CURRICULUM VITAE

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Date of Birth : 16/08/1960

Educational Qualification

1993 –1996	Ph.D. in Molecular Genetics**,** Dept. of Cell and Molecular Genetics, Scottish Crop Research Institute and University of Dundee Scotland, UK Thesis on "Manipulation of potato (*Solanum tuberosum* L) protein quality through genetic engineering"
1981 – 1983	M.Phil. {Botany (Plant Physiology)}, Punjab University, Chandigarh
1979 – 1981	M.Sc. {Botany (Plant Physiology), Punjab Agricultural University, Ludhiana,
1977 – 1979	B.Sc. (Botany, Zoology, Chemistry), Guru Nanak Dev University, Amritsar, Punjab

Research/Academic experience:

Research Experience

Thirty years and **ten months** at three institutes of **Indian Council of Agricultural Research** (ICAR), **Department of Agricultural Research and Education** (DARE), New Delhi in various scientific positions:

i. ICAR-NATIONAL BUREAU OF PLANT GENETIC RESOURCES, New Delhi **20 years**

Principal Scientist (27th July 2006 to date)	10 years 6 months
Senior Scientist (27thJuly 1998 - 27thJuly 2006)	8 years
Scientist (SG) (21st December 1996 -27th July 1998)	1 year 7 months

ii. **SCOTTISH CROP RESEARCH INSTITUTE & UNIV. OF DUNDEE, Scotland, UK**
Commonwealth Fellow/ Scientist (SG) (13thOct.1993-15thDec.1996) **3 years 2 months**

iii. ICAR-CENTRAL ARID ZONE RESEARCH INSTITUTE, Jodhpur, Rajasthan
Scientist (SG) (22nd June 1993- 10th Oct 19930 **4 months**

iv. ICAR-CENTRAL POTATO RESEARCH INSTITUTE, Shimla, Himachal Pradesh
Scientist (24th March 1986 - 21st June 1993) **7 years 3 months**

Academic Experience

i **Seventeen years** as Indian Institute of Agricultural Research **(IARI) Faculty** for **Plant Genetic Resources (PGR)** discipline at ICAR-NBPGR from **1999.**
Course Taught - G-106- **Biotechnology for Plant Genetic Resources** to **M.Sc. PGR** students from 2000-2006.
Supervisor: Two M.Sc. PGR Students of IARI, completed their degrees on GM Diagnostics for Impact Analysis of GM crops on plant biodiversity and on Strategies for Monitoring Adventitious Presence of Transgenes in Maize Collections Employing Different GM Diagnostics.

ii Three Ph. D students completed their degrees on (i) qualitative and quantitative diagnosis of GM crops and study of effect of transgenesis on their secondary metabolite content; (ii) molecular characterization of grape (*Vitis vinifera*) (iii) molecular characterization of safed museli.

iii Co-supervisor of two M.Phil. students worked on different aspects of DNA based GM detection

iv Co-supervisor of two Ph. D Scholars: completed their degrees on Development of DNA-based Diagnostics and Event-based Characterization in GM Food Crops (Maize) and on Qualitative and quantitative analysis of GM vegetable crops.

v Fifteen M.Sc. students worked on molecular characterization of periwinkle, neem, rice and *palmarosa* and PCR-based GM Detection techniques during 2000-2004.

vi Under Team of Excellence: Three Researchers from National Research Institutions/Agricultural Universities worked for 6 months on molecular characterization of rice and neem germplasm under NATP World Bank Projects's Team of Excellence Theme.

Honors/Awards/Fellowship received:

Awards/Fellowships

i. **Agriculture Leadership Award 2015** for **leading role in Biotechnology Research and Development** by Agriculture Today on 18 September, 2015 at New Delhi.

ii. **Best Scientist Award 2015** for **excellence in Professional Education and Industry** by Science and Technology, EET CRS, Research Wing**,** New Delhi on 14 June, 2015, at Bangalore.

iii. Recognition by **OMICS International**, **USA for outstanding contributions in 7th Indo Global Summit and Expo on Food and Beverages**, from 8-10 October, 2015 at New Delhi.

iv. **Commonwealth Fellowship** awarded by **Ministry of Human Resource Development, Govt. of India** and **Association of Commonwealth Universities, British Council, UK** for three years (October 1993-December 1996) for undertaking research on "**Manipulation of potato (*Solanum tuberosum* L) protein quality through genetic engineering"** at Scottish Crop Research Institute, and University of Dundee, Scotland, United Kingdom.

v. **Fellow of Indian Society of Plant Genetic Resources (FISPGR), New Delhi -2010**

International Recognitions

i. Recognized as an International Expert by **Secretariat, Convention on Biological Diversity (SCBD), Montreal**, **United Nations Environment Programme (UNEP), Montreal.** On an invited/sponsored visit, participated in **Workshop of the Network of Laboratories for the Detection and Identification of LMOs,** Joint Research Centre**,** Ispra, Italy, 9-11 June, 2015. (i) Delivered keynote address on **Current Status of GMO Detection in India and Asian Region** (ii) Moderator for one of the key areas, while designing the outline for **capacity-building workshops on the detection and identification of LMOs, on Reporting of analytical results** according to laboratory's policy, and in compliance with international regulations and practices**.**

ii. Recognized as an International Expert by **Secretariat, Convention on Biological Diversity (SCBD), Montreal**, **United Nations Environment Programme (UNEP), Montreal** and nominated Indian expert by MoEFCC, Govt. of India. On an invited/sponsored visit, participated in **Workshop of the Network of Laboratories for the Detection and Identification of LMOs at European Commission's** Joint Research Centre, Ispra, Italy, 25-27 November 2013. (a) Delivered keynote address on **Cost-efficient DNA-based GM detection strategies** (b) Moderator for one of the five prioritized areas namely, "**Experience and case studies on detection and identification**" for the compilation of technical tools and guidance document to be submitted to CBD Secretariat. As an outcome, the submitted draft technical tools/guidance document was adopted in COP-MOP-7, at South Korea in September, 2014.

iii. Recognized as an **International Expert by European Commission, Brussels** for harmonization of norms/guidelines for DNA based GM detection as per international standards ISO/IEC 17025:2005.

Participated in the deliberations and made technical contributions in the following five workshops/plenary meetings organized by European Commission, Brussels:

a. **International Workshop of GMO-analysis Networking** and Brainstorming on **Present and Future of DNA-based diagnostics within the broader context of the bio-based economy** in April 2013, Ispra, Italy

Four plenary meetings of European Networking on GM Detection Laboratories (ENGL), Ispra

b. 15th ENGL meeting- May, 2011, Ispra, Italy
c. 14th ENGL meeting- Nov, 2010, Ispra, Italy
d. 13th ENGL meeting- May, 2010, Ispra, Italy
e. 12th ENGL meeting- Dec, 2009, Ispra, Italy

As an outcome, functional linkage was developed with **European Network of GM Detection Laboratories** (**97 GM detection laboratories** (27 EU member States, 3 non EU States of Europe) and 9 other countries *viz*. Japan, India, China, Singapore, Malaysia, South Korea, Chile, Mexico and Brazil)**,** Joint Research Centre (JRC), Ispra, Italy, from 2009.

iv. Recognized as an **Asian Region's Technical Expert** by European Commission, to represent 14 countries of the region (Ten ASEAN countries + India, China, Japan and South Korea)

Contributed in deliberations of **four EU-Asia Regional Network Meetings on GMO Analysis from 2009-2014**.

a. International Workshop of GMO-analysis Networking, April 2013, Ispra, Italy
b. 4th EU-Asia Network Meeting, May 2012, Manilla
c. 3rd EU-Asia Network Meeting, June 2011, Singapore
d. 2nd EU-Asia Network Meeting, June 2010, Singapore
e. 1st EU-Asia Network Meeting, June, 2009, Malaysia

All these visits were sponsored by European Commission, Brussels.

