



**Department of Agricultural Botany
(Molecular Biology and Biotechnology)
State Level Biotechnology Centre,
Mahatma Phule Krishi Vidyapeeth, Rahuri
Tal. Rahuri 413 722, Dist. Ahmednagar (MS)**

Preamble

Mahatma Phule Krishi Vidyapeeth, Rahuri has contributed in releasing crop varieties and hybrids using classical breeding methods. However, with developments in micro-propagation, the University established independent Plant Tissue Culture Laboratory using funds received from the Statutory Development Board for the rest of Maharashtra in 1992. Consequently with the fast developments in this science, the University established Biotechnology Centre in 2001 with the available resources and by bringing trained personnel under one umbrella. To support this centre, the grants were made available from the University revenue receipts during 2001-03. Looking to the contribution of research made by this centre and today its need for strengthening agricultural research, Dr. M.S. Swaminathan's committee recommended establishment of Biotechnology Research Centre at this University. Accordingly, Government of Maharashtra extended the financial support w.e.f. 2003-04 for construction of independent building, purchase of instruments and furniture for carrying out research in the frontier areas of Biotechnology.

Sixty Seventh Meeting of Statutory Committee's held at MCAER, Pune on 31st Jan., 2006 recommended initiating Post Graduate Degree Programme in Agril. Biotechnology at this centre without additional staff and grants. Accordingly M.Sc. (Agril. Biotechnology) Degree Programme was initiated from the academic year 2007-08 with intake capacity of 8 students per year. The principal mandate of starting this Degree Programme was to cater the needs of the state in developing a skilled manpower required in Molecular Biology & Biotechnology for research activities in SAUs, Semi-Government public and private sector organization.

The centre is also engaged in undertaking basic and applied biotechnological research pertaining to transgenic development, marker assisted selection in relation to disease, pests and drought resistance, QTL mapping, identification of the gene(s) responsible for biotic and abiotic stresses etc. in crop plants.

Biotechnological developments have facilitated identification of genes/QTLs for different traits

and mining of the alleles. Extensive studies have been conducted in sugarcane for gene expression profiling in relation to salinity and drought tolerance. Molecular markers have been extensively used for DNA fingerprinting, divergence studies, molecular tagging and marker trait association studies in various crops. Molecular markers have been identified in soybean for traits of importance viz., rust resistance, long juvenility, seed longevity and shattering tolerance. Kunitz trypsin inhibitor free soybean lines developed by Marker Assisted Selection (MAS) are in advanced trials. Similarly, MAS technology has been used for developing advanced generation of blast resistant rice and drought tolerant chickpea and are in field trials. Micropropagation protocol has been standardized in bamboo and banana. Complete *in vitro* regeneration protocol has been developed for medicinal, aromatic and other important plants. Embryo rescue technique was used to recover wide interspecies cross hybrids.

Plant Biotechnology Laboratory



Faculty

Sr. No.	Name	Designation
1.	Dr. A. A. Kale	Professor of Biochemistry (CAS) & Incharge
2.	Dr. V. P. Chimote	Professor of Botany (CAS)
3.	Dr. P. L. Kulwal	Professor of Botany (CAS)
4.	Dr. A. R. Aher	Assistant Professor of Botany

Academic Programmes

**A) M.Sc.
Molecular Biology & Biotechnology
Capacity of students: 8/Year**

Degree Programme M.Sc. **Name of Discipline** Molecular Biology and Biotechnology

Semester wise Course Layout (As per BSMA Recommendation)

