ANNUAL REPORT
2015–16

ICAR
ICAR-Directorate of Rapeseed-Mustard Research
(Indian Council of Agricultural Research)
Sewar, Bharatpur 321 303 (Rajasthan) India
(An ISO 9001:2008 Certified Organization)

भाकृअनुप
ICAR

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Indian Council of Agricultural Research (ICAR) established ICAR- Directorate of Rapeseed-Mustard Research as a national repository for rapeseed-mustard genetic resources and also for undertaking basic, strategic and applied research to enhance the productivity and quality of oil and seed-meal. The Directorate is assigned the leadership role, not only for the ICAR institutes but also for the Central and State Agricultural Universities, in developing ecologically sound and economically viable agro-production and protection technologies for rapeseed-mustard based on location specific interdisciplinary information through multi-location testing and co-ordination. With a view to further the cause of Yellow Revolution, the Directorate has the responsibility to establish linkages and promote co-operation with national and international agencies in relation the problems of regional and national importance and to extend technical expertise and consultancies in this area.

ICAR-Directorate of Rapeseed-Mustard Research
(Indian Council of Agricultural Research)
Sewar, Bharatpur 321 303 (Rajasthan) India

ICAR-DIRECTORATE OF RAPESEED-MUSTARD RESEARCH
SEWAR, BHARATPUR- 321 303 (RAJASTHAN), INDIA

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ICAR-Directorate of Rapeseed-Mustard Research
(Indian Council of Agricultural Research)
Sewar, Bharatpur-321 303 (Rajasthan), India

Guidance : **Dr. Dhiraj Singh**

Editors : **Dr. Pankaj Sharma, Dr. R. S. Jat, M.S. Sujith Kumar, Reema Rani and Prashant Yadav**

Photography : **Mr. Rakesh Goyal**

Published by : **Dr. Dhiraj Singh**
Director, ICAR- Directorate of Rapeseed-Mustard Research
Sewar, Bharatpur-321 303 (Rajasthan), India
Phone: +91-5644-260379, 260495
Fax: +91-5644-260565
e-mail: director.drmr@gmail.com
Web: http://www.drmr.res.in

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MISSION

Harnessing science and resources for sustainable increase in productivity of Rapeseed-Mustard

Preface

I deem it a great privilege to present 23rd Annual Report of ICAR-Directorate of Rapeseed-Mustard Research comprising salient research achievements and development programmes carried out during the year 2015-16. A new high yielding variety "DRMR 150-35 (Bharat Sarson 7)" has been identified during 22nd AGM of AICRP-RM for early sown rainfed condition in zone V (Bihar, West Bengal, Orissa, Assam, Chhattisgarh, Jharkhand and Manipur). Mustard strain DRMR 1165-40 has been promoted to AVT I in two zones i.e. timely sown (rainfed) zone II and timely sown (rainfed) zone V while DRMRIJ 14-01was inducted for evaluation under timely sown irrigated conditions and promoted to advance stage testing (AVT 1) in zone IV. The major highlights were strengthening of pre-breeding efforts. Previous efforts of widening the genetic base of Indian mustard varieties through re-synthesis were intensified. DRMR-WFYSM 15 genotype having specific traits viz. white flower, yellow seed colour and appressed silique was developed through mutation breeding (gamma irradiation). Standardization of artificial induction of tetraploidy in inter-specific crosses of diploid Brassica species (*B. rapa* x *B. nigra*) has been achieved. A Core set of 147 Indian mustard accessions and trait specific set of 135 accessions were evaluated using 17 agro-morphological traits to facilitate the better utilization of available genetic resources. Arabidopsis derived intron polymorphic markers At5g41560 and At2g36360 linked with white resistance loci AcB1-A4.4 and AcB1-A5.1 were validated and confirmed in white rust resistant donor varieties.

Crop management studies focused upon standardization of (RCTs), enhancing water and nutrient use efficiency. Evaluation of three land use management levels on four oilseed Brassica production system revealed that conventional fertility management significantly improved the mustard seed yield in long term field trial. Dialle crosses were attempted to develop multiple disease resistance. Genotype RH-1231, RH-1239, RH-1235, RH-1230, RH-345 were identified as white rust resistant and RH-1372, RH-1378, RH-1117 showed tolerance to Alternaria blight. The investigation on screening of germplasm lines (>1500) for Sclerotinia rot resistance with artificial stem inoculation technique identified EC 597317, EC 597328, WR 2035, RH1222-28, DRMR 360, DRMR 1493, DRMR 1034 and DRMR 261 as tolerant reaction. Sclerotinia rot management technology was developed and disseminated to farmers. 11 training programmes, one MTC, 6 exhibitions and one winter school were organized at the Directorate. During Beej Pakhwara >500 q quality seed of mustard varieties was sold to farmers. A total of 24 instructional episodes were broadcasted through 10 all India Radio stations. Mera Gaon Mera Gaurav programme scheme was implemented and 25 FLDs were conducted in villages adopted by Directorate. ICAR-DRMR established an apiculture unit and launch of "Siddarth Honey" was done by Hon'ble Minister of State Agriculture and Farmer Welfare Dr. Sanjeev Kumar Balyan.

A brain storming session on "Roadmap for Rapeseed-Mustard" was organized under the chairmanship of Padmabhushan Dr. R.S. Paroda, Ex-DG, during 22ndFoundation Day on 20th October, 2015.Sarson Vigyan Mela, the flagship programme of our institute for farmers was inaugurated by Hon'ble Minister of State for Agriculture and Farmers Welfare, Shri. Mohan Bhai Kundariya. The three day event was a grand success as more than 5000 farmers, farm women, and extension workers participated. In collaboration with DUVASU, Mathura one day awareness cum seed production mela was organized at Madhurikund Farm, Mathura.

With the sense of humility and gratitude, I place on record my heartfelt thanks to Dr. S. Ayyappan, Ex-Secretary DARE and DG; Dr. T. Mohapatra Secretary, DARE and DG, ICAR; Dr. J.S. Sandhu, Deputy Director General (Crop Science) and Dr. B.B. Singh, Assistant Director General (Oilseeds & Pulses) of the Council for their meticulous direction, support and encouragement.

I convey my sincere thanks to all the scientific, technical, administrative and supporting staff for their admirable contributions to this report and also bringing recognition to the Directorate. My sincere appreciation and thanks are due to the editors, Drs. Pankaj Sharma, R.S. Jat, Mr. M.S. Sujith Kumar, Ms. Reema Rani and Mr. Prashant Kumar for their conscientious efforts in bringing out the achievements of the Directorate in the present form.

ICAR-DRMR, Bharatpur
June 30, 2016

D. Singh 30/6/16

(Dhiraj Singh)

Abbreviations

AAU	Assam Agricultural University/ Anand Agricultural University
ADG	Assistant Director General
AICRP	All India Coordinated Research Project
AICRP-RM	All India Coordinated Research Project on Rapeseed-Mustard
ANMR	Additional Net Monitory Return
ARS	Agriculture Research Station
ATMA	Agricultural Technology Management Agency
AVT	Advance Varietal Trial
BARC	Bhabha Atomic Research Center
BAU	Birsa Agricultural University
CAZRI	Central Arid Zone Research Institute
CMS	Cytoplasmic Male Sterility
CIAH	Central Institute of Arid Horticulture
CSAUAT	Chandra Shekhar Azad University of Agriculture and Technology
CV	Coefficient of Variance
DAC	Department of Agriculture and Cooperation
DARE	Department of Agriculture Research and Education
DAS	Days After Sowing
DDG	Deputy Director General
DM	Dry matter/Downy Mildew
DMAPR	Directorate of Medicinal and Aromatic Plant Research
DRMR	Directorate of Rapeseed-Mustard Research
DSI	Drought Stability Index
DST	Department of Science and Technology
DSR	Directorate of Seed Research
DUS	Distinctiveness, Uniformity and Stability
DUSC	Delhi University South Campus
EDI	Entrepreneurship Development Institute of India
FIGs	Farmer Interest Groups
FIRB	Furrow Irrigated Raised Bed System
FLD	Front Line Demonstration
FYM	Farm Yard Manure
GCV	Genotype Coefficient of Variance
IAA	Indole Acetic Acid
IARI	Indian Agricultural Research Institute
IASRI	Indian Agricultural Statistics Research Institute
IBCR	Incremental Benefit Cost Ratio
ICAR	Indian Council of Agricultural Research
IIAB	Indian Institute of Agricultural Biotechnology
IIOR	Indian Institute of Oilseed Research
IHT	Initial Hybrid Trial
IJSC	Institute Join Staff Council
IPR	Intellectual Property Right
IRC	Institute Research Council/International Rapeseed Congress
ISTM	Institute of Secretariat Training & Management
IVT	Initial Varietal Trial
KVK	KrishiVigyan Kendra
LT	Latest Release
LAMP	Linux, Apache, MySQL and PHP Technology
MBC	Microbial Biomass Carbon
MEY	Mustard Equivalent Yield

MoU	Memorandum of Understanding
MPUAT	MaharanaPratap University of Agriculture and Technology
MPKV	Mahatma PhuleKrishiVidyapeeth
MS	Murashage Skoof
MSI	Membrane Stability Index
MSI	Mustard Straw Incorporate
MSL	Mean Sea Level
MTC	Model Training Course
MUFA	Mono Unsaturated Fatty Acid
NAARM	National Academy of Agricultural Research and Management
NAAS	National Academy of Agricultural Sciences
NBPGR	National Bureau of Plant Genetic Resource
NC	National Check
NCD	North Carolina Design
NDN	National Disease Nursery
NGO	Non-Government Organization
NIFM	National Institute of Financial Management
NPTC	Network Project on Transg[illegible]n Crops
NRCPB	National Research Centre of Plant Biotechnology
PAU	Punjab Agricultural University
PCR	Poly cyclic Chain Reaction
PCV	Phenotypic Coefficient of Variance
PPV&FRA	Protection of Plant Varieties & Farmers Rights Authority
PMC	Pollen Mother Cells
PRWC	Percent Relative Water Content
PSB	Phosphorus Solubilizing Rhizobacteria
PUFA	Poly Unsaturated Fatty Acid
RAC	Research Advisory Committee
RCBD	Randomized Complete Block Design
RDF	Recommended Dose of Fertilizers
RCT	Resource Conservation Technology
RFD	Results-Framework Document
R&M	Rapeseed & Mustard
RRS	Regional Research Station
RVSKVV	RajmataVijayaraje Scindia Krishi Vishwa Vidhyalaya
RWC	Relative Water Content
SAC	Space Applications Centre
SAU	State Agricultural University
SDA	State Department of Agriculture
SDAU	Sardar Dantiwada Agricultural University
SGM	Sesbania Green Manure
SIAM	State Institute of Agriculture Management
SKRAU	Swami Keshwanand Rajasthan Agricultural University
SOC	Soil Organic Carbon
SPS	Single Plant Selection
SSG	Supporting Staff Grade
STMS	Sequence Tagged Microsatellites
TSP	Tribal Sub Plan
UAS	University of Agriculture Sciences
VPKAS	Vivekanand Parvatiya Krishi Anusandhan Sansthan
WHO	World Health Organization
WP	Wettable Powder/Whole Pacakge
WSC	Wide Spaced Crop
WUE	Water Use Efficiency
ZC	Zonal Check

Executive Summary

- Indian mustard variety DRMR 150-35 (Bharat Sarson 7) was identified during 22nd AGM of AICRP-RM for early sown rainfed condition in zone V (Bihar, West Bengal, Orrisa, Assam, Chhattisgarh, Jharkhand and Manipur).
- Entry DRMR 1165-40 has been promoted to AVT I in two zones *i.e.* timely sown (rainfed) zone II and timely sown (rainfed) zone V.
- DRMRIJ 14-01 [(MJA27 x MJR9) x IJ 31] inducted during 2014-15 for evaluation under timely sown irrigated conditions. It was promoted to advance stage testing (AVT 1) in zone IV.
- Core set of 147 Indian mustard accessions were evaluated using 17 agro-morphological traits. Trait specific set of 135 accessions were also evaluated.
- A new genotype DRMR-WFYSM15 has been developed through mutation breeding (gamma irradiation) having specific traits *viz*. white flower, yellow seed colour and appressed silique. Artificial induction of tetraploidy in inter-specific crosses of diploid Brassica species (*B. rapa* x *B. nigra*) has been standardized.
- A simple, rapid and reliable PCR based assay has been utilized for detecting *Orobanche aegyptiaca* infestation in mustard crop fields.
- Arabidopsis derived intron polymorphic markers *At5g41560* and *At2g36360* linked with white resistance loci AcB1-A4.4 and AcB1-A5.1 were validated and confirmed in white rust resistant donor varieties.
- In long term experiment with four oilseed Brassica production system with three land use management levels, conventional fertility management significantly improved mustard seed yield by 25.4% over MML.
- More than 1500 germplasm lines screened for Sclerotinia resistance with artificial stem inoculation technique. Germplasm EC 597317, EC 597328, WR 2035, RH1222-28, DRMR 360, DRMR 1493, DRMR 1034 and DRMR 261 were showed tolerant reaction.
- Dialle crosses were attempted to develop multiple disease resistance. RH-1231, RH-1239, RH-1235, RH-1230, RH-345 were identified as resistant to white rust and RH-1372, RH-1378, RH-1117 were observed tolerant to Alternaria blight.
- KVK (ICAR-DRMR), Bansur was conferred with Best Interdisciplinary Team Research award by SSDAT. Six scientists of directorate were awarded /recognized by different societies/ organizations for their meritorious contributions.
- Winter school was organized on "New Paradigms in diseases management: Conventional and Molecular Approaches for rapeseed-mustard production".
- 8.1,0.28,1.3,0.03 and 0.11 q breeder seeds of NRCHB 101, NRCDR 02, Giriraj, DRMR 601 and NRCYS 5-2 respectively, was produced during 2014-15.
- A total of 24 instructional episodes were broadcasted through 10 All India Radio stations. Eleven training programmes of 2-5 days, one model training courses, 6 exhibitions were organized. 100 FLDs were conducted under Mera Gaon Mera Gaurav and 500 FLDs were conducted under NMOOP.
- 539.8 q quality seed of mustard varieties was produced.
- A total of 36 research papers, 3 technical bulletins, 14 technical folders, one book and 3 book chapters were published.
- Dr. Dhiraj Singh, Director and Dr. Pankaj Sharma, Senior Scientist participated in 14th International Rapeseed Congress held at Saskatton, Canada during July 5-9, 2015.
- Resources worth Rs 4782071 were generated.

1 ICAR-DRMR: *An Overview*

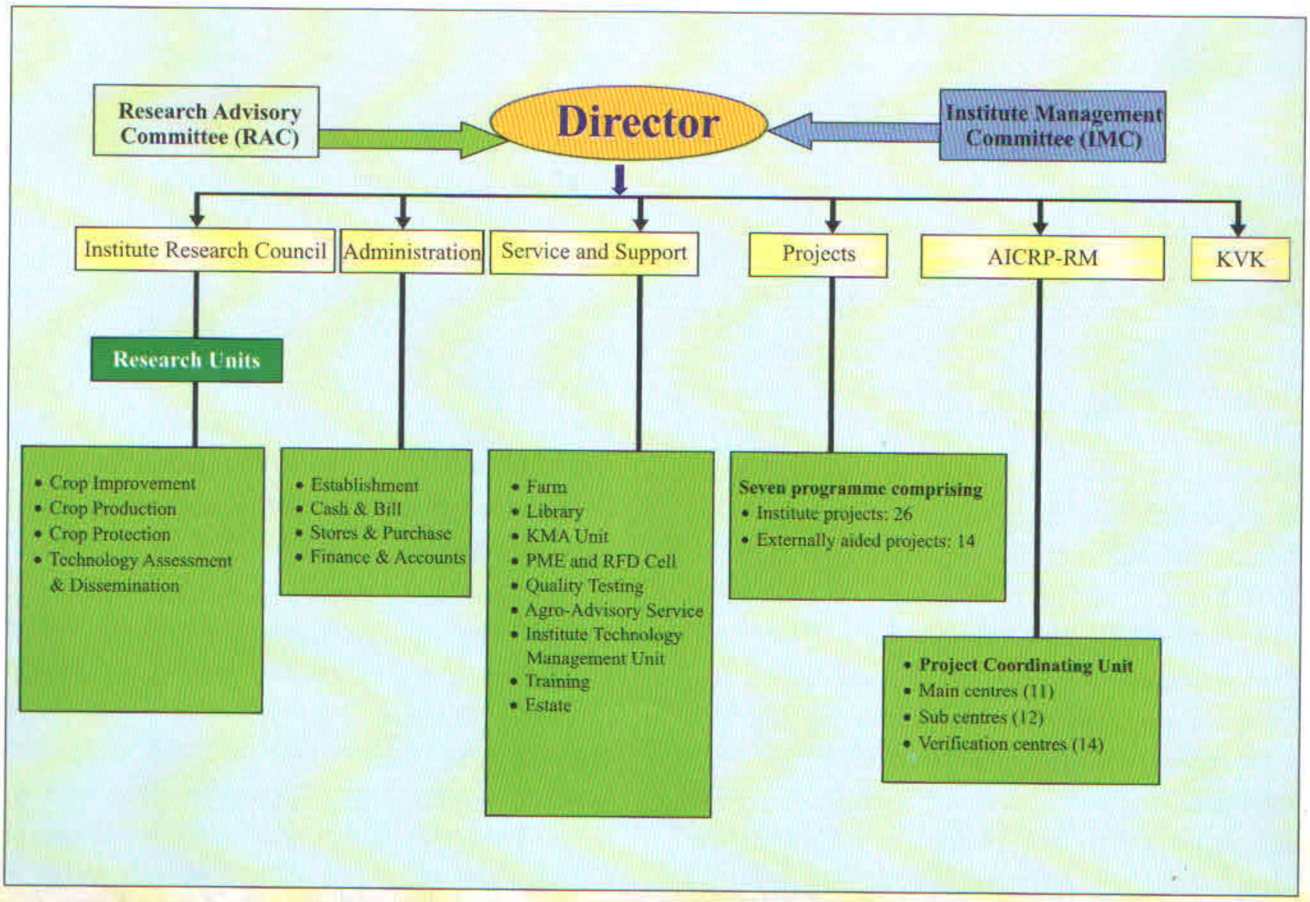
Indian Council of Agricultural Research established All India Coordinated Research Project on Oilseeds (AICRPO) in April 1967 for the improvement of oilseeds in the country. Setting up separate Project Coordinating Unit in the V plan (1974-79) further strengthen the research program on oilseeds, especially rapeseed-mustard. Accordingly, the Rapeseed-Mustard Project Coordinating Unit was established on January 28, 1981, at Haryana Agricultural University, Hisar. During VII Plan (1992-97) on October 20, 1993, ICAR established the National Research Centre on Rapeseed-Mustard (NRCRM) to carry out basic, strategic and applied research on rapeseed-mustard at Adaptive Trial Centre of the State Department of Agriculture, Govt. of Rajasthan at Sewar, Bharatpur on the recommendation of the Task Force constituted in 1990. The centre has been upgraded as Directorate of Rapeseed-Mustard Research in the XI Plan (2007-12). Besides, generating basic knowledge and materials, it also engages in developing ecologically sound and economically viable agro-production and protection technologies. The Directorate also has the responsibility to plan, coordinate and execute the research program through a wide network of 11 main and 12 sub-centres across the country in addition to need-based verification centres under the umbrella of AICRP-RM to augment the production and productivity of rapeseed-mustard. The Directorate is located 7 and 3 km away from the Bharatpur railway station and bus stand, respectively on Agra-Jaipur national highway. Bharatpur, internationally known for Keoladeo National Bird Sanctuary, is on the Delhi-Mumbai main railway track just 36 km ahead of Mathura (UP) and well connected with Jaipur, Delhi, and Agra by road and rail. The campus of the Directorate is spread over an area of 44.21 ha of which about 80% is experimental, and the rest is covered by Administrative-cum—Laboratory building and residential complex. It is situated at 77.27° E longitude and 27.12° N latitude and is 178.37m MSL. The DRMR functions as a fulcrum to support the production system research through different research, service and support units (see organogram) with basic technologies and breeding materials for rapeseed (yellow sarson, toria, taramira, gobhi sarson) and mustard (Indian mustard, Ethiopian mustard) crops.

Objectives

- Utilizing frontier research for better exploitation of genetic resources.
- Development and identification of appropriate production-protection technologies.
- Capacity building and knowledge management through technology assessment, refinement and dissemination.

Functions

- The National repository of rapeseed-mustard genetic resources and information.
- Basic, strategic and applied research improve the productivity and quality of oil and seed meal.
- Development of ecologically sound and economically viable production and protection technologies for different situations.
- Generation of location specific interdisciplinary information based on multi-location testing and coordination.
- Establishment of linkages and promotion of cooperation with national and international agencies to achieve above objectives.
- To extend technical expertise and consultancies.



2 Research Achievements

2.1 Genetic enhancement for stress tolerance in Indian mustard

DRMR CI-10: Breeding for high yield and oil content under normal and moisture stress conditions

Principal Investigator: V.V. Singh, Principal Scientist (Genetics and Plant Breeding)

Co-Investigators: P.K. Rai, Principal Scientist (Plant Pathology) and Bhagirath Ram, Senior Scientist (Genetics and Plant Breeding)

Performance of entries in AICRP-RM trials

Variety DRMR 150-35 (Bharat Sarson 7) (Figure 2.1) was identified during 22nd AGM of AICRP-RM for early sown rainfed conditions in Zone V (Bihar, West Bengal, Orissa, Assam, Chhattisgarh, Jharkhand and Manipur). The variety has given 12.4 and 19.8% higher seed yield over JD-6 and Pusa Mustard 25, respectively in 19 environments across the Zone V.

Figure 2.1. Field view of variety DRMR 150-35

Entry DRMR 1165-40 has been promoted to AVT I in two zones i.e. timely sown (rainfed) zone II and timely sown (rainfed) zone V. Entry DRMR 1153-12 was repeated in AVT I (late sown, zone V). Based on minimum seedling mortality (<20%) and higher seedling dry matter (>40 mg/10 seedling), DRMR 1672-2, DRMR 1617-45, DRMR 1165-40 and DRMR 1191-2 has been identified as thermo tolerant at seedling stage. Genotype DRMR 541-44 has been identified as promising under low light stress. Genotypes DRMR 1165-40, DRMR 10-40, DRMR 1153-12 and DRMR 541-44 were identified as tolerant to moisture stress. DRMR 1153-12 was rated as highly tolerant to terminal heat stress under AICRP-RM trials.

Evaluation of promising entries in station/ advanced trials

During 2015-16, sixty eight entries were evaluated in five station trials for selection of promising entries for varied situations. From station trial of 2014-15, strain DRMR 587-5 recorded maximum yield (2332 kg/ha) in comparison to checks (NRCDR 2, 2233 kg/ha). In another station trial, entry DRMR 1334-45 (2460 kg/ha), DRMR 1360-33 (2450 kg/ha), DRMR 775-1 (2426 kg/ha), DRMR 1566-7 (2411 kg/ha) out yielded best check RGN 48 (2180 kg/ha). In station trial under rainfed conditions, entries DRMR 1679-47 (1031 kg/ha), DRMR 1672-16 (878 kg/ha), DRMR 1492-14 (823kg/ha) and DRMR 1334-46 (865 kg/ha) recorded better yield than the check RGN 48 (670 kg/ha). In trial for earliness, entry DRMR 1616-9 and DRMR 1436-3 recorded more yield i.e. 3287 kg/ha and 3225 kg/ha, respectively in comparison to best check EJ 17 (2929 kg/ha).

Evaluation of half sib progenies for yield components

Observations were recorded on seed yield (g/plant) and other component characters from a set of 120 half sib progenies developed for 3rd cycle of selection. Over all mean of progenies for seed yield/plant were 13.35 g/plant with a range of 3.86 g/plant to 25.52 g/plant. Heritability estimated ranged from 49.9 (harvest index) to 99 (secondary branches/plant). Genotypic and phenotypic coefficient of variations was higher for secondary branches/plant (32.15 and 32.29%, respectively) and seed yield/plant (23.9 and 28.9%, respectively). Progenies, YHS 9 (25.5 g/plant), YHS 17 (24.6 g/plant), YHS 39 (24.3 g/plant), YHS 15 (21.78 g/plant), YHS 63 (21.05 g/plant), YHS 18 (20.76 g/plant), YHS 41 (20.22 g/plant), YHS 26, YHS 36 (20.18 g/plant) and YHS 12 (19.98 g/plant) were significantly superior than the best check (14.5 g/plant).

Evaluation of high oil containing genotypes

19 half sib lines, derived from 3rd cycle of selection were evaluated for oil content along with check Rohini and NRCDR 2. Two derivatives 253-17-3 (43.75%) and 253-16-1 (43.7%) recorded high oil content (>43%) in comparison to Rohini (41.1%).

Observation nursery

Out of 80 advanced progenies grown in observation nursery along with checks (NRCHB 101, RGN 73, RH 749 and NRCDR 2), progenies BPR 1480-38 (2652 kg/ha), BPR 1679-50 (2648 kg/ha), BPR 1480-40 (2553 kg/ha), BPR 1334-43 (2528 kg/ha), BPR 1684-42 (2523 kg/ha), BPR 1686-13 (2484 kg/ha), recorded more than 10% higher plot yield than the best check NRCHB 101 (2223 kg/ha). Same set of observation nursery was sown under rainfed conditions. Where, analysis of variance indicated significant variability among progenies for most of the characters studied except primary branches per plant. The estimates of heritability were high (>50%) for all the characters studied. The genetic advance was highto low for most of the characters studied. The seed yield per plant had positive and significant correlation with plant height, primary branches per plant, fruiting zone length, number of siliquae per plant, main shoot length and siliquae on main shoot. On the basis of plot yield, progenies BPR 1334-25 (1500 kg/ha), BPR 1679-48 (1460 kg/ha), BPR 1676-26 (1453 kg/ha), BPR 1666-31 (1336 kg/ha) were selected in comparison to best check RH 819 (1204 kg/ha).

SSR analysis of full-sib progenies

The cluster analysis of full-sib progenies based on genic-SSRs gave three major groups *viz*., I, II and III and the similarity coefficient ranged between 0.69 and 0.96. Cluster I contained 11 progenies along with two checks, RGN-48 and RGN-229 and grouped with parent Varuna. In this cluster, progeny DFS-90 exhibited highest similarity (89.4%) with parent Varuna followed by DFS-108 (86.4%) and DFS-40 (86.2%).The other progenies which were more close to Varuna were DFS-95(84.7%), DFS-92 (84.4%), DFS-104 (84.4%). DFS-90 and DFS-92 were more close to each other revealing 94.4% similarity. Cluster II consisted of eight progenies and grouped with BPR-148 along with two checks RB-50 and RH-819. The DFS-101 and BPR-148 recorded 84.7% similarity. The other progenies which showed high similarity with parent BPR148 were DFS-81 (84.7%), DFS-106 (84.2%) and DFS-91 (83.9%) while, DFS-74 (75.4%) exhibited lowest similarity. Further, DFS-106 and DFS-107 were closely related having 96.1% similarity. Two progenies namely, DFS-70 and

DFS-93 were entirely separated and clustered together in cluster III and showed a very high level of genetic similarity (95.5%).The highest Nei's (1972) genetic distance (0.961) was observed in progenies DFS-106 and DFS-107, whereas, the lowest genetic distance (0.692) was estimated between BPR-148 and Varuna.

Generation of breeding material

Fresh inter varietal/interspecific crosses were attempted between RH 749/DRMR 150-35, RB 50/RH 406, RH 406/DRMR 150-35, NRCDR 2/Urvashi, NRCDR 2/BPR 543-2, NRCDR 2/BPR 541-4, NRCDR 2/DRMR 261, NRCHB 101/Urvashi, NRCHB 101/BPR 543-2, NRCHB 101/BPR 541-4, NRCHB 101/DRMR 261. Out of 28 F1 planted, 15 were advanced to F2 generation.

Selection from segregating generations

The segregating and non-segregating generations [$F_3$187 SPS (04 crosses), $F_4$85 SPS (04 crosses), F_5 144 (3 crosses), observation nursery 120 (20 crosses)] were grown in augmented blocks with standard checks under irrigated conditions. Under rainfed conditions, [F_2 06, F4 (*B. carinata* type) 81 SPS (3 crosses) F_4 (*B. juncea* type) 163 (9 crosses), $F_5$117 SPS (05 crosses), observation nursery (120 bulk from 20 crosses) were grown along with checks for selection and evaluation. About 1000 individual plants as well as promising lines have been selected. More than 2000 single plants were selfed in different generations. A good spectrum of variability was observed in F_4 progenies of *B. carinata* which consists of early maturity, dwarf plant type, long siliquae and bold seeds.

DRMR CI 12: Widening of gene pool in Brassicas through inter-specific and inter-generic hybridization

Principal Investigator: Arun Kumar, Senior Scientist (Genetics-Cytogenetics)

Co-Investigator: H.S. Meena, Senior Scientist (Genetics and Plant Breeding)

Utilization of artificially colchicine-induced tetraploids of *B. fruticulosa* (4x)

Artificially colchicine-induced tetraploid plants of *B. fruticulosa* (2n= 4x=32), a wild relative of cultivated Brassica confirmed through morpho-cytological studies have been utilized in inter-specific crosses with different varieties of *B. juncea* (Pusa bold, Bio-902, Varuna, Laxmi, Rohini, NRCDR-2, Maya and Vasundhara), *B. carinata* (PC-5-17) and *B. napus* (GSL-1) through sexual hybridization using *B. fruticulosa* (4x) as pollen donar. Seeds were obtained from crosses involving three varieties Varuna, Laxmi and Rohini and no seeds were obtained crosses involving *B. carinata* or *B. napus*.

Cytogenetical investigations in F_1 hybrids

B. fruticulosa (2n=16, FF) has been reported to possess resistance against mustard aphid. Literature reported the synthesis of interspecific hybrids between *B. rapa* (2n=20, AA) and *B. fruticulosa*. However, inter specific hybridization between diploid *B. fruticulosa* and amphidiploid *B. juncea* (2n=4x=36, AABB) could not be achieved. It is evident that when species with different ploidy levels are crossed, hybridization between them is relatively more difficult than when species with the same ploidy level are mated. Keeping these in view, present investigation was undertaken to induce polyploidy, particularly tetraploidy in B. fruticulos a using colchicine and their subsequent utilization in hybridization. Inter-specific F_1 hybrids were synthesized between *B. juncea* (Varuna, Laxmi and Rohini), and *B. fruticulosa* (2n=4x=32). Morphological, cytological and genic-SSR markers based molecular analyses were carried out to confirm the hybrid nature of F_1 plants.

Morpho-cytological studies

Morphological and cytological analyses were carried out to establish the hybrid nature of F_1 plants. The phenotype of F_1 plants was similar to one of parent *B. juncea* type (Figure 2.2). Cytologically, the F_1 plants showed predominance of univalents ranging from 6-26, a typical feature of wide hybrids. Among all the associations, bivalents chromosome associations were observed more frequently and found to be 8II + 18I. The occurrence of trivalent (0-3) and quadrivalent (0-4) in the F_1s indicated homeologous pairing between the two genomes. The number of chiasmata ranged from 8-25 with an average number of 17.15 and the terminalisation coefficient was 0.77. Numerous distributional abnormalities including late disjunction of bivalents and laggards (1-2, bivalents) and intermixing of chromatids were observed at anaphase I and II (Figure 2.3). However, a few cells were recorded with normal distribution of bivalents at AI resulting in some fertile pollen grains in the hybrids.

Figure 2.2. F1 progeny

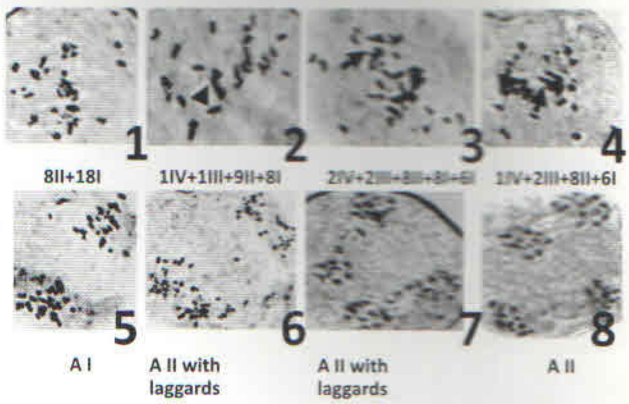


Figure 2.3. Anaphase I and II stages

Molecular analysis of F1 hybrids

High quality of genomic DNA was extracted as described by Murray and Thomson method. A total of 100 EST-SSR markers, using paired-end whole transcriptome sequencing of juncea cv. CS-52 were used for checking hybridity in the F1 hybrid plant. PCR reaction comprised of 10µl containing 0. 5µM of each Primer, 0.5mM of each dNTP, 1X standard Taq buffer and 1.5U Taq polymerase. The PCR products were visualized on 3.5% metaphor (FMC Bio Products, Rockland, ME, USA) gel. Amongst the 100 EST-SSR markers BjSSR-835 used for the study, BjSSR-835 and BjSSR-139 were found to be polymorphic among the parents and were present in the F1s in a co-dominant manner. List of EST-SSR primer amplified in the analysis of F1 hybrids are:

Locus code	Repeat	Primer sequence
BjSSR-835	$(AG)_{13}$	Fp - ACTACAGACAAGCCTGCCTT Rp -GATGTGGTCACAGGATCCAG
BjSSR-139	$(ATC)_8$	Fp-AGCCTGTCAATACCAAGCCC Rp-CAGTGGCTGAACAAAACGCA

The present study suggested that *B. fruticulosa* has partial genome homoeology with *B. juncea* which could be exploited in crop improvement programmes, particularly breeding for tolerance to insect pests, especially mustard aphid and broadening the genetic base in the crop.

Back crossing and seed multiplication in F_1 hybrids

Two F_1 plants obtained from the cross (*B. tournefortii* and *B. rapa*) were back crossed with *B. rapa* (NRCYS-05-02) and seeds have been obtained in BC_1 and segregated into 1:1 ratio. Two types of seeds colour (dark brown and yellow) has been obtained and in pots for multiplication. In *B. rapa* (yellow sarson) brown colored seeds obtained instead of yellow as expected.

Generation advancement and selection from segregating generations

During *rabi* 2015-16 about 80 desirable *B. juncea* type selections were made from F_5 progenies of inter-specific crosses *B. juncea* (NRCDR-2) x *B. carinata* (NRCKR-304) for various component traits such as plant height, seed size, oil content etc. From the same cross 7 *B. carinata* type progenies (F_5) with earliness, low height and other desirable traits were planted at offseason nursery, Wellington (TN) during kharif 2015 for generation advancement. The F_6 generation from these seeds grown at DRMR, Bharatpur and 20 promising *B. carinata* type selections were made for various traits. Now these progenies were numbered as DRMRC 16-1 to DRMRC 16-20. The data on major contributing traits were recorded for *B. carinata* as well as *B. juncea* type progenies.

About 74 single plant selections were made from F_5 populations of inter-specific *B. juncea* (Kranti) x *B. napus* (GCS-6) for siliqua density and other important traits. The data on major contributing traits were recorded in these progenies.

DRMR-CI-14: Breeding for earliness and high temperature tolerance in Indian mustard

Principal Investigator: Bhagirath Ram, Senior Scientist (Genetics and Plant Breeding)

Co- Investigators: V.V. Singh, Principal Scientist (Genetics and Plant Breeding); Sujith Kumar, Scientist (Biochemistry)

Evaluation of germplasm for high temperature stress tolerance

A total of 64 germplasm accessions including checks were evaluated under heat stress conditions during *rabi* 2014-15 in CRBD with three replications for their high temperature stress tolerance at seedling stage and genetic diversity. 100 seeds of each germplasm were sown under heat stress (29^{th} Sept) conditions in 2.5 m single row. The germplasm significantly differed for morphological and physiological traits. Population survival percentage at 10 and 25 DAS decreased continuously with increased heat stress. Percent population survival 10 DAS was maximum in DRMREJ 2010-1 followed by DRMRIJ 447 and Urvashi while, it was low in IIHR 6 (CO-2), BBM 06-02, DU 24 and DRMR-1077. 25 DAS survival was recorded maximum in DRMREJ 2010-1 followed by Maya, Parasmani-3 and P-42 while, it was minimum in BBM 06-02, DRMR-1077 and DU 24. Maximum MSI was recorded in UP I-77 followed by DRMR-1077, UP I-77 and HPLM 06-25, whereas, it was minimum in B/K/S 67, HP 96 and UP II-13. Maximum relative water content was recorded in RH-749, DRMREJ-2010-1, NDRS-2017-1 and HPLM 06-25 whereas, it was minimum in IC 511611, Bharatpur local and KM-555(K611xK). JMM 08-2, UP II-73, NDYR 10 and EC 511664 recorded maximum percent water retention capacity of leaves at 24 h while, germplasm CSR 1138, Parasmani-3 and B-15 recorded minimum water retention capacity. Parasmani-3, BPR 549-9C, EC 414320 and JBT-41/45 recorded maximum seed yield plant-1 whereas, DRMR-1077, CS-54, P-32 and Bharatpur local recorded minimum seed yield per plant-1. The maximum oil content was recorded in NRCDR -02 (43.5%), whereas, HP 02-03-2 had lowest oil content (38.4%). 1000 seed weight ranged from 3.1 g (UP I-66) to 7.4 g (UP I-11), with mean 4.8g.

