SCHEME & SYLLABUS
Ph.D. (Hort.) in Vegetable Science
Programme Code: PHD0016

Department of Agriculture
University Institute of Agriculture
Sant Baba Bhag Singh University

2025

Course Title with Credit Load
Ph.D. (Hort.) Vegetable Science

Course Code	Course Title	Credit Hours
AGR975*	Recent Trends in Vegetable Production	3+0
AGR977*	Advances in Breeding of Vegetable Crops	3+0
AGR979	Abiotic Stress Management in Vegetable Crops	2+1
AGR981	Breeding for Special Traits in Vegetable Crops	2+0
AGR976	Seed Certification, Processing and Storage of Vegetable Crops	2+1
AGR978	Biotechnological Approaches in Vegetable Crops	2+1
AGR980	Biodiversity and Conservation of Vegetable Crops	2+1
AGR982	Advanced Laboratory Techniques for Vegetable Crops	1+2
AGR983	Seminar I	0+1
AGR984	Seminar II	0+1
AGR985,986, 987,988,989 and 990	Research	0+75

*Indicates Core course for Ph.D.

Minimum Credit Requirements for Doctoral Programme

		Doctoral Programme
(i) Course work		
Major courses	:	12
Minor courses	:	06
Supporting courses	:	05
Seminar	:	02
(ii) Thesis Research	:	75
Total	:	100

Major courses: From the Discipline in which a student takes admission. Among the listed courses, the core courses compulsorily to be taken may be given *mark

Minor courses: From the subjects closely related to a student's major subject

Supporting courses: The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments, etc.) or necessary for building his/ her overall competence.

Scheme for Ph.D. (Hort.) Vegetable Science

Semester-I

Sr. No	Subject Code	Type of Course	Subject Name	Credit Hours
1	AGR 975*	CR	Recent Trends in Vegetable Production	3+0
2	AGR 977*	CR	Advances in Breeding of Vegetable Crops	3+0
3	AGR921	SC	Basic Sampling Techniques	2+1
4	AGR507	MC	Principles and Practices of Water Management	2+1
5	AGR985	RC	Research	0+5
Total Credit Hours				17

Semester-II

Sr. No	Subject Code	Type of Course	Subject Name	Credit Hours
1	AGR 976	DSE	Seed Certification, Processing and Storage of Vegetable Crops	2+1
2	AGR 978	DSE	Biotechnological Approaches in Vegetable Crops	2+1
3	MAT529	SC	Experimental Designs	2+1
4	AGR502	MC	Principles and practices of soil fertility and nutrient management	2+1
5	AGR 986	RC	Research	0+5
Total Credit Hours				17

Semester-III

Sr. No	Subject Code	Type of Course	Subject Name	Credit Hours
1	AGR983	DSE	Seminar-I	1+0
2	AGR 987	RC	Research	0+16
Total Credit Hours				17

Semester-IV

Sr. No	Subject Code	Type of Course	Subject Name	Credit Hours
1	AGR984	DSE	Seminar-II	1+0
2	AGR 988	RC	Research	0+16
Total Credit Hours				17

Semester-V

Sr. No	Subject Code	Type of Course	Subject Name	Credit Hours
1	AGR 989	RC	Research	0+16
Total Credit Hours				16

Semester-VI

Sr. No	Subject Code	Type of Course	Subject Name	Credit Hours
1	AGR 990	RC	Research	0+16
Total Credit Hours				16

- ***CR: Core Course, DSE: Discipline Specific Elective, MC: Minor Course, RC: Research Credit**

Course Contents
Ph.D. (Hort.) in Vegetable Science

I. Course Title : Recent Trends in Vegetable Production

II. Course Code : AGR975

III. Credit Hours : (3+0)

IV. Why this course?

India is the second largest producer of vegetables in the world, next only to China. Most challenging task is to ensure for continuous and enough supply of vegetables to growing population. Urban areas are experiencing substantial increase in population; this growth is accompanied with change in food habits and rising concerns for food quality. Here, food quality refers to the optimum levels of the nutrition in the food along with the minimized amount of the chemical (pesticides/ fertilizers) residues used in the production of the vegetables. Vegetables are being highly seasonal; perishable are also capital and labour intensive and need care in handling and transportation. Environmental stress (climate change) and shortage of water and land resources are major constraints haunting the production. Though the advances in science and information technology has resulted in more comfortable world with global linkages, these advances has led to changes in production practices. Thus, the students of vegetable science need to have an understanding of recent trends in production technology of vegetable crops and their management.

V. Aim of the course

To keep abreast with latest developments and trends in production technology of vegetable crops.

The course is constructed given as under:

No.	Block	Unit
1	Recent trends in vegetable production	1. Solanaceous crops 2. Cole crops 1. Okra, onion, peas and beans, amaranth and drumstick. 2. Root crops and cucurbits 3. Tuber crops

VI. Theory

Present status and prospects of vegetable cultivation; nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching; Protected cultivation of vegetables, containerized culture

for year round vegetable production; low cost polyhouse; nethouse production; crop modelling, organic gardening; vegetable production for pigments, export and processing of:

Unit I

Solanaceous crops: Tomato, brinjal, chilli, sweet pepper and potato.

Unit II

Cole crops: Cabbage, cauliflower and knol-khol, sprouting broccoli.

Unit III

Okra, onion, peas and beans, amaranth and drumstick.

Unit IV

Root crops and cucurbits: Carrot, beet root, turnip and radish and cucurbits

Unit V

Tuber crops: Sweet potato, Cassava, elephant foot yam, Dioscorea and taro.

VII. Teaching Methods/ Activities

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Group discussion

VIII. Learning outcome

After successful completion of this course, the students are exposed to:

- Acquire the knowledge about recent trends in production technology of vegetable crops

IX. Suggested Reading

Bose TK and Som NG. 1986. Vegetable crops of India. Naya prokash.

Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. Vegetable crops. Vols. I-III. Naya Udyog.

Brewster JL. 1994. Onions and other vegetable alliums. CABI.