Semester- I

Sr. No.	Course No.	Course title	Credit
A. Major Courses			
1.	MBB 501	Principles of Biotechnology	3 (3+0)
2.	MBB 502**	Fundamentals of Molecular Biology	3 (3+0)
3.	MBB 504**	Techniques in Molecular Biology I	3 (0+3)
Sub Total (A)			9 (6+3)
B. Minor Courses			
1.	BIOCHEM 507	Plant Biochemistry	3 (2+1)
2.	MICRO 504	Microbial Genetics	3 (2+1)
Sub Total (B)			6 (4+2)
C. Supporting Courses			
1.	PP 504	Physiological & Molecular Responses of Plants to Abiotic Stresses	3 (2+1)
Sub Total (C)			3 (2+1)
Total (A+B+C)			18 (12+6)
D. Non-credit Compulsory Courses			
1.	PGS-501	Library and Library Information Services	1 (0+1)
2.	PGS-504	Basic concepts in Laboratory Techniques	1 (0+1)
Sub Total (D)			2 (0+2)
E. Thesis Research Work			
1.	MBB-599	Research Work	5 (0+5)
F. Compulsory Non-Credit Deficiency Courses (Not Completed at UG Level)			
1.	MBB 411	Introduction to Biotechnology	3 (2+1)
2.	MBB 412	Plant Tissue culture	3 (2+1)
3.	MBB 413	Molecular Biology	3 (2+1)

Semester- II

Sr. No.	Course No.	Course title	Credit
A. Major Courses			
1.	MBB 503**	Molecular Cell Biology	3 (3+0)
2.	MBB 505**	Omics and Systems Biology	3 (2+1)
3.	MBB 509	Plant Tissue culture	3 (2+1)
Sub Total (A)			9 (7+2)

B. Minor Courses			
1.	GPB 506	Molecular Breeding and Bioinformatics	3 (2+1)
Sub Total (B)			3 (2+1)
C. Supporting Courses			
Sub Total ©			3 (2+1)
Total (A+B+C)			15 (11+4)
D. Non-credit Compulsory Courses			
1.	PGS-501	Library and Library Information Services	1 (0+1)
2.	PGS-504	Basic concepts in Laboratory Techniques	1 (1+0)
Sub Total (D)			2 (1+1)
E. Thesis Research Work			
1.	MBB-599	Research Work	5 (0+5)
F. Compulsory Non-Credit Deficiency Courses (Not Completed at UG Level)			
1.	MBB 414	Recombinant DNA Technology	3 (2+1)
2.	MBB 415	General Biochemistry	4 (3+1)

Semester- III

Sr. No.	Course No.	Course title	Credit
A. Major Courses			
1.	MBB 506	Plant Genetic Engineering	3 (3+0)
Sub Total (A)			3 (3+0)
B. Minor Courses			
1.	--	---	--
Sub Total (B)			--
C. Supporting Courses			
1.	STAT 522	Data Analysis Using Statistical Package	3 (2+1)
Sub Total (C)			3 (2+1)
D. Master Seminar			
1.	MBB 591	Master's Seminar	1 (0+1)
Sub Total (D)			
Total (A+B+C+D)			7 (5+2)
E. Non-credit Compulsory Courses			
1.	PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1 (1+0)
2.	PGS-504	Basic concepts in Laboratory Techniques	3 (0+1)
Sub Total (E)			
F. Thesis Research Work			
1.	MBB-599	Research Work	10 (0+10)

Semester- IV

A. Thesis Research Work			
1.	MBB-599	Research Work	10 (0+10)
Total			10 (0+10)

Students other than UG degree in Agricultural Biotechnology/ B. Tech. Biotechnology will be required to completed Non-credit deficiency courses (6 to 10 credits) from the above courses related to the discipline in which admitted and as decided by the Student Advisory committee.

List of equipments available at Biotechnology Centre

Sr. No.	Name of Equipment:
1	Deep Freezer (-80)
2	Deep Freezer (-40)
3	Deep Freezer (-20)
4	Refrigerator
5	Thermal cycler
6	Palm PCR machine
7	RT-PCR
8	Generator (35 KVA)
9	Mini and Maxi electrophoresis system including power supply
10	Electronic balance
11	Ice flanking system
12	Liquid nitrogen container with dispenser
13	High speed refrigerated centrifuge
14	Table top centrifuge
15	Elisa reader and Washer
16	Nano drop spectrophotometer
17	Spectrophotometer
18	Laminar Air flow
19	Autoclave
20	Rotary Shaker
21	Micropipettes
22	DNA concentrator
23	Hot plate magnetic stirrer
24	Vortex
25	Micro plate shaker
26	Water bath
27	UV transilluminator
28	Gel documentation system
29	Water purification system
30	Flow cytometer
31	Microarray
32	DNA sequencer (4 capillary)

