crops Production and Management*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
3. Joshi, B.K., Bhatta, M.R., Ghimire, K.H., Khanal, M., Gurung, S.B., Dhakal, R. and Sthapit, B.R. (2017). *Released and Promising Crop varieties of Mountain Agriculture in Nepal (1959-2016)*. LI-BIRD, Pokhara, NARC, Kathmandu and Biodiversity International, Pokhara, Nepal.
4. Joshi, M. (1990). *Trainer's Manual No.8. Oilseeds*. Publishers: Manpower Development Project, Kathmandu.
5. Prasad, R. (2002). *Text book of Field Crops Production*. ICAR, New Delhi.
6. Rathore, P.S. (1999). *Techniques and Management of Field Crop Production*. Agrosbios, Jodhpur, India.
7. Regmi, K.R. (1990). *Trainer's Manual No.9. Grain Legumes*. Publishers: Manpower Development Project, Kathmandu.
8. Singh C., Singh, P. and Singh, R. (2019). *Modern Techniques of Raising Field Crops*. Revised Edition. Oxford and IBH publishing Co. Pvt. Ltd., New Delhi.

FAR WESTERN UNIVERSITY
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Course Code	AGR221 / AGR321
Course Title	Field Crop Production - I / II
Credit Hours	3 (2+1)
Full Marks	75
Theory (Marks)	50
Practical (Marks)	25

Objective (s) of the Course

Upon completion of this course, students will gain scientific knowledge and skills for growing winter season field crops successfully (This course will be offered either in second or third semester depending on the nature of crops and growing season of the crop).

Course Description

Introduction and importance, origin, area, production, productivity, distribution, soil and climatic requirement, constraints and opportunities of production, improved cultural practices: land preparation, seeds and sowing, nutrients, water and weed management, harvesting, threshing, cleaning, drying and storage, and recommended varieties of wheat, barley, buckwheat, potato, lentil, Chickpea, grass- pea, field bean, rapeseed and mustard, and linseed.

Course Breakdown (Theory)

SN	Course Outline	Lectures
1	Wheat cultivation	
1.1	Introduction, importance, origin, area, production, productivity, distribution, major constraints and opportunities of wheat production in Nepal	1
1.2	Soil and climatic requirements during different growth stages of wheat	1
1.3	Cultural practices: Land preparation, sowing time, sowing methods, seed rate, seed treatments, spacing	1
1.4	Nutrient management; Weed management; Water management	1
1.5	Recommended varieties, maturity judging, harvesting, threshing, cleaning, drying and storage	1
1.6	Rice-wheat system: coverage, factors affecting R-W system; Major issues of R-W system	1

2	Barley and Uwa cultivation		
2.1	Introduction, importance, origin, area, production, productivity, major constraints and opportunities of barley production in Nepal		1
2.2	Soil and climatic requirements and classification of barley; Cultural practices: land preparation, seed and sowing, sowing times, seed rate, spacing, manure and fertilizer, irrigation, and weed management, recommended varieties, harvesting, threshing cleaning, drying and storage		1
2.3	Introduction, importance, characteristic, nutritional value and distribution of naked barley (Uwa) in Nepal, differences between barley and Uwa		1
3	Buckwheat cultivation		
3.1	Introduction, importance, origin, area, production and productivity, major constraints and opportunities of buckwheat production		1
3.2	Soil and climatic requirements, types of buckwheat; Cultural practices: land preparation, seed and sowing, manures and fertilizer, weed control, water management, recommended and promising varieties, harvesting ,threshing and storage		1
4	Potato cultivation		
4.1	Introduction, importance, origin, area, production, productivity, distribution, major constraints and opportunities of potato production in Nepal		1
4.2	Soil and climatic requirements, and growth stages of potato		1
4.3	Seed and sowing: true potato seed verses potato tuber; Requirements of quality seed, seed preparation and seed treatments, and dormancy		1
4.4	Planting time, methods, seed size and rate, spacing, and fertilizer management		1
4.5	Inter-culture, earthing up, and weeding, irrigation management, recommended varieties, harvesting, grading and storage		1
5	Lentil cultivation		
5.1	Introduction, importance, origin, area, production, productivity, distribution and major constraints and opportunities of lentil production in Nepal		1
5.2	Soil and climatic requirements, classification, growth stages, and its place in cropping system		1
			1
5.3	6	Chickpea cultivation	
	6.1	Introduction, importance, origin, area, production, productivity, distribution and constraints and opportunities of chickpea production in Nepal	