Chadha KL and Kalloo G (Eds.). 1993-94. Advances in horticulture Vols. V-X. Malhotra Publ. House.

Chadha KL (Ed.). 2002. Hand book of horticulture. ICAR.

Chauhan DVS (Ed.). 1986. Vegetable production in India. Ram prasad and Sons.

Fageria MS, Choudhary BR and Dhaka RS. 2000. Vegetable crops: production technology. Vol. II. Kalyani.

FFTC. Improved vegetable production in Asia. Book Series No. 36.

Ghosh SP, Ramanujam T, Jos JS, Moorthy SN and Nair RG. 1988. Tuber crops. Oxford and IBH.

Gopalakrishanan TR. 2007. Vegetable crops. New India Publ. Agency.

Hazra P and Som MG. 2015. Seed production and hybrid technology of vegetable crops. Kalyani publishers, Ludhiana.

Hazra P. 2016. Vegetable science. 2nd edn, Kalyani publishers, Ludhiana.

Hazra P. 2019. Vegetable production and technology. New India publishing agency, New Delhi. Kallo G and Singh K. (Ed.). 2001. Emerging scenario in vegetable research and development. Research periodicals and Book Publ. House.

Kurup GT, Palanisami MS, Potty VP, Padmaja G, Kabeerathuma S and Pallai SV. 1996. Tropical tuber crops, problems, prospects and future strategies. Oxford and IBH.

Rana MK. 2008. Olericulture in India. Kalyani Publishers, New Delhi.

Rana MK. 2008. Scientific cultivation of vegetables. Kalyani Publishers, New Delhi.

nutritive values. Chapman and Hall.
Saini GS. 2001. A Text Book of oleri and flori culture. Aman Publishing House.
Salunkhe DK and Kadam SS. (Ed.). 1998. Hand book of vegetable science and technology: production, composition, storage and processing. Marcel Dekker.
Shanmugavelu KG. 1989. Production technology of vegetable crops. Oxford and IBH. Sin MT
and Onwueme IC. 1978. The tropical tuber crops. John Wiley and Sons.
Singh DK. 2007. Modern vegetable varieties and production technology. International book distributing Co.
Singh NP, Bhardwaj AK, Kumar A and Singh KM. 2004. Modern technology on Vegetable production. International book distr. Co.
Singh PK, Dasgupta SK and Tripathi SK. 2006. Hybrid vegetable development. International book distr. Co.
Singh SP. (Ed.). 1989. Production technology of vegetable crops. Agril. Comm. Res. Centre.
Thamburaj S and Singh N. (Eds.). 2004. Vegetables, tuber crops and spices. ICAR. Thompson
HC and Kelly WC. (Eds.). 1978. Vegetable crops. Tata McGraw-Hill.

I. Course Title : Advances in Breeding of Vegetable Crops

II. Course Code : AGR977

III. Credit Hours : (3 +0)

IV. Why this course ?

The improvement of vegetable crops has until recently, been largely confined to conventional breeding approaches and such programmes rely on hybridization of plants which have desirable heritable characteristics and on naturally or artificially induced random mutations. The introduction of new genetic information can result in increased resistance to insect pest, diseases tolerance to environmental condition, improved quality, etc. The modern biotechnological tools like molecular assisted selection, double haploidy, genetic engineering, etc. can be of immense importance for rapid development of superior varieties with desirable qualitative and quantitative traits. Therefore, conventional breeding in conjunction with molecular biology has bright prospects of developing high yielding vegetable varieties with high nutraceuticals and bio active compounds suitable for fresh as well as processed market. The students of vegetable science who are having breeding as major subject need to have an understanding of recent technologies in vegetable crops.

V. Aim of the course

To impart knowledge on the recent research trends and advances in breeding of vegetable crops.

The course is constructed given as under:

No.	Block	Unit
1	Advances in Breeding of vegetable crops	I. Solanaceous crops and okra II. Cucurbits and Cole crops III. Legumes and leafy vegetables IV. Root crops and onion V. Tuber crops

VI. Theory

Evolution, distribution, cytogenetics, Genetics and genetic resources, wild relatives, genetic divergence, hybridization, inheritance of qualitative and quantitative traits,

heterosis breeding, plant idotype concept and selection indices, breeding mechanisms, pre breeding, mutation breeding, ploidy breeding, breeding for biotic and abiotic stresses, breeding techniques for improving quality and processing characters, bio- fortification, in-vitro breeding, marker assisted breeding, haploidy, development of transgenic.

Unit I

Solanaceous crops—Tomato, Brinjal, Hot Peeper, Sweet Pepper, Okra and Potato

Unit II

Cucurbits and Cole crops

Unit III

Legumes and leafy vegetables—Peas and Beans, Amaranth, Palak, Chenopods and Lettuce.

Unit IV

Root crops and onion—Carrot, Beetroot, Radish, Turnip, Onion

Unit V

Tuber crops—Sweet potato, Tapioca, Elephant foot yam, Colocasia, Dioscorea

VII. Teaching Methods/ Activities

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Group discussion

VIII. Learning outcome

After successful completion of this course, the students are exposed to:

- Breeding objectives and trends
- Recent Adavnces in vegetable breeding

IX. Suggested Reading

Allard RW. 1999. Principle of plant breeding. John Willey and Sons, USA. Basset

MJ. (Ed.). 1986. Breeding vegetable crops. AVI Publ.

Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. Plant genetic resources: horticultural crops. Narosa Publ. House.

Fageria MS, Arya PS and Choudhary AK. 2000. Vegetable crops: Breeding and seed production. Vol. I. Kalyani.

Gardner EJ. 1975. Principles of genetics. John Wiley and Sons.

Hayes HK, Immer FR and Smith DC. 1955. Methods of plant breeding. McGraw-Hill.

Hayward MD, Bosemark NO and Romagosa I. (Eds.). 1993. Plant Breeding-principles and prospects. Chapman and Hall.

Hazra P and Som MG. 2015. Vegetable science (Second revised edition), Kalyani publishers, Ludhiana, 598 p

Hazra P and Som MG. 2016. Vegetable seed production and hybrid technology (Second revised edition), Kalyani Publishers, Ludhiana, 459 p

Kalloo G. 1988. Vegetable breeding (Vol. I, II, III). CRC Press, Fl, USA.