As an outcome, functional linkage was developed with EU-Asia Regional Network on GMO Analysis (20 GM detection laboratories of 14 countries of the region from June, 2009.

Nominated as a **nodal person** to **represent Asia Region** in an International Workshop of GM Analysis Networking at Ispra, Italy in April, 2013.

v. **FAO Consultant/Technical Expert**: For GM detection and Biosafety issues related to GM Crops in **Regional Workshop on Strengthening National Capacity Building on Biosafety in Asia**, held from 17th-20th June, Bangkok, 2013 sponsored by FAO of UN, Rome

Delivered five key note lectures on biosafety issues pertaining to GM crops, Cartagena Protocol on biosafety and GM detection strategies & issues related with transboundary movement of LMOs.

vi. **FAO Consultant/Technical Expert**: For GM detection and Biosafety issues related to GM Crops in the **Regional Workshop to exchange of information on GMO detection practices and techniques and their progressive harmonization at Regional level,** held at Beirut, Lebanon 24th-27th January, 2011, sponsored by FAO of UN, Rome.
Delivered two key note lectures on biosafety issues related to GM crops and GM detection.
Chaired Two Sessions (i) **Technical session on Biosafety** on 25th January, 2015
(ii) **Plenary Session** on 27th January, 2015.
As an outcome: Functional linkage has been developed with **Near East and North Africa (NENA) Region,** a network of ten countries of NENA region.

vii. **FAO Consultant/Technical Expert**, For GM detection and Biosafety issues related to GM Crops in **"Regional Workshop on Biosafety" (2009)** by FAO of UN, Rome, **Delivered two key note lectures** at Bangkok in December, 2009.

viii. **Invited Technical expert** and **a Panelist**, in an **International meeting of Academic Institutions and Organizations involved in Biosafety Education and Training** by United Nations Industrial Development Organization (UNIDO), Geneva and Secretariat of Convention on Biological Diversity, Montreal at Kuala Lumpur, Malaysia in April, 2007.

ix. **Technical Expert** in the deliberations of **High Level Policy Dialogue on Biotechnology for Food Security and Poverty Alleviation: Opportunities and Challenges** by Asia-Pacific Association of Agricultural Research Institutions, Bangkok, Thailand in November, 2005.

Leadership Role at International Level

i. On invitation of FAO, Rome, as a technical expert **Chaired two sessions: (i) Technical Session on Biosafety on 25th Jan, 2011 (ii) Plenary Session on 27th Jan, 2011** in the **Regional Workshop to exchange of information on GMO detection practices and techniques and their progressive harmonization at regional level**, Beirut, Lebanon, 24th-27th January, 2011.

ii. **Programme Leader** of bilateral Indo-Slovenian Inter Governmental Programme of Cooperation in Science and Technology by DST and Department of Biotechnology and System Biology at National Institute of Biology (NIB), Ljubljana. To execute the programme effectively **two exchange visits of one month each** were undertaken by me to **Department of Biotechnology and System Biology at NIB, Ljubljana in 2011 and 2012**.
Two reciprocal visits by Slovenian scientists were undertaken to my GM detection lab., for developing effective and strong collaboration for developing cost effective GM diagnostics.
The outcome was two joint publications and development of cost efficient GM Diagnostics.

a. **Randhawa GJ**, Singh M, *Morisset D*, Sood P & *Zel J* (2013), Loop-mediated isothermal amplification: Rapid visual and real-time methods for detection of genetically modified crops. ***Journal of Agricultural and Food Chemistry***, 61, 11338-11346 (Impact factor: 2.912)
b. **Randhawa GJ**, *Morisset D*, Singh M & *Žel J* (2014), GMO matrix: A Cost-effective approach for screening for unauthorized genetically modified events in India. ***Food Control***, 38, 124-129 (Impact factor: 2.806).

iii. **Invited speaker** to deliver a **keynote address** on "**Cost-effective Novel Technologies to Check Unauthorized GM Events in Food Chain**" on **invitation** and sponsorship by **Korean Society of Food Science and Technology** in 81st Annual Meeting and International Conference in the session "**New technologies in GM food detection for the future of food safety**" at Republic of Korea from 25th- 27th August, 2014.

(Details of Peer Recognitions at International level Annexure I).

National Recognitions

i. **National Technical Expert Member of Indian Delegation** (2012), **nominated by Ministry of Environment and Forests Climate Change, (MoEFCC), Govt. of India**, in **International meeting Conference of Parties (COP)-Members of Parties (MOP)-6 of Convention on Biological Diversity (CBD), Montreal**, held at **Hyderabad, from 1st-5th October, 2012**, for thematic areas: (a) Handling, Transport, Packing and Identification of LMOs and (b) Capacity building and roster of experts.

ii. **Technical Expert of four member Indian Delegation** (2007), **nominated by MoEFCC, Govt. of India,** under GEF-World Bank project on Capacity Building for the Implementation of Cartagena Protocol on Biosafety.
Study tour undertaken to following regulatory bodies/funding agencies/Universities in Canada/USA for developing collaborations in the area of Agricultural Biotechnology:

(a) Secretariat, Convention on Biological Diversity (b) Canadian Food Inspection Agency
(c) Environment Canada (d) Canadian Seed Growers' Association
(e) US Department of Agriculture (f) GEF Secretariat (g) World Bank
(h)Michigan State University (i) Cornell University

iii. Nominated as technical expert of Indian Delegation (2011, 2010 and 2008), by **Director General, Bureau of Indian Standards, (BIS), New Delhi**, for providing technical support and interventions in three international meetings:
   a. 3rd Meeting of **"Horizontal methods for the detection of biomarkers in: foods; seeds and food crops; fruit; vegetables and derived foods"** ISO/TC 34/SC16 at Beltsville, MD, USA from 25th-27th October, 2011
   b. 2nd Meeting of **"Horizontal methods for the detection of biomarkers Analysis"** ISO/TC 34/SC16, Tokyo, Japan from 9th-11th February, 2010.
   c. 1st Meeting of "**Horizontal methods for the detection of biomarkers in: foods; seeds and food crops; fruit; vegetables and derived foods**" ISO/TC 34/ SC 16, Chicago, USA from 11th-13th November, 2008.

iv. **Expert member of Accreditation Committee of National Accreditation Board for testing and Calibration of Laboratories**, Ministry of Science and Technology, New from 2012-2015.

v. Technical Expert assessor **as per ISO 17025:2005** for DNA based/GM testing of **Agricultural and Processed Food Products Export Development Authority (APEDA)**, New Delhi.

vi. **Technical Expert member** NABL, Ministry of Science and Technology, for revising 102-NABL Guidelines for Biological Testing Laboratories from 2011.

vii. **Technical member of Expert committee on registration of Essentially Derived Varieties of Protection of Plant Varieties and Farmers' Rights Authority**, New Delhi, 2011-2015.

viii. Technical Expert **member of Task Force Biotechnology for Food & Agriculture Sectional Committee, FAD 23** BIS, Manak Bhavan, New Delhi from 2010-till date.

Implementation of Interdisciplinary, multi-institutional, national and international projects in a networking mode

Projects of more than 11.68 crores from external funding agencies *viz*. Global Environment Facility (GEF)-UNEP, GEF-World Bank, FAO, Rome, National Agriculture Technology Project-World Bank and National Agriculture Innovation Project-World Bank, Department of Biotechnology and Department of Science and Technology, Govt. of India, were commissioned and successfully executed by me during the last sixteen years at ICAR-NBPGR. (Details in Annexure II).