Projects Completed by M.Sc. (Agril. Biotechnology) Students				
Sr. No.	Name of M. Tech. Student	Name of Guide	Title of the M. Tech. Thesis	Year
1.	Mr. Wagh Dheeraj S	Dr. AA Kale	Molecular analyses of sugarcane F1s, their parents and some varieties in relation to salt stress tolerance	2009
2.	Mr. Salunke Dnyaneshwar S	Dr. AS Jadhav	Molecular and biochemical analysis in selected genotypes of tomato (<i>Lycopersicon esculentum</i> Mill.) for β -carotene.	2009
3.	Mr. Pawar Bhausahab D	Dr. AS Jadhav	Development of an efficient Agrobacterium mediated transformation system for tomato (<i>Lycopersicon esculentum</i> Mill.)	2009
4.	Mr. Kale Prashant Bhaskar	Dr. VP Chimote	Characterization of microbial flora found in oily spot disease in pomegranate (<i>Punica granatum</i> L.)"	2009
5.	Miss Sadaphal Shubhangi V	Dr. SC Patil	Assessment of molecular diversity in custard apple. (<i>Annona squamosa</i>)	2009
6.	Mr. Kamble Varun A	Dr. AA Kale	Molecular analysis of cytoplasmic male sterility in pearl millet (<i>Pennisetum glaucum</i>)	2009
7.	Mr. Koskewar Sandeep U	Dr. SV Pawar	Micropropagation studies in Sarpagandha (<i>Rauvolfia serpentina</i> L)	2010
8.	Mr. Borse Nilesh B	Dr. VP Chimote	Stability of micropropagated <i>Musa acuminata</i> cv. Grande Naine: A molecular assessment.	2010
9.	Mr. Palan Bhavesh V	Dr. AA Kale	Molecular analysis of cytoplasmic male sterile system of sorghum.	2010
10.	Miss Thokale Suwarna J	Dr. SC Patil	Micropropagation studies in Ashwagandha (<i>Withania somnifera</i>)	2010
11.	Miss Takale Vidya V	Dr. AS Jadhav	Development of Bt-pigeonpea by Agrobacterium mediated transformation.	2010
12.	Mr. Newaskar Ganesh S	Dr. VP Chimote	Molecular characterization of cotton parent progeny combination (<i>Gossypium arboreum</i> x <i>Gossypium anomalum</i>) x <i>Gossypium hirsutum</i> differing for fiber traits.	2010
13.	Mr. Markad Nanasahab R.	Dr. AA Kale	Identification of molecular marker/s associated with salt tolerance in sugarcane	2010
14.	Miss Gulve Dipali P.	Dr. AS Jadhav	Introduction and expression of <i>CryAbc</i> gene construct into tomato.	2010
15.	Mr. Bhat Sudarshan V.	Dr. AS Jadhav	Regeneration study in brinjal (<i>Solanum melongena</i>)	2011
16.	Miss Ghumatkar Reshma M	Dr. AA Kale	Molecular Characterization of sex in <i>Simarouba glauca</i> D.C. using RAPD and ISSR markers	2012