6.2	Soil and climatic requirements, and classification of chickpea; Improved cultural practices: land preparation, manures and fertilizer application, seed and sowing, weed and water management, recommended varieties, harvesting, threshing, cleaning and storage		
7	Grass-pea cultivation		
	Introduction, importance and distribution in Nepal, Anti-nutritional factor and its solution in grass-pea, improved cultural practices of grass pea including relay cropping with rice		
8	Field Beans (<i>Phaseolus spp.</i>) including “RAJMA” cultivation		
8.1	Introduction, importance, origin, distribution and classification of beans (kidney bean, Lima bean, pole bean including Simi, Ghiu Simi, and Jumli Simi)		
8.2	Soil and climatic requirements; Improved cultural practices: land preparation, manures and fertilizer application, seed and sowing, weed and water management, recommended varieties, and harvesting		
9	Rapeseed and mustard cultivation		
9.1	Introduction, importance, origin, area, production, productivity, major constraints and opportunities of rapeseed and mustard in Nepal		
9.2	Soil and climatic requirements, and classification of kinds of rapeseed and mustard grown in Nepal with their characteristics features		
9.3	Improved cultural practices: Place in cropping system, land preparation, seed and sowing: time of sowing, seed rate, and spacing, and manures and fertilizer application		
9.4	Water and weed management, harvesting, threshing, storage and oil quality of rapeseed and mustard		
10	Linseed cultivation		
10.1	Introduction, importance, origin, and distribution in Nepal, soil and climatic requirements and improved cultural practices of linseed production in Nepal		
11	Niger seed cultivation		
11.1	Introduction, importance, origin and distribution in Nepal, soil and climatic requirements and improved cultural practices of Niger production in Nepal		
	Total		

	Improved cultural practices: Manures and fertilizer application, seed and sowing, weed control and water management, recommended varieties, harvesting, threshing, cleaning and storage	
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Course Breakdown (Practical)		
SN	Course Outline	Lectures
1	Planting of winter seasonal crops in agronomy farm of the college	1
2	Classification and study of growth stages of wheat crop	1
3	Classification and morphological characteristics of potato	1
4	Classification and growth stages of a legume	1
5	Sowing and study of different growth stages of lentil, chickpea, rajma and grass pea	1
6	Numerical calculation on seed, fertilizers, pesticides requirements of winter crops like wheat, potato, rapeseed and mustard	1
7	Yield attributes and estimation of yield of winter season field crops	
7.1	Legumes and Oilseed crops	1
7.2	Cereals	1
8	Visit to research station/ agronomy farm to understand different researches	1
9	Fertilizer application (method, time, dose and split) in winter crops	1
10	Rhizobium inoculation in legumes	1
11	Layout and sowing of field crops to conduct field experiment	1
12	Data collection from the agronomic experimentation grown with winter crops	1
13	Visit to nearby farmers to study about grain legumes integration in cropping system	1
14	Calculation of cropping intensity, cropping index and land equivalent ratio	1
	Total	15

Recommended Reading Materials

1. Bhomi, B.K. and Pandey, P. R. (1992). *Trainer's Manual No.18. Potatoes*. Publishers: Manpower Development Agriculture Project.
2. Joshi, B.K., Bhatta, M.R., Ghimire, K.H., Khanal, M., Gurung, S.B., Dhakal, R., and Sthapit, B.R. (2017). *Released and Promising Crop Varieties of Mountain Agriculture in Nepal (1959-2016)*. LI-BIRD, Pokhara, NARC, Kathmandu and Biodiversity International, Pokhara, Nepal.

