Compendium of Products & Technologies

ICAR-National Research Centre on Plant Biotechnology
(Indian Council of Agricultural Research)
Pusa Campus, New Delhi - 110012, India
(An ISO 9001:2008 Certified Institute)

PREFACE

National Research Centre on Plant Biotechnology (NRCPB) has been identified as the lead Centre for promoting and strengthening plant biotechnology research in the Indian Council of Agricultural Research (ICAR) system. It was established in 1985 as 'Biotechnology Centre', a division of the Indian Agricultural Research Institute (IARI), for catering the applications of modern biotechnological tools in Indian agriculture. Under the aegis of ICAR and support from other funding agencies of Govt. of India, such as DBT, DST, DRDO, CSIR etc. over the years it developed state of the art infrastructure facilities and high level of scientific acumen in its human resources. Later in 1993, the centre was upgraded as the National Research Centre on Plant Biotechnology with a mandate of serving as the lead centre, of molecular biology and biotechnology, for research as well as training of human resources in National Agricultural Research & Education System (NARES). In research, development of transgenic crops for improved agronomic traits, heterosis breeding through marker and genomic approaches, structural and functional genomics of major crops, molecular breeding for productivity and quality enhancement, isolation of agronomically important genes and promoters, are the major research areas being pursued in the centre. In human resource development, the centre offers M. Sc and Ph. D programmes in Molecular Biology and Biotechnology (MBB) as a part of IARI-PG school and conducts several short- and long term training programmes for NARES scientists. This compendium is an attempt to showcase a few significant research achievements of the centre that have been translated into products or technologies in Indian agriculture. It also captured a real time enumeration of NRCPB's contribution in generating skilled human resource in plant biotechnology at the national and international levels. I thank all those who have contributed in achieving these milestones and in composing this document.

T R Sharma

Project Director, ICAR-NRCPB, New Delhi

Features of Pusa Jai Kisan

Height	180 cm
Maturity	130-140 days
Test weight	6 g/1000 seeds
Oil content	37-39%
Yield	22-25 Q/ha

Pusa Jai Kisan

Background

Indians heavily depend on rapeseed-mustard for their edible oil requirement. Presently rapeseed-mustard contributes 28.6% in the total oilseed production. The demand for edible oil in the country is expected to be around 24 million tonnes of oilseed by 2020 AD. Therefore, application of molecular biology and tissue culture techniques for developing high yielding mustard plant-types has been a mandate of research at ICAR-NRCPB since its inception.

Technology Developed

A high yielding mustard variety called 'Pusa Jai Kisan' has been developed by the centre using tissue culture generated somaclonal variation. While developing this high yielding variety, a popularly known commercially released mustard variety, Varuna (Type 59) was used as a donor parent for creating somaclonal variation. For tissue culture, hypocotyl region of young seedlings were cultured on artificial medium supplemented with growth hormones. The resulting R-2 generation plantlets were examined for variation and some of them were selected and field tested. One of such selected variants (Selection Bio-902) showed promising results in terms of higher yield over the parent.

Benefits

Bio-902, later commercially released as Pusa Jaikisan performed best for seed yield and other important traits in coordinated trials in Zone IV and demonstrated 17.4% and 19.7% yield superiority over the best performing national varieties like Varuna and Kranti, respectively. Though it was initially released for Rajasthan & parts of Maharastra, in subsequent years it was widely adopted by the farmers of almost entire northern India. Because of its popularity among the farmers and superiority over the other varieties, demand for breeder seed remains very high even after 17 years of its release.

