ANNAMALAI UNIVERSITY

(Accredited with 'A+' Grade by NAAC)

FACULTY OF AGRICULTURE

(Accredited by ICAR)

DEPARTMENT OF HORTICULTURE

Academic Syllabi

Ph. D. (Hort.) Vegetable Science

Under Choice Based Credit System (CBCS) with Outcome based Education

2022-2023 Onwards

Ph. D. (Hort.) Vegetable Science

Semester wise Distribution of Credit

Semester	Major Course	Minor Course	Supporting Course	Seminar	Research	Total credit	Non credit Compulsory course
I	6	3	2	1	2	**15**	-
II	6	3	3	1	10	**22**	-
III	-	-	-	-	16	**16**	Research and Public Ethics
IV	-	-	-	-	16	**16**	**MOOC**
V	-	-	-	-	16	**16**	-
VI	-	-	-	-	15	**15**	-
Total credit	**12**	**6**	**5**	**2**	**75**	**100**	-

Distribution of Courses

Course code	Course Title	Credit hour (Theory + Practical)
	Major Courses	12
VSC 601*	Recent trends in vegetable production	3(3+0)
VSC 602*	Advances in breeding of vegetable crops	3(3+0)
VSC 603	Abiotic stress management in vegetable crops	3(2+1)
VSC 604	Seed certification ,processing and storage of vegetable crops	3(2+1)
VSC 605	Breeding for special traits in vegetable crops.	3(2+1)
	Minor Course	6
VSC 606	Bio diversity and conservation of vegetable crops	3(2+1)
VSC 607	Biotechnological approaches in vegetable crops	3(2+1)
VSC 608	Advanced laboratory techniques for vegetable crops.	3(1+2)
	Supporting Courses	5
COM 601	Advances in Computer Applications	2(1+1)
STA 601	Advances in Designs of Experiments	3(2+1)
	Seminar	
VSC 691	Doctoral Seminar – I	1(0+1)
VSC 692	Doctoral Seminar – II	1(0+1)
	Research	**75**
VSC 694	Doctoral Research	0+2
VSC 695	Doctoral Research	0+10
VSC 696	Doctoral Research	0+15
VSC 697	Doctoral Research	0+16
VSC 698	Doctoral Research	0+16
VSC 699	Doctoral Research	0+16
	Non credit compulsory courses	

NGC 611	Research and Publication Ethics – Contact hours: 2	-
NGC 612	**MOOC – Contact hours: 2**	-

*Compulsory courses

Semester wise Distribution of Courses

Sl. No	Courses	Credit Hours
I	**First Semester**	
1	Major Courses	6
2	Minor courses	3
3	COM 601 Advances in Computer Application	1+1
4	VSC 691 Seminar	0+1
5	VSC 694 Research	0+2
	Total credits	**0+14**
II	**Second Semester**	
1	Major Courses	6
2	Minor courses	3
3	STA 601 Advances in Designs of Experiments	2+1
4	VSC 692 Seminar	0+1
5	VSC 695 Research	0+10
	Total credits	**0+23**
III	**Third Semester**	
1	Research and Public Ethics*	2+0
2	VSC 696 Research	**0+15**
IV	**Fourth Semester**	
1	MOOC*	2+0
2	VSC 697 Research	**0+16**
V	**Fifth Semester**	
1	VSC 698 Research	**0+16**
VI	**Sixth Semester**	
1	VSC 699 Research	**0+16**
	Grand total	**100**

*Non credit compulsory course.

DEPARTMENT OF HORTICULTURE

Ph. D. (Hort.) Vegetable Science

PROGRAMME OUTCOME

PO 1 – The scholar will acquire knowledge on crop improvement, production technologhies, biotechnology and postharvest technologies pertaining to vegetable crops with special reference to advancement in research.

PO 2 – The scholar will gain skills in approaching research problems and define research methodology for problems solving research in the field of vegetable science.

PO 3 – The scholar will be able to do individual research works in vegetable crops.

PO 4 – The scholar will become eligible to work in research programmes offered by national and international organizations and in teaching vegetable science.

PO 5 – The scholar will be able to develop expertize in scientific writing and publication of a research outcome.

VSC - 601 RECENT TRENDS IN VEGETABLE PRODUCTION (3+0)

Learning objectives

- To update the students with latest developments and trends in production technology of vegetable crops.
- To impart knowledge about present status and prospects of vegetable cultivation.
- To gain knowledge about Hi-Tech nursery management.
- To learn about the modern concept in water & Weed Management.
- To acquire Knowledge and skill about the recent trends in nutrient management.

Theory

Present status and prospects of vegetable cultivation; nutritional and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; 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; containerized culture for year round vegetable production; low cost polyhouse; net house production; crop modeling, organic gardening; vegetable production for pigments, export and processing.

Unit-I: Solanaceous and malvaceous vegetables

Tomato, brinjal, chilli, sweet pepper, potato and bhendi.

Unit-II: Cole crops and cucurbits

Cabbage, cauliflower, knol-khol, sprouting broccoli and cucurbits.

Unit-III: Leguminous vegetables and green leafy vegetables.

Peas and beans, amaranthus and drumstick

Unit-IV: Root crops and bulbs

Carrot, beet root, radish and onion.

Unit-V: Tuber crops

Sweet potato, tapioca, dioscorea, elephant foot yam and taro

Lesson plan

Present status and prospects of vegetable cultivation; nutritional and medicinal values; Tomato climate and soil as critical factors in vegetable production; choice of varieties; 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; containerized culture for year round vegetable production; low cost polyhouse; net house production; crop modeling, organic gardening; vegetable production for pigments, export and processing

1. Present status and prospects of vegetable cultivation; nutritional and medicinal values;
2-3. Tomato
4-5. Brinjal
5. Chilli
6-7. Sweet pepper
8. Potato
9-10. Bhendi
11-12. Cabbage
13-14. Cauliflower
15. Knolkhol

16. Sprouting broccoli
17. Pumpkin
18. Ash gourd
19. Bitter gourd
20. Ridge gourd
21. Bottle gourd
22. Snake gourd
23. Cucumber
24. First test
25. **First Test**
26. Watermelon
27. Muskmelom
28. Pointed gourd
29. Turnip
30. Peas
31. French bean
32. Cluster bean
33. Vegetable Cowpea
34. Amaranthus
35. Drumstick
36-37. Carrot
38. Beet root
39. Radish
34-41. Onion
42. Aggregatum onion
43. Tapioca
44. Sweet potato
45. Dioscorea
46. Elephant foot yam
47. Containerized culture for year round vegetable production
48. Low cost polyhouse; net house production; crop modelling,
49. Crop modelling,
50. Organic gardening.
51. Vegetable production for pigments, export and processing.

COURSE OUTCOME

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

CO 1: Advanced technology in vegetable production.
CO 2: Prospects and scope of vegetable production.
CO 3: Modern concepts in water & weed management
CO 4: Methods to combat the nutritional disorders in vegetable crops.
CO 5: Low cost effective techniques for protected cultivation of vegetable crops.