3. Joshi, M. (1988). *Trainer's Manual Wheat*. Publishers: Manpower Development Agriculture Project, Kathmandu.
4. Joshi, M. (1990). *Trainer's Manual No.8. Oilseeds*. Publishers: Manpower Development Project, Kathmandu.
5. Prasad, R (Editor). (2002). *Text book of Field Crops Production*. ICAR, New Delhi.
6. Rajbhandari, B.P. and Bhatta, G. RD (2008). *Food Crops. Agro- Ecology and Modern Agro- Techniques*. HICAST, Kathmandu, Nepal.
7. Rajbhandari, B.P. and Bhatta, G. D. (2009). *Food Crops. Agro- Ecology and Agro- Techniques of Industrial Crops*. HICAST, Kathmandu, Nepal.
8. Rathore, P.S. (1999). *Techniques and Management of Field Crop Production*. Agrosbios, Jodhpur, India.
9. Regmi, K.R. (1990). *Trainer's Manual No .9. Grain Legumes*. Publishers: Manpower Development Project, Kathmandu.
10. Singh, C. (1997). *Modern Techniques of Raising Field Crops*. Oxford and IBH publishing co. Pvt. Ltd., New Delhi.

FAR WESTERN UNIVERSITY
Faculty of Agriculture

Course Code	CPH221
Course Title	Fundamentals of Crop Physiology
Credit Hours	3 (2+1)
Full Marks	75
Theory (Marks)	50
Practical (Marks)	25

Objective (s) of the Course
To impart fundamental knowledge of crop physiology so that the students will understand the general principles and process of crop physiology, the effect of different factors on growth and development of plants and know about plant soil relations.
Course Description
Introduction and importance of crop physiology, concept of plant cell structure and function; Laws of thermodynamics; Diffusion and osmosis; Concept of water potential and water use efficiency; Absorption of water, transpiration and stomatal physiology; Ascent of sap; Mineral nutrition and absorption; Process of photosynthesis and respiration; Translocation of photosynthates; Production of secondary metabolites; Seed germination, dormancy, photo-periodism and vernalization; Process of growth and development in plants; Structure, physiology roles and application of phyto-hormones; Physiological parameters influencing growth and yield of crops.

Course Breakdown (Theory)		
SN	Course Outline	Lectures
1	Introduction: Introduction and importance of crop physiology in agriculture	1
2.	Cell Physiology	
2.1	Overview of a typical plant cell structure	1
2.2	Structure and function of cell organelles	1
3.	Bioenergetics and Biophysical Phenomenon in Plants	
3.1	Laws of thermodynamics and their application in biological world	1
3.2	Process of diffusion and osmosis and their significance in plant life.	1
3.3	Concept of water potential and water use efficiency in plants	1

4.	Absorption of Water and Ascent of Sap	
4.1	Absorption of soil water by plant and factors affecting it	1
4.2	Transpiration and stomatal physiology	1
4.3	Ascent of sap	1
5	Absorption of Nutrients in Plants	
5.1	Physiological functions of nutrients in plants	1
5.2	Ion uptake by roots, mechanism and factors affecting it	1
5.3	Overview of foliar nutrition and factors affecting it	1
6	Photosynthesis	
6.1	Introduction, light reaction (cyclic and non-cyclic photo phosphorylation) and C ₃ cycle	1
6.2	Photorespiration and C ₄ cycle	1
6.3	CAM cycle and factors affecting photosynthesis	1
7	Respiration	
7.1	Types of respiration: aerobic/anaerobic, salt respiration, wound respiration	1
7.2	ATP budget of respiration; Factors affecting respiration	1
8	Translocation of Photosynthetic Products	
8.1	Anatomy of phloem, source and sink concept	1
8.2	Phloem loading and unloading, factors affecting translocation of photosynthetic products	1
9	Secondary Metabolites	
9.1	Introduction to various secondary metabolites: alkaloids, terpenoids and phenolic compounds	1
9.2	Role of secondary metabolites in plant defense	1
10	Physiology of Growth and Development in Plants	
10.1	Growth, development and differentiation; Apoptosis, plasticity and heterophylly in plants	1
10.2	Phases of growth; Factors affecting growth	1
11	Seed Germination and Dormancy	
11.1	Concept and types of seeds germination; Physiological and biochemical changes during seed germination, factors affecting germination	1
11.2	Seed dormancy, types, causes and removal of seed dormancy	1
12	Physiology of Flowering	
12.1	Various theories of flowering	1
12.2	Photoperiodism and vernalization	1
13	Phytohormones	
13.1	Classification, occurrence and biosynthesis of auxin, gibberellin,	1

	cytokinin, ABA and ethylene.	
13.2	Physiological role and mode of actions of auxin, gibberellin, cytokinin, ABA and ethylene	1
14	Physiological Parameters Influencing Growth and Yield in Crop Plants	1
	Total	30