17.	Mr. Gosavi Gokul U	Dr. AS Jadhav	Assessment of heat shock proteins, biochemical constituents and molecular characterization in sorghum in relation to Heat Shock response	2011
18.	Miss Hinge Pushpalata N	Dr. AA Kale	Assessment of heat shock proteins, biochemical constituents and molecular characterization in sorghum in relation to drought response	2011
19.	Mr. Dhage Shishir S	Dr. VP Chimote	Regeneration studies in Fig (<i>Ficus carica</i>)	2011
20.	Mr. Deshmukh Krishna .S.	Dr. AA Kale	Construction of SCAR marker for salinity tolerance in sugarcane	2012
21.	Mr. Panpatil Amol .U.	Dr. VP Chimote	Characterization of gene encoding enzymes involved in reactive oxygen species tolerance during drought stress in sorghum.	2012
22.	Miss Ujjainkar Nayana R	Dr. VP Chimote	Characterization of gene encoding desiccation tolerance protein during drought stress in sorghum.	2012
23.	Miss Mahagaonkar Pooja N	Dr. AS Jadhav	Molecular analysis of sterile, maintainer, restorer and hybrid lines of <i>Gossypium</i> sp.	2013
24.	Mr. Rayate Shriram J	Dr. PL Kulwal	Quantitative trait loci mapping for yield and yield contributing traits in chickpea (<i>Cicer arietinum L.</i>)	2013
25.	Mr. Rahane Vijay B	Dr. SV Pawar	<i>In vitro</i> studies in Malkangoni (<i>Celastrus paniculatus Wild</i>) an endangered medicinal plant	2013
26.	Mr. Jadhav Amol A	Dr. PL Kulwal	Marker-trait association study for grain protein content in chickpea (<i>Cicer arietinum L.</i>)	2013
27.	Miss Bande Rashmi B	Dr. AS Jadhav	Characterization of genes involved during drought stress in pearl millet	2014
28.	Miss Chaudhari Priya G	Dr. AS Jadhav	<i>cryIAabc</i> gene expression study in T2 population of tomato	2013
29.	Mr. Band Naresh S	Dr. AA Kale	SSR and ISSR based DNA fingerprinting and assessment of quality parameters of the rice landraces collected from plain and Western Ghat Zone	2013
30.	Acharya BL	Dr. SV Pawar	Micropropagation studies in Stevia (<i>Stevia rebaudiana</i>)	2014
31.	Miss Hipparkar Maya	Dr. AS Jadhav	<i>cryIAabc</i> gene expression study in T3 population of tomato	2014
32.	Miss Shingare Rohini B	Dr. VP Chimote	Molecular characterization of candidate genes controlling seed coat colour in soybean	2014
33.	Mr. Mokate Yogesh S	Dr. VP Chimote	Molecular diversity analysis in Soybean (<i>Glycine max L. Merrill</i>)	2014

34.	Miss. Borse Vaishali Vasantrao	Dr. PL Kulwal	Marker based diversity in germplasm showing variation for seed weight in chickpea (<i>Cicer arietinum</i> L.)	2015
35.	Miss. Dere Supriya Sitaram	Dr. SV Pawar	Micropropagation studies in bedki (<i>Gymnema sylvestre</i> R.Br.) a rare medicinal plant.	2015
36.	Miss. Patil Nilam Prakashrao	Dr. VP Chimote	Development of molecular diagnosis technique for <i>Xanthomonas axonopodis</i> pv. <i>puniceae</i>	2015
37.	Miss. Pawar Kalyani R.	Dr. VP Chimote	Characterization of T2 population of transgenic tomato having antisense banana <i>ACC oxidase</i> gene	2015
38.	Mr. Nalge Swapnil Sunil	Dr. AS Jadhav	DNA fingerprinting of the soybean cultivars	2015
39.	Mr. Vyawahare Tushar Gajanan	Dr. AS Jadhav	Molecular marker study in the groundnut genotypes showing rust resistance	2015
40.	Mr. Kamble Abhijit Bhimrao	Dr. AA Kale	Validation of SCAR marker for salinity stress in sugarcane germplasm	2015
41.	Mr. Muthe Santosh Tukaram	Dr. PL Kulwal	Validation of known marker(s) linked with the gene <i>Lr34</i> conferring resistance against leaf rust in wheat (<i>Triticum aestivum</i> L.)	2016
42.	Miss Chavan Pooja Narayanrao	Dr. PL Kulwal	Marker assisted foreground selection of backcross genotypes for leaf rust resistance in wheat	2016
43.	Miss Chavan Priti Santosh	Dr. AS Jadhav	Genetic transformation for development of Bt-rice	2016
44.	Miss Barate Pallavi Laxman	Dr. VP Chimote	Evaluation of molecular markers for pod shattering in soybean (<i>Glycine max</i> L. Merrill)	2016
45.	Mr. Shaikh Saddamhussain Aminbhai	Dr. AA Kale	Expression of salinity tolerant genes in sugarcane	2016
46.	Miss Dongare Manjushri Dinkar	Dr. VP Chimote	Molecular characterization of maturity loci in soybean	2017
47.	Miss Shinde Archana Vishwanath	Dr. PL Kulwal	Molecular marker based characterization of chickpea genotypes for wilt and collar rot resistance	2017
48.	Miss Salve Snehal Gorakh	Dr. SV Pawar	Molecular characterization of rabi sorghum genotypes using SSR markers	2017
49.	Mr. Gavhane Dnyaneshwar Bhagwan	Dr. PL Kulwal	Validation of markers for blast resistance in rice (<i>Oryza sativa</i> L.)	2017
50.	Mr. Kalanar Shivaji	Dr. AS Jadhav	Validation of novel markers for rust	2017