Kalloo G. 1998. Vegetable breeding. Vols. I-III (Combined Ed.). Panima Edu. Book Agency. Kumar JC and Dhaliwal MS. 1990. Techniques of developing hybrids in vegetable crops. Agro Botanical Publ.

Paroda RS and Kalloo G. (Eds.). 1995. Vegetable research with special reference to hybrid technology in Asia-Pacific Region. FAO.

Peter KV and Pradeepkumar T. 2008. Genetics and breeding of vegetables. Revised, ICAR.

Peter KV and Hazra P. (Eds). 2012. Hand book of vegetables. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.
Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables Volume II.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509p.
Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables Volume III.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634p.
Rai N and Rai M. 2006. Heterosis breeding in vegetable crops. New India Publ. Agency.
Ram HH. 1998. Vegetable breeding: principles and practices. Kalyani Publishers, New Delhi. Simmonds NW. 1978. Principles of crop improvement. Longman. Singh BD. 1983. Plant Breeding. Kalyani Publishers, New Delhi.
Singh BD. 1983. Plant breeding. Kalyani Publishers, New Delhi.
Singh PK, Dasgupta SK and Tripathi SK. 2004. Hybrid vegetable development. International Book Distributing Co.
Swarup V. 1976. Breeding procedure for cross-pollinated vegetable crops. ICAR.

I. Course Title : Abiotic Stress Management in Vegetable Crops

II. Course Code : AGR979

III. Credit Hours : (2+1)

IV. Why this course ?

Improvement of vegetable crops has traditionally focused on enhancing a plant's ability to resist diseases or insects. That is evidenced by the large number of disease- or insect-resistant cultivars or germplasm released and used. Research on crop resistance or tolerance to abiotic stresses (heat, cold, drought, flood, salt, pH, etc.) has not received much attention. However, that is changing as a result of the research and publicity of global warming. The changing environments pose serious and imminent threats to vegetable production and place unprecedented pressures on the sustainability of vegetable production. The challenges and opportunities coexist for our dynamic and resilient industry. In addition to conserving resources, we should mitigate abiotic stresses and adapt to the warming planet. The student of vegetable science need to know the different methods involved to mitigate the abiotic stress in vegetable crops.

V. Aim of the course

To update knowledge on the recent research trends in the field of abiotic stress management in vegetables.

- To teach management practices to mitigate abiotic stress in vegetable crops The course is constructed given as under:

No.	Block	Unit
1	Abiotic stress management in vegetable crops	I Environmental stress II Mechanism and measurements of tolerance III Soil-plant-water relations IV Techniques of vegetable growing under high stress condition V Use of chemicals

VI. Theory

Unit I

Environmental stress—its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress.

Mechanism and measurements—tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.

Unit III

Soil-plant-water relations—under different stress conditions in vegetable crops production and their management practices.

Unit IV

Techniques of vegetable growing under water deficit, water logging, salinity and sodicity.

Unit V

Use of chemicals—techniques of vegetable growing under high and low temperature conditions, use of chemicals and antitranspirants in alleviation of different stresses.

VII. Practical

- Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops;
- Measurement of tolerance to various stresses in vegetable crops;
- Short term experiments on growing vegetable under water deficit, water logging, salinity and sodicity, high and low temperature conditions;
- Use of chemicals for alleviation of different stresses.

VIII. Teaching Methods/ Activities

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Hands on training of different procedure
- Group discussion

IX. Learning outcome

After successful completion of this course, the students are expected to:

- Acquire the knowledge about effect of different abiotic stresses on vegetables
- Methods to mitigate abiotic stress in vegetables

X. Suggested Reading

Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. Plant genetic resources: horticultural crops. Narosa Publ. House.

Dwivedi P and Dwivedi RS. 2005. Physiology of abiotic stress in plants. Agrobios. Janick

JJ. 1986. Horticultural science. 4th Ed. WH Freeman and Co.

Kaloo G and Singh K. 2001. Emerging scenario in vegetable research and development. Research periodicals and book publ. house.

Kaloo G. 1994.Vegetable breeding. Vols. I-III. Vedams eBooks.

Lerner HR. (Eds.). 1999. Plant responses to environmental stresses. Marcel Decker. Maloo SR.

2003. Abiotic stresses and crop productivity.Agrotech Publ. Academy.

Narendra T. et al. 2012. Improving crops resistance to abiotic stress. Wiley and Sons.US. Peter KV and

Pradeep Kumar T. 2008. Genetics and breeding of vegetables. (Revised Ed.). ICAR. Peter KV and Hazra

P. (Eds). 2015. Hand book of vegetables volume II.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509p.

Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables volume III. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634p. Ram

HH. 2001. Vegetable breeding. Kalyani.

Rao NK. (Eds.). 2016. Abiotic stress physiology of horticultural crops. Springer publication.

I. Course Title : Seed Certification, Processing and Storage of Vegetable Seeds

II. Course Code : AGR976

III. Credit Hours : (2+1)

IV. Why this course?

Every farmer should able to access healthy seeds which are genetically pure, with high seed vigour and good germination percentage. Timely availability of good quality seeds at reasonable price ensures good yield and profit to the farmers. The seeds plays a vital role in agriculture and acts as a carrier of the genetic potential of varieties. Quality seed production which follows efficient certification procedures plays a major role in the increase of food production of our country. To ensure this, the Government has prescribed standards and has brought in seed production techniques, testing, certification and marketing procedures through the Seeds Act, 1966. In the current scenario, the demand for good quality certified seeds far exceed the availability in the market. This manual provides details about production and procurement of good quality seeds.

V. Aim of the course

To impart the knowledge on seed certification, processing and storage of vegetable seeds

VI. Theory

Unit I

Seed certification, history, concepts and objectives, seed certification agency, phases of seed certification, Indian Minimum seed Certification standards, Planning and management of seed certification programmes.