Course Breakdown (Practical)		
SN	Course Outline	Lectures
1	Introduction to equipment and chemicals used in crop physiology lab	1
2	Demonstration of DPD by gravimetric method	1
3	Separation of plant pigments by paper chromatography	1
4	Demonstration of transpiration by cobalt chloride and bell jar method	1
5	Extraction of chloroplast pigments from leaves	1
6	Estimation of water potential by Chardakov's method	1
7	Effect of light and CO ₂ on the process of photosynthesis	1
8	Demonstration of aerobic respiration in plants	1
9	Study the field symptoms of essential macro and micro mineral elements in crop plants	1
10	Study of structure and distribution of stomata in monocot and dicot leaves	1
11	Study of anatomy of C ₃ and C ₄ plant leaves	1
12	Germination under different moisture and temperature regime	1
13	Study effect of Gibberelic acid on seed germination	1
14	Leaf area measurement and calculation of leaf area index	1
15	Calculation of various growth and yield parameters of agricultural crops	1
	Total	15

Recommended Reading Materials

1. Devlin, R. M. and Witham, R. H. (1986). *Plant Physiology*. CBS Publication and Distribution, India.
2. Gupta, U. S. (1978). *Crop Physiology*. Oxford and IBH Publishing Co. Ltd., New Delhi, India.
3. Meye, B. S., Anderson, D. B., Bohning, R. N. and Fratianne, D.G. (1973). *Introduction of Plant Physiology*. D. Van Nostrand Co., New York, US.
4. Salisbury, F. B. and Ross, C.W. (2010). *Plant Physiology*. Wordsworth Publishing Company, California, USA.

5. Saxena, S. K. (1995). *Modern Practicals in Plant Physiology and Biochemistry*. CBS Publication and distribution, New Delhi, India.
6. Taiz, L. and Zeiger, E. (2010). *Plant Physiology (6th edition)*. Sinauer Associates Publisher, Sunderland.

FAR WESTERN UNIVERSITY
Faculty of Agriculture

Course Code	PLB221
Course Title	Fundamentals of Genetics
Credit Hours	3 (2+1)
Full Marks	75
Theory (Marks)	50
Practical (Marks)	25

Objective (s) of the Course

To acquaint the students with the theory and principles of genetics applied in plant breeding for higher agriculture productivity. By the end of the course, the students will be able to:

- i) Discuss and understand the basic concepts of cell, chromosomes and DNA
- ii) Identify various stages of cell division, both mitosis and meiosis
- iii) Apply genetic principles for plant breeding and crop improvement
- iv) Apply chi-square test for fitness of the data
- v) Explain different epistatic factors and generate linkage maps

Course Description

Cytology and cytogenetics, cell division; Mendelian genetics; Life cycle of maize, human, virus and bacteria; Sex determination; Linkage; DNA structure and function, chromosome and its abnormalities, mutation

Course Breakdown (Theory)

SN	Course Outline	Lectures
1	Definitions of cytology, genetics, cytogenetics, plant breeding, inter-relationships among them and with other branches of science	1
2	Genetics history-historical development, cell theory	1
3	Mitosis cell division	1
4	Meiosis cell division	1
5	Life cycles maize and human	1
6	Life cycles virus and bacteria	1
7	Introduction to Mendelian genetics, Mendel's laws of inheritance	1
8	Mendel's experiment and reasons for selecting pea as experimental material, characters studied, reasons for Mendel's success	1
9	Dihybrid ratio exceptions to Mendel's law, backcross and testcross	1
10	Gene action and interaction	1