Genetic diversity for agro-morphological traits under heat stress condition

64 germplasms on the basis of Mahalanobis D^2 following Tocher's method for clustering, were

grouped into eight clusters. Cluster-wise variable number of germplasm developed suggesting considerable genetic diversity in the material. Cluster II was the largest group (18) followed by cluster III (12), cluster IV and V (each 9) and cluster VII (8). Cluster VI (4), cluster VIII (3) and cluster I with only one germplasm. The range of intra cluster distance was 0.003 to 3.147 with maximum 3.147 (cluster VI). The highest intra-cluster distance was shown by cluster VI which indicated presence of high diversity within cluster, hence revealing scope for exchange of genes among germplasm within these clusters. The maximum inter cluster distance was observed between cluster I and VI (8.502) followed by I and VIII (8.106) while minimum inter cluster distance was observed between cluster II and III. Cluster I showed the highest mean value of oil content (43.5%) and fiber content (10.2%). Cluster III showed maximum mean value for seeds per siliqua (13.62). Cluster IV showed maximum mean values for days to maturity (136.3), siliqua length (5.10cm) and 1000 seed weight (5.51g). Cluster V showed highest values for days to 50% flowering, plant height, primary and secondary branches per plant, main shoot length, siliquae on main shoot and number of siliquae per plant. Cluster VII showed maximum mean value for the seed yield per plant (26.31 g).

Breeding material generation

New inter varietal crosses were attempted during rabi 2014-15 between DRMRIJ-31/NRCDR02, DRMRIJ-31/Urvashi, NRCDR 02/RH 749, NRCDR 02/RH-119, RH-749/RH119, RH-749/RH406, RH-119/RH406, Urvashi/BPR-549-9, NRCHB 101/DRMRIJ-31, NRCHB 101/NRCDR 02, NRCHB 101/RH-749, NRCHB 101/RH-119, NRCHB 101/RH-406, and NRCHB 101/Urvashi. Other new crosses were attempted between early x early *i.e.* JN 032/TGP-13, BPR-543-2/Core-4, NRCHB 101/TGP-5, BPR-549-9/ Core-50, GM-2/TGP-7, Urvashi/TGP-20 and BPR-541-2 x TGP-6 and F_1 seeds were harvested.

Single plant selections from F_2 crosses

Large populations of four F_2 selected crosses *i.e.* (GM2 x BPR 549-9), (JN032 x Urvashi), (NRCHB 101 x BPR-549-9) and (BPR-543-2 x BPR 549-9) were raised under heat stress (early) environmental conditions during *rabi* 2015-16. On the basis of earliness, sixty two individual plants were selected (GM2 x BPR 549-9; 14 SPSS), (JN032 x Urvashi; 12 SPSS), (NRCHB 101 x BPR-549-9; 17 SPSS) and (BPR-543-2 x BPR 549-9; 19 SPSS).

Performance of advanced double low ('00') quality lines

11 double low lines were selected among pool of 1200 lines in F_7 generation. 12 advanced quality breeding lines including a check were evaluated during rabi 2014-15 in CRBD with three replications for their per se performance with respect to their oil quality traits.Low glucosinolate (μM/ g of defatted seed meal) was recorded in BPRQ2-2-9 (22.75) followed by BPRQ2-1-5 (25.74) whereas, it was maximum in Pusa mustard 21 (c) and BPRQ2-2-3. Minimum erucic acid was recorded in BPRQ2-2-5 (0.30) followed by BPRQ2-2-10 (0.36) and BPRQ2-2-9 (0.63) while it was maximum in Pusa mustard 21 (c). Maximum oleic acid (%) was recorded in BPRQ2-2-11 (35.50) followed by BPRQ2-1-6 (35.39), BPRQ2-2-10 (35.03) and BPRQ2-2-9 (34.96) whereas, it was minimum in Pusa mustard 21 (31.55) and BPRQ2-1-7 (32.66). The lowest oil content was obtained in Pusa Mustard - 21 (34.5%) while, it was highest in BPRQ-2-2-11 (39.6%). Fiber content was ranged from 7.19 (BPRQ-2-2-11) to 13.05% (Pusa Mustard - 21). Similarly, linoleic and linolenic acid content in the seed oil of different breeding lines also exhibited wide variation. Linoleic acid ranged from 35.84 (BPRQ2-2-11) to 42.07% (Pusa mustard 21) while, linolenic acid varied from 16.64 (BPRQ2-1-5) to 20.79% (BPRQ-2-1-7). BPRQ2-1-5 (20.12 g) followed by BPRQ2-2-11 (19.20 g) recorded maximum seed yield per plant among all the selected quality breeding lines.

DRMR CI-15: Re-synthesis of Indian mustard through inter-specific hybridization.

Principal Investigator: H. S. Meena, Senior Scientist (Genetics and Plant Breeding)

Co-Investigator: Arun Kumar, Senior Scientist (Genetics-Cytogenetic)

S_2 generation of synthetic *B. juncea*

During *rabi* 2014-15, 109 S_1 progenies were planted from 35 inter-specific crosses of *B. rapa* x *B. nigra*. Amongst them, 26 progenies derived from 11 crosses of Toria x *B. nigra*, 28 from 14 crosses of yellow sarsonx *B. nigra* and 55 progenies from 10 crosses between Brown Sarson x *B. nigra* genotypes. Out of them 32 synthetic plants belonging to 12 crosses viz., Jhumka x BN-2, Ragini x BN-2, Pusa Kalyani x SKJ-2, KOS 1 x BN-2, PT-30 x SKJ-2, NDYS-2 x SKJ-2, PusaKalyani x SKJ-2, TH-68 x BN-2, JMT 02-06 x BN-2, Pusa gold x BN-2, YSH 401 x BN-2 and PYS 2005-06 x BN-2 were selected on the basis of morphological characteristics and cytological studies. All of these selected plants were varied from true *B. juncea* type to intermediate types. During rabi 2015-16, single plant progenies (S_2) from them were planted in pots for further selections and stabilization (Figure 2.4). Ten visibly looks like true *B. juncea* type progenies (Syn_2/100-1, Syn_2/100-2, Syn_2/100-5, Syn_2/100-6, Syn_2/100-7, Syn_2/100-8, Syn_2/108-1, Syn_2/108-2, Syn_2/160-1, Syn_2/169-1) were also planted in field to observe their real expression and agronomic worth under field conditions. The data on 133 individual synthetic plants from field were recorded on various traits and a range of genetic variability (Table 2.1). In pots, only 22 progenies showed *B. juncea* type traits and all remaining seems to be reverted back toward parental types, generally rapa type as per their respective female parents.The re-synthesized Indian mustard (*B. juncea*) progenies revealed differential pollen fertility ranging from 76 to 94 % and intermediate type plants showed comparatively less fertility. S_2 progeny of a vigorous *rapa* type plant selected from S_1 generation (Syn_1/167) found to be a tetraploid of Pusa Kalyani.

Figure 2.4. S_2 progenies

Table 2.1. Genetic variability for various traits in re-synthesized *B. juncea* progenies.

Trait / Entry	PH (cm)	PB	SB	MSL (cm)	SMS	SL (cm)	S/S	OC (%)	1000-SW (g)	DF	DM	WR
Synthetic progenies*	130.0-250.0	6.0-18.0	8.0-46.0	40.0-123.0	45.0-127.0	3.0-6.0	4.0-22.0	35.58-42.49	1.66-5.65	25.0-55.0	113-137	R,T,S
Kranti**	212.3	7.6	19.2	74.3	48.6	4.9	12.8	40.0	4.1	46	137.0	S
DRMRIJ-31**	172.2	4.6	14.3	77.0	56.0	6.2	15.5	42.01	5.28	39.0	134.0	S

*Range based on 133 re-synthesized plants; PH-Plant height; PB-Number of primary branches; SB-Number of secondary branches; R-Resistant; T-Tolerant; S-Susceptible. ** Check varieties

S_1 generation

During *rabi* 2014-15 nine *B. rapa* x *B. nigra* inter-specific F_1 crosses were treated with 0.2% colchicine for chromosome doubling and recovery of new synthetic plants. Ten single plants from treated crosses were selected and S_1 progenies planted in pots during *rabi* 2015-16 for selection of synthetic plants. Most of the plants

Figure 2.5. White flowered toria

either reverted back or were nearly sterile and none of the synthetic *B. juncea* plant was recovered. However, a *rapa* type (toria) plantwith completely white flowers was recovered and selected (Figure 2.5). The recovery of white flowered plant might be due to the mutagenic effect of colchicine, as it also acts as a mutagen in very few cases.

Chromosome doubling in F_1 plants of *B. rapa* x *B. nigra*

Thirteen inter-specific F_1 crosses between *B. rapa* x *B. nigra* were planted in pots during 2015-16. About 55 individual F_1 plants were treated with 0.2% colchicine for chromosome doubling. The floral buds were fixed for cytological studies

Figure 2.6. Cross between Jhumka x SKJ-2

and seeds from fertile plants were separately harvested. Two colchicine treated plants from the inter-specific cross, Jhumka x SKJ-2 were looked like *juncea,* based on morphological traits and were fertile (Figure 2.6). Two plants from Ragini x BN-2 and one from YSH 401 x BN-2 were brown seeded, toria type with bilocular siliqua and bold seeds, while their female parents were yellow sarson with teralocular siliquae. Similarly, one plant from YSH 401 (yellow sarson) x SKJ-2 (nigra) was yellow seeded with bilocular siliqua and bold seeds.

Amphidiploids F_2 generation

Eight inter-specific crosses between amphidiploid species (*B. napus* x *B. carinata*) and seeds were recovered from single cross NRCKR 304 x NRCGS-1. F_2 generation was planted during *rabi* 2015-16 and from a total of 27 plants, only two plants morphologically resembled like *B.juncea* and have low fertility.

Cytological studies

Cytological studies were carried out using high resolution bright field microscope for

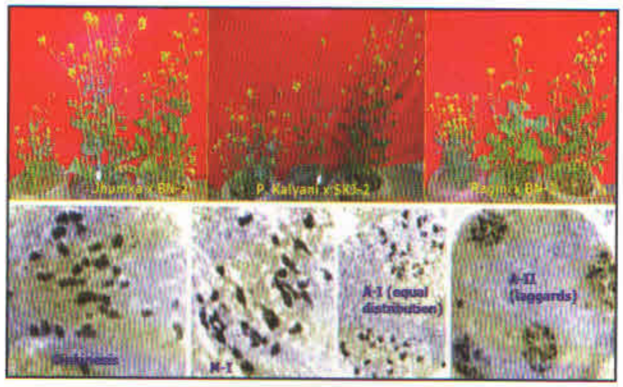


Figure 2.7. Synthetic *B. juncea*

chromosome doubling in F_1 hybrids and confirmation of *B. juncea* type S_1 plants grown during 2014-15 for selection of true synthetic plants. None of the colchicine treated F_1 plant showed chromosome doubling during 2014-15. On the other hand, the results on chromosomal distribution at various stages of meiosis in *B. juncea* type S_1 plants confirmed their synthetic nature having doubled chromosome numbers cells revealed the differential configurations with the formation of univalents, bivalents, multivalents and 18:18 separation. Hence, the re-synthesized plants are in very early stages and unstabilized, therefore, these configurations are generally expected.

F_1 crosses of Indian mustard (*B. juncea*)

Five crosses (TPM-1 x Dwarf; Dwarf x RH 749; NPJ 112 x Dwarf; Dwarf x NRCHB 101 and NRCDR 2 x TM 118) with 6 generations (F_1, B_1, B_2, P_1, P_2 and F_2) were planted in field for their evaluation and generation mean analysis for estimation of gene effects with respect to important traits. Likewise, a set of 27 TTC progenies generated during 2014-15 using F_1 cross NPJ 112 x Dwarf, both of its parents and 9 HYV's were planted in field along with their parental genotypes during 2015-16 for their evaluation and to test non-allelic interactions for different traits. Similarly another 36 F_1 crosses of *B. juncea* for important component traits were planted under field conditions for evaluation. The data were recorded in all the trials on various traits. Three short height, yellow seeded and extra early maturing plants of *B. juncea*; one each from B_1 [(Dwarf x TPM-1) x Dwarf], B_2 [(Dwarf x TPM-1) x TPM-1] and F_2 (Dwarf x TPM-1) having high oil content *i.e.*, 44.04, 43.89 and 44.11%, respectively.

Generation advancement and selection

Six F_2 populations were planted during 2015-16 with 40 rows of 5 m length with row to row distance of 30 x 30 cm. These crosses *viz.*, RH 749 x NRCHB 101, NRCDR 2 x NRCHB 101, YRN-6 x TM 118, WR 2019 x NRCDR 2, WR 2035 x NRCHB 101 and NPJ 112 x Dwarf (RRN 727) were generated for specific component traits, seed yield and oil. A huge variability has been observed for extra early (85 to 105 days), short height (50 to 100 cm), oil content (upto 43.83%) and siliqua orientation in F_2 population of NPJ 112 x Dwarf and for most of the other traits in respective F_2 populations. Similarly, 115 F_3, 37 F_4, 37 F_5 and 10 F_6 progenies were planted

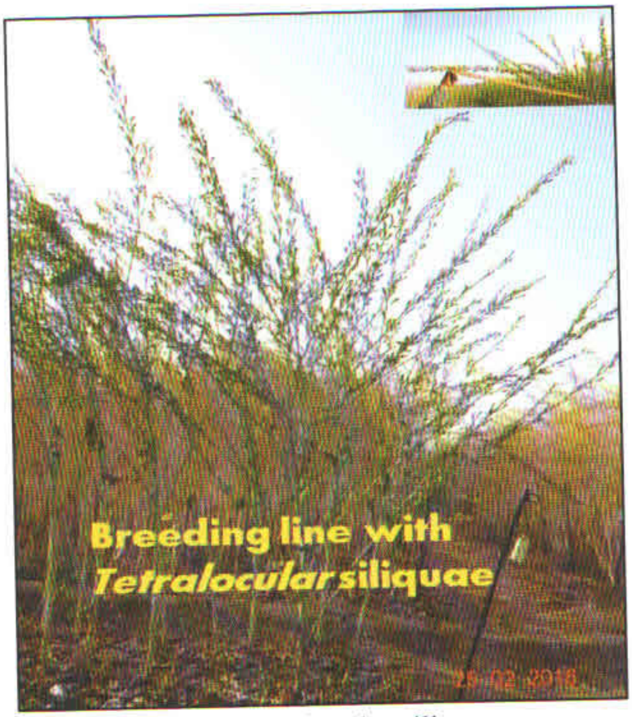


Figure 2.8. Tetralocular siliquae

and selections were made accordingly. One F_5 progeny (10-2-19-23-10) with tetra-locular siliquae, more number of branches, long main shoot, high SMS and bold seed size has been bulked (Figure 2.8) as it revealed no further visible segregations. Nearly 310 SPS from F_2 populations, 102 from F_3 progenies, 45 from F_4 and 32 single plants from F_5 progenies were selected during 2015-16 and all F_6 progenies were bulked. Per cent oil content in selected F_2 F_3, F_4, F_5 plants and F_6 progenies was ranges from 36.53-43.83%, 38.46-44.05%, 37.16-43.89%, 39.90-42.67% and 37.80-42.19%, respectively.

Selections from mutant progenies

A plant with white flowers, yellow seeds and appressed siliquae was selected from M_1 population of cultivar Kranti (irradiated with gamma rays 100kr) during 2013-14. The M_2 and M_4 generations were grown at off-season nursery, Dalang Maidan, HP (*kharif* 2014) and Wellington, TN (*kharif* 2015), respectively. While M_3 and M_5 generations were grown at DRMR, Bharatpur during *rabi* 2014-15 and 2015-16 seasons for rapid generation advancement and fixation of component traits. Now, it is nearly true breeding line with no further visible segregations and the progeny (DRMR-WFYSM 15) has all the three specific traits intact (Figure 2.9). It showed an average seed yield/plant of 19.2g, 1000 seed weight 4.1g, oil content 41.7% and fibre content 7.34%. Similarly during 2014-15 the seeds of variety RH 749 were mutated with gamma rays 100kr from BARC, Mumbai and the M_1 generation was grown in pots at DRMR. From it 21 mutant plants were selected and M_2 progenies were planted in field during 2015-16. The mutant

Figure 2.9. Mutants

progenies were meticulously inspected for various traits and 36 desirable plants were selected. Out of them some plants were completely white rust free and a white flower mutant plant was selected from M_2 mutants of RH 749.

Evaluation of advanced breeding lines

Twenty six advance breeding lines with 4 check varieties *viz.*, RH 749, DRMRIJ 31(Giriraj), NRCHB 101 and Kranti were planted in RCBD with 3 replications for evaluation under timely sown conditions. The data were recorded on various morphological traits. The average oil content in whole trial was recorded as 41.39% which is ranging from 39.95% (RH 749) to 42.16% (DRMR 4456). The values of oil content in advanced breeding lines ranges from 40.20% in DRMR 2035 to 42.16% in DRMR 4456 with an average of 41.42% while in checks it was 39.95% (RH 749) to 42.02% (Giriraj) with an average of 41.18%. Similarly highest values of 1000-SW (5.50g) was recorded for DRMR 4456 with an average of 4.61g in the whole trial.

Fresh F_1 crosses generated

Inter-specific: Ten inter-specific crosses including NRCKR 304 x NRCGS-1, NRCGS-1 x NRCKR 304, GSL-2 x NRCKR 304, GSC-6 x NRCKR 304, NRCHB 101 x *S. alba*, *S. alba* x NRCHB 101, NRCHB 101 x NRCKR 304, NRCHB 101 x NRCGS-1, GSL-2 x IJ-31 and GSC-6 x IJ-31 were generated for both side improvement of contributing traits.

Intra-specific: Sixty (60) crosses between 15 yellow seeded lines and 4 testers (RH 1231, RH 1239, Basanti and Navgold) of *B. juncea* were generated in line x tester fashion to generate test crosses for estimating general and specific combining abilities for disease resistance and other important traits to select best crosses. Similarly BC_1 (WR 2035 x NRCHB 101/ NRCHB 101) was generated through back crossing with recurrent parent of the respective cross. The genotypes RH 1231, RH 1239, Basanti and WR 2035 are completely white rust (*Albugo candida*) free.

Selection of advance breeding line for Sclerotinia rot resistance

Advance breeding line WR 2035 with other genotypes *viz.*, NRCHB 101, Kranti, DRMRIJ 31, Rohini and 5 F_2 populations (72 plants each) were artificially inoculated for Sclerotinia rot incidence during 2015-16 with the help of Plant Pathologist. The genotype DRMR 2035 was found tolerant while all other inoculated genotypes were susceptible. Stems part from resistant and susceptible genotypes were taken for bio-chemical analysis. Similarly in F_2 populations 15 plants revealed tolerance for Sclerotinia and all these plants were derived from the crosses where WR 2035 was one of their parents.

2.2 Designer Brassica for oil quality

DRMRB 7: Proteomic studies in oilseed Brassica

Principal Investigator: Ibandalin Mawlong, Scientist (Biochemistry)

Co-Investigators: M.S. Sujith Kumar, Scientist (Biochemistry); O.P. Premi, Principal Scientist (Agronomy); Arun Kumar, Senior Scientist (Genetics and Plant Breeding)

24 genotypes of *B. juncea* were carried out for the estimation of total soluble protein with nitrogen treatment of 80 kg/ha. The results revealed that there is an increase in total soluble protein too. However, in some genotypes the soluble protein content was inversely related to the amount of nitrogen treated. This correlates with the uptake of nitrogen and there are genotypes that even with increase in nitrogen uptake, decreased soluble protein which were assumed that there could be redistribution of the nitrogen with C-compounds. *B. juncea* protein has always been expressed in terms of total protein but, however, the function of the protein is mainly based on soluble protein. Such as 11S (cruciferin) and 2 S (napin) their importance is in the presence of balanced amino acids that could have future use. Further since 2S is known to be allergic in a set of population therefore the study to reduce their expression level is important. Keeping this, profiling the seed storage protein in the 29 genotypes for control and treated. Surprisingly, the banding patterns to varies, with some showing less expression of the napins proteins (Figure 2.10). Further, it was observed that differences in theα and β chains, which according to Yu (2008) the ratio of α and β chains does affects the digestibility of the protein. This work is the first of its kind to have studied the change in seed storage protein.

Plant seeds stores triacylglycerol (TAG) as food reserves for the germination and postgerminative growth of seedlings. The TAG is present in small discrete organelles called the oilbodies. The oilbodies have a spherical shape and possess a matrix of TAG surrounded with small amount of phospholipid and protein called oleosin. Many studies have showed to have an inter play of protein and oil. We have standardized the protocol for the extraction of oleosin.

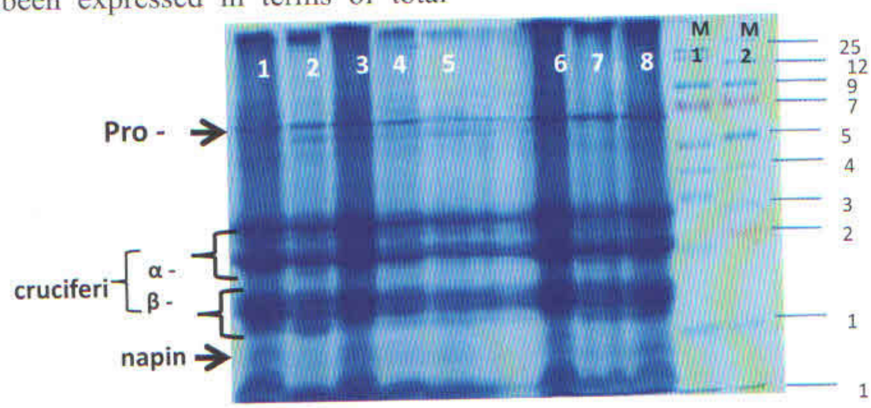


Figure 2.10. Profiling of seed storage proteins in *B. juncea* M 1 and M2 wide range protein ladders; lane 1 to 8 seed storage protein of *B. juncea*

DRMR B8: Screening of oilseed Brassica germplasm for value additon

Principal Investigator: M.S. Sujith Kumar, Scientist (Biochemistry)

Co-Investigators: Ibandalin Mawlong, Scientist (Biochemistry); J. Nanjundan, Scientist (Genetics and Plant Breeding); K.H. Singh, Principal Scientist (Genetics and Plant Breeding)

Biochemical analysis for various quality parameters

Biochemical analysis of 45 genotypes including cultivated species of oilseed Brassica was performed for various parameters of quality.

Seed Coat Colour: The 45 genotypes were analysed for seed coat colour to be scored on a scale of 1 to 5. Seeds were scored assuming a score of 1 for the lightest colour and 5 for the darkest. This score can be used to correlate many other parameters making the screening an easier process (Figure 2.11).

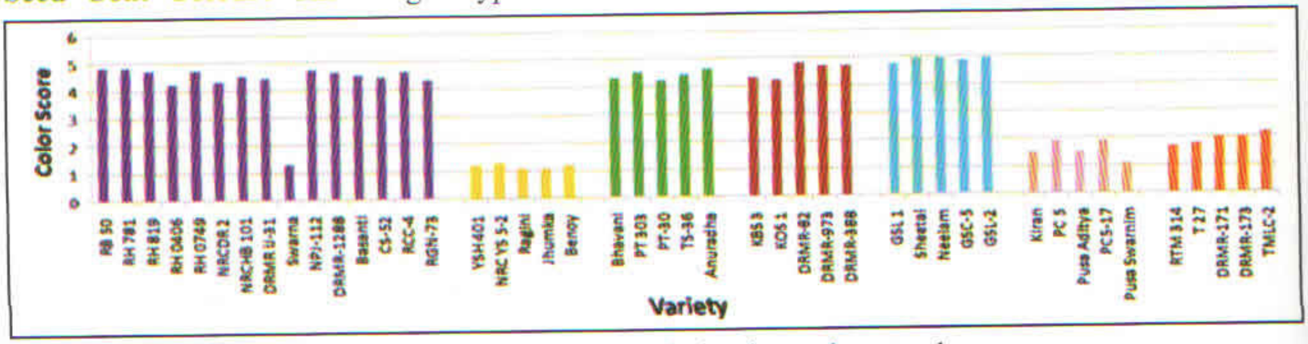


Figure 2.11. Genotypic variation in seed coat colour

Oil Content: oil content was estimated using FT-NIR to compare among the species as well as the varieties. In general the yellow sarson varieties were found to have higher oil content compared to all other species (Figure 2.12).

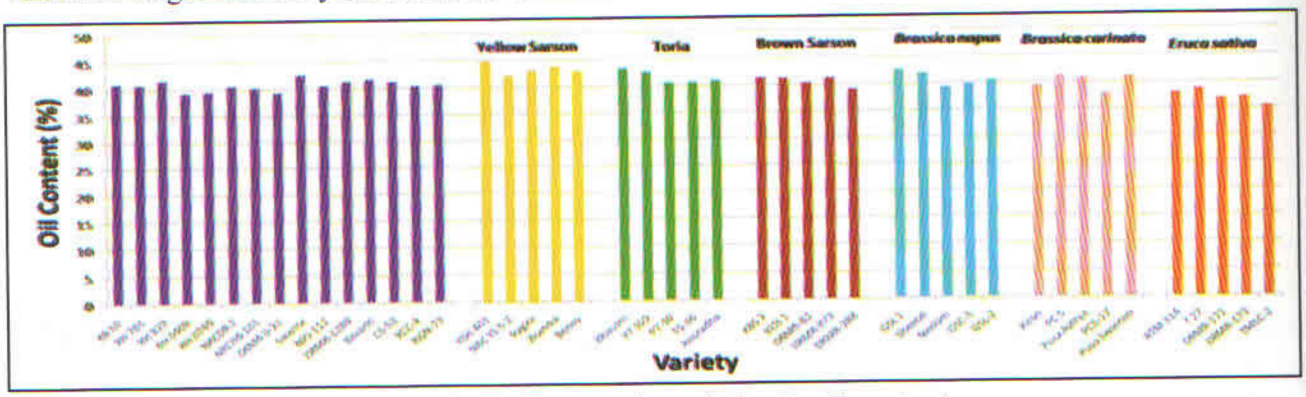


Figure 2.12. Genotypic variation in oil content

Crude Fiber: Crude fiber content was estimated using FT-NIR. There was a negative correlation between the crude fiber and oil content. Fiber content was lowest in the yellow sarson varieties (Figure 2.13).

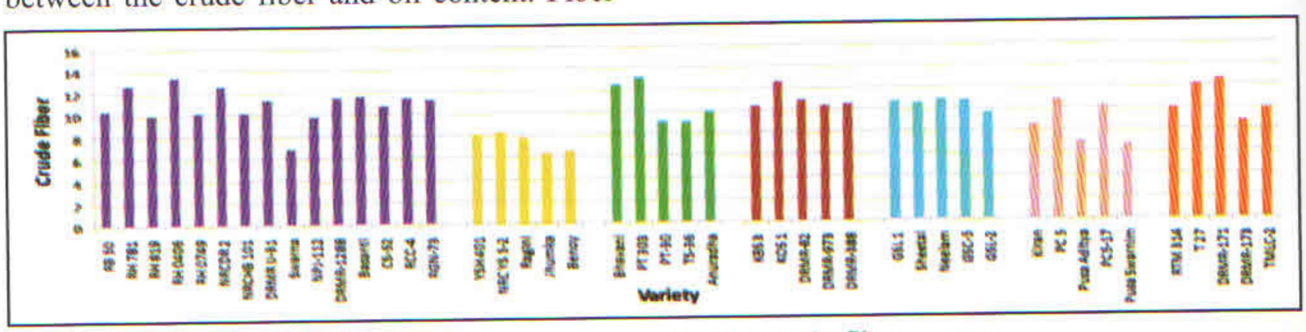


Figure 2.13. Genotypic variation in crude fibre content

Fatty Acid Profile: Fatty acid profiling was done using gas chromatography. Oleic acid is the most desirable mono unsaturated fatty acid among all the fatty acids. It found to be high in Brassica napus varieties (Figure 2.14).

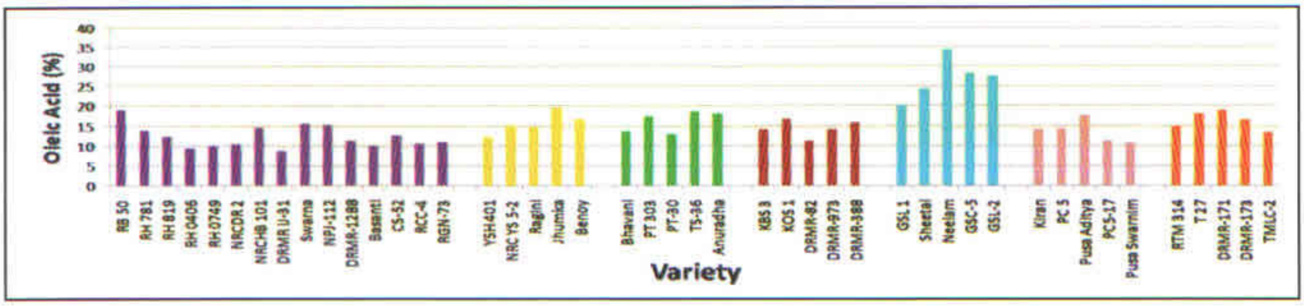


Figure 2.14. Genotypic variation in oleic acid content

Total Antioxidant Capacity: total antioxidant capacity was measured in the methanolic extracts of the seed meal and expressed in terms of ascorbic acid equivalents by spectrophotometric method. Though there was no particular trend for this parameter, we could identify few varieties which are having high antioxidant capacity which is a highly desirable quality as it would enhance the shelf life of oils. It also adds to the quality of seed meal (Figure 2.15).

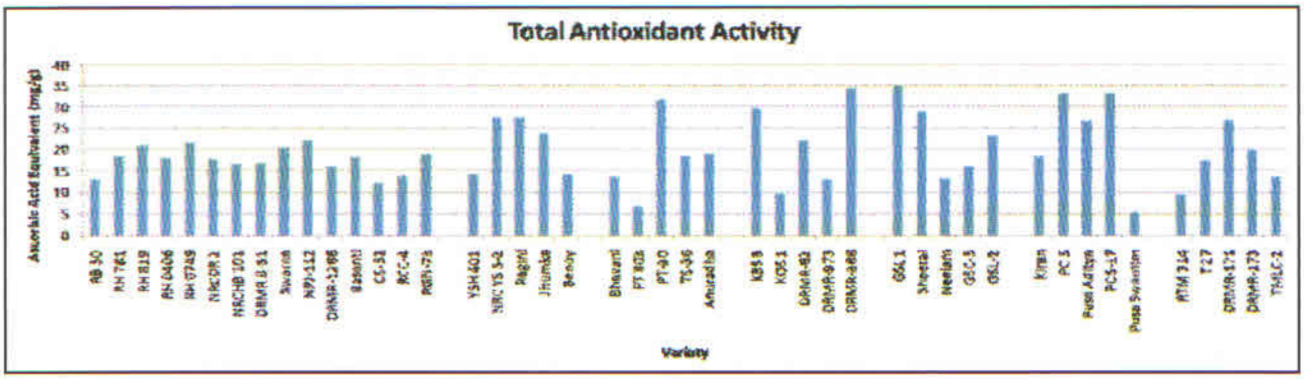


Figure 2.15. Genotypic variation in antioxidant activities

Radical Scavenging Activity: it is one of the indirect ways to measure the antioxidant potential of methanolic extract of seed meal by estimating the DPPH radical scavenging potential spectrophotometrically. Brassica juncea varieties were showing higher activity compared to other species (Figure 2.16).

Figure 2.16. Genotypic variation in RSA

Total Phenol: Phenolic compounds in plants play an important role as primary antioxidants or free radical terminators, suggesting their use to prevent the oxidative breakdown of lipids and to prevent chronic diseases from reactive oxygen species (ROS). The potential antioxidant activity of food and medicinal plants is well known to be associated with phenolic content, type, and structure. Brassica species are in general are rich in many phenolic compounds that add to its antioxidant potential. *Brassica juncea* varieties were found to be high in phenolic content (Figure 2.17).

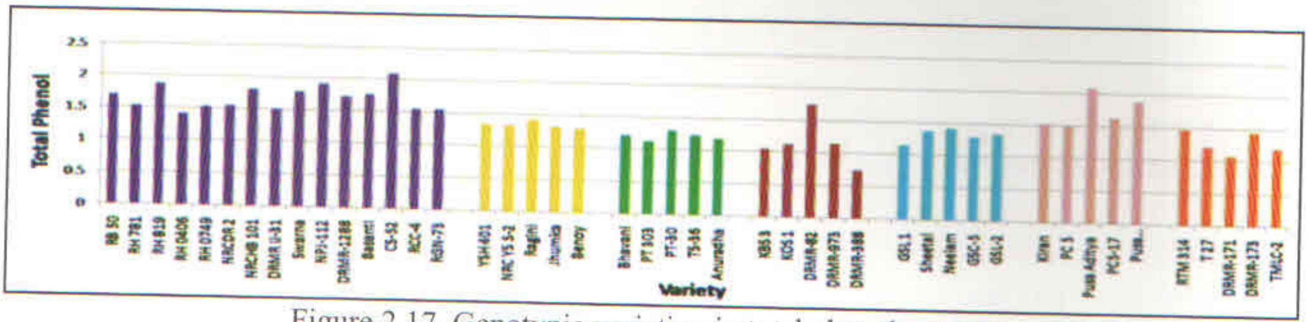


Figure 2.17. Genotypic variation in total phenols content

Total Flavonoids: Flavonoids are the most common group of compounds in the human diet and are found ubiquitously in plants.The widespread distribution of flavonoids, their variety and their relatively low toxicity compared to other active plant compounds mean that many animals, including humans, ingest significant quantities in their diet. Due to their antioxidant potential they are considered desirable in food stuffs. The highest amount was found in *Eruca sativa* varieties followed by *B. carinata* and *B. juncea* (Figure 2.18).

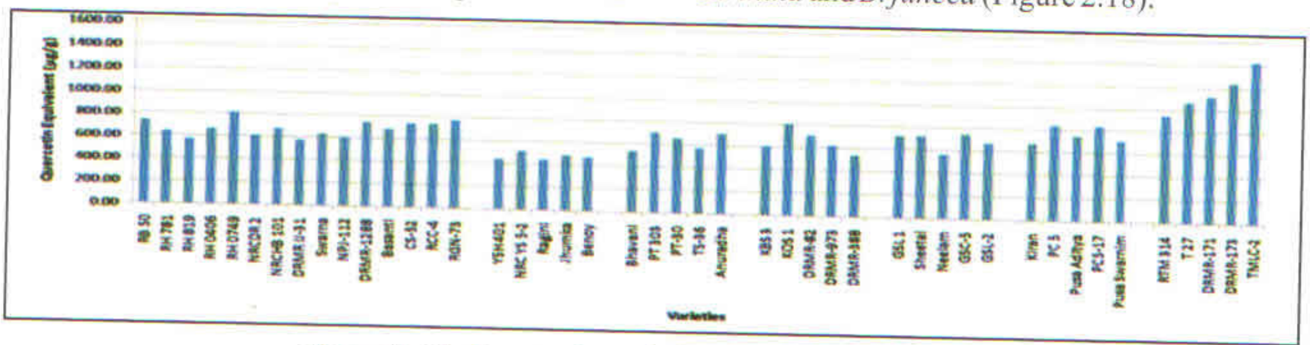


Figure 2.18. Genotypic variation in flavonoids content

DRMR B9: Quantitative and qualitative estimation of glucosinolates and fatty acids in oilseed Brassica

Principal Investigator: Anubhuti Sharma, Senior Scientist (Biochemistry)

Co-Investigators: J. Nanjundan, Scientist SS (Genetics and Plant Breeding), Arun Kumar, Senior Scientist, (Genetics - Cytogenetics)

Quantitative & qualitative determination of secondary metabolites is done by TLC, which were confirmed by HPLC. Using thin layer chromatography (TLC) different components e.g. cinnamic, ferulic, vanillic, p-coumaric etc. are identified. Preliminary study on quantitative analysis of phenolic acids was done by HPLC (Figure 2.19). Cinnamic, ferulic, vanillic, p-coumaric, p-hydroxy benzoic, and caffeic acids were detected. Thus it can be concluded that FA-305, FA-307, FA-311, FA-316, FA-319, FA-322, FA-326, FA-332, FA 337, FA -340, FA 345 and FA-348, FA-361 possess considerable amount of phenolic acids.