Unit II

Principles and procedures of field inspection, seed sampling, testing and granting certification, OECD certification Schemes.

Unit III

Principles of seed processing, Methods of seed drying and cleaning, seed processing plant-Layout and design, seed treatment, seed quality enhancement, packaging and marketing.

Unit IV

Principles of Seed Storage, orthodox/ recalcitrant seeds, types of storage (open, bulk, controlled, germplasm, cryopreservation), factors affecting seed longevity in storage (Pre and post harvest factors).

Unit V

Seed aging and deterioration, maintenance of seed viability and vigor during storage, storage methods, storage structures, transportation and marketing of seeds.

VII. Practical

- General procedures of seed certification;
- Field inspection and standards;
- Isolation and rouging;
- Inspection and sampling at harvesting, threshing and processing;
- Testing physical purity, germination and moisture, grow-out test;

- Visit to regulatory seed testing and plant quarantine laboratories;
- Seed processing plants and commercial seed stores.

VIII. Teaching Methods/ Activities

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation individual or in group
- Hands on training of different procedure
- Group discussion

IX. Learning outcome

After successful completion of this course, the students are expected to:

- Acquire the knowledge on seed certification
- Acquire the knowledge on seed processing and storage

X. Suggested Reading

Agarwaal PK and Anuradha V. 2018. Fundamentals of seed science and technology. Brilliant publications, New Delhi.

Basra AS. 2000. Hybrid seed production in vegetables. CRC press, Florida, USA.

Bench ALR and Sanchez RA. 2004. Handbook of seed physiology. Food products press, NY/ London.

Chakraborty SK, Prakash S, Sharma SP and Dadlani M. 2002. Testing of distinctiveness, uniformity and stability for plant variety protection. IARI, New Delhi

Copland LO and McDonald MB. 2004. Seed science and technology, Kluwer academic press. Fageria MS,

Arya PS and Choudhry AK. 2000. Vegetable crops: breeding and seed production Vol 1. Kalyani publishers, New Delhi.

George RAT. 1999. Vegetable seed production (2nd Edition). CAB International.

Hazra P and Som MG. 2016. Vegetable seed production and hybrid technology (Second revised edition), Kalyani publishers, Ludhiana, 459p

Kalloo G, Jain SK, Vari AK and Srivastava U. 2006. Seed: A global perspective. Associated publishing company, New Delhi.

Singhal NC. 2003. Hybrid seed production. Kalyani publishers, New Delhi.

I. Course Title : Breeding for Special Traits in Vegetable Crops

II. Course Code : AGR981

III. Credit Hours : (2+0)

IV. Why this course?

Many epidemiological studies reveal that people having a high level of consumption of vegetables presents a better health and lower risk of chronic diseases, including cardiovascular diseases and different types of cancer. Vegetables contain many bioactive compounds and represent a major source of antioxidants and other compounds that are beneficial to human health. Consumers are increasingly demanding vegetables with bioactive properties that contribute to maintaining a good health and preventing diseases. In consequence, breeding programmes in vegetables are increasingly considering the content in bioactive compounds as a major breeding objective. In this way, there is an increasing number of breeding programmes and scientific studied aimed at improving the content in bioactive compounds of vegetables, and the trend seems that will continuing in the coming years. In this respect, the particular course has been designed for students of Vegetable Science department.

To impart knowledge on recent developments in breeding for improved nutritional quality in important vegetable crops

VI. Theory

Important nutrient constituents in vegetables and their role in human diet. Genetics of nutrients. Genetic and genomic resources for improving quality traits in vegetables, breeding strategies for developing varieties with improved nutrition for market and industrial purposes. Molecular and biotechnological approaches in breeding suitable cultivars of different crops for micronutrients and color content.

Unit I

Brassica group, carrot and beetroot.

Unit II

Tomato, brinjal, peppers and potato.

Unit III

Green leafy vegetables, Legume crops and okra.

Unit IV

Cucurbitaceous vegetable crops and edible Alliums.

Unit V

Biofortification in vegetable crops, genetic engineering for improvement of quality traits in vegetable crops, bioavailability of dietary nutrients from improved vegetable crops and impact on micronutrient malnutrition, achievements and future prospects in breeding for quality traits in vegetables.

VII. Teaching Methods/ Activities

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Hands on training of different procedure
- Group discussion

VIII. Learning outcome

After successful completion of this course, the students are expected to:

- Know about various special characters of vegetables
- The recent breeding methods to achieve special characters in vegetables

IX. Suggested Reading

Allard RW. 1999. Principles of plant breeding. John Wiley and Sons.

Basset MJ. (Ed.). 1986. Breeding vegetable crops. AVI Publ.

Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. Plant genetic resources: horticultural crops. Narosa Publ. House.

Fageria MS, Arya PS and Choudhary AK. 2000. Vegetable crops: Breeding and seed production. Vol. I. Kalyani.

Gardner EJ. 1975. Principles of genetics. John Wiley and Sons.

Hayes HK, Immer FR and Smith DC. 1955. Methods of plant breeding. McGraw-Hill.

Hayward MD, Bosemark NO and Romagosa I. (Eds.). 1993. Plant Breeding-principles and prospects. Chapman and Hall.

Hazra P and Som MG. 2015. Vegetable science (Second revised edition), Kalyani publishers, Ludhiana, 598p.

edition), Kalyani Publishers, Ludhiana, 459p
Kalloo G. 1988. Vegetable breeding. Vols. I-III. CRC Press.
Kalloo G. 1998. Vegetable breeding. Vols. I-III (Combined Ed.). Panima Edu. Book Agency. Kumar JC and Dhaliwal MS. 1990. Techniques of developing hybrids in vegetable crops. Agro Botanical Publ.
Paroda RS and Kalloo G. (Eds.). 1995. Vegetable research with special reference to hybrid technology in Asia-Pacific Region. FAO.
Peter KV and Pradeepkumar T. 2008. Genetics and breeding of vegetables. Revised, ICAR. Peter KV and Hazra P. (Eds). 2012. Hand book of vegetables. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p
Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables Volume II.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509p.
Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables Volume III.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634p.
Rai N and Rai M. 2006. Heterosis breeding in vegetable crops. New India Publ. Agency.
Ram HH. 1998. Vegetable breeding: principles and practices. Kalyani Publishers, New Delhi. Rout GR and Peter KV. 2008. Genetic engineering of horticultural crops. Academic press, Elsevier, USA
Simmonds NW. 1978. Principles of crop improvement. Longman. Singh BD. 1983. Plant Breeding. Kalyani Publishers, New Delhi.
Singh PK, Dasgupta SK and Tripathi SK. 2004. Hybrid vegetable development. International Book Distributing Co.
Swarup V. 1976. Breeding procedure for cross-pollinated vegetable crops. ICAR.