CO - PO Mapping matrix

	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	2	3	2	2
CO 2	3	1	2	1	-
CO 3	3	2	2	1	1

CO 4	**3**	**1**	**2**	**2**	**1**
CO 5	**3**	**2**	**2**	**2**	**2**

References

1. Bose TK & Som NG. 1986. Vegetable Crops of India. Naya Prokash.
2. Bose TK, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. Vegetable Crops. Vols. I-III. Naya Udyog.
3. Brewster JL. 1994. Onions and other Vegetable Alliums. CABI.
4. FFTC. Improved Vegetable Production in Asia. Book Series No. 36.
5. Ghosh SP, Ramanujam T, Jos JS, Moorthy SN & Nair RG. 1988. Tuber Crops. Oxford & IBH.
6. Gopalakrishnan TR. 2007. Vegetable Crops. New India Publishing Agency.
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3. https://www.freshplaza.com/news-detail.asp?id=29689
4. https://www.vigyanprasar.gov.in/comcom/develop62.htm
5. https://ucanr.org/freepubs/docs/8098

VSC- 602 ADVANCES IN BREEDING OF VEGETABLE CROPS (3+0)

Learning objectives

- The student can able to understand genetics and cytogenetics principles applied in crop breeding techniques
- The student can apply traditional and molecular breeding methods for the enhancement of vegetable crops.
- Interpret about genetic diversity, germplasm resources and conservation,
- The student can able to gain knowledge regarding government policies, industry needs and consumer preferences which can affect the vegetable crop improvement programs.
- Design and present a vegetable breeding research project that meets specific short- term and long-term goals.

Theory

Evolution, distribution, cytogenetics, genetic resources, genetic divergence, types of pollination and fertilization mechanisms, sterility and incompatibility, anthesis and pollination, hybridization, inter-varietal, interspecific and inter-generic hybridization, heterosis breeding, inheritance pattern of traits, qualitative and quantitative, plant type concept and selection indices, genetics of spontaneous and induced mutations, problems and achievements of mutation breeding, ploidy breeding and its achievements, *in vitro* breeding; breeding techniques for improving quality and processing characters; breeding for stresses, mechanism and genetics of resistance, breeding for salt, drought; low and high temperature; toxicity and water logging resistance, breeding for pest, disease, nematode and multiple resistance for the following crops

Unit- I: Solanaceous and Malvaceous vegetables

Tomato, brinjal, chilli, capsicum and okra

Unit- II: Cucurbitaceous vegetables

All gourds, melons, perennial cucurbits

Unit- III: Fabaceous & Cruciferous vegetables

Peas, beans, cabbage, cauliflower, knol khol and turnip

Unit- IV: Root & tuberous vegetables

Carrot, radish, beetroot, tapioca, potato, sweet potato and elephant foot yam

Unit- V: Leafy and bulbous vegetables

Amaranthus, moringa, spinach, palak, lettuce, onion and garlic

Lesson plan

Evolution, distribution, cytogenetics, genetic resources, genetic divergence, types of pollination and fertilization mechanisms, sterility and incompatibility, anthesis and pollination, hybridization, inter-varietal, interspecific and inter-generic hybridization, heterosis breeding, inheritance pattern of traits, qualitative and quantitative, plant type concept and selection indices, genetics of spontaneous and induced mutations, problems and achievements of mutation breeding, ploidy breeding and its achievements, *in vitro* breeding; breeding techniques for improving quality and processing characters; breeding for stresses, mechanism and genetics of resistance, breeding for salt, drought; low and high temperature; toxicity and water logging resistance, breeding for pest, disease, nematode and multiple resistance in the following crops:

1. Introduction about crop improvement in Solanaceous and Malvaceous vegetables
1-2. Crop improvement in Tomato
3-4. Crop improvement in Brinjal
5-6. Crop improvement in Chilli
7-8. Crop improvement in Sweet Pepper
9-10. Crop improvement in Bhendi
11. Introduction about crop improvement in Cucurbitaceous vegetables
12-13. Crop improvement in Ash gourd
14-15. Crop improvement in Ridge gourd
16-17. Crop improvement in Snake gourd
18-19. Crop improvement in Watermelon
20-22. Crop improvement in Muskmelon
23. Crop improvement in Perennial Cucurbitaceous vegetables – Pointed gourd
24. Crop improvement in Perennial Cucurbitaceous vegetables – Ivy gourd
25. **First Test**
26. Crop improvement in Perennial Cucurbitaceous vegetables – Chow- Chow
27. Introduction about crop improvement in Fabaceous and Cruciferous vegetables
28. Crop improvement in Peas
29. Crop improvement in Beans
30. Crop improvement in Cabbage
31. Crop improvement in Cauliflower
32. Crop improvement in Knol-Khol
33. Crop improvement in Turnip

34. Crop improvement in Carrot
35. Crop improvement in Radish
36. Crop improvement in Beet root
37-38. Crop improvement in Tapioca
39-40. Crop improvement in Sweet Potato
41. Crop improvement in Elephant foot yam
42-43. Crop improvement in Potato
44. Crop improvement in Amaranthus
45. Crop improvement in Spinach
46. Crop improvement in Palak
47. Crop improvement in Lettuce
48-50. Crop improvement in Onion
51. Crop improvement in Garlic

COURSE OUTCOME

The scholar will be able to

CO 1: Understand the pollination behavior and fertilization mechanisms of vegetables.

CO 2: Understand the screening techniques for improving vegetables.

CO 3: Know how to design breeding experiments

CO 4: Understand hybridization techniques of vegetables

CO 5: Gain knowledge regarding government policies

CO - PO Mapping matrix

	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	**3**	**2**	**2**	**2**	**2**
CO 2	**3**	**2**	**3**	**3**	**1**
CO 3	**3**	**2**	**2**	**3**	**1**
CO 4	**3**	**2**	**1**	**3**	**2**
CO 5	**-**	**-**	**-**	**1**	**-**

References

1. Dhillon, B.S., R.K. Tyagi., S. Saxena. & G.J. Randhawa. 2005. Plant Genetic Resources: Horticultural Crops. Narosa Publ. House., New Delhi.
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3. www.agritech.tnau.ac.in
4. https://www.iihr.res.in
5. https://www.plantbreeding.org

VSC 603 ABIOTIC STRESS MANAGEMENT IN VEGETABLE CROPS (2+1)

Learning objective

- To update knowledge on the recent research trends in the field of abiotic stress management in vegetable crops.
- To update knowledge on the recent research trends in the field of biotic stress management in vegetable crops.
- To update knowledge regarding vegetable production under stress
- To gain knowledge about various types of environmental stresses and their impact on vegetable production
- To teach management practices to mitigate abiotic and biotic stresses in vegetable production.

Theory

Unit -I: Stress, types and classification

Environmental stress and its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress; root stock, use of wild species, use of anti-transpirants.

Unit –II: Mechanisms of stress in vegetable crops

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

Unit –III: Environmental factors related to stress

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

Unit -IV: Production techniques of vegetables - I

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

Unit –V: Production techniques of vegetables - II

Techniques of vegetable growing under high and low temperature conditions, use of chemicals in alleviation of different stresses.

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, and use of chemicals for alleviation of different stresses.