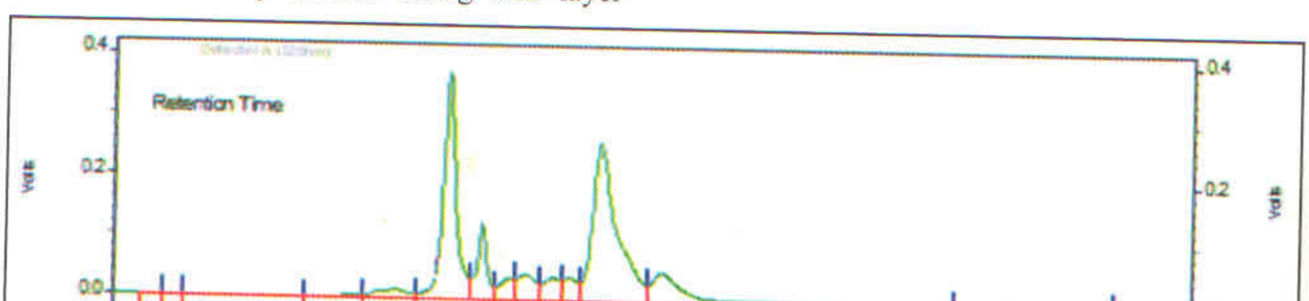


Figure 2.19. HPLC chromatogram showing phenolic acids

2.3 Breeding for yield and quality enhancement in rapeseed-mustard

DRMR CI 5: Development of hybrids in Indian mustard *(B. juncea)*

Principal Investigator: K.H. Singh, Principal Scientist (Genetics and Plant Breeding)

Co-Investigators: J. Nanjundan, Scientist SS (Genetics and Plant Breeding); Ajay Thakur, Scientist SS (Plant Biotechnology); P.K. Rai, Principal Scientist (Plant Pathology); H.S. Meena, Scientist SS (Genetics and Plant Breeding)

Induction/promotion of promising entry/hybrid into AICRP-RM

One entry DRMRIJ 14-01 [(MJA27xMJR9) x IJ 31] inducted during 2014-15 for evaluation under timely sown irrigated conditions, produced 2637 kg/ha seed yield. It was promoted to advance stage testing (AVT 1) in zone IV on the basis of its 10% yield superiority over best check GM 2 (2375 kg/ha). Another entry DRMRIJ 13-38 (JGM1-11/HB 101) was tested during 2014-15 under late sown conditions in AVT 1 in zone V. Due to rejection of data of six out of seven locations, it was decided to repeat this entry during 2015-16. Four new entries; DRMRIJ 15-85 [(EC 399288xPCR 11) x (B33xSanjucta Asech)], DRMRIJ 15-66 (JGM1-11xHB 101), DRMRIJQ 15-01 (EC597313xIJ 31) and hybrid DRMRHJ 3813 were inducted for evaluation under timely sown, late sown, quality and hybrid trials, respectively. Further, 21 entries were inducted for evaluation of disease reaction under NDN, DRMRMJA 35, CMS line of *B. juncea* was found resistant to white rust during 2014-15. This strain has earlier been reported to be resistant against white rust during 2012-13 and 2013-14 under UDN. DRMRIJ 12-28, DRMRIJ 12-06, DRMRIJ 12-40, DRMRIJ 12-44, DRMRIJ 12-50, DRMRIJ 12-39, DRMRIJ 12-48, DRMRIJ 12-52 have expressed resistant reaction against white rust at more than two locations. DRMRIJ 12-28 and DRMRIJ 12-48 expressed resistant reaction against powdery mildew at Morena and S.K. Nagar centres, respectively.

Performance of entries evaluated during 2014-15

The eight white rust resistant entries along with 3 checks (DRMRIJ 31, NRCHB 101 and RGN 73) were evaluated in replicated block design with 3 replications. Three entries showed resistant reaction against white rust. Seed yield of these entries (EC 597320/IJ 31, 1741 kg/ha; SSR2/WF2-1, 1891 kg/ha and DR7/HB 101, 1571 kg/ha) was statistically at par with best check RGN 73 (1709 kg/ha). In station trial 4, 16 strains including two of *B. juncea* and 14 of *B. carinata* were evaluated in replicated block design with 4 check varieties comprising Kranti and Giriraj of *B. juncea* and Kiran and Pusa Swarnim of *B. carinata*. Two entries MCB 1-1-5 (2218 kg/ha) and MCB 1-1-6 (2229 kg/ha) of *B. carinata* out yielded the best check Pusa Swarnim (2091 kg/ha).

Progeny row testing

The 144 progenies comprising 37 of *B. carinata*, 3 of gobhi sarson and 104 of B. juncea were evaluated in paired row plot of 3 m length each in augmented block design. Range of characteristics observed in *B. carinata* and *B. juncea* lines are presented in Table 2.2.

Table 2.2. Range for seed yield and other agronomic traits in progeny row testing

Trait	Range			
	B. juncea		*B. carinata*	
	Minimum	Maximum	Minimum	Maximum
Days to flower initiation	38	70	49	111
Days to flower senescence	86	129	111	139
Days to maturity	132	154	140	166
Plant height (cm)	138	235	123	281
Main shoot length (cm)	28	92	16	81
Seed Yield (kg/ha)	2101	3833	1288	2674
Oil content (%)	38.1	43.1	35.4	40.4
1000-seed weight (g)	2.7	6.3	2.4	4.9

274 inbred lines and 50 germplasms lines were evaluated in two different experiments conducted in augmented block design keeping single row plot of 3 m length each for inbreds and 5m for germplasms. Range for seed yield and other related traits is presented in Table 2.3.

Table 2.3. Range for seed yield and other agronomic traits in inbred and germplasm lines

Trait	Range			
	Inbred		Germplasm	
	Minimum	Maximum	Minimum	Maximum
Days to flower initiation	38	105	42	104
Days to flower senescence	86	140	94	132
Days to maturity	112	156	132	159
Plant height (cm)	73	248	98	300
Main shoot length (cm)	26	122	30	113
Seed Yield (kg/ha)	1000	2698	1150	2119
Oil content (%)	34.3	42.2	34.7	42.0
1000-seed weight (g)	1.7	8.7	1.9	5.5

102 F_1s were evaluated in augmented block design with 3 checks; DMH 1, NRCHB 506 and Kranti. Two promising hybrids MJA11/MJR13 and MJA 14/MJR3 displayed 8.5 and 18.5 % seed yield heterosis over NRCHB 506 (Table 2.4).

Table 2.4. Characterization of promising hybrids

Entry	PP	DFI	DFS	DM	PH (cm)	MSL (cm)	SY (kg/ha)	Heterosis (%)	OC (%)	1000 SW (g)	S/S	SL
DMH-1	17	54	111	131	215	58	2659		40.4	3.39	13	3.3
NRCHB 506	19	52	111	140	204	62	3673		40.6	4.61	14	3.4
MJA 11/ MJR 13	24	51	104	140	196	55	3984	8.5	40.4	3.73	16	4.2
MJA 14/ MJR 3	22	52	117	140	213	65	4355	18.5	41.1	4.69	15	4.2

Generation of crosses: 21 earlier identified heterotic crosses, 50 test crosses, 56 crosses in line xtester design were attempted.

Pre-breeding for genetic enhancement of Ethiopian (*Brassica carinata*) and Indian mustard (*B. juncea*) gene pool

Forty five progenies of *B. carinata* selected from segregating generation of interspecfic crosses between *B. juncea* and *B. carinata* during 2014-15 were evaluated in paired row plots of 3 m length alongwith 2 *B. carinata* checks Kiran and Pusa Swarnim.

Fifty seven lines comprising 30 *B. juncea* and 27 *B. carinata* derived from interspecific cross between *B. juncea* (NRCHB 101) and *B. carinata* (Pusa Swarnim) were evaluated in augmented block design keeping plot size of single row of 3 m length. 60 F_1 crosses between derived *B. carinata* lines and two varieties Kiran and Pusa Swarnim were evaluated in augmented block design. 56 F_1 crosses between derived 14 *B. carinata* lines with 04 released varieties/germplasm lines were attempted. Following 11 interspecific crosses were also attempted to enrich the gene pool of *B. juncea* and *B. carinata*

DRMR CI 06: Oilseed *Brassica* genetic resource management

Principal Investigator: J. Nanjundan, Scientist SS (Genetics and Plant Breeding)

Co-Investigators: K.H.Singh, Principal Scientist (Genetics and Plant Breeding); Pankaj Sharma, Senior Scientist (Plant Pathology)

Re-evaluation of core set and trait specific reference sets in Indian mustard

A core set of 147 Indian mustard accessions were re-evaluated using 17 agro-morphological traits, during the cropping season of 2014-15. Further, the trait specific sets (135 accessions) were also re-evaluated for component traits *viz.*, early flowering (~35 days), plant height (~150 cm), main shoot length (>80 cm), number of siliquae on main shoot (>50), siliqua length (>5 cm), seeds/siliquae (>17), 1000 seed weight (>7 g), oil content (>42%) and harvest index (>25%). The statistical consistency between the core collection and the base collection was tested following standard parameters as given in the power core programme. The comparison of mean, range and variability (CV%) of 17 agronomical traits among base collection, core collection and trait specific collection is given in Table 2.5.

Table 2.5. Mean, range and coefficient of variation for 17 agro-morphological traits in base collection (1643), trait specific reference sets (135) and core set (147) of Indian mustard accessions.

S.N.	Traits	Base collection			Trait specific accessions			Core set		
		1643 IM accessions			135 IM accessions			147 IM accessions		
		Mean	Range	CV (%)	Mean	Range	CV (%)	Mean	Range	CV (%)
1.	Days to initial flowering	49	30-78	10.1	48.9	37.0-71.0	12.1	50.1	35.0-76.0	12.5
2.	Days to 50% flowering	61	34-81	10.7	65.4	49.0-94.0	12.1	68.0	44.0-97.0	13.4
3.	Days to maturity	148	133-163	3.2	137.2	113.0-162.0	5.6	138.0	119.0-151.0	4.4
4.	Plant height (cm)	189	112-260	10.9	205.1	156.0-269.0	10.8	207.5	143.0-289.0	12.1
5.	First basal branching (cm)				60.4	13.0-120.0	37.4	63.5	6.0-144.0	42.2
6.	Fruiting zone length (cm)				84.1	56.0-150.0	14.0	83.0	64.0-107.0	9.2
7.	No. of primary branches	5.7	1.5-13.2	23.4	6.2	3.8-8.4	15.1	6.4	3.0-10.2	20.5
8.	No. of secondary branches	9.5	0.5-24.9	31.9	9.7	3.8-21.0	29.7	10.0	3.0-20.4	33.9
9.	Main shoot length (cm)	64	34-97	14.2	74.0	58.0-105.0	10.6	71.9	33.0-90.0	11.5
10	No. of siliqua on main shoot	43	19-66	15.6	48.8	32.8-70.8	14.5	48.5	24.0-73.6	17.5
11	Siliquae density	0.68	0.38-1.09	15.1	0.7	0.5-0.9	14.1	0.7	0.4-1.1	20.3
12	Siliqua length (cm)	3.8	2.1-6.0	13.7	3.7	2.0-5.1	14.5	4.0	2.5-5.7	12.7
13	No. of seeds per siliqua	13	7-25	15.9	13.0	7.5-18.5	12.6	15.1	7.4-21.5	17.4
14	1000 seed wt (g)	4.6	1.3-7.5	23.3	4.6	1.9-7.4	21.7	4.8	1.5-7.8	27.9
15	Seed yield/plant (g)	12.6	1.3-26.5	36.5	15.2	5.9-27.4	31.2	15.2	4.0-27.7	30.0
16	Harvest index (%)	18.7	6.2-29.9	25.7	19.8	7.1-29.7	19.5	19.8	6.1-27.7	19.2
17	Oil content (%)	40.4	32.3-43.4	2.4	41.2	38.0-44.9	2.4	41.6	39.3-44.0	2.1

Maintenance and multiplication of accessions received from Rothamsted, U.K

A total of 654 *gobhi* sarson accessions received from Rothamsted, UK;EC 763819- EC 764472 were grown for their multiplication/maintenance by adopting proper pollination control measures.

Out of the 654 accessions grown, only 80 accessions could established owing to poor adaptability of winter type exotic *gobhi* sarson genotypes to Indian (Bharatpur) conditions. Further, 916 rapeseed-mustard accessions, 100 varieties, 30 registered lines and 14 other accessions (wild relatives) were rejuvenated/ maintained/multiplied by adopting proper pollination control measures.

Screening of Indian mustard accessions against white rust resistance (at Wellington)

A total of 337 Indian mustard accessions which included core set, trait specific sets, white rust resistant accessions and NGB material were grown at IARI, RS, Wellington, Tamilnadu during the Kharif, 2015 and scored for white rust incidence. A total of 25 accessions were found resistant based on Percent Disease Index (PDI) values whereas, another 23 accessions were found with mixture of both immune and susceptible plants indicating the need for their purification by mass selection. The promising accessions identified are given in Table 2.6.

Table 2.6 Promising accessions identified for white rust resistance at Wellington (kharif 2015)

Alternate ID	IC/EC No.	Other identity
DRMR-107	IC 346769	P 83
DRMR-1993	IC 312514	YS/SKJ 5
DRMR-44		RH 0118
DRMR-2097	IC 426343	SN 55
DRMR-967		HPLM 06-36
DRMR-749	EC 511691	
DRMR-2355		JC 1359-23-558
DRMR-1876	IC 546948	PAB 951
DRMR-673	EC 414304	
DRMR-693	EC 482984	
DRMR-362	IC 511527	KLM 145
DRMR-1808	IC 511444	KLM 169
DRMR-2356		LES 45
DRMR-1825	IC 511461	LET 20

A total of 244 rapeseed-mustard accessions were distributed to various AICRP-RM centres, research organizations and students for their use in research works/varietal developments. The multiplied seeds of 553 accessions which were characterized under Component I of CRP-AB were submitted to the NGB, NBPGR for long term conservation.

2.4 Biotechnological interventions to improve rapeseed-mustard productivity

DRMR BT1: Enhancing the level of resistance/tolerance against Alternaria blight in Indian mustard (*B.juncea*) using biotechnological approaches

Principal Investigator: Ajay Kumar Thakur, Scientist SS (Biotechnology)

Co-Investigators: P.D. Meena, Principal Scientist (Plant Pathology)

Sub-Project 1a: *In vitro* plant regeneration and genetic transformation of *B.juncea* with an antifungal defensin gene

Cotyledon explants procured from 5 days old *in vitro* raised seedlings of *B. juncea* var. NRCDR-2 were pre-cultured on high frequency shoot regeneration medium (MS medium containing 1.5 mg/l BAP and 0.2 mg/l NAA) for 48 hrs and then co-cultivated with *Agrobacterium tumefaciens* LBA 4404 strain harboring *TvD1* and *NtPI* genes in pCAMBIA 2300 binary vector for 48 hrs. Then the explants were transferred to shoot regeneration medium containing 250 mg/l cefotaxime for the inhibition of agrobacterial cells and observed for adventitious shoot regeneration under culture room conditions. Adventitious shoot buds started proliferating after 14-15 days from the cut ends of cotyledon explants. Seven independent putative transgenic events have been developed. The putative transgenic events (shoots) were frequently sub-cultured on to the fresh regeneration medium to check the excessive agrobacterial growth. The putative transformed shoots were multiplied and elongated on the same medium.

When the shoots attained a height of 3-4 cm, they were transferred to root regeneration medium (MS medium containing 0.3 mg/l IAA and 250 mg/l cefotaxime). Root initiation took place within 10-12 days of culture and a 100% rooting rate was reported. When proper root development could take place, the plantlets were taken out from the test-tubes; their roots were washed gently under the stream of running tap water and were kept in 0.3% bavistin for 10-15 minutes. After that, the plantlets were transferred to plastic pots containing autoclaved soilrite and hardened gradually following the standard procedure. Genomic-DNA from seven putative independent transgenic events had been isolated as per the modified CTAB method and quantity of DNA was checked on 0.8% agarose gel. PCR had been carried out using *TvD1* gene specific primers for the confirmation of integration of gene in the plant genome. Three transgenic events were found to be PCR positive for *TvD1* gene and showed an amplification product of 230 bp on agarose gel.

Sub-Project 1b: Introgression of Alternaria blight tolerance from wild crucifers into Indian mustard through embryo rescue approach.

200 crosses, each of *B. juncea* varieties Giriraj and RH 749 x *Sinapis alba* were attempted. 10-12 day-old ovaries were cultured on MS medium supplemented with 2.5 mg/l BAP and 500 mg/l casein hydrolysate (Figure 2.20) and the developing ovules were rescued on culture medium after 30-45 days. 3 ovules in case of RH 749 cross out of a total of 8 and 4 ovules in case of DRMRIJ 31 cross out of a total of 7 cultured ovules showed further germination and were successfully developed into F1 plants (Figure 2.21). Shoot regeneration could take place within 10-12 days after culturing and these shoots are being multiplied and maintained on MS medium containing 2.5 mg/l BAP.

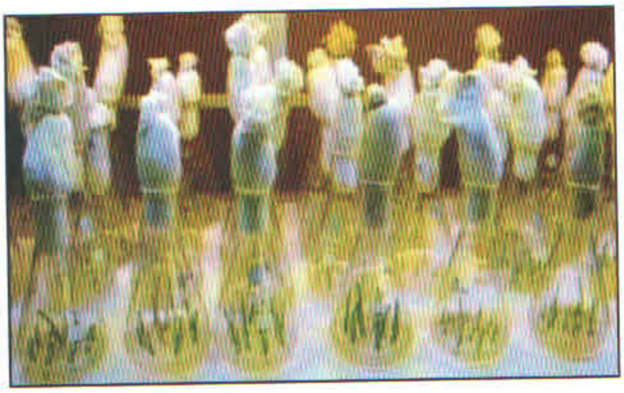


Figure 2.20. 10-12-day-old ovaries obtained from RH 749 x *S. alba* cross cultured on MS medium

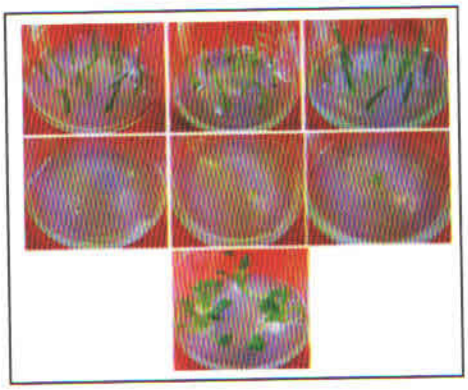


Figure 2.21. Production of intergeneric hybrids between *B. juncea* and *S. alba* by means of embryo rescue (ovary-ovule culture) technique

DRMR BT-3: Marker assisted pyramiding of white rust resistant loci in Indian mustard

Principal Investigator: B.K. Singh, Scientist SS (Plant Biotechnology)

Co-Investigators: P.K. Rai, Principal Scientist (Plant Pathology); Arun Kumar, Senior Scientist (Genetics-Cytogenetics)

Marker assisted pyramiding of white rust resistance loci F_1 hybrids obtained from popular varieties Pusa Bold, Laxmi, Bio-902, Varuna, Maya, Vasundhara, Rohini and NRCDR-2 with white rust resistant genotype. Heera were advanced to BC_4 F_3 stage during 2015-16. At every stage, intron polymorphic (IP) markers At5g41560 and At2g36360 closely linked to white rust resistance loci AcB1-A4.1 and AcB1-A5.1, respectively were used as a replacement for phenotyping in selecting resistant genotypes. BC 4 F_3 seeds harvested will be raised at off-season nursery, IARI Regional Station, Wellington (TN).

DRMR BT-5 Biotechnological interventions for development of *Orobanche* tolerance in Indian mustard (*Brassica juncea L.*)

Principal Investigator: Reema Rani Scientist (Biotechnology)

Associates: Ajay Kumar Thakur, Scientist SS (Biotechnology), Prashant Yadav, Scientist (Biotechnology), M.S. Sujith Kumar, (Biochemistry), O.P. Premi, Principal Scientist (Agronomy)

Targeted Silencing of mannose-6-phosphate reductase gene of *Orobanche aegyptiaca* through Host dependent RNA interference

Mannose 6-phosphate reductase (*M6PR*) is a key enzyme in mannitol biosynthesis in plants. *Orobanche* accumulates high amounts of mannitol, lowering its osmotic potential to a value much more negative than the host; Therefore, it has been suggested that mannitol may be involved in osmoregulation, essential to broomrape for water and nutrient uptake from host, however, it is absent from the major host crop. Keeping these points in view an RNA interference (RNAi) strategy was designed to develop transgenic crop that target mannitol production in the parasite by interfering with the action of the enzyme mannose 6-phosphate reductase.

For development of hpRNAi construct, *Oae* 3'UTR sequences of M6PR gene from *O. aegyptiaca* were PCR amplified using gene specific primers containing XhoI/NcoI, SmaI/XbaI restriction sites. Both sense (SO) and antisense (AS) strands were further cloned into pRT100 expression vector containing CaMV35S promoter, pA tail and spacer intron to form hpRNAi vector. This RNAi cassette, CaMV35Spt:: M6PR::SO::intron::AS-pAwas further cloned into pPZP200lox:35Sde-bar vector to construct binary vector. Screenings of the recombinants were done using restriction digestion and sequencing. In the end recombinants were transformed into *Agrobacterium tumifaciens* for further utilization in plant genetic transformation.

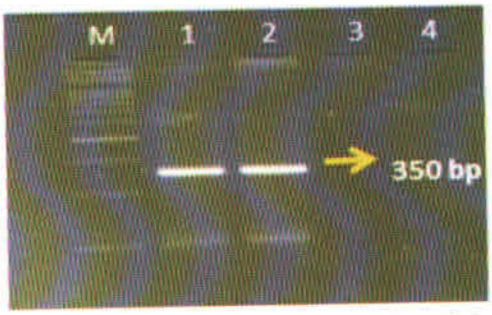
The introduction of RNAi cassette, into *O. aegyptiaca* through transformation in *B. juncea* will facilitate the suppression and degradation of the native M6PR mRNA, resulting in reduced growth of parasitic weed.

T-DNA map of the construct *OaeM6PR* (RNAi) transformation vector

A 220 bp region of the OaeM6PR gene was cloned in sense and antisense orientations with intron (409 bp) as spacer, under the control of CaMV35S promoter.

Development of Molecular Diagnostic for the detection of *Orobanche aegyptiaca* infestation in Mustard crop field.

During the study a high sensitivity soil based PCR diagnostic assay specific to *Orobanche* developed. For this purpose, complementary polymerase chain reaction (PCR) primers based on unique sequences in the internal transcribed spacer (ITS) regions of the nuclear ribosomal DNA of *Orobanche aegyptiaca* were used. Total DNA was extracted from soil samples of *Orobanche* infested mustard fields and subjected to PCR analysis. Using ITS-350 primers, a specific PCR product (350 bp) was amplified and detected in soil samples containing *Orobanche* species, but was not detected in soil sample free of *Orobanche* seeds or tissues. This diagnostic method is simple, reliable, and rapid that could help in assessment of *Orobanche* seed contamination in a crop field. Farmers can directly reap the benefit by testing their soil for *Orobanche* contamination in the field much before sowing of mustard crop.



Agarose gel showing PCR amplification of *Orobanche* DNA from soil of *Orobanche aegyptiaca* infested field, with amplified product of 350bp in lane 1 & 2, whereas control soil DNA was not amplified in lane 3 & 4. M: 100 bp ladder

DRMR-BT 6 : Development of nested association mapping population and mapping traits of economic importance in Indian mustard (*B. juncea*)

Principal Investigator: Prashant Yadav, Scientist (Plant Biotechnology)

Co-Investigator: H.S. Meena, Scientist SS (Genetics and Plant Breeding); M.S. Sujith Kumar, Scientist (Plant Biochemistry); Reema Rani, Scientist (Plant Biotechnology)

A total 53 different varieties for various important traits along with 36 germplasm lines representing the core set were selected and seeds of these genotypes/varieties were sown in two row (3 m). Total 10 crosses were attempted taking Pusa Bold as the common parent. Out of 10 crosses attempted total seven crosses were successful with proper seed setting. DNA was isolated from 79 genotypes by modified C-TAB method and quality and quantity parameters were checked. A total 135 PCR based markers has been screened and among them 50 have shown polymorphism (Figure 2.22 and 2.23).

2.5 Enhancing resource use efficiency and abiotic stress management for resilient rapeseed mustard production system

DRMR CP6: Improved soil resilience under mustard based systems through integrated crop management practices

Principal Investigator: O.P. Premi, Principal Scientist (Agronomy)

Co-Investigator: B.K. Kandpal, Principal Scientist (Agronomy)

The long-term effect of soil organic carbon (SOC) and fertilizer management strategies on traditional fallow-mustard system is being evaluated since 2005-06. Continuous adoption of management strategies significantly influenced the mustard seed yield, soil microbial biomass carbon (MBC) and soil dehydrogenase activity. In general, sesbania green manure (SGM) significantly increased mustard seed yield by 35.6% over control (Table 2.7). Supplementary incorporation of 2.5 t/ha mustard straw before sowing of SGM significantly increased the seed yield by 11.6% over SGM and 51.4% over control. The continuous application of NPK (80:17.4:33.3 kg/ha) maintained

Figure 2.22. DNA sample of 79 Indian mustard genotypes

Fig 2.23. DNA based polymorphic markers showing variation in Indian mustard genotypes.

sustainable higher productivity than other doses. The combined adoption of mustard straw incorporation (MSI)+SGM and balance NPK synergistically increased the seed yield by 85.4% over suboptimal F1, 66.6% over optimal F8 and 38.1% over MSI+SGM

Table 2.7. Effect of integrated nutrient management on seed yield of mustard (kg/ha)

Cropping system (CS)	Fertility levels*								Mean
	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	
Control	1770	1822	1853	1855	1904	1907	1940	1969	1878
Sesbania (GM)	2274	2535	2302	2581	2504	2731	2731	2732	2547
Mustard straw @ 2.5 t/ha + *Sesbania* (GM)	2375	2420	2590	2757	3036	3121	3170	3282	2844
Mean	2139	2259	2249	2398	2482	2586	2608	2661	-
CD (P=0.05)	CS: 201, Fertility level: 182, CS x Fertility level: 315, Fertility level x CS: 355								

*F1: N40 P8.7 K0, F2: N40 P8.7 K33.3, F3: N40 P17.4 K0, F4: N40 P17.4 K33.3, F5: N80 P8.7 K0, F6: N80 P8.7 K33.3, F7: N80 P17.4 K0, F8: N80 P17.4 K33.3 (kg/ha)

In an another long term experiment studied the four oilseed Brassica (OSB) production systems of semi-arid tropics along with three land use management levels (CFM: conventional fertility management-100% RDF, MFM: medium fertility management-50% RDF and subsistence: fertility levels–no fertilizer) in main plot and six SOC management strategies (SGM, MSI, MSI+SGM, mustard straw mulch–MSM, FYM and vermicompost-VC). Overall, CFM significantly improved the mustard seed yield by 24.5% over MML, 63.1% over LML and 193.7% over absolute control (Table 2.8). Among SOC management strategies, MSI+SGM were found most resilient and recorded maximum mustard seed yield.

Table 2.8. Effect of nutrient management strategy on seed yield of mustard (kg/ha)

Fertility management (FM)	Nutrient management strategy (NMS)						Mean
	SGM	MSI	MSI+GM	MSM	FYM	VC	
CFM (100% RDF)	2564	2282	2854	2264	2474	2648	2514
MFM (50% RDF)	1915	2008	2332	1593	2005	2262	2019
Subsistance (No fert.)	1539	1400	1890	1374	1513	1530	1541
Mean	2006	1897	2359	1744	1997	2147	-
CD (P=0.05)	FM: 190, NMS:120, FMxNMS:201, NMSxFM:266						
	Absolute control: 856, Control: 1310						

2.6 Management of biotic stresses in Indian mustard

DRMR PP-1 Management of Sclerotinia rot in rapeseed-mustard

Principal Investigator: Pankaj Sharma, Senior Scientist (Plant Pathology)

Co-Investigator: P.D. Meena, Principal Scientist (Plant Pathology)

Epidemiology

Epidemiological studies of Sclerotinia rot was done using eight dates of sowing starting on Oct 1, 2015 at weekly intervals with three replications in plot size of 4.5x5 m using cultivar RH 749 of Indian mustard. Data for disease incidence was recorded apart from petal infection, weather data and soil moisture to identify the suitable conditions for disease development. Data analysis revealed that incidence of Sclerotinia rot was positively correlated with soil moisture and weather parameters including temperature and relative humidity (R^2 0.69 and 0.45) and negatively with bright sunshine hours, BSSH (R^2 0.43). Combination of cool weather, high soil moisture and less BSSH during the critical stage (60-70 DAS) of crop favoured higher Sclerotinia rot incidence in Indian mustard.

Maximum incidence of Sclerotinia rot was observed in 29 Oct (33.9%) followed by 22 Oct and 15 Oct while it was minimum in 19 Nov (5.1%) sown crop. The highest seed yield was recorded in 8 Oct (2356 kg/ha) followed by 1 and 22 Oct (2234 and 2089 kg/ha, respectively) while it was lowest in 19 Nov (578 kg/ha) sown crop. Disease severity of white rust (WR) was also recorded during the experiment and it was maximum in 5 and 12 Nov sown crop.

Per cent petal infection (PPI) resulted, initiation of SR incidence in first standard week and PPI increased in second standard week in 15, 22 and 29 Oct sown crop. During first fortnight of January, apothecia were also observed on soil surface in *B. juncea* field (Figure 2.24).

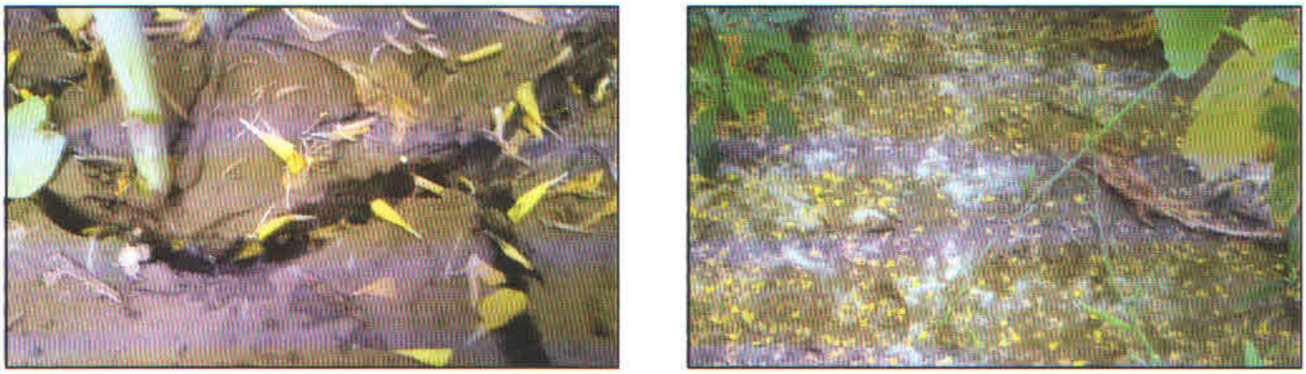


Figure 2.24. Apothecia and mycelial growth on shredded petals in sick plot

Germplasm screening against Sclerotinia rot

Four hundred sixty two (57 SBG, 10 NDN, 307 core collection, 34 exotic, 54 *B. carinata*) germplasm lines of *B. juncea, B. carinata and B. napus* were screened under sick plot at DRMR during 2015-16 season, sown on 2 Nov., 2015 in single row of 3 m length with 30 cm x 10 cm spacing maintaining two test rows per plot along with border rows of cv. NRCYS 5-2 (susceptible check) in randomized block design with two replications. Pathogen inoculum was mass multiplied on autoclaved sorghum grain and mixed with soil prior to sowing to create epiphytotic conditions. Further, the plants were stem inoculated with the mycelial bit of pathogen. Data for reaction to the disease was recorded. Germplasm EC 597317, EC 597328 (exotic), WR 2035, RH 1222-28, DRMR 360, DRMR 1493, DRMR 1034 and DRMR 261 were observed tolerant (lesion size >3.0 cm and disease incidence <10%).

Figure 2.25. Susceptible and resistant reaction on stem

831 germplasm lines received from National Gene Bank, 1105 mutagenic plants (RH 749 treated with different doses of gamma rays and EMS) and advance breeding lines, F_2 population were also screened with artificial stem inoculation for Sclerotinia resistance. DRMR 2035 and other promising lines will be screened under sick plot (Figure 2.25).

Management of Sclerotinia rot

An experiment on management of Sclerotinia rot was laid out in randomized block design with 8 treatments (including control) in three replications on Sclerotinia infested plot at experimental farm, DRMR. The crop was sown on 3 Nov 2015 with seed treatment of *Trichoderma* (8 g/kg) and carbendazim (2g/kg), combinations of seed treatment (ST) and foliar spray (FS) (0.2%) of carbendazim, ST+FS *Trichoderma* and FS *Pseudomonas fluorescens* (10^8 cfu/ml) at flowering stage. Among different treatments, carbendazim ST+FS provided highest yield (1889 Kg/ha) and minimum per cent disease incidence (7.9%) followed by ST *Trichoderma*+ FS carbendazim (1790 kg/ha) as compared to control (1017 kg/ha and 36.2%).

Sclerotial germination and phylloplane microflora

The primary survival (overwintering) structure of *S. sclerotiorum* is the sclerotia which is a hard resting structure consisting of a light colored interior portion, medulla and an exterior black protective covering called rind. The rind contains melanin pigments which are highly resistant to degradation, while the medulla consists of fungal cells rich in β-glucans and proteins. Sclerotia at different temperature range (10, 20, 30, 40, 50, 60 °C) were kept for 4 to 7 days and later incubated on PDA. Sclerotial germination was minimum (40%) only at 60 °C with 7 days treatment while it was 57.5% after 6 days. Other temperature was not able to check the sclerotial germination.

The fresh leaves of *B. juncea* 45 DAS were collected and placed in sterile plastic bags, and immediately brought to the laboratory. Leaves were shaken in flasks filled with 200ml of distilled water. From the suspension 0.2ml was transferred into Petri plates containing potato dextrose agar medium with streptomycin and nutrient agar. The inoculum was spreaded uniformly and kept in BOD for 3-5 days. The fungal and bacterial colonies were observed and pure cultures were maintained. Phylloplane fungi and bacteria were identified referring the standard manuals. A total number of 15 fungal and 2 bacterial species were isolated.

