SYLLABUS

OF

Ph.D. (HORTICULTURE) in Vegetable Science

According to 5th Dean's committee norms of ICAR, New Delhi

(The 5th Dean committee syllabus of ICAR for various PG/UG courses under Faculty of Agricultural Science was approved in 31st Academic Council Meeting of Rajiv Gandhi University held on 29.11.2020 mentioned in minutes Sl. No. AC:31:11)

Department of Horticulture
Faculty of Agricultural Sciences
Rajiv Gandhi University
Rono Hills, Doimukh, Arunachal Pradesh - 791112

Common Academic Regulations for Ph.D. Programme

Credit Requirements for Ph.D Programme

Subject	Doctoral programme
Core/Major Course	12
Optional/Minor Course	06
Supporting Courses	07
Seminar	02
Research	75*
Comprehensive exam	Non-credit**
Total Credits	**102**

Major Courses: The courses in the Department/ Discipline in which a student takes admission.
Minor Courses: The courses closely related to a student's major discipline (Horticultural Sciences).
Supporting Courses: The courses not related to the major discipline. It could be any course considered relevant for student's research work or necessary for building his overall competence.

***Evaluation will be based on satisfactory/unsatisfactory report**
****Comprehensive exam will be completed after completion of the course work (after 2nd semester).**

Evaluation of course work and comprehensive examination

The comprehensive examination (Pre-qualifying examination) is mandatory. As the students will be already tested in course examinations, the comprehensive examination will be based on oral examination by an external expert and the evaluation will cover both the research problem and theoretical background to execute the project. This will be assessed on the aptitude of the student and suitability of the student for the given research topic. The successful completion of comprehensive examination is to obtain the "Satisfactory" remark by the external expert.

Mandatory requirement of seminars

The students will be encouraged to make presentations on the latest developments and literature in the area of the research topic. This will provide training to the students on preparation for the seminar, organizing the work, critical analysis of data and presentation skills etc.

Evaluation of research work

• It is highly desirable for Ph.D. programme and this should be done annually as an essential part of research evaluation. The DRC (Departmental Research Committee) shall review the progress of research and scrutinize annual progress reports submitted by the student.

• Midterm evaluation of Ph.D. (to move from JRF to SRF) is a mandatory requirement for all the funding agencies. Hence, the second review of annual progress report need to be done after completion of two years. The successful completion enables the students to become eligible for SRF.

Prevention of plagiarism

An institutional mechanism should be in place to check the plagiarism. The students must be made aware that manipulation of the data/ plagiarism is punishable with serious consequences.

Teaching assistantship

• Teaching assistantship shall be encouraged. This will give the required experience to the students on how to conduct courses, practical classes, evaluation and other related academic matters. This is an important part of Ph.D. training all over the world and it is expected to address the shortage of faculty in many institutions/universities.

• The fulltime doctoral students of the University with or without fellowship maybe considered for award of Teaching Assistantships in their respective Departments. The Teaching Assistantship shall be offered only to those doctoral students who have successfully finished their course work. Any consideration for award of Teaching Assistantships must have the consent of the supervisor concerned.

• Teaching Assistantships shall be awarded on semester to semester basis on the recommendation of a screening/ selection committee to be constituted by the Vice Chancellor. All classes and assignments given to the Teaching Assistants, including tutorials, practicals and evaluation work shall be under the supervision of a faculty member who would have otherwise handled the course/ assignment.

• Each Ph.D. student may be allowed to take a maximum of 16 classes in a month to UG/ Masters students.

• No additional remuneration shall be paid to the students who will be given Teaching Assistantships.

• At the end of each term, Teaching Assistants shall be given a certificate by the concerned Head of the Department, countersigned by the School Dean, specifying the nature and load of assignments completed.

Registration of project personnel (JRF/SRF/RA) for Ph.D

A provision for project personnel (JRF/SRF/RA) to register for Ph.D programme will be allowed only if they are selected based on some selection process such as walk-in-interview etc. The prior approval of PI of the project is mandatory to consider the application of project personnel (JRF/SRF/RA) for Ph.D. admission. The candidates need to submit the declaration stating that the project work shall not be compromised because of Ph.D. programme.

Degree nomenclatures

The envisaged Ph.D. programme will be Ph.D. (Hort.) in Vegetable Science.

Other academic regulations will be as per RGU ordinances, rules & regulations and according to 5^{th} Dean's committee norms of ICAR, New Delhi.