Lesson plan

1. Stress – definition and classification - Environmental stress and its types
2. Nutrient stress and oxidative stress
3. Classification of vegetable crops based on susceptibility and tolerance to various types of stress
4. Influence of root stock in stress alleviation - use of wild species
5. Use of antitranspirants in management of stress
6. Drought - toxicity symptoms- mechanisms governing tolerance- physiological and biochemical factors with stress-impact on vegetable crops - approaches and advances in management of drought
7. Flooding - toxicity symptoms- mechanisms governing tolerance- physiological and biochemical factors with stress-impact on vegetable crops - approaches and advances in management of flooding
8. Soil salinity- toxicity symptoms- mechanisms governing tolerance- physiological and biochemical factors with stress-impact on vegetable crops - approaches and advances in management of saline soil
9. Sodicity- toxicity symptoms- mechanisms governing tolerance- physiological and biochemical factors with stress-impact on vegetable crops - approaches and advances in management of sodic soil
10. Frost - toxicity symptoms- mechanisms governing tolerance- physiological and biochemical factors with stress-impact on vegetable crops - approaches and advances in management of frost
11. Heat stress- toxicity symptoms- mechanisms governing tolerance- physiological and biochemical factors with stress-impact on vegetable crops - approaches and advances in management of heat stress
12. Temperature and Radiation stress-- toxicity symptoms- mechanisms governing tolerance- physiological and biochemical factors with stress-impact on vegetable crops - approaches and advances in management
13. Nutrient stress and oxidative stress - toxicity symptoms- mechanisms governing tolerance- physiological and biochemical factors with stress-impact on vegetable crops - approaches and advances in management
14. Soil-plant-water relations under drought condition in vegetable crops production and their management practices.
15. Soil-plant-water relations under flooded condition in vegetable crops production and their management practices.
16. Soil-plant-water relations under in vegetable crops production and their management practices.
17. **First Test**
18. Soil-plant-water relations under sodic condition in vegetable crops production and their management practices.
19. Soil-plant-water relations under frost condition in vegetable crops production and their management practices.

20. Soil-plant-water relations under heat stress condition in vegetable crops production and their management practices
21. Techniques of vegetable growing under water deficit condition
22. Techniques of vegetable growing under water logged condition
23. Techniques of vegetable growing under saline soil
24. Techniques of vegetable growing under sodic soil
25. Techniques of vegetable growing under frost condition
26. Techniques of vegetable growing under heat stress condition
27. Techniques of vegetable growing under high and low temperature conditions,
28. Use of chemicals in alleviation of drought condition
29. Use of chemicals in alleviation of flooded condition
30. Use of chemicals in alleviation of saline condition
31. Use of chemicals in alleviation of sodic condition
32. Use of chemicals in alleviation of frost condition
33. Use of chemicals in alleviation of heat stress condition
34. Use of chemicals in alleviation of drought condition

Practical

1. Identification of susceptibility and tolerance symptoms to drought in vegetable crops
2. Identification of susceptibility and tolerance symptoms to flooding in vegetable crops
3. Identification of susceptibility and tolerance symptoms to salinity in vegetable crops
4. Identification of susceptibility and tolerance symptoms to sodicity in vegetable crops
5. Identification of susceptibility and tolerance symptoms to frost condition in vegetable crops
6. Identification of susceptibility and tolerance symptoms to heat stress in vegetable crops
7. Identification of susceptibility and tolerance symptoms to nutrient stress in vegetable crops
8. Measurement of tolerance to drought in vegetable crops
9. Measurement of tolerance to flooding in vegetable crops
10. Measurement of tolerance to salinity in vegetable crops
11. Measurement of tolerance to sodicity in vegetable crops
12. Measurement of tolerance to frost condition in vegetable crops
13. Measurement of tolerance to heat stress in vegetable crops
14. Short term experiments on growing vegetables under water deficit
15. Short term experiments on growing vegetables under salinity and sodicity
16. Use of chemicals for alleviation of different stresses
17. Use of chemicals for alleviation of different stresses

Course outcome

CO 1- Acquire the knowledge about effect of different abiotic stress on production of vegetables.

CO 2- To update knowledge on recent research trends in the field of environmental stress management in vegetables.

CO 3- Gain understanding about technique of vegetable growing under high stress condition.

CO 4- To gain knowledge on use of chemicals and anti-transpirants to alleviate different type of abiotic stresses.
CO 5- To gain skill on the management practices to mitigate abiotic stress in vegetable crops.

CO – PO Mapping matrix

	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	2	2	1	2	1
CO 2	3	2	1	1	1
CO 3	3	2	1	1	1
CO 4	3	2	1	2	1
CO 5	3	3	2	3	2

References

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3. https://www.frontiersin.org
4. https://agritech.tnau.ac.in

VSC - 604 SEED CERTIFICATION PROCESSING AND STORAGE OF VEGETABLE CROPS (2+1)

Learning objective

- To educate the recent trends in the seed processing of vegetable crops.
- To educate the recent trends in the seed storage of vegetable crops.
- To educate the recent trends in the seed certification of vegetable crops.
- To educate the recent trends in the marketing of seeds of vegetable crops.
- To know about policy and seed act related to seed production

Theory

Unit -I: Seed certification and Standards

Seed certification- objectives - organization of seed certification - minimum seed certification standards of vegetable crops - field inspection - specification for certification.

Unit –II: Seed processing equipments

Seed processing - study of seed processing equipments - seed cleaning and upgrading - Seed packing and handling - equipment used for packaging of seeds - procedures for allocating lot number. principles and procedures of field inspection,seed sampling,testing and granting certification

Unit -III: Factors governing seed storage

Pre-conditioning - seed treatment – benefits - types and products - general principles of seed storage - advances in methods of storage(open,bulk,controlled,germplasam,cryopreservation) - quality control in storage - storage containers - seed longevity and deterioration – sanitation - temperature and relative humidity control.

Unit –IV: Seed testing

Seed testing; ISTA rules for testing – moisture - purity germination - vigor test - seed sampling - determination of genuineness of varieties - seed viability - seed health testing; seed dormancy and types of dormancy - factors responsible for dormancy.

Unit -V: Seed Marketing

Seed marketing - demand forecast - marketing organization - economics of seed production; farmers' rights - seed law enforcement - seed act and seed policy.

Practical

Seed sampling, purity, moisture testing, seed viability, seed vigor tests, seed health testing, seed cleaning, grading and packaging; handling of seed equipment and processing machines; seed treatment methods, seed priming and pelleting; field and seed inspection, practices in rouging, seed storage, isolation distances, biochemical tests, visit to seed testing laboratories and processing plants, mixing and dividing instruments, visit to seed processing unit and warehouse visit and know about sanitation standards.