11	Types of epistasis	1
12	Probability testing	1
13	Chi-square testing	1
14	Sex determination in plant and animal	1
15	Linkage, coupling and repulsion phase of linkage, types of linkage	1
16	Theories of linkage, linkage identification experiments, significance of linkage in plant breeding, differences between linkage and pleiotropism	1
17	Crossing over, factors affecting crossing over, mechanism of crossing over, significance of crossing over in plant breeding	1
18	Cytoplasmic inheritance, classes of cytoplasmic inheritance, characteristics influenced by cytoplasmic inheritance, differences between chromosomal and extrachromosomal inheritance	1
19	DNA structure and function, Watson and Crick model of DNA double helix, classification of DNA	1
20	Proof that DNA is the genetic material, transformation, transduction, bacteriophage infection and biochemical evidences	1
21	DNA replication, modes of DNA replication, semi conservative DNA replication, experimental proof of generalized model for DNA replication	1
22	DNA repair, restriction endonucleases, types of DNA repair systems, renaturation and denaturation of DNA	1
23	RNA structure and function, mRNA, rRNA, tRNA and genetic code and their properties	1
24	Central dogma of molecular biology, transcription, translation and protein synthesis	1
25	Regulation of gene expression, important terms related to gene regulation, regulation of gene expression in prokaryotes (Operon model by Jacob and Monad)	1
26	Transposable genetic elements	1
27	Characters of mutations, physical and chemical mutagens, detection of sex linked lethals in <i>Drosophila</i> (CIB method given by Muller)	1
28	Importance of mutation in plant breeding programs, xenia and metaxenia, molecular basis of mutations	1
29	Structural and numerical chromosomal aberrations and types	1
30	Breakage - fusion - bridge cycle in chromosomal aberrations, deletions (deficiency), duplications and significance of chromosomal changes	1

Total	30
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Course Breakdown (Practical)		
SN	Course Outline	Lectures
1	Microscopy	1
2	Mitosis	1
3	Meiosis	1
4	Monohybrid ratio and its modification	1
5	Dihybrid ratios and its modification	1
6	Numerical problem related to Mendel's law of segregation	1
7	Independent assortment	1
8	Numerical problem related to gene actions and interactions	1
9	Epistasis	1
10	Chi-square analysis	1
11	Numerical problem related to Linkage	1
12	Numerical problem related to crossover	1
13	Numeral problem related to sex determination	1
14	Field demonstration of male sterility	1
15	Self-incompatibility in crop plants	1
	Total	15

Recommended Reading Materials

1. Gardner, E. J. (1972). *Principles of Genetics* (No. 4). London, UK, John Wiley and Sons, Inc.
2. Pierce, B. A. (2012). *Genetics: A Conceptual Approach*. Macmillan.
3. Russel, P. J. (2010). *Genetics: A Molecular Approach*, 3rd Edition, Pearson Publication.
4. Snustad, D. P. and Simmons, M. J. (2015). *Principles of Genetics*. John Wiley and Sons.
5. Stickberger, M. W. (2012). *Genetics (3rd Ed.)*. PHI Learning Private Limited, New Delhi India.
6. Welsh, J. R. (1981). *Fundamentals of Plant Genetics and Breeding*. John Wiley and Sons.

FAR WESTERN UNIVERSITY
Faculty of Agriculture

Course Code	SSC221
Course Title	Manure, Fertilizer and Nutrient Management
Credit Hours	3 (2+1)
Full Marks	75
Theory (Marks)	50
Practical (Marks)	25

Objective (s) of the Course
Upon completion of this course, students will be able to understand functions of plant nutrients, concept of soil fertility, and the role of fertilizers, manures, and bio fertilizers to the plants and soils.
Course Description
History of soil fertility and plant nutrition; Essential and beneficial elements, criteria of essentiality, forms of nutrients in soil, source, functions, deficiency symptoms and availability of plant nutrients; Chemical fertilizers – source, composition, use and behavior in soil; Bio-fertilizers and their uses; Preparation of manures, green manures and vermi-composting; Biogas plant slurry; Method of soil fertility evaluation, integrated nutrient management, soil fertility problems in Nepal; Soil management for sustainable agricultural development.

Course Breakdown (Theory)		
SN	Course Outline	Lectures
1	Historical perspective of soil fertility and plant nutrition	1
2	Criteria for nutrient essentiality; Classification of the plant nutrients	1
3	Nutrient mobility in plants and soil, and its importance	1
4	Functions, deficiency symptoms, and management of Nitrogen and Pphosphorus	1
5	Functions, deficiency symptoms, and management of Potassium and Calcium	1
6	Functions, deficiency symptoms, and management of Magnesium and Sulfur	1
7	Functions, deficiency symptoms, and management of Iron, Manganese, Zinc and Copper	1
8	Functions, deficiency symptoms, and management of Boron, Molybdenum, Nickel, Cobalt and Silicon	1