Ph.D (Horticulture) in Vegetable Science

(Semester Break up)

SEMESTER-I

Code	Course Title	Type of Course	Credits
VSC 601	Recent Trends in Vegetable Production	Major	3+0
VSC 602	Advances in Breeding of Vegetable Crops	Major	3+0
STAT 502	Statistical Methods for Applied Sciences	Supporting Courses	3+1
VSC 691	Seminar	Seminar	0+1
	Minor-I	Minor-I	2+1
VSC 699	Research	Research	0+4
	Total		**18**

SEMESTER-II

Code	Course Title	Type of Course	Credits
VSC 606	Biodiversity and Conservation of Vegetable Crops	Major	2+1
VSC 607	Biotechnological Approaches in Vegetable Crops	Major	2+1
STAT 511	Experimental Designs	Supporting Courses	2+1
VSC 692	Seminar	Seminar	0+1
	Minor-II	Minor-II	2+1
VSC 699	Research	Research	0+5
	Total		**18**

SEMESTER-III

Code	Course Title	Type of Course	Credits
VSC 699	Research	Research	0+18
	Total		**18**

SEMESTER-IV

Code	Course Title	Type of Course	Credits
VSC 699	Research	Research	0+18
	Total		**18**

SEMESTER-V

Code	Course Title	Type of Course	Credits
VSC 699	Research	Research	0+15
	Total		**15**

SEMESTER-VI

Code	Course Title	Type of Course	Credits
VSC 699	Research	Research	0+15
	Total		**15**

Note: Minor courses (Minor-I and Minor-II) will be taken from the subject related to student's research work.

Course Contents

Ph.D. (Hort.) in Vegetable Science

Major Courses

Course Title: Recent Trends in Vegetable Production

Course Code: VSC 601

Credit Hours: (3+0)

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 have 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.

Aim of the course

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

The course is constructed given as under:

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

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; net house 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.

Teaching Methods/ Activities

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

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

Suggested Reading

- Bose TK and Som NG. 1986. *Vegetable crops of India*. Nayaprokash.
- Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. *Vegetable crops*. Vols. I-III. NayaUdyog.
- 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 andIBH.
- 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*. 2ndedn, 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. Rubatzky VE and Yamaguchi M. (Eds.). 1997. *World vegetables: principles, production and 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.

Course Title: Advances in Breeding of Vegetable Crops
Course Code: VSC 602
Credit Hours: (3 +0)
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.

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	No.	Unit
1.	Advances in Breeding of vegetable crops	1.	Solanaceous crops and okra
		2.	Cucurbits and Cole crops
		3.	Legumes and leafy vegetables
		4.	Root crops and onion
		5.	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, biofortification, *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

Teaching Methods/ Activities

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

Learning outcome

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

• Breeding objectives and trends
• Recent Adavnces in vegetable breeding

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.

Course Title: Biodiversity and Conservation of Vegetable Crops

Course Code: VSC 606

Credit Hours: (2+1)

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.

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.	Block	No.	Unit
1.	Biodiversity and conservation of vegetable crops	1.	General Aspects: Issues, Goals and Current Status
		2.	Germplasm Conservation: Collection, Maintenance and Characterization
		3.	Regulatory Horticulture: Germplasm Exchange, Quarantine and Intellectual Property Rights

Theory

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, PPV and FR 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.

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.

Teaching Methods/ Activities

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

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.
- Frankel OH and Hawkes JG. 1975. *Crop genetic resources for today and tomorrow*. Cambridge 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

Course Title: Biotechnological Approaches in Vegetable Crops

Course Code: VSC 607

Credit Hours: (2+1)

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.

Aim of the course

To impart latest knowledge in biotechnical advancement in vegetable crops

The course is organised as follows:-

No.	Block	No.	Unit
1.	Biotechnological approaches in vegetable crops	1.	Importance and scope of Biotechnology
		2.	Somatic embryogenesis
		3.	Blotting techniques, DNA finger printing,
		4.	Plant genetic engineering
		5.	Concepts and methods of next generation sequencing (NGS)

Theory

Unit I

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

Unit II

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

Unit III

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. Biosafety 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

Practical

• Micropropagation, Pollen- Ovule and Embryo culture- Synthetic seed production (2);

• *In-vitro* mutation induction, *in-vitro* rooting – hardening at primary and secondary nurseries (3);

• DNA isolation from economic vegetable crop varieties – Quantification and amplification (2);

• DNA and Protein profiling – molecular markers, PCR Handling (2);

• Vectors for cloning and particle bombardment (3);

• DNA fingerprinting of flower crop varieties (3);

• Project preparation for establishment of low, medium and high cost tissue culture laboratories (1).