I. Course Title : Biodiversity and Conservation of Vegetable Crops

II. Course Code : AGR980

III. Credit Hours : (2+1)

IV. Why this course ?

The availability of pertinent gene pool is of utmost importance to mitigate adverse climate and to counter diseases and pests. In addition, specific gene sources (germplasm) would always be necessary to develop superior genotypes. Considering the importance of conserving biodiversity in vegetable crops for future use, the course has been designed.

V. Aim of the course

To understand the status and magnitude of biodiversity and strategies in germplasm conservation of vegetable crops.

The course is organised as follows:

No.	Blocks	Units
1	Biodiversity and conservation of vegetable crops	I General Aspects: Issues, Goals and Current Status II. Germplasm Conservation: Collection, Maintenance and Characterization III. Regulatory Horticulture: Germplasm Exchange, Quarantine and Intellectual Property Rights

Unit I

General aspects: issues, goals and current status: Biodiversity and conservation; issues and goals- needs and challenges; present status of gene centres; world's major centres of fruit crop domestication; current status of germplasm availability/ database of fruit crops in India

Unit II

Germplasm conservation: collection, maintenance and characterization: Exploration and collection of germplasm; sampling frequencies; size and forms of fruit and nut germplasm collections; active and base collections. Germplasm conservation- in situ and ex situ strategies, on farm conservation; problem of recalcitrance- cold storage of scions, tissue culture, cryopreservation, pollen and seed storage.

Unit III

Regulatory horticulture: Germplasm exchange, quarantine and intellectual property rights germplasm exchange, quarantine and intellectual property rights regulatory horticulture, inventory and exchange of fruit and nut germplasm, plant quarantine, phytosanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. IPRs, Breeder's rights, Farmer's rights, PPVandFR Act. GIS and documentation of local biodiversity, Geographical indications, GIS application in horticultural mapping and spatial analyses of field data; benefits of GI protection; GI tagged fruit varieties in India.

VII. Practical

- Documentation of germplasm- maintenance of passport data and other records of accessions;
- Field exploration trips and sampling procedures;
- Exercise on ex situ conservation – cold storage, pollen/ seed storage
- Cryopreservation;
- Visits to national gene bank and other centers of PGR activities;
- Detection of genetic constitution of germplasm;
- Germplasm characterization using a standardised DUS test protocol;
- Special tests with biochemical and molecular markers.

VIII. Teaching Methods/ Activities

- Class room lectures
- Laboratory/ field practicals
- Student seminars/ presentations
- Field tours/ demonstrations
- Assignments

IX. Learning outcome

- The student would be expected to learn about the significance of germplasm
- Various strategies to conserve it in the present context.

X. Suggested Reading

Dhillon BS, Tyagi RK, Lal A and Saxena S. 2004. Plant genetic resource management. – horticultural crops. Narosa publishing house, New Delhi.

Engles JM, Ramanath RV, Brown AHD and Jackson MT. 2002. Managing plant genetic resources, CABI, Wallingford, UK.

University Press, USA.
Hancock J. 2012. Plant evolution and the origin of crops species. CAB International.
Jackson M, Ford-Lloyd B and Parry M. 2014, Plant genetic resources and climate change. CABI, Wallingford, UK
Moore JN and Ballington JR. 1991. Genetic resources of temperate Fruit and nut crops. ISHS, Belgium.
Peter KV. 2008. Biodiversity of horticultural crops. Vol. II. Daya Publ. House, Delhi. Peter KV.
2011. Biodiversity in horticultural crops. Vol.III. Daya Publ. House, Delhi.
Rajasekharan PE, Rao V and Ramanatha V. 2019. Conservation and utilization of horticultural genetic resources. Springer.
Rana JC and Verma VD. 2011. Genetic resources of temperate minor fruits (indigenous andexotic). NBPGR, New Delhi.
Sthapit et al. 2016. Tropical fruit tree diversity (good practices for in situ and ex situ conservation). Bioversity international. routledge, Taylor and Francis Group.
Virchow D. 2012. Conservation of genetic resources, Springer Verlag, Berlin

I. Course Title : Biotechnological Approaches in Vegetable Crops

II. Course Code : AGR978

III. Credit Hours : (2+1)

IV. Why this course?

Biotechnology is a rapidly developing area of contemporary science. It can bring new ideas, improved tools and novel approaches to the solution of some persistent, seemingly intractable problems in vegetable production. Given the pressing need to enhance and stabilize the vegetable production in response to mounting population pressures and increasing awareness, there is an urgent need to explore novel technologies that will break traditional barriers.

V. Aim of the course

To impart latest knowledge in biotechnical advancement in vegetable crops The course is organised as follows:-

No.	Blocks	Units
1	Biotechnological approaches in vegetable crops	I Importance and scope of Biotechnology II Somatic embryogenesis III Blotting techniques, DNA finger printing, IV Plant genetic engineering V Concepts and methods of next generation sequencing (NGS)

VI. Theory

Unit I

Importance and scope of biotechnology – in vegetable crop improvement. In-vitro culture, micropropagation, anther culture, pollen culture, ovule culture, embryo culture, endosperm culture.

Unit II

Somatic embryogenesis – somaclonal variation and synthetic seed production, protoplast isolation, culture, manipulation and fusion. Somatic hybrids and cybrids and their application in vegetable improvement programme.