Reviewer of Peer-reviewed International/National Journals

Springer: Transgenic Research, Journal of Plant Biochemistry and Biotechnology, Food Analytical Methods
Elsevier: Food Control, Food and Chemical Toxicology
ACS Publications: Journal of Agricultural and Food Chemistry
BioMed Central: BMC Biotechnology
Other peer reviewed journals: PlosOne, Food Technology and Biotechnology**,** Indian Journal of Biotechnology, Indian Journal of Agricultural Research, Proceedings of The National Academy Sciences Section B: Biological Sciences, African Journal of Biotechnology.

Patents granted:

Three Patents were granted by the Indian Patent office, New Delhi during 2011-2013, myself being the main inventor:

i. **Patent No. 258165 (2013)**

Diagnostic kit based on polymerase chain reaction for detection of *cry*1*Ac* gene in *Bt* cotton Bollgard-I

Inventors: Randhawa G. J. & Firke P K **2069/DEL/2006**

ii. **Patent No. 254341 (2012)**

Process for enabling simultaneous detection of two transgenes *human serum albumin* (HAS) and *bar* genes using a Multiplex PCR utilizing a combination of novel primers and PCR programme in GM wheat

Inventors: Randhawa G. J., Firke P K and Karihaloo J L **3530/DEL/2005**

iii. **Patent No. 245749 (2011)**

Process for enabling simultaneous detection of two transgenes namely 5 enolpyruvylshikimate-3-phosphate synthase (*CP4EPSPS*) gene/*CaMV* 35S promoter using a multiplex PCR utilizing a combination of novel primers and PCR programme in GM maize

Inventors: Randhawa G. J., Firke P K & Karihaloo J L **3451/DEL/2005**

Summary of Research Publications

H-Index: 13
(Google Scholar)
***I10 Index* 20**
Citations* *521

Research Publications: **62**
Books Edited: **06**
Book Chapters: **14**
Technical Bulletins/Brochures: **11**
Sequences submitted to NCBI: **6**
Short Communications: **31**

List of Publications Annexure II

Significant Research Accomplishments

i. **Rapid, cost-effective and reliable GMO screening assays based on visual and real-time LAMP** targeting commonly employed promoters (*P-35S, P-FMV*), marker genes (*nptII, aadA, uidA*), insect resistant (*cry1Ac, cry2Ab2*) and herbicide tolerant (*epsps*) transgenes, have been developed using two types of chemistries on four amplification systems. These **assays can be used in on-site detection in farmer's fields and at the port of entry** by custom officials without sophisticated equipments and specialized expertise. Event-specific LAMP assays have been developed for Bollgard I and Bollgard II Bt cotton events and GM maize events.

ii. **GMO matrix for 141 GM events of 21 crops with 106 genetic element targets** has been developed. Ten most frequently present targets have been identified to screen these events using a GMOseek algorithm, which is very cost-efficient.

iii. **Development and validation of user-friendly multi-target real-time PCR-based screening system**, simultaneously targeting 47 targets, including 21 GM events of five crops, 5 constructs, 11 transgenes, 4 control elements and 6 endogenous genes.

iv. **PCR-based diagnostics developed for commercially cultivated *Bt* cotton events in the country**, viz., MON531, MON15985, GFM-*cry1A*, Event1 and MLS-9124. **Event-specific LAMP assays for events MON531 and MON15985, two major cotton events** covering more than 95% area under GM cotton cultivation.

v. **Development of multiplex PCR-based screening method employing commonly used marker genes, *viz*., *nptII, aadA, hpt, bar, pat, uidA*** for checking the GM status of a sample irrespective of GM trait & crop.

vi. **Qualitative & quantitative PCR/real-time PCR detection of GM events of ten crops**, *viz*., *Bt* (cotton, maize, rice, okra, potato, brinjal, cauliflower), GM tomato with *osmotin* gene, GM tomato with *AVP1D* gene, GM potato with *AmA1* gene and GM wheat event MON71800.

vii. **GM Potato with Better Protein Quality:** The developed GM potato tubers had more than two fold methionine content with improved protein quality than the normal tubers by expression of heterologous genes **2*S albumin*** from Brazil nut and **10 Kda *zein*** from maize, encoding exceptionally rich sulphur containing amino acid, methionine.

viii. **For nutritional enhancement to combat micronutrient deficiency of Iron and Zinc in Rice:** The most widespread micronutrient deficiencies in human beings particularly in rice growing areas are of Iron and Zinc. So **forty five** colored rice accessions from peninsular India were screened for high content of iron and zinc. **Five rice accessions** had high concentration **(>100 µg/g)** of **iron** and **one accession** had **Zn**. Highest iron content **170 µ/g** and highest Zn content**125 µg/g** was reported.

ix. **Two hundred and five (205) imported consignments comprising of 5,668 accessions** of **14 GM crops** were tested for absence of Terminator Technology and checked other elements of the construct *viz*. promoters, structural and terminator genes.

x. **Allergenicity assessment by *in silico* evaluation of Cry proteins, *viz., Cry1Ac, Cry1Ab, Cry2Ab, Cry1Ca and Cry1Fa/Cry1Ca hybrid* for potential allergenic cross-reactivity employing bioinformatics tools:** (i) FASTA3 of Allergen Online version 10.0 (ii) BLASTX of NCBI Entrez**.** Potential allergenic cross-reactivity of recombinant Cry proteins being expressed in *Bt* crops that were commercialized or under field trials in India was assessed using bioinformatics search tools, showing no significant sequence similarity with the known or putative allergens.

xi. **DNA Fingerprinting/Molecular Profiling of Important Crops**

DNA fingerprints of medicinal plants are of critical value to preempt restrictive patenting and safeguard Indian interests. Hence, DNA fingerprints of 284 accessions of eight

medicinal plants *viz.* **neem (69), plantago (48), palmarosa (45), vetiver (30), chlorophytum (21) periwinkle (13), *Abrus* (8) and *Trigonella* (50)** were developed (2001-2009). DNA fingerprints of released varieties and germplasm accessions of **280 released varieties of Rice (208) and Chickpea (72)** were developed (2002-2006).

xii. **Developed functional Linkages with International organisations For Quality Assurance and Harmonization of GM Detection Protocols, Successfully Participated under ISO/IEC 17043:2010 of accreditation in:**

Twenty Proficiency/Comparative testings, for detection of the unknown levels of different GM events in blind test samples.

a. **Tweleve proficiency testings** organized by **European Commission (EC)-Joint Research Centre (JRC), Italy** from 2010-till date.
b. **Seven proficiency testings** organized by **Grain Inspection, Packers and Stockyards Administration (GIPSA), USDA**.
c. **One proficiency testing** organized by **Brazilian agency Programas Interlaboratoriais e Materiais de Referência–PRIMAR Laboratório Nacional Agropecuário - LANAGRO/ MG Ministério da Agricultura, Pecuária e Abastecimento, Brazil in 2015**
d. **Ring trial for validation of real-time PCR methods** *viz*., *cry1Ab/Ac* and *pubi-cry*, organized by **Federal Office of Consumer Protection and Food Safety, Germany** in **2012**.
e. **Ring trial for validation of real-time PCR methods for quantitative detection of Golden Rice 2,** organized by **European Commission (EC)-Joint Research Centre (JRC), Italy** in **2013**.

xiii. Research studies on various **physiological and biochemical aspects of potato, production of true potato seed** for varietal improvement were undertaken.

xiv. **Developed cost effective micro propagation strategies through tissue culture techniques** for arid plants *i.e. Prosopis cineraria*, *Prosopis juliflora*, j*ojoba*, date palm and *in vitro* tuberization and meristem culture in potato. Cost efficient strategy to prolong the duration of sub culturing was also devised**.**