Hybrid Mustard

Background

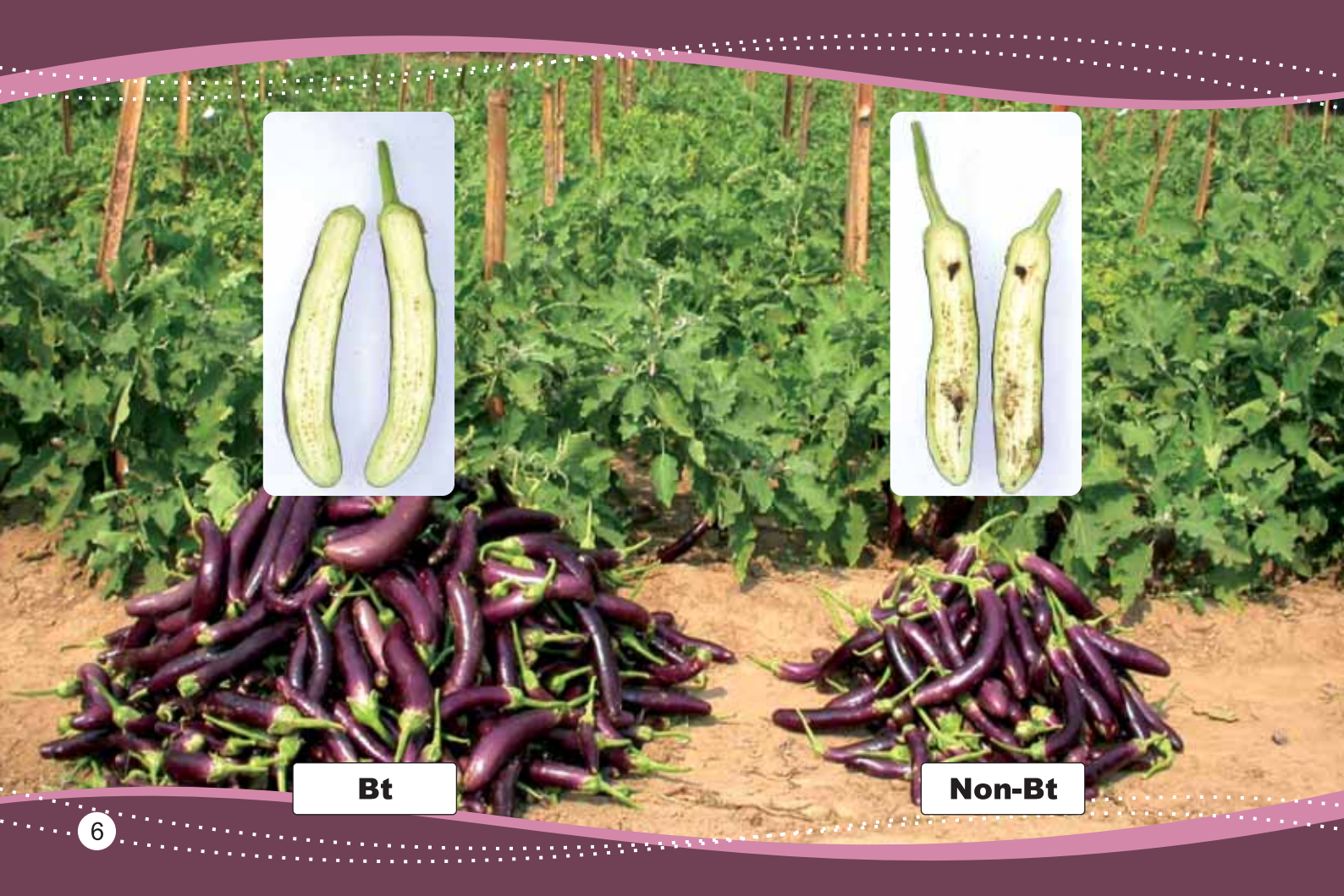
Indian mustard (*Brassica juncea*) is the most preferred oil seed crop especially by people from northern & eastern parts of India for cooking purposes. However, productivity of mustard is low in India compared to its global average. Use of hybrid seeds in mustard cultivation can potentially increase mustard productivity. ICAR-NRCPB has developed several novel cytoplasmic male sterile (CMS) and fertility restorer (Rf) lines of Indian mustard (*Brassica juncea*) through sexual or somatic hybridization.

Technology Developed

For the first time in mustard the cytoplasmic male sterile (CMS) and fertility restorer lines involving a cytoplasm of wild relatives such as *Brassica oxyrhina, Diplotaxis catholica, D. berthautii, D. reucoides, Trachystoma ballii* and *Moricandia arvensis* have been developed at ICAR-NRCPB. Subsequently, *M. arvensis* based CMS and fertility restorer lines have been distributed to Indian mustard breeders for developing commercial hybrids.

Benefits

New mustard hybrids developed by the centre have shown over 17% yield advantage in field trials. Using *M. arvensis* based CMS system, the first mustard hybrid was developed by ICAR-DRMR, Bharatpur which was released as NRC Sankar Sarson. Another hybrid was developed by Adventa India Ltd. The CMS systems developed by ICAR-NRCPB are being used by both public sector and private seed industries for developing hybrids.