Teaching Methods/ Activities

• Class room lectures

• Laboratory/ field practicals

• Student seminars/ presentations

• Field tours/ demonstrations

• Assignments

Learning outcome

The student would be expected to learn

• Different biotechnological tools

• NGS, genetic engineering

Suggested Reading

- Bajaj YPS. (Ed.). 1987. *Biotechnology in agriculture and forestry*. Vol. XIX. Hitech andMicropropagation. 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. Horticultural Sciences–Vegetable Science
- Glover MD. 1984. *Gene cloning: the mechanics of DNA manipulation*. Chapman and Hall.
- 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. NayaProkash.
- Pierik RLM. 1987. *In-vitro culture of higher plants*. MartinusNijhoff 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.

Selected Journals

Sr. No.	Name of the Journal	ISSN No.
1.	*American Journal of Horticultural Sciences*	0003-1062
2.	*American Scientst*	1545-2786
3.	*Annual Review of Plant Physiology*	0066-4294
4.	*California Agriculture*	1097-0967
5.	*Haryana Journal of Horticultural Sciences*	0970-2873
6.	*HAU Journal of Research*	0379-4008
7.	*Horticulture Research*	2052-7276
8.	*Hort Science*	2327-9834
9.	*IIVR Bulletins*	1462-0316
10.	*Indian Horticulture*	0019-4875
11.	*Indian Journal of Agricultural Sciences*	0019-5022
12.	*Indian Journal of Horticulture*	0974-0112
13.	*Indian Journal of Plant Physiology*	2662-2548
14.	*Journal of American Society for Horticutural Sciences*	0003-1062
15.	*Journal of Food Science and Technology*	0975-8402
16.	*Journal of Plant Physiology*	0176-1617
17.	*Journal of Biology and Technology*	0925-5214
18.	*Post harvest Biology and Technology*	0925-5214
19.	*Scientia Horticulturae*	0304-4238
20.	*Seed Research*	2151-6146
21.	*Seed Science*	2317-1537
22.	*South Indian Horticulture*	0038-3473
23.	*Vegetable Grower*	2330-2321

Supporting courses

Course Title: Statistical Methods for Applied Sciences
Course Code: STAT 502
Credit Hours: (3+1)
Objectives: To impart latest knowledge in biotechnical advancement in vegetable crops.
Outcome: Detailed knowledge about trends in biotechnology of vegetable crop will provided for crop improvement.

Theory
Unit I
Probability: Elementary concepts of probability; Addition theorem; Conditional Probability; Multiplication theory; Independence of events.
Unit II
Statistical Methods : Population and its parameters; Sample and its statistics; Frequency distribution; Graphical representation; Measures of central tendency; Measures of dispersion; Moments; Simple correlation and regression.
Unit III
Probability Distributions: Binomial; Poisson & Normal Sample
Survey: Elementary concept; Advantages of sample survey over census; Simple random sampling (SRS); SRSWR and SRSWOR; Drawing of random sample & estimation of average, total etc.; Sampling and non-sampling errors; Concept of stratified random sampling. Design of Experiments: One way and two way classification (orthogonal); Principles of design; Uniformity trial and fertility contour map.

Practical
Unit IV
Lay-out and analysis of CRD, RBD and LSD. Tests of Significance: Hypotheses; Two types of errors; Exact small sample tests: z, t, 2 χ and F-tests. Practicals : Based on above topics.

Course Title: Experimental Designs
Course Code: STAT 511
Credit Hours: (2+1)

Objectives: To impart latest knowledge in biotechnical advancement in vegetable crops.
Outcome: Detailed knowledge about trends in biotechnology of vegetable crop will provided for crop improvement.

Theory
Unit I
Uniformity trails: Size and shape of pots and blocks; Lay-out and analysis of CRD and RBD; Use of Repeated LSD's; Efficiency of blocking; Missing plot techniques and analysis of covariance in RBD and LSD Multiple comparison tests.

Unit II

Factorial Experiments: Interpretation of main effects and interaction; Orthogonality and partitioning of degrees of freedom; Analysis of 2^2, 2^3, 3^2 experiments; Concept of confounding and analysis of some confounded factorial experiments.

Practical

Unit III

Layout and analysis of CRD and RBD; Use of Repeated LSD's; Analysis of 2^2, 2^3, 3^2 experiments.