Leadership demonstrated in research, development and Institution Building

i. <u>GMO Detection Research Centre</u>

GM Detection Lab. NBPGR was project partners for GEF-World Bank funded project for Capacity Building for the implementation of Cartagena Protocol in India Phase-I Project 2004-2007.
Under UNEP-GEF Phase-II Capacity Building Project on Biosafety for LMO Detection in India, being implemented by MoEFCC, a **Stocktaking Assessment of GM Detection Laboratory of NBPGR** was conducted in 2014, along with eight other national laboratories. Based on the assessment report of Dr. Patrick Stolt, Swedish consultant deputed by MoEFCC, it has been proposed to set up a network of laboratories with detection capacities as per international standards and the responsibility of **GMO Detection Research Centre (GDRC)** was entrusted to GM Detection Laboratory at NBPGR in view of **scientific experiences, availability of major equipments required for GMO/LMO testing and international networking**.
Further strengthening and upgradation of GM detection activities at NBPGR as **GDRC** is under progress with the funds of **1 crore** from GEF-UNEP Project.

ii. <u>Advanced Research Infrastructure for Detection and Evaluation of GM crops</u>

Established **GMO Diagnostic Centre** as per International Standards with financial support from National Agricultural Innovation Project (NAIP), ICAR by further strengthening of GM detection Laboratory at NBPGR with funding of **1.51 crores** during 2013-14.

iii. **<u>Establishment of National Containment Facility of CL-4 level</u>**

NBPGR being the **nodal agency for issuing Import permits to public and private sector agencies** for imported germplasm and **transgenic planting material** for research purposes and undertaking quarantine, hence **National Containment Facility of CL-4 level** and **GM detection laboratory** to develop the expertise and infrastructure for molecular testing of imported transgenic material was established way back in **2000 at NBPGR**, being the **key member** of **Interdisciplinary project team,** throughout its all phases over the **last 16 years**. **Phase I-**1999-2002, **Phase II-**2002-2007, **Phase III**-2007-2012 **Phase IV- 2013-2018** (DBT-ICAR MoA Mode).

iv. **Up gradation of GM Detection Laboratory for DNA based detection of imported and indigenously developed GM crops** from 2004-2014.

Sophisticated equipments were procured under different projects for undertaking molecular work, *viz*. Two Gel documentation Systems (10 lakhs each) Two Real Time PCR Machines (20 and 25 Lakhs each) Four Thermal Cycle Machines (5 Lakhs each) Environmental Shaker (12 Lakhs) and Nano drop (6 Lakhs)

v. **Establishment of Molecular Biology laboratory** for **DNA Fingerprinting of Plant Genetic Resources *viz*. medicinal plants, rice** and **chickpea** established, at NBPGR in 1999.

vi. **Establishment of biotechnology laboratory for *in vitro* tuberization and meristem culture for potato improvement at Central Potato Research Institute during 1991-92.**

vii. Establishment of Transgene Bank and Database

In transgene bank, **imported transgenic lines** of **225 imports** of **15 crops** have been kept in safe custody, in double lock & key system under my supervision since 1998 as voucher samples.

viii. Initiation of Multi-disciplinary networking programme

a. Under Networking programme of DBT, worked in an **interlinking mode** for developing GM diagnostics with **four National Institute**s: (i) Central Food and Technology Research Institute,, Mysore, (ii) Centre for DNA Fingerprinting and Diagnostics, Hyderabad ((iii) National Institute on Nutrition, Hyderabad (iv) Indian Institute of Toxicology Research, Lucknow.
   Besides developing PCR based diagnostics in GM crops, successful completion of three rounds of cross validations for PCR-based detection with these National laboratories.
b. Under the Global Environment Facility (GEF)-World Bank sponsored project implemented by Ministry of Environment and Forests, on **Capacity building for implementation of Cartagena Protocol on Biosafety**. **Four National Institutes** worked in a **networking mode**: (i) Biotechnology Dept., G.B. Pant University, Pantnagar (ii) National Research Centre on Plant Biotechnology, New Delhi (iii) GM Detection lab, NBPGR, New Delhi, myself as Project Investigator (iv) Central Food and Technology Research Institute, Mysore.
c. Coordination of production of Film on "**Capacity Building on Biosafety in India**" in association with Project Coordination and Management Unit, MoEF, Govt. of India, reflecting the activities related to biosafety of GM crops, detection of LMOs, and extensive capacity building undertaken in the project at national level by different stakeholders and four partner institutes.
d. **Multidisciplinary Project** on **National Containment Facility for Transgenic Planting Material** since last 16 years Funded by DBT has **team of five plant quarantine scientists** of different disciplines ***viz.*** **Entomologists, Virologists, Nematologists and Pathologists** along with my association as molecular biologist for molecular testing of imported transgenic samples**.**

Human Resource Development

Training courses at the international/national level were organized as **Course Coordinator/Course Director** in the area **of GMO detection and various Biosafety issues pertaining to GM crops**. More than 300 researchers from National Agricultural Research System and other public and private organizations were trained.

International Trainings/Workshops organised

i. **Course Coordinator** of **International Training on DNA based GMO detection for seed testing and certification** for eight delegates from **Nepal** sponsored by **International Food Policy Research Institute (IFPRI) from 30th November-12th December, 2015.**

ii. **Coordinator** of **Asia Sub-regional Training-of-Trainers Workshop on the Identification and Documentation of LMOs** from 21st to 25th November 2011, New Delhi.

To introduce customs officers and other border-control personnel to the requirements of the Cartagena Protocol on Biosafety regarding the identification and documentation of LMOs and to techniques and methodologies. Customs officials and regulators from **13 countries** of the region *viz*. Cambodia, India, Indonesia, Lao People's Democratic Republic, Malaysia, Mangolia, Phillippines, Saudi Arabia, Sri Lanka, Syrian Arab Republic, Thailand, Viet Nam and Yemen.
Appreciation letters from Ahmed Djoghlaf, Executive Secretary, CBD Secretariat, Montreal and Mr. M.F. Farooqi, Additional Secretary, MoEFCC, Govt. of India for my contributions for organizing this international event in my GM detection Laboratory at NBPGR, New Delhi.

iii. **Placement of Research Training Fellow from Non Aligned and other developing countries:** Under promotion of South-South cooperation Ms Cevina Gooria from Ministry of Agro-Industry and Food Security, **Mauritius**, was awarded NAM S &T Research Training Fellowship for Developing Country Scientists, 2012-13 for research project "**Detection of GMOs in Maize from Mauritius: A case study**" for 6 months under Department of Science and Technology, programme for undertaking her work under my guidance at NBPGR, New Delhi.

National Trainings/Workshops organised

iv. Course Coordinator of Five days' Workshop on "**Biosafety and Detection of GM Crops**" organized from 11 to 16 August, 2014 at NBPGR, New Delhi. Scientists and researchers from ICAR Institutes and State Agricultural Universities participated.

v. Course Director of training **programme Molecular Diagnostics for Risk Assessment and Management of GM Crops** sponsored by NAIP from 8-21, November, 2011, trained **15 researchers**. The faculty included **International resource persons, Professor Karim M. Maredia, Michigan State University, USA** and **Dr. Dany Morisset and Dr. David Dobnik, National Institute of Biology, Slovenia**.

vi. Course Coordinator, of **three training programmes** of (i) **Cartagena Protocol: Decisions to Diagnostics** from 23rd-30th November 2006 and two trainings: **Biosafety concerns of transgenics and detection of LMOs** from (ii) 16th to 20th January 2006 and (iii) from 14th to 21st March 2005, more than **50 researchers** were **trained.**

vii. **Orientation Courses on Biosafety Considerations for Evaluation of Transgenic Crops** were conducted, to develop core team of experts for addressing biosafety /regulatory issues related to GM crops in proper perspective. More than **150 researchers** from Central and State Universities and Research Institutions were trained and during the **Seven orientation courses** from: (i) 5th to 13th December 2006, (ii) 7th to 14th November 2005, (iii) 22nd November to 1st December, 2004, (iv) 10th to 18th November, 2003, (v) 20th to 28th November, 2002, (vi) 2nd to 9th November, 2001 (vii) 17th to 26th July 2000 were organized as a key organizer at NBPGR, New Delhi.

viii. **Invited Lectures:** More than 80 invited lectures were delivered at different fora in international and national conferences/symposia/meetings.