Bt
Non-Bt

Bt Brinjal

Background

Brinjal is one of the most commonly grown and consumed vegetable crops in India. This crop is cultivated even by small and resource-poor farmers. A major difficulty to the brinjal growing farmers is damage of fruits by insect-pest Brinjal Shoot and Fruit Borer (BSFB), which often causes significant yield losses amounting up to 70%. Because of the cryptic nature of the pest, topical application of insecticide remains ineffective on the insect-larvae. Also, residual toxicity of the pesticides raises serious concerns to human health and environment. ICAR-NRCPB has developed transgenic plants of brinjal resistant to BSFB by incorporating an in house developed new Bt gene (*cry1Fa1*) using modern biotechnological tools.

Technology Developed

The novel Bt gene (*cry1Fa1*) has been introduced and the protein was expressed in the brinjal variety Pusa Purple Long. The field testing has shown that the Bt-expressing lines are either totally protected or only negligibly affected by BSFB. The Bt gene *cry1Fa1* has been given to many ICAR institutes and liscenced to different companies under public-private-partnership mode.

Benefits

Fruit damage by BSFB in Bt-expressing lines was significantly less (4-7%) compared to the non-Bt lines which were heavily damaged by BSFB to an extent of 35-43%. One of the transgenic lines named as "Event 142" found to be most effective against BSFB was intensively characterized and licensed to private seed companies for biosafety testing and commercialization.



Leaf, neck and seedling blast infection in rice

Leaf and Panicle blast resistant line (nrcpb-lpbd04)


Panicle blast susceptible recurrent parent line

Donor Rice Line for Blast Resistance Gene *Pi54*

Background

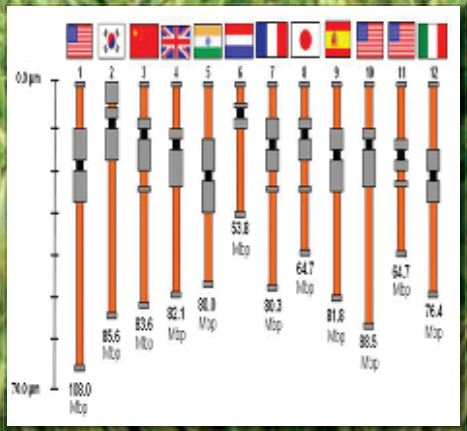
Biotic stresses like rice blast, bacterial leaf blight, sheath blight and stem borer limit rice productivity wherever rice is grown. Of these stresses, rice blast caused by *Magnaporthe oryzae* is a serious constraint in rice production at global level. None of the rice cultivars possesses durable resistance to blast disease because of the highly variable nature of the pathogen. Although chemical control of the disease is feasible, it remains environmentally unsafe. Development of cultivars with genetic resistance to blast is pivotal for sustainable management of the disease.

Technology Developed

A durable blast resistant gene *Pi54* (*Pik*^{h}) was identified and cloned from the *indica* rice line Tetep exhibiting resistance to several strains of *M. oryzae*. The *Pi54* gene, located on chromosome 11, is a dominant and atypical NBS-LRR gene having unique zinc finger domain. Functional complementation indicated that this gene provides stable and high level of resistance to leaf and neck blast against geographically diverse strains of *M. oryzae* collected from different parts of India. This gene is linked with DNA makers which can be effectively used for Marker Assisted Selection (MAS).

Benefits

Blast resistant rice line nrcpb-lpbd04 (where; lpbd stands for leaf and panicle blast donor) is a unique source of blast resistance gene *Pi54* which provides resistance to both leaf and panicle blast. We have also developed DNA markers linked to this gene for use in marker assisted selection. The source of the gene and the markers provide an opportunity to the rice breeders for rapid development of commercial varieties or hybrids of rice resistant to blast disease. The donor line is *indica* type, homozygous and ready for use in MAS. This gene has already been used in developing more than 25 rice varieties in NARES.