	Kisan		resistance in groundnut (<i>Arachis hypogea</i> L.)	
51.	Shirsat Dhananjay Vitthal	Dr. AA Kale	Gene expression profile of sugarcane (<i>Saccharum officinarum</i>) under drought stress	2017
52.	Miss Dudhabate Jayashri Goroba	Dr. PL Kulwal	QTL analysis for blast resistance in rice	2018
53.	Miss Kalunge Sonali Dattaraya	Dr. VP Chimote	Molecular characterization of genes imparting seed longevity in soybean	2018
54.	Prasad Dilip Shelke	Dr. AA Kale	Gene Expression profiling in sugarcane under salinity stress conditions	2019
55.	Tajne Sachin Arunrao	Dr. AS Jadhav	Isolation & cloning of antimicrobial gene from <i>Withania somnifera</i>	2018
56.	More Janardhan Dattatraya	Dr. AA Kale	Molecular and biochemical characterization of endophytic bacteria isolated from sugarcane in response to salinity	2019
57.	Miss Inamdar Shaheen B.	Dr. PL Kulwal	Candidate gene analysis for salinity stress in chickpea (<i>Cicer arietinum</i> L.)	2019
58.	Miss Patil Priyanka D.	Dr. AS Jadhav	Isolation and characterization of antimicrobial gene from onion (<i>Allium cepa</i>)	2019
59.	Miss Rajurkar Shweta M.	Dr. VP Chimote	Molecular characterization of genes conferring seed longevity in soybean [<i>Glycine max</i> (L.) Merr]	2019
60.	Mr. Mule Krushna D.	Dr. AA Kale	Effect of polyamine on gene expression to alleviate drought tolerance in sugarcane	2019
61.	Mr. Patil Akash R.	Dr. SV Pawar	Micropropagation studies in Guggul (<i>Commiphora wightii</i> (Arnott))	2019
62.	Mr. Netawane Akshay L.	Dr. VP Chimote	Molecular characterization of genes conferring seed longevity in soybean [<i>Glycine max</i> (L.) Merr]	2019
63.	Miss. Mote Gopika K.	Dr. AS Jadhav	Screening for antimicrobial gene sequences from medicinal plants (Ashwagandha, Kartoli, Tulas, Korphad)	2020
64.	Miss. Mawalkar Mugdha S.	Dr. PL Kulwal	Characterization of gene responsible for aroma in landraces and improved varieties of rice (<i>Oryza sativa</i> L.)	2020
65.	Miss. Savalkar Ashwini D.	Dr. PL Kulwal	Molecular characterization of safflower by using ISSR marker	2020
66.	Mr. Gore Goroba Dagadu	Dr. SV Pawar	Genetic analysis of leaf blast resistant introgressed lines of rice (<i>Oryza sativa</i> L.)	2020