Technologies transferred/developed:

A. **<u>Technologies Transferred</u>**

GM Detection Laboratory under my supervision developed DNA based technologies for screening and identification of GM crops. These technologies provide efficient GMO screening tools to check the GM status of a sample irrespective of GM crop/trait, in a rapid/cost-efficient way. Visual and real-time LAMP technologies, when combined with fast DNA extraction method, would facilitate on-site GMO screening in farmer's fields and at ports of entry.

i. **ICAR-NBPGR has signed MoA with M/s DSS Imagetech Private Limited, Delhi**, facilitated by Agrinnovate India Limited (AgIn) on **19th August, 2015** with technology transfer fee of **15 Lakhs** for transfer of five DNA-based GMO screening technologies:

   a. Hexaplex PCR targeting six marker genes (*aadA, bar, hpt, nptII, pat* and *uidA*)

   b. Duplex TaqMan Real-time PCR targeting *P-35S* and *T-nos*

   c. Visual Loop-mediated Isothermal Amplification (LAMP)-based technology targeting eight transgenic elements (*P-35S, T-nos, aadA, nptII, uidA, cry1Ac, cry2Ab, cp4-epsps*)

   d. Real-time LAMP-based technology targeting eight transgenic elements (*P-35S, T-nos, aadA, nptII, uidA, cry1Ac, cry2Ab, cp4-epsps*)

   e. TaqMan Real-time PCR-based multi-target system covering 47 targets for screening

Simplex/multiplex PCR-based diagnostics for screening and identification of GM Crops

The GM Detection Laboratory also developed PCR-based diagnostics for screening and identification of GM crops using simplex/multiplex PCR assays for simultaneous amplification of specific transgenes/marker genes/promoter sequences/species specific genes for **ten GM crops** *viz.* **cotton, soybean, maize, mustard, rice, brinjal, cauliflower, okra, tomato and potato**.

These technologies were also successfully transferred to public and private sector for providing testing services for regulatory requirements and for commercialization:

ii. **Punjab Biotechnology Incubator (PBTI), Mohali**, MoU was signed on 4th July, 2014 at one time technology transfer fee of **4 Lakhs.**

iii. **Basmati Export Development Foundation (BEDF), Meerut**, MoU was signed on **15thJuly, 2013** at one time technology transfer fee of **4 Lakhs**.

iv. **Amar Immunodiagnostics Pvt. Ltd. Hyderabad**, MoU was signed on non-exclusive basis on **May, 2010** with technology transfer fees as a onetime cost of **1.5 Lakhs**, towards the development of Technology and further commercialization and royalty @ of 15% on sale of commercial PCR based kits.

Amar Immunodiagnostics has already multiplied the PCR based kits from the transferred technologies for widespread commercial usage. GM detection laboratories in the country are already procuring these kits.

GM detection technologies would also be transferred to regional or zonal GMO testing laboratories and to network of GM testing laboratories being established in the country by MoEFCC, Govt. of India.

B. **Consultancy Services provided for Developing State of the Art Facilities for GM Detection as per International Standards ISO/IEC 17025:2005.**

i. **Punjab Biotechnology Incubator (PBTI), (Agri and Food Testing Laboratory), Mohali**, MoU, was signed at cost of **Rs. 2.34 Lakhs** on **6th February, 2013-30th June 2014**.

ii. Basmati Export Development Foundation (BDEF), Modipuram, Meerut, MoU, was signed at a cost of **Rs. 2 Lakhs** on **15th July, 2013-31st March 2015.**

C. Technologies Developed

GM Detection Technologies:

The developed GM detection technologies would be employed for checking unauthorized GM events in farmers' fields/port of entry and in the supply chain and would also benefit a broad range of stakeholders, including consumers, farmers, regulatory bodies and the agri-biotech industry as they would assist in: i) risk assessment and risk management specifically pertaining to gene flow studies, ii) post release monitoring and iii) solving legal disputes.

i Rapid, user friendly and cost effective Technology developed based on Visual and Real-time LAMP assays for GM detection

Upgradation in GM diagnostics was achieved by developing "Loop mediated Isothermal amplification (LAMP)" assay which does not involve the cycling reaction and amplifies the DNA at a constant temperature in a shorter period of time as compared to PCR. LAMP assays do not require any sophisticated equipments and can be developed on site in a shorter time.

For the **first time in India in 2013**, LAMP assay has been developed for GM detection by our laboratory. This user-friendly developed assay is for visual detection, which can be used at port of entry by custom officials or on-site in farmer's fields, when combined with a fast DNA extraction method, and does not require many laboratory equipments and specialized expertise.

ii GMO Matrix: A cost-effective screening approach using GMO Seek Algorithm

Cost-effective matrix approach to check the GM status of food products and for screening the presence of authorized and unauthorized GM events in India, was developed for detection of **141 GM events** of **21 crops**, targeting **106 genetic elements**. Ten most frequently present targets were identified to screen these events using a GMOseek algorithm. The information given in the matrix is a valuable tool to assist in **detection of accidental presence of unauthorized GM events** in the food and supply chain globally, as well as in the context of the new labelling requirements for food commodities in India. The developed GMO matrix approach would facilitate rapid and cost-effective screening by eliminating the need for development of specific testing methodologies for each GM event[1].

iii Ready-to-use Real-time Multi-target Plate for GMO Screening

Multi-target Taqman®real-time PCR-based screening system was developed for Multi-target plate set up for **21 GM events** of **five GM crops** *viz.* **Cotton, Brinjal, Rice, Corn and Soya** with **47 targets** including, eight transgenes, three marker genes, two promoters, two terminators and five construct-specific elements for screening and detection of Indian GM Crops/Events which were either imported for research purposes or were in BRLI or BRL II field trials.

iv Hexaplex and Octaplex PCR assays for Screening GM Status of the samples:

Multiplex PCR-based diagnostic technology for initial screening of GM status by simultaneous amplification of commonly used marker genes. These developed multiplex PCR assays would be useful in **verifying GM status of a sample irrespective of the crop and GM trait**.

v Quantitative Real-time PCR assays

- ✓ Quantitative Real-time PCR assays were developed targeting specific events/constructs/transgenes using TaqMan & SYBR Green I chemistry, in simplex and multiplex formats with Limit of Detection (LOD) of 0.01% for 22 GM events of six crops.
- ✓

- ✓ **Event-specific Detection of *Bt* Brinjal Event EE-1**

  GM Brinjal Event EE-1 with *cry1Ac* gene for insect resistance in pipeline for commercialization in India. Robust Event-specific Real-time PCR assay to detect brinjal event EE-1, was developed with a sensitivity of 0.01%.

  Pentaplex PCR assay simultaneously targeting four targets of the construct *viz*. *cry1Ac* gene/*CaMV* 35S promoter/*nos* terminator/*aadA* marker gene and endogenous gene *β-fructosidase* was also developed.

vi **Decaplex PCR Assay to Differentiate Two Widely Cultivated Commercialized *Bt* Cotton events*:* MON531 (Bollgard I®) and MON15985 (Bollgard II®))**

BGI® and BG II® are two widely cultivated events. The market price of BG II® comparatively higher as BG II® is a better resistance-management tool due to additional *cry2Ab* gene. It is difficult to differentiate the seeds of these two events, so there are chances of adulteration or mixing of seeds of these events by traders to earn profits. It is important for farmers to get the authentic seeds, so this technology would be useful.