9	Toxicity symptoms of nutrients and their management	1
10	Concept of fertilizers, classification of fertilizers	1
11	Nitrogen fertilizers: Source, composition, uses and behavior in soil.	1
12	Phosphatic fertilizers: Source, composition, uses and behavior in soil	1
13	Potassic fertilizers: Source, composition, uses and behavior in soil	1
14	Concept of organic matter, sources of organic matter	1
15	Composition and decomposition processes of organic matter	1
16	C:N ratio and its significance	1
17	Organic matter and its effect on soil properties	1
18	Roles of bio-fertilizers in soil fertility: Rhizobium, Mycorrhizae, Azotobacter, Azolla and Vermicompost	1
19	Importance of human manure and urine, green manure and bio-slurry	1
20	Different approaches for soil fertility evaluation: Visual diagnosis and plant analysis	1
21	Different approaches for soil fertility evaluation: Biological methods	1
22	Different approaches for soil fertility evaluation: Soil Testing	1
23	Interpretation of the soil testing results	1
24	Factors influencing nutrient use efficiency (NUE) in respect of nitrogen and phosphorus	1
25	Factors influencing nutrient use efficiency (NUE) in respect of potassium and zinc	1
26	Source, method and scheduling of nutrients for different soils and crops grown under rainfed and irrigated conditions	1
27	Soil fertility problems with respect to Nepalese agricultural system	1
28	Concept and approaches of soil management for sustainable agriculture	1
29	Integrated Nutrient Management (INM): Concept and components	1
30	Relevance of INM in context of Nepal	1
	Total	30

Course Breakdown (Practical)		
SN	Course Outline	Lectures

1	Identification of function of equipment used in soil fertility laboratory	1
2	Soil sampling for soil fertility analysis- from crop field	1
3	Soil sampling for soil fertility analysis- from orchard	1
4	Preparation of soil samples for soil fertility analysis	1
5	Soil testing kit method for N, P, K and pH estimation	1
6	Chemical calculation and preparation of standard solution	1
7	Determination of organic matter content of soil	1
8	Determination of total N in soil (Digestion, distillation and titration)	2
9	Determination of available P in soil	1
10	Determination of available K in soil (Digestion and Flame photometer reading)	2
11	Plant sampling and its preparation for nutrient analysis	1
12	Collection and identification of nutrient deficiency symptoms on major agronomical crops	1
13	Collection and identification of nutrient deficiency symptoms on major horticultural crops	1
	Total	15

Recommended Reading Materials

1. Brady, N. C. and Weil, R. R. (2012). *Nature and Properties of Soils (14th Edition)*. Macmillian Publishing Co. Inc., New York
2. Gupta, P. K. (2007). *Soil, Plant, Water and Fertilizer Analysis*. AGROBIOS, Jodhpur, India.
3. KC, T. B. (1991). *Introduction to Soils and Soil Fertility*. Institute of Agriculture and Animal Science, Chitwan, Nepal.
4. Mengel, K. and Kirkby, E. A. (1982). *Principles of Plant Nutrition*. International Potash Institute, Switzerland.
5. Roy, R. N. (2006). *Plant Nutrition for Food Security: a Guide for Integrated Nutrient Management (INM)*. Food and Agriculture Organization, United Nations.
6. Basak, R. K. (2004). *A Text Book on Fertilizers*. Kalyani Publishers, New Delhi.
7. Tisdale, S. L., Nelson, W. L., Beaton J. D. and Havlin, J. L. (1993). *Soil Fertility and Fertilizers (5th Edition)*. Macmillian Publishing Co. Inc., New York.

FAR WESTERN UNIVERSITY
Faculty of Agriculture

Course Code	HRT211
Course Title	Ornamental Horticulture
Credit Hours	2 (1+1)
Full Marks	50
Theory (Marks)	25
Practical (Marks)	25

Objective (s) of the Course
Upon the completion of this course, the students will be able to understand ornamental horticulture and gain basic knowledge and skills on landscape gardening and production system of cut flowers and ornamentals.
Course Description
Definition, history and importance of Ornamental Horticulture, current status of ornamental horticulture industry in Nepal; Classification of ornamental plants, definition, history, scope, features and components of landscape gardening; Elements and principles of landscape gardening design, use of plants in landscape design; Lawn and its management; Flower arrangement and bonsai; Establishment of nursery enterprise and propagation of ornamentals, commercial cultivation of important cut flowers and loose flowers.