0.0 μm
74.0 μm
1
2
3
4
5
6
7
8
9
10
11
12
85.6 Mbp
83.6 Mbp
82.1 Mbp
88.0 Mbp
53.8 Mbp
80.3 Mbp
64.7 Mbp
81.8 Mbp
88.5 Mbp
64.7 Mbp
76.4 Mbp
108.0 Mbp


57.3 cM
110.1 cM
Chromosome Sharing
in IRGSP [Feb. 2002]

Crop Genome Sequences

Background

Sequencing of crop genome has always been a priority among the researchers for developing resources for crop improvement. ICAR-NRCPB has been developed as an advanced centre with state of the art facility for undertaking genome sequencing projects since its first participation in the International Rice Genome Sequencing Project (IRGP). Subsequently it joined hands in International Tomato Genome Sequencing Consortium, International Wheat Genome Sequencing Consortium etc. It has also demonstrated capacity to undertake genome sequencing project of its own by completing the first draft of pigeonpea genome sequence.

Technology Developed

ICAR-NRCPB successfully completed sequencing long arm of rice chromosome 11 in IRGP, chromosome 5 of tomato in Tomato Genome Sequencing Consortium, and chromosome 2A in Wheat Genome Sequencing Consortium in collaboration with UDSC and PAU. It also completed first draft of pigeonpea genome sequence being the nodal centre and demonstrated for the first time the nation's capability to complete genome sequencing project of its own. The centre is also working on generation of draft sequence of more crops like mango, guar, black gram and microbes.

Benefits

Crop genome sequencing information offers various applications in crop improvement. The benefits of sequence information are enormous in both basic and applied research. This will help in identification and characterization of important genes, superior alleles and development of DNA markers for marker assisted selection etc.

Bacterial leaf blight

Infected leaves

Healthy leaves

Improved Pusa Basmati-1

Background

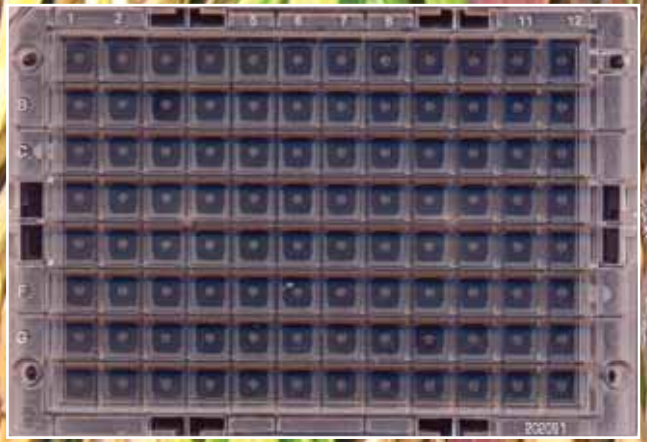
Basmati rice, a gourmet's delight, is widely popular because of its distinct aroma, extra-long slender grains, fluffy texture of cooked grain, palatability and easy digestibility. Owning to its unique characteristics, the demand for this 'Scented Pearl' is high not only in domestic market but also in the international market. India is the leading exporter of the Basmati rice to the global market. The country has exported arround 37.6 lakh MT of Basmati rice to the world for the worth of around Rs. 29.3 thousand crores during the year 2013-14. One of the bottlenecks in productivity of Basmati rice is susceptibility of most of the Basmati varieties to Bacterial Leaf Blight (BLB) disease caused by *Xanthomonas oryzae* pv. *oryzae (xoo).*

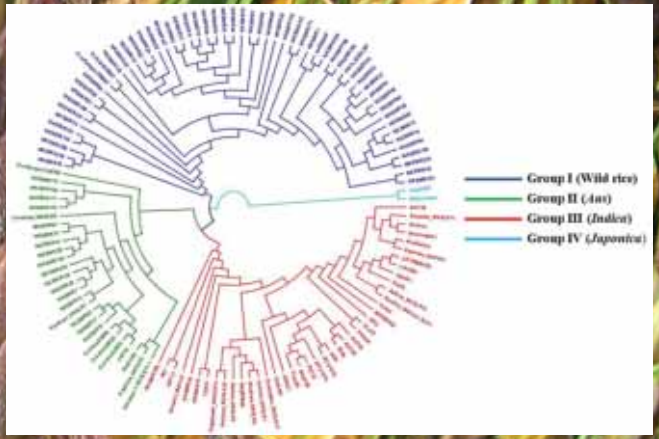
Technology Developed

ICAR-NRCPB has played a pioneer role in developing a new bacterial blight resistant Basmati rice variety known as 'Improved Pusa Basmati 1' and its release for commercial cultivation. ICAR-NRCPB scientist in collaboration with Division of Genetics, ICAR-IARI have transferred two BLB resistant genes namely, *Xa21* and *xa13* from the donor line IRBB5 into the existing cultivar Pusa Basmati through Marker Assisted Selection (MAS). Molecular markers linked to these genes were used in genotypic selection in backcross generation. One of the selected lines (INGR No. 05002) has been registered with NBPGR.