To differentiate MON531 and MON15985 *GM* cotton events, decaplex PCR assay targeting transgenes*, i.e*., *cry1Ac* and *cry2Ab*; marker genes, *i.e., nptII*, *aadA* and *uidA*, control elements, *i.e., CaMV*35S promoter and *nos* terminator; two construct-specific sequences and endogenous *Sad1*gene, was developed.

vii **Decaplex PCR Assay to Differentiate All Five Commercialized Bt Cotton Events**

Decaplex PCR assay for detection of five commercialized *Bt* cotton events MON531, MON15985, Event 1, GFM-*cry1A* and MLS-9124: targeting transgene sequences, specific transgene constructs, events and endogenous *Sad1* gene was developed with Limit of detection up to 0.01%. This would be a reliable tool to identify and discriminate these five *Bt* cotton events.

<u>Technologies developed for Unique Identity System/Cultivar Identification/IPR Protection:</u>

DNA fingerprints can be used to provide proof of or defence against allegations of breach of intellectual property rights. The changing global scenario with respect to ownership of plant varieties and plant genetic resources has necessitated the development of a fool proof identification system. Hence, robust makers have been developed for Unique Identity System/Cultivar Identification/IPR Protection.

viii **SCAR marker developed for identification of Aromatic rice:**

Developed marker **UBC^{291}** discriminates aromatic rice varieties from non-aromatic rice. The marker was cloned, sequenced and converted into SCAR marker. Sequence of developed SCAR marker was submitted as NCBI GeneBank Accession No. DQ220788.

- **Randhawa, G.J.**, Firke, P.K. and Chikhale, N.J. (2005) ***Oryza sativa*** **(indica cultivar-group) SCAR marker genomic sequence. Accession No. DQ220788**

ix **Five STMS markers developed to discriminate basmati rice from non-basmati rice:** STMS markers **RM44/RM201/RM171/RM229/R24** were developed for discriminating basmati rice varieties from non-basmati rice (Sharbati).

x **Twenty four STMS markers developed to discriminate 76 rice cultivars**

xi **Thirty STMS markers developed to discriminate 72 rice varieties generating.**

xii **Fifty SSR markers developed to discriminate 45 colored rice accessions collected from peninsular India.**

xiii **Twelve molecular markers developed to discriminate 40 photoperiod sensitive and insensitive rice varieties**

xiv **(a) Fifteen AFLP markers developed to discriminate 23 chickpea varieties and accessions**

(b) Fourteen SSR markers developed to discriminate of 37 chickpea varieties

(c) Eighteen STMS markers and 15 AFLP markers developed to discriminate 21 chickpea cultivars

xv **SCAR marker $OPC4_{500}$ developed to screen *fusarium* wilt resistant and susceptible chickpea germplasm**: **$OPC4_{500}$** marker specific to resistant parent, was used for testing bulks of resistant and susceptible RILs and was found to co-segregate with the resistant phenotype. The marker was eluted, cloned and sequenced for developing **SCAR marker**, which was **employed to screen *fusarium* wilt resistant and susceptible chickpea germplasm**.

DNA Fingerprints/Molecular Markers (AFLP/ISSR/RAPD) for **284 accessions of eight medicinal plants** *viz*. neem (69), plantago (48), palmarosa (45), vetiveria (30), chlorophytum (21) periwinkle (13), *Abrus* (8) and *Trigonella* (50) were developed.

Recognising the importance of molecular markers in establishing the uniqueness of genotypes, DNA profiles of important crop varieties/genotypes that would help in safeguarding the national interest in relation to valuable plant genetic wealth were developed. As DNA fingerprints of medicinal plants are of critical value to preempt restrictive patenting:

xvi **Six AFLP markers developed to discriminate 22 accessions of neem, 8 exotic** (Tuang, Thailand, CMyene, Myanmar, Vitiane, Laos, CTibbilaran, Pakistan, Yezin, Myanmar, Geta, Nepal, Chamwian, Tanzania collected from Arid Forest Research Institute, Jodhpur and **14 indigenous accessions** collected from three states *viz*. Punjab, Haryana and Rajasthan. The study clearly indicates that Indian neem gene pool is different from exotic accessions.

xvii **Twenty four RAPD markers developed to discriminate 29 neem accessions** collected from **two agro-ecological regions of India** (11 agro-climatic subzones), covering three states, **Punjab, Haryana and Rajasthan**. The degree of genetic variation detected in these accessions suggests that RAPD markers can be used for studying the genetic diversity in neem. The study also demonstrated that neem germplasm collected from north-western plains of India shows no eco-geographical isolation based on sub-zones.

xviii **Thirty AFLP markers developed to discriminate 22 accessions of Vetiver**

xix **Sixteen AFLP markers, Fourteen ISSR primer and 60 RAPD Markers developed to discriminate 48 accessions Isabgol (*Plantago ovata*)**

xx **Twenty five RAPD markers developed to discriminate 24 accessions of Vetiver**

xxi **Thirteen RAPD markers developed to discriminate 34 accessions of Palmarosa (*Cymbopogon martini)***

xxii **Ten ISSR and thirty RAPD markers developed to discriminate 21 accessions of Safed Musali (*Chlorophytum borivilianum*),** a rare Indian medicinal herb collected from Madhya Pradesh, Rajasthan and Haryana.

xxiii **Twenty one ISSR markers and Fourteen RAPD markers developed to discriminate 50 accessions of Trigonella**

xxiv **Twenty ISSR markers and Twenty eight RAPD markers developed to discriminate 8 wild accessions of *Abrus precatorious*.**

xxv **Technology developed for cost effective/efficient micropropagation**

Development of cost effective micro propagation strategies for arid plants *i.e. Prosopis cineraria*, *Prosopis juliflora*, *jojoba*, date palm and *in vitro* tuberization and meristem culture in potato.

Annexure I

Peer Recognition at International level

On International fora presentations/technical deliberations were made in the area of Agricultural Biotechnology and management of plant genetic resources management and had the opportunity to interact with international experts to develop collaborative programmes and functional linkages.

S.No	Country	Purpose	Sponsorship	Month/Year
1.	Ispra, Italy	Recognized as an International Expert for International Workshop of Network of Laboratories for Detection and Identification of LMOs at European Commission's Joint Research Centre, Ispra, Italy by Secretariat of Convention on Biological Diversity, United Nations Environment Programme (UNEP)	Secretariat of Convention on Biological Diversity, UNEP	June, 2015
2.	Gwangju, Republic of Korea	Invited Key note Speaker in 'International Conference on Creative Food Science for the Future	Korean Society of Food Science and Technology	August, 2014
3.	Ispra, Italy	Resource Person in Training workshop on Implementation of Quality Systems/ISO 17025:2005 accreditation	European Commission Brussels, Belgium	May, 2014
4.	Ispra, Italy	Recognized as an International Expert by Secretariat of Convention on Biological Diversity, United Nations Environment Programme, and nominated expert to represent India by MoEFCC, Govt. of India	Secretariat of Convention on Biological Diversity, UNEP,	November, 2013
5.	Bangkok, Thailand	Invited Resource person in Regional Workshop on strengthening Regional Cooperation and National Capacity Building on Biosafety in Asia	FAO, Regional Office for Asia and the Pacific, Bangkok	June, 13
6.	Ispra, Italy	As an invited expert in International Workshop of GMO-analysis Networking and in Brainstorming the Present and Future of DNA-based diagnostics within the broader context of bio-based economy	European Commission, Brussels, Belgium	April, 2013
7.	Ljubljana, Slovenia	2nd Exchange visit under the bilateral project Novel cost-effective methods for GMO detection- an Indo-Slovenian Inter Governmental Programme of Cooperation in Science and Technology, DST at Department of Biotechnology and System Biology at National Institute of Biology	Department of Science and Technology, Govt. of India and National Institute of Biology Department of Biotechnology and Systems Biology	June-July, 2012
8.	Manila, Philippines	As an invited expert in 4th European Commssion-Asia Regional Network meeting on GMO Analysis	European Commission, Brussels, Belgium	May, 2012
9.	Ljubljana, Slovenia	First Exchange visit under the bilateral project Novel cost-effective methods for GMO detection - an Indo-Slovenian Inter Governmental Programme of Cooperation at Department of Biotechnology and System Biology at National Institute of Biology	DST, and National Institute of Biology Department of Biotechnology and Systems Biology	September, 2011