Course Breakdown (Theory)		
SN	Course Outline	Lectures
1	Introduction	
1.1	Importance and history of Ornamental Horticulture.	1
	Definition, historical importance of ornamental horticulture	
	Floriculture industry in Nepal, its status, prospects and constraints	
2	Classification of Ornamental Plants	
2.1	Classification of ornamental plants based on their aesthetic and functional values: Flowering plants, ornamental foliage trees, shrub and shrubberies, climbers, cactus and succulents, bulbous plants; and based on their life cycle:- Annual, biennial and perennial	1
3	Ornamental Gardens and Landscaping	
3.1	Landscape gardening: Definition, history, scope, features and components of landscape gardening	1
3.2	Elements and principles of landscape gardening; Types of	1

	landscape gardening design; Use of plants in landscape design	
4	Lawn Garden	
4.1	Lawn and its preparation; Selection of grasses in different ecological zones, planting and sowing of seeds; Management of lawn grasses	1
5	Flower Design	
5.1	Flower arrangements: Importance, styles (design), materials used in flower arrangements; Eastern and western type of flower arrangements	1
6	Bonsai	
6.1	Introduction and history of bonsai making, selection of plants, style and management of bonsai	
7	Nursery Management	
7.1	Establishment of nursery enterprises; Planning of a nursery enterprises; Nursery media, pot type or containers; Equipment, propagation and structures	1
8	Cultivation Practices of Ornamental Crops Introduction, area, production and distribution, soil and climatic requirements, land preparation, improved varieties, cultural practices, propagation, planting materials, planting time, planting methods, manures and fertilizers, irrigation and drainage, weed management, harvest and post-harvest practices, disorders, diseases and insect pest of the following crops	
8.1	Gladiolus	1
8.2	Rose	1
8.3	Tuberose	1
8.4	Orchids	1
8.5	Carnation and Gerbera	1
8.6	Chrysanthemum	1
8.7	Marigold, Gomphrena and Protea	1
	Total	15

Course Breakdown (Practical)		
SN	Course Outline	Lectures
1	Identification and herbarium collection of ornamentals	1
2	Visit to nursery enterprises, private and public gardens	2
3	Practices in landscape gardening design	1
4	Preparation of flower bed/seed bed/nursery bed	1
5	Media preparation, potting and repotting of ornamental plants	1

6	Designing, development and maintenance of lawn	1
7	Bonsai styling and making	1
8	Arranging flowers for different occasion	1
9	Cultivation of seasonal cut flowers and foliage	2
10	Interior capping and maintenance of indoor plants	1
11	Training and pruning practice of ornamental plants	1
12	Propagation practices in different types of ornamental plants	1
13	Harvesting and post-harvest care of cut and loose flowers	1
14	Total	15

Recommended Reading Materials

1. Anonymous. (2000). *Better Homes and Gardens: The Complete Backyard Book*. Murdoch Books
2. Arora, J.S. (1990). *Introductory Ornamental Horticulture*. Kalyani Publisher, New Delhi.
3. Bose, T.K. and Yadav, L. P. (1989). *Commercial Floriculture*. Naya Prakash, Calcutta.
4. Dirr, M. (2002). *Dirr's Trees and Shrubs for Warmer Climate*. Timber Press
5. Dirr, M. (2009). *Manual of Woody Landscape Plants (6th edition)*. Stipes Publishing
6. Lauria, A. and Victor, H.R. (2001). *Floriculture: Fundamentals and Practices*. Agrobios, India.
7. Mchoy, P., Segall, B. and Donaldson, S. (1997). *Practical Small Gardening*. Acropolis Books.
8. Randhawa, G.S. and Mukhopadhyhy, A. (1986). *Floriculture in India*. Allied Publisher, India.
9. Tony, A. (2003). *So you want to start a nursery*. Timber Press.