67.	Mr. Vasekar Akshay A.	Dr. SV Pawar	Molecular tagging of photoperiod insensitivity and long juvenility in soybean [<i>Glycine max</i> (L.) Merr]	2020
68.	Mr. Gawali Anand H.	Dr. VP Chimote	Identification of molecular markers for high oleic acid in soybean	2021
69.	Mr. Parwate Ashik R.	Dr. SV Pawar	Micropropagation studies in Vekhand (<i>Acorus calamus</i>)	2021
70.	Miss. Sawant Amruta S.	Dr. AA Kale	Molecular analysis of sugarcane under water stress condition at different growth stages with the application of putrescine	2021
71.	Mr. Yenare Snehal A.	Dr. AS Jadhav	Molecular and biochemical studies of antimicrobial properties of turmeric (<i>Curcuma longa</i>).	2021
72.	Mr. Bhandekar Munna C.	Dr. VP Chimote	Characterization of advanced generations of soybean (<i>Glycine max</i> L.) for Kunitz trypsin inhibitor free trait	2021
73.	Mr. Sakhare Vaibhavkumar V.	Dr. PL Kulwal	Molecular marker based characterization of different isolates of dry root rot in chickpea (<i>Cicer arietinum</i> L.)	2021
74.	Miss Nikita Kailas Mhaske	Dr. VP Chimote	Molecular characterization of candidate genes associated with seed longevity in soybean (<i>Glycine max</i> L. Merrill)	2022
75.	Miss Pragati Ramesh More	Dr. AR Aher	Molecular characterization in groundnut by using ISSR markers.	2023
76.	Miss Vishakha Rahul Bhosale	Dr. PL Kulwal	Molecular marker based characterization of chickpea genotypes differing for dry root rot resistance	2022
77.	Memane Akshay Namdev	Dr. PL Kulwal	Characterization of genes responsible for amylose content in rice (<i>Oryza sativa</i> L.)	2022
78.	Wagh Yogesh Gangaram	Dr. AR Aher	Micropropagation studies in Bael (<i>Aegle marmelos</i> L) a medicinal plant	2022
79.	Sahane Rutik Dynaneshwar	Dr. AA Kale	Molecular evaluation of genetic divergence for differential sucrose accumulation in sugarcane.	2022
80.	Miss Monika Dharmendra Andhale	Dr. AA Kale	Molecular characterization of sucrose phosphate synthase gene from sugarcane	2023

Research Recommendations

1. Molecular markers csLV34 and cssfr5 either individually or in combination are recommended for detection and rapid screening of leaf rust resistance gene *Lr34* in aestivum (bread) wheat improvement programmes.
2. For quick and accurate identification of *Xanthomonas axonopodis* pv. *punicae* causing oily spot in pomegranate SCAR-XAP primer amplifying a specific 152 bp fragment is recommended.
3. For soybean rust resistance breeding complementary genes specific Satt 191-222bp(Rpp1b) and Satt 215-123bp (Rpp2) molecular markers simultaneous use is recommended.
4. Developed and validated 'SSScM1' and 'SSScM3' SCAR markers are recommended for early, rapid and precise selection of salinity tolerant plantlets in sugarcane improvement programme.
5. To accelerate breeding of long juvenile soybean varieties capable of withstanding climate change use of SSR markers, Satt-197-179bp and Satt-063-116bp is recommended.
6. Identified sources of heat stress tolerance in chickpea based on biochemical and physiological parameters.
7. Developed three sources of resistance for blast disease in rice.
8. During micropropagation of banana no. of subculture should be restricted to 8 to minimize somaclonal variation.

Institutional Projects (Theme Areas)

1. Marker-Assisted Selection For Crop Improvement
2. Gene Mining (Genes/ cDNA isolation, cloning and sequencing)
3. Candidate Gene Expression /Protein Profiling
4. Candidate Genes /DNA characterization / sequencing
5. Plant Tissue Culture
6. Molecular Diagnosis of microbes/pathogens

Significant achievements of State Level Biotechnology Centre, MPKV, Rahuri

i. Human Resource Development :

- Seventy three students have completed their M.Sc. (Agril. Biotech) degree using facilities of this center's for their post graduate research work.