Blotting techniques, DNA finger printing – Molecular markers/ DNA based markers and role. RFLP, AFLP, RAPD, SSR, SNPs, DNA probes. QTL mapping. MAS and its application in vegetable crop improvement. Allele mining by TILLING and Eco- TILLING.

Unit IV

Plant genetic engineering – Scope and importance, Concepts of cisgenesis, intragenesis and transgenesis. Gene cloning, direct and indirect methods of gene transfer. Role of RNAi based gene silencing in vegetable crop improvement. Bio- safety issue, regulatory issues for commercial approval.

Unit V

Concepts and methods of next generation sequencing (NGS)- Genome sequencing, transcriptomics, proteomics, metabolomics. Genome editing (ZFN, TALENS and CRISPER)

Crops

Solanaceous crops, cole crops, cucurbitaceous crops, root vegetables, garden pea, onion, potato and leafy vegetables

VII. Practical

III Micropropagation, Pollen- Ovule and Embryo culture- Synthetic seed production (2);
IV In-vitro mutation induction, in-vitro rooting – hardening at primary and secondary nurseries (3);
V DNA isolation from economic vegetable crop varieties – Quantification and amplification (2);
VI DNA and Protein profiling – molecular markers, PCR Handling (2);
VII Vectors for cloning and particle bombardment (3);
VIII DNA fingerprinting of flower crop varieties (3);
IX Project preparation for establishment of low, medium and high cost tissue culture laboratories (1).

VIII. Teaching Methods/ Activities

III Class room lectures
IV Laboratory/ field practicals
V Student seminars/ presentations
VI Field tours/ demonstrations
VII Assignments

IX. Learning outcome

The student would be expected to learn
III Different biotechnological tools
IV NGS, genetic engineering

X. Suggested Reading

Bajaj YPS. (Ed.). 1987. Biotechnology in agriculture and forestry. Vol. XIX. Hitech and Micropropagation. Springer.

Chadha KL, Ravindran PN and Sahijram L. (Eds.). 2000. Biotechnology of horticulture and plantation crops. Malhotra Publ. House.

Debnath M. 2005. Tools and techniques of biotechnology. Pointer publication, New Delhi.

Gorden H and Rubsell S. 1960. Hormones and cell culture. AB Book Publ.
Keshavachandran R. 2007. Recent trends in biotechnology of horticultural crops. New India Publ. Agency.
Keshavachandran R and Peter KV. 2008. Plant biotechnology; tissue culture and gene transfer. Orient and Longman, USA.
Keshavachandran R. 2007. Recent trends in biotechnology of horticultural crops. New-India Publication Agency, New Delhi.
Panopoulas NJ. (Ed.). 1981. Genetic engineering in plant sciences. Praeger Publ.
Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK and Mohanadas S. 2001. Biotechnology of horticultural crops. Vols. I-III. Naya Prokash.
Pierik RLM. 1987. In-vitro culture of higher plants. Martinus Nijhoff Publ.
Prasad S. 1999. Impact of plant biotechnology on horticulture. 2nd Ed. Agro Botanica.
Rout GR and Peter KV. 2018. Genetic engineering of horticultural crops. Academic Press Elsveer, USA.
Sharma R. 2000. Plant tissue culture. Campus Books.
Singh BD. 2010. Biotechnology- expanding horizons. Kalyani Publishers, New Delhi.
Skoog Y and Miller CO. 1957. Chemical regulation of growth and formation in plant tissue cultured in-vitro. Attidel. II Symp. On biotechnology action of growth substance.
Vasil TK, Vasi M, While DNR and Bery HR. 1979. Somatic hybridization and genetic manipulation in plants, plant regulation and world agriculture. Planum Press.

I. Course Title : Advanced Laboratory Techniques for Vegetable Crops

II. Course Code : AGR982

III. Credit Hours : (1+2)

IV. Why this course ?

Accurate quality analysis of vegetables warrants stringent measurement protocols besides requisite instruments/ tools and laboratory facilities. Consequently, a specialized course is designed for imparting basic and applied training on physical and biochemical assessment of the vegetable produce.

V. Aim of the course

To familiarize with the laboratory techniques for analysis of vegetable crops. The organisation of the course is as under:

No.	Blocks	Units
1	Advanced laboratory techniques for vegetable crops	I Safety measures and laboratory maintenance II Qualitative and quantitative analysis destructive and non-destructive analysis methods III Chromatographic and microscopic analysis IV Sensory analysis

VI. Theory

Unit I

Safety measures and laboratory maintenance – Safety aspects and upkeep of laboratory, sampling procedures for quantitative analysis, determination of proximate composition of horticultural produce. Standard solutions, determination of relative water content (RWC), physiological loss in weight (PLW), calibration

and standardization of instruments, textural properties of harvested produce, TSS, Specific gravity, pH and acidity.

Unit II

Destructive and non-destructive analysis methods – Refractometry, spectrophotometry, non-destructive determination of colour, ascorbic acid, sugars, and starch in food crops.

Unit III

Chromatographic and microscopic analysis- basic chromatographic techniques, GC, HPLC, GCMS, Electrophoresis techniques, ultra filtration. Application of nuclear techniques in harvested produce. Advanced microscopic techniques, ion leakage as an index of membrane permeability, determination of biochemical components in horticultural produce.

Unit IV

Sensory analysis – Importance of ethylene, quantitative estimation of rate of ethylene evolution, using gas chromatograph (GC). Sensory analysis techniques, control of test rooms, products and panel.

VII. Practical

III Determination of moisture, relative water content and physiological loss in weight;
IV Determination of biochemical components in horticultural produce;
V Calibration and standardization of instruments;
VI Textural properties of harvested produce;
VII Determination of starch index (SI);
VIII Specific gravity for determination of maturity assessment, and pH of produce;
IX Detection of adulterations in fresh as well as processed products;
X Non-destructive determination of colour, ascorbic acid, vitamins, carotenoids, sugars and starch;
XI Estimation of rate of ethylene evolution using gas chromatograph (GC);
XII Use of advanced microscopes (fluorescent, scanning electron microscope, phase contrast, etc.).