DRMR PP 3: Management of Alternaria blight in rapeseed-mustard crops

Principal Investigator: P.D. Meena, Principal Scientist (Plant Pathology)

Co-Investigator: Pankaj Sharma, Senior Scientist (Plant Pathology)

Development of *in vitro* screening technique

Three inoculation methods tested were, seed inoculation, cotyledon inoculation, and seed and cotyledon inoculation using susceptible cultivar Varuna for development of a suitable rapid and economic screening technique for Alternaria blight. *A. brassica* conidia were inoculated directly onto the seedlings with $1.5x10^5$, $2.5x10^5$, $4x10^5$ and $5x10^5$ conidia ml^{-1} concentrations for standardization. Percentage AB severity increased with increase in conidial concentration and it was highest in $5x10^5$ conidia ml^{-1} suspension, and it was used for final screening. Among three screening methods, both seed and cotyledon inoculation method was found highly effective where mean AB severity on cotyledon was 84.6 % in comparison to 49.3 % in inoculation of seed and 62.5% in inoculation of cotyledon. The technique was validated by screening susceptible and putative tolerant genotypes of *B. juncea* namely; PHR-2, EC-299399, PAB-9511, PAB-9534, EC-299296, DRMR-2805, DRMR-2807 and one genotype of

Sinapis alba. Severity of AB was 54% in susceptible genotype and 16.4-21.2% in tolerant genotypes. Conidia number per microscopic field was 21.5 in putative tolerant and 43.5 in susceptible genotypes. Thus, *in vitro* screening of AB using both seed and cotyledon inoculation method was found most effective and could be used for rapid screening at early stages of plant growth.

Rating scale for AB at cotyledonary stage

According to pathogenic symptomatic response of cotyledon infection, a rating scale was developed by using a 0-7 score and interaction phenotype (IP) based on visual evaluation of lesions on cotyledons (NR = No response; F = Light necrotic flecking; FN = Heavy necrotic flecking; ML= minute lesions, FL =Few lesions, NL = numerous lesions, LL = large scattered, and CL = coalescing lesions represents resistant/ tolerant/ susceptible classes were used, adapted with minor modification from the paper of Leckie *et al.* (1996).Per cent AB severity was calculated by formula as:

$$\text{Percent disease severity (PDS)} = \frac{\text{Total sum of numerical ratings x 100}}{\text{Max. rating x No. of samples observed}}$$

However, the AB disease score was given based on host response for different IP. The IP of each individual cotyledon for Alternaria blight pathogen was recorded as rating score for that particular cotyledon (Figure 2.26). Accordingly, cotyledons were categorized into eight IP classes, ranges in numbers from 0 to 7; i.e., 0 = no response, 1 = light small necrotic flecking, 2= heavy necrotic flecking, 3= minute lesions on cotyledon, 4= few lesions on cotyledons, 5= numerous lesions on cotyledons, 6= large scattered lesions, and 7= coalescing lesions including yellowing and rotting (dead).

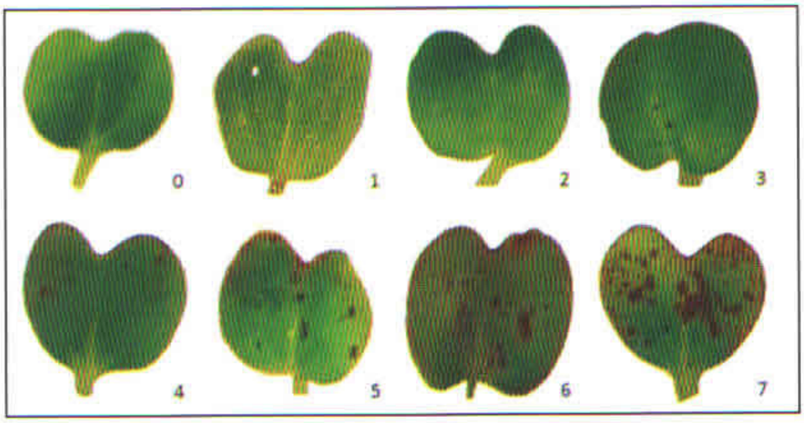


Figure 2.26: Different interaction phenotypes at cotyledonary stage of Indian mustard

Pathogenecity of *A. brassicae* isolates at cotyledonary stage

Thirty isolates of *A. brassicae* (Berk.) Sacc. collected from diverse geographical locations of India were taken to study the pathogenic variability using inoculation of seed and cotyledon of *B. juncea*. In inoculation of both seed and cotyledon method, the highest % AB severity was observed with isolate BAB-39, BAB-47, BAB-06, BAB-08, BAB-12, BAB-28, BAB-43, BAB-55 and least in isolate BAB-49 (34.0), BAB-02 and BAB-20. Results revealed that the isolate BAB-49 was found least virulent, showing little reduction of seed germination, produces small lesion size under field conditions, and least AB severity (34%) with merely 3.17 numbers of conidia per microscopic field (20x) in tissues of cotyledons. Results indicated the existence of pathogenic variability among isolates of *A. brassicae* with their sensitive effect of culture filtrate on seed and cotyledon of *B. juncea*.

DRMR PP 5: Epidemiology and management of white rust

Principal Investigator: P.K.Rai, Principal Scientist (Plant Pathology)

Co-Investigators: Pankaj Sharma, Senior Scientist (Plant Pathology), V.V. Singh, Principal Scientist (Genetics and Plant Breeding)

An experiment was laid out with three dates of sowing *i.e.* Oct. 10, 29 and Nov. 19, 2014 for epidemiological observations. The experiment was laid out under RBD in plot size 5x5m spacing 30x10 cm with four replications using susceptible variety Rohini. Data on disease incidence was recorded twice and disease index was calculated. Disease data was correlated with prevailing weather conditions *i.e.* rainfall and relative humidity. Data on soil moisture was also recorded. The maximum disease index (65.06%) was observed on late sown (19 Nov.) followed by 29 Oct. sown crop (43.8%). The minimum disease index was observed on early sown (8 Oct.) crop. High incidence of staghead (42.5) was observed in 19 Nov. sown crop. High relative humidity during January, 2015 favored the rapid increase in disease incidence in both, early and late sown crop (Figure 2.27).

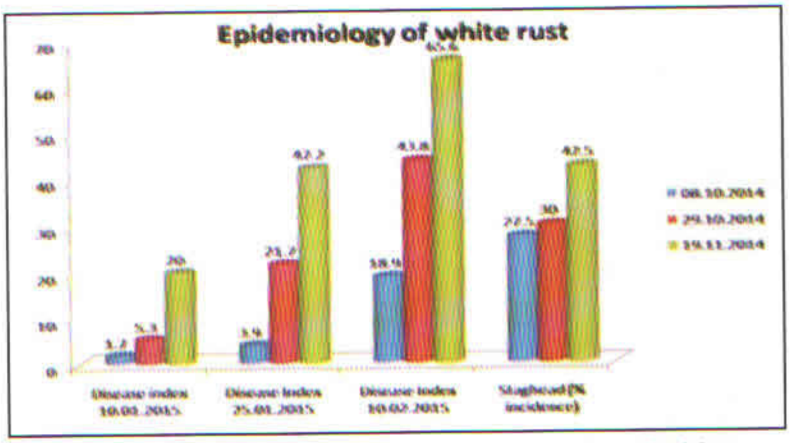


Fig 2.27. Effect of date of sowing on white rust incidence

An experiment was planned to observe the effect of seed/soil and bud inoculation on white rust staghead formation with three treatment *i.e.* sowing with oospores infested seeds, sowing in soil inoculated with oospores and bud inoculation 50 DAS in 4.5x3 m plot size with 4 replications. The sowing was done on 15 Nov., 2014 with 30x10 cm spacing. Observations on disease index; no. of infected leaves/plant; total number of pustules on all infected leaves on 20 randomly selected plants/ plot was recorded (Verma and Petrie, 1979). The maximum staghead formation (23.6%) was observed when buds were inoculated with zoosporangial solutions 50 DAS. Staghead formation in oospore infested soil and seed were 17.9 and 17.2, respectively (Figure 2.28).

In order to standardize differential hosts for identification of *A. candida* races, two isolates *i.e.* Bharatpur and Hisar were inoculated at cotyledonary stage (14 and 21 DAS) on 11 genotypes of rapeseed-mustard (PBC-9221, EC-399301, EC-399301, Rohini, EC-414293, Basanti, PBR-97, EC-399299, DMH-1, GSL-1, Aravali, RH-30). 10 seedlings of each genotype/pot were inoculated with zoospore suspension. Disease reaction was observed 30 DAS. Genotype EC-399301, EC-399301, Rohini, EC-414293, Basanti, PBR-97, EC-399299, Aravali and RH-30 were found susceptible to both the isolates of *A. candida*. Based on reaction to *A. candida* isolates, Rohini, Basanti and RH-30 may be categorized as primary differential. PBC-9221 (*B. carinata*) and GSL-1 (*B. napus*) showed resistance to both the isolates.

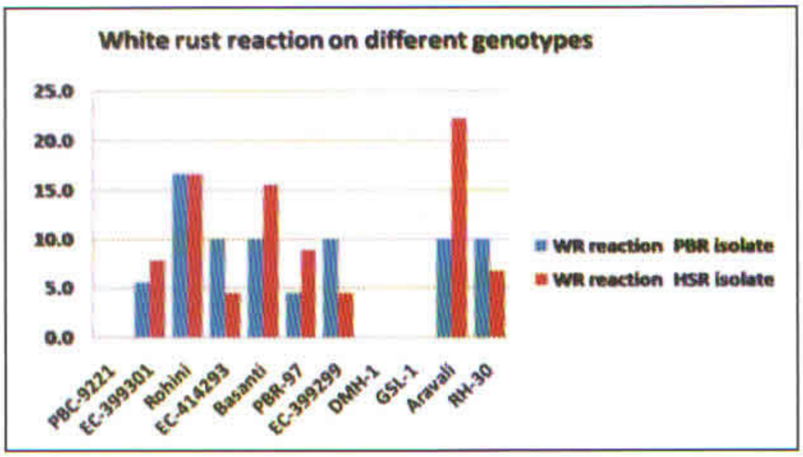


Figure 2.28. White rust reaction on different genotypes

Multiple disease resistance against white rust

In order to develop multiple disease resistance, particularly against white rust and Alternaria blight, in Indian mustard, dialle crosses were made using 11 genotypes of Indian mustard. White rust and Alternaria blight reaction were observed in parents. RH-555, RH-749 and DRMRIJ 31 were susceptible to both white rust and Alternaria blight. RH-1231, RH-1239, RH-1235, RH-1230, RH-345 were resistant to white rust and RH-1372, RH-1378, RH-1117 were tolerant to Alternaria blight. A total 34 entries of rapeseed-mustard including resistant and susceptible checks were sown in augmented design for screening against white rust in paired row of 5m length with 30x10 cm spacing. White rust inoculation was done twice 45 and 60 DAS to create disease pressure. Observation on disease incidence was recorded after 90 and 105 DAS. Entries *viz.*, RH-1231, DRMRIJ-12-14, DRMRIJ-12-28, DRMRIJ-12-37, DRMRIJ-12-40, DRMRIJ-12-41, DRMRIJ-12-44, DRMRIJ-12-48 and DRMRIJ-12-50 gave immune response to white rust. Genotype RH-305, DRMRIJ-12-06, DRMRIJ-12-21, DRMRIJ-12-52, DRMRMJA-35 and RMWR-09-5-1 were highly resistant whereas, genotypes DRMRIJ-12-03, RH-1234, RH-1238, DRMRIJ-12-39 and DRMRIJ-12-51 showed resistant response.

For effective management of white rust with minimum use of chemical fungicides, seven ttreatments involving PGPR and newer fungicides alone and in different combinations *viz.,* seed treatment with metalaxyl 35@ 6g/kg seed + foliar spray of metalaxyl 8% + mancozeb 64% @ 0.2%; seed treatment with mancozeb @ 3 g/kg seed + foliar spray of metalaxyl-M @ 0.2%; seed treatment with metalaxyl 35@ 6g/kg seed + foliar spray of Folicur @ 0.1%; seed treatment with metalaxyl 35@ 6g/kg seed + foliar spray of metalaxyl-M @ 0.2%; seed treatment with metalaxyl 35@ 6g/kg seed + foliar spray of *Bacillus subtilis* (10^9 cfu); seed treatment with metalaxyl 35@ 6g/kg seed + foliar spray of *P. fluorescence* (10^9 cfu) and control are being tested under filed conditions. The experiment was planned in RBD with four replications. Plot size was 5x3m with 30x10 cm spacing. The crop was sprayed twice with fungicide/PGPR wherever required. Disease index on leaves was recorded 90 DAS. The maximum (84.6%) disease reduction was observed in ST metalaxyl 35@ 6g/kg seed + FS metalaxyl 8% + mancozeb 64% @ 0.2% followed by ST metalaxyl 35@ 6g/kg seed + FS metalaxyl-M @ 0.2% and ST metalaxyl 35@ 6g/kg seed + FS Folicur @ 0.1%. ST metalaxyl 35@ 6g/kg seed + FS *P. fluorescence* (10^9 cfu) was least effective (68.7% disease reduction) in controlling the disease followed by ST metalaxyl 35@ 6g/kg seed + FS *Bacillus subtilis* (10^9 cfu).

2.7 Technology assessment and dissemination

DRMR TAD 4: Participatory extension for dissemination of rapeseed-mustard technology

Principal Investigator: Ashok Kumar Sharma, Senior Scientist (Agricultural Extension)

Co-Investigator: Vinod Kumar, Senior Scientist(Computer Application)

Utilization pattern of sources and channels of information

An important pre-requisite for the adoption and diffusion of any technology within a societal system, is the effective communication of information relating to the technology involved. A study was conducted to assess the important sources and channels of agriculture information which were being utilized by the farmers. 25 farmers by taking equal representation from each of the selected 5 villages namely, Dhor, Sinpini, Neotha, Gudawali and Seorawali of Bharatpur districts of Rajasthan, thus making of total sample of 125 farmer respondents were selected (Table 2.9 and 2.10).

Table 2.9. Utilization and credibility of information sources of mustard farmers (N=125)

Information sources	Utilization		Credibility	
	Percent of respondents	Rank	Per cent of respondents	Rank
Fellow farmers	81.6	1	51.2	3
Relatives and friends	78.4	2	73.6	1
Input dealers/company agents	72.0	3	33.6	5
Agriculture supervisors/VLWs	30.4	4	35.2	4
Progressive farmers and opinion investigator	22.4	5	28.8	6
Agriculture officers/ KVK staff/scientist	14.4	6	62.4	2
NGOs personnel	9.6	7	8.0	7

Table 2.10. Utilization and credibility of information channels of mustard farmers (N=125)

Information channels	Utilization		Credibility	
	Percent of respondents	Rank	Percent of respondents	Rank
Group discussion/meetings	78.4	1	40.0	6
Demonstrations	51.2	2	60.0	1
Training	38.4	3	51.2	3
Newspaper	33.6	4	54.4	2
Telephone consultations/SMS	28.0	5	39.2	7
Radio	18.4	6	41.6	5
Farm publication	16.8	7	38.4	8
TV	11.2	8	44.8	4

The study regarding information sources showed that majority of respondents (81.6%) depend on neighbours and other fellow farmers for seeking information and considered them as most utilized source due to easy accessibility, however only 51.2% farmers perceived them as credible source of agriculture information because of the same level of farming and placed at third rank in credibility score. The relatives and friends were the top most credible sources in the view of the respondents and also used by majority of the respondents (78.4%). These sources were among their own social system and easily accessible to them. It was interesting to note that the input dealers and agents of private firms were considered as third most important sources of information as reported by 72% respondents but their low credibility, as only 33.6% farmers perceived them as credible with fifth rank in order of level of credibility of information sources. Farmers reported that since most of all the inputs were only available with private dealers. The field level extension workers are the only official source of agriculture information at grass root level for the farmers in the villages. However due to many constraints, this important source of agriculture information are less available for farmers. Only 30.4% respondents reported for seeking information from field level extension workers. The credibility (35.2%) of this source was also very low. The agriculture officers, KVK staffs and scientists were perceived as second most credible source of information as reported by 62.4% farmers, but these credible sources were being utilized by only 14.4% farmers. Information channels used by respondent farmers, the study reported that group discussion or meetings organized by govt. agencies were the most important medium for the farmers for seeking information (78.4%) with top most rank. It was also worth noting that highly utilized this channel of information does not considered much credible as only 40% respondents perceived it credible and placed at 6th rank. 51.2% respondents reported that demonstrations were also very important channel of agriculture information with top most credibility (60%), followed by utilization of training (38.4%) with 51.2% credibility.

Study the farmers' perception in technology adoption

Adoption of an innovation or a technology by the farmers depends on many factors. A study was conducted to know the farmer' perception of the major factors which affect the adoption of particular technology by them. For the purpose, 125 farmer respondents were selected to identify the important factors affecting adoption behaviour of the farmers. Majority (90%) of mustard growers judged the received information on the basis of comparative advantage (not only higher yields, but also better oils, low cost, etc.). This was given first rank which was followed by the judgement based on compatibility or feasibility of the innovation with their own farming situations and methods (87.08 %). 84.16% respondents reported that they take the decision for adoption of an innovation on the basis of availability of required inputs and resources as it got third rank. An experience of past failure and success was considered by 75.83% respondents before taking the decision for adoption and accorded fourth rank.

An important question is how much yield increase is required for farmers to adopt a given technology. According to Baum et al. (1999), the net benefit should usually be between 50 and 100%, which corresponds to a Benefit-Cost ratioof 1.5-2. If the technology is new to the farmer and they learn some new skills, a minimum rate of return near to 100% is a reasonable estimate to assume adoption. And if the technology simply modifies a current farmer practice (such as a higher/lower fertilizer rate, replacement of varieties etc.), then a minimum rate of return as low as 50% may be acceptable.

Constraints faced by extension workers in transfer of technology

280 extension workers; Rajasthan (160), Uttar Pradesh (80) and Madhya Pradesh (40) who participated in training programmes organized

by ICAR-DRMR during 2014-15 were asked to identify the major constraints faced by them in transfer of technology to the farmers and their training needs. The study revealed (Table 2.11) that lack of knowledge and skill about latest technological advances in the field of rapeseed-mustard was the top most constraint reported by the 78.21% respondents. The lack of practical exposure to technology demonstration unit was perceived second most important constraint by respondents (75.71%). It is worth noting that 74.28% respondents reported non-cooperation and lack of interest of farmers to participate in extension activities/programmes organized by the departments. On the other hand, the 73.21% extension workers reported that area of their working jurisdiction was very large and it was difficult to visit fields and farmers of particular location regularly. The lack of training in extension approaches/methodologies was perceived as one of the major constraints by 70.35 per cent respondents which placed at sixth rank.

Table 2.11. Constraints faced by extension workers in transfer of technology to the farmers.

Constraints	Per cent	Rank
Lack of knowledge and skill about latest technological advances	78.21	I
Lack of practical exposure to technology demonstration unit	75.71	II
Non-cooperation and lack of interest of farmers to participate in extension activities/programmes organized by the department	74.28	III
More jurisdiction area of working	73.21	IV
Involvement in other activities/programmes of other departments more than extension activities of agriculture	72.14	V
Lack of training in extension approaches/methodologies	70.35	VI
Delay in receiving minikit demonstrations/inputs to be given to farmers	68.21	VII (N: 280)
Inferior quality of inputs supplied by cooperative societies under minikit demonstrations	66.42	VIII
Non-availability of recommended inputs (seed, fertilizers, culture, fungicides, insecticides etc.) in the market	64.64	IX
Delay in receiving of guidelines/information about implementation of activities and budget release	63.57	X
Dependency on package of practices developed by the department.	61.75	XI
Lack of opinion Investigatorship in the village	60.00	XII

Training need assessment: The training need assessment showed (Table 2.12) that 86.42% respondents had highest level of training in the aspects of insect-pest and disease management followed by areas of management and use of fertilizers by 82.14%. The training in selection of improved varieties, proper seed rate and sowing method was given the third most important with 81.07%. The training in weed management was the fourth ranked priority as reported by 77.14% respondents.

Table 2.12. Prioritization of training needs of extension workers

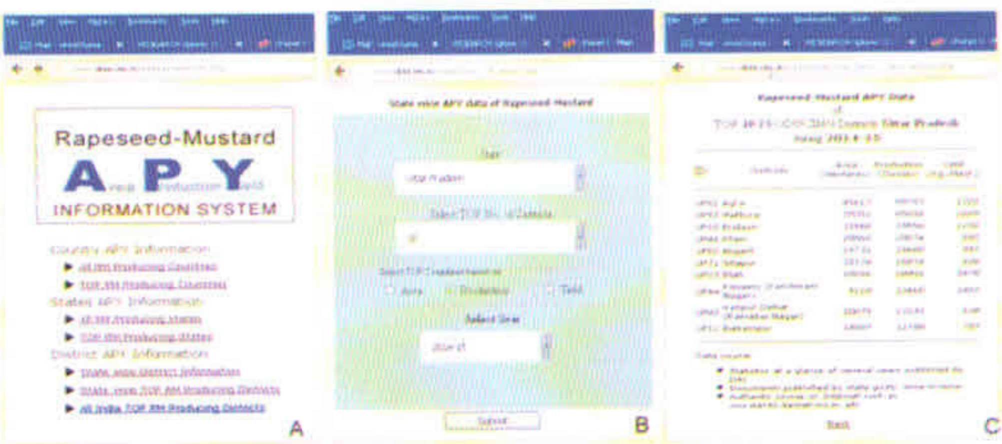
Aspects	Training needs	
	Frequency (%)	Rank
Insect-pest and disease management	86.42	I
Management and use of fertilizers	82.14	II
Selection of improved varieties, proper seed rate and sowing method	81.07	III
Weed management	77.14	IV
Management of abiotic stress and Natural calamities	74.28	V
Seed and soil treatment land preparation or field management	72.14	VI
Harvest, threshing and storage	65.00	VII

DRMR CA-1: Development of application software for rapeseed-mustard information management

Principal Investigator: Vinod Kumar, Senior Scientist (Computer Application)

Co-Investigator: Ashok Kumar, Senior Scientist (Agricultural Extension)

Rapeseed-mustard (RM) production data is essential for estimating the growth of the crop to assess the supply trend. RM production data is available in scattered and in several forms. Availability of reliable data at one place is one of the most critical requirements for efficient policy planning, to consider impact of development programmes and for carrying out an analysis of problems and constraints in growth of the RM and exploring growth prospects. Compiled the information and created the online database of area, production and yield of RM. Presently, it contain the information, 54 years data of 72 RM producing countries worldwide, 48 years data of 26 RM producing states in India and 17 years data of all districts of RM producing states. The database has been developed in user friendly manner and inbuilt queries have been developed for viewing data in several way. This data base is available online on the website of DRMR (www.drmr.res.in/rmdata/rmAPYinfo.php). HTML, CSS, was used for development of user interface; PHP is the middleware and MySql for the backend.



Screen Shots: A) Main Menu B) Query for state wise top districts C) Query output

Externally Funded Projects

ICAR Project: Incentivizing research in agriculture-Indian mustard

(Sub Project-IV): Molecular genetic analysis of resistance/tolerance to different stresses

Principal Investigator: V.V. Singh, Principal Scientist (Genetics and Plant Breeding)

Co-Investigators: Pankaj Sharma, Senior Scientist (Plant Pathology); Bhagirath Ram, Senior Scientist (Genetics and Plant Breeding); Ibandalin Mawlong, Scientist (Plant Biochemistry); Reema Rani, Scientist (Plant Biotechnology)

Physiological characterization of Indian mustard germplasm for heat stress tolerance

Seventy two germplasm accessions including checks were evaluated under heat stress (Sowing date 28 September, 2015) and normal conditions (Sowing date 24 October, 2015) during rabi 2015-16 in augmented design for their per se performance with respect to their high temperature stress tolerance at seedling stage. 100 seeds of each 72 germplasm were sown in two rows of 2.5 m length. Growth and physiological characters, including, population survival (PS) at 10 and 25 days after sowing (DAS), membrane stability index (MSI), excised-leaf water loss (ELWL) and relative water content (RWC) were recorded from five randomly selected plants of each germplasm.

Results indicated that most germplasms respond differently under normal and high temperature stress conditions. The population survival (%) at 10 DAS and 25 DAS under heat stress situation ranged from 7 to 41 (%) and 2 to 30 (%), respectively. The population survival at 10 and 25 DAS decreased with increasing heat stress in all germplasm. However, the less decrement was recorded in BBM 06-02, P 32, HPLM 06-11, UP II-73, DRMRIJ 447 and PBR 378. Under non-stress normal condition, the decrease in population survival was lesser in germplasm B/K/S 55, HPLM 06-25 and BPR-543-2. Membrane stability index (MSI) increased under heat stress in most germplasm. MSI was high in BPR-543-2, MRN-J-2001-3, HP 30, B 337, IC 267700, UP II-73, and PBR 378 under normal and stress conditions, while it was low in DRMR-1998 (1.04 %), DRMR-1077 (1.45 %), IC-511611 (1.56 %) and DU 4 (1.69 %) at high temperature stress relative to the normal. Thermo-tolerant germplasm have less excised-leaf water loss (ELWL) compared to thermo-susceptible germplasm. Germplasm B/K/S 55 (36.99 %), BPR-543-2 (41.29 %), RH 0305 (43.64%), IIHR 6 (CO-2) (45.41%) and B 15(45.58 %) were identified as heat tolerant and germplasm HPLM 06-25, B/K/S 59, B/K/S 50 and SKM 539 as heat sensitive for ELWL, irrespective of environmental condition. In general, heat stress adversely affected relative water content of mustard germplasm. The significantly lower RWC values indicated that in general, the loss of water from leaves at reproductive stage was higher with poor retention. RWC values of germplasm BPR 549-9 (92.11 %), RRN 752 (91.11%), BPR-543-2 (90.86%), MRN-J-2001-3 (89.74%), B 337 (86.67%), RM 14 (85.71%) and DRMR-2001 (85.71%) were higher compared to germplasm lines EC 511664 (66.67%), HP 02-03-2 (71.62%), UP II-73 (71.67%) and UP I-11 (72.58%). Based on population survival (%) at 10 and 25 DAS, MSI, ELWL and RWC values , germplasm UP-II-73, BPR-543-2, MRN-J-2001-3 and HPLM-06-25 were identified as heat tolerant at seedling stage.

Two hundred seeds of each thirty genotypes including tolerant and susceptible were sown in the field under heat stress and normal conditions in CRBD with three replications in two rows of 5 m length for high temperature stress tolerance at seedling stage. The population survival (%) at 10 and 25 DAS under heat stress situation ranged from 39 to 69 (%) and 38 to 72 (%), respectively. Genotype Urvashi (69%), DRMR-HT-13-7 (69%), RH-119 (66%), DRMR-HT-13-13 (65%) and DRMR-HT-729 (64%) attained maximum percent population survival at 10 DAS whereas, genotype Varuna (43%) and DRMR-1672-2 (45%) recorded the minimum percent population survival. Genotype Urvashi (61%), DRMR-HT-13-7 (57%), DRMR-541-44 (56%) and RH-119 (55%) recorded maximum percent population survival at 25 DAS under normal temperature and heat stress situation. Among the genotypes, membrane stability index was recorded maximum in Urvashi (77.97%), DRMR-541-44 (72.22%), DRMR-HT-13-28 (67.86%), NPJ-124 (67.80%) and RH-555 (64.47%) while, it was minimum in BPR-541-4 (3.77%), DRMR-1672-2 (4.84%) and DRMR-1616-47 (7.50%). Genotype DRMR-HT-729 (33.64%), NRCHB 101 (35.42%), Urvashi (36.46%), NPJ 124 (38.71%) and RH 119 (44.52%) were identified as heat tolerant and genotype NRCDR-601 (77.91%), Varuna (73.87%) and DRMR-1187-55 (66.67%), as heat sensitive for ELWL, irrespective of environmental condition. The significantly lower RWC values indicated that in general, the loss of water from leaves at reproductive stage was higher with poor retention. The relative water content (%) ranged from 70.59 to 89.19 under heat stress condition. Under the heat-stress conditions, the RWC values of genotype BPR-543-2 (89.19%), BPR-549-9 (87.30%), DRMR-1616-47 (86.67%), DRMR-1617-45 (85.71%), and DRMR-HT-13-13 (84.99%) were higher compared to genotype DRMR-1672-2 (70.59%) and BPR-541-4 (72.13%). Based on population survival (%) at 10 and 25 DAS, MSI, ELWL and RWC values, genotypes Urvashi, DRMR-HT-13-13, DRMR-541-44, NPJ 124 and DRMR-HT-729 were identified as heat tolerant at seedling stage.

Development of RIL population

Fresh crosses have been attempted between NRCDR 2 X BPR 541-4, NRCHB 101 X BPR 541-4, NRCHB 101 X BPR 543-2 and NRCHB 101 X BPR 543-2 for developing RIL population for high temperature tolerance.

Biochemical characterization of Indian mustard germplasm for heat stress tolerance

Thirty genotypes screened for high temperature tolerance grown under normal and heat stress condition. Out of them; RH-119, NPJ-124, DRMR-1165-40, DRMR-1191-2 showed constant increase in all the biochemical parameters (total chlorophyll, total proline and TAC). Among these, Urvashi, DRMR-HT-729, BPR-543-2, JN-032, BPR-540-6, DRMR-1672-2, DRMR-1165-40, NRCDR-601, VARUNA and DRMR-64 showed increase in at least two of the parameters (Table 2.13).

Table 2.13. Variation in different biochemical parameters of Indian mustard germplasms.

Biochemical parameters	Normal sown condition		Heat stress condition	
	Value mg/g FW	Germplasm	Value mg/g FW	Germplasm
Chlorophyll a	0.89 to 2.21	RH 555 GM2	0.70 to2.23	Urvashi DRMR 1165-40
Chlorophyll b	0.22 to 0.48	RH 555 NRCHB 101	0.02 to 0.51	Urvashi NPJ 124 , DRMR 1616-47
Carotenoid	3.08 to 7.36	RH 555 GM 2	0.12 to7.58	DRMR 1616-47 DRMR 64
Total chlorophyll	1.11 to 2.65	RH 555 GM 2	0.88 to 2.71	Urvashi DRMR 1616-47
Proline	0.20 to 20.9 µmole/g FW	NPJ 113 PM 26	0.17 to 19.23 µmole/g FW	DRMR 1187-55 DRMR HT-729
TAC	0.10 to 43.35 mg/g AAE	NRCDR 601 DRMR HT 729	1.68 to 90.60 mg/g AAE	NRCDR 601 RH 406

Among the germplasm showing constant increase in all the biochemical parameters (total chlorophyll, total proline and TAC) were; EC 511664, CSR 1138 , P 32 , PRO 03-01, UP I-66,UP II-13, DU 24, B/K/S 59, B/K/S 42. B/K/S 55 , RM 14, Parasmani 3 , BPR-543-2 (c), RRN 609, SKM 539, IIHR 6 (CO-2), MRN-J-2001-3, Urvashi, IC 511611, DRMR - 2208, CS 54, RRN 752, , EC 414320, DRMR-1998, HP 30, HP 54,DRMR-2001-3 and Bharatpur local. However, there are germplasm that showed increase in at least two of the parameters (proline and TAC) were; HPLM 06-25, HP 96, BPR-543-2 (c), Urvashi (c), B/K/S 50, P 42, DU 4 and RH 0749 (Table 2.14).

Table 2.14. Variation in different biochemical parameters of Indian mustard germplasms.

Biochemical parameter	Normal sown condition		Heat stress condition	
	Value mg/g FW	Germplasm	Value mg/g FW	Germplasm
Chlorophyll a	0.97 to 2.42	Urvashi KM 555	0.99 to 2.4	UP I-11 CSR 1138 JMM 08-2
Chlorophyll b	0.19 to 0.50	DRMR 1998 KM 555	0.21 to 0.59	DU 4 CSR 1138
Carotenoid	3.07 to 7.76	Urvashi KM 555	0.04 to 8.13	DU 24 CSR 1138
Total chlorophyll	1.20 to 2.93	Urvashi KM 555	1.23 to 3.02	UP I-11 CSR 1138
Proline	0.34 to 22.63 µmole/g FW	UP I -77 CSR 1138	0.03 to 29.58 µmole/g FW	JBT 41/45 CSR 1138
TAC	0.52 to 119.10 mg/g AAE	DRMR 2208 SKM 539	0.52 to 129.60 mg/g AAE	KM 555 SKM 539

Molecular characterization of heat tolerant and susceptible lines

The present investigation was undertaken to identify the suitable SSR primers for genetic analysis of heat tolerant and susceptible germplasm of *B. juncea* and to measure the genetic diversity and relatedness among them using SSR markers.

SSR analysis

PCR amplification of SSR markers was carried out using 70 primer pairs (Figure 2.29).

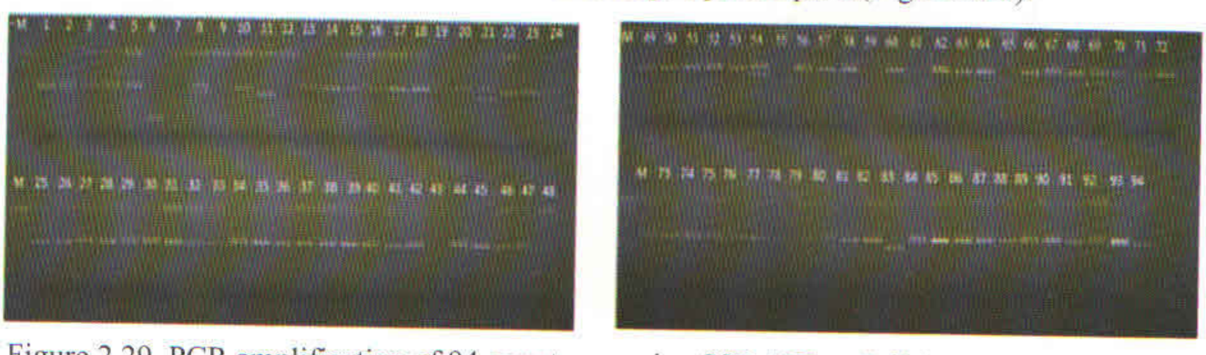


Figure 2.29. PCR amplification of 94 genotypes using SSR 127 on 2.5% agarose gel showing 150-170 bp product size. Lane 1: 100 bp ladder, Lane 1-94: Heat tolerant and susceptible genotype

A total of 50 SSR and 20 EST SSR were tested on 94 genotypes for amplification, out of which 41 markers showed polymorphism, 25 markers exhibited monomorphism whereas 4 markers failed to yield any amplicon. 96 alleles were detected giving a range of 2-4 maximum alleles per locus and amplicon product range of 100-550 bp for each primer.

Sclerotinia stem rot: Evaluation of sources

Thirty four already identified source lines for stem rot tolerance of *B. juncea and B. napus were screened* under sick plot at DRMR during 2015-16 season, sown on 2 Nov, 2015 in single row of 3 m length with 30 cm x 10 cm spacing maintaining two test rows per plot along with border rows of cv. NRCYS 5-2 (susceptible check) in randomized block design with two replications. Pathogen inoculum was mass multiplied on autoclaved sorghum grain and mixed with soil prior to sowing to create epiphytotic field conditions. The test lines were also added sclerotia after sowing. Further, the plants were inoculated at 60 days after sowing on the stem with the pathogen growing on agar blocks and tied to the stem with parafilm (stem inoculation). Data for reaction to the disease was recorded after 3 weeks of inoculation. Among all the test lines EC 597317, EC 597325 (*B. juncea, Australia*) and EC 597328, EC 597333, EC 597340 (*B. juncea*, China) showed tolerant reaction (lesion size >3.0 cm and disease incidence <10%).

Screening of new diverse lines/core set of oilseed *Brassicas*

Two hundred seven germplasm lines of *B. juncea* from core set were screened under sick plot at DRMR during 2015-16 season, sown on 2 Nov 2015 in single row of 3 m length with 30 cm x 10 cm spacing maintaining two test rows per plot along with border rows of cv. NRCYS 5-2 (susceptible check) in randomized block design. After artificial stem inoculation the lesion size and per cent infection were recorded. Among all the tested germplasm SR 15-123, SR 15-193 and SR 15-217 showed tolerant reaction (lesion size >3.0 cm and disease incidence <10%).

Development of RILs based upon available information

Based upon already identified resistance sources, recombinant inbreed lines (RILs) were initiated during 2015-16. EC 597328, EC 597340 (*B. juncea*, China) and DRMR 261 (*B. carinata*, India) were crossed with high yielding *B. juncea* varieties, multiple disease resistance lines and improved germplasms RH 749, NRCDR 2, RH 555, RH 1372, RH 1231, RH 045 and RH 1117. A good number of seeds were harvested from these crosses.

Collection and characterization of available isolates across the country

Twenty five different geographical isolates were already maintained at ICAR-DRMR and during 2015-16, 40 new isolates of *S. sclerotiorum* were collected from different geographical regions of Brassica growing areas in the country. All isolates were cultured and after purification these were maintained.