Lesson plan

1. Seed certification objectives
2. Organization of seed certification
3. Minimum seed certification standards of vegetable crops
4. Field inspection
5. Specification for certification
6. Seed processing
7. Study of seed processing equipments
8. Seed cleaning and upgrading
9. Seed packing and handling
10. Equipment used for packaging of seeds
11. Procedures for allocating lot number
12. Pre-conditioning of seeds
13. Seed treatment, benefits, types and products
14. General principles of seed storage
15. Advances in methods of storage

16. Quality control in storage
17. **First Test**
18. Storage containers, seed longevity and deterioration
19. Seed sanitation
20. Role of temperature and relative humidity control in seed storage
21. Seed testing: ISTA rules for testing
22. Moisture, purity, germination, vigor test
23. Seed sampling
24. Determination of genuineness of varieties
25. Seed viability
26. Seed health testing
27. Seed dormancy and types of dormancy
28. Factors responsible for dormancy
29. Seed marketing: demand forecast
30. Marketing organization
31. Economics of seed production
32. Farmers' rights: PPVFRA
33. Seed law enforcement
34. Seed act and seed policy

Practical

1. Seed sampling and analysis of seed for physical and genetic purity
2. Moisture testing
3. Seed viability
4. Seed vigor tests
5. Seed health testing
6. Seed cleaning, grading and packaging
7. Handling of seed testing equipment and processing machines, mixing and dividing instruments
8. Seed treatment methods, seed priming and pelleting
9. Field and seed inspection
10. Practices in rouging
11. Seed storage
12. Isolation distance
13. Biochemical tests
14. Visit to seed testing laboratories and processing plants
15. Visit to seed processing unit and warehouse
16. Standards of field sanitation
17. Standards of field sanitation

Course outcome

CO 1- The students will acquire knowledge on seed certification.
CO 2- The students will get exposed to principles and procedure of field inspection.
CO 3-The students will understand the principles of seed processing.

CO 4- Will gain comprehensive knowledge on seed storage.
CO 5- The students will get equipped to overcome the problems due to seed aging, seed deterioration, loss of vigour & viability.

CO – PO Mapping matrix

	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	1	1	1	1
CO 2	3	2	-	-	-
CO 3	3	-	2	3	-
CO 4	2	2	-	2	-
CO 5	3	2	2	3	1

References

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2. Singh N, Singh DK, Singh YK & Kumar V. 2006. *Vegetable Seed Production Technology*. International Book Distr. Co.
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E-Resources

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2. https://agritech.tnau.ac.in
3. https://seednet.gov.in
4. http://ciks.org
5. https://eorganic.org

VSC – 605 BREEDING FOR SPECIAL TRAITS IN VEGETABLE CROPS (2+1)

Learning objective

- The present course enables the students to understand the consumption levels of vegetables.
- To understand the basics and principles of breeding programmes in vegetables.
- To impart knowledge on bioactive properties of vegetables.
- To identify the methods that contributes towards lowering the risk of cardiovascular diseases.

- This course also helps to know the breeding programmes and scientific studies on bioactive compounds of vegetables.

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 colour 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:

Bio fortification in vegetable crops, genetic engineering for improvement of quality traits in vegetable crops, bioavailability of dietary nutrients from improved 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.

Practical

Lesson plan

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 colour content.

1. Crop improvement for special traits in Cabbage
2. Crop improvement for special traits in Cauliflower
3. Crop improvement for special traits in Brussels sprout
4. Crop improvement for special traits in Sprouting Broccoli
5. Crop improvement for special traits in Kale
6. Crop improvement for special traits in Kohlrabi
7. Crop improvement for special traits in Carrot
8. Crop improvement for special traits in Radish
9. Crop improvement for special traits in Beet root

11-12. Crop improvement for special traits in Tomato

13. Crop improvement for special traits in Brinjal

14. Crop improvement for special traits in Chilli

15. Crop improvement for special traits in Sweet pepper

16. Crop improvement for special traits in Potato

17. First Test

18. Crop improvement for special traits in Spinach

19. Crop improvement for special traits in Lettuce

20. Crop improvement for special traits in Palak

21. Crop improvement for special traits in Drumstick

22. Crop improvement for special traits in French beans
23. Crop improvement for special traits in Garden beans
23. Crop improvement for special traits in Broad beans
24. Crop improvement for special traits in Garden peas
25. Crop improvement for special traits in Okra
26. Crop improvement for special traits in Melons
27. Crop improvement for special traits in Gourds
28. Crop improvement for special traits in Onion
29. Crop improvement for special traits in Garlic
30. Bio fortification in vegetable crops
31. Bio availability of dietary nutrients from improved vegetable crops and impact on micronutrient malnutrition.
32. Achievements and future prospects in breeding for quality traits in vegetables.
33. Genetic engineering for improvement for quality traits in vegetable crops,
34. Crops bio availability of dietary nutrients from improved vegetable crops

Practical schedule

1. Identification and characterization of Brassica species for breeding purposes.
2.Hybridization techniques in the Brassica group for improving yield and quality.
3.Practical 3: Breeding methods for disease resistance in Carrot and Beetroot.
4.Breeding strategies for pest and disease resistance in Tomato.
5. Cross-breeding techniques in Brinjal for high-yield and quality improvement.
6. Selection and hybridization for fruit quality traits in Peppers.
7. Potato breeding for tuber quality and disease resistance.
8. Breeding for nutritional enhancement in Green Leafy Vegetables.
9. Hybridization and selection for disease resistance and yield in Legume crops.
10. Okra breeding for resistance to abiotic stresses such as drought and salinity.
11.Hybridization techniques for improving fruit quality in Cucurbitaceous crops.
12. Breeding for disease resistance in Cucurbitaceous vegetables.
13. Breeding techniques for enhancing bulb size and quality in Edible Alliums.
14. Biofortification strategies to increase micronutrient content in vegetable crops.
15. Genetic engineering techniques for quality trait improvement in vegetables.
16. Evaluation of bioavailability of dietary nutrients in biofortified crops.
17. Case studies on the impact and future prospects of breeding for quality traits in vegetable crops.

Course outcome

CO 1- Acquire the knowledge on breeding programmes of vegetable crops.
CO 2- Understand the knowledge on recent development in breeding for improved nutritional quality in vegetable crops.
CO 3- Students able to understand the bioactive properties of vegetables.
CO 4- Students able to understand the contribution of breeding of vegetables towards human health.
CO 5- Incorporate the knowledge on breeding programmes and scientific studies on bioactive compounds of vegetables.

CO – PO Mapping matrix

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**
CO1	3	2	2	2	1

CO2	3	2	2	2	2
CO3	3	-	3	-	-
CO4	3	1	2	2	1
CO5	3	1	1	2	1

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VSC – 606 BIODIVERSITY AND CONSERVATION OF VEGETABLE CROPS (2+1)

Learning objective

- To understand the goals, issues and current status of biodiversity and conservation of vegetable crops.
- To gain knowledge about collection, maintenance and characterization of germplasm.
- To impart comprehensive knowledge about germplasm exchange quarantine and intellectual property rights germplasm exchange.
- To know about GIS application in horticultural mapping and spatial analysis of field data.
- To gain knowledge about different strategies to conserve the germplasm in the present context.

Theory

Unit -I: Importance of biodiversity and methods of conservation

Biodiversity and conservation- issues and goals- centres of origin of cultivated vegetables- primary and secondary centres of genetic diversity- present status of gene centres- exploration and collection of germplasm- conservation of genetic resources- *in situ* and *ex situ* germplasm conservation- problem of recalcitrancy- cold storage of seeds- tissue culture- cryopreservation- pollen and seed storage- inventory of germplasm.

Unit –II: Role of National Institutes in conservation and plant quarantine

Introduction of germplasm- plant quarantine- role of national institutes in conservation- TBGRI- NBPGR- etc- intellectual property rights- regulatory horticulture- plant variety

protection authority- maintenance of core group using traditional knowledge for plant conservation. IPRS, Breeders rights, Farmers rights, PPV and FR act. GIS and documentation of local bio diversity, geographical indications.