ii. Molecular Markers for Crop Improvement

- DNA fingerprinting of released and popular varieties of field and horticultural crops
- Divergence analysis of available germplasm necessary for classical breeding programme
- Identified different molecular markers in soybean, rice, chickpea, wheat, sugarcane and cotton for genetic improvement.
- Development of anti-nutritional Kunitz trypsin inhibitor free soybean (Phule Agrani/Sangam/Kimya) using KTI gene linked markers is in progress. Advanced lines are in MLT field trials and are being re-assayed at molecular and biochemical level. .
- Marker-assisted selection programme for blast resistance in rice variety Phule Radha is underway and the progenies are being evaluated under preliminary yield trial. Rice SSR marker RM204 was found significantly associated with blast resistance.
- Marker-assisted selection programme for drought stress tolerance in chickpea is underway in the background of variety Digvijay with genotype ICC 4958 as the donor.
- In chickpea, GDP associated inhibition factor gene marker Chk14a558 was noticed for drought tolerance; while three SSR markers, H4G07, TR72 and H1B04 were found to be promising for heat stress tolerance.
- Molecular marker study for dry root rot tolerance in chickpea is underway.
- SSR Marker gwm148 was found to be associated with heat tolerance trait in wheat
- Soybean SSR markers Satt 674 (qPDH3-5 linked) and SRM1 (qPDH1 linked) were associated with pod shattering tolerance.
- The SSR primer Satt215 amplified Satt215170 p and Satt215150bp markers linked to qPDH3-4 that exhibited contrasting allelic efficiency in genotypes differing for pod shattering.
- Molecular Tagging for important traits like seed longevity, pod shattering tolerance, oleic acid content and rust resistance has been done in soybean.
- Marker-trait associations have been identified for protein content and heat stress response in chickpea.
- Gene pyramiding and confirmation of soybean rust resistance Rpp 1 to *Rpp4* genes was done using linked SSR markers.
- Microsatellite analysis confirmed that the derivatives of the trispecies [*2(Gossypium arboreum* × *G. anomalum*) × *G. hirsutum* var. BWR] line × *G. hirsutum* var. JLH168 hybrid, shared multigenomic background from the three cotton species (A2, AhDh and B1 genome).

- Molecular Tagging for important qualitative traits was done for traits like Fusarium wilt resistance, sucking pest tolerance and male sterility in cotton
- Identified sources of tolerance to heat stress in chickpea.
- Developed sources of resistance to leaf blast in rice.
- Identified source of resistance to dry root rot in chickpea.

iii. Genes/ cDNA isolated cloned and sequenced

- Pearl millet *P5CS* (partial cDNA, 1179 bp) for drought tolerance with NCBI GenBank accession No. FJ827591
- Banana *ACC oxidase* (Full length cDNA, 980 bp) for ripening with NCBI GenBank accession No. EU131109
- Fig *ACC Synthase 1* (partial cDNA, 1059 bp) and *ACCS2* (partial cDNA, 301 bp) for ripening with NCBI GenBank accession No. FJ827771 and FJ827772
- Wild sorghum *LEA1*_{-546bp} and *LEA3*_{-816bp} (Full length cDNA, 980 bp) for drought tolerance with NCBI GenBank accession No. KI637318 and KT030731.

iv. Candidate Gene Expression /Protein Profiling studies

- In sugarcane, under drought stress condition, *DREB* and *IGE* genes were expressed only in drought tolerant cultivar Co-740. Application of putrescine 100 mM in sugarcane under resulted in higher fold expression of genes involved in combating the drought.
- In sugarcane, under salinity stress, *SOS1*, *SOS2*, *SOS3* and *P5CS* genes were up-regulated in the tolerant cultivar CoM- 265 as compared to CoC671. The unique protein bands were resolved by SDS-PAGE (79.49 and 66.18 kDa) and by Native PAGE (63.59, 61.01 and 25.23 kDa) in CoM 0265 variety of sugarcane under salinity condition.
- Different cellulose synthase genes are expressed during cotton fibre elongation in between *G. hirsutum* and *G. arboreum*. In particular, *cesA1* and *cesA2* cellulose synthase genes are highly expressed in *G. hirsutum*; than *G. arboreum* while in *G. arboreum* strong expression of *cesA1b* gene was observed at fibre elongation stage.
- In sorghum, Dehydrin like protein bands of 30 and 35 kDa were observed under drought stress conditions in sorghum, while under heat stress, HSPs of 77.6 and 70.8 kDa were observed in sorghum cv. M 35-1; while HSPs of 73.25 kDa were observed in wild sorghum genotype, IS 18855

v. Candidate Genes /DNA amplified and sequenced

- Antimicrobial *mannose binding lectin (MBL)* (870 bp) cDNA from ashwagandha was synthesized and sequenced. Antimicrobial gene, AceAMP1 specific primers were designed and used for synthesis of corresponding cDNA from onion as well as few medicinal plants.
- Soybean *Phytochrome A3 (E4 gene, two each partial cds. of four varieties)*: Eight accessions each of NCBI GenBank nucleotide and protein accessions for photoperiod sensitivity and

maturity.