Molecular characterization of Sclerotinia tolerant and susceptible lines

High-quality genomic DNA of all the genotypes used in this study was extracted by the slight modifications of DNA extraction method described by Murray and Thompson (1980). Agarose gel electrophoresis was used to quantify the DNA samples. RNase treatment (10mg/ml) was given to remove RNA from DNA samples. These DNA samples are being further used for SSR analysis.

CRP Project on molecular breeding: Molecular breeding for improvement of tolerance to biotic (white rust/stem rot) and quality traits (low erucic acid and glucosinolates) in mustard

Principal Investigator: V.V. Singh, Principal Scientist (Genetics and Plant Breeding)

Co-Investigators: P.K. Rai, Principal Scientist (Plant Pathology); Pankaj Sharma, Senior Scientist (Plant Pathology); Bhagirath Ram, Senior Scientist (Genetics and Plant Breeding); Ibandalin Mowlong, Scientist (Plant Biochemistry); Prashant Yadav, Scientist (Plant Biotechnology)

Validation of reported markers for interogression of white rust resistance and quality traits

Total eighteen genotypes (including donors and recipients) were used for the present study. Donors and recipients used for MAS are as:

Traits	Donor(s)	Recipient (s)
White rust	BEC-144, Bio-YSR,	NRCHB101,DRMR-150-35
Double low	PDZ-1,Heera	NRCHB101,DRMR-150-35

Total genomic DNA was extracted from 5g young and expanding leaves using modified CTAB method of DNA isolation given by Doyle and Doyle (Figure 2.30). The previously identified ure *Arabidopsis* derived intron polymorphic (IP) markers At5g41560 and At2g36360 which were highly linked with AcB1-A4.1 and AcB1-A5.1, respectively were validated with the set of 6 genotypes (donors and recipients) using PCR. PCR-amplified products were electrophoretically separated on 3.5% agarose gel containing 0.01% ethidium bromide, prepared in 1xTAE (Tris-Acetic acid-EDTA). After electrophoresis, the amplification products were visualized in a gel documentation system. At5g41560 and At2g36360 (Panjabi et al., 2010) are genotype-nonspecific markers and gave amplified products of 430 and 750 bp, respectively. The donors namely Bio-YSR, BEC-144, PDZ-1 and Heera exhibited same banding pattern while recipients viz. NRCHB 101 and DRMR-150-35, exhibited different pattern from donors confirming white rust resistant loci 4.1 and 5.1

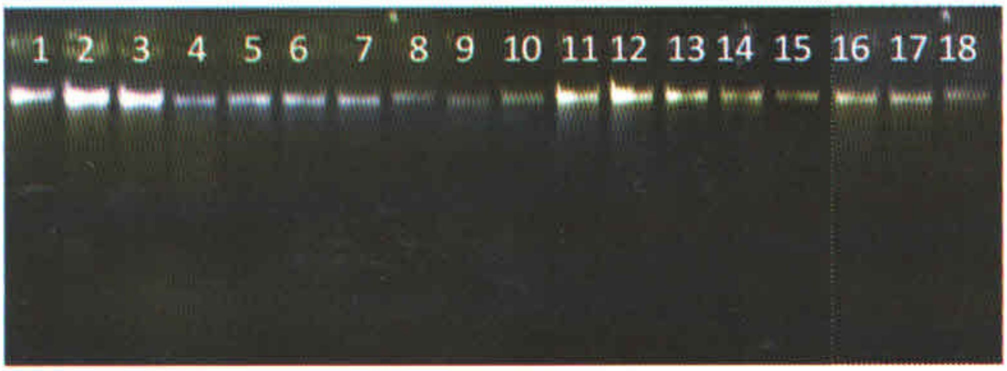


Figure 2.30. Quantification of DNA on 0.8% agarose gel 1-Donskaja 2-BioYSR 3-BEC144 4-PDZ-1 5-EC597325 6-RLC-3 7-Heera 8-PM24 9-PM30 10-NRCDR02 11-DRMRIJ31 12-RH0749 13-RH8812 14-RLC-1 15-RLC-2 16-NRCHB-101 17-DRMR 150-35 18-NRCDR-601

Validation of markers linked to quality traits

Erucic acid: For validation of erucic acid two CAPS markers, FAE II (E1) and FAE III (E2) (Gupta et al., 2004) were used. PCR amplicon of size 432 bp with primer FAE II (E1) followed by restriction digestion with Hpy99 Iat 37°C yielded three bands (432,224,198bp) for higherucic acid in genotypes Bio-YSR, BEC-144, NRCHB101 and DRMR-150-35, whereas in genotypes PDZ-1 and Heera single band of size432 bp was obtained for low erucic acid. Similarly, the PCR amplicon of 427 bp with primer FAE III (E2) followed by digestion with Bgl II at 37°C gave three bands (427,209,198) for low erucic acid in genotypes PDZ-1 and Heera whereas, single fragment of 427 bp was obtained for high erucic acid in genotypes Bio-YSR, BEC-144, NRCHB101 and DRMR-150-35.

Glucosinolate: A set of five primers i.e. (GER-1MRPR+IP3GER-1F(Q1); Myb28(Q2); At5g41(Q3); At5GAJ67(Q4) and GER-5FPF+GER-5MRPR(Q5) (Bisht et al., 2009) were used for amplification of 6 genotypes (donors and recipients). Primers Q1,Q2,Q3,Q4 and Q5 gave amplicons of 950/650 bp, 1020/1000 bp, 800/770 bp, 450/- bp and 350/310 bp for high and low glucosinolate, respectively at

55°C. It was found that among all glucosinolate markers Q1 and Q5 differentiated very well among double low donors and recipients.

Identification of polymorphic SSR markers for background selection

The total numbers of 453 SSR markers were used for parental screening among the 18 genotypes. Out of them 335 (73.9%) SSR gave amplified products of varying sizes in a range of 80-400 bp, 196 SSR (43.2%) were monomorphic while 139 SSR (30.7%) gave polymorphic loci.

Crosses attempted

Crosses with white rust and quality donors were attempted with recipient parents during 2015-16 are:

Traits	Donor(s)	Recipient (s)	Generation
White rust	BEC-144, Bio-YSR	NRCHB101, DRMR-150-35	Crosses attempted
Double low	PDZ-1, Heera	NRCHB101, DRMR-150-35	Crosses attempted

DBT Project: Development of white rust resistant mustard with high oil quality

Principal Investigator: V.V. Singh, Principal Scientist (Genetics and Plant Breeding)

Co-Investigators: P.K. Rai, Principal Scientist (Plant Pathology); Arun Kumar, Senior Scientist (Genetics-cytogenetics); Ibandalin Mowlong, Scientist (Biochemistry)

Validation of reported markers

A total of fifteen genotypes (donors and recipients from all centres) were used for validation of white rust resistance and quality traits.

Donor for white rust	Donor for double low	Recipients
Bio-YSR, BEC-144	PDZ-1, Heera	NRCDR-02/ DRMRIJ-31

Validation of markers linked to white rust

Good quality genomic DNA was extracted from the true leaves using the method described by Murray and Thompson (1980) (Figure 2.31).The previously identified Arabidopsis-derived intron polymorphic (IP) markers At5g41560 and At2g36360 which were highly linked with AcB1-A4.1 and AcB1-A5.1, respectively were validated with the set of 6 genotypes using PCR. At 5g41560 and at 2g36360 are genotype-nonspecific markers and gave amplified products of 430 and 750 bp, respectively.The donors namely Bio-YSR, BEC-144, PDZ-1 and Heera showed same banding pattern while recipients viz., NRCDR-02 and DRMRIJ-31, exhibited different pattern from donors confirming white rust resistant loci 4.1 and 5.1.

Figure 2.31. Quantification of DNA on 1.0% agarose gel 1-Donskaja 2-BioYSR 3-BEC144 4-PDZ-1 5-EC597325 6-RLC-3 7-Heera 8-PM24 9-PM30 10-NRCDR02 11-DRMRIJ31 12-RH0749 13-RH8812 14-RLC-1 15-RLC-2

Validation of markers linked to quality traits

Erucic acid

Two CAPS markers, FAE II (E1) and FAE III (E2) were used for validation of erucic acid and amplification was carried out at 55°C. PCR amplicon of 432 bp with primer FAE II (E1) followed by digestion with *Hpy*99I at 37°C gave three fragments (432,224,198bp) for high erucic acid in genotypes (NRCDR02, DRMRIJ31, Bio-YSR and BEC-144) while single fragment of 432 bp was obtained for low erucic acid in genotypes PDZ-1and Heera.

Glucosinolate

A set of five primers *i.e.* (GER-1MRPR+ IP3GER-1F(Q1); Myb28(Q2); At5g41(Q3); At5GAJ67(Q4) and GER-5FPF+GER-5MRPR(Q5) were used for amplification of 6 genotypes. Primers Q1 and Q5 gave amplicons of 950/650 bp and 350/310 bp for high and low glucosinolate respectively at 55°C and thus differentiated very well among double low donors and recipients. The other three primers (Q2, Q3, Q4) also amplified and the amplicon sizes and of 1020/1000, 800/770, 450 bp were obtained respectively.

Studying the parental polymorphism for identification of polymorphic markers for background selection

A total of 319 SSR markers were used for parental screening among the 15 genotypes. Out of them 227 (71.2%) were amplified and 141 SSRs (44.2%) were found to be monomorphic while 86 SSRs (27.0%) were polymorphic and amplified products of varying sizes in range of 100-400 bp (Figure 2.32.).

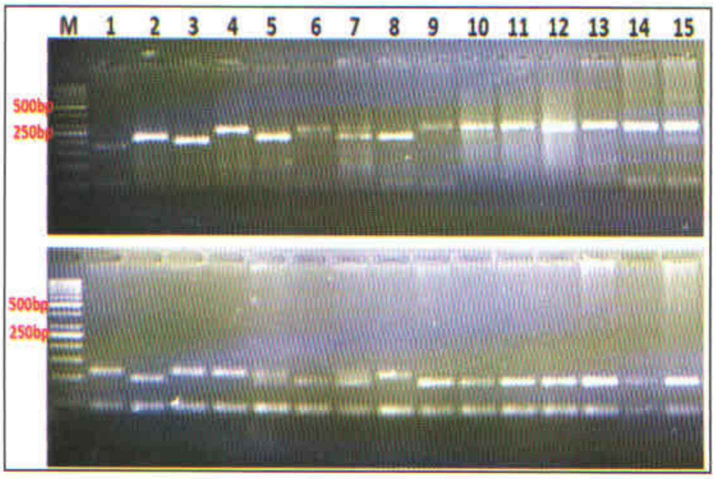


Figure 2.32. Agarose gels showing amplification profiles of genotypes using the primer 234 and 239 Lane M- 50 bp ladder, M-50bp ladder 1-Donskaja 2-BioYSR 3-BEC144 4-PDZ-1 5-EC597325 6-RLC-3 7-Heera 8-PM24 9-PM30 10-NRCDR02 11-DRMRIJ31 12-RH0749 13-RH8812 14-RLC-1 15-RLC-2

Cluster analysis

Based on the presence or absence of amplicons, a binary 1-0 data matrix was created and used to calculate Jaccard's similarity coefficient. Cluster analysis was carried out among the lines based on Jaccard's similarity coefficients using UPGMA and SAHN-clustering algorithm in NTSYS-pc, version 2.02e (Applied Biostatistics) software.

The genetic relationships among the 15 genotypes showed variation. The cluster analysis based on SSRs gave three major groups viz., I, II, III,and the similarity coefficient ranged between 0.21 and 0.76. Cluster I contained donor genotypes for both quality traits and white rust. In this cluster, three white rust genotypes Donskaja, Bio-YSR and BEC-144 grouped together where Bio-YSR and BEC-144 showed 68.6% similarity while three double low genotypes such as PDZ-1, EC 597325, Heera were clustered together. Here, EC 597325 and Heerawere observed to have 56.6% similarity while PDZ-1 and EC 597325 were having 46.7 % similarity.

All the eight recipient genotypes were grouped together in Cluster II. Genotypes NRCDR02 and DRMRIJ 31 showed closer relationship with highest similarity of 76.0% while RH749 and RH 8812 clustered together at 63.5% similarity. Similarly, within this cluster, RLC-1 and RLC-2 were found together at 58.8% similarity whereas PM 24 and PM 30 exhibited lower similarity of 38.8 %. Genotype RLC-3 was entirely separated and clustered in cluster III.

Phenotyping of donors and crossesattempted

Fresh crosses with white rust and quality donors were attempted with all eight recipient parents during 2015-16 Further, BC1 crosses were attempted as described below.

Crosses attempted during 2015-16 (F_1)

Traits	Donor(s)	Recipient(s)	Generation
White rust	Bio-YSR,BEC-144	NRCDR-02 DRMRIJ-31	Crosses attempted
Double low	PDZ-1,Heera	NRCDR-02 DRMRIJ-31	Crosses attempted

Crosses attempted during 2015-16 (BC_11)

F_1	Recurrent	Generation (BC_1)
IJ-31 X Heera	DRMRIJ-31	Crosses attempted
IJ-31 X BioYSR	DRMRIJ-31	Crosses attempted
NRCDR-02 X Heera	NRCDR-02	Crosses attempted

CRP-AB: Management and use of plant genetic resources

Principal Investigator: J. Nanjundan, Scientist SS (Genetics and Plant Breeding)

Component-I: PGR characterization, multiplication and supply

With an objective to multiply and characterize all the rapeseed-mustard accessions available at National Gene Bank, NBPGR and to develop core set and trait specific reference sets, the accessions were grown at ICAR-DRMR, Bharatpur. The details of year wise accessions received from NBPGR for multiplication, characterization/evaluation and the methodology adopted etc. are mentioned in the Table 2.15. During the cropping season of 2014-15, another set of 600 accessions (534 Indian mustard + 09 Karan rai + 02 Gobhi sarson + 08 *B rapa*) were received from NBPGR and characterized. The observations were recorded for 17 agro-morphological traits in 309 Indian mustard accessions (from which competitive 5 plants could be harvested). The data was analyzed and the distributions for various agronomical traits were estimated (Table 2.16). From the 309 Indian mustard, 115 trait specific accessions were selected for component traits and re-evaluated in the cropping season of 2015-16. In the cropping season of 2015-16, the remaining rapeseed-mustard accessions with the NGB, NBPGR, about 6683 accessions, were brought to DRMR, Bharatpur for multiplication and characterization. The details of species wise split up of the rapeseed-mustard accessions and their wild relatives multiplied, characterized/ maintained are mentioned in the Table 2.17.

Component-II: PGR evaluation and use (NBPGR and AICRPs)

The details of year- wise Indian mustard accessions received from NBPGR and numbers of accessions evaluated at different centres under Component II of CRP-AB are mentioned in the Table 2.15. In the year 2014-15, a set of 1000 accessions (978 Indian mustard + 05 *B rapa* + 01 Gobhi sarson) were received from Evaluation Division of NBPGR for evaluation for agronomical performance. Observations on 17 agro-morphological traits were recorded in 783 Indian mustard accessions (from which five competitive plants could be harvested). Similarly, in the year 2015-16, another batch of 1112 Indian mustard accessions were received and evaluated for the same traits (Table 2.18).

Table 2.15. Details of year wise rapeseed-mustard accessions received from NGB, NBPGR, for multiplication, characterization / evaluation

Year	Component	Centres involved	No. of accessions characterized/ evaluated	Traits studies	Design adopted	Checks used	No. of promising acc. promoted for re-evaluation	No. of promising acc. identified
2013-14	Component I	ICAR-DRMR, Bharatpur	600 (576) (481)	Agro-morphological (16)	ABD	PM 25, Maya, RGN 73, Kranti & Pusa Bold	99	22
2014-15	Component I	ICAR-DRMR, Bharatpur	600 (553) (309)	Agro-morphological (17)	ABD	PM 25, Maya, RGN 73, Kranti, Pusa Bold & DRMRIJ 31	69	
	Component II	ICAR-DRMR, Bharatpur	1000 (984) (783)	Agronomical (17)	ABD		104	
	Component II	GBPUA&T, Pantnagar	1000 (951)	Agronomical (20), *Alternaria* blight, white rust & mustard aphid	ABD	PM 25, Maya, RGN 73 & Kranti	16(agro.) +16(WR) + 38 (WR)	
	Component II	PAU, Ludhiana	1000 (891)	Aphids	ABD	PC 10 (RC) & BSH 1(SC)		
	Component II	ARS, PAU, Bathinda	1000	White rust & Alternaria blight	ABD	PBR 357, PBR 91, PBR 210 & Kranti		
	Component II	SAREC, Kangra	1000	Cold tolerance	ABD	RCC 4, RH 0749 & Kranti	150	
2015-16	Component I	ICAR-DRMR, Bharatpur	6683	Agro-morphological (17)	ABD	Pusa mustard 25, Maya, RGN 73, Kranti, Pusa Bold, Girraj and RH 0749	121	
	Component II	CCS HAU, Hisar	1000+112	Agronomical	ABD	Pusa mustard 25, RH 0749, DRMRIJ 31, Kranti and Pusa Bold	25	
	Component II	CCS HAU, Hisar	1000+38+38	White rust & Alternaria blight	ABD	Pusa mustard 25, RH 0749, DRMRIJ 31, Kranti and Pusa Bold		
	Component II	GBPUA&T, Pantnagar	1000 +38+38	White rust & Alternaria blight	ABD	PHR-2, EC 399313 & Rohini	35	38
	Component II	PAU, Ludhiana	1000	White rust & Alternaria blight	ABD	PBR 357, RLC 3 and RL 1359 & GSL 1		
	Component II	SAREC, Kangra	304 (core set)	Cold tolerance	ABD			

Table 2.16. Mean, range and coefficient of variation for 17 agro-morphological traits in 307 NGB (under characterization), 94 NGB (under re-evaluation) and 783 NBPGR (under evaluation) Indian mustard accessions, during 2014-15.

S. No.	Traits	Characterization & re-evaluation			Evaluation		
		307+94 IM accessions			783 IM accessions		
		Mean	Range	CV (%)	Mean	Range	CV (%)
1	Days to initial flowering	56.2	33-88	15.8	66.7	40-100	13.1
2	Days to 50% flowering	76.7	48-110	13.4	91.1	65-122	8.6
3	Days to maturity	140.9	112-161	2.9	133.8	121-148	3.8
4	Plant height (cm)	199.8	103-271	12.0	185.2	97-266	11.8
5	First basal branching (cm)	56.4	8.7-127	41.9	41.2	6.2-112	45.3
6	Fruiting zone length (cm)	81.9	21.2-116.3	12.9	90.1	28-153	17.5
7	No. of primary branches	6.4	2.8-12.2	20.1	6.4	3.6-12.4	21.3
8	No. of secondary branches	11.8	3.5-27.7	34.5	13.7	2.2-39.8	46.6
9	Main shoot length (cm)	69.3	32-98	14.3	69.9	39-110	14.6
10	No. of siliqua on main shoot	48.3	29.5-77.2	13.8	46.9	24-70	15.4
11	Siliquae density	0.7	0.4-1.0	15.9	0.6	0.3-1.0	16.2
12	Siliqua length (cm)	3.5	1.9-5.0	15.3	3.8	2.1-5.2	13.1
13	No. of seeds per siliqua	13.3	6.4-22.4	18.0	12.0	7.1-17.8	16.6
14	1000 seed wt (g)	3.6	1.6-7.4	31.0	3.2	0.9-6.9	32.1
15	Seed yield/plant (g)	15.2	3.1-29.2	39.5	11.6	1.4-26.7	46.8
16	Harvest index (%)	20.2	4.7-29.8	22.8	17.8	2.7-29.5	23.7
17	Oil content (%)	40.6	36.9-42.7	2.1	39.8	36.7-42.5	2.3

Table 2.17. Species wise split up of the rapeseed-mustard accessions multiplied, characterized /maintained at ICAR-DRMR under Component I during 2015-16

S. No.	Common name	Bot. name	No. of accessions			
			Multiplied & Characterized	Multiplied & Maintained	Not established	Total
1	Indian mustard	*Brassica juncea*	2514	1895	348*	**4757**
2	Leafy mustard	*Brassica juncea ssp. rugosa*	10	44	9	**63**
3	Gobhi sarson	*Brassica napus*	27	92	46	**165**
4	Karan rai	*Brassica carinata*	17	18	1	**36**
5	Toria	*B. rapa ssp. toria*	339	125	16	**480**
6	Yellow sarson	*B. rapa ssp. yellow sarson*	541	132	11	**684**
7	Brown sarson	*B. rapa ssp. brown sarson*	32	86	10	**128**
8	Taramira	*Eruca sativa*		260	8	**268**
9	Black mustard	*B. nigra*		1		**1**
10	Jangli /Asiatic rai	*B. tournefortii*		9		**9**
11	White mustard	*S. alba*		2		**2**
12	Raphanus	*Raphanus sp.*		3		**3**
	Total		**3480**	**2667**	**449**	**6596**
	Not germinated					**87**
	Total					**6683**

Table 2.18. Number of accessions evaluated for agronomic traits at ICAR-DRMR under Component II during 2015-16

S. No.	Common name	Bot. name	No. of accessions			
			Evaluated	Maintained	Not established	Total
1	Indian mustard	*Brassica juncea*	435	529	83	**1099**
2		*B. rapa*		11		**11**
3	Taramira	*E .sativa*		1		**1**

Development of trait specific sets in Indian mustard

From the 481 NGB Indian mustard accessions characterized during the years 2013-14, 9⁽ accessions were selected for the component traits like plant height (~150 cm), main shoot length (>80 cm), No. of siliquae on main shoot (>60 cm), siliqua length (>5.0 cm), number of seeds/siliqua (> 17), 1000 seed weight (>7.0 g) and oil content (> 42 %). These accessions were re-evaluated, for second year, in the crop season of 2014-15 and 22 accessions with better performance over check (based on two years data) were identified for their use in trait specific improvement programme (Table 2.19).

Table 2.19 Performance of promising Indian mustard accessions (sourced from NGB, NBPGR) for component traits (based on 2 years data).

S.No	IC No.	Identity/Pedigree	Trait of interest	I year (2013-14)	II year (2014-15)
1.	IC 493388	JMG-152(289)	PH	147	157
2.	IC 493925	IB- 452	PH	148.8	103
3.	IC 493929	IB- 299	PH	143.3	158.8
4.	IC 494374	B- 154	PH	128	150
5.	IC 585437	NC- 57688	PH	147	159
6.	IC 493684	JMG- 55(338)	FZL	95	84
7.	IC 493624	JMG- 12	MSL	81	87
8.	IC 585464	NC- 58311	MSL, TSW	91, 6.23	81, 7.13
9.	IC 494082	B- 56	SMS	72.2	57.8
10.	IC 494089	BDJ- I- 164	SD	1.01	0.967
11.	IC 494140	BDJ- I- 778	SD	1.35	1.009
12.	IC 494255	B- 634	SD	1.08	1.037
13.	IC 494286	BDJ- I- 538	SD	1.04	1.015
14.	IC 494649	IB- 714	SD	1.39	1.085
15.	IC 585500	NC- 58396	TSW	6.38	6.6
16.	IC 494287	IB- 26	SS, OC	17.13, 42.19	18.25, 42.19
17.	IC 493195	JMG-113	TSW	6.12	6.21
18.	IC 493523	JMG- 29	TSW	6.24	7.44
19.	IC 493577	JMG- 48(233)	TSW	6.14	6.28
20.	IC 493676	JMG- 27	TSW	6.47	6.22
21.	IC 493935	JMG- 51	TSW	6.17	7.31
22.	IC 493937	BDJ- I- 509	TSW	6.12	6.69

DST-SERB project: Development of a core set of SSR markers for characterization of *B. juncea* varieties and germplasms

Principal Investigator: Ajay Kumar Thakur, Scientist SS (Plant Biotechnology)

Genomic-DNA from 37 highly genetically diverse germplasm accessions from Indian mustard germplasm core collection along with nine popular varieties had been extracted and purified using already standardized protocol at ICAR-DRMR (Thakur *et al.*, 2013). 500 genomic-SSR markers (from public database) had been evaluated for molecular characterization studies and so far, 290 polymorphic SSRs had been obtained.

DRMR EA 2: Characterization of rapeseed mustard varieties for DUS testing

Principal Investigator: K.H. Sigh, Principal Scientist (Genetics and Plant Breeding)

Under this project the major activities carried on involved testing of 24 varieties (02 New, 01 VCK, 21 Farmers) for DUS Testing with 08 reference varieties. In addition, 120 rapeseed mustard varieties were maintained through appropriate mating system.

BRNR project: Induced mutagenesis for isolation of Alternaria blight resistant mutant in *B.juncea*

Principal Investigator: P.D. Meena, Principal Scientist (Plant Pathology)

Co-Investigators: Dhiraj Singh, Director, ICAR-DRMR; H.S. Meena, Senior Scientist (Genetics and Plant Breeding)

Characterization of Brassica germplasm at hot spots for Alternaria tolerance

6 improved genotypes of *B. juncea* were screened at different locations including Pantnagar, Kangra, Hisar and Bharatpur for Alternaria tolerance during 2013-14. None of the genotype was tolerant against Alternaria blight. In 2014-15, total 675 mutants (G 100kr) of *B. juncea* cultivars NRCHB-101, RH-119, Kranti and Pusa Bold were sown for preliminary screening against Alternaria blight disease at Pantnagar, Kangra, Hisar and Bharatpur. None of the mutants were identified as resistant to Alternaria blight at Pantnagar, Kangra and Bharatpur.

Standardization of rapid screening techniques

Among, three screening methods tested inoculation of both cotyledon and seed method was standardized using susceptible cultivar Varuna. Conidial concentration of 5×10^5 conidia ml-1 was used for final screening of mutants. Inoculation of both seed and cotyledon method was found highly effective where mean AB severity on cotyledon was 84.6%. Thus, in *vitro* screening of AB using inoculation of both seed and cotyledon method was found effective and could be used for rapid screening at early stages of plant growth. A new 0-7 rating scale was also formatted to observe the AB pathogen interaction phenotype at cotyledonary stage of oilseed Brassica.

Seed treatment with mutagens and M_1 generation

In 2014-15, total 200g seed of cultivar Kranti and RH 749 was treated with different doses of gamma rays (90kr, 100kr, 110kr, 120kr). Chemical mutagen EMS (0.5%, 0.75%, 1.0%, 1.25%) was used to treat the same cultivars for identification of Alternaria blight resistant mutants in Indian mustard.

24 treatments with different doses of Gamma rays 90kr, 100kr, 110kr, 120kr, EMS 0.5%, 0.75%, 1.0%, 1.25% and combination of both gamma rays and EMS 90kr+0.5%, 100kr+0.75%, 110kr+1.0%, 120kr+1.25% were undertaken. M_1 generation from above 24 treatments and 80 M_3 mutants from previous year were planted at Bharatpur.

During 2015-16, total 445 mutants of M_2 generation and 80 mutants of M_3 generation was sown at 4 locations for screening against Alternaria blight. Total 500 mutants were harvested for different traits including Alternaria blight tolerant and white rust resistant. Among them 4 mutants were identified as tolerant to Alternaria blight at Pantnagar, Kangra and Bharatpur.

Determination of LD_{50} of ethyl methanesulfonate (EMS) for induction of mutations in rapeseed-mustard

Among chemical mutagens, the alkylating agent, ethyl methanesulfonate (EMS) is the most commonly used mutagen in plants as it causes a high frequency of nucleotide substitutions i.e. point mutations. Hence, an optimum dose is highly desired to produce the high frequency of mutations with minimum killing of trc e individuals. Therefore, the present investigation was undertaken to determine the LD_{50} of EMS and effect of different dosages of EMS on seed germination of RH-749 and NRCHB-101 and one wild relative *S. alba.* Hundred seeds of each genotype for each replication were first pre-soaked in sterilized distilled water for 2 h and then treated overnight with 8 different concentrations of EMS (0.1%, 0.25%, 0.5%, 0.75%, 1.0%, 1.25%, 1.5% and 2%) for 12 h at 24 °C with constant shaking at 100 rpm. The overnight treated seeds were washed 3-4 times under running tap water to remove residual EMS from the seeds. The seeds were placed on Petri dishes on distilled water soaked whatman paper disks. The seeds for control were treated with distilled water only. All sprouted seeds were considered as germinated either the resulting seedlings were normal or abnormal. Observations were recorded on 3 and 6 days after treatment (DAT), the germinated seeds were counted from each Petri plate. Percent seed germination was calculated using average of the three replications and data was analyzed for determining LD_{50}.

EMS dosages and treatment periods on seed germination. EMS doses (LD_{50}) at 0.42%, 0.73% and 0.3% for duration of 12 h were found to be optimum for Indian mustard varieties (RH-749, NRCDR-101) and *S. alba* respectively (Figure 2.33 and 2.34). It might be due to the differences in their genetic constitution and their parentage. The LD_{50} of EMS for *B. juncea* was higher than the S. alba and it also varied for two varieties of *B. juncea*. This information would be highly useful for initiating mutation breeding programme in rapeseed-mustard crops.

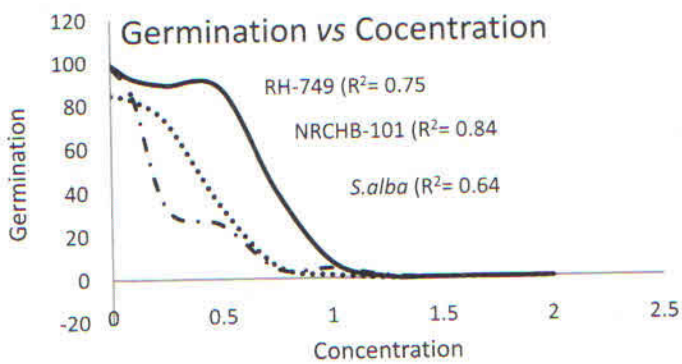


Figure 2.33. Decrease in germination percentage with increasing concentrations of EMS in *B. juncea* (RH-749 and NRCHB-101) and *S. alba*

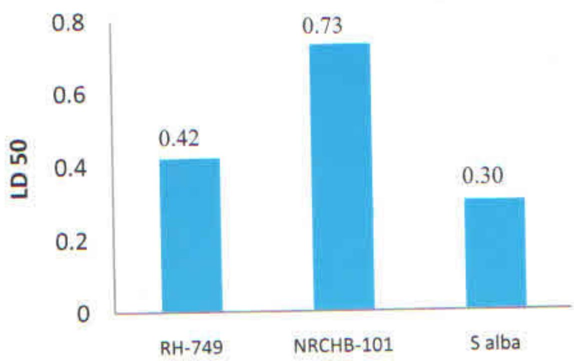


Figure 2.34. Effect of EMS on delayed germination of Indian mustard varieties (RH-749 and NRCHB-101) and *S. alba*

Effect of gamma rays and EMS on germination and cotyledons

Studies were undertaken to induce Alternaria blight resistant mutants by gamma rays and ethyl methane sulphonate (EMS) treatments of *B. juncea* seeds. Different doses of gamma rays 90kr, 100kr, 110kr, 120kr, EMS 0.5%, 0.75%, 1.0%, 1.25% and combination of both gamma rays and EMS 90kr+0.5%, 100kr+0.75%, 110kr+1.0%, 120kr+1.25% were undertaken.

Observations were recorded on 3rd and 6th days after treatment (DAT), the germinated seeds were counted from each petri plate. Percent seed germination was calculated using average of the three replications and data was analyzed for determining LD_{50}. Per cent seed germination was observed higher in EMS in contrast to gamma+EMS and gamma treated mutants.

Effect of mutagens was also noticed in field condition on cotyledons and seedlings. Margins or complete cotyledon were observed in reddish colour was counted to calculate the per cent lethal effect. Maximum lethal effect was noticed on gamma treated seed but effect was comparatively low in gamma + EMS treated seed, while negligible on EMS treated seed. Genetic changes induced by EMS treatment and affecting flowering time, dwarfness, dense silique, bold seed, more primary and secondary branches. As the increase in variation was due primarily to a higher frequency of later flowering plants, these polygenic changes would be of little value in developing better-adapted cultivars. These major gene mutations could be rapidly exploited in the development of agronomically superior cultivars with Alternaria blight resistant in *B. juncea*.

In 2014-15, selections were made for high oil content in the M_2 and further screened for increased oil per cent. Total 13 progeny with a high oil content (>42%) of Kranti and RH 749 with bold seed size were identified and sown. In 2015-16, these lines showed variability in oil content but Kranti E 0.75%-5-1 (43.2%), Kranti E 0.5% P 4-6 (42.9%), Kranti E 1.25% P-13-6 (42.7%), Kranti G 120 kr P-18-3 in M_3 generation.

ICAR-Extra mural project: Study on *Sclerotinia sclerotiorum* with emphasis on management of sclerotinia in Brassica

Principal Investigator: Pankaj Sharma, Senior Scientist (Plant Pathology), ICAR-DRMR, Bharatpur

Co-Investigators: V.V. Singh, (Genetic and Plant Breeding), ICAR-DRMR, Bharatpur; Laxman Prasad, Senior Scientist (Plant Pathology), ICAR-IARI, New Dehli; N.C.Gupta, Scientist (Plant Biotechnology), ICAR-NRCPB, New Dehli

Sclerotinia rot caused by *Sclerotinia sclerotiorum* is a serious threat to oilseed Brassiaca production with substantial yield losses in all growing area. Looking to the disease, Indian Council of Agricultural Research, NewDelhi sanctioneda research project under extra mural scheme on Study of *S. sclerotiorum* with emphasis on management of Sclerotinia rot in Brassica during withfinancial outlay of Rs.95.0 lakh. During 2015-16, at ICAR-DRMR sixty five different geographical isolates of *S. sclerotiorum* were collected and maintained. More than 850 indigenous and exotic germplasm lines were screened with artificial stem inoculation technique. 65 geographical isolates were studied for their morphological variations including mycelial growth, pattern, sclerotia formation, scerotial dimeter etc.

DRMR NP 2b: ICAR-NPTC Brassica functional genomics for Alternaria blight and drought/heat tolerance

Principal Investigator: P.K. Rai, Principal Scientist (Plant Pathology)

Co-Investigators: B.K. Singh, Scientist (Plant Biotechnology); V.V. Singh, Principal Scientist (Genetics and Plant Breeding)

Phenotyping of RIL population for drought tolerance (RohinixPBR-97)

A significant variability was revealed among the RILs (230) through ANOVA for seed yield and component traits. The estimates of mean and range for different characters indicated that seed yield/plant ranged from 11.04 to 33.63 g while glucosinolates content among the RILs varied from 6.69 to 121.66 μM/g defatted seed meal. Estimates of GCV and PCVfor different characters revealed that the phenotypic variances were significantly higher than the genotypic variances reflecting the role of environmental factors on character expression. A narrow difference between the phenotypic and genotypic variances, as expected in augmented designs, was observed. The maximum PCV was observed for glucosinolates (34.21%) followed by seed yield/plant (26.30%), biological yield (21.51%), fibre content (18.98%) and 1000-seed weight (13.86%). The PCV varied from 2.56% (oil content) to 34.21% (glucosinolates). Similarly, the maximum GCV was observed for glucosinolates (33.79%) followed by seed yield/plant (23.65%) and biological yield (20.27%). The heritability estimates were more than 50% for all the characters. High heritability values in conjunction with high genetic advance were observed for glucosinolates (97.56%, 68.75%), seed yield/plant (80.89%, 43.81%), biological yield (88.77%, 39.34%), fibre content (72.63%, 28.35) and 1000-seed weight (58.18%, 16.64). Twenty five promising RILs were identified, primarily on the basis of seed yield/plant (Table 2.20). Seed yield/plant among the selected lines varied from 25.63 g to 34.63 g; 1000-seed weight from 4.11 g to 7.29 g; oil content from 39.32 % to 42.99% and harvest index from 26.13 % to 56.17 %.