Benefits

The BLB resistant Basmati rice i.e. Improved Pusa Basmati 1, has shown 11.9% higher yield as compared to the national check variety Pusa Basmati 1 and 33.5% more yield over Taraori Basmati in agronomic trials.




Group I (Wild rice)
Group II (Aus)
Group III (Indica)
Group IV (Japonica)


1
2
3
4
5
6
7
8
9
10
11
12

50K SNP Chip in Rice for Molecular Breeding

Background

Rice is the primary source of dietary calories for half of the human population. Innovative use of genetic diversity in domesticated and Indian wild germplasms of rice plays a significant role in productivity enhancement of rice. Single nucleotide polymorphism (SNP) is the most abundant form of DNA sequence variation present in the genome. Comprehensive SNP data provide an opportunity for deep exploration of rice diversity and gene-trait relationships in rice improvement.

Technology Developed

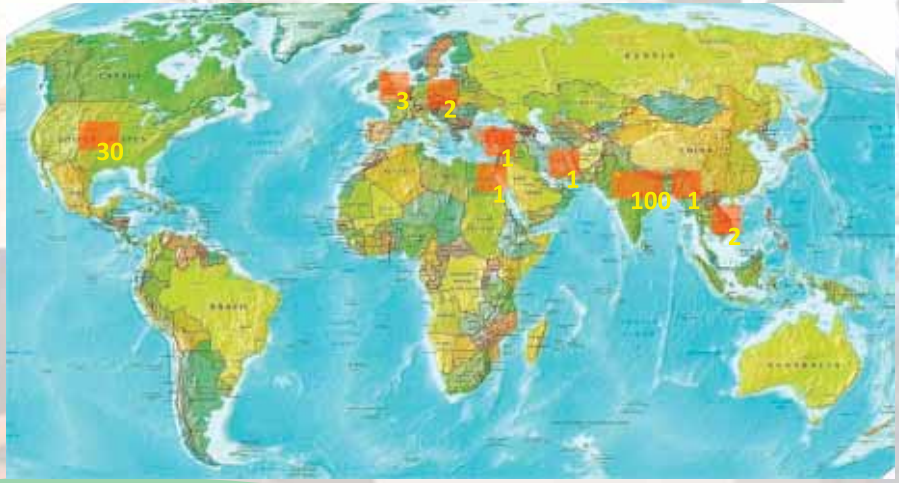
The centre designed and validated a unique SNP genotyping chip for genetic, evolutionary studies and molecular breeding applications in rice. The chip is based on 50,051 SNPs in 18,980 different genes from across the 12 rice chromosomes, including 3,710 single-copy genes conserved between wheat and rice, 14,953 single-copy genes unique to rice, 194 agronomically important cloned rice genes and 123 multi-copy rice genes. The functionality of the chip was validated on 192 rice genotypes including improved cultivars, landraces and Indian wild rice germplasms.

Benefits

The chip showed high success rate and reproducibility due to single-copy gene based assay, with no sequence redundancy and cross hybridization problems. The SNP density in conserved single-copy genes was about three times higher than in unique single-copy rice genes due to ancient origin of the conserved genes. Inclusion of SNPs from agronomically important cloned rice genes provides an opportunity for rice geneticists to identify novel alleles for these traits.

Post Graduate Programme at ICAR-NRCPB

The students of Molecular Biology and Biotechnology (MBB), enrolled in M.Sc and Ph.D programme of IARI, are nurtured in rich academic environment of ICAR-NRCPB and trained for research in the area of plant molecular biology and biotechnology. The institute has been instrumental in shaping the career of its students. The students graduated from this centre have been successful in getting placements in different R & D labs including ICAR, other government and private institutes, industries and foreign labs.