Unit –III: Bio diversity of tropical vegetable crops

Biodiversity of major tropical vegetable crops- Tomato- Brinjal- Chilli- Okra- Amaranthus- Cluster bean- Vegetable Cowpea- Cucurbits- Melons- Moringa- Dolichos bean- Broad bean

Unit -IV: Biodiversity of temperate vegetable crops

Biodiversity of major- temperate vegetable crops- Cabbage- Cauliflower- Knol Khol- Turnip- Brussels sprout- Chinese cabbage- Carrot- Beet root- Radish

Unit -V: Bio diversity of under exploited minor vegetable crops

Under exploited minor vegetable crops- present status and scope- their origin- distribution- biodiversity- conservation and utilization of minor vegetable crops.

Practical

Documentation of germplasm- maintenance of passport data and other records of accessions- field exploration trips- exercise on *ex situ* conservation- cold storage- pollen or seed storage- cryopreservation- visits to national gene bank and other centres of pgr activities- core sampling- germplasm characterization using molecular techniques.

Lesson plan

1. Bio diversity- introduction, principles, goals and issues in conservation
2. Genetic diversity- occurrence and distribution
3. Exploration, collection, characterization, documentation and cataloguing of germplasm
4. Present status of national and international gene banks
5. Role of national institutes in conservation – TBGRI, NPBGR etc.,
6. Germplasm exchange, material transfer agreement and current quarantine protocols
7. Methods for *ex situ* conservation of germplasm and *in situ* conservation of germplasm
8. Use of GIS and documentation of local bio diversity
9. GIS application in horticultural mapping
10. Impact of climate change on bio diversity
11. IPRS, Breeders right, Farmers rights, PPV, FR Act.
12. Benefits of GI protection.
13. Intellectual property rights, plant variety protection authority
14. Status of bio diversity of Tomato
15. Status of bio diversity of Brinjal
16. Status of bio diversity of Chilli
17. **First Test**
18. Status of bio diversity of Okra
19. Status of bio diversity of Amaranthus
20. Status of bio diversity of Cluster bean
21. Status of bio diversity of Vegetable cow pea

22-23. Status of bio diversity of Cucurbits

24-25. Status of bio diversity of Melons

26. Status of bio diversity of Moringa
27. Status of bio diversity of Dolichos bean and Broad bean
28. Status of bio diversity of Cabbage and cauliflower
29. Status of bio diversity of Knol khol and Turnip
30. Status of bio diversity of Brussels sprout and Chinese cabbage
31. Status of bio diversity of Carrot, Beet root and Radish
32. Under exploited minor vegetable crops- present status and scope

33. Minor vegetables- origin, distribution- bio diversity, propagation, conservation and utilization.
34. Minor vegetables- origin, distribution- bio diversity, propagation, conservation and utilization.

Practical

1. Field exploration trips- exercise in collection and characterization
2. Visit to field germplasm unit and documentation of germplasm
3. Practices in maintenance of passport data
4. Practical study on *ex situ* conservation methods
5. Practical study on *in situ* conservation methods
6. Methods of seed storage for short and long term conservation
7. Methods of conservation using vegetative propagules
8. *In vitro* conservation protocols
9. Study of species diversity in horticultural cropping system
10. Visit to regional conservation centres
11. Visit to tropical and temperate vegetable farms
12. Characterization of tomato germplasm
13. Characterization of brinjal germplasm
14. Characterization of okra germplasm
15. Identification of minor vegetable crops and their description
16. Use of molecular tools for characterizing species diversity
17. Estimating extend of diversity through collection and analysis of data

Course outcome

CO 1- The student would be expected to learn about the significance of germplasm.
CO 2- To appreciate about present status of gene centre, germplasm availability and data base of vegetable crops in India.
CO 3- To gain understanding about germplasm characterization using a standard DUS test protocol.
CO 4- To appreciate various techniques used in the conservation of germplasm.
CO 5- To acquire knowledge about benefits of GI protection and GI tagged fruit varieties in India.

CO – PO Mapping matrix

	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	2	2	2	2	2
CO 2	2	2	1	2	1
CO 3	2	2	2	3	2
CO 4	3	2	2	2	1
CO 5	3	2	2	2	1

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VSC - 607 BIOTECHNOLOGICAL APPROACHES IN VEGETABLE CROPS (2+1)

Learning objectives

- To provide an insight into the basic principles of biotechnology
- To impart knowledge on various techniques of biotechnology and their applications.
- To impart knowledge on genetic engineering techniques
- To gain information regarding the molecular markers and their thrust in Horticultural biotechnology

Theory

Unit –I: Importance, history and scope of biotechnology

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: Techniques of tissue culture -I

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.

Unit–III: Techniques of tissue culture -II

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

Unit–IV: Genetic Engineering and Molecular techniques

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: Genetic Engineering and Molecular Techniques

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.

Practical

Tissue culture laboratory organization – aseptic manipulation – culture media

preparation – inoculation of explants for clonal propagation – shoot tip, meristem – callus initiation and multiplication – sub-culturing techniques – regeneration of plants – techniques of anther and ovule culture – somaclonal variation – *in-vitro* mutation – selection for abiotic stresses – development of protocols for mass multiplication – project development for establishment of commercial tissue culture laboratory

Lesson plan

1. Biotechnological approaches in vegetable crop improvement
2. Anther, Pollen, Ovule & Embryo culture in vegetable crops
3. Endosperm and meristem culture in vegetable crops
4. Wide hybridization and embryo rescue techniques in vegetable crops
5. Somatic embryogenesis in vegetable crops
6. Somaclonal variation for vegetable crop improvement
7. Micro-grafting in vegetable crops
8. Protoplast isolation, culture and fusion in vegetable crops
9. Somatic hybrids and their application in vegetable crop improvement
10. Biotechnological approaches in vegetable crop improvement
11. Isolation of secondary metabolites in *in vitro* culture of vegetable crops
12. Cryopreservation and its application in vegetable crops
13. Synthetic seed production in vegetable crops
14. Importance and application of Blotting techniques
15. Importance and application of DNA finger printing
16. Importance of molecular markers
17. **First Test**
18. Application of DNA based markers in vegetable crops-I
19. Application of DNA based markers in vegetable crops-II
20. Importance of QTL mapping in vegetable crop improvement
21. MAS and itsapplication in vegetable crop improvement.
22. Allele mining by TILLING and Eco-TILLING.
23. Plant genetic engineering - Scope and importance
24. Concepts of cisgenesis, intragenesis and transgenesis.
25. Application of transgenics in development of varieties for resistance
26. Application of transgenics in development of varieties for quality improvement
27. Gene cloning techniques
28. Application of genome editing in vegetable crop improvement
29. Role of RNAi based gene silencing in vegetable crop improvement.
30. Bio-safety, regulatory issues for commercial approval.
31. Concepts and methods of next generation sequencing (NGS)
32. Transcriptomics in vegetable crop improvement
33. Proteomics in vegetable crops
34. Metabolomics in vegetable crops

Practical

1. Introduction to micropropagation

2. Invitro shooting and rooting
3. Pollen culture method
4. Ovule culture method
5. Embryo culture method
6. Synthetic seed production
7. Induction of *invitro* mutation
8. Hardening of plantlets
9. Isolation of DNA from economically important vegetable crop varieties
10. Quantification and amplification of DNA
11. DNA and Protein profiling
12. Use of molecular markers for characterization
13. Genetic transformation techniques
14. Genome editing procedures
15. Visit to commercial TC units
16. Project preparation for establishment of low, medium and high cost tissue culture laboratories

Course outcome

CO 1- To understand about somatic embryogenesis and their application in vegetable crop improvement.