FAR WESTERN UNIVERSITY
Faculty of Agriculture

Course Code	ASC211
Course Title	Ruminant Production
Credit Hours	2 (1+1)
Full Marks	50
Theory (Marks)	25
Practical (Marks)	25

Objective (s) of the Course
Upon the completion of this course, the students will be able to identify different breeds of farm animals and have knowledge on management practices.
Course Description
Breeds of cattle, buffalo, sheep and goat; Care and management of cattle, buffalo, sheep and goat; Housing principles and types of housing for ruminants; Artificial rearing of newborn calves, kids, lambs; Feeds and feeding of ruminants; Castration, dehorning/ disbudding, grooming, dipping, dusting, shearing of wool; Judging and selecting of farm animals; Use of draft animals, Milking methods and practices.

Course Breakdown (Theory)		
SN	Course Outline	Lectures
1	Introduction, current statistics, scope and importance of ruminants animals and Zoological classification of ruminants	1
2	Breed characteristics of indigenous breeds of cattle: Khaila, Achami, Lulu, Yak, Nak and Chauri	1
3	Breed characteristics of exotic and Indian breeds of cattle: Jersey, Holstein Frisian, Brown Swiss, Hariyana, Sahiwal and Red Sindhi	1
4	Breed characteristics of buffalo: Lime, Parkote, Gaddi, Murrah, Surti, Jaffarabadi and Nili-Rabi	1
5	Breed characteristics of indigenous goats: Terai, Khari/hill goats, Chyangra and Sinhal	1
6	Breed characteristics of exotic goats: Barbari, Sannen, Jamunapari, Boer and Beetal	1
7	Breed characteristics of sheep - Kage, Bhyanglung, Baruwal, Lampuchhre, Merino, Rambouillet, Romney and Polworth	1

8	Housing system of cattle/buffalo- site selection, provision of housing, types of housing system with its merits and demerits	1
9	Housing system of sheep and goat- site selection, provision of housing and types of housing	1
10	Care and management of pregnant, lactating and new born cattle, buffalo, sheep and goat	1
11	Care and management of heifer, dry animals, and draft cattle and buffalo	1
12	Importance and methods of castration, dehorning, grooming, dipping and dusting of farm animals.	1
13	Improving ruminants through judging and selection	1
14	Sharing, grading for quality assessment, handling and marketing of wool.	1
15	Common milking method and practice	1
	Total	15

Course Breakdown (Practical)		
SN	Course Outline	Lectures
1	Identification of common breeds of Cattle and Buffalo	1
2	Identification of common breeds of sheep and goat	1
3	Housing types and model study of cattle and buffalo with practical references	1
4	Housing types and model study of sheep and goat with practical references	1
5	Identification of Ruminant: Tagging, Branding, Tattooing	1
6	Castration of large ruminants	1
7	Castration of small ruminants	1
8	Dehorning and debudding/disbudding in calves	1
9	Grooming of cattle and buffalo	1
10	Dipping and drenching in sheep and goats	1
11	Study of barn sanitation and maintenance of bio-security at farm level	1
12	Study of milking practices	1
13	Study of wool shearing methods in sheep	1
14	Judging and selection of cattle and buffalo	1
15	Economics of cattle, buffalo, sheep and goat farming (Case study)	1
	Total	15

Recommended Reading Materials

1. Banerjee, C.K. and N.N. Pathak. (2004). *Textbook on Buffalo Production*. Vikas Publishing House Pvt. Ltd. New Delhi.
2. Banerjee, G.C. (2015). *A Text Book of Animal Husbandry (8th Edition)*. Oxford and IBH Publishing. New Delhi.
3. Banerjee, G.C. (2018). *Principles of Animal Nutrition and Feeds*. Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi.
4. Dhital, B and Adhikari, M. (2016). *Principle and Practice of Livestock Production and Management*. Buddha Publication Pvt. Ltd. Kathmandu Nepal.
5. ICAR. (2016). *Handbook of Animal Husbandry*. Indian Council of Agriculture Research, New Delhi India.
6. John, R., Campbell, C., Kenealy, M., Dauglas, C. and Karen, L. (2013). *Animal Science (4th Edition)*. Scientific International Pvt. Ltd. New Delhi India.
7. Prasad, J. (2011). *Goat, Sheep and Pig Production and Management*. Kalyani Publishers, New Delhi India.
8. Prasad, J. (2016). *Animal Husbandry and Dairy Science (6th Edition)*. Kalyani Publishers, New Delhi India.
9. Sastry, N.R.S. and Thomas, C.K. (2018). *Livestock Production and Management (5th Edition)*. Kalyani Publication, New Delhi India.