10.	Ispra, Italy	As an invited expert in 15th ENGL (European networking on GM detection Laboratories) and also participated in the discussion on Low Level Presence of transgenes	European Commission, Brussels, Belgium	May, 2011
11.	Beirut, Lebanon	As an invited expert in Third Regional Workshop to exchange of information on GMO detection practices and techniques and their progressive harmonization. Two presentations were made on Harmonization of GMO Detection Strategies at Regional and Global Level and Biosafety Clearing House in India, and also chaired the plenary session	FAO, Rome	January, 2011
12.	Ispra, Italy	As an invited expert in 14thENGL (European networking on GM detection Laboratories) and also participated in the discussion on Matrix-based GMO Detection Strategy	European Commission, Brussels, Belgium	November, 2010
13.	Singapore	As an invited expert in 2ndEuropean Commission-Asia Regional Network Meeting on GMO Analysis and made a presentation on GMO Status and GMO Analysis in India	European Commission, Brussels, Belgium	June, 2010
14.	Ispra, Italy	As an invited expert in 13th ENGL (European networking on GM detection Laboratories) meeting and made presentation on Harmonisation of GMO Analysis	European Commission, Brussels, Belgium	May, 2010
15.	Ispra, Italy	As an invited expert in 12th ENGL (European networking on GM detection Laboratories) meeting	European Commission, Brussels, Belgium	December, 2009
16.	Bangkok, Thailand	Resource person on GMO Testing Regional workshop on Biosafety and made presentations on (i) GMO Detection: Emerging Scenario (ii) Global and Regional initiatives in the area of GM detection	FAO, Rome	November-December 2009
17.	Melbourne, Australia	Oral presentation on Qualitative and Quantitative Molecular Testing Methodologies and Traceability Systems for Bt Crops Commercialized or Under Field Trials in India in Fourth International Conference on Co-existence between GM and non-GM based Agricultural Supply Chains	Department of Biotechnology, Govt.of India and Indian National Science Academy	November, 2009
18.	Malaysia	As an invited Indian expert at Regional Meeting on GMO Detection, jointly organized by European Commission and Department of Chemistry, Ministry of Science and Technology, Govt. of Malaysia, Selangor	European Commission, Brussels, Belgium	June, 2009

19.	Malaysia	As an invited expert to represent India to participate in International meeting of Academic Institutions and Organizations involved in Biosafety Education and Training in Kuala Lumpur	UNIDO, Geneva Secretariat of Convention on Biological Diversity, Montreal	April, 2007
20.	Turkey	Participated in ISTA GMO Workshop: Methods for detection and statistical aspects at Edge University, Faculty of Agriculture, Izmir	Indian Council of Agricultural Research, New Delhi	March, 2007
21.	United States	As a part of Indian delegation under the Visited Michigan State University, Michigan US Department of Agriculture (USDA), World Bank, GEF Secretariat, Washington DC and Cornell University, Cornell	Project on Global Environment Facility-(GEF) World Bank for the Implementation of Cartagena Protocol on Biosafety & Ministry of Environment and Forests, Govt. of India	February, 2007
22.	Canada	Visited Canadian Food Inspection Agency, Environment Canada, Canadian Seed Growers' Association, Ottawa Secretariat, Convention on Biological Diversity, Montreal Discussions were held for further collaborations and linkages in the area of different biosafety and regulatory aspects of GM crops		February, 2007
23.	Thailand	As an invited delegate to participate in High Level Policy Dialogue on Biotechnology for Food Security and Poverty Alleviation: Opportunities and Challenges, Bangkok	Asia-Pacific Association of Agricultural Research Institutions (APAARI), Bangkok	November, 2005
24.	Italy	Participated Science and policy in Risk Assessment of Transgenic Plants: A case study approach workshop organized by ICGEB, Trieste	ICGEB, Trieste	April, 1999
25.	France	Participated in Conference on Plant Proteins from European Crops, Nantes, France	Scottish Crop Research Institute (SCRI)	November, 1996
26.	The Netherlands	Participated in 4th International Symposium on the Molecular Biology of Potato, Wageningen	Scottish Crop Research Institute (SCRI)	July 1995
27.	United Kingdom	Participated in the Presidential conference on The Impact of genetic variation on sustainable agriculture at University of Dundee	Scottish Crop Research Institute (SCRI) and University of Dundee	September 1994

Annexure II

Commissioning and successful Implementation of Projects of INR 11.65 Crores funded by National/International Externally Funding Agencies as Principal Investigator/ Co-Investigator during last sixteen years at NBPGR, New Delhi

Department of Biotechnology funded Projects

1. National Containment/Quarantine Facility for Transgenic Planting Material

Phase I - 1999-2002 (**265.14 lakhs**), Phase II -2002-2007 (**107.56 lakhs**)

Phase III -2007-2013 (**98.70 lakhs**) Phase IV 2013-2018 (**116.58 lakhs)**

2. Multi-target System for GM Detection and Quantification in GM Food Crops (2011-2014) Budget: **98.0 lakhs**

3. Referral Centre for Molecular Diagnosis of transgenic planting material (2007-2010) Budget: **111.0 lakhs**

4. Development of PCR based Methods for Testing of Transgenic Planting Material (2002-2007) Budget: **30.0 lakhs**

GEF-UNEP/ World Bank funded Projects

5. Strengthening of Capacities for LMO Detection Activities under UNEP-GEF Supported Phase-II Capacity Building Project on Biosafety (**GMO Detection Research Centre**)**: 100 lakhs**

6. Capacity Building for Implementation of Cartagena Protocol on Biosafety (2004-2007): **30.0 lakhs**; ***Funding by GEF-World Bank***

7. Bioprospecting of Genes and Allele Mining for Abiotic Stress Tolerance: Add on component on Molecular Prospecting and Validation of Transgenes for Abiotic Stress Tolerance in GM crops Establishment of GM Diagnostic Centre (2013-2014): **151.0 lakhs**; ***Funding by NAIP-World Bank***

8. Molecular marker-assisted gene tagging in chickpea for genetic enhancement (1999-2004): **27 lakhs**; ***Funding by NATP-World Bank***

Department of Science & Technology funded Project

9. Novel Cost-effective Methods for GMO Detection, under Bilateral Indo-Slovenian Inter Governmental Programme of Cooperation in Science and Technology (2011-2014): **8.0 lakhs**

Food and Agricultural Organization (FAO), Rome

10. Establishment of National Information Sharing Mechanism on the Implementation of Global Plan of Action for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture in India (2004-2006): **26.0 lakhs**

Annexure III

Professional trainings undergone:

S. No.	Training	Period/Duration	Institution
1.	Application of JMP Genomics in Crop Genome data analysis	27th-28th, February, 2013	Under National Agricultural Bioinformatics Grid, National Agriculture Innovation Project at NBPGR, New Delhi
2.	Management Development Programme on Leadership Development	8th-19th October, 2012	National Academy of Agricultural Research Management, Hyderabad
3.	Laboratory Assessor's as per Course ISO/IEC 17025:2005	3rd-7th December, 2012	National Accreditation Board for testing and calibrations of Laboratories, Dept. of Science & Technology, Govt. of India
4.	Latest Methods for detection and statistical aspects of GMO testing	28th- 31st March, 2007	International Seed Association (ISTA), Edge University, Faculty of Agriculture, Izmir, Turkey
5.	Online course on Intellectual Property Rights	1st October -15th November, 2006	WIPO Worldwide Academy, Geneva
6.	Intellectual Property Rights and World Trade Organization (WTO) related issues	27th June-1st July, 2005	Administrative Staff College of India, Hyderabad
7.	Documentation and Information Management of Plant Genetic Resources	4th-15th, February, 1997	National Bureau of Plant Genetic Resources, New Delhi
8.	Recent Techniques in Plant Biotechnology	10th-31st March, 1992	Biotechnology Centre, IARI, New Delhi
9.	Foundation Course on Agricultural Research Project Management	9th June-2nd November, 1987	National Academy of Agricultural Research Management (NAARM), Hyderabad
10.	Recent Tissue Culture Techniques and Electrophoretic methods	18th -28th May, 1987	Division of Biochemical Sciences, and Tissue Culture Laboratory, National Chemical Laboratory, Pune
11.	Recent Tissue Culture Techniques	1st-6th June, 1987	Department of Plant Biotechnology, Bhaba Atomic Research Centre, Mumbai
12.	International training course on modern methods of potato production	1st-30th June, 1986	Central Potato Research Institute, Shimla