Table 2.20. Overall mean value of RILs, their range, genotypic and phenotypic coefficient of variation, heritability

Characters	Mean	Range	GCV	PCV	h2	GA
Plant height (cm)	189.2	168.2-209.6	3.4	4.3	63.1	5.6
Main shoot length (cm)	82.9	65.5-102.0	5.7	7.5	57.6	9.0
Fruiting zone length (cm)	88.7	66.9-104.9	5.4	6.4	70.2	9.3
Siliqua length (cm)	4.5	3.4-5.8	*	*	*	*
Seeds/siliqua	12.7	9.3-16.8	*	*	*	*
Biological yield/plant (g)	63.8	40.8-99.5	20.2	21.5	88.7	39.3
1000-seed weight (g)	5.3	3.3-7.6	10.5	.8	58.1	16.6
Harvest index (%)	29.5	17.4-46.3	*	*	*	*
Seed yield/plant (g)	18.6	11.0-33.6	23.6	26.3	80.8	43.8
Oil content (%)	40.9	38.5-43.4	2.0	2.5	63.6	3.3
Glucosinolates	58.4	6.6-121.6	33.7	34.2	97.5	68.7
Fiber	8.8	2.7-11.9	16.1	18.9	72.6	28.3
Phenol	2.1	1.2-2.8	*	*	*	*

* Genetic parameters could not be calculated because of non-significant progeny mean squares.

Rohini x RH-819

The RILs (220) along with parents and checks were grown in augmented block design and observations were recorded on plant height, main shoot length, fruiting zone length, siliqua length, seeds/siliqua, 1000-seed weight, seed yield/plant, oil content, and glucosinolates, fiber and phenol content. The mean, range, phenotypic, genotypic and environmental variance, genotypic and phenotypic coefficient of variation, heritability in broad sense, and genetic advance were calculated. Correlation studies were carried out to establish the interrelationship between component traits and their contributions towards seed yield. A considerable amount of genetic variability was observed among RILs for all the traits. Twenty-five promising RILs were identified,, primarily on the basis of seed yield/plant (Table 2.21).

Table 2.21. RILs selected on the basis of seed yield/ plant and their different attributes

RIL No.	Seed yield/ plant (g)	Plant height (cm)	Main shoot length (cm)	Fruiting zone length (cm)	Siliqua length (cm)	Seeds / siliqua	1000 seed weight (g)	Oil content (%)	Glucosinolates	Fiber	Phenol
220	36.75	178.97	85.55	93.98	4.72	13.46	5.80	41.10	55.67	9.87	2.14
213	27.05	187.27	87.85	95.18	5.02	11.86	5.10	42.20	72.07	11.37	2.04
222	26.86	199.17	89.75	95.38	5.02	10.26	5.40	42.00	73.07	8.77	2.24
66	26.36	201.82	97.50	97.30	4.57	12.88	5.18	42.75	60.75	10.97	2.16
31	25.73	193.25	83.37	87.93	5.14	16.03	5.15	41.28	34.70	9.00	2.16
24	25.63	193.25	89.47	91.43	4.54	12.63	5.05	42.58	65.40	9.60	2.46
19	25.53	197.95	92.57	98.33	5.04	13.63	4.95	42.48	92.20	11.80	2.06
70	24.46	205.32	98.80	98.90	5.17	12.08	4.98	41.75	73.25	9.97	2.06
57	24.36	202.22	94.90	95.50	4.37	11.48	5.18	41.85	86.75	10.27	2.06
118	23.96	185.32	81.92	89.85	5.17	12.66	5.15	39.95	96.05	8.72	1.96
43	23.93	199.55	90.97	95.83	4.34	12.43	5.35	42.68	67.30	10.70	2.06
38	23.83	185.15	84.17	92.43	4.34	11.83	5.35	41.38	64.40	10.90	1.96
69	23.76	186.62	92.00	95.50	5.07	12.88	4.88	41.65	55.35	9.97	2.16
37	23.73	196.15	91.47	96.93	4.64	10.63	5.75	41.88	82.40	10.10	1.86
56	23.66	196.32	88.60	88.70	3.97	10.88	5.18	41.35	86.45	10.57	2.16
21	23.63	203.15	92.37	98.63	4.94	14.23	5.15	42.68	77.10	10.80	2.06
1	23.53	204.85	93.07	100.03	4.54	13.43	5.25	42.28	89.50	10.50	2.16
114	23.16	184.12	84.62	94.35	4.47	13.26	4.45	41.05	39.25	9.02	2.36
204	22.75	188.67	84.85	90.98	5.02	13.26	6.80	40.00	93.17	9.37	1.94
177	22.60	195.35	85.97	90.85	4.72	14.98	4.73	42.33	56.55	9.55	2.29
121	22.56	186.22	80.42	91.55	5.07	15.46	5.85	41.05	70.75	10.52	2.06
164	22.50	210.15	100.47	106.25	5.12	15.78	5.73	42.83	48.25	9.65	2.39
104	22.46	187.02	72.82	88.95	4.47	15.66	5.05	41.65	75.95	8.72	2.26
72	22.46	189.72	81.90	82.70	4.37	9.48	4.28	42.05	36.25	11.87	1.86
67	22.36	194.92	90.00	93.30	5.07	10.88	4.28	42.15	57.45	11.27	1.96
CD (5%)	2.76	13.76	9.32	10.42	0.97	2.58	0.97	1.42	15.02	1.30	0.36
CV	6.18	2.81	4.23	4.47	7.99	7.54	7.49	1.32	8.79	4.94	6.72

ICAR seed project on seed production in agricultural crops

Principal Investigator: Bhagirath Ram, Senior Scientist (Genetics and Plant Breeding)

Co-Investigators: Ashok Kumar Sharma, Sr. Scientist (Ag. Extension); Pankaj Sharma, Senior Scientist (Plant Pathology) and Incharge Farm

Seed production: 146 q foundation seed of wheat and 114.66 q TL seed of rapeseed-mustard varieties were produced. It also includes 425.18 q TL seed of Indian mustard varieties RH-749, Rohini, NRCDR-02 and NRCHB-101 which was produced at farmer's and Madhurikund farm under participatory mode.

Breeder seed production: Breeder seed of NRCHB 101 (8.1 q), NRCDR 02 (0.28 q), Giriraj (1.3 q), DRMR 601 (0.03 q) and NRCYS 05-2 (0.11 q) was produced during 2014-15.

Institute Technology Management Unit (ITMU)

Principal Investigator: K.H. Singh, Principal Scientist (Genetics and Plant Breeding)

Five varieties/hybrid; Giriraj (DRMRIJ 31), NRCDR 02, NRCHB 101, NRCHB 506 and NRCYS 05-2, developed by DRMR were included under OECD seed scheme, vide DAC. F.No. 14-08/2011-SD.IV dated 24 August 2015. Application of one Indian mustard variety DRMRIJ 31 (Giriraj) was submitted for registration under PPVFRA. Submitted fee to PPVandFRA, New Delhi for maintenance of IPR on 11 rapeseed-mustard varieties. Interactive meetings were held with representatives of Metahelix Life Sciences Ltd Bangluru on 23rd July, 2015 and again on 14th March, 2016 for licensing of DRMR varieties and also with Dr.

Achyut V. Saraswat, Sr. Manager, DS Green Agrotech Pvt. Ltd., Noida.

DRMR NMOOP: Frontline demonstrations and other related activities of Oilseeds

Principal Investigator: Ashok Kumar Sharma, Senior Scientist (Agricultural Extension)

Co-Investigator: Vinod Kumar, Senior Scientist (Computer Application)

During 2015-16, Five hundred FLDs on rapeseed-mustard and 5 trainings of extension workers/input dealers were approved by Department of Cooperation, Ministry of Agriculture, Govt. of India for ICAR-DRMR. FLDs were conducted through different AICRPRM centers across the country. The 5 training programmes of two days each duration on "Scientific production technology of rapeseed-mustard" were organized for 91 extension personnel of State Department of Agriculture from 5 districts namely Jaipur (8-9 Sept. 2015 for 20 personnel), Dausa (15-16 Sept. 2015 for 17 personnel), Tonk (23-24 Sept. 2015 for 16 personnel), Sikar (29-30 Sept. 2015 for 19 personnel) and Bharatpur (4-5 March 16 for 19 personnel) districts of Rajasthan during 2015-16 to make them aware of the new technologies and developments in rapeseed-mustard cultivation so that they communicate the same to the farmers in the field.

3 Transfer of Technology

18th Beej Pakhwada organized

ICAR-DRMR's popular endeavour, 18th Beej Pakhwada was organized during Sept. 14 – Oct 4, 2015, at DRMR to sale the quality mustard seeds of improved varieties namely RH-749, NRCDR-02, NRCHB-101, RH-406, RH-0119, Bio-902, Rohini, Urvashi and hybrid (NRCHB-506) of Indian mustard to rapeseed-mustard growers. The seeds were sold to the farmers on thefirst-come-first-serve basis. All stakeholders appreciated the efforts of Directorate for providing quality seeds at affordable prices to the farmers along with technical guidance and expertise rapeseed-mustard production and protection technologies.

The popularity of ICAR-DRMR by organizing different extension programmes has clearly visible as arecord number of farmers from different states visited during this *Pakhwada* and purchased seeds of different improved varieties of mustard. The visiting farmers were also provided counselling for situation specific varietal selection along with advice on thescientific cultivation of rapeseed-mustard.

About 500 quintal seeds of improved varieties of Indian mustard were sold to thousands of the farmers from Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Uttarakhand, Bihar, Jharkhand,etc.

Front Line Demonstrations (FLDs)

Five progressive farmers from each selected village were given seeds of improved varieties along with fertilizers for conducting FLDs. A total of 125 frontline demonstrations with improved varieties viz. RH 749, DRMRIJ 31 and RH 406 were conducted in selected 25 villages of Bharatpur district of Rajasthan to show the production potential of improved varieties to the farmers and extension workers.

Mera Gaon Mera Gaurav

Mera gaon mera gaurav programme conceptualized by ICAR for the realization of "lab to land" concept has been actively taken up by ICAR-DRMR. Five interdisciplinary groups of five members comprising of both scientific and technical staff was constituted. Each group identified and adopted five villages in the vicinity of the institute and had conducted meetings with farmers of their respective villages before the start of themustard season. The group members visited their respective adopted villages during all stages of farming operations to give necessary advisory. Benchmark reports were made about the farming, climate and social and economic conditions of these selected villages. A biogas plant was also made established in Neotha village of Bharatpur.

Sarson School on AIR

ICAR-DRMR, successfully organized 10

"Sarson School on AIR" (Radio SarsonShiksha Programme) with 10 All India Radio stations of Jaipur, Alwar, Kota, Swaimadhopur, Suratgarh andJhalawar of Rajasthan; and Agra, Mathura, Lucknow, Jhansi and Rampur of Uttar Pradesh during Sept. 2015 to Feb. 2016. It helps in popularization and dissemination of rapeseed-mustard production technology among the farmers promptly. The 24 instructional modules of different aspects of mustard production were developed which were broadcasted coinciding with the different stages of crop growth of mustard at weekly intervals from September 2015 to February 2016 through All India Radio stations; that benefitted to thousands of farmers of Rajasthan and parts of Uttar Pradesh. The programme served as an important link between ICAR-DRMR and the rapeseed-mustard farmers and provides timely advice about various advanced production practices that created confidence for adoption of improved technology among the farmers.

Sarson field day

Two Sarson field days were also organized on 5 March 2016 in Seyorana village and 7 March 2016 in Neyotha villages of Bharatpur (Raj.), selected under MGMG programme, to show the performance and production potential of improved varieties of Indian mustard to the farmers and extension personnel in frontline demonstrations conducted in these villages. About 100 farmers and extension personnel participated in these sarson field days. All appreciated the performance of newly demonstrated varieties in the field and motivated to adopt them in next season.

22nd Sarson Vigyan Mela

ICAR-DRMR organized 22nd Sarson Vigyan Mela during February18-20, 2016. The Melawas inaugurated by Hon'ble Minister of State for Agriculture and Farmers Welfare, Govt. of India Shri. Mohan Bhai Kundariya. He addressed the gathering and urged the farmers to take the benefit of various Government schemes especially Pradhan Mantri Fasal Bima Yojana (PMFBY) and Pradhan Mantri Krishi Sinchai Yojana (PMKSY) which are the national mission to improve farm productivity and ensure better utilization of the resources in the country. He highlighted the importance of soil testing and urged the farmers to get soil health cards. He also visited the exhibition pavilions, apiculture unit and the fields of DRMR and expressed his appreciation.

On the occasion, Hon'ble Member of Parliament, Shri. Bahadur Singh Koli expressed his concern about the rising cost of cultivation and motivated the farmers to adopt low-cost cultivation techniques to improve farm income. He encouraged the farmers to be in touch with the scientists of DRMR to reap the benefits of timely information on farm practices. Dr. Manoranjan Dutta, National Advisor, Oilseed Mission reiterated the importance of extension activities in making the most recent technologies available to farmers.

On the second day of the Mela, Hon'ble DDG, (Crop Science), Dr. J.S. Sandhu, while addressing, encouraged the farmers to be a part of the activities of ICAR-DRMR so that farming techniques, as well as crop varieties that suit the needs of the farmers, can be developed. He also underlined the importance of farm mechanisation and its advantages by giving the example of the wheat and rice growers of Punjab and Haryana, who revolutionised the Indian agriculture and urged the farmers of Rajasthan to follow in themustard crop. Dr. Sandhu mentioned that it was necessary for the Department of Agriculture, KVKs and seed corporations to work in collaboration for better results.

Shri. Shiv Singh Bhont, Mayor, Bharatpur also graced the occasion and addressed the farmers. He spoke about the various schemes by which the farmers can attain self- reliance on irrigation water. He expressed his appreciation for the role of ICAR-DRMR in supporting the mustard growers of the country. Dr. M.L. Jat, Senior Scientist, CIMMYT motivated the farmers to adopt modern cost effective agronomic practices to maximise farm income. Dr. Asha Shivpuri, therenownedpathologist, advised the farmers on various measures to avoid diseases and pests.

In valedictory function of the mela, chief guest, Sh. R. K. Yadavendra, Additional Director, NMOOP, Department of Agriculture, Govt. of Rajasthan addressed the farmers and spoke about the importance of increasing the productivity of crops to address the growing needs and to ensure food security. He pointed out the dangers of relying on chemical fertilizers and pesticides and urged the farmers to withdraw slowly from the use of these harmful chemicals. He enlightened the gathering about the advantage of organic farming.

Ten technical folders/bulletins were also released by the dignitaries during mela. The mustard crop competition, kisangosthis, visit of experimental field, exhibitions, etc. were also organized on all three days in which various subject matter specialists enlightened the farmers about the recent technological advances as well as farming techniques. About 25 exhibitions stalls were also organized by different departments/ research institutes, input dealers, etc. involved in transferring information on improved farming techniques.

The winners of crop competition, kisan Prashnottaries, progressive farmers, NGOs that contributed significantly towards development and dissemination of improved farming techniques of rapeseed- mustard were also honoured. Three days mela was a grand success as more than 5000 farmers, farm women, extension workers, etc. from Rajasthan, Uttar Pradesh, Haryana, Jharkhand, Madhya Pradesh, etc. actively participated in the mela.

Germplasm field day

The potential role of the diverse germplasm in the crop improvement programme is a must. Therefore, a field day was organized to showcase the available genetic variability in the assembled germplasm. Dr. Dhiraj Singh, Director, ICAR-DRMR addressed the participants and elaborated about the 6600 germplasm lines obtained from NBPGR, New Delhi. He emphasised the importance of utilising the diversity in germplasm for crop improvement programmes.

Dr. J. Nanjundan, In-charge Germplasm, explained about the role of rapeseed-mustard germplasm in various breeding programmes. He introduced the different germplasm lines that are of superior quality, high yielding as well as tolerant to biotic and abiotic stresses. Dr. R.K. Tyagi, Head, Division of germplasm conservation, NBPGR and Dr. J.C. Rana, Head, Division of germplasm evaluation, NBPGR participated in the event alongside 25 researchers working on rapeseed-mustard crop from Rajasthan, Uttar Pradesh, Madhya Pradesh, Jharkhand, Punjab and Haryana to evaluate the potential of the germplasm maintained at ICAR-DRMR.

Visitor advisory services

Under Visitors Advisory Services, successfully organized/ coordinated 40 interaction meetings and counselling sessions on rapeseed-mustard cultivation for visiting groups from Rajasthan, Uttar Pradesh, Madhya Pradesh and Gujarat consisting of 1308 stakeholders including 1172 farmers, 62 farm women, 36 students and 38 extension personnel/ teachers. The visiting groups were educated/ trained through lectures, visits to technology park, experimental fields, museum and also provided literature. Besides, other visiting farmers were also provided timely technical advice to their problems in mustard cultivation.

Exhibitions

ICAR-DRMR organized six exhibitions displaying scientific technologies of rapeseed-mustard, research and development activities of DRMR. More than 6000 farmers, farm women, extension personnel, and student were educated through these exhibitions. These were organized at Deen Dayal Dham Mela, Mathura (UP) du n Oct. 9-11, 201, Madhurikund, Mathura (UP) on Feb. 16, 2016; ICAR-DRMR, Bharatpur (Raj.) on Feb. 18-20, 2016 and SKN Agriculture University, Jobner (Raj.) on March 3-4, 2016; IARI, New Delhi on March 19-21 and CSWRI, Avikanagar (Raj.) on March 28, 2016. Visitors were also provided literature on the scientific cultivation of rapeseed-mustard.

Apiculture unit and Siddarth Honey

Under All India Coordinated Research Project on Honey bees & Pollinators, an apiculture unit with 20 honey bee (*Apismellifera*) boxes was

established at ICAR-DRMR during rabi 2015-16. More than 4500 farmers, farm women, and extension functionaries visited the apiculture unit during Sarsonvigyanmela, training programme, exposure farmer visit and other extension activities. Honey produced from mustard was named as Siddarth Honey and launched by Hon'ble State Minister of Agri and Farmer Welfare Dr. Sanjeev Kumar Balyan on Jan 8, 2016, at Krishi Bhawan. Dr. J.S. Sandhu, DDG (Crop Science), Dr. Dhiraj Singh, Director and Dr. Pankaj Sharma, Incharge apiculture were also present during the occasion.

Technology dissemination in Muzaffarnagar (U.P.)

In Western Uttar Pradesh, District Muzaffarnagar is having an area of mustard 3950 ha with productivity 13.5q/ha during 2014-15. To enhance the production and productivity of mustard in village Kutbi and adjoining villages, 104 mustard demonstrations were conducted in 40 ha area with RH 406 and NRCHB 101 varieties. 54 demonstrations of RH 406 gave highest seed yield 22.5 q/ha and average 20.4 q/ha as compared to control (var Urvashi) 17.0 and 14.9 q/ha with an increase of 37.2%. The B:C ratio for RH 406 was 1:3.07. Fifty demonstrations of NRCHB 101 resulted in 20.5 q seed while Urvashi (control) gave 14.0 q which was 46.4 per cent higher with B:C ratio 1:3.0. In a comparison of both improved varieties, farmers prefer RH 406 for its good number of branching, bold seed, no lodging, and less irrigation requirement. A field day was also organized in village Mukundpur on 9.1.2016. Dr. Dhiraj Singh, Director, ICAR-DRMR, Sh. Surendra Pal Singh, progressive farmer village Kutbi, Dr. Pankaj Sharma, and Dr. Anil Khippal delivered

lecture and interacted with farmers. More than 100 farmers, Dr. P.K. Singh, Incharge KVK Muzaffarnagar and their staff also participated in field day. Dr. Pankaj Sharma, Nodal officer, coordinated the FLDs.

Mustard in non-traditional cropping areas: South India

For popularization mustard crop in South India, it was decided with Project Director, Indian Institute of Oilseed Research, Hyderabad to conduct demonstrations of mustard at different selected KVKs of Andhra Pradesh, Telangana, Tamilnadu, and Karnataka. In this regard, 89 FLDs of mustard var NRCHB 101 conducted with 11 KVKs. Results of demonstrations are awaited. Dr. Pankaj Sharma, Nodal officer, coordinated the FLD program.

Popularization of Sclerotinia rot management technology: A success story

Sclerotinia rot (SR) is a menace to the cultivation of oilseed Brassica crops. Infection occurs on leaves, stems and pods at different developmental stages, causing seed yield losses of up to 80%, as well as significant reductions in oil content and quality. Yield losses due to SR in susceptible crops vary and may be as high as 100 percent. The shattering of prematurely- ripened seed pods before harvest, and loss of quality in the form of smaller, shrunken and chaffy seeds has been observed. The Epidemiology of Sclerotinia rot (SR) of Indian mustard (*Brassica juncea* L.) was investigated since 2008-09 to 2014-15 at ICAR-DRMR. It was observed that carpogenic infection initiated in 52 standard weeks (last week of December) and a maximum pressure of SR continued during 1-2 standard weeks (first two weeks of January) when the crop is in full bloom stage. It was observed that the soil moisture is one of the important factors for

the development of SR. Disease outbreaks even in the drier areas occur in irrigated fields since irrigation provides favourable conditions for disease development even though the macroclimatic conditions were unfavourable. A management strategy including seed treatment with carbendazim (2g/kg seed), no crop irrigation during 25 Dec to 15 Jan and foliar spray of carbendazim (0.2%) during the first week of January was formulated and well tested through experiments, on-farm testing, and demonstrations.

The SR management technology was disseminated to farmers and mustard growers through on-campus training, kisan gosthi, farmer-scientist interactions, live field demonstrations at DRMR, AIR, and TV talks, etc. Farmers are aware of the losses due to SR, and now they adopted the technology which minimizes the SR incidence and given higher seed yield.

Review meeting of FLD farmers

A review meeting of FLDs farmers was organised on May 12, 2015, at ICAR-DRMR to discuss the performance of the technologies demonstrated in frontline demonstrations during 2014-15. 100 FLDs on varieties namely RH 749, DRMRIJ 31 and NRCDR 02, and sulphur components in Indian mustard were conducted in different villages of Bharatpur district of Rajasthan to show the impact and production potential of these technological components on farmer's field and for effective transfer of mustard production technologies. The farmers

reported that the improved varieties RH 749, DRMRIJ 31 and NRCDR 02 had ayield advantage of 16, 11 and 13 percent, respectively, over other varieties. The average yield of these improved varieties was 1880, 1820 and 1810 (kg/ha), respectively, despite the adverse weather condition during maturity. Use sulphur through SSP resulted in seed yield 1848 (kg/ha) against average yield of 1745 kg/ha. It was having an yield advantage of six percent.

Sarson farm school

ICAR-DRMR successfully organized 5 Sarson Farm Schools in 5 villages namely Seorana, Chichana, Daurda, Neyotha and Jhangirpur of Bharatpur districts of Rajasthan for effective transfer of mustard production technology to the targeted farmers through demonstrations of improved components of mustard and regular visits/ interaction meetings with farmers during different crop stages in these selected villages.

Model Training Course (MTC)

ICAR-DRMR successfully organized a Model Training Course (MTC) on Advances in seed production/processing and certification in rabi field crops during Dec.02-09, 2015 sponsored by Directorate of Extension, Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India, New Delhi. A

total of 23 officers of State Department of Agriculture from Haryana (1), Jharkhand (2), Madhya Pradesh (5), Maharastra (3), Rajasthan (8) and Tamil Nadu (4) participated in this MTC.

The study of impact of MTC showed that there was 93.5% average improvement in knowledge of participants after the training. There were 86.9% trainees whose expectations from the course were fulfilled to a great extent as they found the course useful with respect to their role and responsibilities. The 82.6% participants rated the course as excellent and 17.4% as very good. Dr. Ashok Sharma coordinated the MTC as Course Director.

Training programmes

ICAR-DRMR organized 11 training programmes for farmers of 2 to 5 days duration and one training programme for extension personnel. Two training programmes of 5 day each were organized for farmer of different districts of Uttar Pradesh during 17-21 Sept. 2015 (29 participants) and 24-28 Sept. 2015 (24 participanta) sponsored by State Institute of Agriculture Management, Rehmankheda,

Luchnow (UP). Three programmes of 5 days each sponsored by PD, ATMA, Gwalior (2-5 Nov. 2015 for 18 farmers) and Bhind (11-15 Jan. 2016 for 22 farmers) districts of Madhya Pradesh and one sponsored by State Institute of Agriculture Management (SIAM), Rehamankhed, Lucknow, Uttar Pradesh (8-12 March 2016 for 18 farmers).

A training programme of 3 days for Jharkhand farmers under Tribal sub Plan (18-20 Feb. 2016 for 33 farmers) and one programme of 2 days for farmers of Ajmer and Alwar district of Rajasthan sponsored by Rajasthan Rural Institute of Development Management, Ajmer, Rajasthan (26-27 Feb. 2016 for 42 farmers). A total of 187 farmers were provided extensive training about scientific production technology of mustard and agriculture management through these programmes.

Four training programmes of two days each were organized for extension personnel of Jaipur (8-9 Sept. 2015 for 17 personnel), Tonk (23-24 Sept. 2015 for 16 personnel) and Sikar (29-30 Sept. 2015 for 19 personnel) district of Rajasthan. One training programme of two days duration on "Scientific production technology of rapeseed-mustard" for 19 field level extension functionaries of State Department of Agriculture from Bharatpur district of Rajasthan was organized during 4-5 March 2016 to make them aware of the new technologies and developments in rapeseed-mustard cultivation. The training programme was sponsored under NMOOP by DAC, MoA, Govt. of India under Annual Action Plan for Implementation of Frontline Demonstrations (FLDs) and other related activities on oilseeds during 2015-16.

Dr Dhiraj Singh, Director, DRMR expressed hope that increased knowledge and skill of participants will motivate the farmers to adopt these technologies and extension personnel to speedy technology dissemination for enhancing oilseed production in the country.

Jai Kisan Jai Vigyan week

Directorate celebrated Jai Kisan Jai Vigyan week during 23-29 December, 2015 on the birth anniversary of Shri Atal Bihari Vajpayee and Late Shri Chaudhary Charan Singh, two former Prime ministers of India. Considering their

immense contribution to promoting the use of science for the welfare of farmers. The direct interaction meetings were scheduled among farmers and scientist for integrating their roles together. Three villages from Bharatpur (Raj.) adopted under MGMG programme, namely Seyorana (26-12-2015), Chichana (28-12-2015) and Neyotha (30-12-2015) were selected by Directorate to motivate the farmers to adopt the scientific technology of rapeseed-mustard. The on-spot solutions to the problems faced by the farmers in rapeseed-mustard cultivation were also provided by the scientists.

4 Training and Capacity Building

Training Attended

Topic	Venue/Date	Participant(s)
Professional attachment training (FOCARS)	PAU, Ludhiana (04.02.15 to 04.05.15)	Prashant Yadav
Professional attachment training (FOCARS)	NIPGR, New Delhi (02.03.15 to 02.06.15)	Reema Rani
Recent Advances in NGS data analysis	ICAR-IASRI, New Delhi (08.01.16 to 17.01.16)	Reema Rani
Recent Advances in Statistical Genetics and *Genomics*	ICAR-IASRI, New Delhi *(04.03.16 to 24.03.16)*	Prashant Yadav
Entrepreneurship Development & Management	EDI, Ahmedabad (02.02.16 to 06.02.16)	Dr. Anubhuti Sharma
MDP for Programme coordinators of KVKs	NAARM, Hyderabad and KVK Sirohi (15.12.15 to 29.12.15)	Dr B.S. Rathore
MIS/FMS	ICAR-IASRI, New Delhi (12.10.15 to 14.10.15)	Ajay Tandon Mukesh Kumar
Management Development Program on Accrued Accounting in Government/ Autonomous Bodies	NIFM, Faridabad (01.02.16 to 06.02.16)	Ajay Tandon

Participants in conference, Meeting, Seminars, Symposia, Workshops

S.N.	Event	Venue	Period	Participant
1	State food security mission executive committee (SFSMEC)	Secretariat, Jaipur	10 April 2015	Dr V V Singh
2	Stakeholders Consultation on Food Fortification	Mumbai	9 May 2105	Dr Dhiraj Singh
3	Agri Search 2050	NAAS Complex, New Delhi	18-19 May 2015	IbandalinMawlong M.S. Sujith Kumar Prashant Yadav
4	Review meeting of BRL-II trial of transgenic mustard hybrid DMH 11	ICAR, KrishiBhavan, New Delhi	19 May 2015	Dr V V Singh
5	Review meeting of BRL-II trial of transgenic mustard hybrid DMH 11	Bathinda, Ludhiana & IARI	19-23 May 2015	Dr Dhiraj Singh
6	4th TSP Workshop on Augmenting rapeseed-mustard production of tribal farmers for sustainable livelihood security under tribal Sub Plan	MPUAT, Udaipur	26-27 May 2015	Dr Dhiraj Singh Dr A. K. Sharma Dr Pankaj Sharma
7	Brainstorming session with the various stakeholders involved in annual oilseeds	IIOR, Hyderabad	27 May 2015	Dr Dhiraj Singh
8	Protocol for Implementation of Seed Bill 2004	NBPGR, New Delhi	29 May 2015	Dr Dhiraj Singh Dr V V Singh
9	Planning and review meeting of XII plan scheme Incentivizing research in agriculture	NBPGR, New Delhi	6 June 2015	Dr V V Singh

10	National Seminar on Climate Change and Smart Agriculture Technology	RVSKVV, Gwalior	12-14 June 2015	Dr Dhiraj Singh
11	Orientation workshop of NMOOP	SIAM, Jaipur	20-21 June 2015	Dr Pankaj Sharma
12	First collaborators project meet of the DBT funded project at ICAR-IARI	New Delhi	22 June 2015	Dr VV Singh
13	QRT Meeting of DSRAAU	AAU, Anand	26-27 June 2015	Dr VV Singh Dr Bhagirath Ram
14	87th ICAR Foundation Day & Award Ceremony and National Conference on KVKs	ICAR Complex, Patna	24-27 June 2015	Dr Dhiraj Singh
15	14th International Rapeseed Congress	Saskatoon, Canada	5-9 July 2015	Dr Dhiraj Singh Dr Pankaj Sharma
16	Task Force on Agriculture Development with special reference to innovation and successes carried out on oilseeds in the country	IIOR, Hyderabad	24-25 July 2105	Dr Dhiraj Singh
17	Breeder seed indent finalization meeting	ICAR Krishi Bhawan, New Delhi	30 July 2015	Dr KH Singh
18	22nd Annual Group Meeting of AIRCP-RM	SIAM, Durgapura, Jaipur	3-5 Aug 2015	Director and 21 scientists & staff
19	Scientific advisory committee meeting	KVK, Bichpuri	19 Aug 2015	Dr Pankaj Sharma
20	Annual KVK zonal workshop of Zone VI	MPUAT, Udaipur	23-25 Aug 2105	Dr Pankaj Sharma
21	10th Review Meeting of ICAR seed project	Goa	23-26 Aug 2015	Dr Dhiraj Singh Dr VV Singh
22	ZREAC meeting	ARS, Navgaon, Alwar	17 Sept 2015	Dr VV Singh Dr Pankaj Sharma
23	Agriculture Empowerment Expedition	Bharatpur, Rajasthan	20 Sept 2015	Dr K H Singh
24	National Dialogue on Efficient Nutrient Management for Improving Soil Health	IARI, New Delhi	28-29 Sept 2015	Dr Dhiraj Singh
25	QRT meeting	Jaipur	8-9 Oct 2015	Dr Dhiraj Singh
26	QRT meeting (DRMR/AICRP-RM)	New Delhi	8-9 Oct 2015	Dr VV Singh
27	Review meeting of Incentivization in Agriculture and CRP on Molecular breeding projects	IARI, New Delhi	28 Oct 2015.	Dr VV Singh
28	Review meeting of CRP on Hybrid Technology	IARI New Delhi	29Oct 2015	Dr KH Singh
29	2nd Hail storm Task Force meeting	Pune	21 Nov 2015	Dr Dhiraj Singh
30	1st review meeting on CRP on molecular breeding and	IARI, New Delhi	24 Nov 2015	Reema Rani
31	Plant Germplasm Registration Committee meeting	NBPGR, New Delhi	7 Dec 2015	Dr VV Singh
32	Workshop on Knowledge Management	ISTM, New Delhi	7-9 Dec 2016	Ajay Tandon
33	National conference on global research initiatives for sustainable agriculture and allied sciences (GRISAAS 2015)	RVSKVV, Gwalior	12-13 Dec 2015	Dr Pankaj Sharma Dr Bhagirath Ram
34	ICAR Extramural project proposal presentation meeting	Krishi Bhawan, New Delhi	21 Dec 2015	Dr KH Singh Dr Pankaj Sharma

35	31st meeting of State Seed Sub Committee for Agricultural and Horticultural Crops for the State of Rajasthan	Pant Krishi Bhavan, Jaipur	22 Dec 2015	Dr VV Singh
36	Mustard Field Day	Mukandpur, Muzaffarnagar	9 Jan 2016	Dr Dhiraj Singh Dr Pankaj Sharma Dr Arun Kumar Sh. Shitanshu Kumar Sh. P.K. Tiwari
37	QRT meeting (DRMR/AICRP-RM)	Ranchi	15-16 Jan 2016	Dr Dhiraj Singh Dr VV Singh
38	QRT meeting (DRMR/AICRP-RM)	Faizabad	18-19 Jan 2016	Dr Dhjiraj Singh Dr VV Singh
39	International workshop on olive and jojoba	SIAM, Jaipur	18-22 Jan 2016	Dr Pankaj Sharma
40	2nd Review meeting of projects on CRP on molecular breeding and Incentivizing research in agriculture	IARI, New Delhi	20 Jan 2016	Reema Rani
41	Review meeting of CRP on Hybrid Technology	IARI New Delhi	21 Jan 2016	Dr KH Singh
42	19th Annual breeder seed review meeting	NBPGR, New Delhi	27 Jan 2016	Dr Dhiraj Singh Dr KH Singh
43	Round table meet on GM seeds and crops	SIAM, Jaipur	28 Jan 2016	Dr Dhiraj Singh Dr VV Singh Dr Pankaj Sharma
44	QRT meeting (DRMR/AICRP-RM)	Hisar	12-13 Feb 2016.	Dr Dhiraj Singh Dr VV Singh
45	QRT meeting (DRMR/AICRP-RM)	Ludhiana	14 Feb 2016.	Dr Dhiraj Singh Dr VV Singh
46	6th International Conference on Plant Pathogens and People	New Delhi.	23-27 Feb 2016	Dr PD Meena Dr Pankaj Sharma
47	Farmer's Field Day	Manipur	26 Feb 2016	Dr Dhiraj Singh
48	Consultative Meeting on Proposed Guidance for Environmental Risk Assessment of Genetically Engineered (GE) Plants	Ministry of Environment, Forests and Climate Change, New Delhi	26 Feb 2016	Reema Rani
49	Annual DUS Review meeting	MPKV Rahuri	26-27 Feb 2016	Dr KH Singh
50	2nd International Conference on 'New challenges in biotechnology and molecular biology in the context of 21st century' organised by Indian Society of Genetics, Biotechnology Research and Development	St. John's College, Agra (UP)	27-29 Feb 2016.	Dr VV Singh Dr. Vinod Kumar Dr. Bhagirath Ram Dr. Arun Kumar Dr. HS Meena Dr. Anubhuti Sharma
51	QRT meeting (DRMR/AICRP-RM)	Gwalior	2 March 2016	Dr Dhiraj Singh Dr VV Singh
52	Mahindra Samridhi Award	New Delhi	3 March 2016	Dr Dhiraj Singh Dr Pankaj Sharma
53	4th UP Agricultural Science Congress	CSAUAT, Kanpur	2-4 March 2016	Dr KH Singh
54	Scientific Advisory committee meeting	KVK, Bansur	4 March 2016	Dr Dhiraj Singh Dr Pankaj Sharma
55	Review meeting of Financial Expenditure under AICRP-RM	Krishi Bhawan, New Delhi	9 March 2016	Dr KH Singh
56	37th Rabi Seminar on oilseeds, oil trade and industry	Baakoli, Delhi	19-20 March 2016	Dr. Dhiraj Singh Dr. Pankaj Shrama

Education & Training

Name of the Student	Name of the Guide	Topic
Deepika Sharma	Dr Ajay K Thakur	Basic exposure to various techniques in molecular biology & biotechnology

Workshop, Meeting, Seminars, Short Courses and Training Organized

14th International Rapeseed Congress at Saskatoon, Canada. July 5-9, 2015

Dr. Dhiraj Singh, Director and Dr. Pankaj Sharma, Senior Scientist participated in 14th International Rapeseed Congress (IRC) held during July 5-9 2015 and presented their research papers. The congress was organized by Canola Council of Canada and Ag-West Bio Inc. at TCU Place, Saskatoon, Canada. Dr. Wilf Keller, President GCIRC welcomes the delegates and inaugurated the congress on 5 July 2015. The IRC is held every 4th year to review international trends in research, marketing and government policies. The IRC also aimed at identifying thrust areas; chalk out future strategies and action plan. There were about 900 participants from almost around 32 countries. The Congress was divided into six parallel thematic area keynotes. There were total five main key note, 30 thematic key note and thirty one technical sessions having 143 oral presentations covering wide-ranging areas of rapeseed-mustard research. Presentation over 500 poster papers covering a spectrum of diverse rapeseed-mustard research areas was another significant highlight of the congress. Dr. Dhiraj Singh presented "Breeding strategies for oilseed Brassica improvement in India" and "Development of core collection and trait-specific reference sets in Indian mustard [*B.juncea* (L.) Czern&Coss.] germplasm". Dr. Pankaj Sharma presented his research findings on "Pathogenic variability of *Sclerotinia sclerotiorum* isolates on Brassica differentials". Dr. Dhiraj Singh also chaired the session during the congress on Expanding rapeseed production. A field tour was also organised by the organizers where different public and private sector viz. Bayer Crop Science, Dow Agro Sciences, BASF, Cargill, Canola Council of Canada were shown their trials on canola varieties, effect of fungicides, and new plant type in *B.napus*. More than 15 participants from Punjab Agricultural University, Ludhiana; CCSHAU, Hisar; Delhi University and private sector were participated in the congress from India.