CO 2-The student will learn different biotechnological tool used in the crop improvement.

CO 3- To know the role of RNAi based gene silencing in vegetable crop improvement.

CO 4- To learn concepts and advanced methods of tissue culture technology.

CO 5- The student would be expected to learn biotechnical advancement in vegetable crops.

CO - PO Mapping matrix

	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	2	2	1	1
CO 2	3	2	2	2	2
CO 3	3	2	2	3	2
CO 4	3	3	3	3	3
CO 5	3	2	2	3	2

References

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VSC – 608 ADVANCED LABORATORY TECHNIQUES FOR VEGETABLE CROPS (1+2)

Learning objective

- To familiarize with the laboratory techniques for analysis of vegetable crops.
- To understand the safety measures and laboratory maintenance.
- To know the qualitative and quantitative analysis method.
- To gain the knowledge on basic chromatographic techniques.
- To gain comprehensive knowledge on sensory analysis technique.

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 solution, 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 analysis

Basic chromatographic techniques, GC, HPLC, GCMS, Electrophoresis techniques, ultra filtration. Application of nuclear techniques in harvested produce.

Unit -IV: Microscopic analysis

Advanced microscopic techniques, ion leakage as an index of membrane permeability, determination of biochemical components in horticultural produce.

Unit -V: 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.

Practical

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

Lesson plan

1. Safety measures and laboratory maintenance
2. Sampling procedures for quantitative analysis.
3. Determination of proximate composition of horticultural produce.
4. Standard solutions, relative water content (RWC)

5. Physiological loss in weight (PLW)
6. Instruments, textural properties of harvested produce, TSS, Specific gravity, pH and acidity.
7. Destructive analysis methods – Refractometry, Spectrophotometry.
8. Non-destructive analysis methods.
9. **First Test**
10. Chromatographic analysis – GC, HPLC, GCMS
11. Electrophoresis techniques, ultra filtration
12. Nuclear techniques in harvested produce.
13. Introduction on Advanced microscopic techniques
14. Membrane permeability, biochemical components in horticultural produce.
15. Sensory analysis- Importance of ethylene
16. Rate of ethylene evolution- using gas chromatograph (GC)
17. Sensory analysis techniques

Practical

1. Safety measures in labs and handling of chemical substances.
2. Common laboratory equipments.
3. Calibration and cleanliness of volumetric glass wares.
4. Methods of expressing strength off solutions
5. Preparation of primary standard solutions and buffer solutions
6. Preparation of standard solutions for nutrient analysis of soil, plant and water.
7. Preparations of different agro-chemical doses for field experiments, preparation of buffer solutions.
8. Handling of instruments
9. Determination of moisture
10. Determination of relative water content
11. Determination of physiological loss in weight
12. Calibration and standardization of instruments
13. Textured properties of harvested produce
14. Determination of TSS,PH,Acidity.
15. Determination of Fibre
16. Determination of protein
17. Determination of Starch Index (SI)
18. Determination of specific gravity for maturity assessment
19. Detection of adulterations in fresh products
20. Detection of adulterations in processed products
21. Introduction on destructive and non-destructive analysis methods
22. Non-destructive determination of colour
23. Non-destructive determination of ascorbic acid
24. Non-destructive determination of vitamins
25. Non-destructive determination of carotenoids
26. Non-destructive determination of sugars and starch
27. Introduction on chromatographic and microscopic analysis
28. Study of basic chromatographic techniques
29. Study of GC, HPLC and GCMS
30. Study of Electrophoresis techniques and Ultra filtration
31. Introduction on advanced microscopes
32. Use of advanced microscope – Fluorescent microscope
33. Use of advanced microscope – Scanning electron microscope
34. Use of advanced microscope – phase contrast microscope

Course outcome

CO 1- The students would be expected to develop skills and expertise on upkeep of laboratories and methods to operate research equipment's.

CO 2- To make aware on safety measure to be taken and upkeep of laboratory.

CO 3- To gain knowledge on principles and methods of destructive and non-destructive analysis.

CO 4- To gain skill on chromatographic and microscopic analysis

CO 5- To acquire skill on handling of research instruments.

CO –PO MAPPING

	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	2	2	-	2	-
CO 2	2	-	-	2	-
CO 3	3	2	2	2	-
CO 4	3	2	2	2	1
CO 5	2	1	2	2	1

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COM 601 ADVANCES IN COMPUTER APPLICATIONS (1+1)

Course Objective

- To acquaint the students with open source tool, Latex typesetting language, Python and its usage in the industry

Theory

Unit I Introduction to Latex:

Introduction to Latex – What is Latex – Document Structure, Start Text works, Title, Section, Table of content – Typesetting Text, Font Effects, Coloured Text, Font Size, List, Comments & Spacing, Special Charcters.

Unit II Packages and Classes in Latex:

Inserting Equations – Mathematical Symbols – Table of Content – Generating New Command – Figure handling numbering, List of figure, List of Tables. Packages – Geometry, Hyperref, amsmath, amssymbol – Classes – Article, Book, report - The BibTex file – Inserting Bibliography – Citing – References.

Unit III MS Access:

MSACCESS: Database, concepts and types - Uses of DBMS in Agriculture; creating database.

Unit IV Introduction to Python:

Python Introduction, Technical Strength of Python, Introduction to Python Interpreter and program execution, Using Comments, Literals, Constants, Python's Built-in Data types, Numbers (Integers, Floats, Complex Numbers, Real, Sets), Strings (Slicing, Indexing, Concatenation, other operations on Strings), Accepting input from Console, printing statements, Simple 'Python' programs.

Unit V Using Databases in Python:

Database Programming: Connecting to a database, Creating Tables, INSERT, UPDATE, DELETE and READ operations, Transaction Control, Disconnecting from a database.

Lecture Schedule

1. Introduction to Latex.
2. Document Structure.
3. Classes.
4. Typesetting Text.
5. Inserting Equations
6. Packages and Mathematical Symbols.
7. List of figure.
8. List of Tables.
9. **First Test**
10. Bibliography and References.
11. MS Access Concepts of Database, Creating Database.
12. DBMS in Agriculture.
13. Introduction to Python.
14. Built-in Data types.
15. Strings.
16. Python Console.
17. Database in Python.