VIII. Teaching Methods/ Activities

III Class room Lectures
IV Laboratory Practicals
V Student Seminars/ Presentations
VI Field Tours/ Demonstrations
VII Assignments

IX. Learning outcome

The students would be expected to develop skills and expertise on
III Upkeep of laboratories and handling of research instruments
IV Principles and methods of various analysis

X. Suggested Reading

AOAC International. 2003. Official methods of analysis of AOAC international. 17th Ed. Gaithersburg, MD, USA, association of analytical communities, USA.
Clifton M and Pomeranz Y. 1988. Food analysis – laboratory experiments. AVI publication, USA.
Linskens HF and Jackson JF. 1995. Fruit analysis. Springer.

Leo ML. 2004. Handbook of food analysis, 2nd Ed. Vols. I-III, USA.
Pomrenz Y and Meloan CE. 1996. Food analysis – theory and practice. CBS, USA.
Ranganna S. 2001. Handbook of analysis and quality control for fruit and vegetable products. 2nd Ed. Tata-McGraw-Hill, New Delhi.
Thompson AK. 1995, Postharvest technology of fruits and vegetables. Blackwell sciences. USA.

Selected Journals

Sr. No.	Name of the Journal	ISSN No.
1.	American Journal of Horticultural Sciences	0003-1062
2.	American Potato Growers	
3.	American Scientst	1545-2786
4.	Annals of Agricultural Research	9703179
5.	Annual Review of Plant Physiology	0066-4294
6.	California Agriculture	1097-0967
7.	Haryana Journal of Horticultural Sciences	0970-2873
8.	HAU Journal of Research	0379-4008
9.	Horticulture Research	2052-7276
10.	HortScience	2327-9834
11.	IIVR Bulletins	1462-0316
12.	Indian Horticulture	0019-4875
13.	Indian Journal of Agricultural Sciences	0019-5022
14.	Indian Journal of Horticulture	0974-0112
15.	Indian Journal of Plant Physiology	2662-2548
16.	Journal of American Society for Horticutural Sciences	0003-1062
17.	Journal of Arecanut and Spice Crops	
18.	Journal of Food Science and Technology	0975-8402
19.	Journal of Plant Physiology	0176-1617
20.	Journal of Biology and Technology	0925-5214
21.	Postharvest Biology and Technology	0925-5214
22.	Scientia Horticulturae	0304-4238
23.	Seed Research	2151-6146
24.	Seed Science	23171537
25.	South Indian Horticulture	0038-3473
26.	Vegetable Grower	2330-2321
27.	Vegetable Science	2455-7552

I. Course Title: Principal and Practices of Soil Fertility and Nutrient Management

II. Course Code: AGR502

III. Credit Hours: 2+1

IV. Aim of the course

To impart knowledge of fertilizers and manures as sources of plant nutrients and apprise about the integrated approach of plant nutrition and sustainability of soil fertility.

V. Theory

Unit I

Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions.

Unit II

Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms;

transformation and dynamics of major plant nutrients.

Unit III

Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management. Soil less cultivation.

Unit IV

Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency; agronomic, chemical and physiological, fertilizer mixtures and grades; methods of increasing fertilizer use efficiency; nutrient interactions.

Unit V

Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic nutrients; economics of fertilizer use; integrated nutrient management; use of vermincompost and residue wastes in crops.

VI. Practical

- Determination of soil pH and soil EC
- Determination of soil organic C
- Determination of available N, P, K and S of soil
- Determination of total N, P, K and S of soil
- Determination of total N, P, K, S in plant
- Computation of optimum and economic yield

I. Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and class discussion

II. Learning outcome

Basic knowledge on soil fertility and management

III. Suggested Reading

- Brady NC and Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu.
- Fageria NK, Baligar VC and Jones CA. 1991. Growth and Mineral Nutrition of Field Crops. Marcel Dekker.
- Havlin JL, Beaton JD, Tisdale SL and Nelson WL. 2006. Soil Fertility and Fertilizers. 7th Ed. Prentice Hall.
- Prasad R and Power JF. 1997. Soil Fertility Management for Sustainable Agriculture. CRC Press.
- Yawalkar KS, Agrawal JP and Bokde S. 2000. Manures and Fertilizers. Agri-Horti Publ.

I. Course Title: Principles and Practices of Water Management

II. Course Code: AGR507

III. Credit Hours: 2+1

IV. Aim of the course

To teach the principles of water management and practices to enhance the water productivity

V. Theory

Unit I

Water and its role in plants; Irrigation: Definition and objectives, water resources and irrigation development in of India and concerned state, major irrigation projects, extent of area and crops irrigated in India and in different states.

Unit II

Field water cycle, water movement in soil and plants; transpiration; soil-water- plant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress condition. Water availability and its relationship with nutrient availability and loses.

Unit III

Soil, plant and meteorological factors determining water needs of crops, scheduling, depth and methods of irrigation; micro irrigation systems; deficit irrigation; fertigation; management of water in controlled environments and polyhouses. Irrigation efficiency and water use efficiency.

Unit IV

Water management of crop and cropping system, Quality of irrigation water and management of saline water for irrigation, water use efficiency, Crop water requirement- estimation of ET and effective rainfall; Water management of the major crops and cropping systems. Automated irrigation system.

Unit V

Excess of soil water and plant growth; water management in problem soils, drainage requirement of crops and methods of field drainage, their layout and spacing; rain water management and its utilization for crop production.

Unit VI

Quality of irrigation water and management of saline water for irrigation, water management in problem soils

Unit VII

Soil moisture conservation, water harvesting, rain water management and its utilization for crop production.

Unit VIII Hydroponics, **Unit IX**

Water management of crops under climate change scenario.