Winter School

Directorate organized 21 days winter school on "New Paradigms in diseases management: Conventional and Molecular Approaches for rapeseed-mustard production" sponsored by ICAR, New Delhi during December 09-29, 2015. A total of 16 participants from Uttar Pradesh, Himachal Pradesh, Jammu & Kashmir, Bihar, Gujarat and Rajasthan participated in winter school. The objective of the winter school was to apprise the participants about concepts of ecologically sound and economically viable agro-production and protection technologies in different situation for the enhancement of oilseed Brassica productivity. Inaugurating the school, Dr. Dhiraj Singh, Director, ICAR-DRMR said that rapeseed-mustard diseases are the key biotic constraint to attain self-sufficiency in ensuring oilseed security in India. Losses due to disease vary from high to low in different areas depending upon the prevailing environmental conditions. The values of technologies have evolved over time through integrated crop production to integrated farming system targeted at improved crop health. The chief guest of the valedictory function, Dr Arvind Kumar, Vice Chancellor, Rani Lakshmi Bai Central Agricultural University, Jhansi (UP) urged all participants to contribute for the development of rapeseed-mustard by adopting recent technologies in the packages and practices of their own institutes or states. Dr. P. D. Meena, Principal Scientist (Plant Pathology) coordinated the school as Course Director.

5 Awards and Recognitions

Dr. Dhiraj Singh, Director ICAR-DRMR, honoured with ISGBRD's Gregor Johann Mendel Award for his outstanding contribution in rapeseed-mustard improvement in the country on the occasion of 2nd International Conference on NCBMBCC organized at Agra during 27-29 February 2016.

Dr. V.V. Singh Principal Scientist (Genetics and Plant Breeding) received Eminent Professor /Scientist Award in 2nd International Conference on NCBMBCC organized at Agra during 27-29 February 2016.

Dr. Pankaj Sharma Senior Scientist (Plant Pathology) received Best Scientist Award ICAR-DRMR 2015 by Dr. R.S. Paroda and Director, ICAR-DRMR, Bharatpur at the occasion of 22nd Foundation day on Oct 20, 2015. He also awarded *Young Scientist Award 2015* and *Best Poster Award on Theme IV* during National Conference at RVSKVV, Gwalior. Dec 12-13, 2015.

KVK (ICAR-DRMR) Bansur received *Best Interdisciplinary Team Research Award by* Society for Scientific Development in Agriculture and Technology, during National

Conference at RVSKVV, Gwalior on Dec 12-13, 2015. Dr. Pankaj Sharma and Dr. B.S. Rathore received the award by Hon'ble Dr. J.S. Sandhu, DDG (CS), ICAR and Dr. A.K. Singh, VC, RSKVV, Gwalior.

Dr. Bhagirath Ram Senior Scientist (Genetics & Plant Breeding) received ISGBRD's Young Scientist award in 2nd International Conference at Agra during 27-29Feb, 2016. He also received the Young Scientist Award of SSDAT during GRISAAS 2015 held at RVSKVV, Gwalior from Dec 12-13, 2015. He also awarded as the personnel of the year contribution in seed production activities of ICAR-DRMR during the year 2014-15 on October 20, 2015.

Dr. Anubhuti Sharma Senior Scientist (Biochemistry) received Young Scientist Award in 2nd International Conference on NCBMBCC held at St. John's College, Agra (UP) from 27-29 February 2016.

Dr. H. S. Meena received Best Poster Presentation Award (3rd prize) in 2nd International Conference by ISGBRD at Agra on 27-29th Feb, 2016. He also received ISGBRD Fellowship Award, 2016 in 2nd International Conference on NCBMBCC at Agra during 27-29 February 2016.

Dr. Arun Kumar received ISGBRD Fellowship Award, 2016 in 2nd International Conference on NCBMBCC at Agra during 27-29 Feb, 2016.

NEW JOINING/ TRANSFER/PROMOTION

New joining

Name	Designation	w.e.f
Dr. Bhagwat Singh Rathore	Sr. Scientist–cum-Head, KVK (ICAR-DRMR), Bansur	13.08.2015

Promotion

Name & Designation	From	To	w.e.f.
Dr. R.C. Sachan	Asst. Technical Officer	Chief Technical Officer	30.01.2015
Dr. H.S. Meena	Scientist (SS)	Sr. Scientist	25-11-2014

Transfer

Name & Designation	From	To	w.e.f.
Dr (Mrs) Anubhuti Sharma, Sr. Scientist (Biochemistry)	ICAR-VPKAS, Almora	ICAR-DRMR, Bharatpur	04.07.2015
Dr. R.S. Jat, Sr. Scientist (Agronomy)	ICAR-DMAPR, Anand	ICAR-DRMR, Bharatpur	04.01.2016
Sh. Mukesh Meena, Scientist (Soil Science)	ICAR-RCER, Patna	ICAR-DRMR, Bharatpur	03.02.2016
Dr. B. K. Kandpal, Pr. Scientist	ICAR-DRMR	ICAR-Head Quarter, New Delhi	14.055.2015
Dr. Y.P. Singh, Pr. Scientist	ICAR-DRMR	ICAR-Head Quarter, New Delhi	01.06.2015
Dr. S.S. Rathore, Sr. Scientist	ICAR-DRMR	ICAR-IARI, New Delhi	30.05.2015
Dr. Binay Kumar Singh	Scientist at ICAR-DRMR Bharatpur	Sr. Scientist at ICAR-IIAB, Ranchi	11.09.015
Dr. Kapila Sekhawat, Scientist	ICAR-DRMR	ICAR-IARI, New Delhi	04.07.2015
Dr. Era Vaidya	ICAR-DRMR	ICAR-NRCPB, New Delhi	21.09.2015

6 Linkages and Collaborations

ICAR-DRMR-IARI Collaborative National Extension programme

Under the programme 14 demonstrations with improved varieties of wheat namely HD 2967, HD 3059 and HD 2985 developed by IARI New Delhi were conducted during 2014-15 under the DRMR-IARI collaborative National Extension Programme for technology assessment and transfer, in Bharatpur and Jaipur district of Rajasthan and Firozabad district of Uttar Pradesh.

The farmers appreciated the performance of these high yielding demonstrated varieties. Varieties HD2967, HD3059 and HD2985 had yield advantage of 40.25, 36.36, and 28.57 per cent over other prevailing varieties. The average yield of these improved varieties was 54.0, 52.5 and 49.5 q/ha. Farmers were satisfied especially with HD 2967 for high yielding, good grain quality, more tillering, long spike.

During 2015-16, five demonstrations on 2 improved varieties viz. HD 2967 and HD 3086 were conducted in five villages, namely Seyorana, Chichana, Daurda, Jhangirpur and Neyotha to assess the performance of varieties in Bharatpur district.

Awareness cum Seed Production Mela

ICAR-DRMR in collaboration with U.P. Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Viswavidyalaya evam Go Anusandhan Sansthan (DUVASU), Mathura organized one day awareness cum seed production mela under ICAR seed project on Feb. 16, 2016 at Madhurikund Farm, Mathura. The awareness programme was focused on demonstration of the potential of improved varieties of Indian mustard and imparted knowledge on improved crop management practices to exploit the full potential of the crop in the region.

Dr B. B. Singh, ADG (Oilseeds and Pulses), ICAR inaugurated the event and briefed about importance of seeds of Indian mustard to the farmers. He also explained about the scope of seed production of Indian mustard in UP. He suggested farmers to take advantage of improved varieties released from ICAR-DRMR, for enhancing their income and profitability. He also appreciated the efforts of ICAR-DRMR for having a large seed production programme of their improved varieties *i.e.* RH-406, RH 749, NRCHB-101 and NRCDR-02 at Madhurikund Farm.

Dr. Dhiraj Singh, Director, DRMR, Bharatpur while addressing the farmers, other stakeholders, scientists from ICAR-DRMR and DUVASU, briefed about the improved technologies developed by ICAR-DRMR. He also reminded the wide yield gap of rapeseed-mustard in different states and requested farmers to come forward for adoption of improved varieties of rapeseed-mustard along with scientific technologies for enhancing oilseed production

for making the country self- sufficient in edible oilseeds. 8 exhibition pavilions were organized collectively by ICAR-DRMR, KVKs and Departments of DUVASU, Mathura for educating the visiting farmers. More than 1000 farmers from Uttar Pradesh and Rajasthan participated in the awareness cum seed production mela.

Farmers were invited to visit the seed production plots during the mela. Best workers involved in seed production at Madhurikund Farm and progressive farmers were also felicitated in the mela. Dr. Sarvjeet Yadav, Director Extension, Dr. S. K. Garg, Dean, College of Veterinary Science, Dr. Ajay Prakash, Director Farm DUVASU and were also participants in this programme.

NEH Component Project

Under this project, successfully conducted demonstration of rapeseed-mustard varieties NRCHB-101, PM-28 and yellow sarson (YSH-401, Pitambari) in rice-fallow areas of Manipur. The crop is grown as sole or mixed crop with other rabi pulses. During 2015-16, cultivation of mustard were taken up at five clusters in different districts of Manipur. In cluster-I, the seed yield of NRCHB-101 ranged from 400 to 1275 kg/ha with an average seed yield of 890 kg/ha. In cluster-II, the seed yield of NRCHB-101 ranged from 255 to 1125 kg/ha with an average seed yield of 824 kg/ha. In cluster-III, the seed yield of YSH-401 ranged from 655 to 1200 kg/ha with an average seed yield of 804 kg/ha.

The maximum seed yield potential of NRCHB-101 (1275 kg/ha) with 130 days duration was obtained by farmer Mr. Thokchom Shyam in cluster I, Thoubal Wangmataba, Thoubal district where proper crop management was followed. While, the maximum seed yield of YSH-401(1200 kg/ha) with 117 days duration was obtained by Mr. Misguide Muinao of Thoyee village in Cluster III.

7 All India Coordinated Research Project on Rapeseed-Mustard

22nd Annual Group Meeting of AICRP on Rapeseed-Mustard was successfully organized by ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur during August 3-5, 2015 at State Institute of Agriculture Management (SIAM), Jaipur. Dr. J. S. Sandhu, DDG (CS), ICAR, New Delhi presided over the inaugural session. Dr. B.B. Singh, ADG (OP), ICAR, Dr. Shital Sharma, Director, SIAM, Jaipur graced the occasion. Dr. Shital Sharma, Director SIAM, Jaipur formally welcomed the dignitaries and participants. He presented the status of oil[illegible] crops including rapeseed mustard in the Rajasthan state. Dr. B.B. Singh, ADG (OP), ICAR, New Delhi sensitized the participants about the shortage of edible oils in the country. He suggested increasing the area under rapeseed-mustard crops through taking it to non-traditional areas for overcoming this shortage. Short duration varieties, which can escape high temperature, can fit well in different cropping systems of these non-traditional areas. Dr. M.L. Jat, Cropping System Coordinator (South Asia), CIMMYT briefly presented the importance of climate-smart agriculture. Research activities and achievements for the year 2014-15 were presented by Dr. Dhiraj Singh, Director, ICAR-DRMR, Bharatpur. Presenting the research highlights, he informed that 5,528 germplasm accessions were maintained, 160 entries were evaluated at 44 locations across the five agro-climatic zones of the country and out of these 23 entries were promoted. He emphasised that '00' genotypes are in advanced stage of testing and biochemical assay for triptophan, mithionine and lignin are established. Therefore, the time has come to release and popularize these '00" material. He informed the house that 21 cooperating centers conducted 523 FLDs on rapeseed (131) and mustard (392) in 62 districts across 13 states of the country. Rajasthan had maximum FLDs (145) followed by Uttar Pradesh (62). On this occasion, five publications were released by the dignitaries.

Dr. J.S. Sandhu, DDG (CS), ICAR, New Delhi expressed his concern about the static production and productivity during last two decades. He encouraged the scientists to introspect about the technologies which performed well under stress environments and different target environments. Deep analysis is required to develop statewise technologies to cater local needs and improving productivity. He suggested that new niches, such as rice fellow in Eastern and North Eastern region, need to be identified for increasing area under rapeseed-mustard. Use of new biotechnological tools such as Marker Assisted Selection (MAS) and Doubled Haploid (DH)

technology need to be adopted for the shorter breeding cycle and increasing selection efficiency. Crop sequences are important to improve farm economy. Therefore, efforts are needed to find out genotypes for different cropping systems. Genotypes suitable for intercropping are also popularised. SDAU, S.K. Nagar and SKUAST, Srinagar centers were conferred with best main and sub-AICRP-RM centre award, respectively.

Twelve sessions including presentation of reports, wherein, all PIs presented the progress report of 2014-15 of their respective disciplines, technical programme formulation, technology dissemination and impact analyses, presentations in key areas, breeder seed production and plenary were held during the meeting. Technical programmes for the year 2015-16 were formulated for various disciplines. In the session on presentation in key areas, five presentations were made. Dr. M. Premjit Singh, Vice Chancellor, Central Agricultural University, Imphal, Manipur made a presentation on "Development of tribal farmers through rapeseed-mustard production in NEH region". He reported major technological gaps in rapeseed-mustard cultivation in North-eastern states and emphasized the importance of zero-tillage cultivation and development of water harvesting structure for enhancing production of rapeseed-mustard in NEH areas. He also presented the performance of improved varieties of rapeseed-mustard demonstrated at farmers' field under tribal sub-plan. Dr. Shital Sharma, Director, State Institute of Agriculture Management, in his presentation, discussed gap productivity analysis of rapeseed-mustard in different districts of Rajasthan. He emphasized for the development of disease and pest resistance varieties, better and effective coordination at the state level and close coordination and periodic interaction between seed producing agencies, seed certification agency, SAUs, and ICAR-DRMR. He also suggested for having more focus on development and popularization of processing technology of mustard like mustard paste, mustard sauce, roasted mustard, mustard powder, etc. Dr. K. S. Varaprasad, Director, ICAR-Indian Institute of Oilseeds Research, Hyderabad also made a presentation on "Scope and strategies for rapeseed-mustard production in South India". He discussed the scope of mustard area expansion in Telangana, Andhra Pradesh, and Karnataka. He emphasized that market infrastructure and industrial process to be created in the new areas to be expanded and there should be price support and MSP implementation. Dr. ML Jat, Senior Cropping Systems Agronomist, CIMMYT-CCAFS South Asia Coordinator made the presentation on "Climate Smart Agriculture (CSA): Why, What, Where and How?" He said that climate-smart agriculture is the need of the hour to meet the demand of food security and mitigate the adverse climatic effects. He emphasized that weather-related risks are increasing in the winter season; therefore systems approach is important for maximizing the yield of the crop. He also discussed the innovative three types of business models: back end (service providers), the front end (markets /export purpose), and end-to-end (value chain approach) for scaling CSA through enhancing the role of private sector in scaling up CSAP. Dr. Dhiraj Singh, Director, ICAR-DRMR, Bharatpur presented the current status and opportunities of rapeseed-mustard production in India. In his presentation, he expressed concern over the decline in area under rapeseed-mustard cultivation in some of the states. The country is importing a huge amount of edible oil due to increase in domestic consumption. Hence, efforts should be made to explore the possibility of bringing rice fallows in eastern and northeastern states under rapeseed-mustard cultivation.

The Variety Identification Committee of AICRP on Rapeseed-Mustard was held on 3rd August 2015 under the Chairmanship of Dr. J.S. Sandhu, DDG (CS). A total of 5 proposals including four of Indian mustard (Albeli 1, SKM 518, DRMR 150-35, CS 11000-1-2-2-3) and one taramira (RTM 1351) were considered for identification. The committee identified two strains of Indian mustard (SKM 518, DRMR 150-35) and one of taramira (RTM 1351) for release under different agro-ecological conditions (Annexure1). More than 170 scientists/personnel associated with rapeseed-mustard research and development in the country participated in this meeting. With the plenary session chaired by Dr. B.B. Singh, ADG (OP), ICAR, the meeting was successfully concluded on 5th August 2015.

The following actions were suggested for implementation:

- In the case of all advanced varietal trials in which some locations remained less than three due to the rejection of trials, shall be repeated during 2015-16.
- In the case of those strains which have been tested in AVT I trial for two years, the decision regarding their promotion will be based upon the average of all valid locations in two years in comparison to best performing the check.
- It was decided to conduct a meeting of all stakeholders for Standardization of protocol for biochemical analyses including fatty acid and glucosinolate analyses.
- In the quality trial, low double strains may be promoted even if their seed yield is 10 percent less than the best check. The decision regarding promotion of strains for the current year shall be made after discussion in the proposed meeting.
- In zone V, early maturing Indian mustard entries shall be tested under normally sown conditions of that zone; hence, no late sown trial shall be conducted in this zone.
- In quality analysis (biochemistry), the promising genotypes that show consistent results should be taken for three years. For quality experiments two checks will be taken, quality and national checks.
- Breeding material from IVT/AVT quality trails should also be tested in the physiology experiments
- In agronomy, long-term experiments should be conducted in system mode.
- Only whole package demonstrations with latest release varieties should be conducted to show the greater impact of developed technologies.
- At least 50 percent zonal varieties must be included in FLDs by each centre recommended for their zones other than its centers.
- Efforts should be made to get a large number of FLDs sanctioned for greater impact in wider areas.
- Concerted efforts should be made to replace the older varieties of rapeseed- mustard with the recently released ones.

The following recommendations were made by multi-location experimentation at various centers:

- Imidacloprid 17.8 SL @ 20g ai/ha or 0.25 ml per liter of water was found effective against painted bug at Bharatpur, Hisar, and Navgaon with higher IBCR.
- Foliar spray of Mancozeb 0.2% 45 DAS followed by Hexaconazole 25 EC @ 0.05% 60 DAS proved effective in controlling the Alternaria leaf blight.
- Foliar spray of Propiconazole 25 EC @ 0.05% was proved effective against powdery mildew and Sclerotinia rot.
- Weed flora from 25 districts, 31 land use conditions across the zones was surveyed. The most common weeds under rapeseed-mustard includes *Chenopodium album/murale, Anagalis arvensis, Cynodon dactylon, Melilotus alba/indica, Cyperus rotundus, Phalaris minor, Fumeria*

parviflora, Vicia sativa, Solanum nigrum, Avena fatua/ludoviciana, Aspodelus tenuifolius, Parthenium hysterophorus, Argemone Mexicana, Medicago denticulate, Convolvulus arvensis, Trigonella polycerta, Rumex acetosella/maritimus/spinosus, Euphorbia hirta/helioscopia, Echinochloa colonum, Spergulla arvensis, Lathyrus aphaca, Poa annua, Polypogon plebejum/ monspeliensis, Sorghum halepense, Cannabis sativa, Orobanche aegyptica and Phyllanthus niruri.

8 Publications

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9 Research Programmes and Projects

Name of Programme	Project Code	Leader/PI
Programme 1. Genetic enhancement for stress tolerance in Indian mustard		**V. V. Singh**
Population improvement for high productivity and oil content in Indian mustard under normal and moisture stressed conditions	DRMR CI-10	V. V. Singh
Widening of gene pool in Brassicas through interspecific and intergeneric hybridization	DRMR CI-12	Arun Kumar
Genetic and molecular basis of heat tolerance in Indian mustard	DRMR CI-14	Bhagirath Ram
Re-synthesis of Indian mustard (*Brassica juncea* L. Czern. &Coss.)	DRMR CI-15	H. S.Meena
Programme 2. Designer Brassica for oil quality		**V. V. Singh**
Breeding for quality traits in Indian mustard	DRMR CI-13	Priyamedha
Proteomics studies in oilseed Brassica	DRMR B-7	Ibandalin Mawlong
Screening of oilseed Brassica germplasm for value addition.	DRMR B-8	M.S. Sujith Kumar
Quantitative and qualitative estimation of glucosinolates and fatty acids in Oilseed Brassica	DRMR B-9	Anubhuti Sharma
Programme 3. Breeding for yield and quality enhancement in rapeseed-mustard		**K. H. Singh**
Development of hybrids in Indian mustard	DRMR CI–5	K. H. Singh
Programme 4. Rapeseed-mustard genetic resource management		**J. Nanjundan**
Augmentation, characterization, evaluation , rejuvenation and maintenance of rapeseed - Mustard germplasm	DRMR CI-6	J. Nanjundan
Programme 5. Biotechnological interventions to improve rapeseed-mustard productivity		**Ajay Thakur**
In vitro plant regeneration and genetic transformation of *Brassica juncea* L. Czern. & Coss. with an antifungal defensin gene	DRMR BT-1	Ajay Thakur
Genetic analysis of white rust resistance loci of Indian Mustard and their marker assisted introgression to some of the popular Indian cultivars	DRMR BT-4	B. K. Singh

Biotechnological interventions for development of Orobanche tolerance in Indian mustard (*Brassica juncea* L.)	DRMR BT-5	Reema Rani
Development of Nested association mapping population and mapping traits of economic importance in Indian mustard (*Brassica juncea*)	DRMR BT-6	Prasant Yadav
Programme 6. Enhancing resource use efficiency and abiotic stress management for resilient rapeseed-mustard production system		**O. P. Premi**
Use of organics in rapeseed-mustard production	DRMR CP-6	O. P.Premi
Evaluation and standardisation of RCTs for mustard based cropping systems under semi-arid conditions of Rajasthan	DRMR CP-11	Kapila Shekhawat
Characterisation and classification of soil - site conditions to delineate rapeseed - mustard production zones	DRMR CP-13*	B. K. Kandpal
Long-term fertility experiment to study changes in soil quality, mustard productivity and sustainability	DRMR CP-14*	S. S. Rathore
Efficient water management in *Brassica juncea*	DRMR CP-15*	S. S. Rathore
Programme 7. Management of biotic stresses in Indian mustard		**P. K. Rai**
Biological control of major pests of Brassicas with special reference to mustard aphid	DRMR ENT-2*	Y. P. Singh
Pest-plant interaction of major pests of Brassicas	DRMR ENT-3*	Y. P. Singh
Management of Sclerotinia rot in Rapeseed - Mustard	DRMR PP-1	Pankaj Sharma
Management of Alternaria Blight in Rapeseed - Mustard	DRMR PP-3	P. D.Meena
Epidemiology and management of white rust	DRMR PP-5	P. K. Rai
Programme 8. Technology assessment and dissemination		**Ashok Kumar Sharma**
Development of application software for rapeseed-mustard information management	DRMR CA-1	Vinod Kumar
Participatory extension for dissemination of rapeseed-mustard technology	DRMR ECT-4	Ashok Kumar Sharma

* RPF III submitted

Externally Funded Projects

Name of Project	Project Code	PI/Leader
Characterization of rapeseed - mustard varieties for distinctness, uniformity and stability (DUS) testing	DRMR EA-2	K. H.Singh
ICAR seed project on seed production in agricultural crops	DRMR EA-4	V. V. Singh
Intellectual property management and transfer/commercialization of agricultural technology schemes	DRMR EA-7	K. H.Singh
Development of a core set of SSR markers for characterization of *Brassica juncea* varieties and germplasm	SB/YS/LS-86/2014	A. K.Thakur
Induced Mutagenesis for Isolation of Alternaria blight resistant mutant in *Brassica juncea*	DRMR EA-9	P. D.Meena
Integrated agromet advisory services for flood prone zone of eastern Rajasthan	DRMR EA-8	O. P. Premi
Development of white rust resistant mustard genotypes with high oil quality	DRMR EA-16	V. V.Singh
Study on *Sclerotinia sclerotiorum* with emphasis on management of Sclerotinia rot in Brassica	DRMR EA-10	Pankaj Sharma
Frontline demonstrations and other related activities of Oilseeds	DRMR NMOOP-1	A. K. Sharma
CRP-Hybrid technology: Indian mustard	DRMR EA-11	K. H. Singh
Pre-breeding for Genetic Enhancement of Indian (*Brassica juncea* Czern&Coss) and Ethiopian mustard (*Brassica carinata* A Braun) Gene Pool	DRMR EA-12	K. H. Singh
XII Plan Scheme National Agriculture Innovation Fund	DRMR EA-13	K. H. Singh
Incentivizing research in agriculture (Molecular Genetics)	DRMR EA-14	V.V. Singh
CRP-Molecular breeding for improvement of tolerance to biotic stresses and quality traits in crops	DRMR EA-15	V.V. Singh

10 IRC, IMC and QRT

Institute Research Council

ICAR-Directorate of Rapeseed-Mustard Research organized its 25th Institute Research Council (IRC) meeting on September 1-2, 2015, under the Chairmanship of Director, DRMR. All scientists presented the research findings of the year 2014-15 and proposed a technical programme for 2015-16. Dr. Sain Das, Former Director, Directorate of Maize Research, New Delhi was the special invitee. The Chairman asked all the scientists to prepare activity profile of each PI and Co-PI clearly spelling out the activity of the project. He said that collaborative efforts were needed to come out with the final product. There should be a time-bound programme of the experiment. All facilities of the institute are to be shared. Technical staff has to be made at technical work. The Chairman, IRC, emphasized that each scientist must follow the recommendations of the Council concerning with respective projects. Dr. Sain Das said that hybrid is the need of the hour, and possibility should be explored for collaboration with other institutions for development of varieties especially hybrids in Indian mustard. He emphasized that scientists have freedom to do research in the system; however, projects that have not produced any results so far must be closed. The projects which are of national importance must be given the priority. The Chairman of IRC assured for full support and facilities for the scientists to carry out their research work and development of scientific work culture in the institute. He urged that all the contributors must be acknowledged, and materials, knowledge and experiences should be shared. IRC also recommended that PIs of the project who got transferred/ promoted from DRMR to another institute shall submit the RPF III of their respective project. The other relevant scientists may be included in the project as Co-PI in place of transferred/ promoted scientists. The IRC expressed satisfaction over the progress made on various projects during 2015-16 and approved the technical programme for 2015-16.

Institute Management Committee

18th Institute Management Committee meeting was held on November 5, 2015, under the chairmanship of Dr. Dhiraj Singh, Director, ICAR-DRMR. The chairman appraised the house about the ongoing research projects and other activities of the Directorate. He also highlighted salient achievements made since the previous meeting. Sh. Shitanshu Kumar, the member secretary, presented the status of proceedings and action took a report on the 17th IMC meeting. He apprised the committee about the extension activities undertaken at the Directorate during August 2014 to October 2015. Dr. Pankaj Sharma presented "Recent advances in Sclerotinia management".

Dr. Dhiraj Singh, Director, ICAR-DRMR, Bharatpur	Chairman
Dr. B.B. Singh, Assistant Director-General, ICAR	Member
Joint Director of Agriculture, Govt. of Rajasthan, Bharatpur	Member
Joint Director of Agriculture (Oilseed), Govt. of Madhya Pradesh, Bhopal	Member
Dr. Swarup Singh, Director, Rajasthan Agri. Research Institute, Durgapura, Jaipur	Member
Dr. A.N. Sharma, Principal Scientist, Directorate of Soybean Research, Indore	Member
Dr. A.L. Singh, Principal Scientist, Directorate of Groundnut Research, Junagarh	Member
Dr. Arjun Lal, Head (Germplasm), NBPGR, New Delhi	Member
Dr. B.D. Sharma, Principal Scientist, CIAH, Bikaner	Member
Finance and Accounts Officer, NRCPB, New Delhi	Member
Sh. Harbhan Singh, Village Daurda	Member
Sh. Ramesh Yadav, Village Pahersar	Member
Sh. Shitanshu Kumar, Administrative Officer, ICAR-DRMR	Member Secretary
Sh. P.K. Tiwari, Finance and Accounts Officer, ICAR-DRMR	Special Invitee

Quinquennial Review Team

The Indian Council of Agricultural Research, New Delhi, vide it's letter F.No. CS.11/ 10/2009-IA.III dated August 5, 2015, constituted the Fourth Quinquennial Review Team (QRT) to review the work done by the ICAR-Directorate of Rapeseed-Mustard Research (DRMR), Bharatpur (Rajasthan) and the All India Coordinated Research Project on Rapeseed-Mustard (AICRP-RM) during the period five years, i.e. 2010-14. The QRT composition is as given below:

Dr. B.L. Jalali, Ex-Director of Research, CCSHAU, Hisar	Chairman
Dr. G.S. Saharan, Ex-Professor, CCSHAU, Hisar	Member
Dr. D.R.C. Bakhetia, Ex-Head, Division of Entomology, PAU, Ludhiana	Member
Dr. Shailaja Hittalmani, Prof & Head, Division of GPB, UAS, Bangalore	Member
Dr. M.L. Jat, Senior Cropping Systems Agronomist, CIMMYT, New Delhi	Member
Dr. M.L. Lodha, Ex-Prof & Head, Division of Biochemistry, IARI, New Delhi	Member
Dr. Dhiraj Singh, Director, ICAR-DRMR, Bharatpur	Facilitator
Dr. V. V. Singh, Principal Scientist (Plant Breeding) DRMR, Bharatpur	Member Secretary

The first meeting of the QRT held at ICAR, New Delhi with Dr. J. S. Sandhu, Deputy Director General (CS), on October 9, 2015. Dr. Sandhu outlined the guidelines and role of the QRT and reiterated its significance in formulating the policy for research and development in this important group of oilseed crops. QRT had interacted with DDG (CS), ADG (OP), ICAR, Vice Chancellors, Dean/Directors, HODs, scientists from DRMR and AICRP centres, State Agriculture officers, KVK staffs, NGOs and farmers during various meetings. The QRT visited six major coordinated centres besides DRMR, Bharatpur.

11 Tribal Sub-Plan

ICAR-DRMR, Bharatpur implemented Tribal Sub-Plan during 2015-16 in collaboration with 4 SAUs viz. AAU, Jorhat (Assam); CAU, Imphal (Manipur); BAU, Ranchi (Jharkhand) and RVSKVV, Gwalior (Madhya Pradesh) was implemented. To augment rapeseed-mustard production through capacity building, exposure visits, organizing field days/ Kisan diwas, on and off-campus training farmer participatory varietal selection / front line demonstrations, providing farm implements, developing rainwater harvesting structures, etc. in selected tribal dominated district of jurisdiction area of respective universities for the sustainable livelihood security of tribal farmers. On-farm demonstrations of the rapeseed-mustard crop in 86 ha area in the project area of Assam, 157.5 ha area of Jharkhand, 60 ha area of Madhya Pradesh and about 1000 ha area of North Eastern States (Manipur, Meghalaya & Arunachal Pradesh) have been laid out during 2015-16. Besides, one three days training-cum-exposure visit to ICAR-DRMR was also organized in collaboration with BAU, Ranchi during 18-20 Feb. 2016 for capacity building of the 31 tribal farmers and two extension staff of Jharkhand for the dissemination of scientific technology of rapeseed-mustard among them.

4th Workshop on Tribal Sub Plan

ICAR- DRMR in collaboration with MPUA&T, Udaipur organized a two-day Workshop on "Augmenting Rapeseed-Mustard Production for Sustainable Livelihood Security of Tribal Farmers under Tribal Sub Plan at MPUA&T, Udaipur during March 26-27, 2015. Dr. O.P. Gill Hon'ble Vice Chancellor, MPUA&T, Udaipur chaired the inaugural session of the Workshop on may 26, 2015. He emphasised that livelihood of tribal farmers depends on farming; therefore development of agriculture must be a priority in the tribal area of the country. Govt. of India launched tribal sub plan by keeping separate funds for the development of different sectors that can provide directly benefit to the tribal population. He said that majority of tribal farmers had small land holdings. Therefore only integrated farming model will be successful in tribal areas. We must identify the agriculture based entrepreneurship suitable to them and should motivate the tribal farmers to adopt them for enhancing their income.

On the occasion, the chief guest Dr. M. Premjit Singh, Hon'ble Vice Chancellor, CAU, Imphal, Manipur said that enhancement of the income from agriculture should be our priority for sustainable livelihood security of the tribal farmers. He mentioned that farmers keep their land fallow after paddy cultivation in North-eastern region, and popularization of rapeseed-mustard cultivation in the area will certainly increase the availability of edible oil in the country and income of the farmers. He appreciated the efforts of tribal farmers to adopt the rapeseed-mustard cultivation under the TSP programme implemented by CAU in North-Eastern region.

Dr. Dhiraj Singh, Director, ICAR-DRMR said that TSP programme is the great opportunity for the development of tribal farmers through making them improve their agriculture by adopting scientific methods. Since rapeseed-mustard is more profitable than other crops under resource constraints condition, therefore it should be practised in non-traditional areas. He appreciated the work done under TSP by different collaborative universities and emphasised that there will be the far-reaching positive impact on the development of the tribal community in the country.

Dr. Ashok Sharma, Nodal Officer of TSP programme, presented the overall activities being carried out under the programme and urged the participants to keep regular contact with the beneficiary tribal farmers and motivate them to adopt the scientific practices of rapeseed-mustard cultivation. Dr. Pankaj Sharma, PI welcomed the participants and introduced about the TSP programme. The progress reports of 2014-15 were presented by concerned PI of the collaborative universities and action plan for 2015-16 were finalized. The project coordinators from, BAU, Ranchi; CAU, Imphal; RVSKVV, Gwalior; AAU, Jorhat, and MPUA&T, Udaipur, participated in the workshop.

TSP activities conducted by CAU, Imphal (Manipur)

ICAR-DRMR and Directorate of Extension Education, Central Agricultural University, Imphal, Manipur collaboratively implemented TSP in rice fellow during rabi 2015-16. During the period, the historical data collection and KAP (Knowledge, Attitude & Practice) survey of the farmers in the project site were undertaken. Depending on the moisture condition in the field, suitability of the field, three methods of traditional zero-tillage cultivation of rapeseed – mustard, *i.e.*, i) As relay crop, ii) Sowing seeds after burning straw, and iii) Sowing seeds and straw mulching are practiced by the farmers of the project site. Based on the available indigenous technical knowledge, an appropriate location specific improved zero-tillage cultivation of rapeseed - mustard was developed by the project team

Considering the water scarcity during rabi season the zero-tillage cultivation in residual soil moisture of rice fallow was demonstrated in 1005.5 ha. Seven districts namely, Imphal East, Bishnupur, Churachandpur, Thoubal, Senapati, Ukhrul, Imphal West of Manipur. One district namely East Siang of Arunachal Pradesh and one district namely Ri-Bhoi of Meghalaya by using three rapeseed varieties viz., M-27, TS-38, and TS-36, one variety of yellow sarson, YSH-401 and one variety of Indian Mustard, NRCHB-101was done. A total of 1230 farmers across nine districts of North Eastern Hill Region were involved in the project for on-farm demonstration and participatory varietal selection:

Since there was no rain throughout the crop period during *rabi*, 2015-16, the average yield in all the rapeseed-mustard varieties was on an average. Under participatory varietal selection trials, rapeseed variety, TS-38 was grown in 213.75 ha across 19 (nineteen) villages in 5 districts of North-eastern Hill Region and the average yield was 6.5 q/ha with a wide variation of yield from lowest 2.5 to highest 12.4 q/ha. Similarly, rapeseed variety, M-27 grown in 460.25 ha across twenty-one villages in five Districts of North-Eastern Hill Region. It gave an average yield of 6.4 q/ha (2.4 to 12.6 q/ha) and TS-36 grown in 163 ha in twelve villages covering four districts of North Eastern Hill Region gave an average yield of 6.3 q/ha (2.4 to 11.2 q/ha). Yellow sarson, YSH-401 grown in 10 ha in two villages of Imphal West and Bishnupur District of Manipur gave an average yield of 7.2 q/ha (3.8 to 10.0 q/ha). The Indian mustard, NRCHB-101 grown in 131.50 ha across nine villages in three districts of Manipur gave the highest average yield of 7.5 q/ha (3.4 to 14.7 q/ha).