Practical Schedule

1. Installation of Latex
2. Basic Latex commands
3. Latex Compilation, Page Layout
4. Building a Latex document, Previewing first.tex
5. Addition of some text in the.tex file, Finding the error and fixing it
6. Type setting of mathematics
7. Writing equations, matrix
8. Two figure next to each other, Formation of table
9. Typesetting with a new chapter heading, List of figures, List of tables
10. Citation, Bibliography, printing your document
11. MSACCESS: Creating Database, preparing queries and reports
12. MSACCESS: Demonstration of Agri-information system
13. Introduction to Python, Working with Data
14. Program Organization, Functions, and Modules, Classes and Objects
15. Inside the Python Object System
16. Testing, Debugging, and Software Development Practice
17. Packages

Course Outcome:

CO 1: Problem solving and programming capability
CO 2: Analyse common problems using Latex
CO 3: Learn categories of programs
CO 4: Construct and execute basic programs in Python
CO 5: Use external libraries and packages with Python

CO-PO Mapping Matrix

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	1	1	2
CO 2	3	3	2	1	2
CO 3	3	3	2	2	3
CO 4	3	3	2	3	3
CO 5	3	3	2	3	3

Suggested Reading

1. Introduction to Latex by Tobias Oetiker
2. LaTeX: A Document Preparation System, 2nd Edition By Leslie Lamport
3. Charles Dierbach, "Introduction to Computer Science using Python", Wiley, 2015
4. Python Programming- A modular Approach (with Graphics, database, Mobile and Web Applications by Sheetal Taneja and Naveen Kumar, Pearson.
5. Head First Python by Paul Berry, O'Reilly

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5. https://www.digitalocean.com/community/books/digitalocean-ebook-how-to-code-in-python.

STA 601 ADVANCES IN DESIGN OF EXPERIMENTS (2+1)

Course Objective

- To acquaint the students to understand the concepts of statistical hypothesis, design of experiments, statistical methods, data collection, analysis and interpretation of results and to acquire Multivariate Statistical Analysis skills.

Theory

Unit–I: Sampling Techniques

Concept of sampling: Sampling vs complete enumeration. Planning of sample survey. Sampling from a finite population. Simple random sampling. Inverse sampling. Stratified sampling. Cluster sampling. Systematic sampling. Multistage sampling. Double sampling. Ratio and regression method of estimation. Non-sampling errors. Concept and levels of measurement. Non-parametric tests - Sign, Wilcoxon, Mann-Whitney U-test, Wald Wolfowitz run test, Run test for the randomness of a sequence. Median test, Kruskal- Wallis test, Friedman two-way ANOVA by ranks. Kendall's coefficient of concordance.

Unit–II: Statistical Methods

Classification, tabulation and graphical representation of data. Descriptive statistics. Theory of probability. Random variable and mathematical expectation. Box-plot. Probability distributions: Binomial, Poisson, Negative binomial, Normal distributions and their applications. Concept of sampling distribution: t, chi-square and F distributions. Tests of significance based on normal, t, chi-square and F distributions.

Unit–III: Correlation and Regression Analysis

Correlation, Rank correlation, Correlation ratio, Intra-class correlation. Test of significance of correlation coefficient. Coefficient of determination.- Path analysis - Regression analysis, Partial and multiple correlation and regression. Estimation of parameters. Predicted values and residuals. Introduction to multivariate analytical tools. Test of hypothesis on means, Multivariate analysis of variance and covariance, Cluster analysis, Classification by linear discriminant function, Canonical correlations, Principal components, Factor analysis, multi-dimensional scaling and Correspondence Analysis. Hierarchical clustering. Principal component analysis.

Unit–IV: Experimental Designs

Need for design of experiments, characteristics of a good design. Basic principles of designs - randomization, replication and local control. Uniformity trials, size and shape of plots and blocks; Analysis of variance and covariance; partitioning of degrees of freedom - Completely randomized design, randomized block design and Latin square design.

Unit–V: Factorial Experiments

Factorial experiments : Layout and analysis of factorial experiments – complete block design – split – plot design : strip-plot design : split split –plot design. Resolvable block designs and their applications. Randomization procedure, analysis and interpretation of results. Analysis of covariance. Missing plot technique and its application to RBD, LSD. Factorial experiments (symmetrical as well as asymmetrical). Factorial experiments with control treatment. Groups of experiments. Transformation of data. Current trends in design of Experiments.

Practical

Exploratory data analysis, Box-Cox plots; Fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal; Large sample tests, Testing of hypothesis based on exact sampling distributions ~ chi square, t and F. Confidence interval. Estimation and point estimation of parameters of Binomial, Poisson and Normal distribution. Correlation and regression analysis. Fitting of orthogonal polynomial regression. Applications of dimensionality reduction and Discriminant function analysis. Non-parametric tests. Analysis of data obtained from CRD, RBD, LSD. Analysis of Covariance, Analysis of factorial experiments without and with confounding, Analysis with missing data. Split plot and strip plot designs. Groups of experiments, Transformation of data. Exercises on various Non-parametric tests; Random sampling, Use of random number tables, Simple random sampling, Determination of sample size, Exercises on Inverse sampling, Stratified sampling, Cluster sampling and Systematic sampling, Estimation using Ratio and regression estimators, Estimation using Multistage design and Double sampling.

Lecture Schedule

1. Classification, tabulation and graphical representation of data.
2. Descriptive statistics.
3. Theory of probability. Random variable and mathematical expectation.
4. Box-plot. Probability distributions: Binomial, Poisson, Negative binomial.
5. Normal distributions and their applications.

6. Concept of sampling distribution: t, chi-square and F distributions.
7. Tests of significance based on normal, t, chi-square and F distributions.
8. Correlation, Rank correlation, Correlation ratio.
9. Intra-class correlation. Test of significance of correlation coefficient.
10. Coefficient of determination.
11. Path analysis.
12. Regression analysis.
13. Partial and multiple correlation and regression.
14. Estimation of parameters. Predicted values and residuals.
15. Introduction to multivariate analytical tools.
16. Test of hypothesis on means, Multivariate analysis of variance and covariance.
17. **First Test**
18. Cluster analysis, Classification by linear discriminant function.
19. Canonical correlations, Principal components.
20. Factor analysis, multi- dimensional scaling and Correspondence Analysis.
21. Hierarchical clustering.
22. Principal component analysis.
23. Need for design of experiments, characteristics of a good design.
24. Basic principles of designs - randomization, replication and local control.
25. Uniformity trials, size and shape of plots and blocks; Analysis of variance and covariance; partitioning of degrees of freedom.
26. Completely randomized design, randomized block design and Latin square design.
27. Factorial experiments: Layout and analysis of factorial experiments.
28. Complete block design – split – plot design.
29. Strip-plot design: split –plot design.
30. Resolvable block designs and their applications.
31. Randomization procedure, analysis and interpretation of results.
32. Analysis of covariance. Missing plot technique and its application to RBD, LSD.
33. Factorial experiments (symmetrical as well as asymmetrical).
34. Factorial experiments with control treatment. Groups of experiments. Transformation of data.

Practical schedule

1. Exploratory data analysis, Box-Cox plots; Fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal; Large sample tests.
2. Testing of hypothesis based on exact sampling distributions ~ chi square, t and F. Confidence interval.
3. Estimation and point estimation of parameters of Binomial, Poisson and Normal distribution.
4. Correlation and regression analysis.
5. Fitting of orthogonal polynomial regression.
6. Applications of dimensionality reduction and Discriminant function analysis. Non-parametric tests.
7. Analysis of data obtained from CRD, RBD, LSD.
8. Analysis of Covariance.
9. Analysis of factorial experiments without and with confounding, Analysis with missing data.
10. Split plot and strip plot designs. Groups of experiments, Transformation of data.
11. Exercises on various Non-parametric tests.