- Soybean *Early Flowering* (*J* gene, complete gene): Six accessions each of NCBI nucleotide and protein accessions for Long Juvenility and maturity.
- Molecular characterization genes conferring seed longevity in soybean, revealed Transperent Testa (TT-10) laccase 931th position SNP shared by all three high seed longevity varieties; while 6 SNPs were shared by two of them. In stachose synthase gene 11SNP were shared only between two high seed longevity varieties, with none being shared by all three together.
- For DNA barcoding: 18 genotypes from 10 *Gossypium* species were used from Germplasm bank, Cotton Scheme were sequenced for their ITS-rRNA region .to get 18 NCBI accessions
- In soybean 525 bp E1 maturity gene sequence analysis revealed twenty two earliness specific SNPs shared by JS2034 and JS9560; while eighteen late maturing specific SNPs were shared by both MAUS61 and MACS1180

vi. Plant Tissue Culture

- Micropropagation protocol has been standardized in bamboo, sugarcane and banana
- Developed regeneration protocol for medicinal, aromatic and other important plants viz. ashwagandha , sarpagandha, fig, gudmar , neem , simarouba , kal lavi etc.
- Interspecies (3 species) cross hybrids were recovered in cotton using embryo culture technique.
- Used embryo culture technique to recue interspecies cross hybrids in *Zizypus*

vii. Molecular Diagnosis of microbes/pathogens

- For designing SCAR-Xap primer for diagnosis, *X. axonopodis pv puniceae* hairpin loop-forming intergenic region genomic sequence with NCBI accession No. FJ827773
- For initial identification of *Xanthomonas axonopodis pv puniceae*, 16S rRNA gene, partial; 16S-23S ITS complete and 23S rRNA gene, partial seq. with NCBI GenBank accession No. FJ827774 was used
- For SNP variation study: *Sclerotium (Athelia) rolfsii* ITS-rRNA sequence 7 NCBI accessions were studied to develop a PopSet.
- *Klebsiella pneumoniae* causing root bark necrosis of pomegranate 16S rRNA gene, partial; 16S-23S ITS complete and 23S rRNA gene, partial seq. sequenced with NCBI GenBank accession No. KY941097.

Ad-hoc Projects (Ongoing)

Sr. No.	Title	Funding Agency
1	Germplasm Characterization and Trait Discovery in Wheat using Genomics Approaches and its Integration for Improving Climate Resilience, Productivity and Nutritional quality	Department of Biotechnology (DBT), Govt. of India
2	Characterization of chickpea Germplasm Resource to Accelerate Genomics-assisted Crop Improvement	Department of Biotechnology (DBT), Govt. of India
3	Spectral response-based breeding in different crops for screening of genotypes for biotic and abiotic stresses	Rajiv Gandhi Science and Technology Commission, Govt. of Maharashtra

Publications

Sr. No.	Name	Designation	Publication links
1.	Dr. A. A. Kale	Professor of Biochemistry (CAS)	https://scholar.google.co.in/citations?hl=en&user=ImvMkiUAAAAJ
2.	Dr. V. P. Chimote	Professor of Botany (CAS)	https://scholar.google.co.in/citations?hl=en&user=OA25ieQAAAAJ
3.	Dr. P. L. Kulwal	Professor of Botany (CAS)	https://scholar.google.co.in/citations?hl=en&user=qNOuOvUAAAAJ
4.	Dr. A. R. Aher	Assistant Professor of Botany	https://scholar.google.com/citations?user=ay9lDIwAAAAJ&hl=en

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