Under the water stress situation where there was no rainfall during the crop period, TS-38 among rapeseed varieties, Yellow sarson YSH-401, and NRCHB-101 among mustard varieties gave a maximum average yield of 6.5, 7.2 and 7.5 q/ha under zero-tillage cultivation. Bee pollination and no chemical method of plant protection may be recommended to the resource poor farmers of the North Eastern Region in the context of climate change.

A total of 118 farmers (101 male and 17 female) involved in rapeseed-mustard cultivation were trained on rapeseed-mustard production technology at the village level through 3 on-farm training programmes. Besides, one farmers' field days was also organized, and 217 farmers including 13 farm women from the project site participated in the field day and farmers-scientists interaction programme. The dignitaries along with the farmers witnessed the bumper crop of rapeseed TS-38, Yellow sarson, YSH-401 introduced from DRMR, Bharatpur, and large-scale demonstrations of zero-tillage cultivation of rapeseed-mustard. One publication on "Success stories on the zero-tillage cultivation of rapeseed-mustard in NEH Region during rabi 2011-12 to 2013-14 (in Manipuri)" was also published. One DDK programme was also telecasted on rapeseed-mustard production technology for dissemination to the farmers and public awareness. Further, the project activities were regularly disseminated through local newspapers.

Farmers were motivated towards improved zero-tillage cultivation of rapeseed-mustard in rice fallow with the non-chemical method of plant protection and bee pollination. The farmers of Manipur who cultivated rice crop only during Kharif with a net profit of Rs. 12,000/ha realized this low-cost technology with a higher net profit of Rs. 19,996 /ha and Rs. 22,396/- Further, the farmers who grow Indian mustard, NRCHB-101 could get a more net profit of Rs. 23,746/ha.

TSP activities conducted by BAU, Ranchi (Jharkhand)

ICAR-DRMR and Directorate of Extension Education, Birsa Agricultural University, Ranchi, Jharkhand collaboratively implemented TSP Project in the tribal region of Jharkhand under Tribal Sub-Plan for Scheduled Tribes" in four tribal dominated districts namely, Ranchi, Lohardaga, East Singhbhum and West Singhbhum during 2015-16. The basic objective of the project was to demonstrate improved proven technology of recently released, high yielding, bold seeded and disease resistant varieties. NRCDR-02, Pusa Mahak and Pusa – 28 were the varieties which were demonstrated in 157.5 ha at farmers field through BAU, headquarter & KVKs during the year under report (2015-16) to bring in the enhanced application of modern technologies to generate yield data and collection of farmers' feedback.

The total area covered under demonstration were 47.5, 30, 50 and 30 ha in Ranchi, Lohardaga, East Singhbhum and West Singhbhum district respectively. All demonstrations were conducted either in rice-fallow or maize-fallow cropping systems in the upland situation. In Ranchi and West Singhbhum districts two varieties viz. Pusa Mahak and Pusa Mustard– 28 were demonstrated, but in Lohardaga and East Singhbhum districts two varieties, namely, NRCDR-02 and Pusa Mahak were demonstrated.

Three different variety of mustard Pusa Mahak, Pusa mustard-28 and NRCDR-02 along with local variety Chotki Sarson were tested at farmers field in three agroclimatic reasons of Jharkhand. The result indicated that both the mustard varieties Pusa-28 (11.80 q/ha) and NRCDR-2 (11.48 q/ha) performed better against Pusa Mahak (10.49 q/ha) and farmers variety Chotki Sarson (6.60 q/ha). The increase in yield over local check was 78.79%, 73.94% and 54.94% in variety Pusa mustard-28, NRCDR-02, and Pusa Mahak, respectively.

Altogether seven field days organized including in Hudu and mundo village and Lohardaga, Kairo block two at Gorgora Muyadih of Jamshedpur and Dhalbhumgarh Block and three at Rukka, Cipra and Kudlong of Nagri and Ormajhi Block. 490 farmers participated in field day during the cropping season; two On-campus training programme were organized at BAU Headquarter in which 70 farmers from Ranchi participated. Six On-farm training programmes on mustard production technology were organized in which 240 tribal farmers participated. Besides, one three days training-cum-Exposure visit to ICAR-DRMR was also organized in collaboration with BAU, Ranchi during 18-20 Feb. 2016 for capacity building of the 31 tribal farmers and two extension staff of Jharkhand for the dissemination of scientific technology of rapeseed-mustard among them.

A major limitation of Jharkhand agriculture is that the majority of the cultivable area remains fallow after Kharif due to lack of irrigation facilities. The improved varieties of rapeseed and mustard and other components of the package of practice introduced through TSP project during rabi season have raised the hope of farmers for increasing their income and sustaining the livelihood.

TSP activities conducted by AAU, Jorhat (Assam)

ICAR-DRMR and Directorate of Research, Assam Agricultural University, Jorhat, Assam collaboratively implemented TSP Project in two districts viz., Dhemaji and Kokrajhar (tribal dominated districts of Assam) during 2015-16 through Regional Agricultural Research Station, North Lakhimpur and Krishi Vigyan Kendra (KVK), Kokrajhar to develop capacity building, on-farm demonstration, dissemination of technology to the tribal farmers and thereby increasing the rapeseed production and productivity of the region.

Under the programme, the Regional Agricultural Research Station, North Lakhimpur (AAU) conducted the demonstrations on Rapeseed (Toria) at Kopahtoli, Dakhin Dhemaji in Dhemaji district in an area of 80 ha covering 50 tribal farmers of Mising tribe. The demonstrations were conducted under rainfed condition. Two already established HYV of Assam (TS-36 and TS-38) along with local variety were used in the demonstration programme. In all the plots the introduced varieties outyielded the popular local varieties. The highest yield was 13.5 q/ha while the productivity of demonstrated varieties and local were 10.8 q/ha, 10.4 q/ha and 7.4 q/ha respectively.

On the other hand, Krishi Vigyan Kendra (KVK), Kokrajhar has also conducted the demonstration in 6.7 ha area on the use of an improved variety of toria with 14 numbers of farmers of Bodo tribes at four locations viz., Kujrabguri, Amlaiguri, Maktaigaon and Malaguri villages of Kokrajhar district with the variety TS-36. Average yield was 8.77 q/ha. The yield performance of the tested variety was much better than those used by the farmers in the neighbouring fields.

During the period, the participating farmers were also imparted with training on modern techniques of raising toria under the rice-fallow situation. Four on- farm training were conducted that benefitted about 200 farmers. Besides, two field days and two scientist-farmers interactions were also organized that benefitted about 180 tribal farmers.

TSP activities conducted by RVSKVV, Gwalior (Madhya Pradesh)

ICAR-DRMR and Director of Extension Services, RVSKVV, Gwalior (MP) collaboratively implemented TSP project in Jhabua district of Madhya Pradesh during 2015-16. During the period, 150 Demonstration were conducted in 60 ha covering six blocks of Jhabua district viz., Thadala (Morjhary, kakanwani, Daulatpura) Rama (Jhumka, Padalghati, Rotala, Gomala, Kokawad, Chapari, Sad), Jhabua (Dharampuri Melpada, Amaly Faliya) Ranapur (Bhurimati, Dahamani Katara), Meghnagar (Sajeli) Petalabad (Mohankot, Kadwali). The seeds of NRCDR-02 and RVM-2 and other critical inputs were provided to the beneficiaries. Average yield in the demonstration plots was 14.3 q/ha while in farmers field average yield were 11.1 q/ha. The yield of demonstration plot was higher by 28.1 percent as compared to farmers field. Maximum yield in the demonstration plot was 15.5 q/ha while the minimum was 10.55 q/ha. Average B:C ratio generated in FLD's was 2.10 as against 1.92 in farmers' practices. During the period, two farmers field day were organized and about 81 farmers including 24 farm women were benefitted. Two on campus and two off campus training were organised that benefitted 174 tribal farmers. Besides, three farmers' scientist interface programmes for 165 farmers were also organized. Ten numbers of dora and hand spray pump were distributed at six different blocks in different villages with 21 beneficiaries.

Monitoring of TSP

Directorate of Extension Education, Central Agricultural University, Imphal, Manipur in collaboration with Directorate of Rapeseed-Mustard Research, Bharatpur (Rajasthan) organized Farmer's Field Day on "Zero Tillage Cultivation of Rapeseed-Mustard in rice fellow" at Upokpi, Bishnupur District Manipur on 24th Feb. 2016. The field day was inaugurated by the Director, ICAR-DRMR, Dr. Dhiraj Singh. Dr. L. Joykumar Singh, Dean, College of Agriculture, CAU, Imphal, Dr. S.S. Nagra, Director of Instruction, CAU, Imphal and Prof. M. Premjit Singh, Hon'ble Vice-Chancellor, Central Agricultural University, Imphal (Manipur) were other dignitaries. Out of 217 nos. of registered farmers/growers, 204 males and 13 females including ten farmers from the state of Meghalaya also participated. Dr. Dhiraj Singh appreciated the work done by the farmers of Manipur under the guidance of Director of Extension Education, CAU, Imphal. All the dignitaries also visited the rapeseed-mustard fields cultivated by the farmers at Upokpi (var. TS-38) and Phubala (var. YSH-401) of Bishnupur district, and it was concluded successfully. Dr. Ashok Kumar Sharma, Nodal officer, TSP monitored the activities of TSP carried out by BAU, Ranchi (Jharkhand) during Feb. 8-9, 2016. He visited FLDs site and participated in 2 field days organized at Mondu village of Lohardagga on Feb. 8, 2016, and Rukka village of Ranchi on Feb. 9, 2016, under TSP programme.

12 Krishi Vigyan Kendra (ICAR-DRMR), Gunta-Bansur

On and off-campus training

Thirty-nine on-campus training including ten sponsored from ATMA and Rajasthan Agricultural Competitiveness Project were organized at KVK. The trainning were on different aspects viz. scientific production technologies for mustard, wheat, barley, cluster bean, sorghum, green gram and cotton crop; insect and disease management in mustard, wheat, cluster bean and cotton crop; integrated nutrient management in wheat, termite and rat control. These training also covered aspects of vermicomposting technology, poly house technology, PPV&FR-2001 act and azola production unit. A total 1186 farmers, farm women, and rural youth were benefited. Fortynine off-campus training were also conducted in different villages of Bansur and Behror Tehsil to enhance knowledge of farmers and farm women on different aspects of crop production, animal husbandry, horticulture and home science during cropping seasons. Through these trainings, 1521 farmers were benefitted.

Front Line Demonstrations

In Kharif 2015, a total of 35 FLDs were conducted on mungbean (IPM-02-03), carrot (Pusa Rudhira and Pusa Vrasti), brinjal (Pusa Shyamala) covering 5.5 ha area in villages of Bansur Tehsil. 200 seedlings of papaya variety honey dewwere also distributed to farmers.

During rabi season 2015-16, one hundred and thirteen FLDs were conducted on mustard var. NRCHB-101, RH-749, and Giriraj covering 30 ha area indifferent villages of Bansur Tehsil. Farmers appreciated the mustard varieties for their high number of branching and seed yield. Nine field days were also organized on the demonstrated crops at the villages, where 241 farmers participated.

Others Demonstrations

Demonstrations one of *Trichoderma viride* and HaNPV were conducted to manage wilt and pod borer in chickpea covering 2.0 ha areas among eight farmers. Its application effectively increased the plant vigor, more branching, and pod formation in an eco-friendly manner.

On-Farm Trial (OFT)

Four OFT on IPM, IDM, weed management and INM were conducted at farmer's field in the mustard crop on white rust, painted bug and Orobanche management. For white rust and stag head management, three treatments were tested. The results of this OFT revealed that seed treatment with apron 35SD and two sprays of ridomil@0.02% gave maximum yield (19.1q/ha) and B: C ratio 2.39 as compared to other two treatments. For management of painted bug, application of malathion 5% dust @ 25kg/ha soil together with seed treatment using imidachlo prid17.8%SL gave maximum yield (17.8q/ha) and the higher benefit-cost (B: C) ratio (2.23).

Kisan gosthi and Kharif Kisan Samellan

A total five Kisan Gosthi were organized in village Ratanpura, Gunta, Rodwal and Khori of Bansur and Behror Tehsil, where 428 Farmers gotbenefited.Kharif Kisan Sammellan was also organized at Gunta-Shahpur village to aware farmers on the issues and opportunities in aKharif season, particularly pearl-millet cotton and cluster bean. In this Sammelan, 250 farmers, farm women, and rural youths participated.

Chief Guest of the programme was Hon'ble MLA Smt. Shakuntala Rawat and guest of honour was Dr. Pankaj Sharma, Sr. Scientist ICAR-DRMR.

Rabi Kisan Samelan/International Soil Day

Rabi Kisan Samelan/International Soil day was celebrated on 5 December 2015 at Bansur. Dr. Dhiraj Singh, Director, ICAR-DRMR,

Bharatpur chaired the function. On this occasion, 828 soil health cards were distributed to the farmers by the chief guest Honorable MLA Smt. Shakuntala Rawat. A Kisangosthi was also organized to address the issues of farmers. About 200 farmers and farm women participated in the function.

Other Extension activities

Three agricultural exhibitions, 52 film shows, 105 diagnostic visits and two animal health camps were conducted. Seventy lectures were delivered in different farmer meetings. Advisory to farmers were also given over telephone and during their visit to KVK. Through these activities, 5452 farmers, farm women, and rural youths were benefited.

113 farmers from KVK Bansur area also visited ICAR-DRMR, Bharatpur for exposure visit during 22nd Sarson Vigyan Mela.

FET (NAARM, Hyderabad)

Field Experience Training (FET) of 21 days was imparted to six trainee scientists of NAARM, at KVK. The course coordinator was Dr. B.S. Rathore, Sr. Scientist cum Head, KVK and Dr. Pankaj Sharma, Sr. Scientist, ICAR-DRMR.

Scientific Advisory Committee (SAC)

Third SAC meeting was organized on 4 March 2016 at KVK Bansur. The meeting was chaired by Dr. Dhiraj Singh, Director, ICAR-DRMR, Bharatpur. The other guests were Dr. Ved Pal Singh (Ex-Professor, CCSHAU, Hisar), Smt. Pushpa Yadav (Sarpanch, Shahpur), Dr. Pankaj Sharma (Sr. Scientist, DRMR, Bharatpur), Sh. Vijay Singh (PD ATMA, Alwar) and Dr. D.K Yadav (Professor & Incharge, ARSS, Kotputli).

Foundation day

On 28 March 2016, 5th Foundation day was celebrated. Progressive farmers, farm women, public representative and scientists from ICAR-DRMR participated in a brainstorming session and discussed various agricultural issues during this event. A total of 40 progressive farmers participated from different villages.

Publications

Twenty popular articles, 77 press releases, and nine extension literature were published and telecasted to different mass media to create awareness about the agricultural advancement to the rural mass.

Instructional Farm

About 30.0 q mustard var. NRCHB-101 was produced from 7.5 ha area of farm.

13 Distinguished Visitors

Name	Designation & Address	Date
Dr. S.K. Agarwal	Ex-Director, ICAR-CIRG, Mathura	May 02, 2015
Dr. Sain Das	Ex-Project Director, ICAR-DMR, Ludhiana	May 08, 2015
Dr. J.B. Choudhary	Former Vice Chancellor, CCSHAU, Hisar, and GBPUAT, Pant Nagar	July 24, 2015
Dr. Rajeev K Varshney	Research Program Director and Director, Centre of Excellence in Genomics (CEG), ICRISAT, Hyderabad	July 24, 2015
Dr. M. Z. Abdin	Head, Deptt of Biotechnology, JamiaHamdard University, Delhi	Sep 02, 2015
Dr. R.S. Paroda	Ex-Secretary DARE and DG ICAR, & Chairman Trust for Advancement o. Agricultural Sciences (TAAS), New Delhi	Oct 20, 2015
Dr. B.L. Jalali	Ex-Director of Research, CCSHAU, Hisar	Nov 23-24, 2015
Dr. G.S. Saharan	Ex-Professor, CCSHAU, Hisar	Nov 23-24, 2015
Dr. D.R.C. Bakhetia	Ex-Head, Division of Entomology, PAU, Ludhiana	Nov 23-24, 2015
Dr. Shailaja Hittalmani	Head, Division of Genetics &Plant breeding, UAS, Bangalore	Nov 23-24, 2015
Dr. M.L. Jat	Senior Cropping Systems Agronomist, CIMMYT, New Delhi	Nov 23-24, 2015
Dr. M.L. Lodha	Ex-Professor & Head, Division of Biochemistry, IARI, New Delhi	Nov 23-24, 2015
Dr. R.K. Tyagi	Head, Economic Botany, Division of Germplasm Conservation, NBPGR, New Delhi	Feb 01, 2016
Dr. J.C. Rana	Head, Division of Germplasm Evaluation, NBPGR, New Delhi	Feb 01, 2016
Dr. J.S. Sandhu	DDG (Crop Science), ICAR, KrishiBhawan, New Delhi	Feb 19, 2016
Sh. Mohanbhai	Minister of State for Agriculture & Farmer's Welfare, Govt. of India	Feb 18, 2016
Sh. Ravi Jain, IAS	District Collector, Bharatpur, Rajasthan	Feb 18, 2016
Sh. Bahadur Singh Koli	Member of Parliament, Bharatpur, Rajasthan	Feb 18, 2016
Dr. Manoranjan Dutta	National Advisor, NMOOP, Govt. of India, New Delhi	Feb 18, 2016
Dr. Asha Shivpuri	Ex-Professor & Head, Division of Plant Pathology, RARI, Jaipur	Feb 19, 2016
Sh. Shiv Singh Bhont	Mayor, Bharatpur, Rajasthan	Feb 19, 2016
Sh. R. K. Yadvendra	Joint Director, NMOOP, Pant Krishi Bhawan, Jaipur	Feb 20, 2016
Dr. Andre Pouzet	Director, International Consultative Group for Research on Rapeseed (GCIRC), Paris, France	Feb 22, 2016

14 Personnel

Director's Office	
1	Dhiraj Singh, Director
2	Veena Sharma, Personal Assistant
3	Lala Ram, Supporting staff (SSG III)
Scientific Staff	
Crop Improvement	
1	V.V. Singh, Principal Scientist (Genetics & Plant Breeding)
2	Bhagirath Ram, Sr. Scientist (Genetics & Plant Breeding)
3	Arun Kumar, Sr. Scientist (Genetics & Cytogenetics)
4	H.S. Meena, Sr. Scientist (Genetics & Plant Breeding)#
5	Priya Medha, Scientist (Genetics & Plant Breeding) on study leave
AICRPRM Unit	
6	K.H. Singh, Principal Scientist (Genetics & Plant Breeding)
Natural Resource Management	
1	B.K. Kandpal, Principal Scientist (Agronomy)*
2	O.P. Premi, Principal Scientist (Agronomy)
3	S.S. Rathore, Sr. Scientist (Agronomy)*
4	R.S. Jat, Sr. Scientist (Agronomy)**
5	Kapila Sekhawat, Scientist (Agronomy)*
6	Mukesh Kumar Meena, Scientist (Soil Science)**
Plant Protection	
1	P.K. Rai, Principal Scientist (Plant Pathology)
2	P.D. Meena, Principal Scientist (Plant Pathology)
3	Pankaj Sharma, Senior Scientist (Plant Pathology)
Plant Biotechnology	
1	Ajay Kumar Thakur, Scientist SS (Plant Biotechnology)
2	B.K. Singh, Scientist SS (Plant Biotechnology)*#
3	Era Vaidya, Scientist (Plant Biotechnology)*
4	Reema Rani, Scientist (Plant Biotechnology)
5	Prashant Yadav, Scientist (Plant Biotechnology)
Plant Biochemistry	
1	Anubhuti Sharma, Sr. Scientist (Plant Biochemistry)**
2	Ibandalin Mawlong, Scientist (Plant Biochemistry)
3	M.S. Sujith Kumar, Scientist (Plant Biochemistry)
Technology Assessment & Dissemination	
1	A.K. Sharma, Senior Scientist (Agricultural Extension)
Agriculture Knowledge Management Unit	
1	Vinod Kumar, Senior Scientist (Computer Apllication in Agriculture)

Technical Staff	
1	U.S. Rana, Chief Technical Officer (CTO)
2	R.C. Sachan, Chief Technical Officer (CTO)#
3	M.L. Meena, Assistant Chief Technica l Officer (ACTO)
4	H.P. Meena, Assistant Chief Technical Officer (ACTO)
5	Ram Narayan, Assistant Chief Technical Officer (ACTO)
6	Karnal Singh, Senior Technical Officer (STO)
7	Kailash Narayan, Senior Technical Officer (STO)
8	Sanjay Sharma, Senior Technical Officer (STO)
9	Govind Prasad, Senior Technical Assistant (STA)
10	Ram Singh, Senior Technical Assistant (STA)
11	R.C. Meena, Senior Technical Assistant (STA)
12	Rakesh Goyal, Senior Technical Assistant (STA)
13	Bachuchu Singh, Technical Assistant (TA)
Administrative Staff	
1	Shitanshu Kumar, Administrative Officer
2	U.C. Sharma, Asst. Admin. Officer
3	Mukesh Kumar, Assistant
4	Poonam Keshri, Assistant
5	G.L. Meena, UDC
6	Pankaj Pathak, UDC
Audit and Accounts Unit	
1	P.K. Tiwari, Finance & Accounts Officer
2	Ajay Tandon, Junior Accounts Officer
3	Ram Sahay, Assistant
Supporting	
1	Lala Ram, Skilled Supporting Staff
2	Tara Singh, Skilled Supporting Staff
3	Kamal Singh, Skilled Supporting Staff
4	Sheetal Kumar Sharma, Skilled Supporting Staff
Krishi Vigyan Kendra, Gunta-Bansur	
1	Bhagwat Singh Rathore, Sr. Scientist & Head**
2	Rupendra Kaur, T-6
3	Sandeep Rastogi, T-6
4	Bajrang Lal Ola, T-6
5	Sunil Kumar, T-6
6	Prem Chand Garhwal, T-6
7	Arvind Kumar Verma, T -6

* Transferred during the year

** New Joining during the year

\# Promoted during the year

Sl. No.	Committee	Members
1	**Priority Setting, Monitoring and Evaluation (PME)**	Dr. V.V. Singh, Principal Scientist (Nodal Officer), Dr. Pankaj Sharma, Sr. Scientist, Dr. Vinod Kumar, Sr. Scientist, Dr. Ibandalin Mawlong, Scientist, Mr. M.S. Sujith Kumar, Scientist
2	**Results-Framework Document (RFD)**	Dr. V.V. Singh, Principal Scientist (Nodal officer), Dr. Vinod Kumar, Sr. Scientist (Co-Nodal Officer), Dr. Pankaj Sharma, Sr. Scientist, Dr. Ashok Sharma, Sr. Scientist, Mr. Shitanshu Kumar, AO, Mr. Sanjay Kumar, STO
3	**Institute Technology Management Unit (ITMU)**	Dr. Dhiraj Singh, Director (Ex-officio Chairman), Dr. K.H. Singh, Principal Scientist (Member Secretary), Dr. Archana Suman, Principal Scientist, IARI, Dr. Arun Kumar, Sr. Scientist, Dr. H.S. Meena, Sr. Scientist
4	**Institute Purchase Committee (IPC)**	Dr. P.K. Rai, Principal Scientist (Chairman), Dr. Arun Kumar, Sr. Scientist (Member), Dr. J. Nanjundan (Member), Mr. Sujith Kumar, Scientist (Member), Sh. Shitanshu Kumar, AO (Member), Sh. PK. Tiwari, FAO (Member)
5	**Institute Joint Staff Committee (IJSC)**	Dr. Dhiraj Singh, Director (Chairman), Dr. K.H. Singh, Principal Scientist (Member Secretary), Mr. Mukesh Kumar Assistant (Member Secretary), Dr. Pankaj Sharma, Sr. Scientist, Dr. Vinod Kumar, Sr. Scientist, Mr. Shitanshu Kumar, AO, Mr. P.K. Tiwari, FAO, Mrs. Veena Sharma, PA, Mr. Govind Prasad, TA, Mr. R.C. Meena, TA, Mr. Lala Ram, TA, Mr. Tara Singh, TA , Mr. Sheetal Kumar Sharma, TA
6	**Institute Research Committee (IRC)**	Dr. Dhiraj Singh, Director (Chairman), Dr. Ashok Sharma (Member Secretary), Scientists of ICAR-DRMR (Member)
7	**Research Advisory Committee (RAC)**	Dr. J. S. Sandhu, DDG Crop Science, ICAR (Chairman), Dr. Dhiraj Singh, Director, ICAR-DRMR,Dr. V.V. Singh, Principal Scientist (Member Secretary), Dr. R.S. Malik, Ex-Principal Scientist, IARI, Dr. M.L. Jat, Programme Coordinator, CIMMYT, Dr. Harvir Singh, Ex-Principal Scientist, DOR, Dr. Asha Shivpuri, Professor and Head (Retd.), RAU, Dr. J.P. Shrivastava, Professor, BHU, Dr. S.P.S. Karwasra, Ex-Director of Research, CCSHAU, Dr. B.B. Singh, ADG (OP), ICAR, Sh. Harbhan Singh (Non-official Member), Sh. Ramesh Yadav (Non-official Member)
8	**Women Complaint Committee**	Reema Rani, Scientist (Chairperson), Dr. Rupender Kaur, SMS (Member), Veena Sharma, PA (Member), Sh. Shitanshu Kumar, AO (Member)
9	**Institute Germplasm Identification Committee**	Dr. Dhiraj Singh (Chairman), Dr. K.H. Singh, Pr.Scientist, Dr. O.P. Premi, Pr. Scientist, Dr. Pankaj Sharma, Sr. Scientist, Dr. H.S. Meena, Scientist, Dr. J. Nanjundan, Scientist (Members)

15 Panorama

International Yoga day

International yoga day was celebrated at ICAR-DRMR campus on 21 June 2015. While addressing the session Dr. Dhiraj Singh, Director drew attention to the health benefits of yoga and recommended everyone to adopt it in their routine lifestyle to maintain good health. Sh. Bhagirath Singh, a trainer from Bharatpur, demonstrated various yoga poses for the session. All the staff and their family actively participated in this event.

Independence Day

On the eve of 15 August 2015, the staff of ICAR-DRMR enthusiastically celebrated the 69th Independence Day. Dr. Dhiraj Singh, Director ICAR-DRMR hoisted the flag and delivered the Independence Day message. He wished all the staff members and their family and spoke about the significant contributions made by freedom fighters for achieving this moment of glory. He also emphasized that the country demands concerted efforts of all employees for enhancing oilseed production and making the country self-reliant to meet growing edible oil demand.

Swachh Bharat Abhiyan

In compliance of "Swachh Bharat Abhiyan" of Hon'ble Prime-Minister, Swachta campaign was organised by the Directorate on 2 October 2015. On this occasion, Director along with all staff members performed cleaning of Directorate premises. Dr. Dhiraj Singh urged everyone to maintain cleanliness of offices, laboratories, guest house, residential complex, farms and adjoining areas of Directorate on a weekly basis.

Foundation Day

ICAR-DRMR celebrated its 22nd Foundation Day with great zeal and zest on 20 October 2015. Dr. Dhiraj Singh, Director, ICAR-DRMR, in his welcome address, highlighted the significant achievements and ongoing programme of ICAR-DRMR. A brainstorming session was organised on "Roadmap for Rapeseed-Mustard". Dr. R.S. Paroda, Ex-DG, ICAR chaired the session along with Dr. Sain Das, Ex-Director, DMR, Dr. M.L. Jat, CIMMYT and Dr. G.S. Saharan, Ex-Professor, CCSHAU. Scientists from various institutes, progressive farmers, and other stakeholders also participated in the storming session. During his thought-provokingaddress, Dr. Paroda enumerated various options for breaking the yield plateau and preventing the crop from biotic and abiotic stresses. He urged that research must be prioritised to fulfill the need of small farmers and emphasized the importance of rooting the research and extension activities on the small and marginal farmers and urged their participation in the technology

development process. He also called for the concerted functioning of research organizations, state agricultural department, KVKs and seed corporations for a better outcome regarding the development of new technologies. Dr. Sain Das pointed out the importance of training programmes and exhibitions for the popularisation of new technologies and varieties. Dr. Jat spoke about the importance of adoption of modern agronomic practices for improving productivity. The Directorate also recognised the contributions from its Scientific, technical and administrative staff during 2014-15 and presented awards in various categories. Dr. Pankaj Sharma, Sr. Scientist, Dr. Vinod Kumar, Sr. Scientist and Dr. Binay Kumar Singh, Scientist (SS) received the best scientist awards. Five technical bulletins from ICAR-DRMR were also published on this occasion.

Hindi Pakhwara

Hindi Pakhwara was organised in Directorate during 14-29 September 2015. On Inaugural day Dr. Dhiraj Singh, Director, DRMR appreciated the efforts of Directorate for Hindi language and motivated everyone to work in Hindi particularly in the transfer of technology from lab to land. Sh.

Rambabu Vidrohi, Hindi Poets, recited several Hindi poems during this event. Dr. Ashok Kumar Gupta, Hindi lecturer, M.S.G. College, Bharatpur gave prominence to the importance of Hindi language in effective communication. Awards were distributed to several employees of DRMR for their maximal contribution for the Hindi language. Dr. Vinod Kumar, Sr. Scientist coordinated the event.

Student exposure to ICAR-DRMR

Forty students of Delhi Public School, Bharatpur visited ICAR-DRMR on April 29, 2015, for their exposure to Directorate and Sh. Ajay Tandon, JAO delivered a talk on financial management system in Govt. sector on Oct 8, 2015. 52 students and two teachers of Delhi Public School, Bharatpur visited ICAR–DRMR for their exposure to ancient and modern Indian agriculture. Dr. Pankaj Sharma, Senior Scientist, highlighted the importance of agricultural science in day to day life of man and enlightened the aspiring students about the prospect of agriculture as their career option. The students visited research farm, agriculture implements, machinery and seed processing plant. During the interaction, students learn various technologies regarding improved crop varieties developed by the institute. Five students and teacher from TM International School, Bharatpur visited ICAR-DRMR on Oct 30, 2015, for exposure and formulation of the scientific project on agriculture. They were exposed to various scientific aspects of realistic agricultural production and technologies. Students posed so many queries to clarify the challenges of modern agricultural technologies amidst climate change, urbanization, and deforestation. The project submitted by students was also selected at the state level. The exposure visits were coordinated by Dr. Pankaj Sharma, Senior Scientist.

Vigilance Awareness Week

ICAR-DRMR observed Vigilance Awareness Week from 26-31 Oct 2015 by administering of the pledge in Hindi and English respectively to all the staff members of the Directorate. Dr. Dhiraj Singh, Director, delivered a talk on "Role of vigilance in theday to day life – an overview of vigilance" and drew focus on Department's role in combating corruption. He also emphasized to follow the ethical standards by one and all to contribute to the nation building. CVC of directorate also expressed his views on the topic "Preventive Vigilance as a tool of Good

Governance" and various vigilance related issues were discussed during an interaction session with the scientists and staff on the same day.

National Unity Day

National Unity Day was observed at DRMR, Bharatpur on Oct. 30, 2015, to commemorate the birthday of the Iron Man of India, Sardar Vallabhbhai Patel. Director, DRMR delivered a seminar and spoke about his instrumental role in keeping India united. He went on to say that if Gandhi is remembered for all his hard work towards gaining independence, then Sardar Patel equally deserves the same amount of appreciation. He also mentioned that Patel's bold courage brought all the 565 princely states into the Indian Union and saved breaking of India into innumerable pieces. With these forewords to the national leader, Director ICAR-DRMR, gave an oath and pledge to the entire gathering in Hindi and English. He also encouraged everyone to make an aspiration and make vigorous efforts to strengthen national reconciliation, develop national statehood and promote prosperity with the sense of thankfulness to peace and stability which we enjoy today.

Republic Day

The Directorate celebrated the 66th Republic day with great spirit on 26 January 2016. Dr. Dhiraj Singh, Director ICAR-DRMR hoisted the National flag. In his Republic day address, he mentioned about the rich cultural heritage of India. He congratulated everyone for their untiring efforts for the Directorate and also reiterated that strong efforts should be made in sustainably enhancing the edible oil production of the country.

ICAR-DRMR in Print media

About 60 news items/stories/advices etc. were published throughout the year in different dailies and weekly Hindi newspapers *viz*., Rajasthan Patrika, Dainik Bhaskar, Srusti Agro, Amar Ujala, Dainik Navjyoti, Rastradoot, Punjab Kesari, Haldhar Times, Krishi Goldline etc. to educate and aware farmers, farmwomen, extension personnel, etc. about scientific Rapeseed-Mustard technology, programmes, and activities of Directorate.

Budget (Rs in Lakhs)

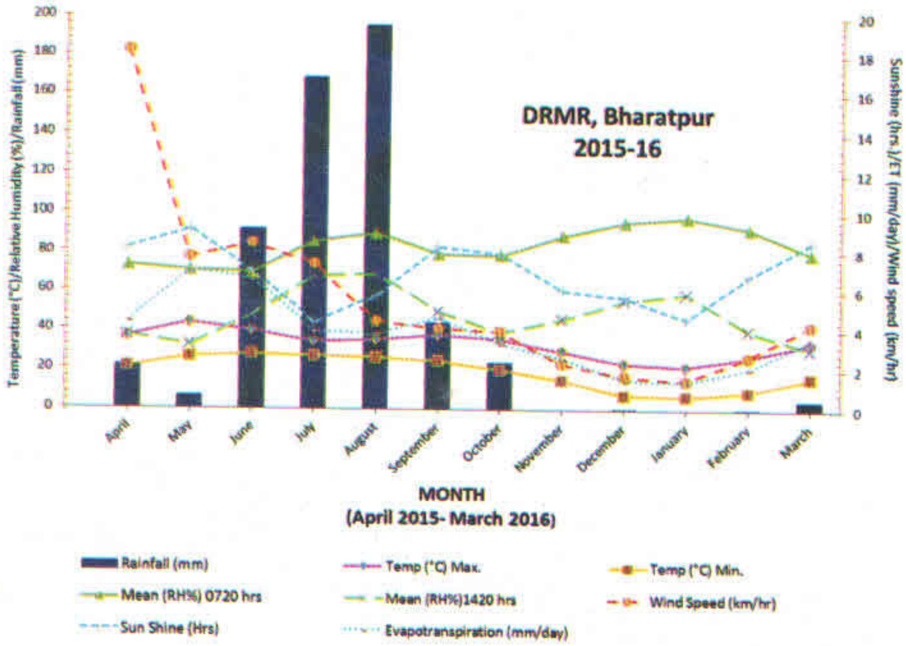
Head	Plan		Non-Plan	
	Sanctioned	Utilized	Sanctioned	Utilized
DRMR	250.00	250.00	543.16	534.30
AICRP-RM	1207.08	1207.08	-	-

Resource generation

Head of Account	Amount (Rs.)
Sale of farm produce	3789526
Sale of tender forms	51500
License fee	340157
Analytical testing fee	95350
Total	**4276533**
Income generated from internal resource generation schemes	
a) Training	100000
b) Guest House	291450
c) Transport charges	112998
d) DRMR	1090
Total	**505538**
Total Income generated	**4782071**

16 Meteorological Data

Overall it was an average monsoon year with total 556.6 mm of precipitation received in 32 rainy days. After few days of drizzling in April, the monsoon became active in last week of June and remained active throughout the July, August, and September. The monsoon withdrew in the first week of October with two rainy days, which was not sufficient for conserved moisture and ultimately affected the mustard sowing in rainfed areas. During cropping season from October-February, 27.9 mm rainfall was received. There were no rains from November to March, which seemed slightly favorable since low incidence of diseases were observed but overall low rainfall affected mustard crop. Throughout the cropping season, the monthly mean temperature remained favourable for rapeseed-mustard production. However, the daily maximum temperature reached around 35°C during October 2016 which affected germination of mustard crop. The evaporation losses ranged from 1.4-7.0 mm/day during the year and 1.4-3.4 mm/day during *rabi* season. The average sunshine during crop season was 4.3-9.1 hours.



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