Placement of MBB Students

Organisations		No. upto 2015
R&D	ICAR & SAU	70
	Other	43
Private academicia		10
Industries		14
Foreign Labs		13
Govt. Jobs		5
Total		**155**

Training of Graduate/Post Graduate Students

Being a government funded institute ICAR-NRCPB undertakes training and guidance of the graduate and post-graduate students from other universities across the country. The students carry out their 3-6 months dissertation work at this centre for partial fulfillment of their graduation and post-graduation degree.

Post Graduate students trained at NRCPB

Year	No. of trainees
2008-09	25
2009-10	9
2010-11	42
2011-12	66
2012-13	47
2013-14	38
2014-15	32
Total	**259**

Development of Skilled Human Resource

Development of skilled human resource in the field of plant molecular biology and biotechnology is one of the mandates of the centre. The centre conducts training programmes for up-gradation of scientists and faculties from ICAR and State Agricultural Universities. NRCPB conducts trainings for 8 -21 days, which are funded by ICAR, NPTC, NAIP, DBT and DOE, Ministry of Agriculture etc. For disseminating recent developments in the field of modern biology among the school children, the centre organizes workshops for the school teachers and plays important role in skill India mission of the Government.

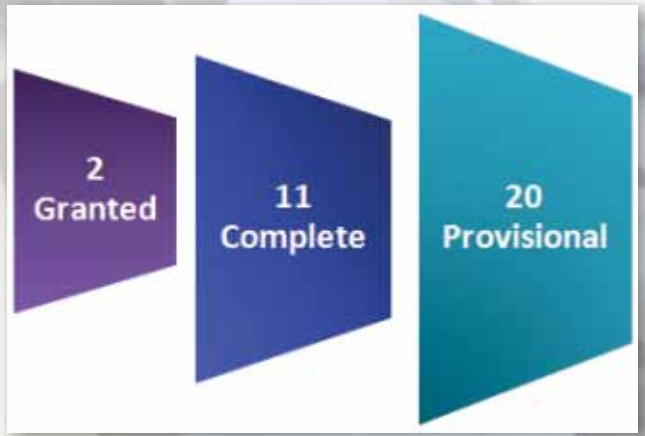
No. of Scientists/Teachers trained (till 2015)

Year	No.
1985-1990	120
1991-1995	40
1996-2000	80
2001-2005	240
2006-2010	40
2011-2015	80
Total	**600**

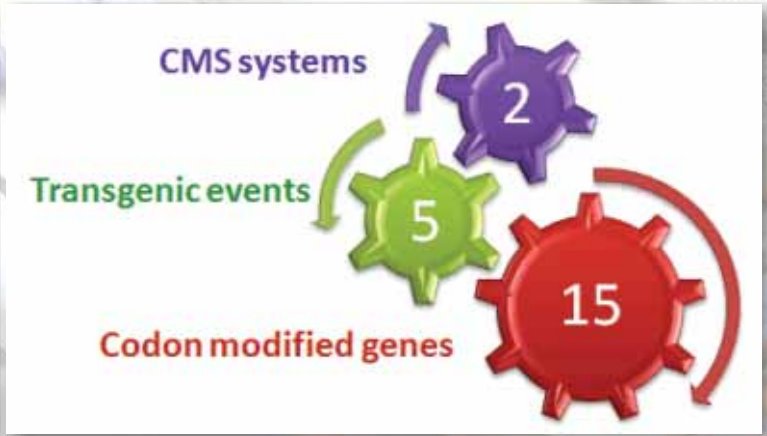
Patents and MoUs

The research mandates of ICAR-NRCPB are oriented around the development of products, processes and patents for advancement of Indian agriculture. The products and patents developed at the centre are commercialized through public-private-partnerships. The centre owns several patents that are at different stages of processing. For commercialization of some of its research products, such as CMS system for hybrid mustard development, codon modified genes, transgenic events etc., ICAR-NRCPB has signed 22 MoUs upto 2015 with private seed companies.

Patents



MoU



Notes


लाल बहादुर शास्त्री केन्द्र
LAL BAHADUR SHASTRI CENTRE
NRC

Designed & Composed by

R.C. Bhattacharya | J.C. Padaria | Monika Dalal | S.K. Sinha

Published by

Dr T.R. Sharma

Project Director

ICAR-National Research Centre on Plant Biotechnology

Lal Bahadur Shastri Centre, Pusa Campus, New Delhi-110012, India

Telephone: +91-11-25848783; Fax:+91-11-25843984

Website: http://www.nrcpb.res.in