DNA-based GM Diagnostics at ICAR-NBPGR: A Success Story

Knowledge Sharing

2016

'GMO Detection Research Centre' strengthened by UNEP-GEF Project, MoEF&CC, Govt. of India

35 Peer-reviewed Publications, 3 Patents
National and International Hands-on-trainings (15)

Transfer of five GMO screening technologies to M/s DSS Imagetech Ltd., N. Delhi

2015

Participation in Twenty Real-time PCR-based Proficiency Testings
(12 with EC-JRC, Italy, and 8 with GIPSA-USDA) as per ISO/IEC 17043:2010

Participation in Six Inter-laboratory Comparison Programs for PCR-based GM detection

National & International Linkages

2014

Development of Cost-/Time-efficient GM Detection Technologies/Strategies : First Time in India

- ✓ Visual and Real-time Loop mediated isothermal amplification (LAMP) system for GM detection
- ✓ TaqMan Real-time PCR based Multitarget system detecting 47 targets in 5 GM crops
- ✓ GMO matrix as decision support system comprising 141 events of 21 GM crops with 106 targets

2013

Transfer for PCR-based Technologies and Consultancy for establishing GM detection laboratory as per ISO/IEC17025:2005, to PBTI, Mohali and BEDF, Meerut

2012

Participation in Collaborative Ring Trials: To check GM contamination in rice (Organized by Federal Office of Consumer Protection and Food Safety, Germany); To detect and quantify Golden Rice 2 (Organized by Joint Research centre (EC-JRC), Italy)

Strengthening of GM detection laboratory by NAIP, ICAR

2011

Enhancement of Technical Expertise by Linkages with International Laboratories; European Network of GMO Laboratories (ENGL), Italy; National Institute of Biology, Slovenia

Public-Private Partnership

2010

Transfer of PCR-based GM Detection Technology to
M/s Amar Immunodiagnostics, Hyderabad

2009

Development of Quantitative Real-time PCR-based GM Detection Assays
(Brinjal, Cauliflower, Cabbage, Cotton, Maize, Potato, Rice, Tomato and Wheat)

2008

Release of PCR-based GM Diagnostic Kits by the Minister of Science & Technology & Earth Sciences at Press Information Bureau, N. Delhi

2007

2006

Development of PCR/Real-time PCR-based GM Detection Assays
(Brinjal, Cauliflower, Cotton, Maize, Mustard, Okra, Potato, Rice, Soybean,Tomato)

2005

Participation in Three Cross-validation Studies with CFTRI, Mysore and CDFD, Hyderabad

2004

Technologies

2003

Development of PCR-based GM Detection Assays
(Maize, Mustard, Soybean & Wheat)

2002

Establishment of Containment Facility of CL-4 level
and GM Detection Laboratory

2001

DNA-based GM Diagnostics at NBPGR: A Success Story

GM Diagnostic Centre

Participation in Ten (10) Real-time PCR based Proficiency Testings as per International Standards ISO/IEC 17043:2010 ; 7 with JRC, Italy, European Commission, and 3 with GIPSA, USDA and validation studies to check GM contamination in rice with Federal Office of Consumer Protection and Food Safety, Germany

Development of Cost-Effective and Rapid Screening Strategies based on GMO Matrix and Loop Mediated Isothermal Amplification (LAMP)

Consultancy to Punjab Biotechnology Incubator, Mohali and Basmati Export Development Foundation (BEDF, APEDA), Meerut to establish GM Detection Laboratory as per ISO/IEC 2005

Qualified Technical Expert and Assessor as per International Standards ISO/IEC 17025:2005, with NABL, New Delhi

23 Peer Reviewed Publications ; 3 Patents Granted

National and International Validations

Enhancement of Technical expertise by linkages with International Labs; European Network of GMO Laboratories (ENGL), National Institute of Biology (NIB), Slovenia

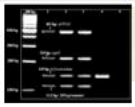
DNA-based diagnostic kits were transferred to Amar Immuno-diagnostics, Hyderabad for commercialization

Public-Private Partnership

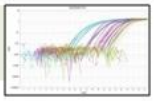
Release of Diagnostic Kits by Sh. Kapil Sibal, Former Minister of Science & Technology & Earth Sciences

Brainstorming Session on GM Chip Technology: Development and Applications" was organized at NBPGR

Imparted hands on trainings at National and International Level (7 National and 1 International level)



Successful completion of three (3) cross-validation studies with Central Food and Technology Research Institute (CFTRI), Mysore and Centre for DNA Fingerprinting and Diagnostics (CDFD), Hyderabad



Development of Qualitative and Quantitative PCR-based GM Detection Methods

Establishment of State of the Art CL-4 level National Containment Facility and GM Detection Laboratory

Development of DNA-based Diagnostics of twelve GM Crops

Cotton, Maize, Rice, Brinjal, Okra, Potato, Tomato, Cauliflower, Cabbage, Soybean

2013
2012
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002
2001

Annexure IV

List of Publications (Year-wise)

1. Singh M, Bhoge RK, & **Randhawa GJ** (2017) Real-time and visual loop-mediated isothermal amplification: Efficient GMO screening targeting pat and pmi marker genes. ***Food Control*** 71, 248-254.
2. Singh M & **Randhawa GJ** (2016) Transboundary movement of genetically modified organisms in India: Current scenario and a decision support system ***Food Cont.*** 68: 20-24.
3. **Randhawa GJ**, Singh M & Sood P (2016) DNA-based methods for detection of genetically modified events in food and supply chain. ***Curr. Sci.*** 110 (6): 1000-1009.
4. Bairwa RK, Singh M, Bhoge RK, Devi C & **Randhawa GJ** (2016) Monitoring adventitious presence of transgenes in ex situ okra (*Abelmoschus esculentus*) collections conserved in genebank: a case study. ***Genetic Resou. Crop Evol.*** 63 (2): 175-184.
5. Bhoge RK, Singh M, Chhabra R, Sathiyabama M & **Randhawa GJ** (2016) Multiplex real-time PCR-based detection and quantification of GM maize events employing SYBR® Green I and TaqMan® chemistries. ***Curr. Sci.*** 110 (8):1446-1451.
6. Bhoge RK, Chhabra R, **Randhawa GJ**, Sathiyabama M & Singh M (2015) Event-specific analytical methods for six genetically modified maize events using visual and real-time loop-mediated isothermal amplification. ***Food Cont.*** 55: 18-30.
7. Singh M, **Randhawa GJ**, Sood P & Bhoge RK (2015) Loop-mediated isothermal amplification targeting insect resistant and herbicide tolerant transgenes: Monitoring for GM contamination in supply chain. ***Food Cont.*** 51: 283-292.
8. **Randhawa GJ**, Chhabra R, Bhoge RK & Singh M (2015) Visual and real-time event-specific loop-mediated isothermal amplification based detection assays for *Bt* cotton events MON531 and MON15985. ***J. AOAC Int.*** 98 (5): 1207-1214.
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