12. Random sampling, Use of random number tables, Simple random sampling, Determination of sample size.
13. Exercises on Inverse sampling, Stratified sampling.
14. Cluster sampling and Systematic sampling.
15. Estimation using Ratio and regression estimators.
16. Estimation using Multistage design and Double sampling.
17. Practical Examination.

Course Outcome

CO 1: Gaining knowledge on basic and recent concepts of statistical methods
CO 2: Proficiency in data Collection, analysis and interpretation of results
CO 3: Understanding the testing of statistical hypothesis
CO 4: Knowledge on multivariate statistical analysis
CO 5: Design of experiments in agricultural field and data for analysis

CO – PO Mapping Matrix

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	1	1	1
CO 2	3	3	2	1	2
CO 3	3	3	2	1	2
CO 4	3	3	1	1	3
CO 5	3	3	1	1	2

Suggested Reading

1. Agarwal, B. L. 2003, Basic Statistics, New Age International. New Delhi.
2. Anderson, T.W. 1958. *An Introduction to Multivariate Statistical Analysis*. John Wiley, New Delhi.
3. Bansil, P.C. 2002. *Agrl. Statistics*. CBS Publishers. New Delhi.
4. Box, G.E.P., Jenkins, G.M. and Reinsel, G.C. 1994. *Time Series Analysis: Forecasting and Control*. Pearson Education, Delhi.
5. Campbell, R.A. 1974. *Statistics for Biologists.* Cambridge University Press. New York.
6. Cochran, W.G. and Cox, G.M. 1957. *Experimental Design.* John Wiley and Sons Inc. New York.
7. Das, M. N. and Giri, N.C. 1986. *Design and Analysis of Experiments.* New Age International. New Delhi
8. Federer, W.T. 2002. *Statistical Design and Analysis of Intercropping Experiments.* Springer-Verlag. New York
9. Gomez and Gomez. 1984. *Statistical procedure for Agrl. Research.* Wiley-interscience. New York
10. Gupta, S.P. 2004, Statistical Methods, S. Chand and Sons. New Delhi. Singh R and Mangat N.S. 1996. *Elements of Survey Sampling*. Kluwer Academic Publishers.

NGC 611-RESEARCH AND PUBLICATION ETHICS (2 +0)

Learning Objectives:

- To impart knowledge on research ethics, academic conduct and Integrity.
- To sensitize the scholars about their responsibilities to science, society and eco-system.
- To equip the scholars with techniques and skills to avoid ethical misconduct.

- To provide hands on experience in the use various software tools in research and publication process.
- To acquaint participants with tools and techniques popularly utilized for ensuring academic standards, avoiding plagiarism, and promoting high impact publication.

Unit 1 Philosophy, Ethics & Scientific Conduct

Introduction to philosophy: definition, nature and scope, concept, branches - Ethics**:** definition, moral philosophy, nature of moral judgments and reactions - Ethics with respect to science and research - Intellectual honesty and research integrity - Scientific misconducts**:** Falsification, Fabrication, and Plagiarism (FFP) - Redundant Publications**:** duplicate and overlapping publications, salami slicing - Selective reporting and misrepresentation of data

Unit 2 Publication Ethics

Publication ethics: definition, introduction and importance - Best practices/ standard setting initiatives and guidelines: COPE, WAME, etc. - Conflict of Interest - Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types - Violation of publication ethics, complaints and appeals - Identification of publication misconduct, complaints and appeals - Predatory publication and journals

Unit 3 Open Access Publishing

Open access publication and initiatives - SHERPA/RoMEO Online resource to check publisher copyright & self-archiving policies - Software tool to identify predatory publications developed by SPPU - Journal finder / journal suggestion tool viz. JANE, Elsevier Journal Finder, Springer Journal Suggestion, etc.

Unit 4 Publication Misconduct

Group Discussions - Subject specific ethical issues, FFP, authorship - Conflicts of interest - Complaints and appeals: examples and fraud from India and abroad - Software tools - Use of plagiarism software like Turnitin, Urkund and other open-source software tools.

Unit 5 Databases and Research Metrics

Databases - Indexing databases - Citation databases: Web of Science, Scopus, etc., - Research Metrics (Journal) - Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score - Research Metrics (Author) - Metrics: h- Index, i10 index, altimetric.

Lecture schedule

1. Introduction to the philosophy: definition, nature and scope,
2. Concept, branches of Philosophy
3. Ethics: definition, moral philosophy, rational and non-rational approaches to ethical issues
4. Nature of moral judgments and reactions
5. Research Process-Research ethics and Guiding principles-Research Ethics Committee-Animal Ethics Committee-Approval
6. Intellectual honesty and research integrity
7. Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP)-
8. Factors facilitating scientific misconducts
9. Ethics and Trust: Anonymity, Confidentiality, Conflicts of interest/role/values/

ownership and Competing interest

10. Literature search- Print, Online, key words- boolean search- Inflibnet-E-databases
11. Fundamentals of manuscript preparation
12. Technical writing skills
13. Publication ethics: definition, introduction and importance
14. Best practices/ standard setting initiatives and guidelines: COPE, WAME, etc
15. Publication misconduct: definition, Authorship-Redundant publications:
16. Duplicate and overlapping publication, Salami slicing
17. **First test**
18. Selective reporting and misrepresentation of data
19. Violation of publication ethics, authorship and contributor ship
20. Identification of publication misconduct, complaints and appeals: examples and fraud from India and abroad-
21. UGC and University guidelines and Punishment
22. Software tools - Use of Reference Management Tools to avoid plagiarism and automation of bibiliography
23. Software tools - Use of plagiarism software like Turnitin, and Urkund
24. Other open source software tools
25. How to publish in scholarly journals?- Open access publication and initiatives-
26. UGC- CARE List-Predatory publication journals
27. Databases -Indexing databases
28. Citation databases: Web of Science, Scopus, etc
29. Journal Metrics- (c) Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
30. SHERPA/RoMEO Online resource to check publisher copyright & self-archiving policies
31. Software tool to identify predatory publications developed by SPPU
32. Journal finder / journal suggestion tool viz. JANE, Elsevier Journal Finder, Springer Journal Suggestion, etc.
33. How to share the publications and know the impact?
34. Author Metrics: Author ID-OrcidID- h- Index, i10 index, altmetrics

Course Outcomes:

CO 1: Will be able to identify the ethical issues in research process based on the concept of philosophy and ethics.

CO 2: Will be able to avoid scientific misconduct like fabrication, falsification and fraud in the research process by following the recommended guidelines.

CO3: Will be able to use tools like Reference Management, Journal Identification, Open Access, Plagiarism Checker and avoid misconduct.

CO4: Will be able to communicate the research findings in approved journals with high journal metrics and also improve the author metrics.

Suggested Reading

1. Barbara H. Stanley, Joan E. Sieber and Gary B. Melton.1996. Research Ethics: A Psychological Approach. University of Nebraska Press
2. Jeffrey A. Gliner, George A. Morgan and Nancy L. Leech.2009. Research Methods in Applied Settings: An Integrated Approach to Design and Analysis. Routledge; 2nd edition
3. Joel Lefkowitz. 2017. Ethics and Values in Industrial-Organizational Psychology. Routledge
4. Sidney Hook, Paul Kurtz, and Miro Todorovich.1977. The Ethics of Teaching and Scientific Research. Prometheus Books