VI. Practical

- Determination of Field capacity by field method
- Determination of Permanent Wilting Point by sunflower pot culture technique
- Determination of Field capacity and Permanent Wilting Point by Pressure Plate Apparatus
- Determination of Hygroscopic Coefficient
- Determination of maximum water holding capacity of soil
- Measurement of matric potential using gauge and mercury type tensiometer
- Determination of soil-moisture characteristics curves
- Determination of saturated hydraulic conductivity by constant and falling head method
- Determination of hydraulic conductivity of saturated soil below the water table by auger hole method
- Measurement of soil water diffusivity
- Estimation of unsaturated hydraulic conductivity
- Estimation of upward flux of water using tensiometer and from depth ground water table
- Determination of irrigation requirement of crops (calculations)
- Determination of effective rainfall (calculations)
- Determination of ET of crops by soil moisture depletion method16. Determination of water requirements of crops
- Measurement of irrigation water by volume and velocity-area method
- Measurement of irrigation water by measuring devices and calculation of irrigation efficiency
- Determination of infiltration rate by double ring infiltrometer

VII. Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and field visit

VIII. Learning outcome

Basic knowledge on water management for optimization of crop yield

IX. Suggested Reading

- Majumdar DK. 2014. Irrigation Water Management: Principles and Practice. PHL Learning private publishers
- Mukund Joshi. 2013. A Text Book of Irrigation and Water Management Hardcover, Kalyani publishers
- Lenka D. 1999. Irrigation and Drainage. Kalyani.
- Michael AM. 1978. Irrigation: Theory and Practice. Vikas Publ.

- Paliwal KV. 1972. Irrigation with Saline Water. IARI Monograph, New Delhi.
- Panda SC. 2003. Principles and Practices of Water Management. Agrobios.
- Prihar SS and Sandhu BS. 1987. Irrigation of Food Crops - Principles and Practices. ICAR.
- Reddy SR. 2000. Principles of Crop Production. Kalyani.
- Singh Pratap and Maliwal PL. 2005. Technologies for Food Security and Sustainable Agriculture. Agrotech Publ.

I. Course Title : Basic Sampling Techniques

II. Course Code : AGR921

III. Credit Hours : 2+1

IV. Aim of the course

This course is meant for students of agricultural and animal sciences other than Statistics. The students would be exposed to elementary sampling techniques. It would help them in understanding the concepts involved in planning and designing their surveys, presentation of survey data analysis of survey data and presentation of results. This course would be especially important to the students of social sciences.

V. Theory

Unit I

Concept of sampling, sample survey vs complete enumeration, planning of sample survey, sampling from a finite population.

Unit II

Simple random sampling with and without replacement, sampling for proportion, determination of sample size, inverse sampling, Stratified sampling.

Unit III

Cluster sampling, Multi-stage sampling, systematic sampling; Introduction to PPS sampling,

Unit IV

Use of auxiliary information at estimation, Ratio product and regression estimators. Double Sampling, sampling and non-sampling errors.

VI. Practical

- Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.;
- Simple random sampling, determination of sample size, inverse sampling, stratified sampling, cluster sampling and systematic sampling;
- Estimation using ratio and regression estimators;
- Estimation using multistage design, double sampling.

VII. Suggested Reading

- Cochran WG. 1977. Sampling Techniques. John Wiley.
- Murthy MN. 1977. Sampling Theory and Methods. 2nd Ed. Statistical Publ. Soc., Calcutta.
- Singh D, Singh P and Kumar P. 1982. Handbook on Sampling Methods. IASRI Publ.
- Sukhatme PV, Sukhatme BV, Sukhatme S and Asok C. 1984. Sampling Theory of Surveys with Applications. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
- Cochran WG. 2007. Sampling Techniques, 3rd Edition. John Wiley & Sons Publication

I. Course Title : Experimental Designs

II. Course Code: MAT529

III. Credit Hours : 2+1

IV. Aim of the course

This course is meant for students of agricultural and animal sciences other than Agricultural Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

V. Theory

Unit I

Need for designing of experiments, characteristics of a good design. Basic principles of designs-randomization, replication and local control.

Unit II

Uniformity trials, size and shape of plots and blocks, Analysis of variance, Completely randomized design, randomized block design and Latin square design.

Unit III

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom. Concept of confounding.

Unit IV

Split plot and strip plot designs, analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, Balanced Incomplete Block Design, resolvable designs and their applications, Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of
results. Response surfaces. Combined analysis.

VI. Practical

• Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments,
• Analysis with missing data,
• Split plot and strip plot designs.

VII. Suggested Reading

• Cochran WG and Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.
• Dean AM and Voss D. 1999. Design and Analysis of Experiments. Springer.
• Montgomery DC. 2012. Design and Analysis of Experiments, 8th Ed. John Wiley.
• Federer WT. 1985. Experimental Designs. MacMillan.
• Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.
• Nigam AK and Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments. ASRI Publ.
• Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley.
• www.drs.icar.gov.in.

I. Course Title : Basic Sampling Techniques

II. Course Code : AGR921

III. Credit Hours : 2+1

IV. Aim of the course

This course is meant for students of agricultural and animal sciences other than Statistics. The students would be exposed to elementary sampling techniques. It would help them in understanding the concepts involved in planning and designing their surveys, presentation of survey data analysis of survey data and presentation of results. This course would be especially important to the students of social sciences.

V. Theory

Unit I

Concept of sampling, sample survey vs complete enumeration, planning of sample survey, sampling from a finite population.

Unit II

Simple random sampling with and without replacement, sampling for proportion, determination of sample size, inverse sampling, Stratified sampling.

Unit III

Cluster sampling, Multi-stage sampling, systematic sampling; Introduction to PPS sampling,

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Use of auxiliary information at estimation, Ratio product and regression estimators. Double Sampling, sampling and non-sampling errors.

VI. Practical

- Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.;
- Simple random sampling, determination of sample size, inverse sampling, stratified sampling, cluster sampling and systematic sampling;
- Estimation using ratio and regression estimators;
- Estimation using multistage design, double sampling.

VII. Suggested Reading

- Cochran WG. 1977. *Sampling Techniques*. John Wiley.
- Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Soc., Calcutta.
- Singh D, Singh P and Kumar P. 1982. *Handbook on Sampling Methods*. IASRI Publ.
- Sukhatme PV, Sukhatme BV, Sukhatme S and Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
- Cochran WG. 2007. *Sampling Techniques*, 3rd Edition. John Wiley & Sons Publication